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ELEMENTS
OF
NATURAL HISTORY
AND
CHEMISTRY.

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WITH
An Alphabetical Comparative View of the Ancient and Modern
Names of CHEMICAL SUBSTANCES, with all the TABLES,
and a Complete INDEX.

To which is prefixed by the TRANSLATOR,
A PREFACE, containing Strictures on the Hiſtory and preſent
State of CHEMISTRY; with Obſervations on the Poſitions,
Facts, and Arguments, urged for and againſt the ANTIPHLOGISTIC
THEORY, and the NEW NOMENCLATURE, by
Meſſrs LAVOISIER, PRIESTLEY, KIRWAN, KEIR, SAGE, &c.

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ELEMENTS
OF
NATURAL HISTORY
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CHEMISTRY.

PART II.

CHAP. VIII.

Genus IV. *Neutral Salts, with a baſe of Magneſia, or Magneſian Salts.*

WE have already ſeen in the hiſtory of acids, that magneſia naturally combines with thoſe ſalts, forming by that combination a peculiar genus of neutral ſalts. Thoſe neutral ſalts are as yet but imperfectly known, few chemiſts having made them the ſubject of their inquiries. The celebrated Dr Black firſt diſtinguiſhed them as a peculiar genus of ſalts; they were before confounded with other neutral ſalts, having an earthy baſe.

Magneſian ſalts poſſeſs generic characteriſtics. Almoſt all of them are ſalt and bitter; and they may be obtained, though not without difficulty, in regular cryſtals. Moſt of them diſſolve very readily in water, and ſome even attract the moiſture of the atmoſphere. They are eaſier decompoſed than ammoniacal or calcareous ſalts: barytes, lime, the fixed alkalis, and even ammoniac in part, rob them of their acids. Ammoniac enters into union with both magneſia and an acid at the ſame time; and thus forms ammoniaco-magneſian ſalts, conſiſting of three principles.

In this chapter we mean to examine ſix of thoſe ſalts; namely, magneſian ſulphate or Epſom ſalt, magneſian nitrate, magneſian muriate, magneſian borate, magneſian fluate, and magneſian carbonate.

Species I. *Sulphate of Magneſia, or Epſom Salt.*

The neutral ſalt formed by the combination of the ſulphuric acid with magneſia, has received the name of *Epſom ſalt*, from Epſom wells in England, where it was formerly obtained in great abundance. It is likewiſe found in the waters of Egra, Sedlitz, and Seydſchutz. Its proper name is *ſulphate of magneſia, or magneſian ſulphate.*

This ſalt has a very bitter taſte, from which it has been called *bitter cathartic ſalt.* In commerce it appears in ſmall needles, terminating in very ſharp pointed pyramids; in which ſtate it is pretty much like ſulphate of ſoda, or *Glauber ſalt:* but it is of a more bitter taſte, does not effloreſce in the air, and when regularly cryſtallized, gives cryſtals of a very different form. When ſuffered to cryſtallize ſpontaneouſly, its cryſtals are fine quadrangular priſms, terminating in pyramids, which are alſo quadrangular. The ſides of thoſe priſms and pyramids are ſmooth and plain, and the cryſtals are generally ſhorter and thicker than thoſe of ſulphate of ſoda. All its other properties, as we we ſhall hereafter ſee, concur to diſtinguiſh it from that perfect neutral ſalt.

Sulphate of magneſia, like ſulphate of ſoda and borax, retains in its cryſtals enough of water to make it ſuſceptible of aqueous fuſion. The moſt moderate heat is ſufficient to melt it: when cooled after this fuſion, it becomes a ſhapeleſs maſs. If it remain expoſed to fire after this aqueous liquefaction, it dries into a white friable maſs, which is the ſalt unaltered, only without the water which entered into its cryſtals. A very intenſe heat is requiſite to bring magneſian ſulphate to an actual igneous fuſion. This ſalt in cryſtals contains a quantity of water nearly equal to half its weight.

Macquer and ſeveral other chemiſts ſay, that when expoſed to the air, it becomes ſomewhat moiſt, and that it may be diſtinguiſhed by this property from ſulphate of ſoda which effloreſces. Bergman again informs us, that when magneſian ſulphate is expoſed to the atmoſphere in a dry ſtate, it immediately loſes its tranſparency, and is at length reduced to a white powder: he adds, that the magneſian ſulphate in ſmall needles, which is commonly ſold in the ſhops, owes its moiſt deliqueſcent appearance to the magneſian muriate which it contains. M. Butini, a citizen of Geneva, to whom we are indebted for a number of valuable experiments on magneſia, mentions his having found ſulphate of ſoda, or Glauber ſalt, in Engliſh Epſom ſalt; and to this the effloreſcence may be attributed. But pure ſulphate of magneſia, though it loſes its tranſparency in the air, is far from being ſo liable to effloreſcence as ſulphate of ſoda, which at the end of a certain time is entirely reduced to duſt.

Sulphate of magneſia diſſolves in water ſo readily, that rather leſs than two parts of cold water are ſufficient to maintain one part of this ſalt in ſolution; and warm water diſſolves a quantity of it equal nearly to twice its own weight. It cryſtallizes by cooling; but in order to obtain it in very regular cryſtals, we leave the ſolution to cryſtallize when cold by ſpontaneous evaporation.

This ſalt ſuffers no alteration from either ſiliceous or aluminous earth.

Barytes decompoſes it, having a greater affinity than magneſia with the ſulphuric acid.

Lime, for the ſame reaſon, decompoſes it. If a little ſulphate of magneſia be poured into lime-water, or a certain quantity of lime-water be poured into a ſolution of this ſalt, a precipitate is produced, conſiſting of magneſia and calcareous ſulphate. Recourſe may be had at any time to the precipitation, as a ſure criterion to enable us to diſtinguiſh magneſian ſulphate from ſulphate of ſoda.

The pure fixed alkalis likewiſe decompoſe ſulphate of magneſia. Cauſtic ammoniac has the ſame influence on this ſalt; and as it does not decompoſe calcareous ſulphate, we learn from theſe facts, that it has a ſtronger affinity with the ſulphuric acid than magneſia, and a weaker than lime. Thus we gain a certain criterion by which we may diſtinguiſh when magneſian ſulphate exiſts in water. In this manner, by the uſe of cauſtic ammoniac, pure magneſia, of which we gave the hiſtory in entering on the conſideration of ſaline matters, may be obtained. Yet Bergman has obſerved, that ammoniac does not effect an entire precipitation of the magneſia of Epſom ſalt; part ſtill remains unaltered. The liquor in which the two ſubſtances are mixed, maintains both ammoniacal and magneſian ſulphate in ſolution at the ſame time. Chemiſts have diſcovered that theſe two ſalts join to form a third, conſiſting of an acid and the two baſes. But to prevent miſtakes,

miſtakes, we muſt obſerve, that though theſe ſalts be found together in the ſame water, yet the one conſiſts of ammoniac in combination with the ſulphuric acid, while the other is a combination of magneſia with the ſame acid. Each poſſeſſes a diſtinct portion of the acid; both the baſes are by no means in union with the ſame portion of the acid: yet theſe two ſulphates have a pretty ſtrong mutual affinity; they cryſtallize together, and thus produce what may be called *a triple ſalt*, or *ammoniaco-magneſian ſulphate.*

We know not well in what manner magneſian ſulphate affects thoſe neutral ſalts which have for their baſe a fixed alkali or ammoniac: probably it would decompoſe the nitric and the muriatic ſalts with theſe baſes by a double affinity.

M. Quatremere Dijonval aſſerts, in a letter to M. de Morveau, (*Journal de Phyſique*, May 1780, vol. xvii. page 391.), that when a ſolution of ſulphate of magneſia is brought into contact with a ſolution of ammoniacal ſulphate, the former ſalt is entirely precipitated without being decompoſed: it falls to the bottom of the glaſs in large cryſtals, the taſte of which indicates their nature. He aſcribes this effect to the property which ammoniacal ſulphate poſſeſſes, of attracting water from ſulphate of magneſia, which he believes to cryſtallize very readily. But this is a miſtake; for the ſalt cryſtallized on this occaſion is a real triple ſalt, or ammoniaco-magneſian ſulphate, as I know from unequivocal experiments.

The carbonic ſalts and magneſian ſulphate mutually decompoſe each other. When a ſolution of carbonate of potaſh or ſoda is poured into a ſolution of magneſian ſulphate, a double decompoſition and a double combination take place. The ſulphuric acid of Epſom ſalt combines with the fixed alkali, and the carbonic acid ſeparated from the alkali unites with the magneſia to form the neutral ſalt known by the name of *mild or efferveſcent magneſia*, and which we call *carbonate of magneſia.* The mild magneſia, uſed in medicine as an excellent purgative, is prepared in this manner. We will give a minute deſcription of the proceſs at the end of this chapter.

According to M. Dijonval, when a ſolution of ſulphate of lime is mixed with a ſolution of ſulphate of magneſia, the latter ſalt is precipitated: but the quantity of calcareous ſulphate that can be maintained in ſolution is ſo ſmall that this phænomenon is ſcarcely diſcernible. Calcareous nitrate and calcareous muriate likewiſe decompoſe ſulphate of magneſia, and are decompoſed by it in their turn: but we cannot think this fact warrants the concluſion which M. Dijonval deduces from it, namely, that the nitric and the muriatic acids have a greater affinity than the ſulphuric acid with magneſia; for it is evident that double elective attraction acts in theſe inſtances.

Bergman ſays, that a quintal of ſulphate of magneſia in cryſtals contains nineteen parts of pure magneſia, thirty-three of ſulphuric acid, and forty-eight of water.

Sulphate of magneſia, or Epſom ſalt, is of conſiderable uſe in medicine. It is a good purgative, and acts at the ſame time as a diſcuſſive. It is even preferred to other purgative ſalts, on account of its extreme ſolubility. It is either given by itſelf, diſſolved in water, in doſes of from one to two ounces; or a dram or two of it is adminiſtered along with ſome other medicine. Moſt waters that are naturally purgative, derive their mineral qualities from it, more eſpecially thoſe of

Egra, Sedlitz, and Seydſchutz: but they likewiſe contain muriate of magneſia.

Species II. *Magneſian Nitrate.*

Magnesian nitrate, which chemiſts have hitherto called *nitre of magneſia*, or *nitrated magneſia*, has been examined by Bergman. That illuſtrious chemiſt ſays, an artificial ſolution of this ſalt gives, after a proper evaporation, priſmatic, quadrangular, and ſpathoſe cryſtals, without pyramids.

This ſalt has an acrid and very bitter taſte; heat decompoſes it; and it imbibes moiſture in the air. It diſſolves very readily in water; a ſlow evaporation is requiſite to make it cryſtallize; and we are even ſo imperfectly acquainted with the laws of its cryſtallization, that we cannot make it aſſume a regular form at pleaſure, like many of the other ſalts. Barytes, lime, and the alkalis, decompoſe it.

As magneſian nitrate is found diſſolved in mother-water of nitre, M. de Morveau has propoſed precipitation by lime-water, as a method of obtaining the magneſia in the great way. This proceſs, being ſo cheap and eaſy, might be employed with great advantage; but as the ſame chemiſt has obſerved that freſh lime-water precipitates pure calcareous nitrate when it is diſſolved in too ſcanty a proportion of water, the magneſia obtained by this proceſs would not poſſeſs the degree of purity requiſite to render it an uſeful medicine, unleſs the mother-water were diluted in a large quantity of common water.

The ſulphuric and the fluoric acids diſengage the acid from nitrate of magneſia. The boracic acid likewiſe ſeparates it with the help of heat, in conſequence of its fixity. Theſe properties of this ſalt have been pointed out by Bergman.

M. Quatremere Dijonval, who has examined many of the combinations of magneſia, has found magneſian nitrate to poſſeſs ſome properties very different from thoſe aſcribed to it by the chemiſt of Upſal. He tells us, that he obtained cryſtals of magneſian nitrate, not liable to deliquium; and adds, that magneſian ſalts are not leſs diſpoſed to cryſtallization and effloreſcence than calcareous ſalts to attract moiſture.

Nitrate of magneſia appears to be capable of decompoſing ſulphate of potaſh, ſoda, or ammoniac, by double affinity. But theſe decompoſitions are not ſo obſervable when ſolutions of the ſalts are mixed together, as the decompoſitions effected by calcareous nitrate; becauſe the nitrates of potaſh, ſoda, or ammoniac, as well as the ſulphate of magneſia, conſequently produced, are all very ſoluble in water; whereas the ſulphate of lime produced by the decompoſition of ſulphate of potaſh, ſoda, or ammoniac by calcareous nitrate, gives a very copious precipitate. By evaporating the liquors, however, we can make ourſelves certain of the effects produced by magneſian nitrate on the above-mentioned ſalts. Nitrates are found to be formed by the union of the alkalis with the nitric acid, and ſulphate of magneſia by the combination of ſulphuric acid from the decompoſed ſalts with the baſe of magneſian nitrate.

M. Dijonval mentions a fact which well deſerves the attention of chemiſts. It is the precipitation of magneſian nitrate by calcareous nitrate. When pure tranſparent ſolutions of theſe two ſalts, ſays he, are mixed together, the magneſian nitrate is immediately depoſited on the bottom of the veſſel in a cryſtalline form, and not at all altered; but the calcareous nitrate remains diſſolved in the liquor. It is very ſingular, that of two ſalts which will remain diſſolved if they be kept ſeparate, one is inſtantly precipitated in cryſtals when they are brought into contact with each other. M. Dijonval thinks, as we have mentioned above, that this depends on the ſtrong tendency of calcareous nitrate to combine with water. This ſalt being, in his opinion, capable of abſorbing a greater quantity of water than what is neceſſary to maintain it in ſolution: when mixed with a ſolution of magneſian nitrate, which has an equal tendency to cryſtallization, it robs this laſt ſalt even of the water of its cryſtals; and the magneſian nitrate then acquiring greater ſpecific gravity, is precipitated in a cryſtalline form. There are, however, ſeveral difficulties not ſolved by this explanation. How can any ſalt, however great its tendency to ſolution, abſorb the water belonging to the cryſtals of another ſalt, when it is itſelf already combined with a quantity of that liquid ſufficient to maintain it in ſolution? If it be anſwered, that it is not ſaturated with water, there muſt then be a certain point of ſaturation, at which calcareous nitrate would ceaſe to precipitate magneſian nitrate; and this ſhould ſurely have been ſhown. But though this were granted, how could calcareous nitrate deprive magneſian nitrate of the water of its cryſtals, and yet ſuffer it to be precipitated in a cryſtalline form? Laſtly, How is it poſſible that magneſian nitrate, after loſing its water of cryſtallization, can be inſtantaneouſly precipitated in cryſtals? We are thus induced to think that ſome particulars muſt have eſcaped M. Dijonval's obſervation; and that the true cauſe of this phenomenon is not likely to be diſcovered till ſuch time as the experiment has been again and again repeated with various quantities of water, and of the ſalts, as well as in various temperatures, &c.

Magneſian nitrate is not applied to any uſe either in the arts or in medicine. Its ſtrong taſte, its tendency to deliquiate, and indeed all its properties, lead us to think, that it would act powerfully on the animal œconomy; and it is much to be wiſhed that it were tried as a diſſolvent and inciſive in all caſes in which medicines of that nature are requiſite.

Species III. *Magneſian Muriate.*

This ſalt, which is a ſaturated combination of the muriatic acid with magneſia, exiſts in all ſalt waters, and in all waters containing magneſian ſulphate in a ſtate of ſolution; ſuch as thoſe of Epſom, Egra, Sedlitz, and Seydſchutz, as well as many others. It is much more common than it was once thought to be.

Magneſian muriate has a very bitter hot taſte. Bergman ſays, that the only way of obtaining it in cryſtals is by expoſing a ſolution of it, highly concentrated by evaporation, to a ſudden and extreme cold. It is then obtained in the form of ſmall needles, having a ſtrong tendency to deliquiate. The ſolution is commonly a tranſparent jelly: But M. Dijonval ſays, that he obtained this ſalt in a regular permanent form; and that it has a tendency rather to effloreſce than to deliquiate.

Magneſian muriate is decompoſed and deprived of its acid by the action of fire. It is very difficult to drive off the laſt remains of the acid: after this operation the magneſia becomes cauſtic.

When this ſalt is expoſed to the air, it appears to attract moiſture eagerly, and is ſoon diſſolved into a liquid. Bergman and ſeveral other chemiſts have taken notice of its poſſeſſing this property. M. Dijonval, however, ſays, that magneſian muriate, like magneſian nitrate, rather effloreſces than attracts moiſture. But this aſſertion needs farther confirmation by experiment.

Magneſian muriate diſſolves very readily in water; it even appears, that a portion of the fluid equal to itſelf in weight is ſufficient to maintain any quantity of this ſalt in ſolution. It is very difficult to obtain this ſalt in regular cryſtals. Evaporation by heat ſucceeds very ill; for it concentrates the liquor too much; which, when cooled, aſſumes almoſt always the conſiſtency of a jelly. Spontaneous evaporation in a ſummer temperature is more likely to cryſtallize this ſalt: but even this method is attended with great difficulties.

Muriate of magneſia, heated in a retort with ſiliceous earth and clay, gives out its acid; but as the action of fire alone is ſufficient to produce this effect, it is not to be attributed to the earths.

Barytes and lime decompoſe this ſalt by precipitating the magneſia. As the mother-waters of muriate of ſoda in ſalt ſprings contain muriate of magneſia mixed with calcareous muriate, the magneſia which theſe ſalts contain may be precipitated in the great way, and at a ſmall expence, by means of lime-water.

The fixed alkalis and cauſtic ammoniac have a greater affinity than magneſia with the muriatic acid, and cauſe the baſe of magneſian muriate to precipitate. The muriate of potaſh, ſoda, or ammoniac, according as the one or the other of theſe ſalts has been employed, remains diſſolved in the liquor. Ammoniac does

not

not entirely decompoſe this ſalt, but forms a triple cryſtallizable muriatic ſalt with the remaining portion of it.

The ſulphuric and the nitric acids decompoſe this ſalt, ſeparating the muriatic acid with effervеſcence. In order to effect theſe decompoſitions, a mixture, conſiſting of one part of either of theſe acids and two parts of muriate of magneſia, is to be diſtilled in a glaſs retort. The acid belonging to the magneſian muriate is volatilized, while the other acids being ſtronger, combine with the magneſia to form magneſian ſulphate or nitrate. The boracic acid likewiſe diſengages the muriatic acid with the help of heat.

Magneſian muriate decompoſes ſulphuric and nitric ſalts, with a baſe of fixed alkali or ammoniac, by the way of double affinity. But in order to render theſe decompoſitions apparent, the ſolutions of the ſalts muſt firſt be poured upon a ſolution of magneſian muriate, and then evaporated, or mixed with ſpirit of wine; for the new ſaline matters formed by the decompoſition remain diſſolved in the water after it is effected.

When muriate of magneſia is brought into contact with muriate of potaſh, and both are in a ſtate of ſolution, the former ſalt is precipitated in cryſtals, according to M. Dijonval, in conſequence of its having a much greater tendency to cryſtallization than the other; which takes poſſeſſion of the water by which it was maintained in ſolution. But it is difficult to conceive how any ſalt which has ſo ſmall a tendency as muriate of potaſh to diſſolve or deliquiate, can rob another ſalt, ſo ſoluble as magneſian muriate, of the water by which it was diſſolved. The ſame chemiſt informs us, that when a ſolution of magneſian muriate is mixed with a ſolution of calcareous muriate, the former ſalt is precipitated in cryſtals. But farther experiments are

are neceſſary to give theſe aſſertions ſuch authority as may intitle them to rank among the elements of the chemical ſcience. Very likely the cryſtals precipitated are not pure, but to be referred to the claſs of triple ſalts.

Magneſian muriate is not applied to any uſe: but, in my opinion, it might be very happily uſed in medicine as a purgative and diſſolvent. Phyſicians always adminiſter ſmall quantities of it when they preſcribe Epſom or Sedlitz waters, or grey marine ſalt; for thoſe ſubſtances ſtill contain more or leſs of it.

Species IV. *Magneſian Borate.*

THIS name is given to the combination of the boracic acid with magneſia. This ſalt is ſcarce known. Bergman has obſerved, that when a portion of magneſia is caſt into a ſolution of the boracic acid it is ſlowly diſſolved. This liquor, when evaporated, affords granulated cryſtals of an irregular form.

Fire melts, but does not decompoſe this ſalt. The acids decompoſe it by attracting the magneſia, and ſeparating the boracic acid. Spirit of wine likewiſe carries off the acid, leaving the magneſia by itſelf. It appears therefore that magneſia does not adhere very cloſely to the acid of borax.

We muſt therefore confeſs ourſelves to be very little acquainted with the properties of this ſalt, as chemiſts have made but very few experiments upon it.

Species V. *Magneſian Fluate.*

Magnesia in combination with the fluoric acid receives the name of *magneſian fluate*, and is not better known than magneſian borate. Bergman is the only chemiſt who has ſaid any thing of it. According to him, the fluoric acid diſſolves magneſia very quickly; and when the acid is nearly ſaturated, a great part of the new-formed ſalt is precipitated.

The ſolution affords, by ſpontaneous evaporation, a kind of tranſparent froth which hangs to the ſides of the veſſel, conſiſting partly of long and very fine cryſtalline threads. There are at the ſame time obtained, in the bottom of the veſſel, ſpathoſe cryſtals in hexagonal priſms, terminating in a ſhort pyramid conſiſting of three rhombs. This ſalt is liable to no alteration from even the moſt extreme violence of fire. No acid has ſtrength to decompoſe it in the humid way. This neutral fluoric ſalt, to which Bergman has attributed ſuch extraordinary properties, is well worthy of a more particular examination.

Species VI. *Magneſian Carbonate.*

This ſalt, to which Dr Black, the firſt diſcoverer of it, has given the name of *mild or effervefcing magneſia*, is formed, as the name we have given it indicates, by a ſaturated combination of magneſia with the carbonic acid. It is commonly prepared by precipitating a ſolution of magneſian ſulphate with carbonate of potaſh or ſoda, in a way which we ſhall deſcribe at the end of this article.

Magneſian carbonate has moſt generally an earthy appearance:

appearance: it is in the form of a very white powder. Yet Bergman and M. Butini of Geneva obtained it in cryſtals by the proceſs which we are hereafter to deſcribe. Like all other carbonic ſalts, it may contain either a greater or a leſs proportion of the acid; and its properties vary according to the proportion in which the acid exiſts in it. Its taſte is crude and earthy. But it affects the inteſtines in a more ſenſible manner; for it is purgative.

This ſalt, when expoſed to fire in a crucible, loſes both the water and the acid which it contains. M. Tingry apothecary at Geneva, has obſerved, that when effervefcing magneſia is calcined in the great way, it bubbles, and exhibits on its ſurface the motion of a fluid. This phænomenon is owing to the diſengagement of the acid gas. There ariſes out of the crucible a thin vapour, which depoſites on contiguous bodies a white duſt that is readily known to be magneſia carried off by the current of the carbonic acid. If a warm body be immerſed in the crucible, the ſalt adheres to it; a cold body attracts ſtill more. Towards the end of the operation, the magneſia diſplays a bluiſh phoſphoric light, which in the dark is very diſcernible.

By calcining carbonate of magneſia in cloſe veſſels, with a pneumato-chemical apparatus, we obtain water and the acid of the ſalt. M. Butini, who performed this operation in a very exact manner, informs us, from a calculation founded on the products which he obtained, that thirty-two grains of common magneſia (what he calls *common magneſia* is a kind of magneſian carbonate prepared for pharmaceutical purpoſes, and not completely ſaturated with the acid) conſiſt of about thirteen grains of pure earth, twelve of the acid, and ſeven of water. Bergman reckons a quintal of this ſalt to contain twenty-five or thirty parts of the acid, according to its particular ſtate, thirty of water, and forty-five of pure magneſia. If expoſed to a more intenſe heat, after loſing its acid it is agglutinated and becomes hard, like pure or cauſtic magneſia.

Magneſian carbonate ſuffers no very remarkable alteration from air; yet, when expoſed to a damp atmoſphere, it aſſumes the form of little clods, and appears to deliquiate in ſome degree.

Water diſſolves but a very ſmall proportion of this ſalt; and its ſolubility in water varies, according as it contains more or leſs of the acid. When a quantity of the ſalt is mixed with a ſmall portion of water, it compoſes a kind of paſte; which, however, is not very tenacious, and dries up without acquiring conſiſtency or ſhrinking into a ſmaller bulk. If diluted in a very large proportion of water, magneſian carbonate diſſolves gradually, at the rate of a quarter of a grain of the ſalt to an ounce of the fluid; as appears when the liquor is evaporated. But there are ways of making this ſalt diſſolve in a much larger proportion; which we will immediately mention.

Pure earths do not decompoſe carbonate of magneſia. Lime robs it of its acid. Lime-water poured into a ſolution of this ſalt, occaſions an obſervable precipitation, however ſmall the quantity of the neutral ſalt diſſolved in the water. The precipitate conſiſts of carbonate of lime, and a little cauſtic magneſia, which is known to be almoſt inſoluble.

The fixed alkalis and cauſtic ammoniac likewiſe decompoſe this ſalt: for they, as well as lime, have a greater affinity than magneſia with the carbonic acid. The reſults of theſe mixtures are carbonate of potaſh, ſoda, or ammoniac, and pure cauſtic magneſia,—which is precipitated.

The ſulphuric, the nitric, and the muriatic acids, decompoſe magneſian carbonate in a directly contrary way, and by that means complete the analyſis of this neutral ſalt. They unite with the magneſia, with which they have a ſtronger affinity than the carbonic; and they occaſion an effervefcence by diſengaging that acid under a gazeous form. The carbonic acid which eſcapes on the occaſion is diſtinguiſhed by its uſual characteriſtics. M. Butini obſerved, in his experiments, that it was rather the fire than the acids which diſengaged the carbonic acid; and that each of thoſe ſalts ſeparated a different quantity. Thus, for inſtance, he found the muriatic acid to diſengage more than the nitric, and the nitric more than the carbonic. From theſe facts he concluded, that neutral ſalts, conſiſting of magneſia in combination with an acid, namely ſulphate and nitrate of magneſia, ſtill retain a portion of the carbonic acid.

The carbonic acid poſſeſſes the property of rendering carbonate of magneſia much more ſoluble than the pure ſalino-terreous matter. M. Butini's late experiments have been chiefly directed to determine the phænomena of this ſolution. He has diſcovered, that when any quantity of common magneſia, not ſaturated with the carbonic acid, is thrown into water in a gazeous ſtate, or impregnated with the acid, the magneſia immediately abſorbs as much acid from the water as is requiſite to ſaturate it, and even does not diſſolve till it be ſuper-ſaturated. This ſolution communicates a green tincture to ſyrup of violets. When expoſed to cold, it loſes its exceſs of acid; but the magneſia is not ſeparated from the water, even though it it be frozen into ice. When a ſolution of magneſia, ſuper-ſaturated with carbonic acid, is expoſed to heat, it loſes its tranſparency, but regains it when ſuffered to cool. This ſingular phænomenon offers to our obſervation, as M. Butini has very well obſerved, a new kind of ſalts, to which it is peculiar to diſſolve in a larger proportion in cold than in hot water. The more magneſia any gaſeous ſolution contains, the ſooner does it loſe its tranſparency by heat. In order to have a proper opportunity of obſerving how this ſalt, from muddy, becomes tranſparent as it cools, the above mentióned chemiſt directs us to take a ſolution, containing two grains of magneſia to an ounce of water, and to heat it to 170° of Fahrenheit's thermometer. Heat gives it a milky conſiſtency; but all the magneſia now precipitated is again diſſolved by cold.

Bergman had before obſerved, that when a ſolution of magneſia impregnated with carbonic acid was ſlowly evaporated, it afforded cryſtals, ſome of which were in tranſparent grains, others reſembled two pencils of rays diverging from one point. M. Butini has obſerved all the phænomena of that cryſtallization with greater accuracy. With the heat of a lamp which was very faint, he evaporated a ſolution containing nine grains of this ſalt to the ounce of water. A pellicle was ſoon formed on the ſurface, the under part of which, as well as the ſides of the veſſel, was in a manner fringed over with bunches of cryſtals. The reſidue exhibited bright needles, conſiſting of ſmall hemiſpherical maſſes with diverging threads. Theſe needles were not a line in length; but when viewed with a microſcope, appeared to be long priſms with ſix ſides, truncated by an hexagon, and reſembling ſome ſpars.

M. Butini has likewiſe diſcovered another way of cryſtallizing magneſian carbonate. It conſiſts in expoſing to the air a ſolution of this ſalt precipitated by heat. At the end of a few days, this ſolution affords cryſtals reſembling thoſe which are obtained by evaporation. Magneſia precipitated from Epſom ſalt by carbonate of potaſh, and afterwards dried, will not cryſtallize in this manner: though diluted in water, it never forms any other than irregular lumps. But a ſolution of ſulphate of magneſia, taken ſoon after it has been precipitated by the ſame ſalt, gives, at the end of ſeveral days, cryſtals in the ſhape of needles. When this ſolution is ſeparated by filtration from its precipitate, it likewiſe gives needles of magneſia. I have often obſerved, that a ſolution of carbonate of magneſia, prepared for the uſe of a laboratory, and kept in well ſtopped glaſs phials, depoſites, after ſome time, a large quantity of very fine bright ſmall needles, which, when viewed through a magnifier, appear to be priſms of ſix ſides.

Perfect neutral ſalts ſuffer no alteration from magneſian carbonates, nor do they produce any change upon it. Only, according to M. Butini, they render it more ſoluble in water. But carbonate of potaſh muſt here be excepted; for it rather deſtroys *its* ſolubility.

Effervefcent magneſia decompoſes calcareous neutral ſalts; and this decompoſition is effected by virtue of a double affinity. We have already obſerved that lime has a greater affinity than magneſia with the acids, and of conſequence decompoſes neutral ſalts, which have magneſia for their baſe. It is to the acid, therefore, that the decompoſition of calcareous ſalts by magneſian carbonate is owing. Lime, on account of the ſtrong affinity which it has with the carbonic acid, forſakes the other acids to combine with it, provided the acids which it deſerts find another baſe with which they can enter into combination. Therefore, when a ſolution of magneſian carbonate is poured into a ſolution of calcareous ſulphate, nitrate, or muriate, the ſulphuric, the nitric, or the muriatic acid, forſaking the lime, combines with the magneſia to form ſulphate, nitrate, or muriate of magneſia; while the lime combining with the carbonic acid ſeparated from the magneſia is precipitated in chalk.

Magneſia in this inſtance, therefore, reſembles ammoniac. When either of theſe ſubſtances is pure and cauſtic, it is incapable of decompoſing calcareous ſalts, as having a greater affinity than lime with the acids. But when united with the carbonic acid, and in the ſtate of neutral ſalts, they then acquire the power of decompoſing calcareous ſalts by double attraction; as has been already ſhown under the articles Sulphate of Lime, Calcareous Nitrate, &c.

The ſalt of which we are ſpeaking is uſed in medicine under the name of *mild or white magneſia.* It was formerly prepared from mother water of nitre, evaporated to dryneſs, or precipitated by fixed alkali. It was originally known by the name of *Count Palma's powder*, and *Sentinelli's powder:* It has ſince been called *laxative polychreſt ſalt by Valentini*, *white magneſia of nitre*, *magneſia of common ſalt;* becauſe it was obtained from the mother water of this laſt ſalt. But when prepared in this manner, it always contains cal-

careous

careous earth, and various other extraneous matters: And therefore, what is at preſent made uſe of, is uſually precipitated from ſulphate of magneſia by vegetable fixed alkali, or carbonate of potaſh.

M. Butini gives an excellent proceſs for obtaining it very fine and in as large a quantity as poſſible. Dilute any quantity of potaſh in twice its weight of cold water: let this lixivium, if the ſeaſon will allow, be expoſed to the air for ſome months, in order that it may abſorb carbonic acid from the atmoſphere, and the earth which it contains may be precipitated: let it then be filtrated: next diſſolve a quantity of ſulphate of magneſia equal to the quantity of potaſh which you have already diſſolved, in water equal to four or five times its weight: filtrate this ſolution, and add a new quantity of water equal to five times the weight of the ſalt. Let this liquor be heated to ebullition, and then poured into the ſolution of vegetable alkali. The precipitate of magneſia is ſoon formed, and the mixture muſt then be well ſtirred, and afterwards filtrated through paper. The precipitate which remains on the paper uſed in the filtration muſt be waſhed with boiling water, to carry off the ſulphate of potaſh intermixed with it. After the water is ſufficiently drained off, the magneſia muſt be taken and ſpread on pieces of paper in thin layers, and put into a ſtove to dry. When thoroughly dried, it appears in the form of white lumps, which crumble between the fingers into a very fine powder that ſticks to the ſkin.

This magneſia, in combination with the carbonic acid, is to be preferred as a purgative; becauſe it is much more ſoluble. It is given in doſes of one or of two ounces, as the caſe requires. But cauſtic magneſia again is preferable to it as an abſorbent; and apothecaries ſhould keep both kinds. The principal reaſon for preferring ſometimes the one, ſometimes the other of theſe, in the practice of phyſic, on account of which apothecaries ought always to keep both kinds, has been very well explained by Macquer in a paper inſerted among thoſe of the Royal Society of Medicine. When magneſia is given as an abſorbent, the deſign of it is to deſtroy and neutralize an acid exiſting in too great abundance in the primary paſſages, as is the caſe with children, young girls, lying-in women, &c. That gaſtric acid is certainly ſtronger than the carbonic. When mild magneſia, therefore, enters the ſtomach, it produces an efferveſcence, more or leſs lively according as there is more or leſs of the acid to be abſorbed in the primary paſſages. The carbonic acid diſengaged by that efferveſcence, diſtends the ſtomach, and frequently occaſions pains, nauſea, vomitings, a difficulty of breathing, with many other ſpaſmodic complaints, according as the ſenſibility of the parts is greater or leſs. In ſuch caſes, therefore, it is much better to make uſe of pure magneſia, which abſorbs the ſour matter as powerfully, and occaſions no efferveſcence.

Again, when magneſia is given as a purgative, and not to abſorb acid matter in the primary paſſages, magneſian carbonate may then be given. The carbonic acid is not diſengaged in this caſe, and the complaints occaſioned by this elaſtic fluid diſtending the ſtomach are not to be feared. Phyſicians ought therefore to be acquainted with theſe two kinds of magneſia, and to know when the one and when the other is to be adminiſtered; and apothecaries ought always to keep both in their ſhops.

M. Butini mentions an artificial mineral water, conſiſting of gazeous water impregnated with magneſia. He obſerves, that this fluid may be made to contain three drams of this magneſian earth to the pound; and that, beſides, it may be as eaſily prepared as acidulated or gaſeous martial waters. In fact, both are prepared preciſely in the ſame way. Phyſicians might find this water uſeful on many occaſions.

CHAP. IX.

Genus V. *Argillaceous or Aluminous Neutral Salts.*

CLAY, or aluminous earth, when very pure, combines very readily with moſt of the acids. From thoſe combinations there reſult neutral ſalts, which are known by the general name of *argillaceous* or *aluminous ſalts*. Excepting the firſt ſpecies, no part of this genus of ſaline matters has yet been examined with proper care by chemiſts. And their properties are therefore ſtill leſs known than the properties of the ſalts belonging to the four preceding genera. Aluminous ſalts are in general more imperfect than any of the neutral ſalts which have hitherto engaged our attention. They yield their acids to the fixed alkalis, ammoniac, barytes, lime, and magneſia. They have a ſour aſtringent taſte.

This genus includes ſix ſpecies;—alum, or aluminous ſulphate; aluminous nitrate; aluminous muriate; aluminous borate; aluminous fluate; and aluminous carbonate.

Species

Species I. *Aluminous Sulphate or Alum.*

Alum is a neutral ſalt, conſiſting of the ſulphuric acid combined with aluminous earth or pure clay, and it merits, of conſequence, the name of *aluminous ſulphate.* Chemiſts have not been always agreed concerning the nature of the baſe of alum. Some formerly diſtinguiſhed it from clay, under the name of *aluminous earth* or *earth of alum.* Margraaf has ſhown that a mixture of this earth with ſilex, both in powder, forms clay. Hellot, Geoffroy, Pott, and more eſpecially M. Baumé, have all formed genuine alum by mixing clay with the ſulphuric acid. Laſtly, if the characteriſtic properties of clay be to form a tenacious paſte with water, and to ſhrink and harden when expoſed to fire; as aluminous earth diſplays theſe properties in an eminent degree, it is therefore to be conſidered as the pureſt part of clay. Such is the opinion which at preſent is generally prevalent among chemiſts concerning this matter. This ſhows ſtill more ſtrongly the propriety of diſtinguiſhing the earth which ſerves as the baſe of alum by the peculiar name of *aluminous earth*; becauſe clay, however pure, always contains a portion of ſiliceous earth.

Aluminous ſulphate, or alum, at firſt affects the organs with a ſweetiſh taſte, and is afterwards felt to be ſtrongly aſtringent. It makes blue paper red; which ſhows it to contain a portion of unſaturated acid. It is capable of a very regular form, which will be deſcribed below.

Alum is ſcarce ever found in nature in a pure inſulated ſtate. Sometimes, however, it is found in places near

near volcanoes, but always mixed with clay. Mineralogiſts, particularly Wallerius, have taken notice of ſeveral ſpecies of native alum; ſuch as ſolid alum, cryſtallized alum, alum in an effloreſcence, white, grey, brown, and black, aluminous earths, and aluminous ſchiſti.

In commerce there are ſeveral kinds of alum known.

1. Ice or rock alum, in pretty large tranſparent maſſes. Bergman imagines it to derive this name from the city of Rocca in Syria, now called *Edeſſa*, in which the earlieſt manufactory of this ſalt was eſtabliſhed; not, as ſome writers would perſuade us, from its reſembling a rock, or from its being obtained from rocks: Alum obtained in this laſt way is very impure.

2. Roman alum, which is prepared in the territory of Civita-Vecchia, and obtained from a place the Italian name of which is *Aluminiere della Tolfa*. This alum is in lumps of the ſize of eggs, and covered over with a reddiſh effloreſcence. It paſſes for pure when ſeparated from the effloreſcence.

3. Neapolitan alum, which is extracted at Solfatara from a particular earth. This alum is in larger lumps than the Roman, and one of its ſurfaces is covered all over with pyramidal cryſtals.

4. Alum of Smyrna. The earlieſt manufactories of alum appear to have been eſtabliſhed in the neighbourhood of Smyrna and Conſtantinople. Some ſpecimens of it are ſhown in the cabinets of the curious.

5. French alum. Alum of all ſizes is prepared by various manufacturers in France, eſpecially at Javel near Paris.

6. Alum may be extracted from effloreſcent ſchiſti and volcanic products. I have obtained it in a pretty large

large proportion from earth that was brought me from Auvergne. This ſalt might be obtained from other ſubſtances of the ſame kind that are to be found in France; and this branch of trade might be thus taken out of the hands of ſtrangers. Alum is likewiſe extracted from earths and ſtones, which are found to contain it in many parts of Germany,—in which it has been manufactured ſince the year 1544, in Spain, in England, in Sweden, and in almoſt all the countries of Europe.

Beckman, in a diſſertation on the ſubject, inſerted among the acts of Gottingen, enters very fully into the hiſtory of this ſalt, and the method of manufacturing it. It appears from his learned reſearches, that the people of the eaſt were the firſt who prepared or extracted alum: for what the ancients, and particularly Pliny, called *chiton*, *trichites*, *calchites*, and which they appear to have confounded with alum, as well as the ϛυπτηρία of the Greeks, ſeems to have been rather martial ſulphate or green copperas in various ſtates. The Italians took a leaſe of the alum manufactories in the neighbourhood of Conſtantinople. About the year 1459, Bartholomew Perdix, or Pernix, diſcovered a mine of this ſalt in the Iſle of Iſchia. Nearly about the ſame time, John de Caſtro found another at Tolfa, and a great number of alum manufactories were ſoon eſtabliſhed in Italy, more eſpecially when Pope Pius II. prohibited the importation of alum from the eaſt. The manufacture paſſed next into Spain, Germany, England, and Sweden, about the beginning of the ſeventeenth century, (V. Beckman).

Aluminous ſulphate is prepared by a variety of proceſſes, according to the country where it is manufactured, and the materials from which it is obtained. Bergman,

Bergman, who has written an excellent diſſertation on the ſubject, divides the matters uſed in preparing alum, and commonly known under the name of *alum ores*, into two kinds: thoſe in which this ſalt exiſts fully formed, and thoſe which contain only its conſtituent principles. No farther proceſs than a lixiviation is requiſite to extract the alum from the firſt; and of this kind are the earth from which it is obtained at Solfaterra, and that which I have mentioned from Auvergne. At Solfaterra this earth is mixed with water, and put into caldrons of lead, partly ſunk in the ground. The natural heat of the earth contributes to the ſolution and cryſtallization of the alum; and it is purified by a ſecond cryſtallization. In the ſame manner might the earths of Auvergne, &c. be lixiviated, the water evaporated in leaden veſſels, and the alum cryſtallized.

As to the natural ſubſtances which contain only the principles of aluminous ſulphate, theſe are much more common than the former; and a preliminary preparation is requiſite before a neutral ſalt can be obtained from them. Aluminous ſchiſti muſt be calcined, in order that the bitumen from which they derive their colour may be burnt, and that the pyrite part of the ſtone, which ſupplies the alum, may be decompoſed. Bergman aſſerts, that if this ſchiſtus be waſhed before being calcined, it gives not a particle of alum. Expoſure to the air produces the ſame effects on pure pyrites ſprinkled with water. The ſpontaneous decompoſition of theſe ſubſtances affords ſulphuric acid, which combines with the clay to form alum. Thoſe pyritous ſubſtances, when brought into a ſtate of effloreſcence, are lixiviated with water; and after being ſuffered to depoſite the iron which it contains, the lixivium

vium is evaporated and put into caſks to cryſtallize. The ſalt falls to the bottom in large cryſtals. A ſtrong ſoapy lixivium is often made uſe of to facilitate the cryſtallization of the alum. This proceſs is followed in ſeveral manufactories: But alum obtained in this manner always contains more or leſs iron. That again which is extracted from ſtones in which it exiſts ready formed is alway purer, ſuch as Roman alum, for inſtance. Alum manufactured by a direct combination of the ſulphuric acid with clay is always mixed with a certain proportion of iron, as the coloured clay from which it is prepared is always impregnated with that metal.

Aluminous ſulphate in a regular cryſtalline form is a perfect octohædron, conſiſting of two tetrahædral pyramids, with their baſes united. This form, however, varies according to the circumſtances of the cryſtallization; the octohædron is more or leſs truncated, irregular, pointed, or flattened. The angles are more or leſs complete, or cut away: the cryſtals are joined, and often enchaſed in each other by means of their pyramids. M. Romé de Lille has very carefully deſcribed all of theſe varieties in the new edition of his Cryſtallography.

A gentle heat liquefies this ſalt: a good deal of aqueous vapour then exhales from it; and it ſwells into a large light maſs, rough, and full of cavities, all over its ſurface. Here, as well as in the inſtance of borate, this phænomenon is owing to the diſengagement of the water, the bubbles of which gradually raiſe and dilate the ſaline particles. Alum in this ſtate receives the name of *calcined alum*. It has loſt under the operation about half its weight. It is now ſomewhat altered, and reddens ſyrup of violets:

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its taſte is ſtronger, the acid not being ſo much in a latent ſtate as before. When diſſolved in water, it gives as a precipitate a ſmall portion of earth. It may be cauſed to cryſtallize; but it ſcarce ſwells at all when calcined anew, as M. Baumé has obſerved. By calcining alum in a machine for diſtillation, we obtain, firſt phlegm, and afterwards towards the end of the operation the acid. But we cannot decompoſe it entirely; for Geoffroy expoſed a quantity of alum in a retort to a very intenſe fire during three days and three nights, without obſerving it to ſuffer any remarkable alteration. I am of opinion, however, that the changes which alum undergoes when long expoſed to the action of fire, have not yet been examined with ſufficient care.

Aluminous ſulphate efforeſces ſlightly, and loſes the water of its cryſtals when expoſed to the air. In cold water it is ſcarce ſoluble; for according to M. Baumé, two pounds of cold water diſſolve no more than fourteen drams of alum: but boiling water diſſolves a quantity equal to more than half its own weight. Eight ounces of the fluid in this ſtate are ſufficient to maintain five ounces of the ſalt in ſolution. It cryſtallizes readily by cooling. Its cryſtals ſeem to be a kind of triangular pyramids, with truncated angles, but are in reality pieces of octohædrons. Depoſited on threads in the middle of the ſolution, they form very regular octohædrons, whoſe pyramids are obliquely truncated.

Siliceous earth effects no diſcernible alteration on aluminous ſulphate. This ſalt may be made to unite with a larger quantity of aluminous earth than it ordinarily contains. M. Baumé has found by experiments, that on ſuch an occaſion it acquires the characteriſtic

pro-

properties of common clay. To ſaturate alum with aluminous earth, a ſolution of the ſalt muſt be boiled with a portion of the earth pure, and the mixture heated till it loſe its ſtiptic taſte. If the combination be properly effected, it now acquires a mild, inſipid, earthy taſte. M. Baumé has obſerved, that when evaporated, it affords ſpangles reſembling mica. The Duke de Chaulnes having left a lixivium of this ſalt ſaturated with earth, expoſed for a conſiderable time to the air, found it to contain at the end of a few months very regular cubic cryſtals. M. le Blanc likewiſe obtained this ſubſtance in cubic cryſtals by a ſimilar proceſs. It appears that alum once ſaturated with earth can never be reduced to the ſtate of pure alum.

Aluminous ſulphate may be decompoſed by barytes or magneſia, each of which has a greater affinity than aluminous earth with the ſulphuric acid. Barytic, or magneſian ſulphate, is the reſult of ſuch a decompoſition.

Lime-water poured into a ſolution of this ſalt precipitates the earth. Both the fixed alkalis and ammoniac decompoſe alum. Carbonate of potaſh, ſoda, ammoniac, lime, or magneſia, likewiſe ſeparates the aluminous earth from this ſalt; but if the precipitation be effected without heat, the precipitated earth ſeizes part of the carbonic acid. But I have obſerved, that when a ſolution of alum is mixed with a hot ſolution of any of the alkaline carbonates, the precipitation is attended with an efferveſcence, owing to the diſengagement of the carbonic acid.

Aluminous earth, when precipitated by any of theſe ſubſtances, ſubſides gradually and in flakes. If dried ſlowly, it becomes very white; when expoſed to fire, it decrepitates like clays. A ſtrong heat renders it pretty hard: its bulk is at the ſame time greatly contracted. It does not melt, though expoſed even to ſo intenſe an heat as that of the burning-glaſs in the garden *de l'Infante.* So tenaciouſly does it retain its water, that the utmoſt force of fire is requiſite to ſeparate it entirely. With water it may be baked into a clammy paſte, that makes, when burnt, excellent porcelain. Aluminous earth poſſeſſes therefore all the diſtinguiſhing properties of argillaceous earths, and Macquer has very juſtly declared it to be the pureſt clay that can be procured.

We know not very well in what manner barytes, magneſia, lime, and the pure alkalis, act on aluminous earth. Probably theſe ſubſtances, eſpecially the laſt of them, would, with the help of fire, reduce it to a vitreous frit. M. Achard has made a ſeries of experiments which verify this conjecture. The colour, the tranſparency, the hardneſs, and indeed all the properties of thoſe ſubſtances, vary according to the proportions in which the principles of which they are formed have been mixed together; as we learn from a diſſertation by the above-mentioned chemiſt on the ſubject.

The ſulphuric acid readily diſſolves aluminous earth when it is cool and wet; but when dry, it diſſolves it not without conſiderable difficulty. Several ounces of this ſolution, taken together, afford cryſtals of alum, mixed with a few ſcales or ſpangles reſembling mica. And M. Baumé tells us, that when this experiment is performed in the ſmall way, only theſe ſcales, and no alum, are obtained. Other acids likewiſe diſſolve this earth, forming with it ſalts which are but little known,

known, but ſhall be mentioned in ſome following articles.

We know not how aluminous earth would act upon the neutral ſalts: but its moſt ſingular property is that of combining in an extraordinary proportion with aluminous ſulphate without communicating to it new properties; of which we have ſpoken above. M. Baumé, to whom we owe that diſcovery, boiled a ſolution of alum with a quantity of earth precipitated from this ſalt by one of the fixed alkalis; and the liquor diſſolved the earth with effervеſcence. When filtrated, it had no longer the taſte of alum, but taſted as hard water. It did not communicate a red colour to the tincture of turnſol, but it gave a green colour to ſyrup of violets. By ſpontaneous evaporation, it afforded a few cryſtals in ſoft ſcales reſembling mica. M. Baumé compares them to ſelenite, or ſulphate of lime. It is by no means eaſy to form alum by adding vitriolic acid to the ſalt thus ſaturated with earth; the mixture is now acid, but not ſtiptic: yet, by a ſpontaneous evaporation for three months, the ſolution afforded cryſtals of alum, mixed with ſome micaceous ſpangles, like thoſe which alum ſaturated with earth afforded. Such is the reſult of the experiments of Meſſrs Macquer and Baumé on aluminous earth.

Alum, when expoſed to fire with combuſtible matters, forms a ſubſtance which kindles in the air, and is called *Homberg's phoſphorus*. That chemiſt, who made this combination known to the world in the year 1711, long laboured to obtain from the human fœces a white oil, which he expected to fix mercury into fine ſilver. His labours on this project gave riſe to ſeveral diſcoveries. The reſidue of that animal matter diſtilled with alum takes fire in the air. Homberg repeated this proceſs again and again, and it always ſucceeded. Lemery the younger, publiſhed in the year 1714 and 1715, two Memoirs, in which he informed the world that pyrophorus might be compoſed out of a great many vegetable and animal matters, treated with alum: but he did not ſucceed in forming it from ſome other ſulphuric ſalts. Thoſe two chemiſts, who conſidered alum as a combination of the ſulphuric acid with calcareous earth, thought that the calcareous earth, being reduced to the ſtate of lime, attracted moiſture from the air; and that the ſulphur, which they knew to be then formed, was inflamed by the heat then produced in the mixture.

Since the time of thoſe chemiſts, Jay de Suvigny, doctor in medicine, has given an excellent memoir on this phoſphorus, inſerted in the third volume of the *Memoires des Savans Etrangers.* In that paper he details a great many experiments, by which he at length effected the compoſition of phoſphorus, not only from alum with various combuſtible matters, which Lemery had effected, but even from moſt ſalts containing ſulphuric acid. That Chemiſt has likewiſe given a theory of the inflammation of phoſphorus when expoſed to the air, which has been unanimouſly adopted by later chemiſts. He takes pyrophorus to contain *glacial oil of vitriol,* which by attracting moiſture from the air, and gradually heating the maſs, kindles the ſulphur, and occaſions a ſpontaneous evaporation.

Pyrophorus is uſually prepared by melting three parts of alum with one of ſugar, honey, or meal, in an iron ladle. This mixture is dried till it become blackiſh and ceaſe to ſwell. It is then broken into pieces, and put into a matraſs, or phial luted with earth; this veſſel is then put into a crucible containing ſand, and heat is applied

applied till a bluiſh flame be ſeen to iſſue from the mouth of the phial. After ſuffering it to burn in this manner for a few minutes, the crucible is removed from the fire. Its contents are left to cool, and the pyrophorus is then poured into a dry flaſk, which admits of being very cloſely ſtopped. This pyrophorus takes fire on being expoſed to the air; and that the more readily in proportion as the atmoſphere contains a greater quantity of aqueous vapour. Its combuſtion may be accelerated by bringing it into contact with humid vapour, ſuch as the human breath. Pyrophorus, if too long expoſed to heat when it is compoſed, becomes incapable of taking fire in the air. When kept in a veſſel not cloſely ſtopped, it is gradually impregnated with moiſture, and loſes its tendency to combuſtion: but it may be reduced by calcining it anew, in the manner above deſcribed.

This was all that we knew of phoſphorus, before M. Prouſt's valuable experiments, of which he has given an account in the *Journal de Medicine* for July 1778. That chemiſt, in the courſe of his chemical operations, having met with a great number of pyrophoric reſidues, which he could not well ſuppoſe to contain any portion of ſulphuric acid, was induced to think that pyrophorus did not owe to that acid its ſpontaneous inflammation. By a very ſimple experiment, he has proved that it does not contain a ſingle particle of ſulphuric acid not in a latent ſtate; for when water is poured on it, no heat is produced. The reſult of all his experiments and obſervations on this head is, that all ſubſtances which leave, on being decompoſed, a carbonaceous reſidue intermixed with an earth or a metallic oxide, are capable of ſpontaneous inflammation in the air. Yet we cannot avoid obſerving, that M. Prouſt, in that part of his reſearches on this matter which he has communicated to the public, does not explain the reaſon why Homberg's pyrophorus takes fire in the air; for according to him, it is a ſubſtance entirely different from thoſe of which he gives an account. His memoir, indeed, ſays nothing at all of the pyrophorus which we have deſcribed above.

Mr Bewly, an Engliſh ſurgeon, in a letter addreſſed to Dr Prieſtley, aſcribes the inflammation of pyrophorus to its containing a ſubſtance capable of attracting nitric acid from the atmoſphere. What ſuggeſted this opinion to him was his diſcovering that ſpirit of nitre inſtantly inflames pyrophorus, though not ſufficiently calcined, or containing ſome portion of moiſture. But, in the firſt place, it is by no means certain that the atmoſphere naturally contains nitric acid: and again, M. Prouſt has diſcovered, that the inflammation of pyrophorus by ſpirit of nitre is owing to the coal which it contains; for the nitric acid detonizes with all carbonaceous matters that are ſufficiently dry, and not too cloſely united by the force of aggregation; as we ſhall explain more at large when we come to the article of coal. Mr Bewly's explanation of this phænomenon is, therefore, not more ſatisfactory than thoſe of former chemiſts.

The only way by which we can hope to diſcover the cauſe of this phænomenon is, making ourſelves intimately acquainted with the nature of Homberg's pyrophorus. It appears to conſiſt of aluminous earth, a looſe carbonaceous matter, ſupplied by the honey or ſugar, &c. a little potaſh, and a ſmall portion of ſulphur, united partly with the aluminous earth and in part with the alkali. When pyrophorus is ſtrongly heated in a pneumato-chemical machine, a large proportion of ſulphurated or *hepatic* hydrogenous gas is ob-

obtained from it. When it becomes incapable of furniſhing this ſubſtance, it is no longer ſuſceptible of inflammation in the air. Pyrophorus, immerſed in vital air, burns rapidly, giving out a very bright red flame. When waſhed with warm water, it affords genuine aluminous *ſulphure,* leaving on the ſurface of the filter or ſtrainer carbonaceous matter with a little aluminous earth. The pyrophorus is then decompoſed. When pyrophorus ceaſes to burn, it is found to have acquired an increaſe of weight by abſorbing a portion of oxigene. If when in this ſtate it be lixiviated, it affords aluminous ſulphate; becauſe the ſulphur burnt by the action of the air forms ſulphuric acid which combines with the aluminous earth. But the ſalt thus obtained is alum ſaturated with earth.

The *Journal de Phyſique* for November 1780, contains ſome obſervations on pyrophorus, in which we are told, 1. That this ſubſtance owes its combuſtibility to its containing a certain quantity of phoſphorus formed by the acid of mucous matters. 2. That an ounce of pyrophorus gives, when diſtilled, from five to ſeven grains of phoſphorus. 3. That pyrophorus may be at any time readily compoſed by triturating fifty-four grains of flowers of ſulphur, thirty-ſix of very dry charcoal of willows, and three of common phoſphorus, together in an iron mortar. The particulars of the analyſis do not exactly correſpond with the inductions deduced from it; for it does not appear that real phoſphorus was obtained. But the memoir contains a number of important facts, which it may be advantageous to any chemiſts who ſhall hereafter attempt an analyſis of pyrophorus to be acquainted with.

Alum is applied to many uſeful purpoſes. In medicine, it is uſed as an aſtringent: but it ſhould be very cautiouſly adminiſtered internally. It is oftener applied externally as a ſtiptic and a powerful deſiccative. It is uſed in gargles, plaſters, collyria, &c.

Few ſaline matters are of more uſe in the arts than alum. Chandlers mix it with their tallow, to render it more ſolid and conſiſtent. Printers rub their balls with calcined alum, to make them take up the ink. Wood impregnated with a ſolution of alum will ſcarcely burn. And the uſe of alum has therefore been propoſed to ſecure houſes from taking fire. It produces the ſame effects on paper as on wood. But paper impregnated with alum ſoon becomes yellow, and ſuffers an alteration of nature.

Bleachers put a little alum into muddy water to purify it. M. Baumé thinks, that on this occaſion the ſalt attracts to it part of the earth ſuſpended in the fluid, and that the earth and the ſalt forming an inſoluble compound, are precipitated together. Some people uſe alum to purify water which they are going to drink. It is uſed in preparing leather; and cloth and paper, on which colours are to be impreſſed, are firſt impregnated with alum.

A ſolution of alum retards the putrefaction of animal ſubſtances. This is an excellent, and a very cheap way of preſerving natural productions which are ſent as ſpecimens from one country into another. Aluminous earth conſtitutes the baſe or body of paſtils or crayons. And, laſtly, this ſalt is, as Macquer ſays, the very ſoul of the art of dyeing. It renders colours deeper and more bright, and it confers ſolidity on the particles of colouring matters; without the help of alum no colour would be permanent or proof againſt water. This property of alum will be examined when we we come to ſpeak of colouring vegetable matters. We will then ſee that alum renders them permanent by changing their nature, decompoſing them, and making them inſoluble in water.

Species II. *Aluminous Nitrate.*

M. Baumé ſays, that the nitric acid entirely diſſolves aluminous earth. This ſolution is limpid, and much more aſtringent than a ſolution of alum. By ſpontaneous evaporation, it gives ſmall pyramidal cryſtals, extremely ſtiptic, and liable to deliquiate.

The other properties of this ſalt have not yet been examined; only we know that it admits of decompoſition by the intervention of the ſame ſubſtances which decompoſe alum. It has not yet been found in nature, but is always a product of art.

Species III. *Aluminous Muriate.*

The muriatic acid diſſolves aluminous earth better than the nitric acid. This ſolution, when the ſubſtances are mutually ſaturated, is gelatinous, nor can it be filtrated without being diluted in a great deal of water. Aluminous muriate has a ſalt ſtiptic taſte; it firſt reddens ſyrup of violets, and afterwards converts it to a green. By ſpontaneous evaporation it gives very ſtiptic cryſtals, the form of which has not yet been examined: lime-water decompoſes them. Aluminous muriate is liable to deliquiate. It has never yet been obtained but by the manipulations of art. Its other properties are unknown.

Species IV. *Aluminous Borate.*

The combination of the boracic acid with aluminous earth, which we call *aluminous borate,* has not as yet been examined. We know that when a ſolution of borate of ſoda is poured into a ſolution of aluminous ſulphate, it produces a light flaky precipitate. The ſulphuric acid forſakes the aluminous earth, in order to combine with the ſoda. The earth again combines with the boracic acid, which is ſeparated at the ſame time. And this new ſalt is by degrees diſſolved again. The liquor thus precipitated by the fixed alkali gives by evaporation a viſcous aſtringent maſs, conſiſting of ſulphate of ſoda and aluminous borate confounded together. This kind of borate may be decompoſed in the ſame manner as alum; but its properties have not yet been examined with ſufficient care.

Species V. *Aluminous Fluate.*

We give this name to the combination of the fluoric acid with aluminous earth. This neutral ſalt is not known, and has never been examined. Scheele, Boullanger, and Bergman, have ſaid nothing about it.

Species VI. *Aluminous Carbonate.*

The combination of the carbonic acid with aluminous earth has been as yet but very little examined. It is certain, however, that the carbonic acid admits of combination with aluminous earth: For, 1. As Bergman has

has remarked, when a ſolution of alum is precipitated by the alkaline carbonates, the filtrated liquor depoſites, at the end of ſome time, a little earth which was held in ſolution by the carbonic acid, and is left in a ſeparate ſtate, as the acid gradually eſcapes. 2. This precipitation, when the matters are cold, takes place without any effervеſcence, and part of the carbonic acid ſeparated by the alkali appears to enter into combination with the aluminous earth, while another part is diſſolved in the liquor.

Beſides, from the decompoſition of many argillaceous earths by ſeveral modern chemiſts, it is at preſent known that they contain carbonic acid; for when diſſolved in the ſulphuric and the muriatic acids, they always effervеſce either more or leſs.

CHAP. X.

Genus VI. *Barytic Neutral Salts, or Neutral Salts with a Baſe of Barytes.*

BARYTES in combination with the acids form a claſs of neutral ſalts, which differ from thoſe which we have hitherto been examining, in form, taſte, ſolubility, and in the laws of their decompoſition. This earthy-alkaline ſubſtance has a greater affinity with the acids than any of the three alkalis, or of the other earths. Theſe alkaline ſubſtances muſt be united with the carbonic acid, to enable them to decompoſe barytic ſalts. Thoſe ſalts are ſix in number, namely, barytic ſulphate, or ponderous ſpar, barytic nitrate, barytic muriate, barytic borate, barytic fluate, and barytic carbonate. To theſe ſix we may add the combinations of barytes with the tungſtenic, the arſenic, the molybdic, and the ſuccinic acids: but as theſe are not much known, we will defer ſpeaking of them till we come to the hiſtory of the four acids to which they owe their formation.

Species

Species I. *Barytic Sulphate, or Ponderous Spar.*

PONDEROUS ſpar, which being inſipid and inſoluble, has been hitherto conſidered by naturaliſts as a ſtone, is produced by the combination of the ſulphuric acid with barytes, and ſhould therefore be called *barytic ſulphate.* This earthy ſalt has been by many naturaliſts confounded with *fluor ſpar*, or calcareous fluate: both indeed have the ſame fracture, and efferveſce in the ſame manner with acids. But the form, the obſcurity, and the ponderoſity of *ponderous ſpar*, plainly diſtinguiſh it from the other. Beſides, it poſſeſſes one chemical quality, which alone might be ſufficient to peculiarize its character. If a ſmall portion of ſulphuric acid be poured on powder of ponderous ſpar, the acid moiſtens the ſpar without diſengaging from it any vapour, or cauſing it to exhale any ſmell; whereas calcareous fluate, or *fluor ſpar*, when treated in the ſame manner, exhales by degrees a gas of a poignant ſmell, which, on coming into contact with air, compoſes a white ſmoke that is ſoon perceived to be fluoric acid. Other naturaliſts have confounded it with *ſelenitous ſpar*: but this ſubſtance again is of a different form, and more ſoluble, and may be decompoſed by the fixed alkalis in a pure or cauſtic ſtate; whereas thoſe ſalts effect no alteration on ponderous ſpar.

Barytic ſulphate abounds in nature. It is almoſt always found along with metal ores. It appears either in cryſtals or in ſhapeleſs maſſes, but is always diſpoſed in layers which vary in thickneſs and extent. It is pretty hard, yet does not give fire with ſteel. The following are its principal varieties.

Varieties.

1. Barytic ſulphate, or *ponderous ſpar*, white, ſemi-tranſparent, and cryſtallized in priſms, of ſix ſides, two of them very large, and the other four very little, terminating in dihædral ſummits. Thoſe cryſtals are diſpoſed in an oblique poſture, on maſſes of the ſame nature with themſelves. They reſemble oblong ſquare plates, the four ſides of which have been cut obliquely. They are often covered with yellowiſh rhomboidal cryſtals. This, as well as the following ſpecies, is called *ponderous ſpar in tables.*
2. Barytic ſulphate, or *milk-white ponderous ſpar*, in tables, but not having their ſides cut aſlant. It is not regularly cryſtallized, but is found in tolerably thick layers, arranged one over another. It is often incruſted with a red duſt, of reddiſh ſilver ore, or *pyrites.*
3. Round, *ſemi-chatoyant*, barytic ſulphate or *ponderous ſpar:* Bologna ſtone. It conſiſts of a number of converging filaments united into laminæ, arranged one over another. This variety is better known than any of the others, on account of its being phoſphoric. It plainly appears to have been agitated and worn by water.
4. Octohædral barytic ſulphate or *ponderous ſpar.* It cryſtallizes like alum. The ſummits of the pyramids are often truncated, ſo as to form a decahædral figure. It exhibits a number of other varieties, according as its angles are prolonged or truncated.
5. Duodecahædral barytic ſulphate or *ponderous ſpar.*

Varieties.

ſpar. It is of the form of certain garnets and ſome pyritous ſtones. It is ſeldomer to be met with than the preceding ſpecies.

6. Pyramidal barytic ſulphate, or ponderous ſpar. Both this and the preceding variety appear in M. Daubenton's table.

I conſider as a variety of *ponderous ſpar* that ſubſtance which is known by the name of *pearl ſpar*, and was formerly, as well as moſt of the preceding varieties, ranked among the *ſelenitous ſpars*. This ſpar conſiſts of ſmall rhomboidal ſcales, which are generally ſparkling, and obliquely diſpoſed one over another. It is opaque, brilliant, ſeemingly micaceous, and ſcattered over calcareous ſpar, quartz, or the firſt of the varieties above deſcribed. It is of a yellow or a dirty green colour, ſometimes of a ſilver white. The Abbé Haüy thinks it to be a genuine calcareous ſpar.

Margraaf, who examined ſeveral varieties of barytic ſulphate, ſuch as Bologna ſtone and white opaque ponderous ſpar, imagined it to be a kind of *ſelenite* or calcareous ſulphate, mixed with a little clay, which rendered it inſoluble. But Gahn, Scheele, and Bergman, found it to be that peculiar earth to which we have given the name of *barytes*. M Monnet has likewiſe found, by examining the ſalts which it forms with acids, that its baſe is of a different nature from calcareous earth; but he imagines it to contain ſulphur ready formed, and takes *ponderous ſpar* to be an earthy *liver of ſulphur* in cryſtals.

Barytic ſulphate, when expoſed to a violent heat, ſuch as that of a porcelain furnace, &c. melts into a glaſs more or leſs coloured. When expoſed to a moderate

derate heat, it ſuffers no alteration. If carried into the dark, after being expoſed for a little to a ſtrong heat, it exhibits a very lively bluiſh light. Lemery tells us, that an Italian ſhoemaker, named Vincenzo Caſciarolo, was the firſt who diſcovered the phoſphoric quality of Bologna ſtone. Finding a ſtone of this kind at the foot of Mount Paterno, its brightneſs and gravity made him think it contained ſilver. He expoſed it to fire, in order no doubt to extract from it if poſſible the precious metal, and obſerved, that when heated it gave light in the dark. Struck with the diſcovery, he repeated the experiment, and it conſtantly ſucceeded with him. A number of chemiſts and naturaliſts have ſucceſſively directed their attention to this phænomenon, and have calcined Bologna ſtone in all the various ways they could contrive. The works of Poterie, Montalban, Mentzel, and Lemery, and the memoirs of Homberg, Dufay, and Margraaf, contain a variety of proceſſes for performing this operation.

This property is at preſent known to be common to all varieties of barytic ſulphate. They are made red hot in a crucible, beat in a glaſs mortar to a powder, formed into a paſte with a little gum adraganth, and divided into cakes of the thickneſs of a knife blade. Theſe cakes are dried, and expoſed to a violent calcination among coals in a ſtrong drawing furnace; nor are they taken out till the coals be entirely conſumed and the furnace cold. The aſhes are then blown off them with a pair of bellows; they are expoſed to the light for a few minutes; and after this, when taken into the dark, they ſhine like a burning coal. Even in water they emit the ſame ſparkling light, but gradually loſe the property; which they regain, however, on being heated anew. But many ſubſtances diſplay the ſame phænomenon. Magneſia, chalk, calcareous ſulphate, and calcareous fluate, &c. become luminous, after being heated. Macquer has obſerved the exiſtence of the ſame property in earth of alum, ſulphate of potaſh, Briançon chalk, and black gun-ſtone calcined:—from which it appears that the preſence of an acid is not abſolutely neceſſary to the production of this phænomenon. Yet ſubſtances poſſeſſing an acid diſplay it in a more eminent degree than others.

Margraaf could obtain no product by heating barytic ſulphate. The ſubſtance, he found, ſuffered no alteration.

This ſalt is abſolutely inſoluble in water. The earthy and the ſalino-terreous matters act not upon it. The pure fixed alkalis do not decompoſe it; which is the moſt ſingular of all its properties. All the other earths and ſalino-terreous matters have a weaker affinity than the fixed alkalis with the ſulphuric acid. But barytes has a ſtronger affinity with the acids than thoſe ſalts. We have therefore obſerved, after Bergman, that this decompoſes both ſulphate of potaſh and ſulphate of ſoda. It has the ſame influence on ammoniacal ſulphate.

The mineral acids cannot act on barytic ſulphate; for the ſulphuric acid adheres with greater force than any of them to the earthy baſe of this ſalt. The neutral ſalts, excepting carbonate of potaſh and of ſoda, are equally incapable of acting upon barytic ſulphate. Theſe two ſaline ſubſtances, however, decompoſe it by double affinity. The barytes is ſeparated from the ſulphuric, becauſe it is attracted by the carbonic acid; while the fixed alkali acts with equal force on the ſulphuric acid. This decompoſition is effected by expoſing to a ſtrong heat in a crucible a mixture conſiſting of two parts of carbonate of potaſh and one of barytic ſulphate in powder. This matter, after being half vitrified by the heat, is lixiviated in diſtilled water. The liquor is filtered, and then affords by evaporation ſulphate of potaſh. The matter which remains on the filter is barytic carbonate. After being well waſhed, it appears in the form of a very white fine pulverulent matter, but almoſt always contaminated with a portion of barytic ſulphate, which has eſcaped decompoſition.

As combuſtible bodies are capable of decompoſing this ſalt, we may make uſe of them too when we wiſh to obtain its baſe ſeparate. When a powder of this ſalt, mixed with a portion of coal equal to an eighth part of its weight, has been expoſed to fire in a crucible, for two or three hours after the crucible became red hot,—if the matter be afterwards poured into diſtilled water, it will inſtantaneouſly communicate to the fluid a reddiſh yellow colour, with all the characteriſtics of a ſolution of earthy *ſulphure*: for the coal robs the ſulphuric acid of its oxigene, and the ſulphur being of conſequence left ſeparate, combines with the barytes, and is thus reduced to *ſulphure* or *hepar*. This ſolution of ſulphure may be precipitated by an acid. The muriatic acid is preferred for this purpoſe, becauſe it combines with the earth to form a ſoluble ſalt; whereas the ſulphuric acid would form barytic ſulphate, which is inſoluble. The liquor is next filtered. The ſulphur ſeparated by the acid remains on the filter; and the water which has paſſed through it holds the barytic muriate in a ſtate of ſolution. This ſolution again may be decompoſed by a ſolution of carbonate of potaſh: the barytes, combining with the carbonic acid, is precipitated; and theſe two principles may be again ſeparated by calcination, as we will ſhow under a different article. This proceſs, which I have often performed, gives but very little barytes; and we find on the filter through which the ſolution of the *hepar* has been cauſed to paſs, after being precipitated by the muriatic acid,—nothing but a few particles of ſulphur, unleſs it be expoſed to a very violent heat. To help the decompoſition of that earthy ſalt, Bergman and Scheele have directed about a fourth part of *fixed ſalt of tartar* to be added to the mixture of barytic ſulphate and coal. The ſulphur and the barytes are then eaſier ſeparated; becauſe the fixed alkali cauſes the matters to ſuffer a more complete fuſion.

From theſe two proceſſes for decompoſing barytic ſulphate, as well as from a view of its properties in general, it appears that the earth or ſalino-terreous ſubſtance, which is the baſe of this ſalt, is of a peculiar nature, differing from aluminous earth, lime, and magneſia.

Barytic ſulphate is of ſome uſe in the arts. Phoſphoric cakes are prepared of it, and the barytes which it contains is extracted for the uſe of chemical laboratories.

Species II. *Barytic Nitrate.*

The nitric acid combines readily with barytes. The reſult of the combination is a neutral ſalt, in large hexagonal cryſtals, or ſmall irregular cryſtals, according to M. d'Arcet. It is with great difficulty that we obtain it in cryſtals.

Barytic nitrate is decompoſed by the action of fire, and gives out vital air.

It attracts the moiſture of the atmoſphere. A conſiderable quantity of water, however, is requiſite to maintain it in ſolution.

Neither the pure alkalis, ſand, aluminous earth, lime, nor magneſia, decompoſes it.

Sulphuric acid poured into a ſolution of barytic nitrate, immediately produces a precipitate of barytic ſulphate. The fluoric acid, too, robs this ſalt of its baſe.

Alkaline carbonate decompoſes it by a double affinity.

This ſalt is but very little known.

Species III. *Barytic Muriate.*

THIS ſalt has been as little examined as the preceding. Bergman ſays that it is ſuſceptible of cryſtallization, and does not diſſolve eaſily. It may indeed be obtained in oblong ſquare cryſtals, pretty much like thoſe of ponderous ſpar in tables.

It is liable to no alteration or decompoſition from ſand, aluminous earth, magneſia, or cauſtic alkali.

The ſulphuric and the fluoric acids decompoſe this ſalt by combining with its baſe.

Carbonate of potaſh or of ſoda precipitates the barytes in combination with the carbonic acid.

Bergman reckons barytic muriate to be one of the moſt ſenſible re-agents, and propoſes to detect, by means of it, even the ſmalleſt portion of ſulphuric acid that can poſſibly be contained in any mineral water. If a drop or two of a ſolution of this ſalt be poured into about

about three pounds of water, containing twelve grains of ſulphate of ſoda in cryſtals, it will immediately produce barytic ſulphate in white ſtriæ, owing to the decompoſition of both the ſalts, and the union of the ſulphuric acid with the barytes. A portion of muriate of ſoda remains diſſolved in the liquor. All ſulphuric ſalts are equally affected by this re-agent; which always decompoſes them to form barytic ſulphate.

Species IV. *Barytic Borate.*

THIS combination of the boracic acid with barytes is entirely unknown. Bergman aſſerts that the acid of borax is among thoſe which have the leaſt affinity with the ſalino-terreous ſubſtances, and ranks it in his table below moſt of the vegetable and animal acids.

Species V. *Barytic Fluate.*

THIS ſalt is as little known as the preceding; and, with many other ſaline matters that have not yet been examined, and on which we are therefore obliged to be very brief, affords matter for new experiments.

Bergman, in his diſſertation on elective attractions, aſſerts, that when fluoric acid is poured into a ſolution of barytic nitrate or muriate, it occaſions a precipitation; and that the precipitate thus produced efferveſces with the ſulphuric acid, which extricates the fluoric from it.

This inſtance proves the fluoric acid to have a greater affinity with barytes than either the nitric or the muriatic acid; and ſhows, that it forms, with this ſalinolino-terreous ſubſtance a ſalt much leſs ſoluble than barytic nitrate or barytic muriate.

Species VI. *Barytic Carbonate.*

Barytes combines with the carbonic acid to form a neutral ſalt poſſeſſed of ſome ſingular properties, and appearing to bear ſome relation to chalk.

We have already obſerved, that it is in conſequence of the affinity ſubſiſting between barytes and the carbonic acid, that barytic ſulphate, and all barytic ſalts in general, are decompoſed by alkaline carbonate. In theſe inſtances, barytic carbonate is always precipitated. This ſalt is likewiſe prepared by expoſing to the air a ſolution of pure barytes. The ſurface of the liquor is gradually covered with a pellicle, which effervеſces with acids, in conſequence of the earth's being impregnated with carbonic acid from the atmoſphere, and becoming thereby leſs ſoluble. This phænomenon reſembles that which is exhibited by lime-water; and though barytes and lime differ widely in many of their other properties, yet here there is a ſtriking analogy between them.

Barytic carbonate loſes its acid when expoſed to fire. If heated in a retort or matras fitted to a pneumato-chemical machine, it gives the acid in its natural gaſeous form. Yet it is exceedingly difficult to ſeparate the acid entirely, and a very intenſe heat is requiſite for the purpoſe.

All the mineral acids decompoſe this ſalt, and diſengage the carbonic acid. A lively effervеſcence is always produced on the occaſion, which diſtinguiſhes this ſalt from pure or cauſtic barytes. Bergman reckons

kons an hundred weight of this ſalt to contain ſeven parts of carbonic acid, ſixty-five of barytes, and eight of water.

Water will ſcarce diſſolve barytic carbonate; but when it is itſelf impregnated with carbonic acid, it diſſolves a portion of this ſalt equal to an 1550th part of its own weight. From this it appears that barytic carbonate is ſtill more difficult of ſolution than pure or cauſtic barytes: for, according to Bergman, water diſſolves about a 900th part of pure barytes. This ſalt therefore appears, in this inſtance, to be ſubject nearly to the ſame laws with chalk or carbonate of lime, and like it is precipitated when the carbonic acid evaporates from the water which maintained it in ſolution. But in other reſpects there is a wide difference between them. The ſalts which barytes forms with other acids, ſhow, as we have above obſerved, that it differs eſſentially from lime.

Barytic carbonate is of no uſe. It is found in nature.

CHAP. XI.

Recapitulation and Compariſon of the Mineral Salts.

AFTER the above account of the preſent ſtate of chemical knowledge reſpecting the properties of mineral ſalts, it may next be proper to take a brief comparative view of the principal characteriſtics, and the mutual affinities of thoſe bodies.

I. Salts are diſtinguiſhed by four general properties; taſte, tendency to combination, ſolubility, and incombuſtibility. Theſe properties exiſt in various degrees of energy; and the various degrees of their energy conſtitute the eſſential differences which diverſify ſaline matters.

II. All ſalts may be arranged under four orders or four principal genera. 1. Salino-terreous ſubſtances, which poſſeſs the properties of both earths and ſalts. 2. Alkalis, the characteriſtics of which are, an urinous taſte, and the property of converting many blue vegetable colours to green. 3. Acids, diſtinguiſhed from other ſalts by their ſour taſte, and by communicating a a red colour to blue vegetable matters. 4. Middle or neutral ſalts, which differ from the preceding as being of a weaker, but a mixed ſalt taſte, bitter taſte, and being leſs ſoluble, &c.

III. There are three ſalino-terreous ſubſtances; ponderous earth or barytes, magneſia, and lime. Their properties are pretty well known; but of their component principles we are ignorant. No chemiſt has hitherto ſeparated any of theſe bodies into diſtinct principles, or formed them by combination. They are, therefore, actually ſimple in reſpect to the preſent ſtate of the ſcience. But they may, one day, perhaps be decompoſed.

IV. We know of three alkalis; potaſh, called alſo *vegetable fixed alkali* and *alkali of tartar;* ſoda, likewiſe known under the name of *mineral alkali* or *marine alkali;* ammoniac or volatile alkali. The two firſt of theſe are dry, ſolid, cauſtic, fuſible, liable to deliquiate, &c. When pure, it is impoſſible to diſtinguiſh between them; but they are readily diſtinguiſhed by the manner in which they combine with acids. Hitherto we have obtained no certain experimental knowledge of their intimate compoſition: No body has yet ſeparated them into principles, or formed them by combination.

The opinion which repreſents them as compounds of earth and water, is nothing more than an ingenious fancy, which muſt be given up becauſe it is ſupported by no poſitive facts. Ammoniac differs from them in appearing under the form of an elaſtic fluid, ſtrongly odorous, and ſuſceptible of an amazing expanſion, &c. It is at preſent known to conſiſt of the baſes of two gaſeous ſubſtances,—inflammable gas or hydrogene, and atmoſpheric mephitis or azote. It is decompoſed on ſome occaſions, and on others formed by combination. It appears that the two fixed alkalis likewiſe contain azote, and that this ſubſtance may be conſidered as the alkalifying or alkaligenous principle.

V. There are ſix acids with which we are well acquainted; the carbonic, the muriatic, the fluoric, the nitric, the ſulphuric, and the boracic acids. Each of theſe is diſtinguiſhed by its peculiar properties. The carbonic, the muriatic, and the fluoric acids, are very eaſily made to aſſume the elaſtic or aeriform ſtate. The caſe is not the ſame with the nitric and the ſulphuric acids. The boracic acid is concrete and cryſtalline. The arſenic, the molybdic, and the tunſtic acids, of which we are to ſpeak in a kind of appendix to this part, are concrete, but pulverulent, and never cryſtalline.

VI. We are now beginning to underſtand the nature of the acids much better than formerly. The hypotheſis which repreſented them as compounds of earth and water has been demonſtrated to be quite improbable. The oxigenous principle, which is the baſe of vital air, is known to enter for one principle into their compoſition. And an acid is often formed by the union of oxigene with ſome combuſtible ſubſtance; with coal in the carbonic acid; with ſulphur in the ſulphuric; and with azote in the nitric acid. Another fact which concurs to prove that oxigene is a conſtituent principle in acids, is, the formation of a great many peculiar acids by the action of the nitric acid on combuſtible bodies.

VII. The acids unite, without ſuffering decompoſition, with aluminous earth, barytes, magneſia, lime, the fixed alkalis, and ammoniac. From theſe combinations there reſult a great many neutral ſalts, which are called *compound*, *middle*, or *neutral*. The ſubſtances which in theſe ſaline combinations neutralize the acids, are called *baſes*.

VIII. The properties of the middle or neutral ſalts are different from thoſe of their component principles; in moſt of them it is impoſſible to recognize any of the properties of either the acid or the baſe. The baſe, however, appears to communicate ſome general or common properties to neutral ſalts; for which reaſon we have claſſed them into genera by their baſes.

IX. On this principle there are ſix genera of neutral ſalts, the order, the compoſition, and the nomenclature; of which it may here be proper to lay again before the reader.

Genus I. *Neutral Salts, with a baſe of Fixed Alkali.*

Species.	Ancient Names.
I. The ſulphuric acid with potaſh. SULPHATE OF POTASH.	*Vitriolated tartar, ſal de duobus, arcanum duplicatum, vitriol of potaſh.*
II. The ſulphuric acid with ſoda. SULPHATE OF SODA.	*Glauber ſalt, vitriol of ſoda.*
III. The nitric acid with potaſh. NITRATE OF POTASH.	*Common nitre, ſaltpetre.*
IV. The nitric acid with ſoda. NITRATE OF SODA.	*Cubic nitre, rhomboidal nitre.*
V. The muriatic acid with potaſh. MURIATE OF POTASH.	*Digeſtive ſalt, febrifuge ſalt of Sylvius, regenerated marine ſalt.*

VI. The

Species.	Ancient Names.
VI. The muriatic acid with ſoda.	
MURIATE OF SODA.	*Marine ſalt, ſea ſalt, common ſalt, kitchen ſalt.*
VII. The boracic acid with potaſh.	
BORATE OF POTASH.	*Vegetable borax.*
VIII. The boracic acid with ſoda.	
SUPERSATURATED BORATE OF SODA, *or* BORAX.	*Common borax, tinckal.*
IX. The fluoric acid with potaſh.	
FLUATE OF POTASH.	*Spathoſe tartar.* *Spar of tartar.*
X. The fluoric acid with ſoda.	
FLUATE OF SODA.	*Sparry ſoda.*
XI. The carbonic acid with potaſh.	
CARBONATE OF POTASH.	*Cretaceous tartar.* *Chalk of potaſh.*
XII. The carbonic acid with ſoda.	
CARBONATE OF SODA.	*Cretaceous ſoda.* *Chalk of ſoda.*

Genus II. *Ammoniacal Neutral Salts.*

Species.	Ancient Names.
I. The ſulphuric acid with ammoniac.	
AMMONIACAL SULPHATE.	*Glauber's ſecret ammoniacal ſalt, ammoniacal vitriol.*
II. The nitric acid with ammoniac.	
AMMONIACAL NITRATE.	*Ammoniacal nitre.*

III The

Species.	Ancient Names.
III. The muriatic acid with ammoniac. AMMONIACAL MURIATE.	*Sal ammoniac.*
IV. The fluoric acid with ammoniac. AMMONIACAL FLUATE.	
V. The boracic acid with ammoniac. AMMONIACAL BORATE.	
VI. The carbonic acid with ammoniac. AMMONIACAL CARBONATE.	*Engliſh ſal volatile.* *Concrete volatile alkali.* *Ammoniacal chalk.*

Genus III. *Calcareous Neutral Salts.*

Species.	Ancient Names.
I. The ſulphuric acid with lime. CALCAREOUS SULPHATE.	*Plaſter.* *Gypſum.* *Selenite.* *Calcareous vitriol.*
II. The nitric acid with lime. CALCAREOUS NITRATE.	*Calcareous nitre.*
III. The muriatic acid with lime. CALCAREOUS MURIATE.	*Fixed ſal ammoniac, oil of lime.* *Calcareous marine ſalt.*
IV. The fluoric acid with lime. CALCAREOUS FLUATE.	*Cubic ſpar, vitreous ſpar, fuſible ſpar or fluor, ſparry fluor, fluorated lime.*

V. The

Species.	Ancient Names.
V. The boracic acid with lime. CALCAREOUS BORATE.	
VI. The carbonic acid with lime. CARBONATE OF LIME.	*Chalk, calcareous ſpar, calcareous earth.*

Genus IV. *Magneſian Neutral Salts.*

Species.	Ancient Names.
I. The ſulphuric acid with magneſia. MAGNESIAN SULPHATE.	*Salt of Epſom or Sedlitz, bitter cathartic ſalt, vitriol of magneſia.*
II. The nitric acid with magneſia. MAGNESIAN NITRATE.	
III. The muriatic acid with magneſia. MAGNESIAN MURIATE.	*Marine ſalt, with a baſe of magneſia.*
IV. The fluoric acid with magneſia. MAGNESIAN FLUATE.	
V. The boracic acid with magneſia. MAGNESIAN BORATE.	
VI. The carbonic acid with magneſia. MAGNESIAN CARBONATE.	*Efferveſcent magneſia.* *Mild, aerated magneſia.* *Magneſian chalk.*

Genus V. *Aluminous Neutral Salts.*

Species.	Ancient Names.
I. The ſulphuric acid with aluminous earth. ALUMINOUS SULPHATE.	*Alum, vitriol of clay.*

Species.	Ancient Names.
II. The nitric acid with aluminous earth. ALUMINOUS NITRATE.	*Argillaceous nitre.* *Nitrous alum.*
III. The muriatic acid with aluminous earth. ALUMINOUS MURIATE.	*Argillaceous marine ſalt.* *Marine alum.*
IV. The fluoric acid with aluminous earth. ALUMINOUS FLUATE.	*Sparry clay.* *Argillaceous fluor.*
V. The boracic acid with aluminous earth. ALUMINOUS BORATE.	*Argillaceous borax.*
VI. The carbonic acid with aluminous earth. ALUMINOUS CARBONATE.	*Efferveſcent clay.* *Argillaceous chalk.*

Genus VI. *Neutral Salts, with a Baſe of Barytes, or Barytic Neutral Salts.*

Species.	Ancient Names.
I. The ſulphuric acid with barytes. BARYTIC SULPHATE.	*Ponderous ſpar.* *Barotic vitriol.*
II. The nitric acid with barytes. BARYTIC NITRATE.	*Ponderous nitre.* *Barotic nitre.*
III. The muriatic acid with barytes. BARYTIC MURIATE.	*Ponderous marine ſalt.*

Species.	Ancient Names.
IV. The fluoric acid with barytes. BARYTIC FLUATE.	
V. The boracic acid with barytes. BARYTIC BORATE.	*Aerated ponderous earth,* *Cretaceous ponderous earth.*
VI. The carbonic acid with barytes. BARYTIC CARBONATE.	*Barotic chalk.*

X. To theſe neutral ſalts we may join thoſe which owe their nature to the arſenic, the molybdic, the tunſtic, and the ſuccinic acids ; calling the firſt, *arſeniates of potaſh, of ſoda, &c.* ; the ſecond, *molybdates of potaſh, of ſoda, ammoniacal, calcareous, &c.* ; the third, *tunſtates of potaſh, of ſoda, of lime, &c.* ; the fourth, *ſuccinates of potaſh, magneſia, aluminous earth, &c.* We will treat of theſe four genera of neutral ſalts in the hiſtory of metallic and bituminous ſubſtances.

XI. Each particular ſalt, whether ſimple or neutral, poſſeſſes certain peculiar characteriſtics, by which it may be diſtinguiſhed from all the reſt. Theſe characteriſtic properties are taſte, form, and alterability—by fire, air, earths, and the various ſaline ſubſtances. In order to learn to diſtinguiſh ſaline bodies readily, we muſt carefully ſtudy all their properties, compare them with one another, and mark their differences and contrarieties.

XII. Tho' moſt ſimple ſalts, and ſtill more the neutral ſalts, be almoſt always products of art, yet nature ſometimes affords them at the ſurface, or a very little beneath the ſurface of the earth. Barytes or pure magneſia have not been yet found in nature. Places lying near volcanoes afford lime : the fixed alkalis never appear in a cauſtic ſtate, but always in combination with acids on the ſurface of the earth: the carbonic acid is diffuſed through the atmoſphere, fills ſome ſubterraneous cavities, and exhales from certain waters: the muriatic acid appears to exiſt in a free ſtate on the ſurface of the ſea: the fluoric acid is never found but in combination with lime: the nitric acid is found beſide or among putrefying matters: the ſulphuric acid has been found in cryſtals by M. Baldoſtari in a grotto belonging to the baths of St Philip in Italy, and by M. Dolomieu in a grotto on Mount Etna. M. Vandelli has obſerved, that in the neighbourhood of Sienna and Viterbo a ſolution of the ſulphuric acid in water filtrates through the rocks. The ſulphureous acid is continually diſengaged in places expoſed to the force of volcanic fires. M. Hoëfer has obſerved the boracic acid in ſolution on the water of ſeveral lakes in Tuſcany.

XIII. Of the forty-two principal * ſpecies of neutral ſalts, of which we have given the hiſtory, only the following perfect neutral ſalts, that is, with a baſe of fixed alkali, are to be found on the ſurface of the earth, in the waters, or in the fluids of organized bodies. Sulphate of potaſh in vegetables; ſulphate of ſoda in water and in ſome plants; nitre in vegetable juices, and in earths impregnated with putrid matters; muriate of potaſh in waters and in marine plants; muriate of ſoda, in earth, water, vegetables growing on the ſea ſhore, and animal humours; carbonate of potaſh in vegetables;

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* We ſpeak not here of the modifications of thoſe ſalts called *ſulphites, nitrites, oxigenated muriates, &c.* nor of the twenty-eight ſpecies which owe their formation to the metallic and bituminous acids: the number of the neutral ſalts would by that means be much increaſed; and beſides, it does not appear that theſe ſalts exiſt in nature.

tables; carbonate of ſoda in an effloreſcence, on the earth, on ſtones, and in animal humours; there is ſome uncertainty in reſpect to borax. Nitrate of ſoda, fluate of potaſh, fluate of ſoda, and borate of potaſh, are always products of art.

XIV. We know of no ammoniacal ſalts exiſting ready formed in nature, but ammoniacal muriate, which is found in places contiguous to volcanoes, and ammoniacal carbonate which is formed in putrid animal matters: ammoniacal ſulphate, ammoniacal nitrate, ammoniacal fluate, and ammoniacal borate, are always formed by the chemiſt in his labroatory.

XV. Calcareous neutral ſalts abound over the ſurface of the globe. We know but of ſix ſpecies of this genus of neutral ſalts; and five of theſe have been found in nature. Calcareous ſulphate or ſelenite exiſts in pretty extenſive ſtrata in hills: carbonate of lime, or calcareous matters, compoſes a conſiderable part of the exterior ſtrata of the globe: calcareous nitrate is always found with common nitre in the beds in which it is produced: calcareous muriate, in like manner, always accompanies muriate of ſoda: calcareous fluate is found in great plenty in mines.

XVI. Magneſian ſalts are much leſs copious in nature; none of them but magneſian ſulphate and magneſian muriate, which are found diſſolved in various waters, can be ſaid to exiſt in nature: magneſian nitrate indeed is ſometimes met with, but always in very trifling quantities. Nature has not yet exhibited to our obſervation either magneſian borate, magneſian fluate, or magneſian carbonate. The laſt of theſe, however, appears to exiſt in ſome ſtones.

XVII. Barytic ſulphate is the only one of the ſix barytic neutral ſalts that has been found in any abun-

dance

dance in the mineral kingdom. It is found in the cliffs of hills, and always in the neighbourhood of mines. Neither barytic nitrate, muriate, borate, nor fluate, has as yet been known to exiſt in nature; but pure barytic carbonate was, a few months ago, diſcovered in England, finely cryſtallized, and in large maſſes.

XVIII. Aluminous ſulphate is almoſt the only aluminous ſalt found in nature. It is met with in places adjacent to volcanoes, and among earths that have been expoſed to the action of volcanic fires. It appears alſo in an effloreſcence, on decompoſed lava, &c. Pyrites in an effloreſcent ſtate likewiſe contain a portion of it. As to aluminous nitrate, muriate, borate, or fluate, theſe are never found among the products of nature. Aluminous earth is often combined with the carbonic acid, and there is ſcarce any earth of the kind from which more or leſs of the carbonic acid may not be obtained by ſtronger acids.

CHAP. XII.

An Examination of ſome general Properties of Salts, particularly Cryſtallization, Fuſibility, tendency to Effloreſce or Deliquiate, Solubility, &c.

IN our hiſtory of ſimple and neutral ſalts, we have conſidered the properties of each ſalt ſeparately: but it may likewiſe be proper to compare them; for from the compariſon we may be able to deduce ſome general principles concerning them. Here then, let us conſider in this point of view the cryſtallization, fuſibility, effloreſcence, deliquieſcence, and ſolubility of ſalts.

Cryſtallization, conſidered as a general property of bodies, is a property by which they tend to aſſume a regular form, when placed in circumſtances favourable to that particular diſpoſition of their particles. Almoſt all minerals poſſeſs this property; but it is moſt eminent in ſaline ſubſtances. The circumſtances which are favourable to the cryſtallization of ſalts, and without which it indeed cannot take place, may be all reduced to the two following: 1. Their particles muſt be divided and ſeparated by a fluid, in order that the correſpond-

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ing faces of thoſe particles may meet and unite.—2. In order that this union may take place, the fluid which ſeparates the integrant parts of the ſalt muſt be gradually carried off, ſo that it may no longer divide them. From this it may be underſtood, that cryſtallization takes place by virtue of the mutual affinity ſubſiſting between the particles of cryſtallizable bodies, by which they tend to unite into one aggregate maſs. Theſe conſiderations lead us to think, that the integrant parts of ſalts have peculiar forms; and that the form of the integrant parts of the ſalt gives to the cryſtal its particular figure. The ſame conſiderations lead us farther to conclude, that the integrant particles of ſalts are ſmall irregular ſided polyhædrons, ſome of their faces being larger, others ſmaller, and that the largeſt of their faces moſt naturally meet and unite. This being allowed, it will be readily underſtood, that when the fluid which ſeparates theſe particles is carried off, their correſponding faces will reunite; and if the fluid go off ſlowly, ſo as to give the ſaline matters time for a regular arrangement, and to allow them to bring their correſponding faces into contact, the cryſtallization will then be regular. But again, if the fluid be too quickly carried off, the ſaline particles muſt unite haſtily, not by their correſponding faces, but by thoſe which are moſt contiguous to each other, and the cryſtallization will then be irregular, and the form of the cryſtals not eaſy to determine. Nay, if the ſolution be very ſuddenly evaporated, the ſalt will appear in a concrete maſs, with nothing of a cryſtalline form.

Theſe are the principles on which we proceed when we attempt to make ſaline matters aſſume the cryſtalline form. All ſalts are ſuſceptible of cryſtallization; but they do not all cryſtallize with equal readineſs.

Some ſalts cryſtallize ſo readily, that we can make them aſſume the cryſtalline form at pleaſure. Others again require more care and many precautions. And, laſtly, there are ſeveral which we have not yet been able to obtain in cryſtals. In order to ſucceed in attempts to cryſtallize ſalts, it is requiſite for us to be well acquainted with the circumſtances moſt favourable to the cryſtallization of each. In ſuch operations it is a neceſſary condition that the ſaline ſubſtances be firſt diſſolved in water: but ſome ſalts are ſo difficult of ſolution that it is almoſt impoſſible to make their integrant particles unite regularly. Such are calcareous ſulphate, calcareous carbonate, calcareous fluate, and barytic ſulphate. In nature, theſe neutral ſalts are daily met with in very regular cryſtals; but art cannot imitate them but by a very tedious proceſs; nay, a number of eminent chemiſts deny the poſſibility of any ſuch proceſs. I take my account of it from M. Achard, who aſſerts, that by this proceſs he obtained calcareous carbonate in cryſtals. This ingenious proceſs conſiſts in making water that has long ſtood over thoſe ſalts which diſſolve with ſo much difficulty, to run along a very narrow canal, and there evaporate very ſlowly. Again, there are other ſaline matters ſo ſoluble, and ſo much diſpoſed to remain in union with water, that it is exceedingly difficult to ſeparate them from it, and make them cryſtallize regularly. This is the character of all deliquiating ſalts, ſuch as calcareous and magneſian nitrate and muriate.

Each particular ſalt, no doubt, muſt cryſtallize in a way peculiar to itſelf; or, what is the ſame thing, the moſt minute particles of every ſaline ſubſtance muſt have a determinate form, by which they are diſtinguiſhed from the integrant particles of every other ſaline matter. This is doubtleſs the cauſe of that amazing variety of forms which cryſtalline bodies exhibit. The ſimple ſalts from the ſalino-terreous ſubſtances to the ſtrongeſt acids, have ſcarce ever a diſtinct, determinate form: and there are but a few circumſtances which can cauſe them to cryſtallize without totally deſtroying their ſaline properties; which actually happens to the oxigenated muriatic and the concrete ſulphuric acids. The cauſtic alkalis, however, cryſtallize in plates, according to M. Berthollet, and the acid of borax is well known to exhibit the ſame figure. But excepting theſe two, none of the ſimple ſalts can be made to aſſume any regular form, either becauſe their nature does not admit of it, or becauſe the means which they employ are inadequate to the purpoſe. But all the neutral or middle ſalts naturally affect a regular form, and we can even cauſe moſt of them to aſſume or reſign it at pleaſure. When we conſider this property by which neutral ſalts are ſo eminently diſtinguiſhed from the ſimple, we are at a loſs to determine whether it be owing to the acids or to the alkaline baſes by which they are neutralized: but it cannot be excluſively aſcribed to either the one or the other; for the ſame acid in combination with various baſes often forms cryſtals of a great variety of figures; while again the ſame baſe in combination with various acids often exhibits a like diverſity of forms. The cryſtallization of neutral ſalts is therefore to be aſcribed to a total change of the properties of both the acid and the baſe.

There are three ways of making ſalts cryſtallize commonly practiſed in the laboratory. 1. The firſt is evaporation. This proceſs conſiſts in heating a ſaline ſolution till the water by which its particles are kept ſeparate be reduced to vapour. The ſlower the evaporation, ſo much the more regular will the cryſtallization of the ſalts be. The proceſs for cryſtallizing ſulphate of potaſh, muriate of potaſh, muriate of ſoda, calcareous ſulphate, and magneſian carbonate, is conducted on this principle. When a ſolution of any of theſe ſalts is evaporated by a boiling heat, the form in which the ſalt is obtained is far from being regular: but if placed on a ſand bath, of the heat of nearly 45 degrees, the ſame ſolution conſtantly gives either ſooner or later very beautiful regular cryſtals: And there is ſcarce any ſalt which may not be made to aſſume a regular form by this proceſs judiciouſly conducted. 2. Cooling is ſucceſsfully applied to cryſtallize ſuch ſalts as are more ſoluble in warm than in cold water. It is eaſy to ſee, that a ſalt of this nature will cryſtallize as ſoon as the water in which it is diſſolved becomes incapable of maintaining it fully in ſolution, in conſequence of its temperature being diminiſhed. That portion of the ſalt which owed its ſolution to the temperature of the fluid, is gradually ſeparated as the liquor cools; and when the water becomes quite cold, no more of the ſalt remains diſſolved but what is ſoluble in cold water. In this proceſs, as in the former, when the ſolution is cooled moſt ſlowly, and the ſaline particles are ſuffered to unite their correſponding faces, the cryſtals are then moſt regular: And therefore ſolutions of ſalts ſhould be for ſome time expoſed to a certain degree of heat; which ſhould be afterwards diminiſhed gradually till it be reduced to the loweſt degree requiſite. It is to be obſerved, that all ſalts ſuſceptible of cryſtallization by this proceſs are in general much more ſoluble than thoſe which are cryſtallized by the firſt proceſs; as they are at firſt diſſolved in boiling water, if the ſolution be ſuddenly cooled, the ſalt falls to the bottom in a ſhapeleſs maſs; but if put on a ſand-bath, and ſlowly cooled, the cryſtallization is always regular. By this means ſulphate of ſoda, nitre, carbonate of potaſh, carbonate of ſoda, ammoniacal muriate, &c. are obtained in fine cryſtals.

3. The third method of cryſtallizing ſalts is ſpontaneous evaporation. This is obtained by expoſing a very pure ſolution of the ſalt which we wiſh to cryſtallize to the temperature of the atmoſphere in a glaſs or ſtone veſſel covered with gauze; which prevents any duſt from falling into the liquor without retarding the evaporation. The veſſel with the ſolution is to be ſet aſide in an apartment not otherwiſe occupied, and there ſuffered to remain till cryſtals appear; four or five months, or perhaps a longer ſpace, will ſometimes elapſe before that happen. The largeſt and moſt regular cryſtals are uſually obtained by this proceſs. Did time allow, it might be applied to all ſalts; for by means of it they are obtained in the higheſt purity. It is abſolutely neceſſary for the cryſtallization of nitrate of ſoda, muriate of ſoda, borax, aluminous ſulphate, magneſian ſulphate, ammoniacal ſulphate, ammoniacal nitrate, &c.

On ſome occaſions two or more of theſe proceſſes are employed together; as for inſtance, in the cryſtallization of ſalts which have a ſtrong tendency to deliquiate, ſuch as calcareous nitrate, calcareous muriate, magneſian nitrate, and magneſian muriate. Solutions are firſt powerfully evaporated, and then expoſed to an extreme cold. But this method never gives regular cryſtals; and ſometimes we obtain by it nothing but ſhapeleſs concrete maſſes. The reaſon why we are able to cryſtallize ſo few of the neutral ſalts, is our not knowing exactly in what ſtate of concentration the ſolutions of various ſalts muſt be, in order that they may afford cryſtals. Though this knowledge might eaſily be obtained, as nothing but time and patience are requiſite for the purpoſe, yet chemiſts have not made it ſufficiently the object of their attention. The ſpecific gravities of ſaline ſolutions muſt be obſerved, in order that we may come to know the degree of concentration requiſite for the cryſtallization of each. In ſome operations on ſalts in the great way, an areometer, or inſtrument for meaſuring the ſpecific gravities of liquids, has been happily employed to determine the point at which the ſolution might be expected to cryſtallize.

Beſides theſe methods of effecting the cryſtallization of ſalts, there are ſeveral circumſtances favourable to that operation, the influence of which it will be proper to eſtimate. Gentle agitation ſometimes contributes to effect a cryſtallization, which might otherwiſe not ſucceed. When veſſels containing ſaline ſolutions are ſhaken or removed from one place to another, we ſometimes ſee cryſtals inſtantly formed, though the ſaline matter was immediately before entirely in ſolution. The contact of the air is indiſpenſably neceſſary to the formation of cryſtals. It often happens that a ſaline ſolution, though evaporated to the proper point, gives no cryſtals, on account of its being confined in a cloſe flaſk; whereas if it were expoſed to the air in an open veſſel, it would cryſtallize with great rapidity. Rouelle the elder made this obſervation in a very accurate manner. The form of the veſſels, too, and extraneous matters happening to be intermixed with the ſolution, have great influence on the cryſtallization of a ſalt. The firſt of theſe circumſtances modifies the figure of the cryſtals, and diverſifies them in an amazing manner. Thus, threads or ſmall ſticks are put into veſſels containing ſaline ſolutions, to make them cryſtallize

with

with greater regularity. The cryſtals are depoſited on the threads, their baſes are then very narrow, and they therefore aſſume a more regular form than when they fall upon the ſides of earthen pots, or any of the other veſſels commonly made uſe of in this proceſs; which being oblique, irregular, and unequal, mutilate and deſtroy the regularity of cryſtals. Extraneous bodies immerſed into ſolutions of ſalts are often ſerviceable; they cauſe the cryſtallization to take place ſooner than it would otherwiſe have done. A bit of wood or a ſtone thrown into a ſalt ſpring, becomes a baſe on which the water depoſites cryſtals of muriate of ſoda. Some chemiſts, in conſequence of obſerving this phænomenon, have been induced to propoſe the immerſion of ſaline cryſtals into ſaline ſolutions, which do not cryſtallize readily. Several have aſſerted this circumſtance to be highly favourable to the cryſtallization of ſuch ſalts as cannot without great difficulty be obtained under a regular form. Theſe are the chief circumſtances which influence cryſtallization. Future obſervation, no doubt, may make chemiſts acquainted with many more.

A ſalt cannot be ſeparated from the water by which it was diſſolved, ſo as to aſſume a regular form, unleſs it retain ſome part of the fluid. The reader may convince himſelf of this fact by taking a portion of ſome ſalt reduced to a powder by heat, ſuch as aluminous ſulphate or borate of ſoda calcined, or dried ſulphate of ſoda, diſſolving it in water, and cauſing it to cryſtallize: and it will be found to have gained an augmentation, ſometimes even of an half more, in conſequence of being cryſtallized; that is, an ounce of ſalt will increaſe to two ounces by cryſtallization. Chemiſts have inferred from this fact, that a ſalt when formed into regular

gular cryſtals, contains more water than when deprived of its cryſtalline form by the action of fire or air. This water, which though not one of its principles as a ſaline ſubſtance, is yet eſſentially neceſſary to its conformation into cryſtals they call *the water of cryſtallization;* becauſe it is in fact an element of ſaline cryſtals. When deprived of this water, cryſtals loſe their tranſparency and regularity of form. Salts contain ſome a greater ſome a leſs quantity of this water of cryſtallization. Some ſalts, ſuch as ſulphate of ſoda, carbonate of ſoda, and aluminous ſulphate, contain a quantity of water equal to half their weight; others, ſuch as nitre, muriate of ſoda, &c. poſſeſs but a ſmall portion of water. The various proportions in which the water of cryſtallization ſubſiſts in the various ſalts has not yet been accurately determined. Salts may loſe this water without ſuffering any alteration of their intimate nature; and the water itſelf is perfectly pure like diſtilled water.

As from what we have ſaid concerning the cryſtallization of ſalts, it appears that ſaline ſubſtances are not all cryſtallized by the ſame proceſs, but obey different laws in their formation into cryſtals; it is plain that we may take advantage of this circumſtance, when we attempt to ſeparate different ſalts from one another. Thus a ſalt which cryſtallizes by cooling may be obtained entirely ſeparate from another which cryſtallizes only by continued evaporation; in this manner are the muriate of ſoda and the ſulphate of ſoda, contained in the ſpring-waters of Lorraine, ſeparated from each other. It often happens, however, that two ſalts when diſſolved in the ſame water, are ſo blended together, that repeated ſolutions and cryſtallizations are neceſſary to effect an entire ſeparation between them. This obſer-

obſervation holds ſtill more ſtrongly in regard to thoſe ſalts which are ſubject to the ſame laws of cryſtallization. Theſe are much more difficult to ſeparate from each other, eſpecially if there be a number of them together. For inſtance, if the ſame water ſhould happen to contain four different ſalts, all equally diſpoſed to cryſtallize by either evaporation or cooling, it would not be poſſible to ſeparate them by one or two ſucceſſive proceſſes of cryſtallization: but the operation would require to be many times repeated, in order that the nice variations which diverſify the characters of thoſe ſalts might be brought to diſplay themſelves: For it is to be remarked, that though two or more ſalts appear ſubject to the ſame laws of cryſtallization; yet when minutely obſerved, the cryſtallization of the one will be always found diſtinguiſhed from that of the other by ſome ſlight differences. Were this not the caſe, they would always cryſtallize together, nor would it be at any time poſſible to obtain them ſeparate; but this ſcarce ever happens, even in regard to thoſe ſalts which cryſtallize in the moſt uniform manner. There are, however, ſome exceptions from this rule: ſome ſalts have a peculiar tendency to mutual adheſion, or an uncommon affinity with each other. Of this kind are all neutral ſalts which owe their formation to the ſame acid, and cryſtallize by the ſame proceſs; ſuch as the magneſian and ammoniacal ſulphates. But theſe ſingular phænomena of neutral ſalts have not been as yet obſerved with enough of attention; and there is here ſtill farther ſcope for the reſearches of the chemiſt.

Laſtly, To conclude this compendious hiſtory of the cryſtallization of ſalts, let us take notice that there is another mode of obtaining them in cryſtals. Saline ſolu-

ſolutions may be precipitated by ſome ſubſtance that has a greater affinity than they with the water. Spirit of wine produces this effect on moſt of the neutral ſalts; on all of them indeed but ſuch as are ſoluble in that menſtruum. The ſame phænomenon takes place when ſalts, differing conſiderably from each other in point of ſolubility, happen to be mixed together, even when ſeveral different ſaline ſolutions are mixed, though the ſalts differ not greatly as to ſolubility. Thus ſulphate of magneſia diſſolved in water precipitates a ſolution of ammoniacal ſulphate. But what paſſes on that occaſion has not yet been obſerved with ſufficient attention to enable me to give a particular account of this ſingular phænomenon.

Fuſion by heat was treated of when we gave the particular hiſtory of each ſaline ſubſtance by itſelf; but we may here compare the different kinds of fuſion of which ſalts are ſuſceptible. Salts are liable to two kinds of fuſion; the one, which is peculiar to ſaline matters, is owing to water, and is called *aqueous fuſion*: the other, which ariſes from a different cauſe, is known by the name of *igneous fuſion*. Aqueous fuſion depends entirely on the water of cryſtallization; which as it exiſts in many ſalts in a large proportion, amounting often to half the weight of the cryſtal, is capable of diſſolving ſuch ſalts when heated to the temperature of 60 degrees. The cryſtalline form then diſappears, the ſalt is diſſolved, and the fuſion which takes place is in fact a real ſolution. This obſervation is ſo juſt, that when a ſalt of this nature, ſuch as ſulphate of ſoda, borate of ſoda, or aluminous ſulphate, is kept for ſome time in this ſtate of fuſion, the water which with the help of heat diſſolved it, is gradually evaporated, and the ſalt is left dry, and no longer appears in a ſtate of fuſion.

fuſion. This apparent or aqueous fuſion has no relation to true igneous fuſion; for all ſalts that have been dried after being once liquefied by their water of cryſtallization are ſuſceptible of the latter. Thus muriate of ſoda, and borate of ſoda, are melted by a ſtrong heat, after ſuffering aqueous fuſion and being dried up by a moderate heat. All ſalts have not an equal tendency to true igneous fuſion: There are ſome, ſuch as nitrate and muriate of ſoda, which melt as ſoon as they begin to become red-hot: others again, ſuch as ſulphate of potaſh and ſulphate of ſoda, require a much more intenſe heat to melt them. Laſtly, Such is the fuſibility of ſome ſalts, that they are capable of communicating this property to other bodies ſcarce fuſible by themſelves. Thus the fixed alkalis communicate their fuſibility to quartz, ſand, and all other ſiliceous earths, which are otherwiſe abſolutely infuſible. This property has acquired to theſe ſalts the title of *fluxes*, becauſe they are employed to promote the fuſion and vitrification of earthy and metallic ſubſtances. We have already remarked in another place, that the laſt degree of fuſibility is volatilization. And we would here obſerve, that all ſaline matters are more or leſs volatile; not one of them but may be volatilized by an extreme heat. Thus ſulphate of potaſh and muriate of ſoda, when heated to the higheſt temperature of which they are capable, are ſublimated into vapour.

Cryſtallized ſalts do not all ſuffer the ſame alteration from the action of air. Some of them ſuffer no diſcernible alteration when expoſed to it, but many loſe ſooner or later their tranſparency and form; and of theſe ſome melt down gradually, acquiring at the ſame time additional weight, while others, as they become pulverulent, ſuffer a diminution of weight. The firſt

of

of theſe alterations is called *deliqueſcence*, the other *efloreſcence*.

That phænomenon which is known by the name of *deliqueſcence*, is ſo called becauſe the ſaline matter which exhibits it then becomes liquid; and a ſalt is ſaid to fall into a *deliquium*, when it melts in this manner on coming into contact with air. The word *defaillance* was formerly uſed by *French* chemiſts as ſynonimous with *deliqueſcence*, but it is now become antiquated, and no longer appears in the writings of chemiſts. The occaſion of this alteration is, that the ſalts attract the moiſture of the atmoſphere; which, in my opinion, is to be conſidered as a real elective attraction between the water and the ſalt, which acts with ſuch ſuperior force as to ſeparate the water from the air of the atmoſphere. There are alſo differences among ſalts, in regard to their tendency to deliquiate, both in reſpect to the rapidity with which this change takes place, and the point of ſaturation at which the phænomenon of deliqueſcence ceaſes. The fixed alkalis, ammoniac gas, the muriatic acid gas, and the concentrated ſulphuric acid, abſtract the water from the atmoſphere, dry up the air, if we may be allowed to uſe the expreſſion, with a very conſiderable force, and abſorb a quantity of the fluid more than equal to their original weight. Dry potaſh particularly diſplays this phænomenon in a very eminent manner; ſo likewiſe does the ſulphuric acid when concreted by cold. Theſe two ſalts firſt become ſoft, and afterwards aſſume a thick liquid conſiſtency, reſembling that of ſome oils; which has cauſed the firſt to receive the name of *oil of tartar*, and the ſecond to be called *oil of vitriol.* But theſe names are improper, and more likely to miſlead than to enlighten a perſon entering upon the ſtudy of che-

chemiſtry. There are other ſalts which have a ſtrong tendency to deliquiate, but do not attract moiſture ſo copiouſly or with ſo much avidity as thoſe above-mentioned. Such are calcareous nitrate and calcareous muriate, magneſian nitrate and magneſian muriate. Laſtly, There are ſome ſalts which, when expoſed to the atmoſphere, only become a little wet, without waſting entirely down, ſuch as nitrate of ſoda, muriate of potaſh, ammoniacal ſulphate, &c.

The phænomenon of efflor eſcence has been ſo named, becauſe the ſalts ſuſceptible of it appear covered over with ſmall white threads, reſembling thoſe ſublimated matters which are known in chemiſtry by the name of *flowers*. This property is the direct contrary of deliqueſcence. In the inſtance of deliqueſcence, the ſaline cryſtals decompoſe moiſt air; becauſe the elective attraction ſuſiſting between the ſalt and the water is ſtronger than that between the water and the air. In efflor eſcence, again, the atmoſphere decompoſes the ſaline cryſtals, as having a greater affinity with water than the ſalts. In efflor eſcence, therefore, the water of cryſtallization is abſtracted from the ſalts; and this is the reaſon why ſalts, when they effloreſce, loſe their form, their tranſparency, and a part of their bulk. It is here of importance to obſerve, that all effloreſcent ſaline cryſtals ſuffer from air an alteration ſimilar to that which they ſuffer from heat. It is a kind of cold calcination which ſlowly decompoſes cryſtallized ſalts, by ſeparating from them the water to which they owe their cryſtalline form, and all their other properties as ſaline cryſtals. When a ſalt therefore effloreſces entirely, it ſuffers exactly the ſame loſs of weight as when it is dried by the action of fire. We may farther remark, that thoſe ſalts whoſe cryſtals effloreſce, belong to the claſs

claſs which is the moſt ſoluble, and cryſtallizes by cooling.

Effloreſcence, like deliqueſcence, is not exactly the ſame in all the neutral ſalts ſuſceptible of it. Some, ſuch as ſulphate and carbonate of ſoda, effloreſce readily and entirely, ſo that after exhibiting this phenomenon, they are found to be wholly reduced to a fine white duſt. As they appear to have loſt, in conſequence of this decompoſition, half their weight, it may be inferred, that their effloreſcing ſo completely is owing to their containing ſo much water of cryſtallization. And it is a fact, that ſalts which are but little ſuſceptible of effloreſcence, ſuch as aluminous and magneſian borate and ſulphate, contain leſs water in their cryſtals. If effloreſcence depend on air's having a greater affinity with water than ſalts have, it muſt follow, that when the atmoſphere is very dry, this phænomenon will take place more readily and in a more remarkable manner, while air loaded with moiſture will not act in the ſame manner on effloreſcent ſalts, but will leave them uninjured. To confirm this aſſertion; if a ſmall portion of water be ſprinkled on ſaline cryſtals ſuſceptible of effloreſcence, the ſurrounding atmoſphere being ſaturated by the abſorption of this water, does not affect that which enters into the conformation of the cryſtals, but leaves them unaltered. But if the cryſtals be not again wetted after the atmoſphere has once abſorbed the water which defended them againſt its influence, the air then makes an impreſſion on the ſaline ſubſtance and deſtroys its cryſtallization. In apothecaries ſhops, this phænomenon is daily obſerved; for they find it neceſſary to keep ſulphate of ſoda, or *Glauber ſalt*, conſtantly wet with a little water, in order to preſerve it in cryſtals.

The ſolution of ſalts in water is one of thoſe phænomena which are moſt worthy of the chemiſt's attention. Some perſons obſerving that it takes place without any ſenſible motion, and without the efferveſcence which always accompanies the ſolution of metals in acids, have propoſed to call the one *ſolution*, and the other, which is attended with efferveſcence, *diſſolution*. But as theſe two expreſſions have preciſely the ſame meaning, and the reciprocal action of acids and metals is a phænomenon very different from the ſolution of ſalts, we do not think that this diſtinction can be attended with any advantage. The ſolution of ſalts has been conſidered by ſome philoſophical chemiſts as being ſimply a mechanical diviſion of the ſaline particles: but the two bodies penetrate each other in a very intimate manner; their temperature too is inſtantly changed, and a real combination appears to take place between the ſalts and the water, which cannot be explained by referring it to the mere ſeparation of the ſaline particles. This appears, not only from the change of temperature which takes place on theſe occaſions, but likewiſe from the poſſibility of ſeparating one ſalt from water by the application of another which has a greater affinity with the fluid: thus potaſh precipitates ſulphate of potaſh, and calcareous carbonate from water in which either of theſe ſalts are diſſolved. All the precipitations of ſalts are far from being well known; and therefore a ſeries of experiments inveſtigating them would be of great uſe to chemiſtry. The reader might obſerve in the particular hiſtory of every ſaline ſubſtance, that they poſſeſs different degrees of ſolubility; ſome having ſuch a tendency to combine with water, that they remain always fluid, as for inſtance, the ſulphuric and the nitric acids; while others, ſuch as barytic ſulphate, are almoſt per-

perfectly inſoluble. Several chemiſts have already attempted to exhibit in tables the various degrees of ſolubility of the different ſalts. But ſuch tables muſt always be incomplete till ſuch time as the ſolubilities of the different ſalts be very accurately determined by a numerous train of experiments. We may here again take notice, that all ſimple ſalts, whether alkaline or acid, conſtantly produce heat when diſſolved in water; whereas cold is conſtantly excited during the ſolution of neutral ſalts. The changes of temperature which the different ſimple and neutral ſalts ſuffer on being diſſolved in water are not yet fully known; but chemiſts are now beginning to pay more attention to that object than they formerly did. Some uſeful diſcoveries will ſurely be the reſult of ſuch a train of reſearches; it has already led to the knowledge of ſome truths, which were not even gueſſed at before. For inſtance, when we obſerve that the neutral ſalts which produce moſt cold when diſſolved, ſuch as ſulphate of ſoda, ammoniacal nitrate, and ammoniacal muriate, are much more ſoluble in warm than in cold water; is it not reaſonable to infer, that this phænomenon is owing to their finding in warm water a greater quantity of heat than it is requiſite for them to abſorb, in order that they may be liquefied? And in fact they are eaſily deprived of this exceſs of heat by the action of air; ſo that part of the ſalt is precipitated in cryſtals as the liquor cools.

CHAP. XIII.

Of the Elective Attractions which take place between different Saline Matters.

THE numerous diſcoveries made by chemiſts concerning the nature of ſaline matters ſince the middle of the preſent century, have eſtabliſhed it as a certain fact, that there ſubſiſt between theſe matters different degrees of affinity or elective attraction. Geoffroy was the firſt who compared them together; but late reſearches have ſhown, that his table was very erroneous. Bergman has corrected his errors, and has made us acquainted with many more of the elective attractions ſubſiſting among ſalts: Yet, on conſulting the articles of the celebrated Swediſh chemiſt's table, which relate to the elective attractions of ſaline ſubſtances, we find ſeveral which are not founded on a ſufficient number of experiments, and the uncertainty of which he himſelf acknowledges. Inſtead of extending the theory of elective attractions to ſo great a number of ſalts as Bergman has, we muſt confine it in the

the preſent ſtate of chemiſtry to the examination of the affinities which take place between thoſe ſaline matters whoſe nature and properties are beſt known.

Of the ſix ſpecies of acids which we have examined, the ſulphuric acid appears to be the ſtrongeſt, or to have the moſt remarkable elective attractions for the different baſes; that is to ſay, it ſeparates moſt of the alkaline or ſalino-terreous baſes from the other acids; it decompoſes nitrates, muriates, fluates, borates, and carbonates, by extricating their acids.

The nitric acid generally holds the ſecond rank: it yields the alkaline baſes to the ſulphuric acid, but attracts them from the four following acids.

In order to make the reader better acquainted with the different affinities which take place between the mineral acids and the ſaline baſes of the ſame kingdom, we ſhall lay them down in the order in which Bergman arranges them in his Table of Affinities. Let us conſider, 1. Each acid as related to the different ſaline baſes with which it may be combined: 2. Each of the alkaline matters in relation to the acids which ſaturate them, and to the degree of force with which they combine with theſe ſalts.

I. The elective attractions of the ſulphuric acid for the different baſes, are arranged by Bergman in the following order, beginning with that baſe with which it has the ſtrongeſt adheſion *.

The

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* We have already given the order of the affinities of the acids with the baſes in the hiſtory of each of thoſe ſubſtances; but we think proper to exhibit them here in columns, as is done in tables of affinities, in order that they may appear under one point of view, and be compared together. A.

The SULPHURIC ACID.

Barytes.
Potaſh.
Soda.
Lime.
Ammoniac.
Magneſia.
Aluminous earth.

As the nitric and the muriatic acids attract the alkaline baſes in the ſame order, we may give them immediately after the ſulphuric acid.

The NITRIC ACID.

Barytes.
Potaſh.
Soda.
Lime.
Ammoniac.
Magneſia.
Aluminous earth.

The MURIATIC ACID.

Barytes.
Potaſh.
Soda.
Lime.
Ammoniac.
Magneſia.
Aluminous earth.

Barytes has therefore a greater affinity than any of the other baſes with the ſulphuric, the nitric, and the muriatic acids, and decompoſes all neutral ſalts that are formed by the union of theſe acids with the alkaline matters. Bergman places magneſia before ammoniac, becauſe, he tells us, that ſalino-terreous ſubſtance decompoſes ammoniacal ſalts. We may remark, that ammoniac decompoſes magneſian ſalts more completely. Magneſia indeed is never entirely precipitated by this alkali. Mixed or triple ſalts are found to remain in the liquor, which are formed by the union of the magneſian with the ammoniacal ſalts. We apprehend, notwithſtanding our reſpect for the authority of Bergman, that there is a greater affinity between ammoniac and the acids than between the acids and magneſia: for though magneſia diſengages a little ammoniac from ammoniacal ſalts in the humid way, yet it does not decompoſe theſe ſalts by diſtillation. We have therefore placed ammoniac before magneſia; and we think Bergman's table needs this correction.

II. The elective attractions of the fluoric acid for the alkaline baſes are very different from thoſe of the three foregoing acids. The alkalis yield this acid to lime and the two other ſalino-terreous ſubſtances. A ſolution of barytic fluate in hot water is precipitated by lime-water; and the precipitation is immediately followed by the formation of calcareous fluate. The caſe is the ſame with the other fluoric neutral ſalts: lime deprives them of the acid,—as Bergman ſhows in his eighth table, which is thus arranged.

THE FLUORIC ACID.

Lime.
Barytes.
Magneſia.
Potaſh.
Soda.
Ammoniac.
Aluminous earth.

The ſame phænomena take place in the dry way; for calcareous fluate is decompoſed by carbonate of potaſh and of ſoda, but not by the pure and cauſtic fixed alkalis.

III. Bergman exhibits in his tenth table the affinities of the boracic acid in the ſame order with thoſe of the fluoric; becauſe, when borax is heated with quicklime in water, the quicklime ſeizing the acid forms with it calcareous borate which is ſcarce ſoluble, and leaves the ſoda pure. As to the other baſes, he gives the order of their affinities with this acid only by analogy; and he acknowledges his diſpoſition of them to be no more than a probable conjecture. *Quod idem accidat*, ſays he, *cum alkali vegetabili, acido boracis ſaturato, hactenus tantum probabilis eſt conjectura, æque ac terræ ponderoſæ et magneſiæ poſitura.*

THE ACID OF BORAX.

Lime.
Barytes.
Magneſia.

Potaſh.

Potaſh.
Soda.
Ammoniac.
Aluminous earth.

IV. The elective attractions of the carbonic acid are ſomewhat different from thoſe which have been laid down as belonging to the other acids. This acid adheres more ſtrongly to barytes, and next after barytes to lime, than to any other ſubſtance. Ammoniac ſeparates it from magneſia, as Bergman has ſhown by very accurate experiments. Here therefore we cannot make the obſervation which we have made with reſpect to the other acids; and we ſhall give part of the twenty-fifth column of that celebrated chemiſt's table of affinities, which exhibits the attractions of the carbonic acid for the ſeveral ſaline baſes.

THE CARBONIC ACID.

Barytes.
Lime.
Potaſh.
Soda.
Magneſia.
Ammoniac.
Aluminous earth.

V. The ſeven earthy or alkaline baſes whoſe combinations with the mineral acids we have examined, differ from one another in their elective attractions for the ſame acids. Five of them, namely the two fixed alkalis, ammoniac, lime, and aluminous earth, agree in the order of their affinities. All the five adhere to the acids in the following order; the ſulphuric acid, the nitric acid, the muriatic acid, the fluoric acid, the boracic acid, and the carbonic acid. But barytes and magneſia differ from the five firſt baſes in their affinities with the mineral acids, and agree with each other.

Bergman diſpoſes the elective attractions of barytes and magneſia, in reſpect to the mineral acids, in the following order.

BARYTES AND MAGNESIA.

The ſulphuric acid.
The fluoric acid.
The nitric acid.
The muriatic acid.
The boracic acid.
The carbonic acid.

The only difference between theſe affinities and thoſe of the five foregoing baſes, is, that the fluoric acid here ſtands before the nitric and the muriatic acids; which ſhows that barytic and magneſian nitrates and muriates are decompoſed by the fluoric acid;—whereas barytic and magneſian fluates are not liable to be deprived of their baſes by the nitric and the muriatic acids.

VI. The elective attractions of which we have given an account, ſhow the order of the ſimple decompoſitions which are effected when three ſaline matters are mixed together. But it is not enough to know theſe affinities or ſimple elective attractions; we muſt alſo attend to thoſe which take place among four ſaline ſubſtances.

It is to be remembered, that by double affinity, we underſtand a double affinity in virtue of which a compound of two bodies which could not have been deſtroyed by either a third or a fourth body ſeparately, is yet decompoſed with the greateſt facility when theſe two laſt bodies are combined together. This double elective attraction often takes place among neutral ſalts. Thus, calcareous ſulphate, nitrate, or muriate, cannot be decompoſed by either ammoniac or the carbonic acid taken ſeparately: becauſe the firſt of theſe bodies has leſs affinity than lime with the ſulphuric, the nitric, and the muriatic acids; and the ſecond again has leſs affinity with lime than even theſe acids: But when theſe calcareous ſalts are brought into contact with a compound of ammoniac and the carbonic acid, that compound deſtroys the adheſion of their principles. In that chapter in which I treated of affinities in general, I have ſhown how this phænomenon may be explained, by numbering the degrees of the attractive force exerted on the occaſion. I have attempted to apply the idea to ſaline matters; but as we are ſtill but imperfectly acquainted with the nature and the combinations of the fluoric and the boracic acids, I have applied it only to the ſulphuric, the nitric, the muriatic, and the carbonic acids, conſidered in relation to the mineral ſaline baſes, and the degrees of adheſion which they appear to have with theſe baſes. The numbers which I have employed to expreſs the different degrees of adheſion, are founded on the reſult of ſimple decompoſitions. Perhaps they do not expreſs accurately the force of affinity; but the deſign of employing them is only to ſhow the cauſe of double affinities.

I will firſt give a table, expreſſing in numbers the affinities of the four acids with ſix baſes; not including barytes, becauſe we are not yet well enough acquainted with the various ſaline combinations into which that ſubſtance enters. Afterwards, I ſhall lay down in particular tables the double affinities known to ſubſiſt among the neutral ſalts; adopting Bergman's mode of arrangement, which I have already deſcribed under the article of affinities in general. I may here obſerve, that in this ingenious arrangement, to which the only addition that I have made is expreſſing the affinities in numbers, the ſum of the two vertical numbers which indicate the divellent attractions, is to be conſidered as ſtanding in oppoſition to the ſum of the horizontal numbers which indicate the quieſcent attractions; which oppoſition of attractions is the cauſe of the decompoſition effected by double affinity.

TABLE *of the Degrees of Attraction between four Acids and ſix Baſes, expreſſed in Numbers.*

COLUMN FIRST.

The ſulphuric acid combines with	Potaſh, with an affinity equal to	8
	Soda	7
	Lime	6
	Ammoniac	4
	Magneſia	3½
	Aluminous earth	2

COLUMN

COLUMN SECOND.

The nitric acid combines with	Potaſh, with an affinity equal to	7
	Soda	6
	Lime	4
	Ammoniac	3
	Magneſia	2
	Aluminous earth	1

COLUMN THIRD.

The muriatic acid combines with	Potaſh, with an affinity equal to	6
	Soda	5
	Lime	3
	Ammoniac	2
	Magneſia	1
	Aluminous earth	$\frac{1}{2}$

COLUMN FOURTH.

The carbonic acid combines with	Lime, with an affinity equal to	3
	Potaſh	2
	Soda	1
	Ammoniac	$\frac{3}{4}$
	Magneſia	$\frac{1}{3}$
	Aluminous earth	$\frac{1}{4}$

A TABLE *exhibiting ten Kinds of double Affinity which take place among the ſeveral Neutral Salts, in Numbers taken from the preceding Table.*

I.

		Nitre.			
Sulphate of potaſh.	Potaſh.	7	The nitric acid.		Calcareous nitrate.
	8 quieſcent	divellent affinities	affinities 4	12 *	
	The ſulphuric acid.	6	Lime.		
		13			
		Calcareous ſulphate.			

II.

		Muriate of potaſh.			
Sulphate of potaſh.	Potaſh.	6	Muriatic acid.		Calcareous marine ſalt.
	8 quieſcent	divellent affinities	affinities 3	11	
	The ſulphuric acid.	6	Lime.		
		12			
		Calcareous ſulphate.			

III.

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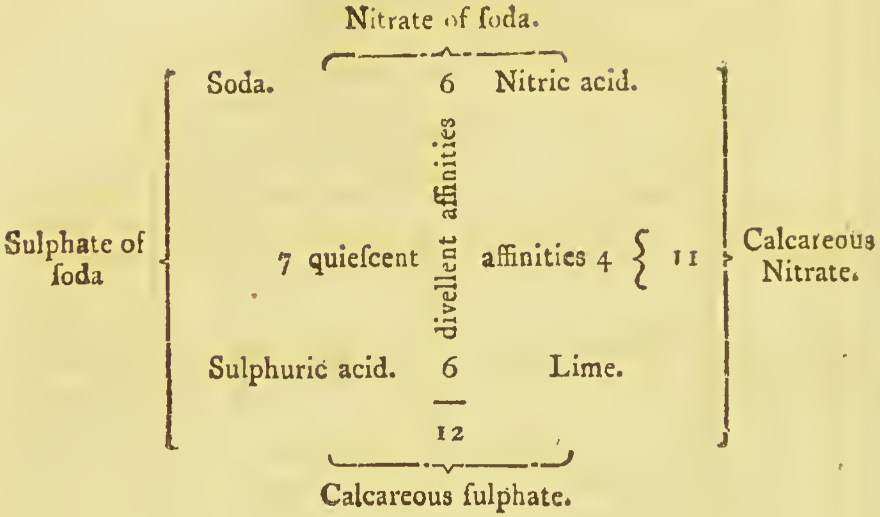
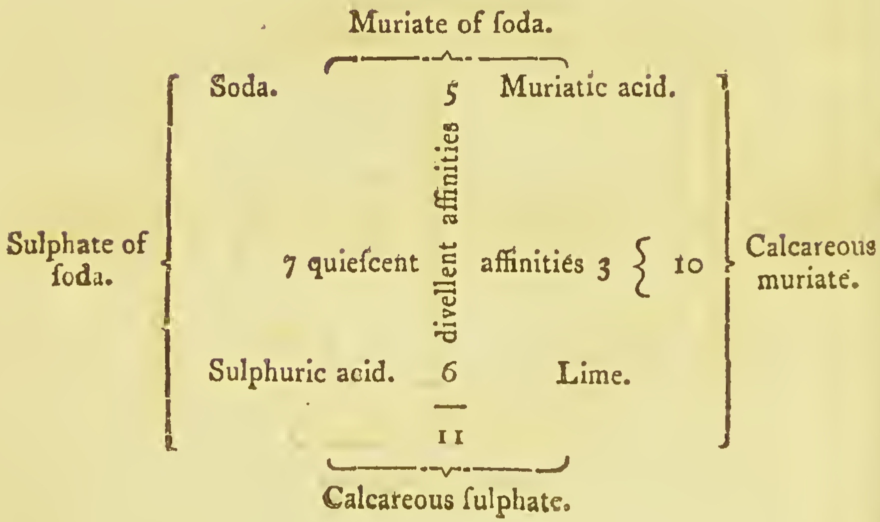
* The number placed on the right ſide, between the ſmall and the large bracket, is the ſum of the two horizontal or *quieſcent* affinities; and the decompoſition cannot take place unleſs this ſum be leſs than that of the two *divellent* affinities. A.

III.

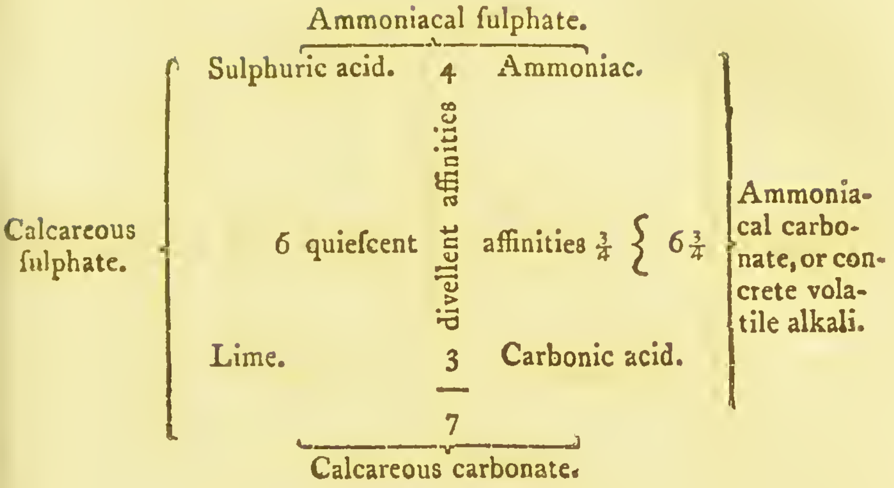

Nitrate of ſoda.
Soda.
6
Nitric acid.
Sulphate of ſoda
7 quieſcent
divellent affinities
affinities 4
11
Calcareous Nitrate.
Sulphuric acid.
6
Lime.
12
Calcareous ſulphate.

IV.

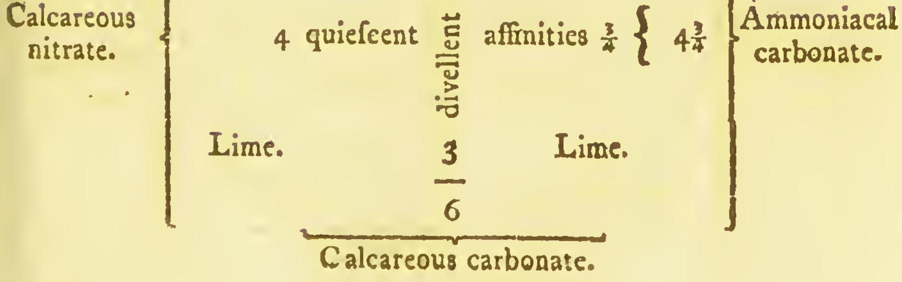

Muriate of ſoda.
Soda.
5
Muriatic acid.
Sulphate of ſoda.
7 quieſcent
divellent affinities
affinities 3
10
Calcareous muriate.
Sulphuric acid.
6
Lime.
11
Calcareous ſulphate.

V.

V.


Ammoniacal ſulphate.
Sulphuric acid.
4
Ammoniac.
Calcareous ſulphate.
6 quieſcent
divellent affinities
affinities ¾
6¾
Ammoniacal carbonate, or concrete volatile alkali.
Lime.
3
Carbonic acid.
7
Calcareous carbonate.

VI.


Ammoniacal nitrate.
Nitric acid.
3
Ammoniac.
Calcareous nitrate.
4 quieſcent
divellent affinities
affinities ¾
4¾
Ammoniacal carbonate.
Lime.
3
Lime.
6
Calcareous carbonate.

VII.

VII.

		Ammoniacal muriate.		
	Muriatic acid.	2	Ammoniac.	
Calcareous muriate.	3 quieſcent	divellent affinities	affinities ¾ { 3¾	Ammoniacal carbonate.
	Lime.	3	Carbonic acid.	
		5		
		Calcareous carbonate.		

VIII.

		Magneſian ſulphate, or Epſom ſalt.		
	Sulphuric acid.	3½	Magneſia.	
Calcareous ſulphate.	6 quieſcent	divellent affinities	affinities ½ { 6½	Magneſian carbonate, or effervеſcent magneſia.
	Lime.	3	Carbonic acid.	
		6½		
		Calcareous carbonate,		

IX.

IX.

Magneſian nitrate.

Nitric acid. 2 Magneſia.

divellent affinities

Calcareous nitrate. 4 quieſcent affinities $\frac{1}{3}$ { $4\frac{1}{3}$ } Magneſian carbonate.

Lime. 3 Carbonic acid.

5

Calcareous carbonate.

X.

Magneſian muriate.

Muriatic acid. 1 Magneſia.

divellent affinities

Calcareous muriate. 3 quieſcent affinities $\frac{1}{3}$ { $3\frac{1}{3}$ Magneſian carbonate.

Lime. 3 Carbonic acid.

4

Calcareous carbonate.

Theſe ten are not the only affinities ſubſiſting among the neutral ſalts which we have examined. We have ſeen, for inſtance, that the barytic ſalts are not decompoſed by potaſh, but are liable to decompoſition by carbonate of potaſh, or carbonate of ſoda; and that calcareous fluate is ſubject to the ſame laws. Theſe two inſtances of double affinity, and perhaps ſome others which are but imperfectly known, have not been exhibited in the foregoing table; becauſe we are not ſufficiently acquainted with the elective attractions of barytes, and the fluoric acid, to repreſent them by numbers. When the experiments neceſſary to make us ſufficiently acquainted with theſe affinities ſhall have been made, it will no doubt be neceſſary to change the numbers, and to adopt others expreſſive of the newly diſcovered affinities: But the method will ſtill remain; it can only be rendered more accurate.

SECTION III.

Of MINERALOGY.

Combuſtible Bodies.

CHAP. I.

Of Combuſtible Bodies in general.

WE have already ſpoken of combuſtion in the hiſtory of air. The order which we follow, renders it neceſſary for us to give here a brief recapitulation of what was before ſaid on this ſubject.

According to Stahl, a combuſtible body is a compound containing fixed fire or phlogiſton. His theory repreſents combuſtion as the diſengagement and paſſage of this fire from a fixed into a free ſtate. Light and heat are ſignals indicating its diſengagement. When the phænomenon ceaſes, the body which has diſplayed it enters into the claſs of incombuſtible matters;

ters: by reſtoring its phlogiſton, or by uniting with it the matter of fire fixed in ſome other body, we render it again combuſtible. But this theory is attended with four material difficulties. 1. The exiſtence of phlogiſton cannot be demonſtrated. 2. The weight of combuſtible bodies is conſtantly found to be increaſed after combuſtion; and it is hard to conceive how this can happen to any body when it loſes one of its principles. 3. Another ſtrange circumſtance is, that any body ſhould loſe part of its weight, by that acceſſion of phlogiſton which cauſes it to paſs from an incombuſtible to an inflammable ſtate. 4. Stahl does not appear to have conſidered that air is neceſſary to combuſtion.

A more careful obſervation of the laſt of theſe phænomena, and of the increaſe of weight which bodies acquire during their combuſtion, has given riſe to the following theory.

What renders a body combuſtible is its having a ſtrong tendency to combine with the oxigenous principle, which is the baſe of vital air. Combuſtion is the very act by which this combination takes place; it never happens but when the oxigene loſes the caloric by which it was maintained in a gaſeous ſtate. This opinion is founded on the four following facts: 1. No body can burn without vital air. 2. When the air is pureſt, the act of combuſtion is then moſt rapid. 3. By combuſtion air is abſorbed, and the burnt body gains additional weight. 4. Laſtly, A body burnt in the air acquires a quantity of oxigene equal in weight to what the ſurrounding atmoſphere loſes; which oxigene may be often extracted by methods which we ſhall hereafter deſcribe.

Macquer attempted a reconciliation of this theory with

with Stahl's, by explaining phlogiſton to be light in a fixed ſtate, and aſcribing to vital air the power of precipitating light. He thought, that in every act of combuſtion, phlogiſton was ſeparated into the ſtate of light by vital air, which occupied its place in the combuſtible body; and he conſidered light and vital air as two ſubſtances which mutually precipitated each other. When fixed light is cauſed to paſs out of a combuſtible body into a body that is already burnt; the vital air, according to this theory, yields its place in the one body to light, and ſeizes that which the light has left unoccupied in the other. But within theſe few years, the chemical doctrine on this head has attained a degree of ſtrictneſs and accuracy which neither requires nor allows our having recourſe to ſuch forced and complicated theories. We may here recapitulate it, in order to repreſent it with ſtill more plainneſs and perſpicuity than before.

Vital air is compounded of a baſe named *oxigene*, which is ſuſceptible of fixation, and is maintained in ſolution in the ſtate of an elaſtic fluid by light and caloric. When a combuſtible body is heated in this fluid, it decompoſes the vital air, and ſeizes its baſe or oxigene. The caloric and light being then ſet at liberty, regain their original rights, and eſcape in poſſeſſion of all their diſtinguiſhing properties; namely, the firſt in the form of heat, the ſecond in the form of flame. According to this doctrine, vital air is the only combuſtible body. This theory does not abſolutely deny the exiſtence of a phlogiſtic principle; for light acts the part which was aſcribed to it. But it differs from Stahl's theory, in repreſenting the phlogiſton which he placed in the combuſtible body, as a principle not of it, but of the body by which combuſtion is maintained. The ſame ob-

objection may indeed be made againſt the exiſtence of oxigene which has been urged againſt Stahl's phlogiſton. We are entirely unacquainted with any ſuch principle in a pure or inſulated ſtate: it is always combined with caloric in vital air, or with combuſtible bodies after they have ſuffered combuſtion. Like phlogiſton, it only paſſes from one combination into another; but never diſplays itſelf in a pure ſeparate ſtate. There is, however, a mighty difference between the two theories. The latter, to which we aſcribe truth and accuracy, is founded upon plain facts; the increaſe of weight which a combuſtible body gains, and the diminution of weight which the ſurrounding atmoſphere ſuffers from combuſtion; whereas ingenuity has never been able to eſtabliſh Stahl's theory on ſuch a baſis.

Combuſtible bodies differ in their tendency to combine with oxigene; and it would appear that a body is more or leſs combuſtible, according as it has a nearer or a more diſtant relation to this principle. So that the order in which combuſtible bodies tend to combuſtion may be determined, and a table conſtructed to expreſs their various affinities with the baſe of vital air.

This difference of affinity between combuſtible bodies and oxigene is the cauſe of that diverſity of phænomena which ſuch bodies exhibit when they enter into combination with this elaſtic fluid.

We may diſtinguiſh four different kinds of combuſtion.

1. Combuſtion with flame and heat, as in the inſtance of ſulphur, &c.

2. Combuſtion with heat without flame, as in many of the metals, &c.

3. Com-

3. Combuſtion with flame without heat, as in phoſphori, &c.

4. Slow combuſtion, apparently without either flame or heat; which happens when certain combuſtible bodies are brought into contact with air, or when oxigene fixed in ſome body, and ſeparated from caloric, paſſes unobſerved out of that body into another.

Beſides theſe leading diſtinctions, combuſtion is varied by many other phænomena, peculiar to particular combuſtible bodies. The velocity, the colour, and the extent of the flame, the ſmell which accompanies it, the quantity of oxigene abſorbed, the form, the colour, and the weight of the reſidue of the burnt body, with many other particulars, which it would be improper to enlarge upon here, but which ſhall be conſidered with all the attention they merit, when we give the hiſtory of each combuſtible body by itſelf, form ſo many eſſential diſtinctions, by means of which combuſtible ſubſtances may be diſtributed into claſſes.

When we conſider all the varieties which combuſtible bodies exhibit during their combuſtion, we cannot avoid agreeing that the cauſes from which they proceed are ſtill unknown; and there are ſtill important diſcoveries to be made on this article of the theory of chemiſtry. The different affinities of combuſtible bodies with the oxigenous principle, may ſerve to explain a part of the phænomena. Indeed it is natural to think that a body having a ſtrong tendency to combine with this principle, muſt afford moſt heat, motion, and light, when the combination takes place; becauſe ſuch a body will ſeparate oxigene from vital air in a more forcible manner than any other whoſe tendency to combine with it is weaker. But yet this doctrine does not account for the diverſity of colour which diſtinguiſhes the flame that proceeds from different inflammable bodies; why, for inſtance, copper gives a green flame, &c. Neither does it explain, not at leaſt in an experimental way, why ſome combuſtible matters burn without giving out any apparent flame, unleſs we agree with ſome philoſophers, that light and heat are the ſame, only the one in a more attenuated, the other in a more condenſed ſtate. But it is well known with what difficulties this opinion is attended. If we reflect, that light is one of the principles of vital air, and is diſengaged during combuſtion, we may perhaps be induced to think, that this body is diſengaged in a different manner by different combuſtible matters: that, in ſome inſtances, the whole of light, conſiſting of ſeven rays or principles, is completely diſengaged; while in others, as when nitrous gas acts on combuſtible bodies, only the orange ray is ſeparated; and in others, the green, or yellow, as when zinc and copper act on combuſtible bodies. But this hypotheſis, which has been already mentioned in the hiſtory of combuſtion under the article of Air, is ſtill unſupported by experiments. It is enough that it is almoſt demonſtratively proven, that the light diſengaged by combuſtion exiſts not in the combuſtible body, but in vital air. How indeed can we imagine, that a body ſo much attenuated, and ſo elaſtic as light, ſhould be ſuſceptible of fixation and ſolidity? Is not it more natural, and more conſiſtent with ſound philoſophy, to think that light, inſtead of being ſuſceptible of ſolidity, muſt rather poſſeſs the property of deſtroying the ſolidity of ſolid bodies; and that it is one of the cauſes of the elaſticity of vital air, which is nothing but a combination of oxigene, which in a ſeparate ſtate is ſolid, with the caloric principle, and with light?

There

There are, therefore, ſtill a few difficulties to reſolve in the hiſtory of combuſtion: But it is now ſufficiently proven, that combuſtible bodies, on being burnt, undergo a total change of nature; that the oxigene which becomes fixed in them, in conſequence of their combuſtion, always increaſes their abſolute weight; and that this principle then aſſumes a more ſolid form, than when, in combination with caloric and light, it conſtituted vital air.

We divide the combuſtible matters of the mineral kingdom into five genera; namely, diamond, hydrogenous or inflammable gas, ſulphur, metallic, and bituminous matters.

CHAP. II.

Genus I. *Diamond.*

DIAMOND is a ſubſtance of a peculiar kind; it is ranked among ſtones, becauſe it poſſeſſes their hardneſs, inſipidity, and inſolubility. It is, beſides, the moſt tranſparent, and the hardeſt of minerals. It is ſo hard, that the beſt tempered ſteel is incapable of penetrating it; nor can diamonds be cut by any other means but by rubbing them on one another.

Diamonds are found in the Eaſt Indies, particularly in the kingdoms of Golconda and Viſapour. We likewiſe get them from Brazil; but the Brazilian diamonds appear to be of an inferior quality: they are known in commerce by the name of *Portugueſe diamonds.*

Diamonds are commonly met with in an ochreous yellowiſh earth, beneath rocks of grit-ſtone and quartz; ſometimes, too, they are found in the beds of rivers: thoſe found in this ſituation have been carried off by the ſtream from diamond mines. Diamonds are ſeldom above

above a certain ſize. The Indian monarchs keep up the largeſt of them, to hinder their price from falling. Diamonds do not diſplay all their luſtre immediately after being taken out of the earth; they are brilliant only when found in water. All that are dug from mines are covered with an earthy cruſt; and when it is taken off, they exhibit, according to M. Romé de Lille, a ſecond, of the ſame nature with calcareous ſpar.

Diamonds have often an irregular form, and are eiten flat or round. Sometimes they exhibit regular octohædral cryſtals, conſiſting of two quadrangular pyramids, joined at the baſe; they are likewiſe found with 12, 24, and 48 faces.

Some diamonds are perfectly tranſparent, and of the fineſt water; there are others ſpotted, veined, clouded; theſe are much leſs valuable than the former. Some, again, are uniformly and deeply tinged with yellow, red, blue, or black; but theſe are very rare.

Diamonds appear to conſiſt of laminæ, diſpoſed one over another. They are eaſily ſplit, by ſtriking them with an inſtrument of well-tempered ſteel. But there are ſome diamonds which appear to conſiſt not of laminæ, but of fibres interwoven, ſo as to reſemble the knots of wood. Theſe laſt are ſo very hard, that they cannot be wrought; the lapidaries call them *natural diamonds*.

The tranſparency and hardneſs of the diamond, and the regular cryſtalline form which appears to be moſt natural to it, induced naturaliſts to rank this ſubſtance among vitrifiable ſtones. They conſidered it as the matter of the pureſt and moſt homogeneous rock-cryſtal. They thought it unalterable by fire; becauſe when jewellers heat diamonds ſpotted with yellow, even

even till they become red, the ſpots are indeed converted to black, but the luſtre of the ſtone is not diminiſhed. Yet diamond was known to be more ponderous and harder than rock-cryſtal, and to poſſeſs electrical properties in a very eminent degree. But theſe peculiarities were aſcribed to its extreme purity.

All tranſparent, ſtony, or ſaline bodies, are known to refract light in the direct ratio of their denſities; but combuſtible bodies refract light in the double ratio of their denſity. The peculiar brilliancy of the diamond appears to depend on its capacity of refracting light in ſo eminent a manner. As it is ſo highly tranſparent, and light is ſo ſtrongly refracted between its laminæ, when its ſurfaces are multiplied by cutting, each of its facets affords a ſheaf of very ſplendid light. And therefore thoſe diamonds which are cut into facets all over their circumference, have a much ſuperior luſtre to thoſe which are cut only on one ſide. On this account, lapidaries give the firſt the name of *brilliants*, while they call the others *roſes*.

Boyle aſſerted that fire altered diamonds, and diſengaged from them acrid vapours; but this fact did not immediately engage the attention of philoſophers. But in the years 1694 and 1695, Coſmo III. Great Duke of Tuſcany, ſaw the ſubſtance of diamond entirely deſtroyed by the heat of a burning-glaſs. The Emperor Francis I. likewiſe witneſſed at Vienna the deſtruction of diamond by the fire of a furnace.

M. d'Arcet, in his valuable experiments on ſtony matters expoſed to a violent and continued heat, has not neglected diamonds. He informs us, that vapours iſſue from the ſides of their laminæ; and that if this evaporation be cauſed to ceaſe, what remains of the diamond

diamond is found to have ſuffered no alteration of nature, but a diminution of bulk.

M. d'Arcet, wiſhing to know whether the evaporation of diamond was ſimply a decrepitation, contrived to treat it in veſſels variouſly cloſed. He took a ſphere of porcelain paſte, and after cutting it into halves, put a diamond in the middle ; he then joined the two ſections nicely together, ſo that the diamond formed to itſelf a cavity within the ſphere, without leaving any void ſpace around it. Putting thoſe balls into an oven, and leaving them there till they were fully burnt, he then broke them, and found the diamond evaporated, and the place which it occupied empty, tho' he could perceive no chink or fracture any where over the ſurface of the ball.

M. d'Arcet varied this experiment many ways ; uſing ſometimes balls of porcelain paſte, ſometimes crucibles of burnt porcelain, ſtopped at the mouth with the ſame matter, and coated over with a fuſible ſubſtance ; which being vitrified by fire, ſealed the veſſel hermetically. M. d'Arcet always found the diamond to diſappear ; and inferred, that it was ſuſceptible of evaporation without the help of air.

Meſſrs d'Arcet and Roux have ſince obſerved, that ſo intenſe an heat is by no means neceſſary to effect the volatilization of diamond : And in the year 1770, M. Roux volatilized a diamond in the medical ſchools in five hours, in a cupelling furnace.

In the year 1771, Macquer obſerved a new phænomenon relative to the deſtruction of this ſubſtance. He made uſe of Pott's furnace, on which he had made ſeveral improvements in volatilizing a diamond. This furnace, when fitted with a pipe or chimney, ten or twelve feet high, produces an heat equal to that of a fur-

furnace for hard porcelain. Macquer put a muffle in the middle of his furnace, and the pipe which was fitted to it was only two feet long. He put a diamond, cut into a brilliant, and weighing three-ſixteenths of a carat into a cupel, which he at firſt placed near the mouth of the red-hot muffle; and to prevent the diamond from burſting into pieces, he put the cupel containing it, not at once, but gradually, into the muffle. On obſerving the diamond at the end of twenty minutes, he found it to have increaſed in bulk, and become much brighter than the capſule in which it was placed. At laſt he obſerved a kind of lambent phoſphoric flame, which glowed in a very diſtinct manner around the ſtone; but he could not perceive any of thoſe acrid vapours which Boyle mentions. The diamond being replaced in the muffle, diſappeared entirely at the end of thirty minutes, ſo as to leave no veſtige of it behind. Thus Macquer, in leſs than an hour, volatilized a diamond weighing nearly four grains; and obſerved, that the combuſtion of this, like that of other combuſtible bodies, is attended with a diſcernible flame.

This fact, which was firſt communicated to the world by Macquer, has been ſince confirmed by repeated trials. M. Bucquet in the year 1775 volatilized a diamond of about three grains and an half. He made uſe of Macquer's furnace, but without the pipe; and the muffle was left open during all the time of the operation, in order that what paſſed during the combuſtion of the diamond might be ſeen. It continued about five minutes without being inflamed, and the ſpace between the inſtant of its inflammation and its being totally volatilized was five-and-twenty minutes.

As none of theſe experiments ſhowed what became of of the diamond, Meſſrs Macquer, Lavoiſier, and Cadet, reſolved to make ſome new experiments on this ſubſtance in cloſe veſſels. They diſtilled twenty grains of diamond in a ſtone retort, fitted with an apparatus proper for retaining the products, if there ſhould be any. They expoſed it to the utmoſt violence, without obtaining any product. After the operation, they found the diamonds pretty entire, yet not quite ſo heavy as before. From this circumſtance, they ſuſpected that this loſs of weight was owing to the diamonds being partly burnt, with the help of the ſmall portion of air contained in the veſſels: the diamonds were, beſides, covered over with a blackiſh and ſeeming carbonaceous cruſt, which ſoon diſappeared when they were rubbed on a grind-ſtone.

While chemiſts were employed in experiments on the nature of the diamond, the lapidaries always thought it abſolutely indeſtructible. M. le Blanc, one of theſe artiſts, took a diamond to M. Rouelle to expoſe it to fire, but inſiſted on incloſing it in a way of his own. Accordingly, he put it into a crucible, with a cement of chalk and coal reduced to powder. This crucible was incloſed in another, which was cloſely covered and luted with founder's ſand. It was then put into the fire, and left expoſed to it for four hours. At the end of that time, both M. le Blanc's diamond and others which M. Rouelle had expoſed to the fire were vaniſhed. M. Maillard, another lapidary, waited on M. Cadet, when Meſſrs Macquer and Lavoiſier were engaged with him in experiments on this ſubſtance, bringing with him three diamonds, which he propoſed to expoſe to fire after cementing them in his own way. He preſſed the bowl of a tobacco-pipe full of pounded charcoal, and putting his diamonds in the middle, covered the pipe with an iron plate, which he luted to it with founder's ſand. The pipe was put into a crucible lined with chalk, and coated over with ſand wet with ſalt water. The whole was put into Macquer's furnace, and expoſed to ſuch an heat, that at the end of two hours the apparatus was become ſoft and ready to melt. The crucible was now vitrified, and had loſt its ſhape. It was cautiouſly broken, and the pipe was found whole: the charcoal within it was perfectly black, and the diamonds had loſt nothing. They were only a little blackened on the ſurface; but they recovered their whitene\u017fs and luſtre on being rubbed on a grind-ſtone. Macquer repeated this experiment with the ſame ſucceſs in the great furnace in which the hard porcelain of Seves is burnt. But, on this occaſion, part of the iron which covered the pipe having been melted, it had reached the diamond, and ſcorified it on one ſide; but the other was perfectly unaltered. The fire had been kept up for four-and-twenty hours.

M. Mitouard having had occaſion to expoſe ſeveral diamonds to fire in cloſe veſſels, and with various cements, obſerved, that charcoal was more effectual for preventing the combuſtion of this body than any other matter.

From theſe facts, all chemiſts were led to think, that diamond burns like other combuſtible bodies; and that, like charcoal, it cannot be deſtroyed by fire without being in contact with air. Yet the numerous and accurate experiments of M. d'Arcet appeared to eſtabliſh a contrary doctrine. To determine this matter, Macquer filled ſeveral bowls of burnt porcelain, and ſeveral crucibles of porcelain paſte with powder of charcoal. In the crucibles of unburnt porcelain the charcoal was reduced to aſhes, and the aſhes were even vitrified;

vitrified; but in the veſſels of burnt porcelain the charcoal appeared to have ſuffered no alteration: and he thence concluded, that there is a great difference between theſe two kinds of veſſels. He thinks, that while porcelain is burning chinks are produced in it, which though ſcarce diſcernible, are ſufficient to facilitate combuſtion; and that, as the porcelain ſhrinks in when it cools, all the chinks are cloſed up, and diſappear after it is burnt.

To theſe, M. Lavoiſier has added new experiments, proving, that diamond does not burn unleſs it be in contact with air. He expoſed diamonds to the focus of M. de Trudaine's lens, after covering them with a bell, into which he made water or mercury riſe by emptying it of air. This chemiſt, in experiments on the effects of the burning-glaſs, which he made in conjunction with Meſſrs Macquer, Cadet, and Briſſon, had already obſerved, that when diamonds are ſuddenly expoſed to a ſtrong heat, they crackle and ſcintillate; which never happens when they are ſlowly and gradually heated. He likewiſe obſerved the diamonds to melt in ſome parts of their ſurface; ſuch of them as were for ſome time expoſed to the heat of the lens were penetrated all over their ſurface with ſmall holes, like a pumice-ſtone. When he heated them in the pneumato-chemcial machine above deſcribed, he was convinced, that the diamond burnt only for a certain time, in proportion to the quantity of air contained in the bell-glaſs. He examined the air in which the diamond had burnt, and found it preciſely ſimilar to that which remains after the combuſtion of any other combuſtible body; that is, it had loſt that proportion of vital air which renders atmoſpheric air fit for combuſtion. One circumſtance which deſerves to be taken notice of, is,

that

that the air which remained after the combuſtion of diamond precipitated lime-water, and contained carbonic acid.

In order to determine with ſtill greater certainty the nature of diamond, M. Lavoiſier attempted to burn it under a bell-glaſs filled with carbonic acid. The diamond ſuffered ſome loſs, which was owing no doubt to a portion of air mixed with the acid. He is alſo of opinion, that the loſs which diamond ſuffers on ſuch occaſions is owing to its being volatilized: and he infers from this inſtance, that this body may be entirely volatilized, if it be incloſed in a cloſe veſſel, and a ſtrong enough heat applied to it. M. Lavoiſier having ſubmitted charcoal to the ſame operation, obtained a ſimilar reſult, in regard both to its combuſtion and its volatilization. He obſerved too, that the ſurface of diamond always becomes black.

From theſe facts it follows, that diamond is a ſubſtance very different from ſtones; that it is actually a combuſtible body, which burns with flame whenever it is made red-hot in contact with air: In a word, that it is a volatile combuſtible body, for diamond never leaves any fixed reſidue; and that it perfectly reſembles charcoal in the manner in which it is affected by fire; though very different from it in tranſparency, gravity, hardneſs, and many other properties. All of the above experiments, as well as the art of ſplitting diamonds, ſhow, that this body conſiſts of laminæ, or layers arranged one over another; that there is ſometimes between the layers an extraneous colouring matter, to which the carbonaceous coating with which ignited diamonds are covered, eſpecially when in cloſe veſſels, is poſſibly owing. This coloured layer, which is ſometimes nearer to, and ſometimes more remote from, the ſur-

ſurface, often defeats the attempts of the lapidary to whiten ſpotted diamonds. If it be near the ſurface, it is eaſy to deſtroy it, and render the diamond entirely white. But when it is ſunk deep within the body of the diamond, it is impoſſible to remove it, without deſtroying ſucceſſively the laminæ by which it is covered: and in that caſe, a diamond will be ſometimes entirely deſtroyed before it loſe its colour.

Notwithſtanding all theſe experiments, we know not yet of what principles diamond is compoſed: in the preſent ſtate of our knowledge, it is to be conſidered as a peculiar combuſtible body, different from all others.

Diamond is of no uſe but as an ornament: but its property of refracting the rays of light, of decompoſing them, and exhibiting to the eye the moſt brilliant and lively colours, renders it ſo truly valuable, that the eſteem in which it is held is not to be attributed to the caprice of faſhion. Its value is farther increaſed by its exceſſive hardneſs, which enables it to retain the poliſh, its ſcarcity, and the ingenious art with which it is cut. It is uſed for engraving on glaſs and on hard ſtones, and to cut theſe bodies into any required form and ſize.

Diamond-powder is uſed for grinding and poliſhing whole diamonds.

CHAP. III.

Genus II. *Hydrogenous Gas.*

WHAT Dr Prieſtley calls *inflammable air*, and we *hydrogenous gas*, is an aeriform fluid, poſſeſſing all the apparent properties of air. It is about thirteen times lighter than common air; it does not contribute to maintain combuſtion, and it is almoſt inſtantaneouſly fatal to animals by throwing them into high convulſions. It has a ſtrong ſmell. One of its characteriſtic properties is, to take fire when, being in contact with air, an inflammable body is brought near it, or the electric ſpark cauſed to paſs through it.

Hydrogenous gas has been long known both in nature and art. Metal, and coal mines, the ſurface of maſſes of water, and animal or vegetable matters in the ſtate of putrefaction, afford many inſtances of natural, combuſtible vapour. Art has laboured to produce ſimilar vapours, by diſſolving metals with the ſulphuric and muriatic acids, and by diſtilling animal and vegetable ſubſtances. But, before Dr Prieſtley,

ley, no perſon thought of collecting thoſe vapours in receivers, in order to examine their properties. He diſcovered that they conſtitute a kind of permanent elaſtic fluid.

Hydrogenous gas diſplays all the phænomena characteriſtic of combuſtible bodies in a very eminent degree. Like them, it does not burn but when in contact with air: when pure, it burns with a flame which is more or leſs red; it gives a blue or yellow flame when combined with any ſubſtance capable of modifying its properties. It often crackles, and gives out, when burning, ſmall bright ſparks, with a noiſe ſimilar to that which is produced by the detonation of nitre. It produces, when burning, a lively heat. It is kindled by contact with the electric ſpark.

It burns with the greateſt rapidity when it is ſurrounded with a great quantity of air. As the aggregation of the two fluids is the ſame, it is poſſible to mix them ſo, that a particle of hydrogenous gas ſhall be involved among particles of air; and it then burns with great rapidity. This happens when a mixture, conſiſting of two parts of atmoſpheric air and one of hydrogenous gas, is inflamed. The mixture kindles, burns in an inſtant, and produces a ſmart exploſion like that of gun-powder: but again, hydrogenous gas by itſelf burns but ſlowly, and only at the ſurface.

It may likewiſe be made to burn in an inſtant, and with great violence, by mixing two or three parts of it with one of vital air or oxigenous gas: it then produces a much greater exploſion than in the above inſtance.

Mr Cavendiſh ſome years ago obſerved, that whenever

ever hydrogenous gas is burnt, drops of water always appear. On burning this gas in a veſſel filled with vital air above mercury, a vacuum is produced in the veſſel, the mercury riſes, and great drops of very pure water are ſeen to trickle down the ſides of the veſſel, their quantity ſtill increaſing as the combuſtion goes on. M. Lavoiſier combined ſuch a quantity of theſe two elaſtic fluids as afforded ſeveral drams of water. He took care to make both the fluids paſs through a glaſs cylinder, filled with dry cauſtic fixed alkali, in order to purify them entirely from any portion of water which might be intermixed with them. The weight of the water obtained anſwered exactly to that of the elaſtic fluids conſumed. And he concluded from this experiment, that water is actually a compound of theſe two fluids, in the proportion of ſix parts of oxigene to one of hydrogene. For it is eaſy to underſtand, after what has been already laid down, that the caloric and the light of vital air, and hydrogenous gas, are diſengaged during their combuſtion. And the diſengagement of theſe principles accounts for the weight of water being ſo very different from that of oxigenous or hydrogenous gas. The gravity of water is to that of hydrogenous gas in the proportion of 11,050 to 1, if we ſuppoſe the levity of this gas to be to that of atmoſpheric air in the proportion of 13 to 1; The diſparity will be ſtill greater, if the levity of hydrogenous gas be eſtimated at 16, which may be fairly done when it is perfectly pure.

Water obtained by the combuſtion of vital air with hydrogenous gas is found to contain ſome grains of nitric acid. In order to underſtand how this acid is formed, we may reflect, that Mr Cavendiſh produced nitric gas by combining, through means of the electric ſpark, ſeven parts of vital air with three of azotic gas from the atmoſphere.

But the vital air which M. Lavoiſier made uſe of for his experiment was extracted from red precipitate, or mercurial oxide precipitated by the nitric acid; and that oxide might perhaps afford the ſmall portion of azote which enters into its compoſition: wherefore the nitric acid obtained in this experiment is not to be conſidered as in any degree falſifying the aſſertions of M. Lavoiſier concerning the production of water. If with this fine experiment we compare that by which the ſame chemiſt decompoſed water, by making it fall on red iron, zinc, and coals, as well as boiling oils, and obtained a quantity of the hydrogenous gas proportioned to the quantity of the body burnt, we will find good reaſon to conclude, that the theory of the compoſition of water is as well ſupported as any other chemical theory.

The proportion in which the component principles of water are united in it, appears from the moſt accurate experiments to be 85 parts of oxigene to 15 of hydrogene in weight.

We want only one thing, to know the nature of hydrogenous gas. Is it a ſimple ſubſtance, or a compound ſubject to no varieties, but always the ſame in ſpecies? May it be conſidered as the phlogiſton of Stahl, which ſeveral Engliſh chemiſts, at the head of whom is Mr Kirwan, think it to be?

With regard to the firſt queſtion, it is nearly agreed among chemiſts, that all ſubſtances, however different in nature, which contain inflammable gas, afford it preciſely the ſame in all its properties.

There are indeed ſome who ſtill acknowledge ſeveral ſpecies of inflammable gas; ſuch as the inflammable gas obtained from iron and zinc by water, which burns with a red flame, and detonizes with pure air; that which M. de Laſſone obtained from Pruſſian blue, and from the reduction of flowers of zinc by charcoal, which burns in air without detonization; the inflammable gas that riſes from marſhes, and burns with a blue flame, without detonization; and that which is obtained by the diſtillation of organic matters, and reſembles the gas of marſhes. But we have learned from a ſtrict analyſis of the two laſt, that they are compounds of genuine, pure, and detonating hydrogenous gas, with azotic gas or carbonic acid in various proportions. In the year 1782, I was led to think, with the illuſtrious Macquer, that there is only one ſubſtance of this kind, which, by combining with different ſubſtances, undergoes various modifications. The experiments of many celebrated natural philoſophers, particularly of Cavendiſh, Prieſtley, Watt, Kirwan, Lavoiſier, Monge, Berthollet, de Morveau, &c. have ſince eſtabliſhed the truth of this opinion. The mixtures of the other gaſes, and the ſolution of coal, ſulphur, and phoſphorus in hydrogenous gas, the weight of which they augment, and render it leſs combuſtible, afford us reaſon to think, that the ſeeming varieties of inflammable gas are owing to ſuch mixtures or combinations. To me therefore it appears to be at preſent fully demonſtrated, that there is only one ſpecies of inflammable gas, produced by the decompoſition of water, and capable of producing water by combining with vital air; in a word, that there are no ſpecies belonging to this genus but hydrogenous gas, which is more or leſs inflammable, and variouſly coloured,

loured, according as it is mixed or combined with other bodies.

As to the ſecond queſtion; there are indeed ſeveral facts which appear to ſupport the opinion of Bergman and the Engliſh chemiſts, who take hydrogenous gas to be Stahl's phlogiſton: but there are many more which oppoſe our adopting that opinion. It appears that the combuſtible ſubſtances in which Stahl allowed the exiſtence of phlogiſton, do not all afford this elaſtic fluid, and that water always contributes to its formation. Mr Kirwan, who has been engaged for ſeveral years in examining this important queſtion, has not yet, as far as we know, been able to determine it by any deciſive experiment. Under ſome other articles of this work we will give our opinion of the hydrogenous gas, which that celebrated chemiſt obtained from an amalgam of zinc, as well as of ſome other analogous experiments, which have been urged by ſeveral philoſophers againſt the doctrine which we advance. We will not here enter into a detail of the objections which may be made to it; for we might poſſibly not be underſtood by thoſe whoſe ſtudies in chemiſtry have not extended farther than the foregoing chapters of our work: but thoſe objections ſhall be ſtated in the chapters concerning metallic ſubſtances, phoſphorus, &c. However it be, we muſt here acknowledge the phænomena may be explained on the ſuppoſition that hydrogene is the ſame with phlogiſton; but we cannot help obſerving, at the ſame time, that the theory of phlogiſton requires to ſupport it ſome forced and improbable ſuppoſitions, and is far from being equally ſimple and ſatisfactory with that which we have adopted as the plain ſimple reſult of facts *.

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[*] See Mr Kirwan's work on this ſubject; or the French tranſlation of that work, with the notes added.

No chemiſt has yet analyſed hydrogenous gas into principles: it is to be conſidered as a ſimple ſubſtance in the preſent ſtate of our knowledge: hydrogene, its baſe, combines entirely with pure air, or oxigene; and water is formed by the combination. The reader will obſerve, that we have ſaid nothing of the theories of thoſe writers, ſome of whom have aſſerted inflammable gas to be a compound of air with the matter of fire, while others repreſent it as a modification of light, fire, the electric fluid, &c. Theſe aſſertions are too vague, bear too great a reſemblance to the inaccurate and ambiguous language of the infancy of natural philoſophy, and are too inconſiſtent with experiments, to merit a ſerious diſcuſſion. Hydrogenous gas, no doubt, contains a good deal of ſpecific heat or caloric, perhaps even of the matter of light; nor is it always ſeparated from theſe gaſeous matters whenever it loſes its ſtate of elaſticity, and paſſes into liquid combinations.

Hydrogenous gas does not combine with water; it may be long kept under that fluid, without ſuffering any alteration. At length, however, it is ſo much altered, as to be no longer ſuſceptible of inflammation. Dr Prieſtley has not determined the nature of this change, nor the ſtate of the water which produces it. Probably, if ſuch an experiment were carefully performed, it would throw much light on the nature of this combuſtible body.

Hydrogenous gas is not known to act either on earths or on any of the three ſalino-terreous ſubſtances; but it deſtroys the whiteneſs of barytes, and communicates to it a colour; which has cauſed it to be conſidered as the calx or oxide of ſome metal ſtill unknown.

We know not what effects the alkalis and the acids

are

are capable of producing on this gas, nor what changes it produces on them. It would probably decompoſe ſome acids, particularly the ſulphuric acid and the oxigenated muriatic acid, by combining with their oxigene to form water. As to the ſulphuric acid, there is reaſon to think it liable to ſuch a decompoſition; for as ſulphur does not decompoſe water (a fact of which we will afterwards have occaſion to take notice), the baſe of vital air has certainly a ſtronger affinity with hydrogene than with water. The oxigenated muriatic acid has ſo conſiderable an exceſs of oxigene, and that ſo imperfectly united with it, that we may with good reaſon think that hydrogenous gas would carry off part of it to form water.

Hydrogenous gas does not ſeem capable of acting on neutral ſalts; but its influence on ſaline ſubſtances in general has not yet been examined.

This gas is become a ſubſtance of much more conſequence than formerly, ſince it has been made uſe of to fill aeroſtatic machines: a diſcovery which we owe to Meſſrs Montgolfier. Its ſpecific levity, which is thirteen times greater than that of air, cauſes thoſe machines to riſe in the atmoſphere. It is more than probable that it performs an important part in all the phænomena of meteors; that there is a great quantity of it diffuſed through the atmoſphere; and that the electric ſpark kindles it, and cauſes it to produce water. Perhaps it is carried about in the winds as a kind of natural aeroſtatic.

Attempts have been made to ſubſtitute it in the room of other combuſtible matters for ſome of the purpoſes of life; to give light and heat, and to diſcharge fire-arms, &c. M. Volta has conſidered it in this laſt point of of view, and has propoſed ſeveral ways of making uſe of it. M. Nerete, in the *Journal de Phyſique* for January 1777, has given a deſcription of a chaffing-diſh with inflammable gas. M. Furſtenberger, a natural philoſopher at Bale, M. Brender, an ingenious mechanic of Augſburgh, and M. Ehrman Lecturer in Natural Philoſophy at Straſburgh, have contrived lamps which may be kindled at night by means of the electric ſpark. Laſtly, Artificial fires, affording a very agreeable ſpectacle, are made with glaſs tubes, variouſly bent, and pierced with a great many holes. Inflammable gas is introduced into theſe tubes from a bladder full of it, through a copper cock. When the bladder is preſſed, the inflammable gas paſſes into the tube, iſſues out thro' all the holes, and is kindled by a burning taper.

CHAP. IV.

Genus III. *Sulphur.*

SULPHUR is a combuſtible body; dry, very brittle, of a citron yellow colour, entirely without ſmell, except when it is burnt, and of a peculiar taſte, which is weak, though perceptible enough. When rubbed, it becomes electric. When a large piece of it is expoſed to a moderate but ſudden heat, as for inſtance, by being compreſſed in the hand, it crackles and breaks into pieces.

Sulphur abounds in nature; ſometimes it is found pure, and ſometimes in combination with other ſubſtances. It is our buſineſs here to ſpeak only of the former. The following are the varieties of pure ſulphur.

Varieties.

1. Tranſparent ſulphur in octohædral cryſtals, with two truncated pyramids. It is generally de-

Varieties.

depoſited by water on the ſurface of a calcareous ſpar. Cadiz ſulphur is of this kind.

2. Tranſparent ſulphur in irregular fragments. The ſulphur of Switzerland is in this ſtate.
3. Whitiſh pulverulent ſulphur, depoſited in ſiliceous gæodes. There are flints found in Franche-Compté, &c. full of ſulphur.
4. Pulverulent ſulphur, depoſited on the ſurface of mineral waters; ſuch as thoſe of Aix-la-Chapelle, of Enghien near Paris, &c.
5. Cryſtalline ſulphur that has been ſublimated; the cryſtals are tranſparent: it is found in places adjacent to volcanoes.
6. Pulverulent ſulphur ſublimated by volcanoes; its form is irregular, and it is often intermixed with ſoft ſtones, as may be obſerved at Solfatara, in the neighbourhood of Naples.
7. Sulphur in ſtalactites, formed by volcanic fires.

Beſides theſe ſeven varieties of pure mineral ſulphur, this ſubſtance is found in combination with various other matters. It is moſt frequently united with metals, which are then in the ſtate of *pyrites*, or metallic ſulphurs and ores. Sometimes it exiſts in combination with calcareous matters in the ſtate of earthy ſulphur or liver of ſulphur: fetid calcareous ſtones and ſwine-ſtone appear to be of this nature.

Recent diſcoveries extend the empire of this mineral ſtill farther. It ſeems to be daily formed in animal and vegetable matters beginning to putrefy. Though theſe ſpecies of ſulphur belong not properly to the mineral king-

kingdom; yet, to complete the natural hiſtory of this ſubſtance, we will ſubjoin them to the preceding varieties.

Varieties.

8. Sulphur in cryſtals, formed by the ſlow decompoſition of an accumulation of animal-matters. Such is the ſulphur found in the old lay-ſtalls, near the gate of St Anthony.
9. Pulverulent ſulphur, formed by vapours ariſing from animal matters in the ſtate of putrefaction; it is found on ſtable-walls, and in privies, &c.
10. Sulphur extracted from various vegetables, particularly from dock-root, from ſpirit of cochlearia, &c. For this diſcovery we are indebted to Meſſrs Baumé and Deyeux, members of the College of Pharmacy, and Lecturers in Chemiſtry, &c.
11. Sulphur obtained by M. Deyeux by an analyſis of animal matters, particularly of the white of an egg.
12. Sulphur obtained from horſe-dung. This combuſtible body has been found in horſe-dung at the inſtant of its emiſſion. Very probably future obſervation may diſcover it in many other animal matters.

But none of all theſe varieties of ſulphur is that which is uſed in the arts. That ſulphur is extracted by diſtillation from metallic compounds, of which it is a principle, and which are called *pyrites*. In Saxony and Bohemia, it is put into earthen tubes in ſmall pieces,

pieces, and thus placed on an oblong furnace. One end of the tube ſtands in the furnace, and the other paſſes into a ſquare veſſel of caſt-iron containing water. The ſulphur accumulates in this receiver; but it is very impure. To purify it, it is melted in an iron ladle; the earthy and the metallic parts are then precipitated. It is next poured into a copper boiler, in which it is farther purified by depoſiting other extraneous matters. After being kept here in fuſion for ſome time, it is poured into cylindrical wooden moulds, which give it the form in which we uſually ſee it in commerce. The precipitate which ſubſides to the bottom of the boiler while it is in fuſion, is grey and very impure. It is very improperly called *quick ſulphur*. In other places, as at Rammerlſberg for inſtance, ſulphur is extracted from pyrites by a ſimpler proceſs. The ſulphur of maſſes of pyrites roaſted in the open air, is taken off in ladles, and purified by a ſubſequent fuſion.

Sulphur ſuffers no alteration from the contact of light. When heated in cloſe veſſels, it becomes ſoft, and melts; and when afterwards cooled, it generally aſſumes a red, a brown, or a greeniſh colour, and a needle form. The proceſs by which M. Rouelle cryſtallized it, was ſuffering the ſurface to congeal, and afterwards pouring off the fluid beneath: the under ſurface of the cruſt then exhibited the ſulphur in needles croſſing each other in various directions.

When melted ſulphur is gently heated, it volatilizes in ſmall pulverulent parcels of a citron yellow, which are called *flowers of ſulphur*. This operation is employed ſucceſsfully to purify ſulphur, though it is the pureſt part which is volatilized. For performing this operation, common ſulphur in powder is put into an earthen cucurbite, which is fitted with earthen pots inſerted one in another, and known by the name of *aludels*. The uppermoſt of theſe pots is terminated by a reverſed funnel; the opening of which forms a ſlight communication between the interior part of the cucurbite and the air. The cucurbite is then heated till the ſulphur become liquid; which at that degree of heat is ſublimated, and fixed on the ſides of the aludels.

Flowers of ſulphur, when prepared in the great way, often contain a little ſulphuric acid, which is formed by the combuſtion of a ſmall quantity of the ſulphur, in conſequence of the veſſel's containing a ſmall portion of air. They may be entirely purified by waſhing them. The ſulphur made uſe of in medicine, and in nice chemical experiments, ſhould be prepared in this manner.

When ſulphur is heated in ſuch a way that air has acceſs to it, it kindles and burns with a blue flame as ſoon as the heat cauſes it to melt, if the heat to which it is expoſed be but inconſiderable; but when expoſed to a ſtrong heat, it gives a lively white flame. In the firſt of theſe inſtances it diffuſes a ſuffocating ſmell; and by collecting the vapours which exhale from it, we obtain a portion of very ſtrong ſulphureous acid. When it burns rapidly it has has no ſmell, and the reſidue is not ſulphureous, but ſulphuric acid. Stahl, who thought ſulphur to be a compound of this acid with phlogiſton, imagined, that when burnt it loſt its inflammable principle, and was of conſequence reduced to an acid. He has collected ſuch a number of facts in ſupport of his opinion, as could not but prevail with ſucceeding chemiſts to adopt it. But ſince chemiſts have begun to attend to the influence of air in combuſtion (a circumſtance to which Stahl appears to have paid ſcarce any attention), ſeveral of them, ſtruck with the difficulty which has hitherto been found in all attempts to prove the exiſtence of phlogiſton, and with the facility with which all objections againſt that doctrine may be anſwered by means of the late diſcoveries concerning the nature of air, have adopted an opinion directly oppoſite to Stahl's concerning the nature and the combuſtion of ſulphur.

The following are the facts on which this new opinion is founded. Hales obſerved, that ſulphur abſorbs a great quantity of air when it burns. M. Lavoiſier has ſhown that ſulphur is ſubject to the ſame laws with other combuſtible bodies: That is, 1. It cannot burn, except vital air have acceſs to it. 2. During its combuſtion, it abſorbs the pureſt part of that air. 3. That part of atmoſpheric air which remains after it has contributed to the combuſtion of ſulphur, can no longer ſerve the ſame purpoſe. 4. The ſulphuric acid produced by the combuſtion of ſulphur is equal in weight not only to the quantity of ſulphur, but alſo to the portion of air that has been conſumed. 5. Conſequently ſulphur muſt combine with the baſe of pure air, or oxigene, in order to form ſulphuric acid. That acid is therefore a compound of oxigene with ſulphur; and the laſt of theſe is not a compound body, but one of the principles of the ſulphuric acid. It forms the acid by combining with the baſe of vital air or oxigene; and this combination takes place when it is expoſed to combuſtion. Heat is neceſſary to make it burn; for, by dividing it, and deſtroying its aggregation, it promotes its combination with oxigene. When once burnt, or combined with oxigene, it is no longer ſuſceptible of inflammation, but becomes an incombuſtible body.

It abſorbs various quantities of oxigene, and becomes more or leſs acid, according to the manner in which it is burnt. Such is the theory of the difference between the ſlow and the rapid combuſtion of ſulphur, and between the ſulphureous and the ſulphuric acids, which are produced by theſe combuſtions. Stahl thought, that when ſulphur burnt ſlowly, it did not loſe all its phlogiſton; and that the ſulphuric acid was odorous and volatile in conſequence of its retaining part of it. It is now experimentally proved, that when ſulphur burns ſlowly, it does not abſorb the full quantity of oxigene, with which it is capable of uniting; but when it burns rapidly, it abſorbs as much of that principle as is neceſſary for the formation of the ſulphuric acid. The ſulphureous acid, in combination with alkaline matters, paſſes into ſulphuric acid by abſorbing gradually the baſe of vital air from the atmoſphere.

This theory ſerves equally to explain what happens when ſulphur is formed by the combination of the ſulphuric acid with certain combuſtible matters, as in the inſtances we have already mentioned, with ſulphate of potaſh and of ſoda, ammoniacal, calcareous, magneſian, aluminous, and barytic ſulphate, when heated with coal. The combuſtible body ſeizes the oxigene contained in the ſulphuric acid, and leaves only the ſulphur, which is its other principle. Whenever, therefore, the ſulphuric acid is converted into ſulphur by a combuſtible body, the latter is conſtantly reduced to the ſtate of a burnt body, as we ſhall have occaſion to ſee in the hiſtory of ſeveral of the metals. On this account a large quantity of carbonic acid is obtained, when ſulphur is artificially produced, as the oxigene of the ſulphuric acid is united with the pure carbonaceous

matter.

matter. The reader may recollect, that the exiſtence of oxigene, or the baſe of pure air in the ſulphuric acid, is eaſily demonſtrable. Various attempts have been made to determine by experiment the proportions in which oxigene and ſulphur are combined in the ſulphuric acid, in the ſame manner as the proportion of the nitric, the carbonic, and the phoſphoric acids have been determined.

Sulphur is neither liable to any alteration from air nor ſoluble in water. If, after being kept in fuſion till it become thick, it be poured into water, it then becomes red, and retains a certain degree of ſoftneſs, ſo that it may be kneaded in the hand; but in a few days it loſes theſe properties. Water dropped on ſulphur does not ſeem to be decompoſed, nor contribute to the combuſtion of the ſulphur; from which it appears, that the baſe of vital air or oxigene has a greater affinity with hydrogene than with ſulphur. This aſſertion is confirmed by the manner in which hydrogenous gas acts on the ſulphuric acid, for it robs it of its oxigene.

Sulphur does not act at all on ſiliceous earth; it combines with aluminous earth, but not without great difficulty. This earth, however, when it is very much attenuated, appears to reduce it to the ſtate of an hepar or fetid ſulphure, as may be obſerved in the preparation of pyrophorus.

A compound of ſulphur with alkaline matters is generally called *alkaline ſulphure*, *hepar*, or *liver of ſulphur*. This compound is generally of a lighter or a deeper brown colour, like the liver of animals: vital air decompoſes it; water diſſolves it, cauſing it to give out a fetid ſmell; the acids precipitate the ſulphur, extricating from it a peculiar gas, which was at firſt named *hepatic gas;* but to which, in alluſion to its nature,

ture, we now give the name of *ſulphurated hydrogenous gas*. There are ſix ſpecies of alkaline ſulphures produced by barytes, magneſia, lime, the two fixed alkalis, and ammoniac or volatile alkali. We may examine the properties of each of theſe by itſelf.

Pure barytes does not act ſtrongly on ſulphur, when they are heated together in water; the product is a weak ſulphurated or hepatic liquor: but in the dry way, the two bodies enter into a much more intimate combination. Therefore, when a mixture, conſiſting of eight parts of barytic ſulphate in powder with one part of coal, is expoſed in a crucible to a ſtrong heat, an incoherent maſs is obtained without fuſion, which readily diſſolves in warm water, and has the ſmell and all the other characteriſtics of an hepar. The ſolution is of an orange or golden yellow colour. I have diſcovered that it cryſtallizes by cooling. Barytic ſulphur in cryſtals is of a yellowiſh white colour: when expoſed to the air, it attracts moiſture from it, aſſumes a deeper colour, and is decompoſed; for the ſulphur is precipitated, and barytic ſulphate formed. This ſulphur, when precipitated by acids, gives out an elaſtic fluid, known by the name of *ſulphurated hydrogenous gas*, which has been mentioned above, and the peculiar properties of which we will afterwards examine. When barytic ſulphate is precipitated by the ſulphuric acid, the precipitate is found to conſiſt of both ſulphur and barytic ſulphate; but when the nitric, or the muriatic acid is employed, the barytic nitrate, or muriate remains in ſolution, and only the ſulphur ſubſides.

Sulphur combines with pure magneſia with the help of heat. The neutral ſalt, which we call *carbonate of magneſia*, is commonly uſed for this combination, as diſſolving moſt readily in water. A ſmall portion of magneſian carbonate, with an equal quantity of flowers of ſulphur, is put into a bottle full of diſtilled water. This veſſel, entirely emptied of air, and cloſely ſtopped, is expoſed for ſeveral hours to the heat of a balneum-mariæ; the water is then filtered; it has the fetid ſmell of rotten eggs; it communicates an high colour to ſolutions of metals; it gives by ſpontaneous evaporation ſmall cryſtalline needles; in a word, it is a genuine magneſian ſulphure. The magneſia may be precipitated by one of the fixed alkalis,—which have a greater affinity than it with ſulphur. The acids ſeparate the ſulphur in the form of a white powder; from which its exiſtence in this mixture is certainly known. Such was the liver of ſulphur which M. le Roi, phyſician at Montpelier diſſolved in pure water, in order to form an imitation of ſulphureous mineral waters. But it is now known, that ſcarce any of theſe waters contains genuine ſulphure; they are mineralized by ſulphurated hydrogenous gas.

Lime unites with ſulphur with much more rapidity and eagerneſs than either of the ſalino-terreous ſubſtances. When a little water is poured on a mixture of quicklime with ſulphur in powder, the heat diſengaged by the action of the water on the lime occaſions a combination between the lime and the ſulphur. If more water be added, the mixture aſſumes a reddiſh colour, and exhales a fetid odour. It retains in ſolution the ſulphur in combination with the lime. It is difficult to prepare this calcareous ſulphure in any other way but the humid. When the lime is not very quick, and does not produce much heat on coming into contact with water, it is often found neceſſary to aſſiſt the combination by a moderate fire. This compound is of a lighter or a deeper red, according to the cauſticity of the lime. I have obſerved, that when the ſolution is much concentrated, it depoſites, by cooling, a layer of ſmall needle cryſtals, of an orange yellow, arranged in tufts, which to me appeared to be compreſſed tetrahædral priſms, terminating in dihædral ſummits. In the air theſe cryſtals gradually loſe their colour, and become white and opaque, without ſuffering any alteration of form. Calcareous ſulphure, moiſtened with a little water, and diſtilled in a pneumato-chemical machine, is decompoſed in part, and affords a large proportion of ſulphurated hydrogenous gas. If evaporated to dryneſs, and calcined in a crucible till it ceaſe to fume, what remains after the operation is calcareous ſulphate formed by lime and the ſulphuric acid produced by the ſlow combuſtion of the ſulphur. Calcareous ſulphure is very ſoon altered by air; as its gas flies off it loſes its ſmell and colour. When diſſolved in a large quantity of water, it ſuffers the ſame alteration; eſpecially if it be ſhaken, as M. Monnet has obſerved in his Treatiſe on Mineral Waters: what remains after theſe alterations is calcareous ſulphate. If preſerved in bottles, partly empty, it depoſites a blackiſh cruſt on the ſides of the bottles, and cruſts or pellicles are from time to time formed, which ſink to the bottom of the liquor. If the veſſel containing it be cloſely ſtopped, it remains long unaltered, as I have often obſerved in my own laboratory. I know of ſome of this preparation which was made up 15 years ago, and which ſtill retains its colour and ſmell, and affords a copious precipitate when acids are applied to it. Calcareous ſulphure is decompoſed by the pure fixed alkalis, which have a greater affinity with ſulphur than ſulphur has with lime. Acids precipitate the ſulphur in the form of a very fine white powder, which has received the name of *magiſter of ſulphur*. The carbonic acid effects this precipitation, as well as the reſt of the acids. The manner in which neutral ſalts act on calcareous ſulphure is unknown.

The two fixed alkalis, in a pure or cauſtic ſtate, act in a very remarkable manner on ſulphur. They form with it thoſe ſulphures which are moſt permanent and leaſt liable to decompoſition. I have diſcovered that the fixed alkalis when dry and very cauſtic, act upon ſulphur even cold. All that is requiſite to promote this phænomenon is to triturate ſolid potaſh or ſoda in a mortar with powdered ſulphur. The mixture becomes ſoft, aſſumes a yellow colour, exhales a fetid odour, and forms a ſulphure. But when it is diſſolved in water, the ſolution is only of a pale yellow colour, and does not contain ſo great a quantity of ſulphur as the ſame ſulphure prepared with heat. Alkaline ſulphure is prepared in two ways in the laboratory,—the dry, and the humid way. The following are the particulars of the firſt proceſs: Equal parts of pure and ſolid potaſh or ſoda and powdered ſulphur are put into a crucible; heat is then applied till the mixture be entirely heated: when in fuſion, it is poured on a plain marble ſurface; and when cooled, it diſplays a deep red colour, like the liver of an animal. M. Gengembre, who has read before the academy an account of ſome very valuable experiments on ſulphurated hydrogenous gas, has made an important obſervation on alkaline ſulphure prepared in the dry way. It is, that this compound is not at all fetid, and exhales no ſulphurated hydrogenous gas while it continues dry. Till it be diſſolved in water, or attract moiſture from the atmoſphere, it never gives out any ſmell; from which

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circumſtance it appears, that the diſengagement of the fetid gas is effected by water, as we ſhall afterwards more particularly explain. The two fixed alkalis, when pure and cauſtic, act preciſely in the ſame manner on ſulphur, diſſolving it likewiſe in the dry way. Theſe combinations of the cauſtic alkalis with ſulphur have as yet been but very little examined; alkaline ſulphure has been almoſt always compoſed with fixed alkali, ſaturated with the carbonic acid. There are, however, conſiderable differences between theſe two ſulphures. Firſt, thoſe which are made up with effervescent fixed alkali require more time to be taken up in the preparation; for fixed alkali is leſs active in this ſtate than when pure. But the moſt important difference which we have had occaſion to obſerve, as ſubſiſting between ſulphures made up with cauſtic fixed alkali and thoſe made up with effervescent fixed alkali in the dry way, is the comparative ſtate of their ſaturation. The former are more fetid, and browner, when diſſolved, and the gas which they afford is much more inflammable than that given out by the others. The latter are of a paler colour, which is often a greeniſh grey; their ſmell is fainter, and their compoſition leſs laſting. It appears that the fixed alkalis retain a portion of carbonic acid when in union with ſulphur; for the gas of theſe ſulphures, in which ſulphur is united with alkaline carbonate, is not inflammable till after being waſhed in lime-water, which carries off the acid. In the preſence of this acid therefore, and in its power of enfeebling the cauſtic qualities of alkali, we find the cauſe of thoſe appearances which diſtinguiſh cauſtic ſulphures from ſuch as are not cauſtic.

Solid alkaline ſulphure, compoſed with either of the cauſtic fixed alkalis, is extremely fuſible: air decompoſes it like calcareous ſulphure. When heated in cloſe veſſels, after being moiſtened with a little water, it affords a large proportion of ſulphurated hydrogenous gas. After being melted, it may be cryſtallized by cooling; but its cryſtallized form has not yet been well deſcribed. While hot and dry, it is of a brown colour; in proportion as it cools, and attracts moiſture from the air, it loſes that colour, and becomes paler; in a ſhort time air cauſes it to aſſume a greeniſh yellow colour; it is again diſſolved into a liquid, and becomes, after ſome time, ſulphate of potaſh or of ſoda. It diſſolves eaſily in water; and immediately begins to exhale a peculiar fetid odour. The odorous gas, which before had no exiſtence, is now formed by the re-action of the water. This ſolution has a deep red, or a green colour, according as the alkaline ſulphur is newly prepared or old. Alkaline liver of ſulphur or ſulphure prepared in the humid way, by heating in a matraſs cauſtic fixed alkali diſſolved in water, with a quantity of ſulphur in powder equal to half its weight, exhibits the ſame properties as this ſolution; and we may give the hiſtory of both at once under the common name of *liquid alkaline ſulphure.*

Liquid alkaline ſulphure, when highly concentrated, depoſites by cooling irregular needles. It is liable to decompoſition by the action of heat; when diſtilled in a pneumato-chemical machine, it gives ſulphurated hydrogenous gas. Air likewiſe decompoſes it; and it is then covered with pellicles, and depoſites ſulphur, and becomes turbid. Bergman and Scheele have proved this decompoſition to be owing to the vital air diffuſed through the atmoſphere. In fact, when a little liquid alkaline ſulphur is put into a bell-glaſs containing vital air, the oxigene is entirely abſorbed, and the vital air de-

decompoſed. Scheele has even propoſed this as an eudiometer; and it is now acknowledged to be one of the beſt.

Neither the earths nor the ſalino-terreous ſubſtances act upon liquid alkaline ſulphure when it is very pure: but when it has been prepared with carbonate of potaſh or ſoda, lime-water renders it turbid. The acids decompoſe it, by combining with the alkali, and precipitate the ſulphur in the form of a fine white powder. The nitric acid, according to M. Prouſt, produces a detonation, when it is poured on ſolid alkaline ſulphure. When any large quantity of the oxigenated muriatic acid is poured on a ſolution of alkaline ſulphure, it does not produce any precipitate, or at leaſt but a very trifling one; becauſe it diſſolves the ſulphur again, in conſequence of its oxigene being nearly free, and uniting ſo rapidly with that combuſtible body ſo as to convert it into ſulphuric acid. The certainty of this fact may be farther proved by pouring a portion of barytic muriate into the mixture; a copious precipitate of barytic ſulphate is then produced. All the acids, when they decompoſe this ſulphure, cauſe it to give out a gas, which may be collected into a pneumato-chemical machine, and is worthy of a particular examination.

In order to obtain this gas, an acid muſt be poured on alkaline ſulphure in powder: a lively effervеſcence is then produced, which would not take place in the ſame manner if the acid were poured into a ſolution of the alkaline ſulphure. This phænomenon, which has not yet ſufficiently engaged the attention of chemiſts, depends upon two circumſtances. 1. Solid alkaline ſulphure does not contain hepatic gas or ſulphurated hydrogene ready formed, as has been obſerved by M. Gen-

Gengembre; and when an acid is poured upon it, the water which holds the acid in ſolution contributes to the formation of hepatic gas. As a large quantity of this gas is inſtantly produced, finding no body to retain it in ſolution, it flies off, occaſioning at the ſame time a conſiderable effervefcence; ſo that if the experiment be made in a tubulated flaſk, with its tube inſerted into a bell-glaſs filled with water, the elaſtic fluid may be eaſily collected. 2. The ſolution of alkaline ſulphure contains a good deal of gas ready formed; but part of it has been already diſengaged, when the ſulphur was diſſolved; and when an acid is added, the portion of gas which it diſengages is gradually diſſolved in the water; ſo that it produces no ſenſible effervefcence, or at leaſt a very inconſiderable effervefcence, and no great quantity of gas can be collected.

Sulphurated hydrogenous gas, which is the ſame in all earthy or alkaline ſulphures, and is always an evidence of their exiſtence, has been long known by its fetid ſmell and its action on metals and metallic oxides, eſpecially thoſe of lead and biſmuth, which it very ſoon blackens. Its fetor is quite inſufferable; it is inſtantly fatal to animals; it communicates a green colour to ſyrup of violets, and burns with a light blue flame. If ſet on fire in a large bell-glaſs, very ſuitable for the purpoſe, it clouds the ſides of the veſſel, as it burns, with a depoſite, which is certainly ſulphur. Vital air decompoſes this gas; whenever it comes into contact with atmoſpheric air, there is a portion of ſulphur ſeparated from it. For this reaſon, the ſulphureous waters, mineralized by it, do not contain genuine alkaline ſulphur; though ſulphur be ſeen ſwimming on their ſurfaces, and found depoſited in the arches or baſons in which

which it is contained: the waters of Aix-la-Chapelle, Enghein, &c. afford inſtances of this. The ſulphureous depoſites which may be obſerved in flaſks containing ſolutions of alkaline ſulphur, are likewiſe owing to this decompoſition of ſulphurated hydrogenous gas by vital air. Bergman attributes this inſtance of decompoſition to the ſtrong affinity between pure air and phlogiſton. Hepatic gas he conſiders as a combination of ſulphur, phlogiſton, and the matter of heat. When one of theſe principles is ſeparated, the other two can no longer remain in union. M. Gengembre, ſtruck with this phænomenon, that ſulphurs neither contain nor exhale ſulphurated hydrogenous gas, except when diſſolved in water, or made up in the humid way, thinks, that the fluid may poſſibly contribute to its formation by undergoing a decompoſition,—that while its vital air unites with one part of the ſulphur, its hydrogene, which is at the ſame time diſengaged, diſſolves likewiſe a ſmall portion,—and that this ſolution conſtitutes ſulphurated hydrogenous gas. He imitated the formation of this gas by melting ſulphur above mercury, under a bell-glaſs filled with hydrogenous gas, by the action of the rays of the ſun collected in a lens nine inches in diameter. The ſulphur was partly diſſolved, and communicated to the gas all the characteriſtic properties of hepatic gas. But as ſulphur by itſelf does not decompoſe water, and as oxigene has a greater affinity with hydrogene than with ſulphur, M. Gengembre thinks, that alkali promotes the decompoſition of water by ſulphur, in conſequence of its tendency to unite with the body produced by the combination of ſulphur with oxigene; that is, with the ſulphuric acid. In ſupport of this theory, M. Gengembre obſerves, that the more power acids have to retain their oxigene, ſo ſo much the more ſulphurated hydrogenous gas do they diſengage from alkaline ſulphures, becauſe the water is then decompoſed rather than the acid. Such, in his opinion, is the reaſon why the muriatic acid affords one half more of this gas than the nitric acid ; as has been remarked by Meſſrs Scheele and Sennebier. Laſtly, Scheele's proceſs for obtaining a conſiderable quantity of ſulphurated hydrogenous gas, by diſſolving, in a dilution of the ſulphuric acid in water, an artificial pyrites, conſiſting of three parts of iron and one of ſulphur, ſtrongly confirms this opinion. It appears then, that vital air decompoſes ſulphurated hydrogenous gas by combining with the hydrogene to form water, while the ſulphur is precipitated.

Water diſſolves ſulphurated hydrogenous gas readily enough ; and the ſolution is a perfect imitation of mineral waters.

The earths and the alkaline ſubſtances ſeem to have no power of action on this gas.

The ſulphuric acid does not decompoſe this gas ; but the ſulphureous acid robs it of its ſulphur, becauſe the oxigene of this gas being partly in a free ſtate, unites more readily with the hydrogene of the gas.

The red nitrous acid in which the oxigene is but very feebly retained, acts with great ſtrength in decompoſing this gas, and precipitates the ſulphur. This acid is very happily employed to determine whether ſulphur exiſts in mineral waters.

Alkaline ſulphure decompoſes earthy neutral ſalts as well as ſolutions of metals ; as we ſhall hereafter ſee.

Liquid ammoniac has ſcarce any power of acting on concrete ſulphur, Yet Boerhaave aſſerts, that, when that liquor ſtands long over flowers of ſulphur, it tinges them with a golden colour, To make theſe two bodies enter into combination, one of them muſt be in the ſtate of vapour when they are brought into contact. For this purpoſe, a mixture, conſiſting of equal parts of quick-lime and ammoniacal muriate, and half a part of ſulphur, is ſubmitted to diſtillation. In this proceſs, which muſt be carefully conducted, a reddiſh yellow liquor is obtained, of a pungent and fetid alkaline ſmell; in a word, a genuine ammoniacal ſulphur, which exhales a whitiſh ſmoke when brought into contact with air, from which property it has received the name of *Boyle's fuming liquor.* Heat decompoſes this ammoniacal ſulphure: in a certain ſpace of time, a great many ſmall *iriſed* needles, a line or two in length, are formed in it: they appear to be concrete ammoniacal ſulphure in cryſtals. A thin, blackiſh, and often golden cruſt is formed on the ſides of the veſſels. Lime and fixed alkali decompoſe the fuming liquor; the acids too precipitate the ſulphur with great facility, and diſengage ſulphurated hydrogenous gas in an highly inflammable ſtate. From theſe decompoſitions there reſult different ammoniacal ſalts, according to the nature of the acid employed. A miſtake which I made in one of my courſes, led me to obſerve a fact which deſerves to be laid before the reader. Wiſhing to precipitate Boyle's fuming liquor, I took up a flaſk ſtanding on my table, and inſcribed *ſpirit of vitriol:* it was almoſt empty, which hindered me from obſerving that what it contained was ſulphuric acid highly concentrated. I poured a few drops of it on ammoniacal ſulphure; a rapid motion was inſtantly excited, a very thick white cloud aroſe out of the veſſel containing the mixture, and it produced a report like that of a large gun; the liquor ſpringing out of the glaſs, was carried to a conſiderable

ſiderable diſtance; the glaſs became very hot, and burſt into pieces; on ſome of its fragments there remained a little ſulphur in a thick yellowiſh magma. I repeated this experiment many times with proper precautions, and ſtill found it attended with the ſame reſult; a violent motion was produced, and the mixture was carried to a diſtance. But theſe ſeveral phænomena ſucceed each other ſo rapidly, that it is impoſſible to avoid confounding them. I have not found the moſt fuming nitrous acid to produce the ſame effects on ammoniacal ſulphure that had been prepared ſome time before. The mixture was violently agitated; a conſiderable degree of heat and ebullition was produced, a white cloud of ammoniacal nitrate iſſued from the veſſel; but there was no exploſion, ſuch as the concentrated ſulphuric acid produces on the ſame hepatic liquor, however long it may have been prepared. M. Prouſt affirms, that when nitrous acid is poured on two drams of Boyle's fuming liquor, it produces as violent a ſhock as two grains of fulminating powder could produce. But this phænomenon does not take place unleſs the ammoniacal ſulphure have been recently prepared.

Ammoniacal carbonate likewiſe combines with ſulphur. When theſe two bodies, both in a vaporous ſtate, come into contact, they combine to form a concrete ammoniacal ſulphure. It is obtained by diſtilling a mixture conſiſting of equal parts of carbonate of potaſh or lime and ammoniacal muriate, together with half a part of ſulphur. This ſulphure is of a brown red colour, and in cryſtals; when diſſolved, it exhales ſome white vapour: heat decompoſes it; air alters it, and deſtroys its colour. It is liable to decompoſition by acids, &c. The ſulphurated hydrogeneous gas which

which it affords, contains carbonic acid. It is to be obſerved, that this concrete ammoniacal ſulphure is nothing but ammoniacal carbonate, contaminated with a little of Boyle's liquor; for it is impoſſible for ammoniac to hold ſulphur in ſolution when combined with the carbonic acid, as this acid readily precipitates the ſulphur of ammoniacal ſulphure.

Several of the acids have a ſtronger or a weaker power of action on ſulphur. If ſulphuric acid be boiled on ſulphur, the acid acquires an amber colour, and a ſulphureous ſmell; the ſulphur melts and ſwims like oil: when cooled, it is formed into concrete globules of a lighter or a deeper green, according as the ſulphur has been for a longer or a ſhorter time in ſolution. A ſmall portion of the ſulphur remains diſſolved in the acid, but may be precipitated, as M. Baumé has ſhown, by means of alkali. This experiment, and ſeveral others of the ſame nature, have led M. Berthollet to think that the ſulphureous is nothing but the ſulphuric acid, holding ſulphur in ſolution. And his opinion actually agrees with all the modern experiments which have any relation to this matter; for they concur in ſhowing, that the ſulphureous differs from the ſulphuric acid only by containing a greater proportion of ſulphur.

The flaming red nitrous acid acts powerfully on ſulphur. M. Prouſt firſt obſerved, that when red nitrous acid is poured on melted ſulphur, it occaſions detonation and inflammation. M. Chaptal has made a ſeries of experiments on this matter. By diſtilling nitrous acid on ſulphur, he diſſolved it ſo as to produce ſulphuric acid: and it appears therefore, that oxigene has a greater affinity with ſulphur than with azote or radical nitre.

The common muriatic acid effects no alteration on this combuſtible body; but the oxigenated muriatic acid acts upon it with more energy. But our experimental knowledge of this fact is ſo imperfect that it is unneceſſary for us to inſiſt longer upon it here.

Sulphuric neutral ſalts are incapable of acting on ſulphur; but nitric ſalts cauſe it to burn rapidly, even in cloſe veſſels. The theory of this important phænomenon is very ſimple. Nitre decompoſed by heat affords a very conſiderable quantity of vital air: ſulphur is a very combuſtible ſubſtance, or, which is the ſame thing, has a ſtrong tendency to combine with oxigene; nitre affords the principle neceſſary to its combuſtion; ſo that the atmoſpheric air is no longer requiſite to make it flame. The products obtained by this operation are very different, according as the nitre and the ſulphur are employed in different proportions. If a mixture conſiſting of eight parts of ſulphur and one of nitre be ſet on fire in a cloſe veſſel, the ſulphur burns with a very lively white flame, and is converted into ſulphuric acid. This method has been uſed for theſe twenty years in England and Holland for preparing this acid, which was formerly obtained from *vitriol.* In England, large glaſs balloons, with very large necks, holding each four or five hundred pints, were the veſſels firſt uſed in making this preparation. A number of theſe were arranged together on a bed of ſand; they were diſpoſed in two lines at a proper diſtance from each other, ſo that a perſon might conveniently go and come between them: a few pounds of water were put in each of the veſſels, and a ſtone pot was introduced into the neck of each, having upon it a red-hot ladle of caſt iron with a long handle. Into this ladle, by means of another ladle of white iron, there was put a mixture of ſulphur and nitre in due proportions: after which

which the aperture of the balloon was ſtopped with a piece of wood. The heat of the ladle kindled the mixture; the ſulphur was burnt with the vital air of the nitre; and after the combuſtion was effected, the ladle was taken out, and the vapours ſuffered to condenſe. The ſame operation was repeated on all the balloons of the two rows; ſo that when the operator returned to the firſt balloon, he found the vapours entirely condenſed, and might proceed to burn in it a new quantity of the mixture. When the water was ſufficiently ſaturated with the acid, it was poured out into glaſs retorts: the water was then ſeparated by diſtillation, and the acid concentrated, till a phial containing an ounce of diſtilled water would receive a quantity of it weighing one ounce ſeven drams and an half. Such was the Engliſh proceſs for preparing *oil of vitriol*, or concentrated ſulphuric acid. But it was attended with great expence, on account of the high price and the brittleneſs of the balloons. A few years ago, there was a method contrived of burning ſulphur on a ſort of gridirons in large apartments lined all over with lead; the ſulphuric acid, as it condenſed, is conveyed by gutters into a reſervoir, and afterwards concentrated by the action of fire. This is the proceſs uſed in the manufactory of Javelle near Paris; the eſtabliſhment of which cannot but be of advantage to the arts. It is of conſequence to obſerve, that the ſulphuric acid thus obtained is always in union with a little ſulphur and ſulphate of potaſh; it is likewiſe found to contain a little aluminous ſulphate and ſome ſulphate of lead. But theſe ſubſtances are mixed with it in ſo inconſiderable a proportion, that their effects are of no conſequence in moſt of the occaſions on which this ſaline matter is employed: beſides, it may be eaſily purified, by diſtilling it to dryneſs, ſo as to be ſuitable enough even for the niceſt chemical experiments.

If inſtead of an eighth part of nitre, we burn equal parts of ſulphur and of nitre; then, inſtead of ſulphuric acid in a free ſtate, the product obtained is ſulphate of potaſh, formed by the combination of that acid with the fixed alkaline baſe of nitre. Salt obtained in this manner was called *Glaſer's polychreſt ſalt.* It was prepared by caſting into a red-hot crucible, a mixture conſiſting of equal parts of ſulphur and nitre. The reſidue was diſſolved in water, and the ſolution evaporated to a pellicle; it was then filtered, and afforded by cooling cryſtals of genuine ſulphate of potaſh; which received their particular denomination, becauſe Glaſer was the firſt who made known this mode of preparation: but the ſalt thus obtained differs in no reſpect from common ſulphate of potaſh.

Gun-powder, the terrible effects of which are owing to its ſtrong tendency to combuſtion, is a mixture of ſulphur and nitre with charcoal. Moſt part of it is nitre; the proportion of charcoal is much leſs; and it contains but a very trifling quantity of ſulphur. An hundred pounds of gun-powder from Eſſone near Corbeil, contain ſeventy-five pounds of nitre, nine and an half of ſulphur, and fifteen of charcoal. This mixture is triturated for ten or twelve hours in wooden mortars, with peſtles of the ſame ſubſtance; a very ſmall portion of water is from time to time poured upon it. When the fluid is almoſt wholly evaporated by the trituration, ſo that the powder may be put on a ſtone-plate without wetting it, it is then taken away to be granulated. The granulation of powder is accompliſhed by paſſing it thro' ſeveral ſkin-ſieves, which are moved backwards and forwards in a

ſtraight

ſtraight line. The holes of thoſe ſieves are of various ſizes, the ſmalleſt being thoſe which form grains of gun-powder. The granulated powder is next ſifted to ſeparate the duſt: it is then carried to the houſe for drying it; which is a ſhed expoſed to the ſouth, and receiving the rays of the ſun through glaſs windows. Cannon-powder receives no farther preparation. Muſket-powder is glazed, that it may not ſoil the hands. To perform this operation, a caſk with a ſquare axis paſſing through it, which communicates with a water wheel, is half filled with powder. The motion of the caſk occaſions a continued friction, by which the grains of the powder are worn ſmooth. The powder thus glazed, is paſſed through a ſieve to ſeparate the duſt; and afterwards through another ſieve, which divides the grains into two kinds of muſket-powder, a finer and a coarſer. M. Baumé, in conjunction with the Chevalier d'Arcy, has made a ſeries of laborious experiments on the preparation of powder, on the different degrees of the force of this compound ſubſtance, according as its ingredients are mixed in different proportions, and on its analyſis. In the courſe of theſe, the gentlemen have made a variety of diſcoveries, of which we ſhall here mention only the moſt important, and ſuch as have a more immediate connection with the theory of chemiſtry. 1. No good powder can be made without ſulphur, though this mode of preparing it has been attempted by ſeveral people: ſulphur increaſes its ſtrength amazingly. 2. All coals, whether light or ponderous, except ſuch as are formed by the combuſtion of animal matters, are equally proper for this compoſition. 3. Coal is one of the moſt eſſential parts of powder; for a mixture of ſulphur and nitre is far from producing the ſame effects as when coal is added.

4. The goodneſs of powder depends entirely on the ſubſtances of which it is compoſed being duly proportioned, and the trituration being continued till the matter riſe in duſt all around the mortar. 5. The effects of powder are much more powerful when it is ſimply dried that when it is granulated. The moiſture neceſſary to make powder aſſume a granulated form cryſtallizes the nitre, which is then ſeparated from the other ſubſtances; and it may be perceived in the interior part of the grains, if they be cut aſunder, and examined through a magnifier. 6. Glazed or muſket-powder has leſs ſtrength than cannon-powder, which has not undergone the ſame operation; becauſe the particles of the former are more cloſely united, and of conſequence not ſo inflammable.

As to the analyſis of powder, M. Baumé effected that in a very ſimple way. His proceſs conſiſts in waſhing cannon-powder, after it has been ſufficiently pulverized, with diſtilled water, and evaporating the water; by this firſt operation the nitre is obtained; the reſidue is the charcoal and the ſulphur. The ſulphur ſeems to be in part fixed by the coal, ſo that it cannot be entirely ſeparated by ſublimation. M. Baumé employed a faint heat, capable of burning ſulphur but not charcoal. The charcoal, however, always retains a little ſulphur; for as that chemiſt has obſerved, it exhales a ſulphureous ſmell till it be entirely reduced to aſhes. He eſtimates the ſulphur retained by the charcoal at one twenty-fourth part of the total weight. The powder may likewiſe be diſſolved, by expoſing it entire and unwaſhen to the action of a moderate fire. This fact was known to Mr Robins, who gives an account in his Treatiſe on Gunnery, written in Engliſh. Poachers are ſaid to be in the practice of depriving powder of its ſulphur by heating it on warm aſhes in a tin plate. They are perſuaded from experience, that powder thus deprived of its ſulphur, expels the ſhot to a farther diſtance, and is leaſt injurious to the fire-arms.

Chemiſts and natural philoſophers have entertained various opinions concerning the violent effects of gunpowder. Some have attributed them to the reduction of the water to vapour ; others to the ſudden dilatation of the air. M. Baumé thinks that they are owing to the formation of nitrous ſulphur at the moment of combuſtion. In my opinion this phænomenon may be very eaſily explained, with the help of the modern diſcoveries. In order to underſtand my theory, the reader muſt firſt take notice, that whatever paſſes during the inflammation of powder is owing to its extreme combuſtibility. But both ſulphur and charcoal, when they have undergone a conſiderable comminution, are very inflammable bodies. The intimate mixture which has ſuch an influence on the ſtrength of powder, according the valuable experiments of M. Baumé, is the ſole cauſe of the effects which it produces. The nitre is equally diſtributed through all the integrant parts of theſe extremely combuſtible bodies. As the quantity of the nitre is much more conſiderable than that of either of them, each particle of the ſulphur and the charcoal is incloſed, and as it were incruſted in nitre. Each of the two combuſtible bodies has of conſequence much more vital air than is requiſite to make it burn completely; for it has been ſhown that nitre, when acted upon by heat, gives out a conſiderable quantity of that fluid. The ſame thing happens therefore in this caſe as when a combuſtible body is immerſed into a veſſel filled with vital air. On ſuch an occaſion it is known, that the body ſcintillates while it burns, and is much ſooner conſumed than it would have been in atmoſpheric air. From this we can eaſily conceive the cauſe of the rapid inflammation of gun-powder; why it takes place in cloſe veſſels as well as in the open air; and why, when any obſtacle is oppoſed to ſo terrible an agent, it produces ſuch exploſions, and expels the obſtacle with ſuch violence.

The effects of this mixture of nitre, ſulphur, and charcoal, are nothing in compariſon with thoſe produced by another mixture called *fulminating powder*. That powder is made up of three ounces of nitre, two of carbonate of potaſh, or *fixed ſalt of tartar, very dry*, and one of powdered ſulphur. This mixture is triturated in a hot marble mortar with a wooden peſtle, till the three matters be fully mixed. A dram of this powder expoſed to a moderate heat in an iron ladle, melts, and in a ſhort time produces a detonation as loud as the report of a cannon. To underſtand the cauſe of this phænomenon, which is the more aſtoniſhing, becauſe fulminating powder does not need to be incloſed and preſſed together like gun-powder, in order that it may produce it, we muſt obſerve, 1. That does not take place, except when the mixture is ſlowly heated, till it become liquid. 2. That when fulminating powder is caſt on burning coals, it only melts like nitre, without noiſe. 3. That a mixture of ſulphure of potaſh with nitre, in the proportion of one part of the firſt ſubſtance to two of the ſecond, fulminates more rapidly, and with as much noiſe as that which is made up of ſulphur, nitre, and alkali. It appears therefore, that when fulminating powder is heated, it produces ſulphure of potaſh before detonizing. This fact alone explains the phænomenon which we are conſidering. When nitre in cryſtals and ſulphure of potaſh are expoſed to the action of heat, ſulphurated hydrogenous gas is diſengaged from the ſulphure, and vital air from the ſalt. Theſe two gaſes, which, as we have ſeen in the hiſtory of hydrogenous gas, are capable of producing a ſmart detonation, are inflamed by a part of the ſulphur which kindles of itſelf. But as the thick fluid through which they muſt paſs oppoſes an obſtacle to their inflammation, and as they kindle on all ſides at once, they ſtrike the air with ſuch rapidity in their combuſtion, that it reſiſts them in the ſame manner as the ſides of fire-arms reſiſts gun-powder. This reſiſtance appears evidently from the effects which fulminating powder produces on the ladle in which it is expoſed to the fire; the bottom of that veſſel is pierced through, or bulged outwards, and its ſides are bent inwards, as if it had been expoſed to the action of a force directed perpendicularly downwards, and of another acting laterally.

The laſt mixture of nitre and ſulphur which we have to conſider is called *powder of fuſion.* It is made up of three parts of nitre, one of ſulphur, and one of ſaw-duſt. A little of this powder is put into a nut-ſhell, with a bit of copper rolled together; fire is then ſet to it; it kindles and burns with rapidity, melting the piece of copper, which is afterwards found in that ſtate in the bottom of the ſhell; though the ſhell is only blackened, not burnt. But it is neceſſary to immerſe it in water as ſoon as the powder ceaſes burning. This experiment proves the powder employed in it to be a very fuſible matter. But as it is moſtly owing to the action of the ſulphur on the metal, we will take

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more particular notice of it in the hiſtory of metallic matters.

The muriatic, the fluoric, and the boracic neutral ſalts, have no power of action on ſulphur. We have ſeen, that the alkaline carbonates unite with this ſubſtance, and render it ſoluble in water, by forming alkaline ſulphures which are not cauſtic.

Hydrogenous gas does not act in a determinate manner on ſulphur. Formerly, it was quite natural to find a ſtrong analogy between theſe two bodies; for when ſulphuric acid diluted in water is combined with combuſtible matters, it produces hydrogenous gas; and if it be concentrated, it affords ſulphur. Sulphur is likewiſe formed in large maſſes of putrefying animal matters. When combined with alkaline matters, ſulphur appears to ſuffer an alteration of nature, paſſing into the ſtate of ſulphurated or *hepatic* hydrogenous gas. Laſtly, Hydrogenous gas acts on a great many bodies, nearly in the ſame way as ſulphur. We might ſtill think, therefore, that theſe two bodies were in ſome meaſure the ſame, were it not fully demonſtrated, that hydrogenous gas is almoſt always produced by the decompoſition of water, and equally certain that ſulphur is never a principle of that ſubſtance.

Sulphur is capable of combining with many other ſubſtances; but as we are ſtill unacquainted with thoſe ſubſtances, we will defer giving an account of their union with this mineral, till we come to deſcribe their properties.

Sulphur is an excellent medicine for pituitous diſeaſes of the lungs, and ſtill more ſo for cutaneous diſorders. It is ſucceſsfully adminiſtered in the caſe of the humid aſthma, and in ſcorbutic eruptions, &c. It is given either in flowers or in lozenges made up with ſugar.

gar. It is mixed with fats into an ointment for rubbing ſuch parts of the body as are affected with the itch. Alkaline ſulphures have been propoſed as remedies for obſtructions, numbneſs, palſies, cutaneous diſorders, &c. Some phyſicians have ſuppoſed, that ſulphur is not diſſolved in animal humours; yet it is certain that it penetrates to the extremities of the moſt minute veſſels; for the breath, the urine, and the ſaliva of perſons, who make uſe of ſulphur are impregnated with it. Sulphurated hydrogenous gas diſſolved in mineral waters, as in thoſe of Cauterets, Aix-la Chapelle, Barege, Enghien, &c. communicates to them inciſive qualities, which render them very ſerviceable in diſorders of the ſkin, lungs, and joints, and in palſies, &c.

Sulphur is no leſs uſeful in the arts. It is one of the moſt neceſſary ingredients of gun-powder. It is uſed in taking the fineſt impreſſions of engravings on ſtone; it is made into combuſtible matches; it is burnt to whiten ſilks, to deſtroy certain colours, and to put a ſtop to the fermentation of wines, &c. It has been propoſed for fixing iron in ſtones, &c.

CHAP. IV.

Genus IV. *Metallic Subſtances in general.*

METALLIC ſubſtances are a very important and uſeful order of natural bodies, in their application to the purpoſes of common life, in chemiſtry, and in medicine. They are eſſentially different from ſaline and earthy matters, both in their phyſical characteriſtics and in their chemical properties.

Before entering upon a particular examination of each of theſe ſubſtances, it will be proper to conſider them in general. In doing this, we will treat, 1. Of their phyſical properties. 2. Of their natural hiſtory. 3. Of the art of aſſaying them, or determining their nature and quantity. 4. Of metallurgy, or the art of working them in the great way. 5. Of their chemical properties. 6. Of the means of diſtinguiſhing them from one another, and of the diſtinctions neceſſary to be made among them.

§ 1.

§ I. *Of the Phyſical Properties of Metallic Subſtances.*

METALLIC ſubſtances are abſolutely opaque; much more ſo than ſtones; for a very thin plate, even of the moſt opaque ſtone, is in ſome degree tranſparent; whereas the thinneſt plate that can be formed of any metal is equally opaque with the largeſt maſs. The opacity of metallic ſubſtances renders them peculiarly ſuitable for reflecting the rays of light: no body poſſeſſes this property in ſo eminent a degree as they; glaſs mirrors muſt be coated with metal in order that they may reflect objects. This property peculiar to metals is the cauſe of their luſtre or brilliancy; a quality which is always in the compound ratio of the denſity or hardneſs of any metal which enables it to receive a fine poliſh, and of its colour. White metallic ſubſtances reflect more rays, and are more brilliant than thoſe which are coloured.

The ſpecific gravity of metallic ſubſtances is much more conſiderable than that of other mineral bodies. A cubic foot of marble weighs but two hundred and fifty-two pounds; a cubic foot of tin, which is the lighteſt of all metals, weighs five hundred and ſixteen pounds. This ſuperior gravity of metals, which ſo much exceeds that of earthy matters, depends no doubt on their extraordinary denſity, to which they owe likewiſe their luſtre and opacity.

Moſt metallic ſubſtances may be dilated by repeated percuſſion, or by ſtrong preſſure. This property, which is peculiar to theſe ſubſtances, and of which we have not before had occaſion to take notice in any of the matters which we have hitherto been examining, bears the name of *Ductility*. It may be diſtinguiſhed into two kinds: the one, ductility under the hammer, or *malleability*, makes thoſe metals to which it belongs to admit of being beaten out into thin plates without breaking: lead and tin are metals poſſeſſing this kind of ductility. The other is the continued and almoſt extreme prolongation of metallic matters, ſo as to form them into threads of more or leſs fineneſs: this is the ductility of wire, of which iron, copper, and gold are ſuſceptible. It is likewiſe called *tenacity*. It is of the more conſequence to diſtinguiſh accurately between theſe two ſpecies of ductility, becauſe they appear to be really very different from each other; for metallic ſubſtances which are very malleable often have ſcarce any tenacity; while others, which have much of the ductility of wire, are ſcarcely malleable. The tenacity of metals may be very accurately expreſſed by mentioning the weight which a wire of any metal of a known diameter is capable of ſuſtaining without breaking. Both of theſe properties ſeem to depend on the particular form of the integrant parts of the various metals to which they belong. Metals which admit of being beat out into thin plates, ſeem to conſiſt of ſmall laminæ, which, when compreſſed, are removed from a vertical to a lateral direction in regard to each other, ſo that the ſuperficies of the maſs is increaſed while its thickneſs is diminiſhed. Thoſe again which are ſuſceptible of being ſpun into wire, ſeem to have a fibrous contexture: their fibres being diſpoſed in collateral bundles, unite and eke out one another, when expoſed to that violent preſſure which forms them into wire.

But the ductility of metals goes only a certain length. When any metal, however ductile, has been repeatedly beaten with an hammer, it becomes hard and brittle, and its length can be no farther extended. This property is named *induration*. When an indurated metal is ſlowly heated with proper precautions, it regains its ductility, and may be again ſtruck with the hammer without danger of breaking. It appears that the parts of any metal are lengthened out under the hammer only in proportion as they find ſpace, which they may occupy when they flee the preſſure to which they are expoſed. And it may be eaſily underſtood, that when thoſe parts have been once ſo cloſely compreſſed by percuſſion that ſcarce any interſtices remain between them, they can no longer eſcape from under the hammer, and the metal muſt therefore break into pieces. Heat, by dilating the metal, again ſeparates its parts, and produces new ſpaces between them, which afford them room to unite more cloſely in conſequence of repeated percuſſion.

As ſome metallic ſubſtances are not at all ductile, chemiſts and naturaliſts have diſtinguiſhed them into claſſes, according as they poſſeſs or want this property. They give the name of *metals* to thoſe ſubſtances in which the properties of ductility, opacity, gravity, and metallic brilliancy are united; and they call thoſe *ſemimetals*, which, though apparently metallic, are deſtitute of ductility. But this diſtinction, though accurate enough, is inſufficient to divide all metallic matters into two claſſes; for, from the amazing ductility of gold to the ſingular brittleneſs of arſenic, we find all metals poſſeſſed of this property,—varying in them indeed by inſenſible degrees: and the difference between the ductility of gold and that of lead is perhaps ſtill more conſiderable than that which ſubſiſts in this reſpect between lead and zinc, which is reckoned a ſemi-metal; or between zinc and arſenic. So imperceptible are the gradations by which nature paſſes from one body to another, riſing from the loweſt to the higheſt in the ſyſtem of things.

Metals, conſidered with reſpect to their ductility, may be arranged in the following order. Gold is the moſt malleable of all metals: ſilver, copper, iron, tin, and lead, follow in the order in which they are here expreſſed. The ſemi-metals have been conſidered as deſtitute of ductility. We ſhall ſee, however, that mercury and zinc poſſeſs this property in a certain degree. As to tenacity, gold poſſeſſes this property likewiſe in the moſt eminent degree; next follow iron, copper, ſilver, tin, and lead. We know not well in what degree platina poſſeſſes this property.

Metallic ſubſtances are ſuſceptible of a regular form, which is ſometimes conferred on them by the hand of nature; and they readily receive it from art. Naturaliſts have long been acquainted with this property of metals; native biſmuth, virgin ſilver, with ſome other metals, are of a regular form in their natural ſtate. Even the alchemiſts painfully obſerved the ramified or ſtellate figures on the ſurface of antimony and biſmuth. M. Baumé, in his rational and experimental chemiſtry, informs us, that metallic matters, after being melted, aſſume, if ſlowly cooled, a regular ſymmetrical arrangement. The Abbé Mongez, regular canon of St Genevieve, has made a ſeries of inquiries and experiments on the cryſtallization of metallic matters. M. Brongniart, lecturer on chemiſtry in the King's garden, has alſo turned his attention to this object; and many other chemiſts have repeated their experiments. The general reſult is, that all metals are ſuſceptible of cryſtallization; and though the cryſtalline form of ſome among them may appear different, moſt of them exhibit the ſame octohædral form, with ſome variety of modifications.

Some metallic matters have both taſte and ſmell; ſuch as arſenic, antimony, lead, copper, tin, and iron. Theſe properties are invariably met with in all the metals that are moſt liable to alteration; ſometimes even in ſo eminent a degree, that they corrode and entirely deſtroy the organs of animals.

§ 2. *The Natural Hiſtory of Metallic Subſtances.*

METALLIC ſubſtances exiſt in the interior parts of the earth in four different ſtates. In the firſt, the metal is virgin or native; that is, poſſeſſed of all its properties. Gold is always found in this ſtate; ſilver, copper, mercury, biſmuth, and arſenic, are often found in their native beds in a ſtate of equal purity: Nature ſeldom preſents us with iron, and ſtill ſeldomer with lead, zinc, antimony, &c. in this ſtate.

The ſecond ſtate in which metallic ſubſtances are found is that of *calces*, or oxides; in which ſtate they have not the appearance of metals, but rather reſemble ochres or earthy matters. Copper is often found in the ſtate of a green or blue oxide; iron in a yellow, red, or brown oxide; lead in a white, grey, yellow, reddiſh, and even nitrous oxide; zinc in the ſtate of calamine; cobalt in red flowers; arſenic in a white oxide, &c.

The third ſtate natural to metals, that in which they are commonly found, is in ores. In this ſtate the metallic ſubſtance is combined with a combuſtible matter, which renders it incapable of exerting its properties till it be ſeparated from that matter. This matter, which is called the *mineralizer*, is either ſulphur or ſome other metal. Some chemiſts aſſert, that ſulphur is the moſt common mineralizer. It is united with ſilver in vitreous ſilver ore. Copper ores always contain a very large proportion of ſulphur. Iron is combined with this ſubſtance in the martial pyrites; lead in the galena; mercury in cinnabar; zinc in blend; laſtly, biſmuth is ſometimes, and arſenic often, found in union with ſulphur.

It is proper to obſerve, that all metals have not the ſame affinity with ſulphur. Some of them contain a great quantity, and are eaſily deprived of it. Their metallic luſtre is but little altered by it. Copper, lead, and antimony are of this character. Others again contain but a ſmall portion of ſulphur; but that ſo intimately united with them as to deſtroy all their metallic properties: cinnabar affords an inſtance of this fact.

One metal is ſometimes in union with another; but arſenic is the great mineralizer. Iron, tin, and cobalt are often found in union with arſenic; ſometimes a metal is united with both ſulphur and arſenic at the ſame time; as for inſtance, in the ore of red antimony, and in red ſilver. Laſtly, there are ſome metallic ores which conſiſt of ſeveral metals, with ſeveral mineralizing ſubſtances, ſuch as grey copper ore, grey ſilver ore, and ſome others.

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The fourth ſtate in which metals are found in the bowels of the earth is in combination with acid ſaline ſubſtances. The ſulphuric acid is often found in combination with metals: the oxides of zinc, lead, copper, and iron, are generally in the ſtate of ſulphates: the carbonic acid is one of the common mineralizers of metals: the muriatic, the arſenic, and the phoſphoric acids have been within theſe few years proved to contribute at times to the ſame end.

Metallic ſubſtances are not nearly ſo copious as ſtony matters in the terreſtrial globe. The ſtate in which mineralized metals are moſt commonly found is in veins obliquely interſecting the ſtrata of earths and ſtones of which mountains are compoſed. Metals in the ſtate of oxides or ſalts are often found in maſſes, which have been carried down, and ſometimes cryſtallized, by water. Some metallic ores are found in ſhapeleſs lumps; theſe owe their formation to ſome ſingular accidents.

Veins of metal run between ſtony matters, which ſeem to have been formed at the ſame period. Theſe are generally quartz and ſpar, and form two ſtrata: the one lying beneath the vein of ore is called *the bed*, or *floor* of the mine; the other, which covers it above, is called its *roof*. Theſe ſtones conſtitute what is called the *gangue*, or *matrix of the mine*, which muſt not be confounded with the mineralizer; for the mineralizer is ſo intimately united with the metal, that it cannot be ſeparated from it otherwiſe than by a chemical proceſs; whereas the gangue may be ſeparated by a mechanical operation. The gangue conſiſts of cryſtallized ſtones; and is therefore to be diſtinguiſhed from the rock which forms the maſs of the hill through which the mine runs. Veins of metal are divided into *rich* or *poor*, *large* or *ſmall*, *ſtraight* or *crooked*.

Metallic ores appear to owe their formation entirely to water. Moſt of them are in cryſtals, or mixed with ſubſtances which would have ſuffered an alteration of nature, if they had been expoſed to the action of fire, ſuch as calcareous ſtones and ſulphur. We find likewiſe among them bodies which ſtill exhibit a vegetable or animal organization, which would alſo have been deſtroyed, had it been expoſed to the action of fire. There are perhaps ſome ores which owe their formation to fire: ſuch as the ſpecular iron ore of Mont d'Or in Auvergne. But ſuch inſtances are rare.

Mines are more generally found in hills than in plains, and almoſt always in hills forming a continued range. It is obſerved, that plants growing on hills which contain metallic matters are never luxuriant, but dry and dwarfiſh: trees in ſuch a ſituation are crooked and ill ſhaped: ſnow melts there almoſt as ſoon as it falls; and the ſand is metal-coloured. Springs of metallic mineral-water are found in the neighbourhood. By examining the waters of theſe ſprings, and the ſand over which they flow, it may be determined with a good deal of certainty whether they communicate with veins of metallic matters. When veins of metal appear near the ſurface, ſuch an indication may be conſidered as a good reaſon for piercing the ground to a greater depth. The boring inſtrument brings up ſpecimens of the ſubſtances which compoſe the interior part of the mountain, and of the metallic mineral matter which it contains; thereby ſhowing the nature of that matter, as well as the reſiſtance, which muſt be overcome in order to penetrate to it.

§ III. *Of the Art of Aſſaying Ores, or Docimaſia.*

WHEN a certain quantity of ore is obtained, it is next to be aſſayed, in order that its nature may be exactly determined. This aſſaying of ores is one of the moſt important branches of chemiſtry, and is known by the name of *docimaſia.* Every different ore muſt be aſſayed in a particular manner: yet there are certain general operations common to all proceſſes of aſſaying.

Specimens of the ore are firſt ſelected from among the richeſt, the pooreſt, and thoſe of a middle nature between the two. This ſelection is abſolutely neceſſary; for if only a rich ſpecimen were aſſayed, too flattering hopes might be excited; were the ſpecimen aſſayed from the pooreſt, the reſult might be too diſcouraging. The ſpecimens thus ſelected are piled one above another, and well waſhed with water. The fluid carries off the gangue in powder, while the more ponderous mineral remains in the bottom of the veſſel. The ore thus waſhed muſt next be roaſted with due care, in order that as much as poſſible of the mineralizer may be carried off by ſublimation: the mineral when ſubjected to this operation muſt be incloſed in a ſmall earthen pot covered over with another. This is a neceſſary precaution, as ſome ores burſt into pieces when expoſed to the action of fire, and fly out of the veſſel if it be left open; and ſuch an accident would render the reſult quite uncertain. When this roaſting is performed in the open air, it generally reduces the metal to an oxide; and if it be of a volatile nature, even drives off a part of it; and therefore we would rather adviſe the roaſting of ore in a ſtone retort. This proceſs is indeed more tedious and difficult; but it diſcovers the nature and quantity of the mineralizer, affords a much more accurate analyſis of the mineral under examination. When an ore has been kept red-hot, till it ceaſe to exhale vapours, the roaſting is then finiſhed. The ore was weighed before and after being waſhed, in order that the quantity of its gangue might be exactly determined; and it is to be again weighed after the roaſting, in order that it may be known how much it loſt by the operation.

After being roaſted, the ore muſt next be melted. For this purpoſe, it is mixed with three parts of black flux and a little decrepitated muriate of ſoda: the mixture is put into a crucible, which is covered cloſe with a lid, and placed in a good fuſing furnace. The alkali of the black flux melts the metal, and abſorbs any part of the mineralizer which may ſtill remain in the ore. The coal of the tartar which is found in the black flux ſerves to reduce the oxide of the metal, by abſorbing its oxigene. The muriate of ſoda hinders the mixture from ſuffering any loſs while in fuſion; becauſe being, when melted, lighter than any of the other matters, it always occupies the upper part of the crucible, covers the mixture, and is the only one of the ſubſtances of which any part is loſt.

When the fuſion is finiſhed, the contents of the crucible muſt be permitted to cool ſlowly. The matter may be inferred to have been completely melted, if the metal be united in one lump, the ſuperior ſurface of that lump being of a convex form; if no grains of it appear intermixed with the ſcoriæ; and if the ſcoriæ be united in one compact, uniform, vitreous maſs, covered over with a cruſt of melted marine ſalt. The lump of metal is to be carefully weighed, and the proportion in which the metal exiſts in the ore is then diſcovered.

But ſome ores are harder and more refractory. Fluxes of a more active nature, and thoſe in greater quantity, muſt then be employed; ſuch as borax, pounded glaſs, fixed alkali, &c. The ſame mineral often contains an intermixture of perfect and imperfect metals. Theſe may be ſeparated by heating the lump of metal in the air. The imperfect metal is converted to an oxide, and carried off, leaving the perfect metal in a ſtate of purity. This operation bears the general name of refining. The perfect metal obtained by this proceſs is almoſt always a mixture of gold and ſilver. Theſe two metals are ſeparated by a ſolvent which acts on the ſilver, leaving the gold uninjured: this operation is called *parting* them. The reſidues of all theſe proceſſes ſhould be weighed with the aſſay-balance.

Accurate as this ſeries of proceſſes may appear, it is often of leſs utility than one leſs nicely conducted; for where works of this kind are conducted on a great ſcale, cheaper materials are uſed, and leſs caution is obſerved. Ore is then to be aſſayed by melting it on coals in a fuſing furnace. The coals reduce the metallic oxide; and the fixed alkali, which is produced as they burn, abſorbs part of the mineralizer. It is ſometimes found neceſſary to add a ſmall quantity of filings or ſcoriæ of iron, in order to facilitate the fuſion of very refractory ores.

There is a method of aſſaying metals in the humid way, which may be employed to diſcover what metals are contained in pieces of ore meant to be laid up in collections of the objects of natural hiſtory. A ſmall bit, broken off from the piece of ore, is digeſted among acids, which diſſolve the metal, and ſeparate the mineralizer. The ſalt produced by the union of the metal with the acid ſhows the quality of the metal. But as all metals are not ſubject to the action of acids, only certain ores can be aſſayed in this manner. Bergman has written an excellent diſſertation on the aſſaying of metals in the humid way, which the reader may conſult with advantage.

§ IV. *Of the Art of Extracting and Purifying Metals in the great way, or of Metallurgy.*

WHEN it appears from a particular aſſay, that the working of a mine is likely to be profitable, the following train of operations are then to be employed for the purpoſe. A perpendicular ſquare pit is dug in the ground, large enough to admit ſtraight ladders on which the workmen may go down and come up. An axis is uſually placed over the mouth of the pit, for the purpoſe of raiſing up buckets filled with the mineral; pumps too are ſometimes put into it for carrying off the water. If the mine be ſo deep that one perpendicular pit cannot be carried down ſo far as to reach the floor of the ore, an horizontal drift is formed, at the end of which a new ſhaft is ſunk and this is done repeatedly, till the laſt ſhaft penetrate to the bottom of the mine.

If the rock through which the works are carried be ſo hard and firm as to be in no danger of falling down,

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there will then be no occaſion for propping it with any artificial ſupport. But if they be cut through ſoft ſtone, or earth likely to crumble down; it will then be neceſſary to prop the galleries or drifts, and to line the ſhafts with planks.

It is an object of conſequence to procure regular ſupplies of freſh air in mines. Where it is practicable to open a paſſage from the bottom of a ſhaft, which may communicate with the plane below, a current of air is eaſily produced. Where this cannot be effected, a new ſhaft is ſunk at that part of the gallery which is moſt diſtant from the former ſhaft. When one of theſe two ſhafts is higher than the other, the air eaſily circulates: but if they be equally high, a current of air cannot be produced. When the laſt is the caſe, a fire is kindled in a furnace over the mouth of one of the ſhafts, and ſufficient ſupplies of freſh air are thus conveyed regularly into the gallery.

Water is very troubleſome in mines. If it flow ſlowly through the earth, it is then conducted in a channel along the floor of the mine, and conveyed by a ſloping drift into the next river. If it riſe in greater abundance it is carried off by pumps. Sometimes when a rock is cut, a quantity of water burſts out, ſufficient to fill all the galleries in an inſtant. The reſounding of the rock when it is ſtruck, warns the workmen before this event take place; and they prepare for it by forming a door in one of the galleries: one of the miners cuts the rock to give vent to the water, and inſtantly retires, ſhutting the door, which hinders the water from overtaking him.

Vapours conſiſting of carbonic acid and hydrogenous gas iſſue from mines, and are either diſengaged or formed by by the mutual re-action of the mineral and metallic matters. The fires which are neceſſary to ſoften the rock, generally contribute to the diſengagement of thoſe gaſeous ſubſtances; the dangerous effects of which cannot be otherwiſe prevented, but by rapid currents of air, or by detonation.

When the mineral is dug and brought out of the earth, it is then pounded, waſhed, roaſted, melted, and refined. It is pounded by large knockers moved by water: theſe are called (in French) *bocards*. When it is pounded, it is put on inclined tables to be waſhed, in order that the water may run off, and carry with it the gangue. Ores containing much ſulphur ſhould be roaſted in the open air; thoſe which contain but a little ſulphur may be roaſted in the furnaces in which they are to be afterwards melted. Some ores melt by themſelves; others require fluxes to diſpoſe them to fuſion, and muſt likewiſe be put into contact with charcoal. Furnaces for fuſion are of various kinds, according to the country and quality of the ore. Furnaces for refining are conſtructed nearly in the ſame manner as the others. Sometimes the ſame furnace ſerves for both operations. When metals are thus reduced, there are almoſt always ſeveral of them intermixed together. They muſt then be ſeparated by proceſſes entirely of a chemical nature, which ſhall be deſcribed when we treat ſeparately of the different metals.

§ V. *Of the Chemical Properties of Metallic Subſtances.*

ALL the chemical properties of metallic ſubſtances concur to repreſent them as ſimple matters, not liable to decompoſition. The alterations which they ſuffer from heat, air, and ſaline ſubſtances, are always owing to combination; not one of thoſe alterations can with any reaſon be compared to an analyſis, as we are about to ſhow by a particular account of the phænomena which they exhibit on ſuch occaſions.

Light appears to alter the colour and luſtre of ſome metallic ſubſtances. Some metals, when incloſed in tranſparent veſſels, are ſullied, and acquire gradually a new colour, which deprives them of their brilliancy. This kind of alteration has not been farther obſerved.

Heat effects ſome changes on the aggregation of metals, with various degrees of quickneſs and facility. All metallic ſubſtances are liable to melt on being heated in cloſe veſſels; ſome of them long before becoming red-hot, others at the very inſtant when they become red, and others not till a conſiderable time after. There are as many different degrees of the fuſibility of metals as there are different kinds of metals. If left to cool after melting, they aſſume a cryſtalline form. If urged with a violent fire, they boil like fluids, and are reduced to vapour. Mercury has long been known to poſſeſs theſe properties. Goldſmiths often ſee gold and ſilver boil when in fuſion. M. Buffon obſerved,

ſerved, that when ſilver plates were expoſed to the focus of a large concave mirror, a white ſmoke aroſe from the ſurface of the plates. Meſſrs Macquer and Lavoiſier having cupelled ſilver in the focus of Tſchirnhauſin's lens, ſaw the metal exhale in ſmoke: a plate of gold expoſed to that ſmoke was completely ſilvered over. Gold expoſed to the ſame focus likewiſe exhaled a ſmoke which gilded ſilver. The chimnies of goldſmiths and aſſayers are filled with gold and ſilver in ſmoke. Copper, tin, lead, zinc, antimony, biſmuth, and arſenic, may be volatilized with great eaſe.

The ſurfaces of all melted metals are convex; and when they are in very ſmall maſſes, they compoſe perfect ſpheres. This effect is owing to the affinity of aggregation, which cauſes the particles of metals mutually to attract each other, and to the weakneſs of their tendency to combine with the body on which they are placed. This is a general property of fluids, and may be obſerved of oil in reſpect to water, and of water in reſpect to fat bodies.

When metals are expoſed in the air to the action of fire, they ſuffer conſiderable alterations; ſome ſooner, ſome later. Thoſe which ſuffer no ſenſible alteration on ſuch occaſions are called *perfect metals:* thoſe again which are entirely deprived of their metallic properties by this proceſs are called *imperfect metals.* This alteration of metallic matters which we call *oxidation,* is a real combuſtion. Like the combuſtion of all other combuſtible ſubſtances, it cannot be effected without the help of air. And when it has taken place for ſome time in a certain quantity of air, it cannot be continued, at leaſt without a ſupply of freſh air. The air in which metals are burnt becomes mephitic. The combuſtion of of metallic ſubſtances is attended with a flame more or leſs lively. Zinc, arſenic, iron, gold, and ſilver, diſplay a diſtinct flame; ſuch likewiſe is that of lead, tin, and antimony, when they are expoſed to an intenſe heat. The longer metals are expoſed to the action of fire in contact with air, the more entirely are they diveſted of their metallic properties. Some of them ſeem to acquire the characteriſtics of earthy matters; and in that ſtate they are called *metallic earths* or *calces*. But the name of *metallic oxides* is more expreſſive of their real nature; for it is fully demonſtrated, that thoſe burnt metals are not earths, as they were a few years ago believed to be, but combinations of the metals with oxigene. Metallic oxides have no longer the brilliancy and fuſibility of the original metals; nor have they any longer an affinity even with the metals to which they owe their formation. If urged with fire, they are volatilized, or melt into glaſs. This glaſs is the more tranſparent and infuſible, in proportion as the metals have been more completely oxidated; that is, in proportion as they contain a greater quantity of oxigene. Metallic oxides combine with ſaline and earthy matters. Several of them poſſeſs the characteriſtics of ſaline ſubſtances. When arſenic is highly oxidated, it becomes a peculiar acid; the properties of which have been examined by Scheele and Bergman. Rouelle informs us, that the oxide of antimony diſſolves in water like arſenic.

Some metallic oxides are reduced to metals when expoſed to the action of fire, and give out, as they are reduced, an aeriform fluid, which is very pure vital air. We are indebted to M. Bayen for the firſt certain information which we obtained on this head. He obſerved, that when oxide of mercury was heated in cloſe

cloſe veſſels, it gave out a good deal of air, and was then reduced to the ſtate of running mercury.

Dr Prieſtley, on examining this air, found it to be much purer than atmoſpheric air; and at the period of this diſcovery we may date the riſe of that accurate knowledge which we at preſent poſſeſs of the laws of the calcination of metals. Let us take a ſhort review of the phænomena which attend this operation. A metal cannot be *calcined*, unleſs it be in contact with air. The greater the quantity of the air brought into contact with the metal, the more completely is the metal *calcined*. A given quantity of air cannot ſerve to *calcine* any more than a given quantity of metal; as M. Lavoiſier has ingeniouſly ſhown by *calcining* lead by means of a reflecting mirror in a bell-glaſs containing a known portion of air. When a metal is *calcined*, it abſorbs a part of the ſurrounding air; for the mercury over which it is *calcined* riſes in the veſſel in proportion as the *calcination* proceeds. It is to this abſorption of oxigene that metallic calces owe the increaſe of weight which they gain by *calcination;* for when it is extracted from the oxide of mercury, that oxide returns to the ſtate of a metal, and ſuffers a loſs of weight preciſely equal to the weight of the vital air obtained from it by diſtillation. Theſe phænomena ſhow evidently that *calcination* is nothing but the combination of the metal with the baſe of pure air, or the oxigene contained in the atmoſphere. This combination is often effected merely by the contact of air and water in metals liable to ruſt. The reaſon why heat is neceſſary to the oxidation of moſt metals is, becauſe by diminiſhing the aggregative force by which the integrant parts of thoſe bodies adhere together, it increaſes in the ſame proportion their force of affinity or combination; and thus promotes the combination

bination of the oxigene with the metal. In this operation, therefore, as in moſt ſolutions, heat is no more than an auxiliary. The air which has been once employed in the oxidation of a metal, can no longer contribute to maintain combuſtion; becauſe it is deprived of its vital air, the principle which rendered it ſerviceable to combuſtion and reſpiration. The greater the proportion of the vital air contained in the atmoſpheric fluid, ſo much the ſooner will it reduce a given quantity of metal to an oxide. I have often obſerved, that by immerſing melted lead, biſmuth, &c. in a veſſel filled with vital air, a much greater quantity of metallic oxide may be obtained in a given time than if the metals were expoſed for the ſame ſpace to the action of atmoſpheric air. All of theſe facts, and a great many more, which will be found under the hiſtory of the different metals when we come to treat of them ſeparately, concur to prove that a metallic oxide is nothing but a chemical combination of a metal with the oxigene of the atmoſphere; that calcination is merely the act by which this combination takes place; and that as vital air is fixed on the occaſion, what remains of atmoſpheric air after it has contributed to the calcination of a metal is nothing but azotic gas.

The reduction of metallic oxides by the uſe of combuſtible matters, farther illuſtrates and confirms this theory. To reduce a metallic oxide to a metal, it is often found neceſſary to heat it in a cloſe veſſel with ſome combuſtible matter, ſuch as fats, oils, charcoal, &c. On all ſuch occaſions the metallic oxide is decompoſed, and loſes the oxigene to which it owed its character as ſuch. In order to underſtand what paſſes on this occaſion, we muſt reflect, 1. That metals are not the moſt combuſtible bodies in nature; or, what is is the ſame thing, that metals have not the greateſt poſſible affinity with oxigene. 2. That animal or vegetable combuſtible matters have a ſtronger affinity with oxigene than metallic ſubſtances have. 3. That, of conſequence, when a metallic oxide is reduced with the help of charcoal, the charcoal having a greater affinity with oxigene, or being more combuſtible than the metal, robs the oxide of the principle to which it owes its character, and cauſes it to paſs into the ſtate of a metal. And operations of this kind ſucceed beſt in cloſe veſſels; becauſe when the combuſtible matter is not in contact with air, it cannot burn without abſorbing the oxigene of the oxide. For this reaſon the pure carbonaceous matter which combines with the oxigene of the metallic ſubſtance, is changed into carbonic acid during the reduction of the metal.

Having given the hiſtory of the calcination of metals according to the modern theory, we cannot avoid taking ſome notice of Stahl's doctrine on this head, which was almoſt univerſally received among chemiſts till the period of the late diſcoveries concerning air and combuſtion. Stahl conſidered metallic ſubſtances as compounds of peculiar earths with phlogiſton. *Calcination* was, in his opinion, merely the diſengagement of the *phlogiſton;* and he thought that the reduction of metals reſtored to them the principle which they had loſt by *calcination.* This theory is directly contrary to the modern theory: it repreſents metals as compound ſubſtances; whereas the doctrine at preſent received conſiders them as ſimple bodies. According to Stahl, they loſe, when *calcined*, one of their component principles; but the facts on which the modern theory is founded, prove that they enter, on that occaſion, into a new combination. Laſtly, That great man imagined

imagined, that metallic oxides regained by reduction the *phlogiſton* of which the metals had been deprived by the action of fire: but the moderns have ſhown reduction to be merely the ſeparation of the oxigene which entered into combination with them when they were *calcined.*

After this ſlight compariſon of the two theories, let us attempt to ſhow which of them is ſupported by the greateſt number of facts. Stahl, while he was ſo eager to demonſtrate the exiſtence of *phlogiſton* in metals, ſeems to have overlooked the influence of air on their *calcination.* Beccher, Ray, Boyle, and ſeveral other chemiſts, had, however, ſuſpected, before his time, that this element was the principal agent on the occaſion. And however ſatisfactory the theory of Stahl may have appeared till the æra of the new diſcoveries concerning air, yet it muſt always have appeared inconſiſtent with thoſe facts, which prove that air acts, and is a neceſſary agent in the *calcination* of metals. Stahl's theory was therefore imperfect, as being inſufficient to explain a number of the phænomena. It gives no reaſon, for inſtance, why metallic oxides are weightier than the metals before *calcination.* It is impoſſible to conceive how any body can acquire additional weight, in conſequence of loſing one of its conſtituent principles; and as gravity is one of the eſſential properties of all bodies, the ingenious explanation of this phænomenon which M. de Morveau has given in his Diſſertation on *Phlogiſton,* cannot be conſidered as fully ſatisfactory; eſpecially ſince it has been diſcovered that there is a portion of air in metallic oxides. From theſe facts, therefore, it appears that the pneumatic theory has by much the advantage over Stahl's. Macquer, with a judicious diſcretion which we cannot ſuf-

ſufficiently praiſe, attempted to reconcile the modern diſcoveries with the doctrine of *phlogiſton.* According to that celebrated chemiſt, metals never loſe their *phlogiſton* or ſuffer *calcination* but when the pure air of the atmoſphere is precipitated, and combined with their ſubſtance; the light which they contain is then diſengaged: and when they are reduced, light, with the help of heat, expels the pure air which had entered into combination with them, and aſſumes its place. So that light and pure air may be conſidered as mutually precipitating one another. But as light, and that principle to which Stahl gave the name of *phlogiſton,* have not yet been ſhown to be the ſame, and as the exiſtence of light as a principle in combuſtible bodies is equally uncertain, Macquer's opinion can be viewed in no other light but as an hypotheſis, which may be entirely overlooked, but cannot be admitted as well founded.

It is therefore at preſent an inconteſtible fact, that metallic oxides are compounds of the metals with oxigene: it is much to be wiſhed that we knew the various elective attractions ſubſiſting between that principle and the different metallic ſubſtances. M. Lavoiſier has already turned his attention to this important object of chemical reſearch: but his experiments are not yet ſufficiently numerous, nor their reſults ſufficiently accurate, to enable us to enter here into minute particulars on this head.

Metallic ſubſtances are altered by air; their ſurfaces loſe their luſtre, and are ſometimes covered over with ruſt. Chemiſts conſider ruſt as a metallic oxide. We will, oftener than once, have occaſion to review this ſubject, and to ſhow, that water in vapour oxidates a number of metallic ſubſtances, and that the carbonic acid of the atmoſphere combines with them after their calcination.

Water diſſolves certain metals; on others it has no power of action: when in vapour it contributes highly to the formation of ruſt on thoſe metals which are ſuſceptible of it. We know, from M. Lavoiſier's late diſcoveries, that it acts with great energy in effecting the oxidation of the moſt combuſtible metals, ſuch as zinc and iron; and that it is decompoſed on ſuch occaſions into oxigene, which combines with theſe metals; and into hydrogene, which is diſengaged in union with a large proportion of caloric; and of conſequence in the form of a very light gas.

Earthy matters appear to have no power of action on metallic ſubſtances; but they may be combined with metallic oxides by fuſion.

We are entirely ignorant of the manner in which the ſalino-terreous matters act on the ſubſtances which we are now examining.

The alkalis diſſolve ſome metals; they act, however, but weakly on moſt of them. Water or air appear to contribute greatly to the oxidation of thoſe metals which are liable to ſuch a change by the action of alkalis.

The acids produce a much greater alteration on metallic ſubſtances, diſſolving them with more or leſs difficulty. The ſulphuric acid then produces either hydrogenous or ſulphureous gas, according as it is diluted in water or concentrated. In the firſt inſtance, the water is decompoſed, and gives out hydrogenous gas, while it communicates its oxigene to the metals: in the ſecond, the acid itſelf is decompoſed; and while part of its oxigene combines with the metallic ſubſtances, the reſt remaining in union with the original proportion of ſulphur, conſtitutes by that means ſulphureous acid gas. When the ſulphuric acid is in either of theſe inſtances ſaturated with a metallic oxide, it forms what was formerly known by the name of *vitriol;* which when in cryſtals is to be conſidered as a compound of four bodies, namely, metal, oxigene, ſulphuric acid, and water. Theſe metallic ſulphates are ſubject to many varieties in their colour, tendency to cryſtallization, ſolubility in water, ſuſceptibility of decompoſition by heat, by vital air,—the oxigenous part of which they abſorb, by the alkalis which ſeparate the metallic oxides, &c.

The nitric acid appears to act more quickly on metals than the ſulphuric acid; but it generally adheres to them with much leſs force. While it acts on theſe ſubſtances, a conſiderable quantity of nitrous gas is diſengaged; the metal is more or leſs oxidated; and is either precipitated, or remains in union with the acid. Stahl aſcribed this effect to the diſengagement of the phlogiſton of metals. Modern chemiſts now think that it is owing to the decompoſition of the nitric acid, and the ſeparation of part of its oxigene from the azote, its other principle; for we have elſewhere ſhown theſe two gaſeous bodies to be the component principles of the nitric acid. Nitrous ſolutions of metals, or metallic nitrates, are more or leſs liable to cryſtallization, and to decompoſition by heat, air, or water. Alkaline matters ſeparate the metallic oxides: the nitric, like the ſulphuric acid, has various degrees of affinity with the different metals. M. Prouſt has diſcovered that a number of metallic ſubſtances are inflamed when they come into contact with this acid.

The muriatic acid ſeldom acts with much energy

ergy on metals. The water which is in union with it, firſt oxidates the metals, producing by this means the hydrogenous gas which is diſengaged from ſolutions effected by this acid. Theſe ſolutions effected by the muriatic acid are generally more permanent than either of the two laſt-mentioned acid ſolutions of metals, and uſually more difficult to decompoſe by heat. Sometimes they afford cryſtals, but ſeldom without conſiderable difficulty. The muriatic acid has a greater affinity than either of the two preceding acids with moſt metallic ſubſtances; which enables it to decompoſe both ſulphuric and nitric ſolutions of metals. Metallic muriates are often volatile.

The oxigenated muriatic acid oxidates moſt metals with a good deal of energy, on account of its containing an exceſs of oxigene, and that not very cloſely united with it. It diſſolves them in the ſame way in which water diſſolves ſalts, without efferveſcence.

The carbonic acid acts but faintly on metals; yet Bergman has ſhown it to be capable of combining with moſt of them. In nature we often find metals in combination with this acid; and theſe compounds are ſometimes in cryſtals: they are known by the name of *ſparry metal,* ſuch as ſparry iron, ſparry lead. But we rather give them names analogous to thoſe of the other ſalts formed by this acid, calling them *carbonate of iron, carbonate of lead,* &c.

The fluoric and the boracic acids have an equal tendency to combine with metallic matters: but the compounds which they then form are but little known.

Some among the combinations of metals with acids are ſuſceptible of cryſtallization; others cannot be made to aſſume any regular form. Fire decompoſes ſome of them; others ſuffer no alteration from that agent. Moſt of them are altered by air, the oxigenous part of which they abſorb. All of them are more or leſs ſoluble in water, and liable to decompoſition by that fluid, when a great quantity of it is cauſed to act on them, as has been obſerved by Macquer. All of them are precipitated by aluminous earth, barytes, magneſia, lime, and the alkalis; which ſubſtances have, in general, a ſtronger affinity than metallic oxides with the acids.

When ſeveral metals are employed to ſeparate other metals from their ſolutions, the metals that are precipitated regain their metallic form and luſtre; becauſe the oxigene which was united with them, while they were in a ſtate of ſolution, is ſeparated and combined with the precipitant metal, which is in its turn diſſolved in the acid. M. Lavoiſier, therefore, with good reaſon conſiders theſe precipitations of metals by one another, as owing to their having various affinities with the oxigenous principle.

Neutral ſalts ſuffer but little alteration from metallic matters when the two ſubſtances are brought together in the humid way; but when a mixture of a ſalt with a metal is heated, ſeveral of the ſalts are liable to be decompoſed. Several ſulphuric ſalts form ſulphur on ſuch an occaſion. M. Monnet is the only chemiſt who has obſerved antimony to be capable of effecting the decompoſition of neutral ſalts in this way. In a ſeries of experiments on this ſubject, I have found, that ſeveral other metals, ſuch as iron, zinc, &c. decompoſe ſulphate of potaſh, &c.

Nitre detonizes with moſt metallic ſubſtances, and oxidates them with more or leſs energy. The cauſe of this phænomenon is, that oxigene has a ſtronger affinity

nity with moſt metallic ſubſtances than it has with the azotic principle. Metals oxidated by this ſalt are called *metallic oxides* by nitre. The alkaline baſe of this ſalt often diſſolves a part of the oxides.

Ammoniacal muriate is decompoſed by ſeveral metals, and by the oxides of almoſt all metallic ſubſtances. Bucquet, who made a ſeries of experiments on this ſubject, remarked, that all metallic ſubſtances on which the muriatic acid is capable of acting without an intermedium, are liable to be entirely decompoſed by ammoniacal muriate; that hydrogenous gas is diſengaged when theſe decompoſitions take place; and that metals which do not admit of ſolution by the common muriatic acid, are not liable to this decompoſition. The ammoniac obtained on theſe occaſions is always very pure and cauſtic.

Almoſt all combuſtible mineral matters combine readily with the metals. Hydrogenous gas colours them, and reduces ſome of their oxides; having, as Dr Prieſtley has proved by ſome very ingenious experiments, a greater affinity with oxigene than what moſt metals have. The reduction of metallic oxides by hydrogenous gas is accompanied with the production of a certain quantity of water by the combination of the hydrogene with the oxigene diſengaged from the metals.

Sulphur combines with moſt of the metals: the combination of ſulphur with a metal forms an artificial ore. When ores of this kind are moiſtened, or expoſed to humid air, they are vitriolized, or changed gradually into metallic ſulphates. Alkaline ſulphure diſſolves any metal. Sulphurated hydrogenous gas colours and decompoſes metallic oxides, reducing them at the ſame time by the abſorption of their oxigene.

Metals combine more or leſs readily with one another: the reſults are mixtures; the properties of which render them very uſeful in the arts.

§ VI. *Methodical Diviſion of Metallic Subſtances.*

AS metallic ſubſtances are pretty numerous, it appears neceſſary to divide them into certain orders, and to diſtinguiſh metals poſſeſſing ſimilar properties from thoſe of which the properties are different. We may conſider ductility as the firſt characteriſtic of metals. Such metallic ſubſtances as poſſeſs not this property, or poſſeſs it but in a very inferior degree, have received the appellation of *ſemi-metals.* Thoſe, again, which are highly ductile, are called *metals.* The ſemi-metals are either very brittle under the hammer, or in a ſmall degree malleable. This diſtinction occaſions a ſubdiviſion of theſe ſubſtances. Metals may be alſo ſubdivided, in reſpect of the manner in which they are affected by fire. Some metals, when heated in the air, are eaſily oxidated: others again ſuffer no alteration when they are treated in the ſame manner. The former are *imperfect metals;* the latter *perfect metals.* That we may not multiply theſe diviſions as we proceed in our hiſtory of metallic ſubſtances, we ſhall here give a table, in which metals are claſſed according to their natures.

Metallic Subſtances are either

Scarcely ductile,

SECT. I.
Semi-metals.

DIVISION I.

Some of them break into pieces under the hammer.

Arſenic.
Molybdena.
Tungſten.
Cobalt.
Biſmuth.
Antimony.
Nickel.
Mangneſe.

DIVISION II.

Others have a ſort of ſemi-ductility.

Zinc.
Mercury.

Or highly ductile.

SECT. II.
Metals.

DIVISION I.

Some are eaſily reduced to oxides, when heated in the air.

Imperfect Metals.

Lead.
Tin.
Iron.
Copper.

DIVISION II.

Others cannot be reduced to oxides by the ſame proceſs.

Perfect metals.

Silver.
Gold.
Platina.

C H A P.

CHAP. VI.

*Of Arſenic and its Acid**.

ARSENIC is placed at the head of the ſemi-metals, becauſe it bears a conſiderable relation to ſalts. Kunckel thought it to be a coagulated aquafortis. Beccher and Stahl conſidered it as a ſaline matter. Scheele has proved, that it forms a peculiar acid; and Brandt and Macquer have ſhown it to be a genuine ſemi-metal. When arſenic poſſeſſes all the properties natural to it, it has all the characteriſtics of a metallic matter. It is then perfectly opaque, and has the gravity and luſtre which diſtinguiſh thoſe ſubſtances.

Native arſenic is often found in black maſſes, almoſt without luſtre, and very heavy: it has ſometimes the diſtinguiſhing luſtre of metals, and it then reflects the colours of the rainbow: its fracture is ſtill more brilliant, and ſhows it to conſiſt of a great number of ſmall ſcales. When thoſe ſcales or ſhells are obſervable on the exterior part of the maſs, it is then called *teſtaceous arſenic*,

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* We give the name of *arſenic* to the ſemi-metallic matter commonly known by the name of *regulus of arſenic*. That denomination is improper and ought to be laid aſide. What is called *white arſenic* is the oxide of this ſemi-metal. A.

arſenic, or improperly *teſtaceous cobalt*, becauſe formerly when the metallic character of arſenic was unknown, and its oxide was obtained in a large proportion from cobalt ore, teſtaceous arſenic was thought to be cobalt ore. Virgin arſenic is very eaſily known when it has the metallic luſtre, and is in ſmall ſcales; but when it is black, and its texture cloſe grained, the only way of diſtinguiſhing it is by its gravity, which is very conſiderable, and by obſerving whether or not it is diſperſed in white ſmoke, having a ſtrong ſmell of garlic when laid on burning coals. Great plenty of this laſt kind is found *à St Marie aux Mines.* It is mixed with grey ſilver ore. It is likewiſe found in the cobalt mines of Saxony, and at Andrarum in the province of Schonem in Sweden.

Arſenic is ſometimes found in nature in a white oxide, which is alſo of a vitreous appearance, but oftener in the form of light duſt, or mixed with ſome particular earths. This oxide is likewiſe found at *St Marie aux Mines.* It is known by its white ſmoke, and by the garlic ſmell which it diffuſes when thrown into the fire.

Arſenic is often combined with ſulphur; it then forms *orpiment* and *realgar*, or the yellow and the red ſulphurated oxides of arſenic. Native *orpiment* appears in yellow, brilliant, and ſeemingly talcky maſſes, of various ſizes and various degrees of brilliancy: it is often mixed with *realgar*, and it ſometimes approaches to green. *Realgar* is of a red colour, more or leſs lively and tranſparent, and often cryſtallized in bright needles. A good deal of it is found at Quito and on Mount Veſuvius. The only difference between theſe two ſubſtances ſeems to be, that the one has been formed by a more intenſe heat than the other.

Miſpikel,

Miſpikel, or arſenical pyrites, is the laſt ore of arſenic. It contains that ſemi-metal in combination with iron. *Miſpikel* is ſometimes found in cubic cryſtals, but oftener without any regular form. This ore is of a white, *chatoyant* colour. Wallerius calls it white cubic arſenic.

Arſenic is alſo found among cobalt, antimony, tin, iron, copper, and ſilver ores.

Pure arſenic, called alſo *regulus of arſenic*, is of a blackiſh grey colour, and reflects the colours of the rainbow. It is very ponderous, and very friable.

When arſenic is expoſed to fire in cloſe veſſels, it is ſublimed, but not decompoſed: It is even one of the moſt volatile metallic matters. When ſlowly ſublimated, it cryſtallizes in triangular pyramids. When arſenic is heated in the air, it is very ſoon converted into an oxide, and diſſipated in the form of a white ſmoke, which exhales a ſtrong ſmell of garlic. Red arſenic burns with a bluiſh flame. On that occaſion, it combines with the oxigene of vital air, and forms a compound known by the name of *white arſenic* or *calx of arſenic*, and which we call oxide of arſenic. This is the reaſon why arſenical ores of cobalt give out in the furnace a great deal of white ſmoke, which is condenſed in the chimney into a white, ponderous, vitrified matter, that is depoſited in layers, and is ſold very improperly under the name of arſenic. It is properly an oxide of vitreous arſenic.

The oxide of arſenic is eſſentially different from the oxides of all other metallic ſubſtances: it has a very ſtrong, and even a cauſtic taſte; it is a ſtrong poiſon. When expoſed to fire in cloſe veſſels, it is volatilized by a moderate heat into a white cryſtalline powder, known by the name of *flowers of arſenic.* When the heat is a little ſtronger, it is vitrified as the ſublimation takes place. The glaſs produced is very tranſparent, and cryſtallizes into flat triangular ſolid figures, with truncated angles. It very ſoon loſes its tranſparency in the air. No metallic oxide is really volatile of itſelf; that of arſenic is the only one which exhibits ſuch a property; it is at the ſame time very fuſible and very vitrifiable. Beccher attributed the gravity and volatility of arſenic to a peculiar principle, which he called *mercurial* or *arſenical earth*, and of which Stahl has not been able to demonſtrate the exiſtence.

Arſenic in the ſtate of regulus does not act in a ſenſible manner on combuſtible bodies; but the oxide of arſenic produces a ſenſible alteration upon them, and at the ſame time reſumes its metallic luſtre. Stahl thought, that, on this occaſion, the combuſtible body reſtored to the arſenic the phlogiſton which it had loſt by calcination: But the moderns have proved, that the oxide of arſenic is a compound of arſenic and oxigene, and that the combuſtible body, having a greater affinity with oxigene than arſenic has, in conſequence of its poſſeſſing that property, cauſes the oxide of arſenic to return to the metallic ſtate. To ſucceed in reducing oxide of arſenic, it muſt be made into a powder, and baked into a paſte with black ſoap: this paſte is to be put into a matraſs, and placed on a ſand bath; a moderate heat muſt at firſt be applied, in order to dry up the oil: when humid vapours ceaſe to exhale, the fire muſt be increaſed in order to ſublime the arſenic; the matraſs is then to be broken, and the upper part of it is found to contain a cake, having the appearance and metallic luſtre of arſenic: moſt of the carbonaceous matter of the oil remains at the bottom of the matraſs.

Arſenic, when expoſed to the air, becomes ſenſibly black. Vitrified oxide of arſenic, on ſuch an occaſion, loſes its tranſparency, and acquires a lacteous appearance, ſuffering at the ſame time a ſort of efflorеſcence.

Arſenic does not appear to be liable to ſuffer from the attacks of water, but its oxide is readily diſſolved in that menſtruum: Warm water diſſolves rather leſs of it than cold: The ſolubility of this ſubſtance varies alſo according as it has been more or leſs perfectly oxidated. When a ſolution of oxide of arſenic is ſlowly evaporated, it gives yellowiſh cryſtals in triangular pyramids: no other metallic oxide is known to diſſolve ſo readily in water. This property of oxide of arſenic, together with its ſapidity, renders it not very different in nature from ſaline matters.

Oxide of arſenic unites readily enough with earth by fuſion; it becomes fixed with them, and accelerates their vitrification: but all glaſſes into the compoſition of which it enters are liable to be very ſoon ſullied in the air. It is not known in what manner the ſalino terreous ſubſtances act on arſenic and on its oxide. The cauſtic fixed alkalis, though they do not act in any ſenſible manner on arſenic, diſſolve its oxide very readily. Macquer, in his ingenious experiments on this matter, (*Academ. Mem.* 1746,) has obſerved, that when powdered oxide of arſenic is boiled in liquor of fixed nitre, or a ſolution of cauſtic potaſh, it is completely diſſolved, and forms a brown gelatinous fluid, the conſiſtency of which gradually thickens. This compound, to which he gives the name of *liver arſenic*, is not ſuſceptible of cryſtallization: it becomes hard and brittle: it is liable to deliquiate, and ſoluble in water: ſome brown flakes are precipitated when it is diſſolved: When urged by a ſtrong fire, liver of arſenic loſes the arſenic which it contains. Acids decompoſe it: Soda mixed in the ſame manner with arſenic, ex-

exhibits the ſame effects; but its ſolution afforded Macquer irregular cryſtals, the form of which he found it impoſſible to determine.

The ſulphuric acid cold, even though it be concentrated, produces no effects on arſenic; but when boiled with this ſemi-metal in a retort, the acid gives out a good deal of ſulphureous gas; after that, a little ſulphure is ſublimed, and the arſenic is then found to be reduced to an oxide, but without being diſſolved. The ſulphuric acid likewiſe diſſolves oxide of arſenic when it is concentrated and boiling; but when the ſolution cools, the oxide is totally precipitated. When it enters into this combination, it becomes fixed in a very conſiderable degree. Bucquet aſſerts, that when it is entirely freed of the acid by lixiviation, it regains all its original properties.

The nitric acid, when applid to arſenic, acts vigorouſly upon it, and reduces it to an oxide. When aſſiſted by a moderate heat, the ſame acid likewiſe diſſolves oxide of arſenic in a pretty conſiderable proportion: though ſaturated with either of theſe ſubſtances, it retains its natural ſmell: when violently evaporated, it produces a ſalt which, according to Bucquet, has no regular form, but is ſaid by M. Baumé to be partly cubic and partly cut into diamond points. Wallerius ſays its cryſtals reſemble thoſe of nitrate of ſilver. Nitrate of arſenic powerfully attracts the moiſture of the air: it does not detonize on the coals, nor is it liable to decompoſition by water or acids: the alkalis do not cauſe it to yield a precipitate; yet, according to Bucquet, they decompoſe it, for when a nitric ſolution of arſenic, mixed with an alkaline lixivium, is evaporated, common nitrate and arſeniate of potaſh is obtained. We will hereafter ſee, that chemiſts, being all very much

much perplexed with the ſingular nature of the ſolutions of arſenic and oxide of arſenic in acids, never diſcovered what paſſed when this oxide was combined with the nitric acid, nor once ſuſpected the production of the arſenic acid. Here we would only remark, that the oxide of arſenic deprives the nitric acid of a great part of its oxigene.

The muriatic acid, with the help of fire, diſſolves both arſenic and its oxide, according to Bucquet. Either fixed or volatile alkali is capable of precipitating this combination. M. Baumé ſays, that regulus of arſenic is ſoluble in the boiling muriatic acid, and afterwards is precipitated in a yellow powder, reſembling ſulphur. Meſſ. Bayen and Charlard, in their experiments on tin, have eſtabliſhed it as a fact, that, when cold, the muriatic acid is entirely incapable of acting on arſenic; and that when warm, it acts on it but very faintly, in a manner ſcarcely diſcernible.

We are perfectly ignorant how the other acids affect arſenic or its oxide. A mixture of arſenic with nitre, put into a red hot crucible, gives a ſmart detonation: the nitric acid calcines and burns the ſemi-metal. The fixed alkali, which was the baſe of the nitre, and the oxidated arſenic, combined in part with the fixed alkali, are found in the crucible after the operation.

A mixture conſiſting of equal parts of oxide of arſenic and nitre, diſtilled in a glaſs retort, gives ſpirit of nitre in very red vapours. The acid cannot be condenſed till a little water be put into the ball of the retort, which gives it a blue colour. Beccher, Stahl, and Kunckel, have deſcribed this operation. Macquer repeated it with care; and on examining the reſidue of which thoſe chemiſts had made no mention, found it to be a peculiar neutral ſalt, and has given it the name of of *arſenical neutral ſalt;* it ſhould be called arſeniate of potaſh. When this ſalt is diſſolved in water, and the ſolution evaporated in the air, it gives very regular cryſtals in tetrahædral priſms, terminating in pyramids with four equal faces. The form of the cryſtals ſometimes varies.

When arſeniate of potaſh is expoſed to fire, it eaſily melts, and remains in a ſtate of fuſion without being alkalized, and without loſing any part of its arſenic by volatilization; from air it ſuffers no ſenſible alteration. It is much more ſoluble in water than pure oxide of arſenic; and more of it diſſolves in hot than in cold water.

None of the acids decompoſes it pure; but what they cannot effect pure, they can perform by double affinity. If a ſmall portion of ſulphate of iron or *martial vitriol* be mixed with a ſolution of this ſalt, a double decompoſition and a double combination follow. The ſulphuric acid forſakes the iron in order to combine with the potaſh, and the arſenic acid is ſeparated from the alkali, and combines with the iron oxide. Combuſtible matters decompoſe arſeniate of potaſh with great energy.

The oxide of arſenic likewiſe decompoſes nitrate of ſoda by diſtillation, forming with its baſe arſeniate of ſoda, which, according to Macquer, is very little different from arſeniate of potaſh, and cryſtallizes preciſely in the ſame manner. This oxide acts in the ſame way on ammoniacal nitrate, and combines with its baſe to conſtitute ammoniacal arſeniate. It was thought that a great many precautions were neceſſary in performing this operation, becauſe in cloſe veſſels ammoniacal nitrate detonizes by itſelf: but M. Pelletier has proved, that even ſeveral pounds of it may be made together without any danger. Macquer's diſcovery of the arſeniacal neutral ſalt led the way to the diſcovery of the arſenic acid; for that illuſtrious perſon obſerved and aſſerted that the oxide of arſenic acted the part of an acid in this ſalt. But it is to Scheele, as we ſhall hereafter mention, that we are really indebted for an accurate knowledge of thoſe new combinations.

Oxide of Arſenic does not decompoſe alkaline muriates. Like arſenic itſelf, it ſeparates ammoniac from ammoniacal muriate, but not without great difficulty.

The action of combuſtible mineral matters on arſenic has not yet been examined. It appears, that the oxide of this ſemi-metal may be reduced by hydrogenous gas, which has more affinity than arſenic with oxigene, or the baſe of vital air.

Oxide of arſenic combines very readily with ſulphur. When theſe two ſubſtances are melted together, they form a yellow or red volatile body, the taſte of which is rather weaker than that of pure oxide of arſenic, but which is not more ſoluble in water than that ſubſtance. This yellow ſulphurated oxide of arſenic has been called *factitious orpin* or *orpiment :* It cryſtallizes in triangular figures like vitreous oxide of arſenic. When red it is called *realgal*, *realgar*, *factitious rizigal* or *red arſenic.* The name which we give to this compound is red ſulphurated oxide of arſenic. Some chemiſts have imagined it to differ from the yellow or orpiment only in containing more ſulphur; but Bucquet has ſhown, that the compound of ſulphur and oxide of arſenic becomes red after being melted; for to expoſe orpiment to a pretty ſtrong heat is all that is neceſſary to make it paſs into the ſtate of *realgar.* I am convinced that realgar is far from being ſo volatile as orpiment; for when this mixture of oxide of arſenic and ſulphur is ſublimated

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in a matraſs, red ſwollen laminæ are found at the bottom; which appear evidently to have been melted. There is no difference between artificial orpiment and realgar and the ſame ſubſtances natural. They are liable to be decompoſed by lime and the alkalis, which have a greater affinity with ſulphur than the oxide of arſenic has: yet this oxide, like the acids, poſſeſſes the property of decompoſing alkaline ſulphures.

All the properties of the oxide of arſenic concur to ſhow, that when this ſemi-metallic combuſtible matter is united with the baſe of vital air, it acquires the character of a ſaline ſubſtance: The theory which we laid down when treating of ſalts in general is therefore confirmed by theſe facts. Macquer, in his valuable diſcoveries concerning arſeniate of potaſh, obſerved, as was before mentioned, that oxide of arſenic acted the part of an acid in the compoſition of that ſalt: but it was hard to conceive, how that oxide, when diſſolved in potaſh without any intermedium, could differ ſo conſiderably from the combination of the ſame ſubſtances produced by decompoſing nitre with oxide of arſenic.

The diſcovery of the oxigenated muriatic acid ſuggeſted to Scheele, that ſomething analogous might happen when nitre was diſtilled with oxide of arſenic. The nitric acid, he imagined, ſeized what phlogiſton ſtill remained in the oxide; upon which the oxide was left in the ſtate of the peculiar acid which we call the arſenic acid. He prepared this acid by a proceſs analogous to that by which he produced the oxigenated muriatic acid. One part of that proceſs conſiſted in diſtilling a mixture of the oxigenated muriatic acid with oxide of arſenic. According to him, the muriatic acid then ſeizes the phlogiſton of the oxide, leaving it in the ſtate of an acid. The arſenic acid may be alſo prepared by diſtilling ſix parts of nitric acid upon one of its oxide. The acid gives out a good deal of nitrous gas; and the oxide of arſenic aſſumes the character of an acid. It muſt be expoſed for a conſiderable time to a ſtrong heat, in order that the ſuperfluous nitrous gas may be diſengaged.

What happens in theſe operations is conſiderably in favour of the modern doctrine. In fact, on one hand, one can ſcarce agree with Stahl in acknowledging the exiſtence of phlogiſton in oxide of arſenic; and again, nothing can be more natural than the manner in which the modern doctrine repreſents this oxide as paſſing from an oxide to an acid by the influence of ſpirit of nitre, or the oxigenated muriatic acid. Oxide of arſenic appears to have a great affinity with oxigene, when it is not already ſaturated with it. When diſtilled with the nitric, or the oxigenated muriatic acid, it deprives either of theſe acids of its oxigene. The more oxigene it contains, the nearer does it approach in nature to ſaline ſubſtances; and when fully ſaturated it acquires all the diſtinguiſhing properties of acids; which, as we have ſhown above, are nothing but combuſtible matters combined with oxigene, which communicates to them their ſaline properties. From this theory it may be eaſily underſtood why oxide of arſenic, when not ſaturated with oxigene, but ſimply oxidated by fire, does not form arſeniate of potaſh; and why it never compoſes that ſalt till after being previouſly treated with the acids which it decompoſes, by depriving them of their oxigene with the help of heat.

The arſenic acid is very different from common oxide of arſenic. Its ſapidity is ſtronger. Fire fixes it; and this proceſs is employed to ſeparate it entirely from any remainder of oxide of arſenic which it may ſtill retain. It is doubtleſs by acquiring the properties of an acid that oxide of arſenic becomes of a fixed nature when combined with the ſulphuric acid. That acid cauſes it to melt into a tranſparent glaſs: it communicates its fuſibility to earthy matters; and it even appears capable of corroding glaſs. It communicates a faint red tinge to blue vegetable colours. I have obſerved, that, when expoſed to the air, it loſes its tranſparency, waſtes away in ſcaly fragments, which are generally pentagonal, and gradually attracts moiſture. It diſſolves in two parts of water: It combines readily with lime,—and with barytes and magneſia, but with more difficulty. With the alkalis it forms neutral ſalts, which, according to Bergman, are decompoſed by lime. The ſame chemiſt informs us, that barytes and magneſia have likewiſe a greater affinity with this acid than the alkalis: but a great many more experiments muſt be made before we can be fully acquainted with all the properties of the arſenic acid. M. Pelletier prepared this acid by decompoſing ammoniacal nitrate with oxide of arſenic. The ammoniacal arſeniate thus formed was deprived of its ammoniac by heat; and after it had been for ſome time expoſed to the action of fire, the arſenic acid remained pure and ſolitary in the bottom of the retort.

Bergman obſerves, that the ſpecific gravity of arſenic varies from that which diſtinguiſhes it in the metallic ſtate, to that which belongs to it when an acid: The following are the gravities which he aſcribes to it in its various modifications: regulus of arſenic 8,308: vitreous oxide of arſenic, 5,000: white oxide of arſenic 3,706: arſenic acid, 3,391.

Arſenic is made uſe of in ſeveral of the arts, more eſpecially in dyeing. Arſeniate of potaſh is likewiſe uſed; and M. Baumé has long manufactured it for the purpoſes of the arts.

The facility with which oxide of arſenic diſſolves in water, or any aqueous fluid, renders it a very dangerous poiſon. The following ſymptoms appear when a perſon has taken this poiſon: His mouth becomes dry, his teeth are ſet on edge, and his throat contracted; he has an involuntary ſalivation, and an acute pain in his ſtomach: he feels an extreme thirſt and nauſeas, and vomits ſlimy bloody matters: he feels at the ſame time very intenſe colic pains; his body is bedewed with a cold ſweat, and he is agitated with convulſions. Theſe ſymptoms are ſoon followed by death; and oxide of arſenic is known certainly to have been the cauſe by examining the aliments in which it is ſuſpected to have been given. The preſence of the poiſon is determined by drying part of thoſe aliments, and throwing it on burning coals: if impregnated with arſenic it exhales a white ſmoke, having a ſtrong ſmell of garlic.

It was formerly the practice to make perſons poiſoned with arſenic drink milk, or ſome mucilaginous liquid or mild oil, with a deſign to relax the viſcera, and to diſſolve and carry off moſt of the arſenical poiſon. Navier, a phyſician at Chalons, who has laboured to diſcover ſome remedy capable of counteracting the poiſonous effects of oxide of arſenic, has found a matter which combines with this ſubſtance in the humid way, ſaturates it, and almoſt totally diveſts it of its cauſticity. That ſubſtance is calcareous or alkaline ſulphure; and this ſulphure is ſtill better for the purpoſe if it be impregnated with a little iron. A ſolution of oxide of arſenic decompoſes ſulphures without exhaling any ſmell: the oxide combines with the ſulphur to form orpiment, entering at the ſame time into union with

with the iron, if the ſulphure contain any. Navier preſcribes a dram of *liver of ſulphur* in a pint of water, to be taken in glaſſes, or five or ſix grains of dry ſulphure of potaſh in pills, with a glaſs of warm water above each pill. When the firſt ſymptoms are removed, he recommends the uſe of ſulphureous mineral waters. From his own experience he informs us, that they have very happy effects in removing the tremors and paralytic affections, which are the uſual conſequences of taking arſenic, and end in conſumption and death. Navier likewiſe approves of the uſe of milk, becauſe it diſſolves oxide of arſenic as well as water; but diſapproves of oils, becauſe they do not diſſolve it.

CHAP. VII.

Of Molybdena, and the Molybdic Acid.

WE give the name of *molybdena* to a new ſemi-metal diſcovered by M. Hielm, which is obtained from the mineral ſubſtance known by the ſame name. This ſubſtance is not to be confounded with common *lead ore*, plumbago, or the matter of the black pencils uſed in drawing, which is at preſent known under the peculiar name of *carbure of iron*. The confounding of theſe matters has produced that contrariety which appears in the reſearches of all the chemiſts who have examined them from Pott to Scheele. It is to be obſerved, that *carbure* of iron or *plumbago* is much more common than molybdena, of which there are but a very few ſpecimens in the cabinets of the curious; and that therefore the experiments of chemiſts, except thoſe of Meſſrs Quiſt and Scheele, have been almoſt always made on the former.

It is very difficult to diſtinguiſh the one from the

other

other by external appearance. Molybdena, however, feels rather more greaſy than the other ſubſtance: it conſiſts of hexagonal ſcaly laminæ of various ſizes, and ſcarce adhering together. It ſpots the fingers, and leaves bluiſh or ſilver grey marks upon paper. When reduced to a powder,—which; however, its elaſticity renders difficult to be done—the powder is bluiſh: it may be cut with a knife; it does not break into pieces, nor has a granulated contexture like plumbago. Scheele's proceſs for pulveriſing ore of molybdena was, to throw a little ſulphate of potaſh into a mortar together with this ore, and afterwards to waſh the powder with warm water, which carried off the ſalt, leaving the ore pure. The analyſis of this ore, effected in various ways, ſhows it to be a compound of ſulphur with the ſemi-metal which we are conſidering: but it is very difficult to obtain the ſemi-metal ſeparate. The illuſtrious Scheele could not reduce this ſemi-metal, either with black flux and coal, or with borax and coal, or with oil. Bergman informs us, that M. Hielm was more ſucceſsful, and obtained ſo much of the ſemi-metal as to be able to diſtinguiſh its properties; but ſince that, M. Hielm has publiſhed nothing concerning the matter himſelf.

M. Pelletier, in his experiments concerning the reduction of the oxide of molybdena, and the nature of the molybdic acid, could never obtain a lump of molybdena; what he obtained was a friable, blackiſh, agglutinated matter, of a metallic luſtre: through a magnifier, it appeared to conſiſt of ſmall, round, grey, ſparkling grains, which M. Pelletier takes to be the metal, or pure molybdena. Manganeſe has never yet been obtained in any other form but that of ſmall grains. The following are the properties which this ſemi-metal has been found to poſſeſs. It is grey, and conſiſts of ſmall agglutinated brittle grains, which are very infuſible. When heated in the air, it is converted into a white volatile oxide, which, like oxide of antimony, cryſtallizes by ſublimation into ſparkling needled priſms. This oxide becomes acid when it is ſuperſaturated with oxigene, forming that ſaline product which is ſo well known from Scheele's reſearches. The nitric acid eaſily calcines molybdena, converting it into a white oxide, or even into the molybdic acid. Oxide of molybdena becomes blue and ſparkling when it is reduced to a metallic ſtate. Alkalis, with the help of heat, oxidate and diſſolve this ſemi-metal. It may be mixed with lead, copper, iron, and ſilver; the mixtures thus made up are granulated, greyiſh, and very friable. Laſtly, in union with ſulphur, it forms ſulphure of molybdena; a compound which is entirely the ſame with the ore of this metal, improperly known by the name of *molybdena and potelot.* As this laſt is the ore on which Scheele made his experiments, and as it is from this mineral, which is much better known than the metal which it contains, that he prepared the molybdic acid, we ſhall examine its properties more particularly.

When native *potelot*, or ſulphure of molybdena, is expoſed to fire in an open veſſel, it exhales ſulphur, and evaporates almoſt totally in white ſmoke. When heated in a ladle with the blow-pipe, it gives out the ſame ſmoke; which is condenſed into yellowiſh cryſtalline laminæ, and aſſumes a blue colour when brought into contact with combuſtible bodies. M. Pelletier, upon calcining ſulphure of molybdena in a crucible, with ano-

another crucible covering it, obtained white ſparkling needled cryſtals, reſembling that matter which is called *ſilver flowers of antimony*. This ſublimated oxide of molybdena poſſeſſes all the diſtinguiſhing characteriſtics of an acid; but this would be too tedious, and too expenſive, a proceſs for the preparation of the molybdic acid.

The ſaline earths and the fixed alkalis, when melted with ſulphure of molybdena, diſſolve both the ſulphur and the metal.

Several of the acids produce remarkable alterations on this ore. The ſulphuric acid, concentrated, reduces the metal to an oxide, giving out a quantity of ſulphureous acid by the way of ebullition.

The muriatic acid has no power of acting on this mineral.

The acid of arſenic, when diſtilled with ſulphure of molybdena, is robbed of its oxigene, which combines with the ſulphur to form ſulphureous acid, volatilizes into *orpiment* with the remaining part of the ſulphur, and changes part of the molybdena into molybdic acid, leaving, however, moſt of it ſtill in the metallic ſtate. From this experiment M. Pelletier concluded, that molybdena is in the metallic ſtate in its ore.

On diſtilling 30 ounces of nitric acid, diluted in water with an ounce of molybdena at 5 different times; that is, 6 ounces of the acid at a time, a great quantity of nitrous gas is diſengaged, and there remains in the retort a white powder; which muſt be waſhed with a ſufficient quantity of cold diſtilled water, in order to carry off what remains of the extraneous acid, and is ſoluble at that temperature: ſix drams and an half of pure molybdic acid remains after this edulcoration.

Scheele, to whom we owe this diſcovery, gives it as his opinion, that the nitric acid on this occaſion ſeizes the phlogiſton, and flies off in red vapours. It likewiſe burns the ſulphur of the molybdena; for which reaſon, the water uſed in waſhing the acid of molybdena contains ſulphuric acid, which may be obtained by evaporation in a concentrated ſtate, ſtill retaining, however, a little molybdena in ſolution: that ſubſtance communicates to the evaporated liquid a ſparkling blue colour. My opinion is, that in this inſtance, and in all others in which nitric acid, being diſtilled on any ſubſtance, reduces it to an acid, the nitric acid is decompoſed; and that the diſengagement of the nitrous gas, and the formation of the ſulphuric and the molybdic acids, are owing to the oxigene of the nitric acid being ſeparated and fixed in the molybdena.

The molybdic acid obtained by the ſame proceſs is in the form of a white powder; its taſte faintly acid and metallic. When heated in a ladle with the blowpipe, or in a crucible with acceſs of air, it is volatilized in a white ſmoke, which condenſes into needled cryſtals, and part of it fixes on the ſides of the crucible. Even after edulcoration it retains a portion of ſulphureous acid: which may, however, be completely diſengaged from it by the application of a ſtrong heat.

This acid is ſoluble in boiling water; Scheele diſſolved a ſcruple of it in 20 ounces of water. The taſte of this ſolution is ſingularly acid, and almoſt metallic: it reddens tincture of turnſole, decompoſes a ſolution of ſoap, and precipitates alkaline ſulphures, or *livers of ſulphur:* it becomes blue, and loſes its conſiſtency when expoſed to cold.

The concentrated ſulphuric acid, with the help of heat,

heat, diſſolves a large proportion of the molybdic acid. This ſolution, when cooled, becomes thick, and aſſumes a beautiful blue colour. Theſe two phænomena may be cauſed to diſappear by heating, but they appear again when the liquor is again cooled. If this combination be expoſed to an intenſe heat in a retort, the ſulphuric acid will volatilize, leaving the molybdic acid dry in the bottom of the veſſel.

The nitric has no power of acting on the molybdic acid.

The common muriatic acid diſſolves a large proportion of it. This ſolution affords a deep blue reſidue when it is diſtilled to dryneſs: the reſidue, if urged with heat, is ſublimed, and one part of the ſublimate is white, the other bluiſh. The ſublimate is liable to deliquiate, and tinges metals: the muriatic acid is oxigenated when it paſſes into the receiver. It is eaſy to conceive, that in this operation the muriatic acid deprives the molybdic of part of its oxigene; and of conſequence part of the molybdic acid paſſes into the ſtate of molybdena.

The molybdic acid, with the help of heat, decompoſes the alkaline nitrates and muriates, by diſengaging their acids, and combines with their baſes to form neutral ſalts; the properties of which Scheele has not fully examined. This acid likewiſe diſengages the carbonic acid from the three alkalis, and forms neutral ſalts with their baſes.

Though Scheele does not make us acquainted with all the properties of theſe neutral ſalts, to which we give the names of *molybdates of potaſh*, *of ſoda*, *of ammoniac*, *&c.*; yet he takes notice of three of them, which may be uſed as general characteriſtics. He has obſerved, 1. That fixed alkali renders the molybdic acid

cid earth more ſoluble in water. 2. That the ſame ſalt hinders the molybdic acid from being volatilized by heat. 3. That molybdate of potaſh is precipitated by cooling in ſmall granulated cryſtals; and that it may be alſo ſeparated from its ſolvent by the ſulphuric and the muriatic acids.

The molybdic acid decompoſes barytic ſulphate and nitrate. The barytic molybdate formed on theſe occaſions is ſoluble in water.

The molybdic acid appears to decompoſe ſulphate of potaſh in part; and diſengages from it by a ſtrong heat a little ſulphuric acid.

The molybdic acid diſſolves ſeveral metals, and aſſumes a blue colour, in proportion as it gives up to them a part of its oxigene. It precipitates various metallic ſolutions, &c.

CHAP. VIII.

Of Tungſten, and the Tunſtic Acid.

THAT mineral which the Swedes call *tungſten*, and to which ſeveral naturaliſts, and particularly Bergman in his Sciagraphy, have given the name of *ponderous ſtone, lapis ponderoſus*, has been conſidered by Cronſtedt as an iron ore, and has received from him the denomination of *ferrum calciforme, terrâ quâdan incognitâ intime mixtum.* Moſt of the German naturaliſts have reckoned it among the tin ores, under the name of *white tin cryſtal*, or *zinn-ſpath ;* and in almoſt all cabinets of natural hiſtory it is ranked as a kind of tin.

No ſtrict analyſis of this mineral had been made before Scheele attempted it. That chemiſt, on examining this pretended tin ore, diſcovered it to conſiſt of a peculiar acid in combination with lime. Bergman made a ſeries of experiments on this matter with the ſame reſults. This diſcovery was made in the year 1781. Thoſe two Swediſh chemiſts were induced, from

from an examination of the properties of this mineral, to think the acid which they found it to contain of a metallic nature.

Since that period, Meſſrs D'Elhuyar of the Royal Society of Biſcay, M. Angulo of the Academy of Valladolid, and M. Crell, have repeated the Swediſh chemiſts' experiments with the ſame reſults. From what we have already ſaid of this natural ſalt and its acid, the reader will have perceived, that what the Sewedes call *tungſten*, is a ſalt formed by the union of the tunſtic acid with lime: we apply the name *tungſten* to the ſemi-metal which appears to be the baſe of the acid, calling this ſpecies of ore *tunſtate of native lime.*

Meſſrs d'Elhuyar of the Biſcayan Society, have diſcovered, that *wolfram,* which was formerly thought to be an ore of poor iron, is a combination of the tunſtic acid with iron and manganeſe. They have obtained a peculiar regulus of this mineral. The wolfram which they have analized was from the tin-mine of Zinwalde. It appears in compreſſed hexahædral priſms; it has the metallic luſtre; its fracture is foliated; and it may be cut with a knife. It contains in the hundred weight 22 parts of black oxide of manganeſe, 12 of oxide of iron, 64 of tunſtic acid, and 2 of quartz. Native tunſtate of lime from Schleckenwelde in Bohemia contains, according to thoſe gentlemen, 68 pounds of tunſtic acid and 30 of lime.

Such are the two known ores of the new ſemi-metal which we call *tungſten.* Meſſrs d'Elhuyar melted one part of wolfram with four parts of carbonate of potaſh; they lixiviated that mixture; the water diſſolved the tunſtate of potaſh; and, with the nitric acid, they precipitated the tunſtic acid in a yellow powder. This precipitate, when put into a crucible with charcoal, and urged with fire, afforded a metallic button, conſiſting of a number of ſmall friable globules. The following are the properties which they obſerved in this new ſemi-metal: Its ſpecific gravity was conſiderable, but never above 17.6; it appeared to be very infuſible, even more ſo than manganeſe; it was inſoluble in the three ſtrongeſt acids, and even in the nitro-muriatic acid; it entered readily into combination with ſome metals, particularly with iron and ſilver, on the properties of which it produced a ſingular change: it was eaſily reduced to an oxide, and its oxide was yellow, but changed to blue when expoſed to heat, and was inſoluble in acids, but ſoluble in alkalis, and remained diſſolved in water, when triturated with it, in imitation of an emulſion. Though ſome of theſe characteriſtics be analogous with thoſe of molybdena, as Bergman and Scheele had before obſerved in their experiments on the molybdic acid; yet taken all together, they may be allowed to diſtinguiſh tungſten as a peculiar ſemi-metal. But many more experiments than have yet been made are neceſſary to make us fully acquainted with its properties. Thoſe chemiſts who have turned their views to this object, have made many more experiments on native tunſtate of lime than on the ſemi-metal obtained from it by Meſſrs d' Elhuyar. In order to give a full account of their diſcoveries concerning this mineral, it will be neceſſary for us to inſiſt for ſome time on its properties.

Native tunſtate of lime is ſtill but very ſcarce. It is found in the iron mines of Bitſberg, and in the tin-mines of Schleckenwalde in Bohemia; and moſt of the white tin cryſtals of Sauberg, near Ehrenfriendersdorf are tunſtate of lime. Beſides, on aſſaying the white tin cryſtals preſerved in cabinets, in a way which we ſhall deſcribe, we find among them ſome ſpecimens of this ſubſtance, which were not before ſuſpected to be ſuch.

Tunſtate of lime ſuffers no ſenſible alteration from heat: the action of the blow-pipe makes it decrepitate, and fall into duſt, but does not melt it. A blue flame gives it a faint colour; but nitre diveſts it of that colour.

Boiling water has no power of acting on this metallic ſalt in powder; and it is abſolutely inſoluble. The action of air, earths, the ſalino-terreous ſubſtances, and the cauſtic alkalis on this ſalt, has not yet been attended to.

When the ſulphuric acid is heated and diſtilled on tunſtate of lime, it paſſes without ſuffering any alteration; the reſidue aſſumes a bluiſh colour; when lixiviated in boiling water,. it affords a little calcareous ſulphate; which proves that this ſubſtance contains lime, and that the ſulphuric acid decompoſes but a very ſmall part of it.

The weak nitric acid acts on this ſalt with the help of heat, but without producing any diſcernible effervefcence. This acid communicates to it a yellow colour, by which it is diſtinguiſhed from real tin ore, and decompoſes it by abſtracting the lime. About twelve parts of nitric acid in the ſtate of common aquafortis, are required to effect the entire decompoſition of one part of calcareous tunſtate. Scheele, in performing this operation, applied the nitric acid, not all at once, but at ſeveral different times. After obſerving the action of three parts of the weak nitric acid on one of this neutral ſalt, he poured upon it two parts of cauſtic ammoniac;

niac; the powder which the weak nitric acid turned yellow was rendered white by the alkali: he continued to apply the acid and the alkali ſucceſſively till the calcareous tunſtate was entirely diſſolved. From four ſcruples which he ſubjected to this proceſs he had three grains of a reſidue, which appeared to him to be pure ſiliceous earth. On precipitating the nitric acid employed in this operation by pruſſiate of potaſh, and afterwards by potaſh, he obtained two grains of pruſſiate of iron, or Pruſſian blue, and fifty-three grains of chalk: the ammoniac being combined with the nitric acid afforded an acid precipitate. In this experiment the nitric acid decompoſes the calcareous tunſtate by ſeizing the lime; and the tunſtic acid thus ſeparated is attracted by the ammoniac. The ammoniacal ſalt formed by this laſt ſolution is decompoſed by the nitric acid, which has a greater affinity with the ammoniac than the ammoniac has with the tunſtic acid. This laſt acid being much leſs ſoluble than ammoniacal nitrate, is precipitated gradually, as it is left at liberty, in the form of a white powder. That powder muſt be lixiviated with cold diſtilled water, in order that the tunſtic acid may be obtained very pure.

This acid may likewiſe be obtained by a different proceſs, which Scheele employed with the ſame ſucceſs. One part of native calcareous tunſtate in powder with four parts of carbonate of potaſh are melted together in an iron crucible; the maſs is lixiviated with twelve parts of boiling water; nitric acid is poured upon it till it ceaſe to effervеſce; it is again melted with four parts of carbonate of potaſh, and again lixiviated with water, and treated with nitric acid till it ceaſe to effervеſce: there now remains nothing but a little ſiliceous earth, all the tunſtic ſalt being de-

compoſed.

compoſed. In fact, during the fuſion, the potaſh is united with the tunſtic acid, forming with it a peculiar neutral ſalt; while the carbonic acid, combining with the lime, converts it into chalk. When the melted maſs is lixiviated, the water diſſolves the tunſtate of potaſh, which is much more ſoluble than chalk, and the chalk remains alone. The nitric acid employed after the water diſſolves the chalk with efferveſcence, without affecting that portion of the calcareous tunſtate which the four former parts of the alkali have failed to decompoſe. At the ſecond operation, the ſalt having been completely decompoſed by the four former parts of carbonate of potaſh, the nitric acid carries off all the chalk; ſo that by means of the eight parts of fixed alkali and a little aquafortis ſucceſſively applied, the principles of the calcareous tunſtate are entirely ſeparated; its acid is united with the potaſh, and its lime with the nitric acid. On precipitating the calcareous nitrate by potaſh, we learn what quantity of lime was contained in the calcareous tunſtate ſubmitted to the proceſs; all that now remains to be done is, to ſeparate the tunſtic acid from the fixed alkali. To effect that, the proceſs deſcribed in the former experiment is employed. A ſufficient quantity of nitric acid is poured into the lixivium of the melted mixture of tunſtate of lime with carbonate of potaſh: The lixivium becomes turbid, and thickens; becauſe as the nitric acid has a greater affinity than the tunſtic with the fixed alkali, the tunſtic acid is precipitated in powder, while the liquor ſtill retains the nitre in ſolution. The precipitate is waſhed with cold water; and the tunſtic acid is then obtained pure in the form of a white powder, as in the former operation. This proceſs is even preferable to the former, as being eaſier, and leſs expenſive.

The muriatic acid acts on calcareous tunſtate in the ſame manner as the nitric acid, decompoſing it with equal energy; and as it communicates to it a yellower colour, Bergman recommends the uſe of it, for aſſaying and examining this earthy ſalt.

The tunſtic acid obtained by any one of theſe three proceſſes, appears, as we have already mentioned, in the form of a white powder. When expoſed to the action of the blow-pipe, it becomes yellow, brown, or black; but without melting or being volatilized. It diſſolves in 20 parts of boiling water. The ſolution has an acid taſte, and reddens tincture of turnſole.

The tunſtic acid appears to form with barytes a ſalt which is abſolutely inſoluble in water; with magneſia it forms another ſalt ſcarcely ſoluble.

When a ſolution of this acid is poured into lime water, it produces a ſmall portion of precipitate, which may be conſiderably increaſed by applying heat. Scheele thinks this precipitate to be regenerated calcareous tunſtate.

The tunſtic acid, when ſaturated with potaſh, affords a ſalt, which is precipitated in very ſmall cryſtals, the form of which is not certainly known. Scheele ſays nothing of the combination of this acid with ſoda. According to him, it forms with ammoniac a ſalt in ſmall needles. When this ammoniacal tunſtate is expoſed to heat in a retort, the ammoniac eſcapes, and the tunſtic acid remains in a dry yellowiſh powder: the ſame ſalt decompoſes calcareous nitrate to form tunſtate of lime.

When the tunſtic acid is heated with the ſulphuric acid, it aſſumes a bluiſh colour; with the nitric and the muriatic acids it changes to a citron yellow: it communicates

nicates a green colour to alkaline ſulphure, and precipitates it. Scheele has not determined to what cauſes theſe changes of colour are owing.

That chemiſt, obſerving that the tunſtic acid is eaſily coloured by combuſtible bodies, as alſo that, like borax, it communicates a blue colour to vitreous fluxes, heated this acid with lintſeed oil in a crucible: but he obtained no metal by this proceſs, only the acid was blackened. Bergman, however, concludes from the gravity of this acid being ſo conſiderable, from its colouring inflammable bodies, and from its being liable to precipitation by Pruſſian of potaſh, or Pruſſian alkali, that it is originally of a metallic nature.

We have mentioned the proceſs by which Meſſrs d'Elhuyar reduced the tunſtic oxide obtained from Wolfram into metallic globules; and the metallic nature of this acid can no longer be conſidered as problematical.

CHAP. IX.

Of Cobalt.

COBALT or cobolt is a ſemi-metal of a white colour, inclining a little to red, of a fine cloſe grain, very brittle, and eaſily reducible to powder by the action of a peſtle. In the hydroſtatic balance, it loſes about an eighth part of its weight. Its ſpecific gravity is, according to Bergman, about 7,700. It cryſtallizes in bundles of needles, arranged one over another.

Cobalt has never been found in nature in a pure and native ſtate; it is almoſt always in calx, and combined with arſenic or its acid, with ſulphur, with iron, &c. The following are the principal ſpecies of cobalt, diverſified by variety of combination, as they have been arranged by Bergman and Mongez.

1. Native cobalt united with arſenic. This is a ſolid, grey, ponderous ore, ſomewhat brilliant and granulated in its fracture: it gives fire with ſteel, and becomes black when expoſed to fire. The nitric acid diſ-

diſſolves it with efferveſcence; with the muriatic acid it forms a ſympathetic ink.

2. Cobalt in the ſtate of an oxide. This ore, which appears to be cobalt oxidated by acids, is commonly of a blackiſh grey colour, ſometimes reſembling lamp-black, generally friable, and pulverulent. It ſtains the fingers; when compact, its fracture exhibits roſe-coloured ſpots. Sometimes it reſembles the ſcoriæ of glaſs; a circumſtance which has led ſome naturaliſts to give it the name of *vitreous cobalt ore*. When this ore is pure it contains no arſenic; but it is often mixed with martial ochre.

3. Cobalt in combination with the acid of arſenic, *flowers of cobalt*, *red*, *roſe coloured*, or *coloured like peach bloſſoms*. The acid of arſenic which Bergman and M. Mongez have diſcovered in this ſubſtance, gives it its colour. This ore is either in maſſes or in powder, or in a ſtriated efflореſcence or in four-ſided priſms, with ſummits of two faces. In fire, it gradually loſes its colour as the arſenic acid is diſengaged.

4. Cobalt ore united with iron and the ſulphuric acid; *ſpecular cobalt ore*. It has been very improperly called *ſulphureous cobalt*; for it contains no ſulphur, but a little of the ſulphuric acid. This ore is white or grey, very brilliant, and the richeſt of all cobalt ores; it generally gives fire with ſteel.

5. Cobalt combined with ſulphur, arſenic, and iron. This mineral bears the name of *white* or *grey cobalt ore*; it is of a whitiſh grey colour, and cryſtallized in complete or truncated cubes, ſo as to form ſolid figures of fourteen, eighteen, or twenty-ſix facets. Its fracture is ſparry and lamellated. On its ſurface it ſometimes exhibits dendrites in leaves reſembling fern: In this ſtate

ſtate it is called *knit cobalt ore.* White cobalt ore is but ſeldom regularly cryſtallized, but its character may be always diſtinguiſhed by its whitiſh grey colour, its ſpecific gravity which is leſs than that of the preceding ſpecies, and the red efflorеſcence which almoſt always appears on its ſurface.

In aſſaying cobalt ore, it is firſt pounded and waſhed, and afterwards roaſted to ſeparate the arſenic. The cobalt remains in the ſtate of a lighter or deeper black oxide: this oxide is mixed with three parts of *black flux* and a little marine ſalt: it is melted in a covered crucible with the heat of a forge fire: when it is entirely melted, and the matter perfectly liquid, the crucible is then cooled; as it cools, the matter which it contains is gently ſtirred, in order to precipitate the ſemi-metal, which is accumulated in a button at the bottom of the veſſel. This button ſometimes conſiſts of two metallic matters, its upper part conſiſting of cobalt, and the under part of biſmuth: a ſlight blow with an hammer ſeparates the two.

Modern mineralogiſts, particularly Bergman and Mr Kirwan, propoſe the nitric acid for aſſaying cobalt ores. That acid diſſolves both iron and cobalt. Theſe matters are precipitated with carbonate of ſoda, and the precipitated cobalt is diſſolved by the acetous acid. Scheffer recommends the melting of cobalt ores with three parts of potaſh and five of powdered glaſs, as a good way of determining their colouring power.

In operations in the great way, cobalt is never obtained in the metallic form. After the cobalt ore is pounded and waſhed, it is next roaſted in a furnace which terminates in a long horizontal flue, ſerving inſtead of a chimney. In this flue the ſublimated oxide of arſenic is condenſed and melted into glaſs, which is ſold

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in commerce under the improper denomination of *white arſenic.* If the ore happen to contain a little biſmuth, that matter, being very fuſible, falls to the bottom of the furnace, and the cobalt remains in the ſtate of a dark grey oxide, which is called *zaffre.* The zaffre in commerce is never pure; it is mixed with a quantity of pulverized flint, amounting to three times its own weight. When this mixture is expoſed to an intenſe heat, it melts into a dark blue glaſs, known under the name of *ſmalt.* This ſmalt is ground to powder in mills, and diluted in water: the firſt portion which ſubſides, being larger grained, is called *coarſe azure;* the water is decanted off while it is ſtill turbid, and affords a ſecond precipitate; it is thus decanted for four times ſucceſſively, and at each time gives a finer precipitate than before; the laſt precipitate is the fineſt of all, and is improperly called *azure of four fires.* This azure is uſed in ſeveral of the arts for communicating a blue colour to metals and glaſſes, &c.

The *zaffre* of commerce, when melted with three times its own weight of black flux, a little tallow, and a little marine ſalt, affords the ſemi-metal improperly known by the regulus of cobalt. It is very difficult to reduce zaffre: A great quantity of flux muſt be employed, and care muſt be taken to keep the crucible long enough red hot, in order that the matter may become very fluid and ſettle, and in order too that the ſcoriæ may melt into a blue glaſs: the cobalt is then precipitated and accumulated under the ſcoriæ in a metallic button.

When cobalt is expoſed to fire, it does not melt till it becomes very red. This ſemi-metal is very difficult of fuſion, and appears very fixed in the fire: it is not known even whether it would be poſſible to volatilize it it in cloſe veſſels; but we know, that when ſuffered to cool ſlowly, it cryſtallizes into needled priſms, diſpoſed one over another, and bundled together: as M. Mongez has obſerved, they bear a pretty exact reſemblance to a maſs of baſaltes crumbled down into pieces. All that is neceſſary in order to ſucceed in effecting this cryſtallization is, to melt a quantity of cobalt in a crucible till it ſuffer a kind of ebullition, and then, taking the veſſel out of the fire, to ſet it upon one ſide, as ſoon as the ſurface of the ſemi-metal which it contains becomes fixed. This inclination of the veſſel cauſes that part of the metal which is ſtill in a ſtate of fuſion to run off, while that which adheres to the ſides of the veſſel in a kind of gæode, formed by the cooling of the ſurfaces of the cobalt, is fringed with priſmatic cryſtals piled together.

When melted cobalt is expoſed to the air, it is in a ſhort time covered over with a dark and duſky pellicle, which is nothing but an oxide of this ſemi-metal, formed by its combination with the oxigene of the atmoſphere. When a large quantity of oxide of cobalt is wanted, it may be produced more readily by reducing the ſemi-metal to a powder, and expoſing it in a ſhallow veſſel under the muffle of a cupelling furnace, ſtirring it conſtantly to change the ſurfaces. This powder, after being kept red hot for ſome time, loſes its brilliancy, gains an increaſe of weight, and becomes black. The utmoſt force of fire is requiſite to melt this black oxide of cobalt into a deep blue glaſs.

Cobalt is tarniſhed a little in the air, but ſuffers no injury from the attacks of water. This ſemi-metal does not combine with earths, but its oxide unites with them by fuſion to form a very fine blue glaſs, which no intenſity of fire can render volatile. This property of of oxide of cobalt renders that ſubſtance very uſeful in painting enamels, porcelain, and pottery.

We know not well in what manner barytes, magneſia, and lime act upon cobalt. Alkali diſſolved in water produces an evident alteration upon it; but the alterations which it ſuffers from the ſeveral alkalis have not yet been ſufficiently attended to.

All the acids diſſolve this ſemi-metal, but with various phænomena, according to the ſtate of the ſemi-metal and the ſtate of the acid.

The ſulphuric acid muſt be concentrated and boiling to diſſolve cobalt. This ſolution is effected in a glaſs phial or a retort. When the acid is almoſt totally evaporated into ſulphureous gas, the reſidue is waſhed; one part of it diſſolves in the water, communicating to it a roſe or a greeniſh colour; this is ſulphate of cobalt: the reſidue is cobalt oxidated by the acid, the oxigene of which has entered into combination with the ſemi-metal. M. Baumé aſſerts, that when the ſulphuric ſolution of cobalt is ſufficiently evaporated and cooled, it affords two ſorts of cryſtals; the one ſort ſmall, white, cubic cryſtals; the other ſpecies, ſquare greeniſh cryſtals, ſix lines in length, and four in breadth. The laſt of theſe he takes to be ſulphate of cobalt: the former owe their formation to ſome other metallic matters in union with the cobalt. The cryſtals of ſulphate of cobalt which are moſt frequently obtained in the form of ſmall needles, and which M. Sage deſcribes as rhomboidal, tetrahædral priſms, terminating in a dihædral ſummit, with rhombic faces, are liable to decompoſition by fire; the reſidue is oxide of cobalt, not reducible by itſelf. Barytes, magneſia, lime, and the three alkalis, likewiſe decompoſe this ſalt, and precipitate the cobalt in a roſe-coloured oxide: 100 grains of cobalt diſſolved in ſulphuric acid, afford, when precipitated by pure ſoda, about 140 grains of a precipitate; and when precipitated by carbonate of ſoda, 160 grains. This increaſe of weight is owing to the combination of the oxigene of the ſulphuric acid with the cobalt; in the ſecond inſtance, the carbonic acid combining with the oxide of cobalt likewiſe contributes to the increaſe of its weight. The ſulphuric acid, diluted in water, acts on zaffre, and diſſolving part of it, forms with it ſulphate of cobalt.

The nitric acid diſſolves cobalt with effervеſcence, with the help of a moderate heat: as the oxigenous principle of the acid unites with the cobalt, a quantity of nitrous gas is diſengaged. When the ſolution is ſaturated, its colour is a roſe brown or a bright green: when evaporated by a ſtrong heat, it affords nitrate of cobalt in ſmall bundled needles. This ſalt is very liable to deliquiate: On coals it boils, but does not detonize, and leaves a deep red oxide. It is decompoſed by the ſame ſaline intermediates which decompoſe ſulphate of cobalt. If, on theſe occaſions, more alkali be added than what is neceſſary to precipitate the oxide of cobalt, this laſt ſubſtance is then entirely diſſolved, and the precipitate diſappears.

The muriatic acid does not diſſolve cobalt when cold, but with the aſſiſtance of heat it diſſolves a certain portion of it. This acid acts with more vigour on the oxide of the ſemi-metal, forming a reddiſh brown ſolution, which, when heated, becomes green. When this ſolution is evaporated and highly concentrated, it affords muriate of cobalt, which cryſtallizes in ſmall needles, and is very liable to deliquiate. Heat communicates to it at the firſt a green colour, and afterwards decompoſes it.

Aqua regia, or the nitro-muriatic acid, diſſolves cobalt ſomewhat eaſier than the pure muriatic acid, but not with ſuch energy as the nitric acid. This ſolution has been long known by the name of *ſympathetic ink*, and is not viſible till it be heated. Writing performed with this ink, though inviſible when cold, appears when heated of a beautiful ſea-green colour, but diſappears again when the paper becomes cold. This property belongs to the ſolution of oxide of cobalt in the muriatic acid. The nitric acid, which is part of the compoſition of aqua regia, ſerves no other purpoſe but that of helping to diſſolve the cobalt, and to maintain it in ſolution. The green colour which cobalt ink diſplays when heated, and loſes again when it becomes cold, was thought to be owing to a metallic ſalt which was cryſtallized by heat, but when expoſed to the cold air, attracted ſo much moiſture as diſſolved it, and made it diſappear: but it has ſince been ſhown, that a ſolution of muriate of cobalt in water, aſſumes ſame colour when expoſed to a certain degree of heat.

The boracic acid does not diſſolve cobalt without an intermedium; but when a ſolution of borate of ſoda is mixed with a ſolution of this ſemi-metal in any one of the before-mentioned acids, a double decompoſition is effected; the ſoda combines with the acid in which the metallic oxide was diſſolved, and the boracic acid combining with that oxide forms an almoſt inſoluble neutral ſalt, which is precipitated: on ſeparating the ſupernatant liquor by a filter, the borate of cobalt is obtained ſeparate.

Scarce any of the neutral ſalts are liable to be affected by the action of cobalt. When expoſed to fire with nitre, it is reduced to an oxide. Put into a red hot crucible a mixture conſiſting of one part of cobalt with two or three of nitre well dried, no detonation will take place;

place; but ſeveral ſmall ſcintillations ſufficiently diſcernible will be ſeen to follow; in conſequence of which, part of the cobalt will be found changed into an oxide of a lighter or deeper red, and often of a greeniſh colour.

This experiment, and all the reſt which have been made on the reciprocal action of nitre and metallic matters, require to be carried farther. Cobalt does not decompoſe ammoniacal muriate. Bucquet performed this experiment with the greateſt care, but did not obtain a particle of ammoniac. This muſt depend on the muriatic acid having ſo little power of action on this ſemi-metal.

We know not in what manner hydrogenous gas acts upon cobalt. Sulphur combines with this ſubſtance, but not without great difficulty; but the alkaline ſulphures render this combination eaſier. The product is an artificial ore, with facets of various ſizes, or of a finer or a coarſer grain, and of a white or a yellowiſh colour, according as the proportion of the ſulphur is greater or leſs. M. Baumé, who has given an excellent account of this combination in his Theory and Practice of Chemiſtry (*vol.* 2. *page* 288 *to* 297), obſerves, that it may be decompoſed by the acids, and that fire is not capable of ſeparating all the ſulphur.

Cobalt in its metallic ſtate is of no uſe; but its oxide is uſed to give a blue colour to glaſs, enamel, pottery, and porcelain. It is alſo uſed for making ſympathetic ink.

CHAP. X.

Of Biſmuth.

BISMUTH, formerly named *tin glaſs*, is a ſemi-metal of a yellowiſh white colour, very ponderous, and diſpoſed in large plates. It yields a little to the hammer like an elaſtic body, but ſoon breaks into ſmall ſpangles, and is at laſt reduced to powder. In water it loſes one tenth part of its weight. It cryſtallizes into polygon priſms, which are diſpoſed in quadrangular ſolids, reſembling the volutes of Grecian architecture, or perfectly the ſame with thoſe of muriate of ſoda. It has ſcarce any taſte or ſmell.

In nature, biſmuth is generally found in a metallic form. The properties by which it is known are, a ſparkling yellowiſh colour, ſuch a degree of ſoftneſs as renders it liable to be cut with a knife, a lamellated form, and a ſtrong tendency to fuſion. It is uſually cryſtallized in triangular plates arranged one above another. I have in my poſſeſſion ſome ſpecimens of this ſemi-metal, in which its cryſtals are very regular octohædrons,

hædrons. Its gangue is commonly quartzoſe. It is found at Scala in Neritia, in Dalecarlia, and at Schneeberg in Germany.

A number of modern mineralogiſts doubt the exiſtence of arſenical ore of biſmuth: Some, however, aſſert it to be *chatoyant*, and generally arranged in ſmall, glittering, light grey laminæ: They tell us alſo, that it is almoſt always mixed with native biſmuth and cobalt: the reddiſh effloreſcence of the laſt of which ſubſtances is ſometimes obſervable on the ſurfaces of ſpecimens of biſmuth.

Sulphureous ore of biſmuth, or native ſulphure of biſmuth, which is taken notice of by mineralogiſts, is of a whitiſh grey colour, ſometimes inclining to blue, with facets or needled priſms. The luſtre and colour of this ore are the ſame with thoſe of lead ore or galena: it has almoſt always ſquare facets; but it has never been obſerved in real cubic fragments: it may be cut with a knife: it is very rare, but found at Baſtnaes in Sweden, and at Schneeberg in Saxony.

Cronſtedt ſpeaks likewiſe of an ore of martial biſmuth, which he ſays is found in cuneiform ſcales at Konſberg in Norway.

Laſtly, biſmuth is ſometimes found in the ſtate of an oxide. It is then in the form of a granulated effloreſcence, and of a greeniſh, but never of a red colour, on the ſurface of biſmuth ore. Mr Kirwan thinks this oxide to be biſmuth combined with the carbonic acid. Some mineralogiſts aſſert, that there is a ſulphate of native biſmuth mixed with this calx.

The proceſs for aſſaying biſmuth ore conſiſts in melting it in a crucible by a moderate heat, with the help of a certain quantity of reducing flux. As biſmuth is

volatile,

volatile, it muſt be melted as quickly as poſſible; nay, the beſt way of performing this operation is in cloſe veſſels, as Cramer recommends.

It is equally eaſy to melt biſmuth ore in the great way. Dig a pit in the earth; cover it with billets of wood; ſet fire to the wood, and throw the ore, previouſly broken, upon it while burning; the biſmuth melts and runs into the pit, where it is moulded into an orbicular cake. In ſome places the trunk of a pine is laid on one ſide and hollowed, then covered with wood; the wood is kindled, and the biſmuth thrown upon it while it burns. The ſemi-metal then melts, and runs through the pine into a cavity in the earth. The liquid biſmuth is drawn from this reſervoir, and poured into iron or ingot moulds.

Biſmuth ſuffers no alteration from the contact of light: it is extremely fuſible, and melts long before becoming red hot. When heated in cloſe veſſels it is entirely ſublimated: If left to cool ſlowly, it cryſtallizes in Greek volutes. It is one of thoſe metallic ſubſtances which cryſtallize moſt readily. M. Brongniart was the firſt chemiſt who ſucceeded in cryſtallizing it.

If biſmuth be held in fuſion, in contact with air, its ſurface is ſoon covered with a pellicle, which changes into a greeniſh grey or brown oxide, called *cinder* or *calx of biſmuth.* By calcining nineteen drachms of biſmuth in a glaſs capſule, M. Baumé obtained twenty drachms thirty-four grains of oxide. When biſmuth is made red hot, it burns with a faint and ſcarcely diſcernible blue flame. Its oxide evaporates in the form of a yellowiſh ſmoke, which, on coming into contact with cold bodies, is condenſed into a duſt of the ſame colour, improperly called *flowers of biſmuth.* What makes this duſt volatilize, is the rapidity with which biſmuth burns;

burns; for if it be expoſed by itſelf to fire, it does not ſublimate, but melts into a greeniſh glaſs. Geoffroy, the ſon, obſerved, that towards the end of the operation this ſublimated oxide of biſmuth is of a beautiful yellow orpiment colour.

The grey or brown, ſublimated or vitreous oxides, are combinations of this ſemi-metal with oxigene, or the baſe of vital air. They cannot be reduced without the addition of a third matter, becauſe the mutual affinity between the two principles of which they are compoſed is very conſiderable. But hydrogenous gas, charcoal, and all organic combuſtible matters which contain both of theſe bodies, decompoſe that oxide, and reduce it to a metal by attracting its oxigene, with which they have a greater affinity than biſmuth has.

M. d'Arcet having expoſed biſmuth in a bowl of unburnt porcelain to the heat of a furnace for burning that ſubſtance, the ſemi-metal ran through a crevice in the crucible, leaving in the veſſel a glaſs of a dirty violet colour, though the biſmuth that ran out of the bowl was yellowiſh. From this fact, and others of the ſame kind, it appears, that there is a difference between metallic glaſſes formed in the air, and glaſſes of the ſame matter which have not been expoſed to air during their formation.

When biſmuth is expoſed to the air, it is ſomewhat tarniſhed, and a little whitiſh ruſt is formed on its ſurface. It ſuffers no injury from the attacks of water, nor does it combine with earths; but its oxide combines with all earthy matters, promoting their fuſion. It communicates a greeniſh yellow tincture to thoſe glaſſes, into the compoſition of which it enters.

We know not in what manner the ſalino-terreous ſubſtances and the alkalis act upon this ſemi-metal.

Biſmuth produces an alteration on the concentrated and boiling ſulphuric acid, decompoſing it in part, and cauſing it to exhale ſulphureous gas. The maſs remaining in the veſſel after the decompoſition of part of the acid is white. What is in a ſaline ſtate may be ſeparated by water from that which is pure oxide, and contains ſcarce any acid. The lixivium on being evaporated affords ſulphate of biſmuth in ſmall deliqueſcent needles. This ſalt may be decompoſed by fire, by the ſalino-terreous ſubſtances, by the alkalis, and even by water applied in a large enough quantity.

The nitric acid diſſolves biſmuth with amazing rapidity, or rather the ſemi-metal decompoſes the acid by robbing it very quickly of part of its oxigene. The mixture becomes very hot, and exhales very thick red vapours. If this combination be effected in a pneumato-chemical machine, a great deal of nitrous gas is obtained; and this is a very ſpeedy and convenient way of obtaining that gas. During the ſolution, a black powder is precipitated, which Lemery took for bitumen, but Pott thinks to be oxide of biſmuth very much calcined. M. Baumé thinks it ſulphur; it is poſſibly charcoal. The nitric ſolution of biſmuth is colourleſs: when highly ſaturated, it depoſites cryſtals without evaporation. Evaporation and cooling give a nitrate of biſmuth, concerning the form of which chemiſts are not agreed. M. Baumé ſays, that this ſalt is in large needles pointed at one end. M. Sage deſcribes its cryſtals as tetrahædral priſms, a little compreſſed, and terminating in two obtuſe trihædral pyramids, the ſides of which are a rhombus and two trapezia. By a ſlow evaporation I have obtained it in very large flattened rhomboids, perfectly ſimilar to the calcareous ſpar of Iceland.

Nitrate of biſmuth detonizes with a faint noiſe into reddiſh ſparks; it then melts and ſwells, leaving a greeniſh yellow oxide, which cannot be reduced without the addition of ſome other ſubſtance. When this ſalt is expoſed to the air, it loſes its tranſparency, and the water of its cryſtals eſcapes. When an attempt is made to diſſolve it in water, it becomes white and milky, giving a precipitate of oxide of biſmuth.

The ſame thing happens when the nitric ſolution of biſmuth is poured into water. Moſt part of the oxide of this ſemi-metal is then precipitated in the form of a white powder called *white paint* or *magiſtery of biſmuth.* A ſolution of 100 grains of this metal in the nitric acid affords 113 grains of precipitated oxide, the increaſe of weight being owing to the oxigene abſorbed. To obtain this precipitate very white and fine, a great quantity of water muſt be uſed in the preparation of it. The ladies uſe it for whitening the ſkin; but it unluckily blackens it when it comes into contact with any odorous combuſtible matter; nay, ſcarce any other metallic matter poſſeſſes this property in ſo high a degree. Though the nitrate of biſmuth be moſtly decompoſed by the water, yet there ſtill remains a portion of it in ſolution, which cannot be precipitated by any other matter but lime or the alkalis. All ſolutions of biſmuth may be in like manner precipitated by water. We are ſtill ſtrangers to the nature of nitrite of biſmuth.

The muriatic acid acts with ſome difficulty on this ſemi-metal: it muſt be concentrated and digeſted for a long time over the biſmuth in order to produce any effect upon it. But this ſolution ſucceeds better when a great quantity of the muriatic acid is diſtilled on the metal: a fœtid odour exhales from this mixture; the reſidue is to be waſhed with water, which carries off a part of the metallic oxide combined with the acid. Muriate of biſmuth cryſtallizes with difficulty: it may be cauſed to ſublime, and it then forms a kind of ſoft fuſible ſalt, improperly called *butter of biſmuth*, which powerfully attracts moiſture from the atmoſphere. Water decompoſes it, cauſing it to precipitate a white oxide.

We know not in what manner the other mineral acids act upon biſmuth.

Common nitre calcines biſmuth, but without any ſenſible detonation. This ſemi-metal does not at all decompoſe ammoniacal muriate; but its oxide ſeparates completely the ammoniac. In this operation a great quantity of ammoniac gas is obtained, and the reſidue is a combination of the metallic oxide with the muriatic acid. As biſmuth acts not on ammoniacal muriate, on account of the muriatic acid having ſo little power of action on this ſemi-metal, it is very remarkable that its oxide ſhould poſſeſs ſuch a property; and the fact may be conſidered as a proof that this ſubſtance is in its nature not very different from ſaline ſubſtances.

Hydrogenous gas alters the colour of biſmuth, giving it a violet tinge.

Sulphur combines with this ſemi-metal by fuſion. From this combination there reſults a ſort of bluiſh grey ſparkling ore, which cryſtallizes into beautiful tetrahædral needles, in their colours reſembling pieces of the moſt beautiful antimony.

Biſmuth is uſed by workers in tin, to communicate a proper hardneſs to that metal. It may be employed inſtead of lead for the cupellation of the perfect metals; becauſe like lead it melts into a glaſs, which is abſorbed by the cupels. Geoffroy the younger obſerved a ſtrong relation to ſubſiſt between this ſemi-metal and

lead.

lead. We can only gueſs at the effects of biſmuth on the animal œconomy. It is thought, with great appearance of probability, that like thoſe of lead they might be dangerous. This ſemi-metal is even known to produce ſome unfavourable effects when applied externally.

Oxide of biſmuth is uſed under the name of *white paint*, for whitening the ſkin; but the perſon who uſes it muſt be careful to avoid all ſtrong ſmelling matters, particularly ſuch as are fœtid. The vicinity of ſlaughter-houſes, privies, common ſewers, and almoſt any ſtrong ſmelling matter, has ſuch an influence on this oxide that it turns it black. The vapour of alkaline ſulphures, or of eggs, acts with great energy in producing the ſame effect. A very common experiment in natural philoſophy fully proves this fact:—A few characters are written on the firſt leaf of a clean paper book, containing an hundred pages; the laſt leaf is impregnated with a little liquid alkaline ſulphure; in a few moments the hepatic vapour is conveyed by the air between the intermediate leaves to the oppoſite ſide of the book, where it communicates a deep brown colour to the characters which were traced on the firſt page. It has been ſaid, that the ſulphurated or hydrogenous gas penetrates through the paper: but M. Monge has proved, that it is the air which carries it from leaf to leaf; for when the leaves are glued together the phænomenon does not take place.

CHAP. XI.

Of Nickel.

CRONSTEDT, who conſidered nickel as a peculiar ſemi-metal, firſt made it known to the world in the Acts of the Academy of Stockholm for the years 1751 and 1754. According to him, this ſemi-metal is of a ſparkling colour, inclining to red, eſpecially on its outſide. It is very brittle, and its fracture ſhows it to conſiſt of facets, by which it may be diſtinguiſhed from cobalt. M. Arvidſſon, who, in conjunction with Bergman, publiſhed a theſis on the properties of nickel, which has been tranſlated, and inſerted in the *Journal de Phyſique* for October 1776, obſerves, that nickel obtained by the roaſting and fuſion of its ores, as Cronſtedt directed, is ſo far from being pure, that it contains ſulphur, arſenic, cobalt, and iron. As Bergman, by a number of ingenious proceſſes, ſeparated moſt of theſe extraneous matters, and obtained a ſpecies of nickel, differing in many of its properties from that deſcribed by by Cronſtedt, we ſhall ſpeak of it as the pure metal, after giving the hiſtory of its ores.

Nickel is found in combination with ſulphur and arſenic. Its ores are red-coloured like copper: they are almoſt always covered with a greeniſh grey effloreſcence: the Germans call it *kupfer nickel*, or *falſe copper*. That mineral abounds at Freyberg in Saxony; and is generally mixed with grey cobalt ore; but its red colour and greeniſh effloreſcence diſtinguiſh it from this ore, which is grey or black, with a red effloreſcence: its cryſtals are often cubic. Wallerius calls kupfer-nickel, cobalt ore of a red copper colour: he thinks it to be a compound of cobalt with iron and arſenic. Linnæus takes it to be copper mineralized by arſenic. M. Romé de Lille follows Wallerius in ranking it among cobalt ores, and conſiders it as an alloyed cobalt. M. Sage, on treating this ore with ammoniacal muriate, obtained from it iron, copper, and cobalt. He thinks it to be a mixture of theſe three metallic matters with arſenic. A little gold is alſo found in it according to this chemiſt. It is proper to obſerve, that the reſults of this gentleman's experiments on it were different from thoſe obtained by Bergman. His experiments, he tells us, were performed on the kupfer-nickels from Biber in Heſſe and Allemont in Dauphiny.

Cronſtedt aſſerts, that nickel may be ſeparated from the metallic matter to which the Germans give the name of *ſpeiſs*, and which is gathered in the crucibles in which ſmalt is melted. M. Monnet thinks that the ſpeiſs manufactured at Gengenback, about fourteen leagues from Straſburgh, is genuine nickel. And as the cobalt ore uſed at that place in making ſmalt is very pure, he concludes, that the nickel is produced by the cobalt

cobalt itſelf, as we ſhall afterwards ſee. But M. Baumé obtained nickel from almoſt all the various ores of cobalt by means of alkaline ſulphure. It appears, therefore, that the cobalt ore uſed at Gengenback, contains a portion of nickel which is imperceptible to the eye, on account of its being ſo intimately united with the cobalt.

In order to extract nickel from its ore, it is firſt ſlowly roaſted, to drive off part of the ſulphur and arſenic which it contains. It is gradually changed into a greeniſh oxide; and, according to Bergman and Arvidſſon, the greener this oxide, ſo much the more nickel does it contain. It is next melted with three parts of black flux and muriate of ſoda; and this fuſed matter affords a regulus, ſuch as that which Cronſtedt has deſcribed, but which is far from being pure nickel: the ſcoriæ are brown or blue. A number of chemiſts, ſince Mr Arvidſſon's experiments were communicated to the world, have been induced to conſider this metallic ſubſtance as a natural mixture of iron, cobalt, and arſenic. As to copper, nobody but M. Sage has obtained any of it from kupfer-nickel. M. Monnet thinks that nickel is nothing but cobalt purified of its iron and arſenic. By examining the properties of this ſemimetal, we will underſtand the facts on which theſe ſeveral opinions are founded. We agree with Bergman in thinking, that what has occaſioned the miſtakes of chemiſts concerning this ſubſtance, is the extreme difficulty of obtaining nickel in a ſtate of great purity; a fact which is fully proved in the above-mentioned diſſertation of M. Arvidſſon. It is certain, that when refined to as pure a ſtate as poſſible, it exhibits ſome very ſingular properties; and that hitherto it has neither been ſeparated into ſeveral metallic ſubſtances by analyſis,

lyſis, nor formed by the combination of thoſe metals of which it has been thought to conſiſt; and therefore we have the greateſt reaſon to conſider it as a peculiar ſemi-metal, at leaſt till ſome farther experiments convince us of the contrary.

The ſemi-metal which we obtain by ſimply fuſing roaſted kupfer-nickel, has reddiſh white facets, and is very brittle. It contains a great deal of arſenic, cobalt, and iron. M. Arvidſſon ſubjected it to ſix ſucceſſive calcinations; each of which continued from ſix to fourteen hours. After each of theſe proceſſes, he reduced the ſemi-metal. He obſerved, that when calcined, arſenical vapours, and a white vapour not having the ſame ſmell, were exhaled from the matter in calcination. A mixture of charcoal reduced to powder facilitates the volatilization of the arſenic. The nickel, though its weight was much diminiſhed by thoſe ſix calcinations, ſtill ſmelled of arſenic, and continued to be attracted by the magnet. He afterwards melted it ſix times with lime and borax, and calcined it a ſeventh time, with an addition of charcoal, till ſuch time as it ceaſed to exhale arſenical vapours. This oxide was ferruginous, and clouded with green ſpots. When reduced, it afforded martial ſcoriæ, and a metallic button which was ſtill attracted by the loadſtone. The ſame proceſſes on a variety of ſpecimens from different countries were always attended with the ſame reſults. M. Arvidſſon employed ſulphur, ſulphure of potaſh, the detonation of nitre, as well as ſolution in the nitric acid and ammoniac, with a view to ſeparate the iron from nickel: but by none of theſe means could he effect his purpoſe. From theſe experiments he concluded it to be impoſſible to obtain this ſemi-metal in a ſtate of perfect purity; and likewiſe, that the only way of of ſeparating the ſulphur is by repeated calcination; that arſenic adheres to it more obſtinately than ſulphur; that even the arſenic however may be entirely extracted from it by the uſe of powder of charcoal and nitre; that cobalt is ſtill more intimately combined with this ſemi-metal, as the nitre cauſes it to be taken notice of, though nothing in the appearance of the matter indicates its preſence; and that it is impoſſible to free nickel entirely from a mixture of iron: for after being heated in all the above-mentioned ways, it ſometimes attracts the loadſtone more than ever. From all theſe facts, M. Avidſſon has been induced to think, that nickel is nothing but iron in a peculiar ſtate; and he gives a comparative view of many of the properties of this metal with thoſe of cobalt, iron, and the loadſtone. And from the reſemblance which prevails among theſe ſubſtances, he concludes the three metallic matters to be nothing but different modifications of iron. But what ſeems to have chiefly contributed to make M. Arvidſſon form this concluſion concerning nickel, is its magnetic powers. But we cannot think it fair to confound together ſubſtances, on account merely of their agreeing in one leading property, ſuch as this; for magnetic powers may poſſibly not be peculiar to iron, but common to it with other metallic ſubſtances. I am therefore of opinion, that though nickel be liable to be attracted by the loadſtone; yet as purified by M. Arvidſſon, it may be allowed to be a peculiar ſemi-metal. For, as I have already mentioned, we can neither extract from it any other metallic ſubſtance, nor imitate its compoſition by any mixture of metals: and beſides, it has properties peculiar to itſelf, which we are now to examine. Mr Kirwan proceeds upon the ſame idea of it in his Mineralogy.

It diſplays no facets, as Cronſtedt has aſſerted; but its fracture is granulated: it is nine times as heavy as water: it has not that brittleneſs which Cronſtedt aſcribed to it; but, on the contrary, its ductility is ſo conſiderable, that Bergman was in doubt whether to rank it among the ſemi metals or among the metals. It is little eaſier to melt than iron; it is very fixed in its nature. When heated in the air, it is calcined into a green oxide; and the purer the nickel, ſo much the deeper is the colour of the oxide. We know not whether this oxide be fuſible into a glaſs. It is reducible with fluxes and combuſtible matters, which decompoſe it as well as every other metallic oxide. We are equally ignorant of the effects of air and water on nickel. When its oxide is fuſed with vitrifiable matters in making glaſs, it communicates to them an hyacinth colour more or leſs red. The manner in which lime, magneſia, and the three pure alkalis act on nickel, is ſtill unknown.

M. Sage ſays, that when four parts of concentrated ſulphuric acid are diſtilled on one of regulus of kupfer-nickel in powder, it is converted into ſulphureous acid; the reſidue is greyiſh; and when diſſolved in diſtilled water, it becomes of a beautiful green colour. It affords foliated cryſtals of an emerald colour. According to M. Arvidſſon, the ſulphuric acid forms with oxide of nickel a green ſalt, in decahædral cryſtals; theſe conſiſt of two quadrangular pyramids, joined and truncated near the baſe.

This oxide diſſolves very readily in the nitric acid. Nitrate of nickel cryſtallizes, according to M. Sage, into rhomboidal cubes; all the other ſolutions of nickel or its oxide in the muriatic acid, or in any of the vegetable acids, are of a lighter or a deeper green. The fixed alkalis ſubſide in a greeniſh white precipitate; after which they are again diſſolved, and the liquor then becomes

becomes yellowiſh. When ammoniac is poured into a ſolution of nickel in nitric acid, the mixture aſſumes a beautiful blue colour. The ſame phænomenon takes place when this ſalt is mixed with precipitates of the ſemi-metal produced by the fixed alkalis. As ſolutions of copper exhibit the ſame colour with ammoniac, which colour is even conſidered as a ſure proof of the preſence of the metal wherever it appears, it has been thought, and ſome people are ſtill of opinion, that nickel contains a portion of copper: Yet Cronſtedt in vain attempted by every known means to obtain copper from a ſolution of nickel to which ammoniac had communicated a blue colour; beſides, the ſalt diſſolves copper inſtantaneouſly, but not nickel. From this circumſtance Bergman concludes, that this is an original property of nickel, and not owing to copper intermixed with it. This chemiſt, after keeping nickel for eight days in aerated water, could not perceive any proofs of its being ſoluble by the carbonic acid.

Nickel detonizes with nitre. This detonation enabled M. Arvidſſon to diſtinguiſh the cobalt intermixed with this ſemi-metal, which would otherwiſe have eſcaped his obſervation. After detonation, the nickel is more or leſs oxidated, according as a greater or a leſs quantity of nitre was employed on the occaſion. This neutral ſalt likewiſe enables oxide of nickel to communicate a deeper hyacinth colour to glaſſes; and cauſes the glaſſes impregnated with that oxide to reſume their colour after being deprived of it by fuſion: a circumſtance which happens often enough not only to oxide of nickel, but likewiſe to that of the ſemi-metal, which we are next to examine.

When oxide of nickel is melted with borax, it communicates to it alſo an hyacinthine colour.

It partly decompoſes ammoniacal muriate. The reaſon of M. Sage's obtaining a ferrugineous ſublimate in this experiment, muſt have been his having employed a regulus not ſo pure as that which M. Arvidſſon made uſe of. For M. Arvidſſon aſſerts, that the ſublimate of ammoniacal muriate, produced by this metal, was white; and when tried with nut-galls, afforded no evidence of its containing iron. A little ammoniac and a little muriatic acid paſſes off: the reſidue, when reduced, proves to be nickel, which is found to have loſt ſomewhat of its magnetic power.

We know not in what manner hydrogenous gas acts upon nickel.

This ſemi-metal readily combines with ſulphur by fuſion. It then forms a kind of hard mineral, of a yellow colour, with ſmall ſparkling facets. When expoſed to a ſtrong heat in the air, it crackles and ſcatters around luminous ſparks, like thoſe which fly from red iron hammered in the forge. Cronſtedt, to whom we owe this fact, did not purſue the experiment far enough: Only he obſerved, that this phænomenon cannot take place if the mineral be covered with melted glaſs ſo as to ſeclude it from the contact of air; from which it appears that this effect is owing to the rapid combuſtion of the nickel occaſioned by the ſulphur. The ſame chemiſt informs us, that this ſemi-metal is ſoluble in alkaline ſulphures, producing a compound ſimilar to yellow copper ore. A ſeries of fuſions and calcinations are requiſite to ſeparate nickel from ſulphur.

Nickel combines with arſenic, and adheres to it with great obſtinacy. M. Monnet, who at firſt followed Cronſtedt in thinking nickel a peculiar ſemi-metal, on obſerving that, when united with arſenic, it forms a blue glaſs like that of cobalt, concluded nickel to be nothing

nothing but cobalt purified from all mixture of arſenic and iron. Of conſequence, M. Monnet muſt conſider cobalt as well as nickel to be a mixture, not a peculiar metal. Bergman thinks the reaſon of nickel affording a blue colour with the help of arſenic to be, that the cobalt, of which nickle always contains a portion, tho' the nickel be ſo predominant in the mixture as to render the cobalt imperceptible, is oxidated and ſeparated by the arſenic applied, and then begins to diſplay its properties, and more eſpecially that one by which it is fuſible into a blue glaſs. We have already ſhown, that repeated calcination with powdered charcoal is requiſite to effect an entire ſeparation between nickel and arſenic.

Nickel combines ſtill more intimately with cobalt than with arſenic: it is exceedingly difficult to ſeparate theſe two ſubſtances. Cobalt often exiſts in combination with nickel, without affording any indication of its preſence: the only ſubſtances that can detect it by fuſion are nitre, borax, and arſenic.

Cronſtedt tells us, that nickel forms with biſmuth a brittle ſcaly regulus. Theſe two ſemi-metallic matters may be ſeparated, imperfectly indeed, by ſolution in the nitric acid, in conſequence of nitrate of biſmuth poſſeſſing the property, which we have taken notice of, of being decompoſable by water.

Nickel has not hitherto been applied to any uſe.

CHAP.

CHAP. XII.

Of Mänganeſe.

A Mineral of a dark grey colour, which ſoils the fingers, and is uſed in glaſs-works for colouring or whitening the glaſs, has long been known under the name of *black magneſia* or *manganeſe*. From its property of acting in this manner on glaſs, the glaſs-makers who uſe it call it *glaſs ſoap*. It was once conſidered by moſt naturaliſts as a poor iron ore, both on account of its colour and becauſe its ſurface is generally coated with a ferruginous earth. Pott and Cronſtedt, on making an accurate analyſis of this ſubſtance, determined it not to be of a ferruginous nature. Cronſtedt found it to contain a little tin. M. Sage reckons it a zinc ore, and thinks it to be formed by the combination of zinc and cobalt with the muriatic acid. He adds, from his own obſervation, that it is ſometimes found to contain iron or lead.

The gravity of this mineral, its property of ſtaining glaſs, and that which it poſſeſſes of giving a whitiſh pre-

precipitate when any alkaline pruſſiate is poured upon any ſolution of it, led Bergman to ſuſpect, as he informs us in the laſt paragraph of his Diſſertation on Elective Attractions, that it contained a peculiar metallic ſubſtance. His ſuſpicions have been fully confirmed by the experiments of M. Gahn, Doctor of medicine, who was one of his pupils, and who, in conjunction with Scheele, diſcovered the phoſphoric acid in bones. That phyſician was the firſt who obtained regulus of manganeſe; very probably by treating the mineral with a reducing flux. No doubt, a very intenſe heat muſt be neceſſary for ſuch an operation; for I once ſaw M. Brongniart, a very dexterous and experienced chemiſt, make an ineffectual attempt to reduce this mineral to a metallic button in a furnace in which it was expoſed to a very ſtrong heat. I have been aſſured, that this has been effected in Paris by means of M. Morveau's flux, with which he obtained iron in a button of thoroughly melted metal. But M. de la Peyrouſe is of opinion, and I cannot help agreeing with him, that the flux is of no advantage, but rather hurtful in this operation. I have tried this reduction in a very good furnace, conſtructed in the laboratory of the Veterinarian ſchool at Alfort. I have never yet obtained a well-formed button; but I have obtained a conſiderable quantity of grains, two or three lines in diameter. I repeatedly employed fixed alkali and borax without effect. Each of the metallic grains which I obtained in my ſeveral operations was incloſed in a kind of glaſs or vitreous frit of a deep green colour.

On our principles, this matter is to be regarded as a peculiar ſemi-metal, as it cannot be analyſed, and as, beſides, it diſplays properties which belong to no other

ther metallic ſubſtance. To render our nomenclature uniform, we ſhall call this ſubſtance *manganeſe.*

This ſemi-metal is at preſent much better known than formerly, having been ſo painfully examined by Bergman, Scheele, Gahn, Rinman, d'Engeſtroem, Ilſeman, and de la Peyrouſe. Whatever I ſhall advance concerning it, ſhall be founded either on the experiments of theſe chemiſts or on my own. I muſt firſt obſerve, that as it is ſo very difficult to extract the pure ſemi-metal from the ores of manganeſe, the properties of the oxide are therefore much better known than thoſe of the pure metallic ſubſtance. Scheele, one of the moſt ſkilful chemiſts of the preſent age, appears to have been unable to reduce this ſubſtance; for he deſcribes none of the properties which it poſſeſſes in its metallic ſtate.

Ores of manganeſe are diſtinguiſhed by their form, and by their colour, which is grey, brown, or black, and more or leſs brilliant. There are a great many varieties of this ore.

1. Ore of manganeſe, cryſtallized into tetrahædral, rhomboidal, or ſtriated priſms, according to their length, and ſeparate from one another.

2. Ore of manganeſe, cryſtallized in priſms bundled together.

3. Ore of maganeſe, cryſtallized in ſmall needles, diſpoſed in the form of ſtars.

4. Ore of manganeſe, in a black friable effloreſcence; which ſoils the fingers like ſoot.

5. Velvet ore of manganeſe. This is an efflореſcence in very ſmall needles, of a beautiful black colour, reſembling black velvet.

6. Compact ſhapeleſs ore of manganeſe; of a black grey colour, generally with cavities, but very ponderous,

rous. It ſoils the fingers, and is ſometimes found to contain brilliant needles. The Perigueux ſtone belongs to this variety.

7. Sparry manganeſe, found in the iron mines of Klapperud, at Freſko in Dahlland, and deſcribed by M. Rinman.

8. Native manganeſe in metallic globules, found at Sem in the county of Foix by M. de la Peyrouſe. That naturaliſt has deſcribed a great many varieties of manganeſe ore which he found in the ſame place, in the *Journal de Phyſique* for January 1780.

Scheele diſcovered oxide of manganeſe in vegetable aſhes; and he thinks it owing to this ſubſtance, that fixed alkali, when calcined, often aſſumes a green or blue colour. The green colour which potaſh takes when treated with lime, and the roſe colour which I have often obſerved in its combination with acids, are, in his opinion, owing to the metallic oxide. All coals contain a ſmall portion of it.

The fracture of pure manganeſe is of a ſparkling white colour; its texture is granulated like that of cobalt. It is hard, and breaks into pieces, after yielding a little to the hammer. It is more difficult to melt than iron; a circumſtance which made Bergman at firſt conjecture it to have ſome relation to platina.

When manganeſe is heated in the air, it is changed into an oxide, which is at firſt whitiſh, but becomes gradually blackiſh as it is more and more calcined. I have obſerved, that the ſmall grains of manganeſe obtained by the proceſs above-mentioned, are very ſoon altered by the contact of air; they are inſtantly tarniſhed, and aſſume by and by a black or violet colour;

lour; ſoon after they fall down into a black duſt reſembling native oxide of manganeſe.

This rapid oxidation of regulus of manganeſe by the contact of air has always appeared to me a very curious and ſingular fact. The globules of this metal are hard, brilliant, and very refractory, and they may be long preſerved in a well ſtopped flaſk, provided their ſurface be unbroken, and covered with a thin cruſt of oxide formed during the fuſion of the ſemi-metal: but if one of theſe globules be broken into three or four pieces, and their fractures expoſed to the air, you in a few minutes ſee their colour change from a white to a purple, a violet, or a roſe colour; and at laſt almoſt to a brown. If theſe fragments be left in a phial containing a certain quantity of air, and gently ſhaken from time to time, at the end of a few months they will be found reduced to a powder almoſt entirely black. This is a kind of metallic pulverization or efloreſcence, ſimilar to that of ſaline or pyritous ſubſtances. It proves the exiſtence of a ſtrong mutual attraction between manganeſe and the oxigene of the atmoſphere, and the eagerneſs with which theſe two ſubſtances tend to unite.

The action of manganeſe on earths and ſalino-terreous ſubſtances has not been examined. The oxide of this ſemi-metal communicates a brown or violet colour to glaſs; which colour is ſuſceptible of many modifications, and may be eaſily deſtroyed by the action of combuſtible matters. Nitre reſtores this brown or violet colour by ſuppling the manganeſe with a new quantity of oxigene. This is the reaſon why the matraſſes and retorts of white glaſs which we uſe in our laboratories, in extracting vital air from nitre, always acquire a brown or violet colour. Scheele has made a great many ingenious experiments on this colouring of glaſs by oxide of manganeſe.

We know not well in what manner the alkalis act upon manganeſe; but we know that the oxide of this ſemi-metal combines with ammoniac, and is reduced by it. Bergman obſerves, that a peculiar gas is diſengaged on this occaſion, which he thinks to be one of the principles of ammoniac, but ſays nothing farther concerning it. M. Berthollet has diſcovered that it is azotic gas, and the hydrogene of the ammoniac enters into combination with the oxigene, which it carries off from the manganeſe, thus reducing it to a white ſemi-metal. Scheele has given the name of *cameleon mineral* to a combination of potaſh with oxide of manganeſe, which in warm water takes a beautiful green, and in cold water a red colour. Oxigene and caloric ſeem to be the chief cauſes of theſe phænomena. Perhaps azote, which I conſider as the alkalifying, or *alkaligenous* principle, is diſengaged from the potaſh in this operation; and is in part the cauſe of theſe ſingular modifications of colour.

The ſulphuric acid is decompoſed by manganeſe, but diſſolves its oxide. This ſolution is coloured and loſes its colour on the addition of a combuſtible matter, ſuch as ſugar or honey; it affords a tranſparent ſulphate of manganeſe, of which the cryſtals are parallelopipeds. This is decompoſed by fire; and it then affords vital air. The alkalis ſeparate from it an oxide of manganeſe, which acquires a beautiful colour on being expoſed to the air.

The nitric acid diſſolves this ſemi-metal, giving out at the time red vapours. Its oxide ſuffers no injury from the attacks of this acid, unleſs the acid be red,

or

or ſome combuſtible body, ſuch as honey or ſugar, be added. The alkalis cauſe theſe ſolutions to yield a white precipitate, ſoluble in acids; which when heated becomes black, and is more completely oxidated. Bergman thinks manganeſe to be one of thoſe metallic ſubſtances which have moſt affinity with ſalts; for in his table of chemical attractions, he places it near the top of thoſe columns which exhibit the ſeveral affinities of the acids with the various ſubſtances with which they have a tendency to combine.

The muriatic acid alſo diſſolves manganeſe; and when it effects this ſolution cold, the ſemi-metal communicates to it a deep brown colour: when the ſolution is heated, it loſes its colour. Water precipitates it, and alkalis decompoſe it.

We have ſeen, under the hiſtory of that acid, that when it is diſtilled on the oxide of this ſemi-metal, the oxide becomes black, and returns nearly to the metallic ſtate, by giving up part of its oxigene to the muriatic acid, which goes off in the form of oxigenated muriatic acid gas. This acid has a greater affinity than the ſulphuric acid with manganeſe; for when a ſulphuric ſolution of the ſemi-metal is poured into a quantity of muriatic acid, a precipitate is formed, which Bergman, from its property of being ſoluble in alcohol, has decided to be muriate of manganeſe; as that property is known not to belong to ſulphate of the ſame ſemi-metal.

The fluoric acid diſſolves but very little of oxide of manganeſe. The beſt way of combining theſe two ſubſtances is, according to Scheele, to decompoſe ſulphate, nitrate, or muriate of manganeſe by ammoniacal fluate.

The carbonic acid diſſolves a ſmall quantity of manganeſe by digeſtion, with cold; potaſh, with acceſs of air, precipitates the metallic oxide.

Scheele has examined the action of nitre, borax, and ammoniacal muriate on oxide of manganeſe. With the aid of heat, the oxide diſengages the acid from nitre: With potaſh it forms a deep green maſs, which is ſoluble in water, and communicates its own colour to the water in which it is diſſolved. This green colour is owing to the iron contained in the manganeſe; as the iron is precipitated, the ſolution becomes blue. Water and acids precipitate this alkaline ſolution. This is Scheele's *cameleon mineral*, above mentioned.

When nitrate of potaſh is heated in glaſs veſſels impregnated with manganeſe, it communicates to the glaſs a violet colour; and the more the oxide is calcined, ſo much the deeper is the colour which the glaſs acquires.

When borax is melted with oxide of manganeſe, it acquires a brown or violet colour.

Ammoniacal muriate gives, on being diſtilled with this metallic oxide, pure ammoniac; and the ammoniac is in part decompoſed. Scheele, who firſt obſerved this fact, informs us, that an elaſtic fluid is at the ſame time diſengaged, which he conſiders as one of the principles of ammoniac; but he has not determined the nature of that fluid; and M. Berthollet has ſince diſcovered, that when ammoniac is decompoſed by a metallic oxide, the hydrogene, which is one of the principles of that ſalt, unites with the oxigene of the oxides to form water; while the azote, the other principle of the ammoniac, paſſes into an aeriform or gaſeous ſtate by entering into combination with caloric.

We know not in what manner hydrogene and ſulphur act upon manganeſe and its oxide. Even the white oxide of arſenic appears to be capable of depriving this acid of a part of its oxigene; for it diſcolours glaſſes which have been ſtained brown by this ſubſtance.

To theſe properties of manganeſe Bergman adds, that it can never be entirely purified from iron; and therefore this new ſemi-metal, like nickel, is unknown as it exiſts in a ſtate of purity. Scheele, who made an accurate analyſis of natural manganeſe, found it to contain iron, lime, barytes, and a little ſiliceous earth.

Oxide of manganeſe is employed, under the name of *black magneſia*, in glaſs works, both to purify white glaſs from yellow, green, or blue ſtains, and to give it a violet colour. Probably this phænomenon is owing to the action of the oxigene ſeparated by heat, upon ſubſtances that are coloured.

Native oxide of manganeſe is at preſent employed in the preparation of the oxigenated muriatic acid, and in many other preparations.

This native oxide, when heated by itſelf in a pneumato-chemical machine, affords very pure vital or oxigenous gas. This is the only vital air proper for being adminiſtered to ſick perſons, in the caſes in which vital air is conſidered as a remedy.

The affinity of manganeſe with the principle of combuſtion, is a fact which in many inſtances ſerves to direct the operations of modern chemiſts.

[End of Vol. II. of the Original.]

CHAP. XIII.

Of Antimony.

ANTIMONY, *ſtibium*, is a ponderous ſemi-metal of a ſparkling white colour, and bearing a ſtrong reſemblance to tin or ſilver. It appears to conſiſt of laminæ arranged one over another, and its ſurface exhibits a kind of cryſtals in the form of ſtars or fern leaves. It likewiſe appears in trihædral pyramids, conſiſting of figures like hoppers, ſtanding on their angles one above another; theſe hoppers appear to reſult from the accumulation of quadrangular or octohædral pyramids. In water this ſemi-metal loſes one-ſeventh of its weight: it is eaſily reducible to powder. It acts in a very ſenſible manner on the ſtomach; for it is both emetic and purgative.

Native antimony is rarely to be met with: it has been diſcovered by M. Anthony Schwab at Sahlberg in Sweden. M. Schreiber, director of the mines of Allemont in Dauphiny, has found native antimony in thoſe

thoſe mines. This native antimony is in large plates, and diſplays all the properties of that which is extracted from ore; only it contains one or two hundredth parts of arſenic.

M. Mongez the younger has diſcovered a native oxide of antimony in fine white needles, intermixed with antimony, or bundled together like zeolite. He found this oxide on the native antimony of Chalanges in Dauphiny.

This ſemi-metal is generally combined with ſulphur, and it then forms what has been improperly called antimony, but is in propriety of language an ore or ſulphure of antimony. This mineral is of a blackiſh grey colour, in plates or needles of various ſizes, friable, and either ſcattered about ſingly or joined together in ſome form. It is ſometimes mixed with other metals; and of theſe moſt frequently with lead or iron. It abounds in Hungary and in France in the provinces of Bourbon, Auvergne, and Poitou. Naturaliſts have diſtinguiſhed this ore into a great many varieties, according as its filaments are ſtellated, irregular, parallel, *chatoyant*, &c. When it is mixed with a portion of arſenic, or has been altered by the vapours of alkaline or combuſtible matters, it appears in needles of a deep red colour, bearing a conſiderable reſemblance to beautiful cobalt flowers, but rather more opaque. We may now conſider the ſeveral varieties of this ore.

Varieties.

1. Sulphure of antimony, cryſtallized in hexahædral priſms, terminating in tetrahædral pyramids, obtuſe and ſolitary.
2. Sulphure of antimony in ſtriæ, or conſiſting of large ill-ſhaped needles, lying together in irregular bundles.

Varieties.

3. Sulphure of antimony in ſtellated ſtriæ. Its needles are divergent from a common center.
4. Lamellated ſulphure of antimony; it conſiſts of plates of various ſizes, reſembling the lead ore known by the name of *galena.* This variety is ſometimes ſparkling: when it has this property it is called *ſpecular antimony.*
5. Red ſulphure of antimony. This is a granulous efflorefcence on the ſurface of needles of antimony: it is ſometimes cryſtallized in red priſms or needles, the colour of which varies in deepneſs and brightneſs. In this ſtate ſome naturaliſts call ſulphure of antimony *native kermes* or *native golden ſulphur.*

Formerly, ſulphure of antimony was not treated as an ore in order to obtain from it the ſemi-metal: it was only melted to ſeparate the gangue and any other metallic matters which might adhere to it. In that operation two pots are employed; one of them in which the ore is melted, with a number of holes in its bottom; the other ſtanding beneath it to receive the ſulphure of antimony as it melts, is buried in the earth; a fire is made around the upper pot: at firſt a moderate heat is applied, becauſe the ore is very fuſible, but towards the end of the operation the fire is increaſed, in order that all the ore contained in the mineral may melt and run off. A portion of the other metals, and particularly of the iron which is mixed with this ore, runs off at the ſame time, and theſe metals form a ſtratum of ſcoriæ, on the ſurface of the ſulphure of antimony in the inferior pot. Although the ſulphure of antimony which comes from Hungary be commonly reckoned the pureſt, yet it is cerrain, that from whatever

ever place this mineral come, it is always ſufficiently pure and proper for the purpoſes to which it is applied, when its needles are regularly formed, and unmixed with ſcoriæ. It is to be obſerved, however, that the ſulphur and the antimony are not always combined in the ſame proportion in this ſulphure; and of conſequence it becomes neceſſary to examine it, whenever it is meant to be employed in the preparation of medicines, as it is much to be wiſhed that the ſtrength of antimonial preparations were uniformly the ſame.

Sulphure of antimony melts very readily, as may be obſerved in the proceſs by which it is ſeparated from its gangue. If urged with fire after being melted in open veſſels, it loſes its ſulphur, which goes off in yellow flowers; the metallic part is alſo reduced with great eaſe to an oxide, and it then flies off in white vapours; but a moderate heat, inſufficient to melt ſulphure of antimony, volatilizes the ſulphur by ſlow degrees; and the metal then combines gradually with the oxigene of the atmoſphere, forming by that combination grey oxide of antimony. This operation cannot be very well effected unleſs the ſulphure be ſo much divided as to expoſe a great deal of ſurface to the atmoſphere: it is therefore for this purpoſe reduced to powder, and expoſed to a ſlow fire on a varniſhed earthen pan. A gentle heat muſt at firſt be applied, on account of the mineral being ſo fuſible; but as the operation advances and the ſulphur goes off, the antimony becomes more refractory, and the fire may then be increaſed till it redden the capſule containing the mineral. The operator may conclude that his work goes ſucceſsfully on, when he feels no other ſmell but that of ſulphur exhaling from the roaſted mineral, and obſerves that it does not form into clods; but when

when the ſulphure becomes clotted, and the ſulphur is decompoſed as it volatilizes (which is indicated by the ſuffocating ſmell of the ſulphureous acid), the heat is then too intenſe, and ought to be diminiſhed.

Though ſulphur appears not to be very cloſely combined with antimony in its ore, yet it is impoſſible to drive it entirely off by roaſting. The grey oxide of antimony prepared by the above proceſs always retains a pretty conſiderable quantity of ſulphur, even though the ſemi-metal have been calcined till it loſt its metallic properties.

When the grey oxide of antimony is, by itſelf, urged with fire, it melts into a glaſs of a reddiſh brown or an hyacinth colour. This glaſs is more or leſs fuſible, and more or leſs tranſparent, according as the mineral from which it is formed has been more or leſs calcined. If they contain but a little ſulphur and a great deal of oxigene, the glaſs which it affords is tranſparent and ſcarce fuſible: this is *glaſs of antimony*, properly ſo called, or vitreous oxide of ſulphurated antimony. If the oxide contain a large proportion of ſulphur, and be leſs remote from the metallic character, it produces a glaſs which is more fuſible and opaque; this glaſs is called *liver of antimony*, becauſe it is of a dark red colour, like that of the liver of animals. When oxide of antimony has been ſo completely calcined that it will ſcarce melt, a little ſulphur or ſulphure of antimony caſt into the crucible in which it is expoſed to heat, will cauſe it to melt in an inſtant.

When grey or vitreous oxide of antimony are heated in a crucible, with an equal quantity of black flux and a little black ſoap or oil, they are reduced to pure antimony. The black flux ſerves two purpoſes in this operation: the alkali which it contains combines with the ſulphur,

ſulphur, of which fire alone could not free the oxide, and the carbonaceous matter contributes to the reduction of the metallic oxide. Antimony is thus prepared in the great way in commerce; it is then called *regulus of antimony*. The ſemi-metal is moulded into flat orbicucular cakes, which exhibit on their ſurface a cryſtallization reſembling fern leaves.

Antimony is liable to no alteration from the contact of light. It does not melt till it be red hot; and on being expoſed to an intenſe heat in cloſe veſſels, it is entirely volatilized without ſuffering decompoſition. If it be left to cool ſlowly after being melted, and the fluid part be poured off after the ſurface is conſolidated, what remains will be found cryſtallized in pyramids or hoppers, as we have mentioned above.

The ſemi-metal, when melted in open veſſels, is very quickly oxidated. A thick white ſmoke riſes from it, and is precipitated at the ſurface of the melted metal, or fixes on the lid of the crucible in the form of ſmall white needles: this is a ſublimated metallic oxide which has been improperly called *ſilver flowers of regulus of antimony*, or *ſnow of antimony*. In preparing a certain quantity of this matter, a crucible is placed horizontally in a furnace, ſo that its rim is exactly fitted to the mouth of the furnace to which it is luted with clay. The antimony is put into this crucible: a degree of heat is applied ſufficient to melt the ſemi-metal and raiſe it in ſmoke: the ſmoke is received into a ſecond crucible covering the firſt; and it is there condenſed into very ſlender, white, and brilliant needles, which appear to be four-ſided priſms.

The white ſublimated oxide of antimony, not only volatilizes during the burning of the ſemi-metal; but, when urged with fire, it is ſublimated even by itſelf. This oxide may be likewiſe melted into an orange-coloured

coloured glaſs: this glaſs is paler and more tranſparent than that which is formed with the grey ſulphurated oxide of antimony; but it is alſo much more difficult to melt.

Antimony ſuffers no alteration from combuſtible matters; but they decompoſe the oxide, reſtoring it to the ſtate of a regulus. As oxide of antimony is almoſt always very completely oxidated or highly ſaturated with oxigene, it is exceedingly difficult to make it repaſs into the metallic ſtate; and as it is alſo a very volatile ſubſtance, it becomes neceſſary to perform this reduction in cloſe veſſels. The white ſublimated oxide appears to be ſoluble in water, and to have acquired by ſublimation ſome ſaline properties. Rouelle was the firſt who made this obſervation on flowers of antimony. Some other metallic oxides, particularly thoſe of arſenic, molybdena, and tungſten, become ſaline and acid when ſaturated with oxigene; and perhaps the ſame property may be, one day or other, diſcovered to belong to oxide of antimony.

Antimony is but very little altered by air; its ſurface is only a little tarniſhed. It is not ſoluble in water; yet ſome phyſicians ſuſpect that it communicates to this fluid a very diſcernible emetic quality. White oxide of antimony, when diſſolved in water, communicates to that fluid emetic properties. This power of action, together with its volatility and ſolubility, gives this oxide a kind of analogy with oxide of arſenic. Many mineralogiſts have been of opinion that the ore of antimony is never without arſenic. It is certain, that both the ore and the regulus, when reduced to powder and thrown upon coals, exhale an odour which is eaſily diſcerned to be arſenical; and when a perſon is for ſome time expoſed to that vapour, he feels it to act upon him as a cathartic and a weak poiſon; as I myſelf have ſeveral times experienced in my laboratory.

Earthy ſubſtances have no power of action on antimony: its oxide enters with eaſe into the compoſition of glaſſes, communicating to them an orange colour of a nearer or a more remote reſemblance to the hyacinth.

We are unacquainted with the manner in which the ſalino-terreous ſubſtances and the alkalis act upon antimony: we know more concerning the influence of the acids on this ſemi-metal.

The ſulphuric acid, when boiled ſlowly over this regulus, is itſelf decompoſed, and oxidates a part of the ſemi-metal; a good deal of ſulphureous gas is exhaled from it, and towards the end of the operation there is a little ſulphur ſublimated. The maſs which remains, after the decompoſition of the acid, is a compound, conſiſting of a good deal of metallic oxide with a ſmall portion of the ſemi-metal, combined with the acid, ſo as to form ſulphate of antimony The ſaline part is ſeparated by means of diſtilled water. This ſalt, when evaporated with a ſtrong heat, is very deliqueſcent, and not ſuſceptible of cryſtallization: fire eaſily decompoſes it; pure water, the ſalino-terreous ſubſtances, and the alkalis, likewiſe ſeparate its principles. It is very difficult to reduce oxide of antimony that has been formed and precipitated by the ſulphuric acid.

The nitric acid attracts antimony with eagerneſs: the acid is decompoſed, oxidates moſt of the metal, and diſſolves a part of it. This ſolution takes place readily enough when the ſubſtances are cold:—the ſalt produced, after being ſeparated by lixiviation from the part which is oxidated, gives by evaporation nitrate of antimony, which is very liable to deliquiate, and is decompoſed by fire, and by the ſame intermedia which decompoſe ſulphate of antimony. The oxide of antimony formed by the nitric acid is very white: it is likewiſe one of the moſt refractory and the moſt difficult to reduce of all the metallic oxides.

The muriatic acid appears to have more difficulty than any of the other acids in acting on antimony. Yet it diſſolves the ſemi-metal with the help of a long digeſtion; but does not oxidate it ſo much as the ſulphuric and the nitric acids. I have obſerved, that when the acid remains for a long time over antimony in powder, it acts ſlowly on the ſemi-metal, diſſolving a good quantity of it. The muriate of antimony obtained in ſmall needles by a violent evaporation, is very liable to deliquiate. It melts in the fire; it volatilizes, and is decompoſed by diſtilled water like the ſublimated muriate of antimony, called *butter of antimony*, which we will ſoon have occaſion to conſider; and which differs but very little from this compound. M. Monnet, who has given a good deſcription of this combination effected by a pretty intenſe heat, obſerves, that there is a very conſiderable difference between that which is prepared with the oxide and that made up with the ſemi-metal; the former being of a more fixed nature, and cryſtallizing in laminæ, like ſulphate of lime and the boracic acid. That ſalt is beſides decompoſable by water. We have had occaſion to obſerve, that in ſolutions of antimony by the muriatic acid effected by diſtillation, there is always a portion of ſalt which is never volatilized by the action of fire, but reſembles the ſalt mentioned by M. Monnet. This is owing to its having been highly oxidated by the acid. This obſervation may be in like manner applied to almoſt all ſolutions of metals, which are found to exiſt in many different ſtates, according as the metal which they

they contain is more or leſs completely calcined or oxigenated. M. Monnet affirms as a certain and invariable fact, that 12 grains of oxide of antimony are ſufficient to ſaturate half an ounce of common muriatic acid; the preciſe ſtrength of which he does not determine. Bergman ſays, that the muriatic acid has a greater affinity than any of the other acids with antimony. The oxigenated muriatic acid oxidates antimony with the greateſt eaſe.

Aqua regia, or the nitro-muriatic acid, diſſolves this metal with more energy than either of the two acids of which it is made up; for the muriatic acid has in this compound acquired new activity, in conſequence of being united with the oxigene ſeparated from the nitric acid. Nitro-muriate of antimony is very deliqueſcent, and may be decompoſed like the other ſaline combinations of this ſemi-metal.

Sulphure of antimony, or the natural combination of ſulphur with the ſemi-metal, is generally more entirely diſſolved, but leſs completely oxidated, by acids than the ſemi-metal. Sulphur appears to defend antimony in ſome meaſure from the attacks of thoſe ſaline ſubſtances. The nitro-muriatic acid acts gently on this mineral: it may be advantageouſly employed to ſeparate the ſulphur which it precipitates in the form of a white powder. M. Baumé recommends for this operation *aqua-regia*, conſiſting of four parts of the nitric with one of the muriatic acid: but he has not mentioned the preciſe degrees of ſtrength which the acids ought to have. When this mixed acid ceaſes to act on ſulphure of antimony on which it has been poured, the ſolution is then filtrated, and the ſulphur remains on the filter. By weighing this ſulphur, the reſpective quantities of ſulphur and antimony contained in the ore

analized come to be known. But it is to be obſerved, that this ſulphur always contains a ſmall portion of oxide of antimony; and therefore this experiment cannot be thought very accurate, at leaſt if the oxide be not previouſly purified by acids from the ſulphur intermixed with it.

The action of the other acids in antimony has not as yet been examined.

This ſemi-metal decompoſes many neutral ſalts. M. Monnet, in his Treatiſe on the Solution of Metals, deſcribes an operation, ſhowing that antimony decompoſes ſulphate of potaſh. He melted in a crucible a mixture conſiſting of one ounce of that ſalt with half an ounce of this ſemi-metal. The product was a yellow, vitriform maſs, extremely cauſtic, being nothing elſe but antimoniated ſulphure of potaſh. When this maſs was diluted in hot water, and afterwards cooled, it afforded a reddiſh ſulphurated oxide of antimony, or genuine *kermes*. On this occaſion, according to the new doctrine, the ſemi-metal, by depriving the ſulphuric acid of its oxigene, cauſes it to paſs into the ſtate of ſulphur. I have made a ſeries of experiments which prove that many other metallic ſubſtances decompoſe ſulphuric ſalts, as I ſhall ſhow in the following chapters.

Antimony decompoſes nitrate of potaſh with great rapidity. If equal parts of this ſemi-metal and nitre in powder be thrown into a red-hot crucible, the ſalt gives a ſmart detonation, and burns the metal by means of the oxigene which it ſupplies. After the operation, the fixed alkaline baſe of the nitre and the antimony in the ſtate of a white oxide are found in the crucible.

This oxide has received the name of *diaphoretic antimony*. We call it *oxide of antimony by nitre*. Not antimony,

timony, but its ore, or native ſulphure of antimony, is moſt frequently uſed for this preparation. Only a larger quantity of nitre muſt then be added; ſuch as three parts of the ſalt to one of the mineral, in order that not only the metal but likewiſe the ſulphur united with it may be burnt. The reaſon why the ore is preferred to the ſemi-metal is, that the ſulphur renders the detonation of the nitre more rapid and more complete, and greatly facilitates the combuſtion of the antimony.

The matter remaining in the crucible after the detonation, conſiſts of oxide of antimony, combined in part with the fixed alkali of the nitre, and with ſo much of the nitre which has eſcaped detonation; it contains likewiſe a little ſulphate of potaſh, formed by the union of the acid of the ſulphur, with the fixed alkali of the nitre. This compound has been named *ſolvent of Rotrou*, or *unwaſhed diaphoretic antimony.* This matter is caſt into hot water, and diluted by the ſolution of the ſaline part, while the metallic oxide remains ſuſpended in the water. The turbid water is decanted off, and the fixed white oxide ſuffered to ſubſide. After paſſing thro' this proceſs, the unwaſhed diaphoretic antimony receives the name of *waſhed diaphoretic antimony.* It is moulded into little balls, and then carefully dried. The ſaline part of the mixture remains diſſolved in the ſupernatant water, as well as a part of the metallic oxide, ſtill in union with the nitrated potaſh. If an acid be poured on this liquor, it combines with the acid, and the oxide of antimony is precipitated. This oxide is improperly called *ceruſe of antimony*, or *materia perlata* of Kerkringius. The liquor that remains after the precipitation of the *materia perlata* contains a little nitre which has eſcaped detonation, a ſmall portion of ſul-

ſulphate of potaſh produced by the detonation, and the neutral ſalt newly formed by the combination of the acid with the alkali, by which the metallic oxide was held in ſolution. Though the nature of this ſalt varies according as one or another of the acids is employed, yet it has been called, but very improperly, *Stahl's antimoniated nitre.* It very often contains not a grain of nitre; for the ſulphuric or the muriatic acid may be with equal advantage employed to precipitate the oxide of antimony. And when the oxide is properly precipitated, no part of it remains combined with the neutral ſalt.

Oxide of antimony obtained by nitre may be melted, as well as the before-mentioned oxides of the ſemi-metal, into a glaſs: but being very much calcined, it is no eaſy taſk to melt it. For the ſame reaſon, it is equally difficult to reduce this oxide to a metallic ſtate, even more difficult than to reduce oxide of antimony that has been oxidated and ſublimated by fire. It is not yet known whether this oxide be ſoluble in water and acids.

Antimony appears to be capable of decompoſing muriate of ſoda; for if a mixture of the two ſubſtances be heated in a retort, agreeably to what has been remarked by M. Monnet, ſublimated muriate of antimony paſſes into the receiver. He does not deſcribe the reſidue.

This ſemi-metal, according to Bucquet, has ſcarce any power of decompoſing ammoniacal muriate; no *butter* or ſublimated muriate can be obtained by this decompoſition, agreeably to what has been aſſerted by Juncker.

All combuſtible matters act more or leſs on this ſemi-metal. Hydrogenous gas alters its ſurface and colour.

It acts with ſtill more energy on ſolutions of antimony. On my cauſing a quantity of that gas obtained from iron and the aqueous ſulphuric acid to paſs into a nitro-muriatic ſolution of antimony, the ſolution became inſtantly turbid, and depoſited a matter of an orange yellow colour, reſembling *golden ſulphur*, but never reſembling real *kermes*. White oxide of antimony, when expoſed in the ſame manner to hydrogenous gas, both dry and diluted in water, ſuffered no alteration.

Sulphur combines readily with antimony to form an artificial ore, which is an exact imitation of native ſulphure of antimony. To effect this combination, equal parts of ſulphur and antimony are to be haſtily melted together in a crucible; and the product is a needled mineral of a dark grey colour, which never contains ſo much as half its weight of ſulphur, unleſs the two ſubſtances have been mixed together in the proportion of a part and an half of ſulphur to a part of the ſemimetal. I have even obſerved, on melting an ounce of antimony in a retort with an ounce of ſulphur, the product to be ten drams of ſulphure of antimony, and to contain of conſequence only two drams of ſulphur; while the reſt of that combuſtible ſubſtance had ſo ſwelled by fuſion as to make its way into the receiver. No more therefore than one part of ſulphur is requiſite to communicate to four parts of antimony the character of ſulphurated ore of antimony. And in pharmacy therefore, it is very neceſſary to examine in what proportion the two ſubſtances are united in any quantity of this ore uſed in preparing medicines, in order to eſtimate the effects which it may produce in combination with other ſubſtances.

The alkaline ſulphures, or *livers of ſulphur*, entirely diſſolve antimony, forming in conſequence of the ſolution a yellowiſh matter, from which a precipitate of antimoniated ſulphur may be obtained by an acid, which inſtantaneouſly communicates to it an orange colour. *Hepatic* gas, or ſulphurated hydrogene, acts on ſolutions of this ſemi-metal preciſely in the ſame manner as hydrogenous gas.

Antimony combines with arſenic and with biſmuth; but theſe metallic mixtures have not yet been examined with ſufficient care.

Such are the principal properties of this ſemi-metal: But it is neceſſary to examine in a particular manner its ore, which has improperly received the name of *antimony*. As this mineral is moſt commonly uſed, and in a great many very valuable pharmaceutical preparations, it is natural to think that its properties muſt be much better known than thoſe of the ſemi-metal which it contains. The alchemiſts, who paid much attention to this ſubſtance, were the diſcoverers of ſome part of that knowledge which we at preſent poſſeſs concerning its properties: And indeed no ſubſtance has undergone more experiments than have been on ſulphure of antimony. We have already ſeen, that with the help of heat, a portion of ſulphur may be ſeparated from it; and that from this operation there reſults a grey oxide, fuſible into *glaſs* or *liver* of antimony, according as the calcination is more or leſs completely effected. But roaſting and combuſtion by nitre are not the only means of ſeparating from antimony the ſulphur which it contains. This ſeparation may be likewiſe effected by preſenting to the mineral ſome ſubſtance having a greater affinity with the metal than the metal has with the ſulphur, or having a greater affinity with the ſulphur than it has with the metal.

We have an inſtance of the firſt of theſe decompoſitions when acids are applied to crude ſulphure of antimony. Thoſe ſalts, eſpecially the nitro-muriatic acid, diſſolve the ſemi-metal, and ſeparate the ſulphur, cauſing it to ſwim on the ſurface of the ſolution. The metal even appears to diſſolve eaſier and more completely in ſulphure of antimony than when it is pure; as we have already remarked. Iron and ſome other metallic ſubſtances attract the ſulphur from this regulus.

Nitre is ſucceſsfully employed with this ſulphure in the preparation of a number of medicines of ſome conſequence. We have already ſeen, that when one part of this ore is made to detonize with three parts of nitre, both the ſulphur and the metal are burnt, and what remains is a white metallic oxide mixed with alkali. When equal parts of nitre and ſulphure of antimony are cauſed to detonize together, the detonation is leſs briſk, on account of the proportion of the nitre being leſs. This mixture therefore requires to be poured by ſpoonfuls into a red-hot crucible; whereas that which is intended to form white oxide, or *diaphoretic antimony*, needs only to be kindled once, when it immediately detonates, till the whole be reduced to a white maſs. When the detonation of this mixture, conſiſting of equal parts of nitre and ſulphure of antimony is effected, the whole maſs is urged with heat till it melt; and inſtead of *diaphoretic antimony*, the crucible is found to contain an opaque brown maſs, ſparkling, extremely brittle,—in a word, a brown opaque *glaſs of antimony* covered with ſcoriæ. It is eaſy to obſerve, that in this operation, the quantity of the nitre is not ſufficient to burn all the ſulphur. That portion of the ſulphur which eſcapes combuſtion, cauſes the

the oxide of antimony to melt together with itſelf. When this mixture is not urged with fire till it be brought into a ſtate of fuſion, the product obtained is nothing but a vitreous ſcoria, which was formerly called *Rulland's falſe liver of antimony.* This matter, when reduced to powder and waſhed in water, forms *crocus metallorum;* which is nothing but vitreous oxide of antimony pulverized, and ſeparated from the ſaline matters, with which it is mixed in conſequence of the detonation of the nitre.

There are two other preparations ſimilar to the foregoing, and, as well as it, true ſulphurated glaſſes of antimony. The one is the ruby of antimony or *magneſia opalina;* which is obtained by melting in a crucible equal parts of decrepitated muriate of ſoda, nitre, and ſulphure of antimony. The melting of this mixture, which is not preceded by detonation, affords a vitreous maſs of a light brown colour, very brilliant, and covered over with white ſcoriæ. The other very improperly called *medicinal regulus*, is prepared by melting a mixture conſiſting of fifteen ounces of ſulphure of antimony, twelve ounces of decrepitated muriate of ſoda, and three ounces of tartar. From the fuſion of this mixture there reſults a gliſtering black glaſs very opaque and very denſe, and of which the appearance does not, in the ſmalleſt degree, reſemble that of metals. Theſe two compounds, which differ in ſome external properties from true *liver of antimony*, doubtleſs owe thoſe properties by which they differ from it to the marine ſalt uſed in preparing them; but its effects on this mineral have not yet been exactly eſtimated.

To extract antimony from its ore in the ſmall way, no more nitre muſt be employed but what is requiſite to burn the ſulphur; and ſome other matter which may promote

promote the reduction of that part of the metal, which is reduced to an oxide during the operation, muſt be likewiſe added to the mixture. For that end, take eight ounces of ſulphure of antimony in powder, ſix ounces of tartar, and three ounces of nitre; mix theſe matters well together, and put the mixture by ſpoonfuls into a red hot crucible: the nitre will detonize with the tartar and the ſulphure of antimony, forming black flux, and the antimony will be at the ſame time melted. When the matter is ſufficiently melted, let it be poured into an iron cone greaſed and made hot: let the cone be ſtruck with a few blows while the mixture is poured in; let the whole be ſuffered to cool, and the regulus will be found in a pyramidal form at the bottom of this veſſel. This ſemi-metal is covered over with reddiſh black ſcoriæ, which readily attract the moiſture of the atmoſphere. When the upper ſurface of the regulus is convex, and exhibits a regular ſtar, it may be conſidered as pure. This ſtar, which ſuggeſted to the imaginations of the alchemiſts the moſt extravagant notions, depends on the manner in which the ſemi-metal cryſtallizes as it cools. The outer edges cool firſt; and the fluid matter being then driven towards the centre produces this cryſtallization, which never takes place but on ſmall maſſes of antimony; for in large cakes of this ſemi-metal, as the fluid matter undulates round ſeveral centres, inſtead of a ſtar, the cryſtallization exhibits fern-leaves under different angles. Reaumur has ſhown that ſudden cooling prevents this ſtellated cryſtallization from taking place; and that if even one ſide of the cone be ſuddenly cooled, only half a ſtar is obtained *. The quantity of metal obtained by this proceſs

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* There is doubtleſs ſome analogy between the way in which metallic buttons cryſtallize on their ſurface and the form which they aſſume,

proceſs is not equal to an half of the ſulphure of antimony employed on the occaſion, although the mineral generally contains more regulus than ſulphur, becauſe part of the ſemi-meal enters into combination with the ſaline matters which form the ſcoriæ.

Theſe ſcoriæ are compound bodies, conſiſting of a great many principles. They are found to contain the fixed alkali of the nitre and the tartar, combined with the ſulphur of the antimony in the ſtate of alkaline ſulphure. This ſulphure holds in ſolution a portion of oxide of antimony, and is mixed with a little ſulphate of potaſh, formed in conſequence of the ſulphuric acid produced by the combuſtion of the ſulphur having combined with part of the alkali which belonged to the nitre. Laſtly, theſe ſcoriæ contain likewiſe a carbonaceous matter which they owe to the tartar. On boiling them in a large quantity of water and filtrating the boiling liquor, this carbonaceous matter is left on the filter. This ſolution is clear while it remains warm, but as ſoon as it cools, it becomes turbid, and depoſites a reddiſh matter, which is at preſent thought to be antimoniated ſulphure of potaſh. This precipitate is called *kermes mineral* by the dry way. When the liquor ceaſes to depoſite a precipitate, it then affords by evaporation a matter not ſo deep coloured as *kermes*, which is a real antimoniated ſulphure of potaſh. It affords likewiſe ſulphate of potaſh. If, inſtead of evaporating the liquor, you pour an acid into it, it gives a precipitate of ſulphurated oxide of antimony of an orange yellow

ſume, when by a well-conducted cooling, and by ſeparating the fluid from the fixed part, art diſpoſes them in ſeparate cryſtals. This has engaged the Abbé Mongez's attention in his reſearches concerning the cryſtallization of metals. A.

yellow colour; which was formerly called *golden ſilver of antimony*, and ſeems to differ but little from *kermes*.

If a quantity of ſulphure of antimony reduced to powder be boiled for a few moments in water containing carbonate of potaſh or of ſoda, either of theſe efferveſcent alkalis diſſolves the ſulphur, and forms by that means an alkaline ſulphure, which holds a part of the oxide of antimony in ſolution: this boiling liquor is filtered; and by cooling it depoſites as a precipitate that portion which it contains of *kermes* or red ſulphurated oxide of antimony. When this liquor is cooled and filtered, a new precipitate of orange coloured ſulphurated oxide of antimony may be obtained from it by acids. If an alkaline lixivium be boiled anew over this reſidue, *kermes* may be again obtained. But this *kermes* is of a paler colour than that which was at firſt obtained; and the oftener the operation is repeated the more does the precipitate differ in nature from genuine *kermes*. The alkali appears to diſſolve more of the ſulphur than of the oxide of antimony; and ſulphure of antimony ſhould not therefore be boiled oftener than once or twice in the alkali. This operation is generally called the preparation of *kermes* by the humid way.

This name was given it by a Carthuſian friar, named *Simon;* doubtleſs, becauſe its colour reſembles that of the animal called *kermes* *, which is uſed in dyeing.

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* The animal *kermes*, or *ſcarlet grain* uſed in dyeing, is the ſkin of a female inſect, which fixes on the holm or ilex, and gradually increaſes its bulk into the form of a cap. It loſes the annular form which diſtinguiſhes thoſe animals. Under this cap are contained the eggs of the inſect. The young inſects iſſuing from the eggs pierce through the ſhell; and the females being without wings, fix upon the leaves of trees and die there, after being impregnated by the males who are winged The cochineal inſect is another ſpecies, in nature ſimilar to this; as we ſhall ſhow when we come to ſpeak of the animal kingdom. A.

ing. Mineral kermes has been alſo called *Carthuſian powder,* becauſe it was at firſt prepared in a laboratory belonging to that order. Glauber appears intitled to the merit of being the diſcoverer of this medicine; for he prepared it with ſulphure of antimony and liquor of nitre fixed by coal. But he has deſcribed his proceſs in an unintelligible language; nay almoſt in alchemical ſymbols. Lemery, who laboured much in inveſtigating the nature and the combinations of antimony, and who has given, under a different name, a preparation ſimilar to *kermes,* may be regarded as being properly the inventor of this compoſition. It was, however, offered to the world as an entirely new preparation many years after the publication of that chemiſt's work; and it owes its celebrity to the ſurpriſing cures which it effected when firſt adminiſtered by the Carthuſian friar Simon. He received it from a ſurgeon of the name of *Ligerie,* who was not himſelf the inventor of it. Ligerie ſaid that he had it from M. Chaſtenay, the King's Lieutenant at Landau, to whom it was ſaid to have been communicated by an apothecary who pretended to be a diſciple of Glauber's. Dodart, at that time firſt phyſician to the king, applied to Ligerie to publiſh his receipt for making *kermes;* and it was accordingly communicated to the world by that ſurgeon in the year 1720. Lemery, the ſon, in the Memoirs of the Academy, aſſerted his father's right to the honour of this diſcovery: and with the more reaſon, becauſe moſt apothecaries in preparing *kermes,* ſtill follow the proceſs of that ſkilful chemiſt.

Ligerie's proceſs conſiſts in boiling a pint of rainwater for two hours with four ounces of liquor of nitre fixed by coals, and a pound of ſulphure of antimony broken into ſmall pieces; filtrating the boiling liquor;

boiling

boiling the ſame ore with three ounces of new liquor of fixed nitre diluted in a pint of rain water; and, laſtly, ſubjecting the ſecond reſidue to a third boiling, with the ſame lixivium as before, namely, adding to it two ounces of liquor of fixed nitre with a pint of rain water. The liquor is then filtered, and ſet aſide till it depoſite the *kermes;* it is then waſhed till it become inſipid, dried, and after ſpirit of wine has been burnt over it, reduced to powder. This proceſs is tedious, and affords but very little *kermes;* for all that is obtained is at moſt but two or three drams to the pound of ſulphure of antimony. It is likewiſe very troubleſome, on account of ſo much boiling and evaporation of water. Laſtly, Three-fourths of the ore of antimony are loſt in this proceſs; becauſe the quantity of the alkali employed is ſo ſmall in proportion to that of the mineral.

M. Baumé, who follows Lemery, gives two proceſſes for preparing in a very ſimple manner, and in a very ſhort time, a great quantity of kermes, or red ſulphurated oxide of antimony; the dry, and the humid way. In the firſt, a mixture conſiſting of a pound of ſulphure of antimony, two pounds of very pure alkali of tartar, and an ounce of ſulphur, all pulverized, is melted in a crucible. Thus melted, the mixture is poured into an iron mortar, where it is again pulverized, though not ſo completely, as ſoon as it cools: it muſt then be boiled in a ſufficient quantity of water; and this liquor, filtered through grey paper, affords by cooling kermes of a brown red colour: it muſt be waſhed, firſt with cold and after that with boiling water, till it be ſufficiently purified from any mixture of ſaline matter; it is then dried, pulverized, and paſſed through a ſilken ſieve.

To prepare *kermes* in the humid way, the ſame chemiſt directs to boil a lixivium, conſiſting of five or ſix pounds of pure fixed alkali with fifteen or twenty pounds of river water: into this liquor, when boiling, caſt four or five ounces of levigated ſulphure of antimony; ſtir the mixture; and after it has boiled for a moment filtre it: this filtered liquor depoſites a great deal of kermes by cooling; which muſt be waſhed in the ſame manner as that prepared by fuſion. This proceſs, according to M. Baumé, affords twelve or thirteen ounces of kermes to the pound of antimony. He aſſures us, that the kermes obtained by theſe two different ways is entirely the ſame.

The theory of this operation, or the nature of kermes, are not yet well known; tho' many eminent chemiſts have been engaged in the reſearch. It is generally thought that the alkali diſſolves the ſulphur of the ore, and that the ſulphure whichis then formed diſſolves the antimony. Yet the ſemi-metal is not entirely diſſolved; for in Lemery's proceſs by the humid way, a grey powder is precipitated during the boiling of the liquor, which melts without any addition into real antimony. The precipitation of *kermes*, by the cooling of the lixivium, which though at firſt reddiſh and tranſparent, gradually loſes its colour as the *kermes* ſubſides, is another ſingular phenomenon. This compound is thought to be a kind of antimony ſuperſaturated with ſulphur, and when hot ſoluble in fixed alkali. If you make a lixivium containing precipitated kermes, the kermes will be again diſſolved by heat. The lixivium, which by cooling gave a precipitate of kermes, contains likewiſe antimoniated ſulphure of potaſh. When an acid is poured upon it, an orange matter is precipitated, known by the name of *golden ſulphur of antimony*;

and much more emetic than kermes. It is thought to contain more ſulphur than kermes, and leſs of the metallic oxide.

Geoffroy, who in the years 1734 and 1735 communicated to the Academy ſeveral Memoirs concerning kermes, made a great many experiments, with a view to accompliſh an analyſis of it. He conſiders the action of acids as the moſt effectual means that can be employed for that purpoſe: theſe ſalts are thought by him to diſſolve the ſemi-metal, and leave the ſulphur naked; and thus he thinks the proportion in which the two principles of kermes are united in it may be eſtimated. An ounce of kermes contains, according to Geoffroy, ſeventeen grains of metal, thirteen or fourteen grains of fixed alkali, with forty, or one and forty grains of ſulphur. But many chemiſts are at preſent of opinion, that kermes contains not a particle of alkali. M. Baumé ſays, that this ſalt is not one of its conſtituent principles, and may be entirely ſeparated from it, only by waſhing the maſs in plenty of boiling water. M. Deyeux, who has turned his inquiries to the ſame ſubject, agrees in opinion with M. Baumé. In a ſeries of experiments performed in conjunction with the Duke of Rochefoucauld, I have had an opportunity of being fully convinced of the ſame truth: but one fact particularly worthy of notice is, that, as the circumſtances of the preparation of kermes vary, it alſo appears to vary greatly in its nature. It may contain more or leſs ſulphur; and it may be naturally inferred that its effects muſt vary, according as the proportion of its principles is varied. It appears in general, that the ſtate of the ſulphure of antimony, the various proportions in which its principles are united, and its being

ing more or leſs attenuated or divided, as well as the quantity and the particular ſtate of the alkali in point of cauſticity, the quantity of the water, the time during which the lixivium is boiled, with many other ſuch circumſtances, produce great variations on the nature of *kermes*. In order to obtain it always with the ſame ſtrength, the proportion of the ſubſtances of which it is compoſed, and the circumſtances in which it is prepared, ſhould always be the ſame. Without entering into a very minute detail of all the phænomena which kermes has offered to our obſervation, when treated with a great many different intermedia, we ſhall only add, 1. That the cauſtic alkalis produce a ſingular alteration upon it, and diſſolve it even when cold. 2. That the energy with which the acids act on this ſubſtance is much diverſified, and that it is very difficult to determine by means of them the quantity and the ſtate of the ſemi-metal, and the ſulphur which enter into its compoſition; becauſe the ſulphur ſeparated from kermes by acids carries always along with it a certain quantity of oxide of antimony.

The cauſtic alkalis act with much more energy than the effervescent alkalis on ſulphure of antimony; the former produce more kermes in proportion to their quantity; and the kermes into which they enter, is of a much deeper colour than that which owes its formation to the latter. Lime, or lime water, when digeſted over antimony in powder, affords, even without the application of heat, at the end of a few days, a kind of kermes or golden ſulphur, of a beautiful red colour. Ammoniac alters it in the ſame manner. By diſtilling ammoniacal muriate with ſulphure of antimony, we obtain a pulverulent purple ſublimate, which appears to be a kind of antimoniated ſulphure, with a baſe of ammoniac.

Laſtly, To conclude the hiſtory of the decompoſition of ſulphure of antimony, a number of other metallic ſubſtances ſeparate the ſulphur from this compound, having a greater affinity with it than antimony has. Tin, iron, copper, and ſilver, are all of them capable of effecting this decompoſition. It is only neceſſary to heat tin or ſilver with this ore till they melt. Theſe metals unite with the ſulphur, leaving the antimony in a ſolitary ſtate. Iron and copper produce the ſame effect: theſe muſt be firſt filed down, and made red hot in a crucible; after which the ſulphure of antimony is added to them, and ſoon decompoſed. The mineral haſtens their fuſion; and the ſemi-metal is ſeparated. It muſt be confeſſed, however, that the antimony obtained by theſe proceſſes is never pure: it ſtill retains a part of the metallic ſubſtances which were employed to ſeparate the ſulphur. Its form and colour always indicate this; and it is diſtinguiſhed by the name of the metal with which it is alloyed.

Antimony is employed in many of the arts; more eſpecially in caſting types for printing It was formerly uſed as a purge. For this end, a quantity of water or wine was drunk, after ſtanding over night in veſſels of this ſemi-metal. But as the particular temperature of the place and the ſtate of the wine, as being more or leſs acid, neceſſarily rendered it uncertain what quantity of the metal might be at any time diſſolved, this medicine has been with good reaſon given up, as being very little to be truſted. For the ſame reaſon, the perpetual pills are no longer uſed, which were little balls of this ſemi-metal ſwallowed as a purgative. The ſtate of the digeſtive juices, the nature of the mucus in the primary ducts, and the differences between different individuals in point of ſenſibility, rendered the effects of thoſe pills uncertain, and frequently dangerous.

Crude ſulphure of antimony, Rotrou's ſolvent, the oxide of antimony known by the name of *diaphoretic*, kermes mineral, and golden ſulphur, are the only antimonial preparations at preſent uſed in medicine. Sulphure of antimony is employed as a ſudorific in cutaneous diſtempers. It is ſuſpended in a linen bag in the veſſels in which ptiſans for theſe diſorders are prepared: A number of phyſicians deny that it produces any good effects when adminiſtered in this way. It is likewiſe levigated and made up into pills, which are taken for the ſame complaints.

Rotrou's ſolvent, or alkaline oxide of antimony, is recommended as a very effectual remedy in diſorders occaſioned by the thickening of the lymph; ſuch as ſcrophulous caſes, and all ſwellings of the glands in general. A number of phyſicians truſt but little to the effects of waſhen diaphoretic antimony: they think it a pure oxide of antimony, entirely deſtitute of virtue. Yet it is to be remembered, that Rouelle, the younger, found this oxide to be ſufficiently ſoluble, and that in conſequence of its poſſeſſing this property, it muſt be capable of producing ſome effects in medicine. Beſides, as we know not in what manner the gaſtric juices, and thoſe of the inteſtines, act on metallic oxides, we muſt not venture to pronounce that a ſubſtance which is apparently inſoluble and inſipid, can have no virtues when taken inwardly. Experience proves, however, that this medicine produces ſcarce any effect in the moſt obſtinate cutaneous diſorders, however long we continue to apply it. Unwaſhed diaphoretic

phoretic antimony, or Rotrou's ſolvent, is preferable, becauſe, on account of its containing alkali, it is much more active than the laſt-mentioned medicine. A medicine called *La Chevelleray's powder* is ſtill uſed in ſuch caſes. It conſiſts of diaphoretic antimony calcined ſeven times ſucceſſively, with freſh nitre each time, and lixiviated after each operation. It differs but very little from waſhed diaphoretic antimony; for when this ſemi-metal has been once well calcined, as it is when detonized with a quantity of nitre equal to three times its own weight, it is no longer ſuſceptible of calcination; and therefore no detonation can be obſerved in this operation. This medicine is abſolutely incapable of producing any effects when deprived of alkali.

Kermes mineral is one of the moſt valuable medicines that are prepared of antimony. It is inciſive, and is very happily adminiſtered in pituitous affections of the ſtomach, the lungs, the inteſtines, and even of the urinary paſſages. It is moſt frequently uſed in caſes when the breaſt is affected, in order to aſſiſt expectoration. It ought not to be given, however, till the inflammation be abated. It is likewiſe given ſucceſsfully, in ſmall doſes frequently repeated, in catarrhs of the breaſt, the humid aſthma, cutaneous diſorders, ſwellings of the glands, &c. It is given in doſes of from half a grain to two or three grains, in certain drinks or pills. Sometimes it occaſions vomiting; and it often occaſions ſweat, or a profuſion of urine.

Golden ſulphur, as being a violent emetic and purgative, is but little uſed. It was formerly adminiſtered in the ſame caſes in which kermes is preſcribed; but its effects are much more uncertain.

There are likewiſe ſeveral other preparations of antimony, which are very advantageouſly employed in medicine: But as they are made up with vegetable matters, we will ſpeak of them on another occaſion. This is among the moſt valuable of metallic ſubſtances in medicine; and phyſicians cannot ſtudy its properties with too much attention. Scarce any other metallic ſubſtance has more engaged the attention both of alchemiſts and chemiſts; and we have deſcribed a number of valuable preparations into which it enters.

CHAP. XIV.

Of Zinc.

ZINC is a ſemi-metallic ſubſtance, ſparkling, of a bluiſh white colour, and cryſtallized in narrow laminæ; it has neither taſte nor ſmell. It cannot be reduced into a powder like the other ſemi-metals: it yields under the hammer, and may even be beat out a good deal, provided it has not been too much hammered before. We owe the knowledge of this property of zine to M. Sage. When zinc is wanted to be very much attenuated, it muſt be granulated, by being poured melted into cold water, or filed down. It greaſes the files employed for this purpoſe, and fills up their teeth. Macquer ſays, that when it is expoſed to the moſt intenſe heat which it can bear without melting, it becomes ſo brittle that it may be pulveriſed in a mortar. This property eſtabliſhes a wide diſtinction between zinc and thoſe metals which are rendered more ductile by the action of heat, and renders it eaſy for us to reduce a maſs of this metal to ſeparate particles. It may be likewiſe reduced to the ſame ſtate by triturating it when melted, and ſtirring its particles to prevent their adhering together as they cool. This operation muſt not be performed in an iron mortar, for zinc always diſſolves a portion of that metal: a marble peſtle and mortar ſhould be uſed for the purpoſe.

In water zinc loſes about a ſeventh part of its weight. The brilliant, and in a manner regular facets, which appear in the fracture of the pigs into which zinc is made up for commerce, are a proof that this ſemi-metal is capable of cryſtallizing in a determinate manner. The Abbé Mongez ſucceeded in cryſtallizing this ſemi-metal. Its cryſtals are bundles of ſmall quadrangular priſms, diſpoſed in all directions, and of a blue colour, which is changeable if expoſed to the air while the metal is hot.

M. Sage thinks zinc to be, next after iron, the moſt common of all metals. He affirms that he has found it in all martial pyrites: and M. Grignon aſſerts that the *cadmia* of the furnaces in which iron ores are treated, always contains a good deal of zinc.

Native zinc is very rare: moſt naturaliſts even doubt of its exiſtence. But M. Valmont de Bomare informs us, that he has ſeen ſpecimens of this ſubſtance in the mines of lapis calaminaris in the Dutchy of Limburgh, and in the mines of Goſlard. It was in ſmall pliant filaments, of a greyiſh colour, and very inflammable.

This metal is ofteneſt found in the ſtate of oxide: it then conſtitutes the *lapis calaminaris*, which in point of form is ſubject to very many varieties. Sometimes it is in cubic, priſmatic, foliated, or laminated cryſtals; but ofteneſt in irregular maſſes. Its colour too varies. It is ſometimes white, ſometimes grey or yellow, and ſometimes reddiſh. It is a hard body, but never ſo very hard as to give fire with ſteel. It is found in pretty large quarries in the Dutchy of Limburgh, in the county of Namur, and in Nottingham and Somerſetſhires in England. Theſe quarries of *lapis calaminaris*, are often found to contain marine bodies, calcareous ſpar, &c.; a circumſtance which proves them to have been depoſited by water. The lapis calaminaris is ſtill called *natural* or *foſſil cadmia.* Bergman, who has analized zinc ores in a very accurate manner, has found almoſt all calamines to contain ſiliceous and aluminous earth, and oxide of iron in various proportions: calamines contain from .04 to .30 of metal.

Zinc, in combination with ſulphur, forms what is called *blende* or *falſe galena.* This ſulphure of zinc is commonly in ſcales; ſometimes it appears in cubic cryſtals, more or leſs truncated. As to colour, it is ſometimes lead coloured, but generally black or reddiſh: There is alſo found at Ronſberg in Norway, at Goſlard, and at St Marie, a yellow and tranſparent ſpecies of this ſubſtance. Some blendes are phoſphoric when rubbed in the dark. Some of them poſſeſs this property in ſuch a degree, that all that is neceſſary to make them diſplay it, is to rub them with a tooth-pick. Blende has received the name of *ſterile nigrum ;* becauſe, when melted in order that the zinc which it appears to contain might be extracted, no zinc is obtained, as the ſemi-metal is volatilized while it is in fuſion. All blendes, when they are either rubbed or diſſolved in acids, exhale a very ſenſible ſmell of liver of ſulphur. Cronſtedt thinks them to conſiſt of zinc combined with ſulphur by the intermedium of iron. M. Sage is of opinion, that they contain an earthy ſulphure, or liver of ſulphur.

Zinc is likewiſe found in a ſaline ſtate, combined with the carbonic, or with the ſulphuric acid. The firſt of theſe compounds is known by the name of *vitreous zinc ore,* or *ſpar of zinc.* This ore is white, grey, or bluiſh, and gives fire with ſteel: it is ponderous, ſometimes cryſtallized, and ſometimes ſtalactitical, or irregularly

gularly ſhaped. It diſſolves with effervefcence in acids, giving out carbonic acid. Bergman reckons every 100 grains of it to contain 65 of oxide of zinc, 28 of carbonic acid, 6 of water, and 1 of iron.

Native ſulphate, or vitriol of zinc, is found in rhomboidal cryſtals or white ſtalactites. It is often cryſtallized, like amianthus, in ſilky filaments, or in fine needles: it is ſometimes confounded when in this ſtate with *feathered alum*. It is found in Italy, and in the mines of Goſlard in Hartz.

We may now proceed to arrange zinc ores in the following manner, according to the ſeveral ſtates in which the ſemi-metal is found.

State I. Native zinc.

1. In pliant filaments, greyiſh, and inflammable.

State II. Zinc in Oxide; *Calamine.*

Varieties.

1. Oxide of zinc, or white calamine in tetrahædral priſmatic cryſtals, ſhort and bundled together in a confuſed manner. It ſometimes inclines to green.
2. Oxide of zinc, or calamine cryſtallized in pyramids, reſembling the hog's tooth calcareous ſpar; its colour, white, grey, greeniſh, or reddiſh. Meſſrs Sage and Romé de Lille think that this calamine is produced by the decompoſition of calcareous ſpar. It is indeed often

Varieties.

often found to be in part calcareous and hollow within.

3. Solid, and as it were worm-eaten oxide of zinc or calamine. It is furrowed, cellular, and in ſome manner cryſtallized in dendrites.
4. Solid, compact calamine or oxide of zinc; *lapis calaminaris.* That which we get from the county of Namur is always calcined. There is an order againſt exporting it till it have undergone that operation.
5. Oxide of zinc, or calamine in greeniſh or yellowiſh ſtalagmites.
6. Oxide of zinc, or calamine in a zeolite form, known by the name of *Zeolite of Friburgh.* M. Pelletier has diſcovered that this pretended pearl-coloured zeolite contains to 100 parts,—from 48 to 52 of ſiliceous earth, 36 of oxide of zinc, and from 8 to 12 of water.

State III. Zinc mineralized by ſulphur: Sulphure of zinc, blende.

Varieties.

1. Bluiſh grey blende, or ſulphure of zinc, of a metallic appearance, and in cubic or rhombic cryſtals.
2. Black ſulphure of zinc, or blende, either in cryſtals, or irregularly ſhaped.
3. Red or reddiſh brown ſulphure of zinc or blende.
4. Phoſphoric ſulphure of zinc, or blende, of a yellowiſh green, or a red colour.

5. Greyiſh

5. Greyiſh yellow ſulphure of zinc, or blende, mixed with galena or petroleum.
6. White blende, or ſulphure of zinc.
7. Waxen yellow blende, or ſulphure of zinc.
8. Sulphure of zinc, or blende in a ſtate of decompoſition, its plates ſeparated, and its brilliancy deſtroyed. It paſſes into the ſtate of oxide of zink, or calamine.

State IV. Saline zinc.

Varieties.

1. Carbonate of zinc, ſparry zinc, or vitreous ore of zinc.
2. Sulphate of zinc, in rhomboidal cryſtals, in ſtalactites, or in ſilky filaments.

In aſſaying calamine, it is generally ſufficient to reduce it to powder, to mix it with coal, and to heat the mixture in a crucible covered with a red copper-plate; on which the copper immediately becomes yellow, and is converted into braſs. Bergman has analized calamine much more accurately by the humid way: he made uſe of the ſulphuric acid in analizing pure calamine and carbonate of zinc: the ſolution he found to contain both ſulphate of zinc and ſulphate of iron; the laſt he decompoſed by a known weight of zinc, and afterwards precipitated it with carbonate of ſoda. He has determined, that 193 grains of this precipitate are equal to 100 grains of zinc; from the weight of the precipitate he deducts the weight of the zinc employed to precipitate the iron.

As moſt calamines are of a more compound nature than

than this, and contain ſiliceous earth, aluminous earth, and chalk combined with oxide of zinc, of iron, and even of lead; Bergman firſt treats thoſe ores three times ſucceſſively with two parts of nitrous acid each time: on heating them till they become dry, the acid calcines the iron and renders it inſoluble; the ſecond addition of nitric acid ſerves to diſſolve whatever is ſoluble; and the iron, the ſiliceous earth, and the aluminous earth, remain ſeparate. The acid holds in ſolution the calcareous earth and the oxides of zinc and lead. The muriatic acid is employed to precipitate the oxide of lead; the ſulphuric acid to ſeparate the lime; as to the lime it is precipitated by the alkaline pruſſiates. Bergman takes one fifth of the weight of this precipitate to be the oxide of the zinc contained in the calamine. He has employed likewiſe another proceſs, in which he diſtilled the ſulphuric over calamine till only a dry reſidue remained; this reſidue he lixiviated in hot water: he then precipitates this lixivium with cauſtic ammoniac, which ſeparates the iron and the aluminous earth, but not the oxide of zinc, which is ſoluble in ammoniacal ſulphate.

As to the aſſaying of blendes, formerly they were firſt roaſted, and then treated in the ſame way as calamines. M. Monnet firſt aſſerted that theſe ores might be very well aſſayed by diſſolving them in aquafortis, which combines with the metallic ſubſtance and ſeparates the ſulphur. The oxide of zinc is then reduced, after being ſeparated by diſtillation from the nitric acid. Bergman has made a ſeries of experiments on theſe ores, no leſs accurate than thoſe which he has made on calamines; and has purſued M. Monnet's concerning the aſſaying of them by the humid way to a much greater length. He firſt ſeparates by diſtillation, the

water,

water, the arſenic, and a part of the ſulphur which they contain: he next treats them with ſuch acids as act upon them with the moſt force; and finiſhes the operation by precipitating theſe ſolutions with various re-agents.

The ores of zinc are not wrought in order to extract the ſemi-metal which they contain. By melting lead-ore mixed with blendes, zinc is obtained in the form of oxide; which is ſublimed in the chimnies of furnaces, and there produces greyiſh incruſtations, which are called *tuttia* or *cadmia fornacum*. Another portion is obtained in the metallic form by cooling the anterior part of the furnace. The zinc being reduced to vapour by the action of the fire, is there condenſed, and falls in grains on powder of charcoal, covering a ſtone placed beneath in the furnace. The powder of coal preſerves the ſemi-metal from being calcined; it is then melted anew in a crucible, and caſt into pigs. This is the proceſs by which the greateſt part of the zinc which paſſes in commerce is obtained at Rammelſberg, either in oxide or in metal. This zinc is always combined with a portion of lead which alters its nature. That which is prepared in China, and comes to us from the Indies, under the name of *tutenag*, is much purer *; but we are unacquainted with the proceſs by which it is prepared. M. Sage ſays, that the Engliſh extract zinc, in the great way, from lapis calaminaris by diſtillation; but the apparatus which they employ is kept a ſecret.

Zinc expoſed to heat in cloſe veſſels melts on becoming red hot, and volatilizes without being decompoſed. If ſuffered to cool ſlowly in a veſſel from which

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* Mr Kirwan gives the name of *tutenag* to a variety of the brittle calamine of China, of which M. Engerſtrom has given an analyſis in the Memoirs of Stockholm, 1775. That ore is very rich, and contains from $\frac{60}{100}$ to $\frac{90}{100}$ of zinc.

a part of the melted ſemi-metal may run out, the remaining part cryſtallizes into needled priſms. M Mongez uſes for this purpoſe a roaſting pot with ſeveral holes in its ſides and bottom, which he ſtops with earth of bones. When the ſurface of the zinc cools, all the holes are gradually ſtopped ; and the metal is ſtirred with a red iron introduced by one of them. This ſimple proceſs cauſes the melted zinc to run out ; and the roaſting pot is then ſhaken till the metal ceaſe to run, and the portion which is cool cryſtallize. If left in the veſſel, it takes a metallic colour : if expoſed to the air, it aſſumes the ſhades of the rainbow. When melted zinc is brought into contact with the air, it is covered with a grey pellicle, which is ſoon converted into a yellowiſh oxide, not very refractory, but eaſily reducible. This oxide weighs more than the zinc of which it is formed ; but if the ſemi-metal be violently heated, it burns with a white or a greeniſh yellow flame, which is very brilliant, and reſembles the flame of phoſphorus. The oxide is carried up and volatilized by the current of this flame, but condenſes in the air into the form of very light white flakes, which are called *flowers of zinc, pompholix, nihil album, philoſophical wool* or *cotton.* They are a thoroughly calcined oxide of zinc ; and their gravity is greater than that of the ſemi-metal from which they are formed : for M. Baumé obtained ſixteen ounces ſix drachms and fifty four grains of this oxide from a pound of zinc. It is not volatile of itſelf ; and its ſublimation is owing to the rapidity with which the zinc burns ; for if this oxide be expoſed to fire after being volatilized, it remains fixed : it retains a phoſphoric light which it diſplays in the dark ; it melts into a glaſs ; but a very intenſe heat is requiſite : Vitrified oxide of zinc is of a beautiful pure yellow colour.

The

The oxide and the glaſs of zinc are nothing but a combination of the ſemi-metal with oxigene, or the baſe of vital air. The only difference between the white oxide and the glaſs ſeems to be, that in the latter the principles are more intimately united. This compound is one of thoſe metallic oxides which are indeſtructible; nor can it be reduced without the addition of another body. In order to reduce it, we muſt bring it into contact with ſome combuſtible ſubſtance. On expoſing to an intenſe heat a mixture of white oxide of zinc with coal or any other combuſtible matter, zinc is obtained; and the coal is partly burnt by means of the oxigene, of which it robs the metallic oxide. Zinc has therefore leſs affinity than coal with oxigene, though it appears to be the more combuſtible of the two. This operation ſucceeds beſt in cloſe veſſels: and we are told, that the Engliſh reduce lapis calaminaris by diſtillation.

Zinc is ſcarce alterable by air: only its ſurface is a little tarniſhed, and it ſeems beginning to oxidate.

Water acts powerfully on zinc when the ſemi-metal begins to become red hot. It eaſily reduces zinc to an oxide, giving out at the time a good deal of hydrogenous gas, which ſhows that it is decompoſed by the ſemi-metal, which with the help of an high temperature deprives it of its oxigene. Meſſrs Lavoiſier and Meuſnier were fully convinced of this fact by their experiments on the decompoſition of water. A little carbonaceous matter from the zinc is held in ſolution by the hydrogenous gas obtained in this proceſs.

Zinc has no power of action on ſiliceous or on aluminous earth; but its oxide enters into vitreous compounds, and communicates a yellow colour to glaſs.

Neither barytes, nor magneſia, nor lime, acts upon zinc.

When

When liquor of cauſtic potaſh or ſoda is boiled over this ſemi-metal, it blackens its ſurface, and diſſolves a certain quantity of oxide, which, as M. de Laſſonne has ſhown, may be ſeparated from it by acids. Ammoniac acts leſs effectually on zinc hot, on account, no doubt, of its volatility: when it is digeſted cold, however, over zinc, it diſſolves a little of it. In the ſolution of zinc by the three alkalis, a certain quantity of hydrogenous gas is diſengaged; the production of which is owing to the decompoſition of the water: ſo that it is this fluid which acts on the ſemi-metal, reduces it to an oxide, and renders it in part ſoluble in alkalis.

The ſulphuric acid, diluted in water, diſſolves zinc cold. As the ſolution takes place, the ſemi-metal aſſumes a blackiſh grey; a conſiderable degree of heat is excited; and a black powder is precipitated; the nature of which was long unknown, but which is now known to be *plumbago:* a good deal of hydrogenous gas, with a little carbonaceous matter diſſolved in it, is diſengaged. This elaſtic fluid, which has the ſame ſmell as the gas obtained when iron is diſſolved by the ſame acid, is certainly owing to the water; for the concentrated ſulphuric acid never diſſolves zinc without the help of heat, and the gas which it then affords is ſulphureous. The water, therefore, begins with oxidating the zinc, and the acid then diſſolves the oxide of the ſemi-metal. When hydrogenous gas is no longer diſengaged, the effervеſcence ceaſes, and the ſmell of the ſolution changes, becoming perfectly the ſame with that of greaſe a little rancid. The liquor is whitiſh and ſomewhat turbid: by dilution in water it becomes tranſparent. When evaporated it affords a white ſulphate of zinc, rather more ſoluble in hot than in cold water; of which a portion cryſtallizes by cooling. This ſalt may be eaſily

enough

enough obtained in very regular cryſtals, which are uſed in the arts under the name of *white copperas, white vitriol, Goſlard's vitriol.* On expoſing to the air for a few days a ſolution of this ſalt in boiling water, a little evaporated, it affords tetrahædral priſms, terminating in pyramids having likewiſe four ſides: the ſides of theſe priſms are ſmooth. Such is the form which Meſſrs Sage and Romé de Liſle aſcribe to them, and my obſervations enable me to confirm what they have advanced. Bucquet obſerved the priſms to be rhomboidal; yet M. Monnet aſſerts, that it is very difficult to make this ſalt cryſtallize, and that it is obtained in regular cryſtals without conſiſtency, by being violently evaporated and ſuddenly cooled. The white oxide of zinc likewiſe diſſolves in the ſulphuric acid, forming the neutral ſalt of which we are ſpeaking.

This ſalt has a pretty ſtrong ſtyptic taſte. According to Hellot, it loſes a part of its acid by the action of fire. That acid poſſeſſes the characteriſtic properties of the ſulphureous acid: it becomes hot when mixed with the concentrated ſulphuric acid, as has been remarked by Macquer. After being expoſed to the action of fire, this ſulphate of zinc appears to be converted into ſulphite of zinc; the properties of which are not well known. Sulphate of zinc, when very pure, ſuffers ſcarce any alteration from air: in time its oxide becomes more completely calcined by abſorbing more oxigene: it then becomes yellow, and not entirely ſoluble in water. Sulphate of zinc is decompoſed by aluminous earth, barytes, magneſia, lime, and the three alkalis. The oxide of zinc precipitated by theſe ſubſtances may be again diſſolved in acids, and even in alkalis. Ammoniac acquires, in this ſolution, a dirty brown colour. Sulphate of zinc decompoſes nitre, and is itſelf decompoſed by that neutral ſalt. By diſtilling this mixture, two kinds of nitrous acid are obtained; which do not mingle together, as well as glacial ſulphuric acid. We will ſpeak more particularly on this matter under the article ſulphate of iron; or *martial vitriol.*

We find in commerce a ſulphate of zinc under the name of *white copperas*; which is prepared in the great way at Goſlard. Blende is roaſted; a portion of the ſulphur then burns, and affords ſulphuric acid; which diſſolves the oxide of zinc. The ore is next waſhed; and the lixivium, after being ſuffered to ſettle, is decanted off, evaporated, and thus cryſtallized. This ſalt is then melted by a moderate heat, in order to free it from the water of its cryſtals, and left to cool. By this proceſs it is condenſed into white, opaque, and grained maſſes like ſugar. *Vitriol of Goſlard*, when diſſolved in boiling water, cryſtallizes by cooling; and its cryſtals are a little reddiſh. The colour is aſcribed to the impurities of the ſalt; which is thought to contain a ſmall portion both of lead and of iron. To purify it, a little zinc may be caſt into the ſolution. This ſemi-metal precipitates the oxide of lead and iron, becauſe it has a greater affinity with the ſulphuric acid than they have. The liquor is now filtrated; and after paſſing through the filter, contains nothing but pure ſulphate of zinc. What eſpecially leads us to think it oxide of iron which often alters the *vitriol of Goſlard* is, that the zinc which paſſes in commerce is ſometimes attracted by the loadſtone; a property which it muſt, no doubt, owe to iron. If a perſon were to make experiments, therefore, on this ſemi-metal, it would be proper to uſe no ſpecimens but ſuch as he had himſelf prepared by reducing precipitate of ſulphate of zinc, after purifying it as we have directed. We muſt, however, obſerve, that the reaſon why pigs of zinc are attracted

tracted by the loadſtone at the part where they have been cut, is often nothing elſe but their having been cut with iron ſciſſars or wedges.

The nitric acid, when weak and diluted in water, combines with zinc cold, and with great rapidity. A conſiderable heat is produced on this occaſion, as well as when the ſame ſemi-metal is diſſolved in the ſulphuric acid. The lively effervеſcence which takes place when this combination is effected, occaſions the diſengagement of a great quantity of nitrous gas, which the air renders inſtantly red when the operation is performed in an open veſſel: but by itſelf this gas is colourleſs; and it may be collected under water by immerſing into a quantity of that fluid the extremity of the veſſel containing the mixture. This experiment proves that zinc decompoſes the nitric acid by robbing it of a part of its oxigene. If the zinc be mixed with a little iron, it is covered with a reddiſh ochreous powder; which is nothing but a portion of that metal thoroughly calcined by the acid: if pure, it precipitates ſome flakes of a black matter, or carbure of iron, in the ſame manner as when in combination with the ſulphuric acid: a much greater proportion of oxide of zinc will remain diſſolved in the nitric than in the ſulphuric acid. M. Baumé ſays, ſix ounces of this acid diſſolve five drachms and an half of zinc in leſs than two hours. The nitric ſolution of zinc is of a greeniſh yellow colour, and a little turbid when new made; but after being ſuffered to ſettle for ſome time, it loſes this colour and becomes tranſparent. Altho' the acid with which it is made be diluted in water; yet it is ſo very cauſtic as to corrode the ſkin. I obtained from this ſolution by evaporation and cooling, cryſtals in compreſſed and ſtriated tetrahædral priſms, terminating in four-ſided ſtriated pyramids. When this nitrate of zinc is placed on burning coals, it immediately

diately melts and runs into ſeparate portions, which detonate as they become dry; and the detonation is attended with a faint reddiſh flame. It does not, however, exhibit the ſame phænomenon when melted in a crucible: it cannot then be dried even by the moſt moderate heat without ſuffering ſome alteration. Nitrous gas eſcapes from it; its colour becomes a brown red, and its conſiſtency gelatinous. If cooled when in this ſtate, it retains its ſoftneſs for ſome time; and if the application of heat be continued, it dries ſuddenly up into a yellowiſh oxide. Hellot obtained from nitrate of zinc by diſtillation a very fuming nitrous acid; and obſerved it to aſſume a red colour in melting. It may be underſtood, that when heat diſengages nitrous gas from this ſalt, it paſſes into the ſtate of *nitrite of zinc:* It affords alſo a certain quantity of oxigenous gas or vital air. Nitrate of zinc readily attracts the moiſture of the atmoſphere; on which event it loſes its regularity of form. What remains of the cryſtals of this ſalt, after a few days expoſure to the air, is only ſtriated pointed priſms without any determinate form. We know not whether it be decompoſable by other acids. Meſſrs Pott and Monnet affirm, that oxide of zinc has a ſtrong affinity with all theſe ſalts; but does not combine with any one of them in preference to the reſt. According to Hellot, oxide of zinc forms the ſame ſalt by ſolution in the nitric acid. If nitrous acid be employed to effect this ſolution, nitrite of zinc is produced; the nature of which is not exactly known.

The muriatic acid acts on zinc in as rapid a manner as the nitric acid. A conſiderable quantity of hydrogenous gas is diſengaged during the lively effervefcence with which this act of combination is accompanied: its properties are the ſame with thoſe of the hydrogenous gas produced by the ſulphuric acid acting upon this ſemi-

ſemi-metal; and, as in that inſtance, it ariſes from the water decompoſed by the zinc. A blackiſh matter is gradually depoſited in flakes by the liquor; which can be nothing but a combination of carbonaceous matter with iron. The ſolution of zinc by the muriatic acid is colourleſs; nor does it afford cryſtals by evaporation. When heated, it aſſumes a blackiſh brown colour, exhales the acrid and pungent vapours of the muriatic acid, and becomes much thicker: it has been expoſed to the air in this ſtate for eight days without giving cryſtals. By diſtillation it affords a ſmall portion of very fuming muriatic acid and ſolid fuſible muriate of zinc. Meſſrs Hellot and Monnet have given very good deſcriptions of this operation. In my courſes of lectures I have repeated it ſeveral times, and have obtained, firſt, a ſmall portion of yellowiſh acid, and afterwards a congealed matter in the neck of the retort. This muriate of zinc was of a beautiful milk-white colour, very ſolid, and formed, like ſtalactites, of ſmall radiated needles: it melts by a mild heat. I preſerved ſome of it for a number of years in well-ſtopped glaſs-flaſks; it had acquired but little moiſture in all that time; the parts which touched the glaſs were become a little yellowiſh, and the bottom of the glaſs was coloured like a rainbow. This alteration is, no doubt, the effect of light. In the retort uſed in the above proceſs of diſtillation there remains a vitriform and deliqueſcent blackiſh matter. The muriate of zinc which Hellot obtained by diſtillation was yellowiſh; the ſulphuric acid, he ſays, diſengages the muriatic acid. We know nothing of oxiginated muriate of zinc.

The liquid carbonic acid, when zinc or oxide of zinc is put to digeſt in it, diſſolves, according to Bergman, a pretty conſiderable quantity of it in the ſpace of twenty four hours. This ſolution, when expoſed to the air, is

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covered over with a pellicle which reflects various colours, and is actually, according to the celebrated chemiſt above quoted, carbonate of zinc.

We are not as yet well acquainted with the manner in which the fluoric and the boracic acids act upon zinc.

All ſolutions of zinc in acids are precipitated by lime-water, magneſia, fixed alkali, and ammoniac. The oxide of this metal then appears in the form of white or yellowiſh flakes, according to the ſtate of the ſolution and the purity of the precipitant. It may be reduced by means of zinc: it is ſoluble in acids and alkalis. By adding more alkali than is requiſite to precipitate the oxide of zinc diſſolved in an acid, the precipitate is cauſed to diſappear gradually, and the liquor to aſſume a dirty yellow colour; an indication that the oxide is diſſolved in the alkali. When, inſtead of pure or cauſtic alkalis, carbonate of potaſh, ſoda, or ammoniac is employed to ſeparate zinc from acids, there is ſcarce any efferveſcence; the precipitate is whiter than in the former caſe, and the carbonic acid appears to unite with the oxide of zinc; ſo that in this caſe there are two decompoſitions and two new combinations.

Zinc decompoſes a number of the neutral ſalts: When expoſed to fire in a crucible with ſulphate of potaſh, it decompoſes that ſalt, and forms ſulphure of potaſh, in the ſame manner as antimony. In this operation, the zinc ſeizes the oxigene of the ſulphuric acid; and the acid paſſing into the ſtate of ſulphur, is then diſſolved by the potaſh: the ſulphure formed by this combination diſſolves a portion of the oxide of zinc. All ſulphates are equally liable to be decompoſed by zinc.

When this metal is reduced to filings or powder, it makes nitre detonize with amazing rapidity. If the mixture be made very dry, and caſt by ſpoonfuls into a red crucible, it produces a clear red flame. So vigorous is this inflammation, that it darts the burning matter to a diſtance from the crucible; which renders it neceſſary for the operator to be very cautious. The zinc burns with the help of the oxigene of the nitre which is decompoſed, and is reduced to an oxide, which is more or leſs complete according as a greater or a leſs quantity of nitre has been employed. A part of the reſidue is ſoluble in water. That part conſiſts of potaſh in combination with ſo much of the oxide of zinc, and may be precipitated by acids. Reſpour aſcribed to this ſolution the property of diſſolving all metals; if we may believe Hellot, who has given it as the *alkaeſt* of that alchemiſt.

Zinc appears from Pott's experiments to be capable of decompoſing muriate of ſoda. It acts with peculiar force in decompoſing ammoniacal muriate: M. Monnet affirms, that when this ſalt is triturated with the ſemi-metal, there is ammoniac diſengaged, Bucquet has obſerved, that when this ſalt is diſtilled with zinc, a good deal of ammoniac gas is obtained, as well as of hydrogenous gas, produced when the muriatic acid enters into combination with the ſemi-metal. The diſengagement of the ammoniac, ſo eaſily effected, he perceived to be owing to the lively re-action of the zinc on the muriatic acid. Oxide of zinc is alſo diſengaged on the occaſion, according to Hellot. The reſidue of this decompoſition is muriate of zinc, which may be ſublimated.

When a ſolution of aluminous ſulphate is boiled with filings of zinc, it is decompoſed, and ſulphate of zinc is formed in conſequence of its decompoſition.

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The baſe of that ſalt therefore appears to have leſs affinity than zinc with the ſulphuric acid We owe this fact to Pott. We will hereafter have occaſion to make a ſimilar obſervation concerning ſeveral other metallic ſubſtances.

The effects of hydrogenous gas on zinc have not yet been attended to; only I have obſerved, that if the ſemi-metal be immerſed into the gas, it aſſumes after ſome time a very bright changeable blue colour; but I have not purſued this alteration farther. It does not reduce the oxide of this ſemi-metal, which retains its oxigene with ſo much force as even to decompoſe water.

Zinc appears at firſt to be almoſt incapable of combining with ſulphur. When theſe two ſubſtances are melted together, they melt without entering into any kind of union. Yet M. Dehne has obſerved, that if they be kept together in fuſion for ſome time, the zinc is partly calcined, aſſumes a brown or a grey colour, and acquires an increaſe of weight. M. de Morveau has ſince diſcovered, that oxide of zinc combines eaſily with ſulphur by fuſion, producing by this combination a grey mineral, very like the *blende* of Huelgoet. Sometimes bright yellow priſmatic needles are found ſticking to the lid of the crucible in which this combination is accompliſhed. M. de Morveau obſerves, that it is the more probable that the natural *blende* is formed by the combination of oxide of zinc with ſulphur, as we find no native zinc.

M. Malouin did not ſucceed in combining zinc with alkaline ſulphure, though he attempted it both in the humid and the dry way, and with various proportions of the ſubſtances.

The ſame chemiſt combined zinc with arſenic. He has

has obſerved that it does not unite ſo well with the oxide of arſenic. However, in an experiment in which he diſtilled a mixture of oxide of arſenic, tallow, and zinc, he obtained a blackiſh maſs reſembling blende, but ſofter than that ore. It appears likewiſe, that when zinc and oxide of arſenic are diſtilled together, the former deprives the latter of a part of its oxigene; for part of the ſemi-metal is calcined, while part of the oxide paſſes into the metallic ſtate. It would be of conſiderable ſervice to chemiſtry to determine, by a ſeries of experiments, the reciprocal action of metals and metallic-oxides; together with the various degrees of affinity with which oxigene adheres to each of theſe ſubſtances.

We know not whether it be poſſible to combine zinc with cobalt.

It does not combine with biſmuth; and when theſe two ſemi-metals are melted together, the biſmuth, being the moſt ponderous of the two, ſinks under the zinc, and they may be ſeparated by a blow with an hammer.

When zinc is melted with antimony, it gives an hard brittle mixture, which Malouin only mentions.

Zinc is of great uſe in the arts. It enters into ſeveral metallic mixtures; particularly in tombac and prince's metal. Filings of zinc are mixed with powder to produce bright, ſparkling artificial ſtars in fire works. Several perſons have propoſed the uſe of this metal as being ſtill more effectual than tin, for plating over the inner parts of copper veſſels. Malouin, after comparing theſe two metallic ſubſtances, in two Memoirs, which appear among thoſe of the Royal Academy of Sciences for the years 1743 and 1744, gives an account of ſome experiments which he made concerning the plating of

copper

copper veſſels with zinc. The reſult of his reſearches is, that this kind of plating might be more exactly ſpread over the copper, and would be much harder and much leſs liable to melt than a plating of tin; and of conſequence more laſting, and leſs likely to fall off the copper. Macquer acknowledges theſe advantages, but makes ſome very important obſervations on the uſe of zinc for plating kitchen utenſils. He thinks it dangerous, becauſe it is ſoluble in vegetable acids, ſuch as vinegar, verjuice, &c. and is a pretty ſtrong emetic. He proves this laſt fact by vitriol of zinc, which was formerly adminiſtered to excite vomiting, under the name of *gilla vitrioli*, and referring to Gaubius, who mentions a celebrated remedy for convulſive complaints, known by the name of *luna fixata Ludemanni*, as being ſublimated oxide of zinc. This luna fixata was a ſtrong emetic, and was adminiſtered in very ſmall doſes. But may we not preſume that theſe obſervations can refer only to ſulphate of zinc, and to the oxide of that ſemi-metal, and reſpect neither the ſemi-metal itſelf nor the ſalts which it forms by combining with vegetables? M. de la Planche, doctor in medicine of the faculty of Paris, has, by a ſet of experiments made with care upon himſelf, determined theſe conjectures to be not only plauſible, but certainly true. He ſwallowed ſalts formed by zinc with vegetable acids, in much ſtronger doſes than what could poſſibly be contained in any aliments prepared in copper veſſels plated with tin, without ſuffering from them any bad effects. However, as too much attention cannot be paid to whatever concerns the health and lives of mankind in general, it would certainly be highly improper to form any decided opinion concerning this matter, till it be determined by a great many experiments in what manner zinc and the ſalts which it forms with vegetable acids can affect the animal œconomy.

The German phyſicians employ ſublimated oxide of zinc ſuccesſfully as an antiſpaſmodic in convulſions and epileptic fits. It is not much uſed in France. It might, however, be of ſome utility if given in pills, and in doſes of half a grain a-day. I am told, that at Edinburgh a much more conſiderable doſe has been given without any ſenſible effects. This fact contradicts what Gaubius tells of the emetic powers of zinc.

Pompholix, *tuttia*, &c. are uſed as excellent deſiccatives for humours affecting the eyes, &c.

CHAP. XV.

Of Mercury.

MERCURY, or quickſilver, has the opacity and brilliancy of metals; next after gold and platina, it is the moſt ponderous ſubſtance known. A cubic foot of mercury, if very pure, weighs nine hundred and forty-ſeven pounds; in water it loſes one-thirteenth of its weight. As it is habitually fluid, we know nothing concerning its ductility or tenacity, and are at a loſs what rank to aſſign it among metals. However, its exceſſive weight, habitual fluidity, extreme volatility, together with the ſingular alterations which it is liable to ſuffer by combination, cauſe it to be conſidered with great probability as a peculiar ſubſtance, not otherwiſe related to metallic matters, but by its brilliancy, gravity, and combuſtibility; which might therefore be with more propriety claſſed by itſelf. We give it between the ſemi-metals and the metals.

It was long thought that mercury could not loſe its fluidity; but the academicians of Peterſburgh have proved

ved the contrary. Thoſe philoſophers made a number of experiments upon it during the ſevere cold of the year 1759, by a mixture of ſnow with fuming ſpirit of nitre, till the mercury fell in a thermometer graduated after de Liſle to 213 degrees, correſponding to 46 degrees below the freezing point in Reamur's thermometer. Thoſe gentlemen, obſerving that the mercury then ceaſed to ſink, broke the glaſs in which it was contained, and found it frozen into a ſolid body, which might be beaten out by the hammer. From this experiment it appears that mercury is ſuſceptible of concretion like other metallic ſubſtances; and in that ſtate poſſeſſes a certain degree of ductility. They could not exactly eſtimate the ductility of mercury; for at every ſtroke of the hammer, ſome point of the metal became ſo hot as to melt and run.

M. Pallas, in the year 1772, ſucceeded in effecting the congellation of mercury at Kraſnejark, by a natural cold of 55½ degrees; and obſerved, that it then reſembled ſoft tin; that it might be beaten out into thin plates; that it might be eaſily broken, and the fragments, when placed near each other, united of themſelves. Mr Hutchins, in 1775, obſerved the ſame facts at Fort Albany; and Mr Bieker at Rotterdam in 1776, at 56 degrees below Zero. At laſt, in the year 1783, the congelation of mercury was effected in England by a more moderate heat; and 32 degreees under Zero, in Reaumur's thermometer, was determined to be the term at which this congelation takes place. The mercury's falling lower in former inſtances, is therefore to be aſcribed to the contraction or condenſation of the ſolid metal. Mercury is therefore the moſt fuſible metal known; the moſt intenſe cold that is known in thoſe countries in which it is native is never ſufficient to render it ſolid. Probably, if in the above experiments the cold which froze mercury had been gradually applied to it, it would have cauſed that metallic matter to aſſume a regular cryſtalline form.

The habitual fluidity of mercury has cauſed it to be conſidered as a peculiar metallic water, and it has been called *aqua non madefaciens manus;* water that does not wet the hands. It is true, mercury does not wet the hands, nor any of thoſe bodies which are liable to be made wet by water, oil, and other liquors: but the cauſe of this phænomenon is, that there ſubſiſts but little affinity between this metallic fluid and thoſe bodies. For, when mercury is brought into contact with any ſubſtance with which it can combine, ſuch as gold, ſilver, tin, &c. it adheres to theſe bodies, and wets them to ſuch a degree, that they cannot be dried without evaporating over a fire the mercury with which they are coated.

Mercury being a metal in fuſion, when divided into ſmall parts always takes a perfect globular form; when incloſed in a phial its ſurface is convex. This laſt phænomenon depends on mercury's having ſo little affinity with glaſs, and on the ſtrong mutual attraction of the integrant parts of this metal; for when mercury is put into a metal veſſel with which it has an affinity, its ſurface appears concave, like that of any other fluid, as it then combines with the ſides of the veſſel.

The taſte of mercury is imperceptible to the nerves of the organs of taſte; but it produces a pretty ſtrong effect on the ſtomach and the inteſtines, as well as on the ſurface of the ſkin. Inſects and worms are much more ſenſible of its taſte than any other animal. Mercury kills them very quickly, and is therefore preſcribed by phyſicians as an excellent cure for worms. Some ſkilful phyſicians have been induced to think, from its poſſeſſing the power of curing the itch and ſeveral cutaneous diſorders, that theſe are occaſioned by certain inſects penetrating thro' the texture of that organ. But this opinion has not been generally adopted, though ſeveral naturaliſts have deſcribed the animal which cauſes the itch, &c.

Mercury, when rubbed between the fingers, exhales a peculiar faint ſmell. If it be ſhaken when very pure, it is ſometimes, and particularly in hot weather, obſerved to ſparkle with a phoſphoric light, which, tho' not ſtrong, is yet ſufficiently diſcernible. Many natural philoſophers have obſerved this of the mercury of the barometer. On immerſing the hand into this metallic fluid, a perſon feels a ſenſation of cold, which would ſuggeſt that its temperature is colder than that of the atmoſphere: but on immerſing a thermometer, we ſoon find the temperature of the maſs of mercury to be the ſame with that of the atmoſphere. This phenomenon, which eludes our obſervation, muſt be entirely owing to the mercury's attracting the heat from the hand with great rapidity; for mercury is known to be a powerful conductor of heat.

When mercury is divided by a rapid and continued motion, ſuch as that of a mill-wheel, it is by degrees converted into a very fine black powder, called *Æthiop's per ſe*, on account of its colour: as mercury is in this inſtance in ſome degree calcined, we call this powder *black oxide of mercury*. On being expoſed to a moderate heat, or triturated in an hot mortar, it recovers its uſual fluidity and metallic luſtre.

Mercury is not one of thoſe metals which are moſt plentiful in nature. It is found in the earth, either in a virgin ſtate, poſſeſſing all its properties, or in a ſtate of oxide, or in combination with acids, ſulphur, and ſome

ſome other metallic matters: in this laſt ſtate, it is ſaid to be mineralized by theſe ſeveral ſubſtances.

Fluid mercury is found either in globules or in larger maſſes in earths and ſoft ſtones, and moſt frequently in the cavities and interſtices of its ores. At Ydria in Spain, and in America, it is gathered in the cavities and clifts of rocks. Sometimes too it is found in clay at Almaden, and in beds of chalk in Sicily. Laſtly, it is found among ſilver, and lead ores, as well as mixed with white oxide of arſenic.

M. Sage has diſcovered an ore of mercury in oxide from Ydria in Friuli. It is of a red brown colour, very ſoft and granulated in its fracture: globules of running mercury are ſometimes found in it; it is reducible by heat without addition. Mr Kirwan conſiders it as a combination of oxide of mercury with the carbonic acid. One hundred parts of this ore afford 91 of mercury.

In the year 1776, Mr Woulfe found, at Obermuſchel in the Duchy of Deux-Ponts, an ore of mercury in cryſtals, ponderous, ſparry, white, yellow, or greeniſh, which, on aſſaying it with alkalis, he found to contain both ſulphuric and muriatic acid: it is a compound of ſulphate of mercury with corroſive mercurial muriate. M. Sage affirms it to contain 86 parts of mercury to the hundred weight. The ſame chemiſt deſcribes a brown corneous ore of mercury found in Carinthia.

In nature, mercury is ofteneſt combined with ſulphur. The compound which it then forms is called *cinnabar*, This mineral ſubſtance is red, and has not in the ſmalleſt degree a metallic appearance; becauſe though the proportion of the ſulphur be very ſmall, yet the two bodies are very completely combined together. Cinnabar is found in the Duchy of Deux-Ponts, in the

the Palatinate, in Hungary, in Friuli, at Almaden in Spain, and in South America, where it chiefly abounds at Guamanga in Peru. It is ſometimes in compact maſſes, varying in colour from a pale to a deep and blackiſh red; ſometimes in tranſparent ruby-coloured cryſtals; and often in a ſort of ſcales or foliated plates. When in a very bright red powder it is called *native vermilion*, or *cinnabar in flowers*. Laſtly, it is found in various countries in ſulphate of lime, and mixed with iron, pyrites, and ſilver.

Mr Cronſtedt, in his mineralogy, ſpeaks of an ore of mercury in which that ſubſtance is combined with ſulphur and copper. That ore is of a blackiſh grey colour, brittle, and ponderous; its fracture is vitreous, and it decrepitates when expoſed to fire. It is found at Muſchel-Landſberg.

The ſame mineralogiſt affirms, that mercury has been often found amalgamated with virgin ſilver in the ore of Sahlberg in Sweden. M. Romé de Liſle has in his cabinet a ſpecimen which he thinks to be of this kind.

M. Monnet, in his ſyſtem of mineralogy, ſpeaks of an ore brought from Dauphiny in the year 1768, by M. de Montigny, which contains mercury, ſulphur, arſenic, cobalt, iron, and ſilver. He has found it to contain in the hundred weight, a pound of mercury and three or four ounces of ſilver.

From this ſhort account of mercury, as it exiſts in the interior parts of the earth, it appears that all its ores may be arranged under the following varieties.

State I. Native mercury.

In earths and ſtones, but ofteneſt in its own ores.

State II. Native oxide of mercury.

State III. Native ſulphate and muriate of mercury.

State IV. Mercury mineralized by ſulphur; cinnabar.

Varieties.

1. Tranſparent cinnabar, of a red colour, and cryſtallized in very ſhort triangular priſms, terminating in triangular pyramids.
2. Tranſparent red cinnabar in octohædral cryſtals, conſiſting of two triangular pyramids, joined at the bottom, and truncated.
3. Solid compact cinnabar, either of a brown red or a clear red colour. It is ſometimes in leaves.
4. Red cinnabar, arranged in ſtriæ, on a ſtony gangue, or on ſolid cinnabar. It is ſometimes needled, like cobalt.
5. Cinnabar in flowers, native vermilion. This cinnabar is of a ſparkling red colour reſembling ſattin, and adhering to various gangues in the form of a very fine powder; ſometimes it is cryſtallized in very ſmall needles, and it is then very like the laſt of the foregoing varieties.

State V. Mercury combined with ſulphur and copper: Cronſtedt's black vitreous ore of mercury.

State VI. Mercury mixed with ſulphur, arſenic, cobalt, iron, and ſilver.

State VII. Mercury mixed with ſilver: native amalgam of ſilver.

In order to know the nature of an ore containing mercury, it muſt be pounded and mixed with lime, alkalis, &c, placed on a warm brick, and covered with a bell-glaſs; the mercury is then reduced to vapours, and again condenſed on the ſides of the glaſs. If it be wiſhed to know the quantity of the mercury which the ore contains, then after being pulverized and waſhed, it is diſtilled with ſome matters capable of combining with the ſulphur, and ſo diſengaging the mercury. Water is previouſly put into the receiver, and the mercury falls under the water. By weighing the ore exactly before aſſaying it, and afterwards the mercury obtained by diſtillation, it is known what quantity of the metal the ore can afford.

Virgin mercury is eaſily ſeparated by grinding down the ſtones with which it is mixed, and diluting them in water. The metal is precipitated, and the earth mixes with the water. In this manner is the mercury extracted from the ores of Ydria in Friuli.

Cinnabar is never roaſted; becauſe, as it is volatile, it would be diſſipated by fire. But in nature, it is almoſt always mixed with a calcareous or a martial ſubſtance,

ſtance, which contributes as an intermedium to its decompoſition with the help of fire.

Anthony de Juſſieu has given, in the Memoirs of the Academy for the year 1719, a deſcription of the proceſs by which mercury is extracted from cinnabar at Almaden in Spain. That ore contains iron with a ſmall portion of calcareous ſtone. It is put into furnaces of the form of a reverberating furnace; the furnaces are heated by combuſtible matters put into the aſh-pan. The furnace has no apertures but eight holes with which it is perforated behind. To each of theſe holes a line of aludels is fitted; the laſt of which joins a ſmall building at a pretty conſiderable diſtance from the furnace. Between the furnace and the ſtructure where the rows terminate there is a ſmall terraſs on a level with the apertures of the furnace and the building. That terrace conſiſts of two inclined planes, which ſupport the aludels. If the aludels be any where ſo unſkilfully joined as to ſuffer the mercury to eſcape, it is collected at the junction of the inclined planes of the terrace. When the fire is applied to the cinnabar, the iron and the calcareous ſtone abſorb the ſulphur; the mercury is reduced into vapour, enters the aludels, and paſſes towards the little building. After the diſtillation, all the aludels are conveyed into a ſquare chamber, where they are emptied, and all the mercury collected into a pit in the middle of the chamber, towards which the floor is inclined all around it.

Anthony de Juſſieu obſerves, that cinnabar ore does not give out any exhalation noxious to vegetables, and that the grounds adjoining to the mines of Almaden are very fertile. He has alſo obſerved, that the working of thoſe mines is not, as had been thought, injurious to the health of the workmen. Thoſe who work in the interior

interior parts of the mine as ſlaves are the only ſufferers; for the fire which they are obliged to kindle always volatilizes a portion of the mercury, and they are of conſequence continually ſurrounded with mercurial vapours.

M. Sage, in the Memoirs of the Academy for the year 1776, has deſcribed the proceſs by which mercury is extracted from cinnabar in the Palatinate. The furnace is a gallery containing forty-eight retorts of caſt iron, each an inch in thickneſs and three feet nine inches in length, containing about ſixty pounds of matter. Theſe retorts are immoveably fixed upon the furnace. A mixture, conſiſting of three parts of ore well pounded, with one part of ſlaked lime, is introduced into them with braſs ladles. It is heated with mineral coal put in at the two ends of the furnace, the ſides of which are ſo perforated with holes as to admit enough of freſh air to make the coals burn. The heat, with the re-action of the lime on the ſulphur, volatilizes the mercury, which is collected into earthen receivers fitted to retorts, and about a third part full of water. This operation takes up about ten or eleven hours.

Mercury obtained from cinnabar is very pure, and contains not a particle of extraneous matter; ſcarce any is to be got ſo pure in commerce. Almoſt all the mercury ſold by merchants is more or leſs mixed with extraneous matters; it has the appearance of being a little tarniſhed, and inſtead of dividing into globules when it runs, it falls into a flat ſurface ſet round with points. The merchants then ſay that *it draws a tail.*

Mercury ſeems to ſuffer no alteration from light. It is one of thoſe fluid matters which are the eaſieſt and the moſt uniformly heated, that is, whoſe dilatation proceeds in the moſt conſtant manner. This has been

been ſhown to be the caſe by Meſſrs Bucquet and Lavoiſier, in their experiments on the effects of heat on different fluids, read before the Academy of Sciences. This phænomenon ſhows mercury to be the moſt proper fluid for forming accurate thermometers, by nicely indicating the degrees of heat.

This metallic fluid, when expoſed to fire in cloſe veſſels, boils like other fluids. This property is not peculiar to it; ſilver, gold, and moſt other metals diſplay the ſame phænomenon. It is true, that as mercury is more fuſible than any other metal, it boils quicker, and continues to boil longer after being red-hot. Ebullition is nothing but the paſſing of a body from a liquid to a vaporous ſtate. This vapour of mercury, which ſoon becomes very apparent in the form of a white ſmoke, and obſcures the tranſparency of the veſſels into which it is received, is condenſed by cold into drops of liquid mercury; which, when the diſtillation has been carefully performed, are found to have ſuffered no loſs nor alteration. Mercury is therefore a very volatile ſubſtance, which may be diſtilled like water, and in this property it bears a near relation to the ſemi-metals.

Boerhaave diſtilled the ſame quantity of mercury 500 times ſucceſſively, without effecting any alteration upon it; only it appeared to become more ſparkling, more ponderous, and more fluid; which might be owing to its being rendered more pure by diſtillation. He obtained a ſmall quantity of grey powder, which appeared to be mercury very much attenuated, and became again fluid and brilliant on being triturated in a mortar. This was black oxide of mercury; and its production muſt have been owing to air contained in the diſtillatory apparatus.

Diſtillation is a method for purifying mercury, and ſeparating from it the fixed metals by which it is uſually altered as it appears in commerce. The extraneous metal is found in the retort, forming in ſome places a brilliant, and in others a blackiſh cruſt By weighing this reſidue, we learn what quantity of matter altered the mercury.

The extraordinary gravity of mercury has induced chemiſts to think that it contains a large proportion of the pure earthy principle or vitrifiable earth. But when that principle predominates in any body, it renders it ſolid; and inſtead of being ſolid, mercury is very fuſible: the earthy principle is in an eminent degree fixed, but mercury very volatile. Beccher, obſerving this oppoſition between the qualities of mercury and thoſe of vitrifiable earth, was induced to allow in this fluid the exiſtence of a peculiar earth, to which he gave the name of *mercurial*, aſcribing to it both gravity and volatility. Mercury was then, according to that chemiſt, a compound of three earths, vitrifiable, inflammable, and mercurial. But no perſon has as yet demonſtrated the exiſtence of the latter in any body, and the opinion is therefore to be conſidered as an aſſertion deſtitute of proof. Mercury appears to me to be like other metallic ſubſtances, a peculiar combuſtible body, the principles of which have not yet been ſeparated. As to the vitrifiable earth, the properties of which we examined in the beginning of this work, we do not think that we can admit its exiſtence in mercury any more than in the other metals, becauſe no ſuch principle is ever extracted from it. What Beccher and Stahl diſtinguiſhed by that appellation in mercury and other metallic ſubſtances, is very far from being a ſimple earthy matter, as we ſhowed when ſpeaking of metallic oxides in general.

Mercury in vapours has a conſiderable expanſive force, and is capable of producing lively exploſions when attempts are made to confine it. Hellot related to the Academy, that a certain perſon, wiſhing to fix mercury, put a quantity of it into an iron ball, well ſoldered together, and threw the ball into the middle of an hot furnace. But no ſooner was it red hot than the mercury burſt out and eſcaped with a conſiderable noiſe. M. Baumé relates, in his *Experimental Chemiſtry*, a fact nearly ſimilar, to which Geoffroy the apothecary was witneſs.

Mercury is much more ſuſceptible of calcination by the contact of air and of many other bodies, than it has till very lately been thought to be. A blackiſh grey pellicle is inceſſantly forming on its ſurface, which is a true mercurial oxide.

When heated with acceſs of air, this metal changes in a few days into an earthy powder, which is red, brilliant, and diſpoſed in ſmall ſcales. This powder has nothing of a metallic aſpect, and is really oxide of mercury. The alchemiſts thought that mercury was fixed in this operation, and therefore gave the powder the improper name of *precipitate per ſe*. As mercury, tho' very volatile, yet needs the concourſe of air in order that it may be calcined, a pretty convenient inſtrument, called *Boyle's bell*, has been contrived for the purpoſe. It is a very large broad cryſtal bottle; a quantity of mercury is incloſed in it; and as it forms a very thin layer, it of conſequence exhibits an extenſive ſurface. The ſtopper, which exactly fits the mouth of the bottle, is a cryſtal cylinder with a capillary pipe. The bottle is placed on a ſand-bath, and heated till the mercury boil. The aperture of the cylinder is of ſuch a ſize as to admit the air without ſuffering the mercury to eſcape.

After digeſting it in this manner for ſeveral months, the oxide formed on the ſurface of the mercury is ſeparated. Its ſeparation is effected by putting the whole upon a piece of thick cloth, and preſſing it till the mercury paſs through, leaving the oxide upon the cloth. A flat-bottomed matraſs is equally proper for the purpoſe. A quantity of mercury ſufficient to form a thin ſtratum is poured into it: the neck of the matraſs is drawn out by means of a lamp into a capillar pipe, and the point broken off. This method, which we owe to M. Baumé, affords a veſſel more proper for reducing mercury to an oxide, as it contains more air; it may alſo be heated with more eaſe and at leſs expence than *Boyle's hell*, and is not ſo eaſily broken. In order that this experiment may ſucceed, the mercury muſt be night and day for ſeveral months expoſed to an heat ſufficient to make it boil gently. By placing a number of matraſſes on the ſame ſand-bath, a greater quantity of precipitate *per ſe*, or red oxide of mercury, is obtained, and a certain quantity of it may even be prepared in fifteen or twenty days.

The precipitate *per ſe* is a true oxide of mercury, or a combination of this metallic ſubſtance with oxigene, which it gradually attracts from the atmoſphere. What proves this in a convincing manner is, 1. That mercury can never be reduced into precipitate *per ſe* without air: 2. That vital air is neceſſary to the formation of this compound; none of the various gaſes can contribute to the oxidation of mercury: 3. That mercury in this inſtance gains an increaſe of weight: 4. That when the precipitate *per ſe* is heated in cloſe veſſels, it is entirely reduced to running mercury, giving out at the time a large quantity of elaſtic fluid, in which combuſtible bodies burn four times as quick as in common

mon air. The exiſtence of this fluid was firſt obſerved by Dr Prieſtley; he gave it the denomination of *dephlogiſticated air;* we call it *oxigenous gas* or vital air. Mercury, on being thus reduced, loſes the increaſe of weight which it had acquired by being calcined.

M. Lavoiſier, from conſidering the laſt of theſe facts, together with the other phænomena of calcination, indicating air to be neceſſary to and conſumed during that operation, has inferred, by an analogy equally fair and probable with any other in phyſics, that metallic oxides are combinations of the metals with the oxigenous part of air. As the *precipitate per ſe* may be eaſily analyſed by heat into two principles, pure vital air and running mercury, this inſtance contributes greatly to illuſtrate and eſtabliſh the pneumatic theory. It may be eaſily underſtood in what manner the baſe of vital air, or oxigene fixed in mercury, diſengages itſelf on regaining its elaſticity by means of heat. Thus to reduce red oxide of mercury, it muſt be heated in very cloſe veſſels: if air be admitted, it remains ſtill in the ſtate of oxide, becauſe it always finds in the atmoſphere a body with which it is capable of uniting; the only body which poſſeſſes the power of calcining it. This is what induced M. Baumé to maintain that the *precitate per ſe* was not reducible, but, on the contrary, was ſublimed in reddiſh ruby-coloured cryſtals: while M. Cadet has aſſerted that all *precipitates per ſe* are equally reducible into running mercury. Macquer has proved, by an ingenious and natural account of the facts, that each of theſe chemiſts had good reaſon for what he advanced; and that when oxide of mercury is heated with concourſe of air, it is entirely ſublimated, and may even be melted into a glaſs of a moſt beautiful red colour; as has been obſerved by Mr Keir a learned Scotch chemiſt,

chemiſt, in his tranſlation of the Chemical Dictionary; whereas this ſame oxide, which is ſublimated when expoſed to the contact of air, is reduced to running mercury, and gives out vital air when urged with an intenſe heat in cloſe veſſels.

As the brilliancy is ſullied by particles of duſt depoſited on its ſurface by the air, it has received the name of *the loadſtone of duſt:* But it appears that all bodies poſſeſs the ſame property; only the ſuperior luſtre of mercury renders it more obſervable in that metal. Beſides, mercury ſuffers no alteration from the duſt which it thus attracts; and on being filtrated through a piece of goatſkin to ſeparate thoſe extraneous particles, it recovers all its luſtre.

Mercury appears not liable to ſolution in water: Phyſicians, however, are in uſe to hang a bag filled with mercury in ptiſans to be given for worms,—while they are boiling. We are even aſſured, that experience has evinced the good effects of this practice: Lemery has proved, that mercury loſes nothing of its weight in this decoction. Perhaps a principle analagous to ſmell may on that occaſion exhale from this metal, ſo ſubtle and fugitive, that its weight cannot be diſtinguiſhed, and may communicate an anthelmintic virtue to the water.

Mercury is not more diſpoſed to unite with earths than the other metallic ſubſtances. Its red oxide, or *precipitate per ſe*, might be fixed in glaſſes, and colour them; as is obſerved of the oxide of arſenic.

We know not in what manner barytes, magneſia, lime, and the alkalis act upon mercury.

The ſulphuric acid acts not upon this metallic ſubſtance unleſs when concentrated. To effect this ſolution, put into a glaſs retort one part of mercury, and pour upon it a part and an half of concentrated ſulphuric acid. Let this mixture be heated; a lively efferveſcence is gradually raiſed; the ſurface of the mercury becomes white; and a powder of the ſame colour is ſeparated, and being diſperſed through the acid, renders it turbid. A conſiderable quantity of ſulphureous gas is diſengaged, and may be collected above mercury. This, as we have ſeen, when ſpeaking of the ſulphuric acid, is the proceſs by which this gas is uſually obtained. There paſſes at the ſame time a portion of water, containing ſulphureous acid gas. When the diſtillation is continued till no more of the ſulphureous acid can be produced, there is then found in the bottom of the retort a white, opaque, and very cauſtic maſs, which weighs one third more than the mercury from which it is produced, and attracts a little moiſture from the atmoſphere. The greateſt part of this maſs is an oxide of mercury, which is combined with a ſmall portion of ſulphuric acid. This matter has been remarked by Kunckel, Macquer, and Bucquet, to be in its nature pretty much fixed. The ſulphuric acid is decompoſed by a double elective attraction: the mercury being a combuſtible ſubſtance combines with the oxigene of the acid, while the heat diſengages the ſulphureous gas and the water. The metal is then in the ſtate of an oxide, and muſt of conſequence be much more fixed than running mercury.

A part of this ſulphuric mercurial maſs is diſſolved in water. The fluid, when liberally poured upon it, dilutes the maſs, and, if cold, cauſes it to precipitate a white powder: if the water employed be boiling, the powder takes a beautiful bright yellow colour; and the hotter the water, and the greater the quantity of it poured on the maſs, ſo much the more lively is the colour which the powder aſſumes. The moſt ancient name

name of this matter was *turbith mineral*, or *yellow precipitate:* we call it yellow mercurial oxide. The water in which it has been waſhed is decanted off; boiling water is again poured upon it, and it now acquires a brighter yellow colour. A third waſhing purifies it from all remains of the ſulphuric acid. It is now deſtitute of taſte; and when urged with fire in a retort, it firſt becomes of a deeper colour, and is afterwards reduced to running mercury, giving out at the ſame time a conſiderable quantity of vital air. Kunckel mentions this reduction. It ſucceeded with Meſſrs Monnet, Bucquet, and Lavoiſier, who traced it through all its circumſtances. I have repeated it ſeveral times with ſucceſs. It proves, as we have already ſeen, that the ſulphuric acid conſiſts of ſulphur, oxigene, and water; but a pretty ſtrong fire is requiſite to reduce this oxide. Perhaps the reaſon why M. Baumé did not obtain running mercury, which has induced him to aſſert that this yellow oxide does not reſume a metallic form unleſs ſome combuſtible ſubſtance be added, was his not having applied to it a ſufficient heat. By continuing to heat the mercurial ſulphuric maſs in the ſame retort in which it was diſſolved, without diluting or waſhing it to carry off the acid, we likewiſe decompoſe the oxide: it is reduced to running mercury when the oxigene which it had attracted from the ſulphuric acid acquires elaſticity, and becomes of conſequence vital air by combining with heat.

The water poured on the white ſulphuric mercurial maſs receives that portion of the acid which is not decompoſed, but remains in the maſs. But as oxide of mercury is ſoluble in the ſulphuric acid, that ſaline ſubſtance always carries off with it ſo much of the oxide; and the ſubſtance which remains diſſolved in the water after the reduction is therefore true ſulphate of mercury. When evaporated by a ſtrong heat, it depoſites that ſalt in ſmall needles; the form of which cannot be determined, becauſe they are ſoft and very liable to deliquiate. If boiling water be caſt on thoſe cryſtals of ſulphate of mercury, they become yellow and return to the ſtate of mercurial oxide, the water ſeparating the acid and leaving the oxide pure. The ſame thing happens when, after having evaporated the firſt lixivium of the mercurial maſs by an intenſe heat, we, inſtead of cryſtallizing, dilute it in a large quantity of boiling water: it precipitates a yellow powder which is a true oxide. If cold water be uſed, the precipitate is white; but by pouring boiling water on the white precipitate we may render it yellow. We can likewiſe at pleaſure render the ſolution of mercurial oxide decompoſable or not decompoſable in water. All that is requiſite for this purpoſe is to evaporate the oxide by a violent heat, or to make the acid receive as much of the mercurial oxide as it is capable of diſſolving: theſe two bodies are then eaſily ſeparated by water. On adding a little of the acid, the fluid ceaſes to precipitate it. I received full conviction of this fact by diſſolving *turbith mineral* well waſhed in the weak ſulphuric acid. This ſolution not being overcharged with mercurial oxide is not precipitated by water. But if the acid be charged with as much as it can diſſolve with the help of heat, which happens when the oxide is added till it refuſe to diſſove it; ſuch a ſolution, on being poured into cold water, forms a white precipitate, and a yellow precipitate when poured into hot water. If a little ſulphuric acid be added to it when in this ſtate, it ceaſes to yield a precipitate. The white mercurial oxide depoſited by ſulphate of mercury ſuperſaturated with mercury, when poured into cold water is very ſoloble : we can make it diſappear by adding ſulphuric acid to the mixture.

Sulphate of mercury may be decompoſed by magneſia and lime, which cauſe it yield to a yellow precipitate. The fixed alkalis ſeparate from it a yellow oxide nearly of the ſame colour : Ammoniac precipitates but very little of ſulphate of mercury, and that very ſlowly. It is to be obſerved, that theſe precipitates of mercury vary in colour according to the ſtate of the ſolution and the ſubſtance by which they are precipitated; the quantity varies too. A ſaturated ſolution gives the moſt copious precipitate. Again, if a ſolution not ſaturated with mercury be decompoſed, each flake of the oxide ſeparated by the firſt drops of the precipitant matters is again diſſolved by the exceſs of acid. When this exceſs of acid is ſaturated, the precipitate is permanent. From this it appears, that the alkalis act rather on the acid in combination with mercury than on the free acid. All of theſe mercurial oxides precipitated by alkaline ſubſtances may be reduced by themſelves in cloſe veſſels. In order to obtain them pure, we muſt waſh them repeatedly with diſtilled water.

Mercury decompoſes the nitric acid with the greateſt rapidity. The ſolution is effected cold, and with more or leſs activity, according to the ſtate of the acid. Common aquafortis acts upon mercury without giving out any great quantity of red vapour. When a little of the fuming nitrous acid is added, or the mixture heated, the re-action of the matters is then very rapid, a very large quantity of nitrous gas is diſengaged, and the mercury reduced to oxide remains in ſolution. The liquor is greeniſh, but loſes that colour at the end of a certain time. By this proceſs, the nitric acid may be cauſed to receive a quantity of mercury equal to itſelf in weight. Bergman has obſerved, in his Diſſertation on the Analyſis of Waters, that nitrous ſolutions of mercury differ from one another according to the manner in which they are prepared. That which has been effected cold, and without the diſengagement of any great quantity of red vapour, is not decompoſable by diſtilled water; but if the ſolution have been promoted by heat, and have given out a conſiderable quantity of nitrous gas, it will then be liable to precipitation by water, and cannot be employed in analizing waters with any certainty of its effects; as we ſhall ſhow when ſpeaking of mineral waters. I take this phænomenon to be owing to the ſame cauſe in the nitrous ſolutions as in the ſolution by the ſulphuric acid. The nitric acid may, with the help of heat, be ſuperſaturated with oxide of mercury, which it holds ſuſpended, if we may be allowed the expreſſion. This ſolution, with an exceſs of mercury, may be precipitated by diſtilled water, which changes the denſity of the liquor, and diminiſhes the adherence of the mercurial oxide to the nitric acid. The precipitate is therefore a genuine oxide, which becomes very yellow if the ſuperſaturated ſolution be poured into boiling water, but white when poured into cold water. It may be inſtantly coloured by waſhing it in hot water. Again, as the cold ſolution contains only nitrate of mercury without exceſs of oxide, heat being requiſite to ſuperſaturate the acid with the oxide, diſtilled water cannot therefore precipitate it. I am induced to think this by a fact which I have often obſerved; it is, that the ſame mercurial ſolution may be at pleaſure rendered decompoſable or not decompoſable in water, by adding alternately mercury and acid, ſo as to make it paſs from the one ſtate to the other. All that is requiſite for that, is to diſſolve mercury cold in the nitric acid, ſuffering the acid to receive as much mercury as poſſible. This ſolution is not decompoſable in water, though it gives out nitrous gas. On adding mercury till it be ſaturated with as much as it can diſſolve with the help of heat, it is rendered ſuſceptible of precipitation by water. The ſame theory very well explains why a nitrous ſolution, not liable to be precipitated by water, becomes ſo when heated. Heat diſengages nitrous gas; and that can never be effected without deſtroying a portion of the acid: the proportion of the mercurial oxide to the acid then becomes greater: it is no longer combined with the mercurial nitrate; but only adheres to it, and is ſo ſuſpended in it that it may be eaſily precipitated by water. I am certain that the precipitate which ſolutions of mercury yield by water is only an exceſs of oxide; and that the ſolution, after giving ſuch a precipitate, ſtill retains a portion of true nitrate of mercury, which may be decompoſed by alkalis in the ſame manner as the ſulphuric mercurial maſs lixiviated in order to the preparation of *turbith* mineral. This portion of nitrate of mercury may even be cryſtallized. The exceſs of mercurial oxide which renders the nitric ſolutions ſuſceptible of decompoſition by water, is attended with another circumſtance which promotes that decompoſition. The oxide is ſo highly calcined or oxigenated as to have but little adheſion to the nitric acid.

The ſolution of mercury in the nitric acid is exceedingly cauſtic; it corrodes and deſtroys animal organs. When it falls on the ſkin, it produces deep purple ſpots, which at a little diſtance appear black. Theſe continue till the epidermis fall off in ſcales. It is uſed

in

in ſurgery as a powerful eſcharotic, under the name of *mercurial water*.

The ſolution of mercury in the nitric acid affords cryſtals, which differ in form, according to the ſtate of the ſolution and the circumſtances of the cryſtallization. On obſerving theſe varieties carefully, I diſtinguiſhed four kinds of them very diſtinct from each other, which I ſhall deſcribe.

1. A cold ſolution affords by ſpontaneous evaporation for ſeveral months very regular tranſparent cryſtals. M. Romé de Lille has deſcribed them very accurately. They are flat ſolid figures with fourteen ſides, formed by the junction of two tetrahædral pyramids, cut very near the baſe, and truncated at the four angles which reſult from the junction of the pyramids.

2. If the ſame cold ſolution be evaporated by heat, and left to cool, it depoſites at the end of four-and-twenty hours a kind of acute priſms, ſtriated obliquely acroſs their length, which are formed of ſmall plates covering each other like tiles, in the manner which botaniſts call *imbricatim*. On a near examination of the elements of thoſe irregular priſms, I perceived the plates to be ſolids with fourteen facets, reſembling the cryſtals obtained by ſpontaneous evaporation, but ſmaller and more irregular.

3. A nitric ſolution effected by means of a moderate and well-managed heat gives, by cooling, cryſtals in very long and very acute flat needles, ſtriated lengthwiſe. Theſe are the cryſtals moſt commonly obtained from this ſolution; and they have been deſcribed by a great many chemiſts, by Macquer, Rouelle, Baumé, &c.

4. Laſtly, If this ſolution be heated till it become decompo-

compoſable by water, it is then uſually formed into an irregular white maſs, reſembling the ſulphuric maſs. I have ſometimes ſeen, on that occaſion, a confuſed maſs of very long ſlender, flexile needles, gloſſy like ſattin, and moved about with the motion of the liquor; they perfectly reſembled the brilliant, ſilvered dendrites, which I have often obſerved on the ſides of bottles containing *acetite of potaſh*, or *foliated earth of tartar.* It is proper to add, that this laſt ſolution of mercury gives irregular confuſed cryſtals, or ſhapeleſs maſſes, only becauſe it contains an exceſs of the metallic oxide, and may therefore be rendered ſuſceptible of regular cryſtallization by adding more of the acid.

Theſe ſeveral nitrates of mercury exhibit nearly the ſame appearances. They are very cauſtic, and corrode the ſkin as well as their ſolutions; they detonize when put on burning coals. With reſpect to this property, it is to be obſerved, that it belongs in a much more eminent degree to the moſt regular cryſtals with fourteen faces, than to thoſe which are in the form of ſmall needles; and that the white maſs precipitated from the ſolution, after it has been expoſed to a ſtrong heat, is entirely deſtitute of it. The detonation of nitrate of mercury is ſcarce obſervable in newly formed cryſtals; to render it more ſenſible, the nitrate muſt be left to dry for ſome time on blotting paper. If the cryſtals be then put on a burning coal, they melt, become black, and extinguiſh the flame of that part of the coal on which they lie. But their edges being dried, throw out little reddiſh ſparks with a noiſe ſimilar to a faint decrepitation. When dry, they emit a more lively whitiſh flame; but it very ſoon ceaſes.

Mercurial nitrate melts when heated in a crucible; very thick red vapours then exhale from it: as it loſes its

its water and its nitrous gas, it aſſumes a deep yellow colour, which changes firſt to an orange, and afterwards to a bright red: in this ſtate it has been called *red precipitate.* We diſtinguiſh it by the name of *red oxide of mercury by the nitric acid.* It ſhould be made in matraſſes with a moderate heat when it is meant to be employed in ſurgery as a cauſtic, in order that it may retain a portion of the acid to which it owes its corroſive powers: But when it is made very hot, it becomes merely oxide of mercury, formed by the combination of that metal with the oxigene of the nitric acid. Nitrate of mercury diſtilled in a retort, affords, in the firſt place, an acidulous phlegm and nitrous gas: it is now in the ſtate of red precipitate. On being made very hot, it gives out a conſiderable quantity of vital air mixed with a little azotic gas; and the mercury is ſublimated in a metallic form. This experiment made by M. Lavoiſier with the utmoſt accuracy, led him to the diſcovery of the component principles of the nitric acid; as we have mentioned in our hiſtory of that acid.

Nitrate of mercury becomes yellowiſh, and is very ſlowly decompoſed in the air. It diſſolves readily enough in diſtilled water, is more ſoluble in boiling than in cold water, and cryſtallizes by cooling. When this ſalt is diſſolved in water, part of it is precipitated without being diſſolved, and acquires a yellowiſh colour. M. Monnet calls that matter *nitrous turbith;* and obſerves, that a good deal of it may be obtained by waſhing a nitric mercurial maſs evaporated to dryneſs, as is done in preparing *red precipitate.* When nitrate of mercury is to be entirely diſſolved, diſtilled water muſt be uſed, and aquafortis poured into it till the precipitate diſappear. I have obſerved, that when boiling

boiling water is poured on very pure nitrate of mercury, the ſalt becomes inſtantly yellow, and affords an oxide of a deeper colour, which on being expoſed to fire, becomes red much ſooner than that which owes its formation to the ſulphuric acid. Yellow oxide of mercury by the nitric acid, is generally more completely calcined than that which is prepared with the ſulphuric acid: the reaſon of which is, as we have already obſerved of other combuſtible ſubſtances, that the oxigene is more eaſily diſengaged from the nitric than from the ſulphuric acid. This is what renders the nitric acid more decompoſable than the ſulphuric acid.

Barytes, magneſia, lime, and the alkalis, decompoſe nitrate of mercury, and precipitate the mercury in the ſtate of oxide. Theſe precipitates vary in colour, gravity, and quantity, according to the ſtate of the ſolution. The cauſtic fixed alkalis form a yellow precipitate, which is more or leſs brown or brick-coloured according to their cauſticity. Ammoniac cauſes the nitric ſolution of mercury in a good condition, that is, when water cannot decompoſe it, to yield a ſlate-grey precipitate; whereas the ſame ſalt produces a white ſediment in a ſaturated ſolution of mercury liable to be precipitated by water: theſe diſtinctions have been very accurately obſerved by Bergman. Theſe precipitates are merely oxides of mercury more or leſs calcined. They are all reducible without addition, by heat, in cloſe veſſels; and when reduced, they give out pure air. Thoſe which have been precipitated by alkaline carbonates, afford a certain quantity of carbonic acid by the action of heat. Thoſe which have not been precipitated by carbonates, but only expoſed to the contact of atmoſpheric air, diſplay the ſame phenomenon, for they abſorb that acid from the atmoſphere; a property which is common to all oxides of mercury, and even to thoſe of ſeveral other metals.

Oxides of mercury precipitated from ſolutions by alkaline intermedia, poſſeſs a peculiarity which has been diſcovered by M. Bayen, and is worthy of being here taken notice of They detonize like gun-powder when expoſed in an iron ſpoon to a gradual heat, after being triturated with flowers of ſulphur in the proportion of half a drachm to ſix grains. After the detonation, there remains a violet-coloured powder, which may be ſublimated into cinnabar.

The ſulphuric acid, and the ſalts into which it enters, are alſo capable of decompoſing nitrate of mercury; for this acid has a greater affinity than the nitric acid with mercury. If a portion of ſulphuric acid, or of a ſolution of ſulphate of potaſh, ſulphate of ſoda, &c. and in general of any ſulphuric ſalt, be poured into a nitric ſolution of mercury, a whitiſh precipitate is formed, if the ſolution be not ſaturated; which inclines more to yellow in proportion as the mercurial nitrate contains leſs acid, and more mercurial oxide. This precipitate is either ſulphate of mercury or yellow oxide. M. Bayen has obſerved that it always retains a little nitric acid.

The muriatic acid does not act in a ſenſible degree on mercury; although it has a greater affinity with the oxide of this metal than any of the other acids. It combines with the oxide to form a peculiar ſalt. This combination takes place whenever the muriatic acid is brought into contact with that oxide, and the oxide divided into very minute particles. If a little muriatic acid be poured on a nitric ſolution of mercury, the acid ſeizes the oxide of the metal, and forms with it a ſalt which is precipitated in a kind of whitiſh coagulum, called

called *white precipitate.* Muriatic ſalts with alkaline or ſalino-terreous baſes, produce preciſely the ſame effects, and form beſides nitric ſalts, differing according to their baſes. But it is of importance to obſerve concerning this precipitation, that it does not take place if the oxigenated muriatic acid be employed; for though that acid attracts the oxide of mercury from the nitric acid, the ſalt which it forms with it is very ſoluble in water; whereas that which the common muriatic acid forms with this acid is not at all ſoluble in water.

This acid has likewiſe a greater affinity with oxide of mercury than the ſulphuric acid has; and when poured into ſolutions of this metal with the ſulphuric acid, it produces precipitates in the ſame manner as in ſolutions of mercury with the nitric acid. The compound of the muriatic acid with oxide of mercury is capable, as above obſerved, of two different ſtates, according as the acid is ſimple or oxigenated: with the oxigenated muriatic acid it conſtitutes corroſive mercurial muriate; with the ſimple muriatic acid, it is mild mercurial muriate.

There are ſeveral ways of preparing *corroſive ſublimate,* or corroſive mercurial muriate. The moſt common way is, by mixing equal parts of dried mercurial nitrate, decrepitated muriate of ſoda, and calcined or white ſulphate of iron or *martial vitriol;* putting this mixture into a matraſs, of which two thirds muſt remain empty; immerſing the mixture into a ſand-bath, and heating it gradually till its bottom be made red hot. The ſulphuric diſengages the muriatic acid from the ſoda: the ſoda again ſeparates the nitrous acid from the mercury, which has robbed it of part of its oxigene; and becomes of conſequence oxigenated muriatic

riatic acid: After that, it combines with the oxide of mercury, and forms corroſive mercurial muriate, which is ſublimed into flat pointed cryſtals, that fix on the upper part of the matraſs. The nitric acid is diſperſed in nitrous gas; the reſidue is reddiſh or brown, and contains oxide of iron and ſulphate of ſoda, formed by the combination of the ſulphuric acid with the baſe of the marine ſalt. In Holland, this ſalt is prepared in the great way, by triturating together equal parts of mercury, muriate of ſoda, and ſulphate of iron, and expoſing the mixture to an intenſe heat. In this way of preparing *corroſive ſublimate*, the ſulphuric acid, diſengaged by heat from ſulphate of iron, appears to convert the ſimple into oxigenated muriatic acid; for no other but this laſt acid could diſſolve all the mercury employed on the occaſion. Corroſive mercurial muriate may be likewiſe obtained, by ſublimating a mixture of ſulphate of iron, muriate of ſoda, and mercurial precipitate by fixed alkali, or any other kind of mercurial oxide.

Boulduc has given a very good proceſs for preparing corroſive mercurial muriate: but Spielman remarks, that it was before ſuggeſted by Kunckel in his Chemical Laboratory. It conſiſts in heating in a matraſs equal quantities of ſulphate of mercury and decrepitated muriate of ſoda. Muriate of mercury is volatilized, and what remains is only ſulphate of ſoda. This mode of operation affords very pure corroſive mercurial muriate, whereas that which we get in commerce, and even that which is prepared in the ſmall way with ſulphate of iron, always contains ſome mixture of iron. Boulduc's proceſs is both eaſier and leſs expenſive. It likewiſe proves, that the ſulphuric acid poſſeſſes the property of oxigenating the muriatic acid.

M. Monnet informs us, that he obtained this ſalt alſo by treating in a retort very dry muriate of ſoda with mercurial oxide, precipitated from the nitrous ſolution of mercury by fixed alkali. In all theſe proceſſes for preparing corroſive mercurial muriate, the operator ſhould beware of breaking the veſſel containing the ſublimate till it be perfectly cool, leſt he ſuffer from the vapours of the ſalt. Laſtly, There is yet another and more expeditious way of preparing corroſive mercurial muriate: it conſiſts in pouring oxigenated muriatic acid into a ſolution of nitrated mercury, and evaporating the mixture ſlowly: when the nitrous acid is diſengaged, the liquor affords, by cooling, cryſtals of corroſive mercurial muriate. There is reaſon to think, that when Scheele's oxigenated muriatic acid becomes better known, apothecaries will prepare corroſive mercurial muriate either by this laſt proceſs or by ſimple ſolution.

Corroſive mercurial muriate is a neutral ſaline ſubſtance, which well merits the attention of chemiſts and phyſicians. It poſſeſſes a number of valuable properties, of which we ſhall give the hiſtory. This ſalt has a very cauſtic taſte. When but the ſmalleſt quantity touches the tongue, it leaves for a long time after a ſtiptic and metallic impreſſion, which is very diſagreeable. This impreſſion extends even to the larynx, ſhutting it ſpaſmodically; and it remains long, particularly on perſons of very delicate nerves. This ſalt acts in a ſtill more ſenſible manner on the coats of the ſtomach and the viſcera. When ſuffered to act upon them for ſome time, it corrodes them, ſo as to deſtroy their ſubſtance: It is of conſequence one of the ſtrongeſt poiſons known. The cauſticity of corroſive mercurial muriate appears to depend on the ſtate in which the

the mercury exiſts in the ſalt, as has been very ingeniouſly explained by Macquer. It cannot, as ſome authors have imagined, be aſcribed to the muriatic acid; for the quantity of the mercury is more than three times as much as that of the acid. Accordingly it has been obſerved by Rouelle, that this ſalt communicates rather a green than a red colour to ſyrup of violets. The taſte, too, of corroſive mercurial muriate is much ſtronger than that of the muriatic acid. A perſon may take a drachm of muriatic acid diluted in water, without ſuffering any harm: whereas a few grains of corroſive mercurial muriate taken in the ſame quantity of water are a certain poiſon. Bucquet thought this exceſſive ſapidity to depend on the combination of the two bodies which compoſe this ſalt. One of his ſtrongeſt proofs was drawn from that law of the affinity of compoſition by which it is eſtabliſhed, that compounds poſſeſs new properties entirely different from thoſe of the bodies of which they are compounded.

Corroſive mercurial muriate ſuffers no ſenſible alteration from light. Heat volatilizes and half vitrifies it. When expoſed to a ſtrong heat in the open air, it is diſſipated in a white ſmoke; the effects of which are very energetic, and very noxious to the animal œconomy. When heated ſlowly and by degrees, it is ſublimated in a regular cryſtalline form. Its cryſtals are priſms, ſo compreſſed that it is impoſſible to determine the number of their faces. They terminate in very acute points; and have been with good reaſon compared to the blades of poignards thrown very confuſedly together. Fire does not decompoſe this ſalt; it ſuffers no alteration from air. It diſſolves in nineteen parts of water, and cryſtallizes by evaporation into flat priſms, very acute at their extremities, reſembling thoſe obtained by ſublimation. The ſpontaneous evaporation of its ſolution afforded both me and M. Bucquet ſeveral times oblique-angled parallelopipeds, with their extremities truncated ſlopewiſe. M. Thouvenel has obtained that ſalt cryſtallized in hexahædral priſms, a little compreſſed.

Barytes, magneſia, and lime decompoſe corroſive mercurial muriate, cauſing it to yield a precipitate of oxide of mercury. The *phagedenic water* uſed by ſurgeons as a corroſive, is prepared by caſting half a dram of this ſalt in powder into a pound of lime-water; a yellow precipitate is formed, which renders the liquor turbid, and it is employed before the precipitate ſubſide. The fixed alkalis ſeparate from corroſive mercurial muriate an orange oxide, which when ſuffered to ſettle for ſome time, acquires a deeper colour. Ammoniac cauſes this ſalt to yield a white precipitate; which, however, ſoon aſſumes a ſlate colour.

The acids, and the alkaline neutral ſalts, produce no alteration on corroſive mercurial muriate.

This ſalt contracts an intimate union with ammoniacal muriate; but neither of them is decompoſed. Either by ſublimation, or by cryſtallization, it forms with it a very ſingular ſaline compound, which the alchemiſts valued highly, and called *alembroth ſalt*, *ſalt of art*, *ſalt of wiſdom*, &c. The ammoniacal muriate renders the corroſive mercurial muriate very ſoluble; for according to M. Baumé, three ounces of water containing nine drachms of the former ſalt diſſolve five ounces of the latter. This laſt ſolution is effected with the help of heat, and when it cools, the ſalt ſubſides into a maſs. With this ſalt a preparation is made up which is called *white precipitate*. It is prepared by caſting into a ſolution of a pound of ammoniacal muriate

ate an equal quantity of corroſive mercurial muriate in powder. When this ſalt is fully diſſolved, a ſolution of carbonate of potaſh is poured into the mixture and produces a white precipitate: this precipitate is waſhed, formed into little balls, and dried in the air. In this operation the potaſh diſengages the ammoniac; which, in its turn, precipitates the mercury in a white oxide. This precipitate becomes yellow when expoſed to heat, or even to light.

Corroſive mercurial muriate is altered by hydrogenous gas. Sulphur produces no change on it, but alkaline ſulphure decompoſes it as well as the other ſolutions of mercury: the immediate product of this decompoſition is a black precipitate which reſults from the combination of the ſulphur with the mercury. Moſt of the ſemi-metals which we have examined are capable of decompoſing this ſalt: and as each of theſe inſtances of decompoſition is attended with peculiar phænomena, they therefore deſerve to be ſeparately and carefully examined.

When two parts of corroſive mercurial muriate with one of arſenic are diſtilled by a moderate heat, there paſſes into the receiver a matter of the conſiſtency of oil, and tranſparent, of which one part is very ſoon condenſed into a kind of white jelly, improperly called *corroſive oil*, or *butter of arſenic*. If the heat be continued after this product has paſſed off, running mercury is obtained; and by this proceſs we may attain an accurate knowledge of the principles of corroſive mercurial muriate. Muriate of arſenic does not appear to be ſuſceptible of cryſtallization; it melts by a moderate heat, and its taſte is ſo cauſtic that it inſtantaneouſly deſtroys our organs. It diſſolves in water, by which it is partly decompoſed: we are ignorant of its other properties. It cannot be obtained with oxide of arſenic; becauſe when that ſemi-metal is already ſaturated with oxigene, it cannot diſengage mercury from its combination with the muriatic acid by abſorbing oxigene.

The effects of nickel, cobalt, and manganeſe, on corroſive mercurial muriate, have not yet been examined. As to biſmuth, antimony, and zinc, thoſe three ſemi-metals decompoſe this ſalt very readily. By diſtilling two parts of corroſive mercurial muriate with one of biſmuth, we obtain a thick fluid ſubſtance, which congeals into a kind of greaſy maſs that melts on being expoſed to heat, and yields a precipitate when plentifully waſhed: in a word, this compound is ſolid muriate of biſmuth. Poli, who has given an account of this proceſs in the Hiſtory of the Academy for the year 1713, tells us, that when this *butter of biſmuth* is ſeveral times ſublimated, there remains in the veſſel a powder coloured like oriental pearls, very ſoft and gluey: He propoſes the uſe of this powder in painting.

When twelve ounces of antimony are completely mixed with two pounds of corroſive mercurial ſublimate, the mixture gives out heat: a circumſtance which proves that theſe two bodies act rapidly on each other. On diſtilling this mixture by a moderate heat, we obtain a thick liquor which is fixed in the receiver, and often even in the neck of the retort, into a white maſs called *butter of antimony*. The quantity of this ſublimated muriate of antimony is commonly ſixteen ounces and a few drachms. The reſidue conſiſts of mercury and a grey powder of antimony which ſwims on the ſurface of the metallic fluid. On continuing the diſtillation after the muriate of antimony has paſſed into the receiver, and uſing a new balloon, we obtain running mercury; but it is contaminated with a little muriate of of antimony, as that ſubſtance cannot be entirely taken away from the neck of the retort. M. Baumé, who has given a good account of this operation, ſays, that by this proceſs twenty-two ounces of running mercury may be obtained, one ounce of antimony in powder mixed with mercury, and ſix drachms twenty four grains of antimony melted in the retort. The antimony is partly calcined: it affords a red and partly white oxide, which is ſublimed. In this inſtance the antimony is calcined by the oxigene ſeparated from the mercurial oxide, and combines with the muriatic acid to form muriate of antimony. This decompoſition likewiſe takes place when ſulphure of antimony is employed. By diſtilling one part of that mineral in powder with two parts of corroſive mercurial ſublimate, ſublimated muriate of antimony is obtained; but the reſidue, inſtead of containing running mercury, is a combination of mercury with ſulphur. That combination may be ſublimated by a very ſtrong heat into red needles, which are improperly called *cinnabar of antimony.*

Sublimated muriate of antimony, or the combination of the muriatic acid with antimony, is not produced unleſs when the ſemi-metal attracts from the mercury the oxigene which it contains; as has been already obſerved of arſenic. This compound is in a cryſtalline form. It cryſtallizes into very large parallelopipeds. It is ſo cauſtic, that it inſtantly deſtroys our organs and burns vegetable matters. It is very liable to alteration by the contact of light. It melts with the moſt moderate heat, and becomes fixed by cooling: it is this property which has procured it the name of *butter* of antimony. It readily loſes its whiteneſs, and takes a colour. It may be rectified by diſtillation. It attracts the moiſture of the atmo-

atmoſphere, by which it is again diſſolved into a thick and ſeemingly oleaginous fluid: in water it is diſſolved only in part; for the greateſt portion of it is decompoſed by that fluid. When ſublimated muriate of antimony is caſt into diſtilled water, it immediately gives a very copious precipitate, which is called *emetic powder*, or *powder of Algaroth*, from the name of an Italian phyſician who uſed it as a medicine. It has likewiſe been improperly called *mercury of life*. This precipitate is an oxide of antimony ſtrongly purgative and emetic, even when given in very ſmall doſes of three grains and an half to the doze. In order to render it very pure, it muſt be repeatedly waſhed in diſtilled water. It differs in poſſeſſing theſe properties from the other oxides of this ſemi-metal, which are far from acting in ſo energetic a manner on the animal œconomy. A portion of this oxide is diſſolved in the water, in which muriate of antimony is waſhed, by means of the acid which mixes with the fluid. We have an opportunity of obſerving this fact on pouring a little alkali into that liquor: a white precipitate is produced in conſiderable abundance; and butter of antimony therefore appears to owe its property of being decompoſable in water to its containing an exceſs of this oxide; and its forming into a ſolid maſs may be attributed to the ſame cauſe. Sublimated muriate of antimony diſſolves with heat and effervescence in the nitric acid. From that ſolution there is diſengaged a large quantity of nitrous gas, which excites a conſiderable emotion in the mixture; the muriate of antimony diſappears, and the liquor appears of a reddiſh yellow colour. This is a ſolution of oxide of antimony in the nitro-muriatic acid. It very ſoon depoſites the oxide of antimony in the form of a powder, and even of a white magma. If the ſolution

tion of muriate of antimony by the nitric acid be evaporated to dryneſs as ſoon as made, it yields a very white oxide: It is diluted with a quantity of the ſame acid equal to its own weight, and again evaporated: the powder is yet a third time mixed with the ſame quantity of nitric acid and evaporated to dryneſs: it is then heated in a crucible, which is kept red hot for about half an hour, and after that ſuffered to cool. The oxide now taken out of the crucible is white above; and roſe-coloured on the under part. The two portions are mixed, and form by their mixture what is called *Bezoar mineral.* Macquer conſiders this medicine as a perfect oxide of antimony, and thinks it to be the ſame with *diaphoretic antimony.* Lemery, however, who has given an accurate deſcription of this preparation, adviſes to calcine it till it have ſcarce any acidity; wiſhing it to retain *ſome* acid; which muſt certainly change the properties of the oxide of antimony.

Corroſive mercurial muriate is decompoſed by zinc; as has been aſſerted by Pott; and as I myſelf have found by repeated experiments. If you diſtill in a glaſs retort a mixture conſiſting of two parts of this ſalt with one of zinc in filings, or coarſe powder; a white and ſolid ſalt aſcends from the mixture; and is cryſtallized in ſmall needles joined together in a form reſembling the little bundles of which ſtalactites conſiſt. This muriate of zinc emits a thin ſmoke when it is taken out of the receiver: it melts by a moderate heat; is coloured by inflammable vapours; and laſtly, is partly decompoſed in water like ſublimated muriate of antimony.

The moſt ſingular property which corroſive mercurial muriate exhibits in regard to the alterations which it ſuffers from metallic ſubſtances, as well as the moſt important property which it poſſeſſes, is its power of of combining with running mercury. When ſaturated with that metallic fluid it loſes moſt of its properties, particularly its taſte and ſolubility. The old way of producing this combination was by triturating in a glaſs mortar corroſive mercurial muriate with running mercury, adding the mercury by degrees till it refuſed to unite with the mercurial muriate. Lemery and M. Baumé have obſerved, that the ſalt takes up a quantity of mercury equal to about three fourths of its own weight. The mixture was then put into ſmall phials, two thirds of each of them being left empty, and ſublimated three times ſucceſſively. Care was taken to ſeparate at each time a white powder, which is found above the ſublimated matter, and is very corroſive. This product is called *ſweet ſublimate, mercurius dulcis*, or *aquila alba:* It ought to be called *ſweet mercurial muriate*. Its inſipidity, its cryſtalline form, and its being almoſt abſolutely inſoluble, diſtinguiſh it from corroſive mercurial ſublimate. The cryſtals which it affords by ſlow ſublimation are tetrahædral priſms terminating in four-ſided priſms. We often find among them two very long tetrahædral pyramids, joined at the baſe, and forming very acute octohædrons.

The proceſs for preparing ſweet mercury, which we have here deſcribed, is attended with ſeveral inconveniences. To triturate corroſive mercurial muriate with running mercury till the mercury be entirely confounded with the mercurial muriate, is a very tedious and a very difficult taſk. A very minute acrid duſt ariſes from the mixture while it is triturated; and the operator muſt bind a cloth over his mouth and noſe to ſecure himſelf againſt the dangerous effects of that duſt. The mercury is never entirely incorporated with the mercurial muriate; and the ſublimation is very ſlow. M. Baumé

Baumé adviſes to pour a little water on the matters as they are triturated. That fluid aſſiſts the trituration, and hinders the ſaline duſt from riſing. He likewiſe employs levigation, which contributes greatly to make the mercury incorporate with the ſalt. Laſtly, to make ſure of obtaining mild mercurial muriate without the leaſt mixture of corroſive, Zwelfer, Cartheuſer, and M. Baumé propoſe to pour on mild mercurial muriate, after it has been once ſublimated, a quantity of hot water to diſſolve the corroſive muriate, and then dry the ſalt, which is after this found to be much milder than before. M. Cornette, to hinder the volatilization of the corroſive mercurial muriate triturated with the mercury, propoſes to make uſe of nitrate of mercury precipitated by ammoniac, which unites with corroſive mercurial muriate much more readily than running mercury. But as this oxide is not ſo pure as mercury, we cannot depend ſo much on the virtues of the preparation into which it enters. M. Bailleau, an apothecary in Paris, has given the Royal Society of Medicine a proceſs for preparing mild mercurial muriate, without being expoſed to any of thoſe accidents which render the preparation of it in the common way ſo very dangerous. This proceſs conſiſts in forming a paſte with corroſive mercurial ſublimate and water, and triturating it with running mercury. Half an hour's trituration is here ſufficient; becauſe the water contributes to confound the two ſubſtances together. The proceſs ends with digeſting the mixture on a ſand-bath by a moderate heat; the matter changes its original grey colour for white, and forms a very mild mercurial muriate, which needs only to be ſublimated, in order that it may be perfectly pure.

M. Baumé has made ſeveral experiments on mild mercurial muriate. He has ſhown, that it cannot receive an additional quantity of mercury; that it cannot exiſt in a middle ſtate between corroſive and mild mercurial muriate; as where a ſmaller portion of mercury is mixed with the corroſive mercurial muriate than what is requiſite to make it paſs into the ſtate of mild mercurial muriate, a portion of this latter ſalt is formed, in proportion to the quantity of the mercury and the exceſs of the corroſive; and the reſt of the corroſive mercurial muriate is volatilized without ſuffering any alteration of its properties. Theſe two compounds are ſeparable by hot water.

From the reſearches of the ſame chemiſt we learn farther, that it is poſſible to change the mild into corroſive mercurial muriate, by ſublimating it with decrepitated marine ſalt and white calcined ſulphate of iron. In this operation the muriatic acid being diſengaged and oxigenated by the ſulphuric acid, unites with the mercurial oxide of the mild mercury, and converts it into corroſive muriate. M. Baumé is convinced that mild mercurial muriate differs greatly from the corroſive, as it cannot unite with ammoniacal muriate as the corroſive mercurial muriate does in the preparation of *alembroth* ſalt, or ammoniaco-mercurial muriate. It is even from the conſideration of its poſſeſſing this property, that he adviſes to waſh mild mercurial muriate with water impregnated with a little ammoniacal muriate, to carry off all the corroſive mercurial muriate which renders that ſalt ſo very ſoluble. Laſtly, he has diſcovered, that at each ſublimation mild mercurial muriate loſes a part of its mercury, and affords of conſequence a certain quantity of corroſive mercurial muriate; ſo that by repeated ſublimation mild mercurial muriate may be entirely changed into corroſive. From this laſt fact it follows, that the medicine, known by the name of *mercurial panacea*, which conſiſts of mild mercurial muriate nine times ſublimated, is ſo far from being rendered milder by being ſo often ſublimated, as moſt chemiſts and phyſicians think, that at the end of the proceſs it differs in no reſpect from what it was at firſt. A circumſtance attending the operation may be conſidered as a farther proof of this aſſertion; at each ſublimation a ſmall quantity of white powder which riſes firſt is taken off, which powder is nothing but corroſive mercurial muriate. It is to be obſerved, that there remains in the phials a reddiſh powder when mild mercurial muriate is prepared. It is an oxide of iron produced from the ſulphate of iron, which is employed in preparing the common corroſive mercurial muriate. Part of that oxide aſcends with the ſalt in its ſublimation; nay, the mercurial ſalt in vapour is often found to carry up with it even pieces of glaſs.

Late experiments on the oxigenated muriatic acid render the theory of the formation of mild mercurial muriate much more clear and intelligible than it formerly was. It has of late been proved, that corroſive mercurial muriate is a compound of oxigenated muriatic acid with oxide of mercury, and that mild mercurial muriate is formed by the common muriatic acid with the ſame metallic oxide: or, what amounts to the ſame thing, that in corroſive muriate the oxide is much more calcined than in mild muriate. Thus when running mercury is triturated with corroſive mercurial muriate, the mercury ſeizes the exceſs of oxigene contained in the muriatic acid, or in the former mercurial oxide; and as a larger quantity of mercurial oxide, and that leſs completely calcined, now combines with the ſame quantity of muriatic acid, the nature of the ſalt is of conſequence altered, and it becomes leſs ſaline, more inſipid, and more inſoluble: in a word, its qualities

are

are weakened in proportion as the quantity of the mercurial oxide is increaſed.

The boracic acid does not diſſolve mercury without an intermedium; but, in the ſtate of oxide, it acts in a very diſcernible manner on this ſemi-metal. Theſe two ſubſtances may be combined by the way of double affinity. When a ſolution of common borax is poured on a nitric ſolution of mercury, a very copious yellow precipitate is produced, which was firſt made known by M. Monnet. In this operation the ſoda of the borax, uniting with the nitric acid, forms nitrate of ſoda; while the boracic acid unites with the mercurial oxide to form an almoſt inſoluble neutral ſalt which is precipitated. The liquor being filtrated and evaporated, affords fine brilliant pellicles of mercurial borate. We muſt, however, obſerve, that the ſalt contains a portion of oxide of mercury not combined with the boracic acid, becauſe there is always an exceſs of ſoda in common borax. To obtain borate of mercury by this proceſs, the borate of ſoda employed muſt be fully neutralized, that is, completely ſaturated with boracic acid. This ſalt, when expoſed to the air, turns ſenſibly green; ammoniacal muriate renders it very ſoluble, and forms with it a compound reſembling ammoniaco-mercurial muriate. Lime-water makes it yield a yellow precipitate; the colour of which changes to a deep red: with potaſh it yields a white precipitate. According to the academicians of Dijon, corroſive mercurial muriate is likewiſe decompoſed by borax, which produces in a ſolution of it a brick-coloured precipitate. Water boiled over this precipitate becomes of a lacteous appearance on the addition of a fixed alkali; which proves it to contain mercurial borate.

We know not in what manner the fluoric acid acts upon mercury; and we are no leſs ignorant of the effects which the carbonic acid produces upon it. We know only that water impregnated with this acid never acts upon mercury; though ſolutions of mercury decompoſed by alkaline carbonate afford precipitates very different from thoſe produced by the ſame ſalts in a pure cauſtic ſtate, and mercurial oxide readily abſorbs carbonic acid from the atmoſphere.

The neutral ſalts have but very little power of action on mercury. Although this aſſertion chiefly regards the various ſulphuric ſalts, yet I have remarked, that quickſilver incorporates readily with ſulphate of potaſh.

Mercury does not appear capable of altering ammoniacal muriate by diſtillation. Bucquet, who made this experiment, has obſerved, that one part of the ſalt is not quite ſufficient to abſorb two parts of mercury, and the mixture gives no ammoniac by diſtillation. Yet the Count de Garaye had made up with theſe two ſubſtances a medicine to which he gave the name of *tincture of mercury*. Macquer, on examining his proceſs, found it to be perfectly conſiſtent with what he had advanced. It conſiſts in triturating in a marble mortar an ounce of running mercury with four ounces of ammoniacal muriate, moiſtening the mixture with a little water till the mercury be entirely incorporated with the ſalt, leaving that matter then expoſed to the air for five or ſix weeks, and ſhaking it from time to time. It muſt, at the end of this time, be triturated anew, put in a matraſs upon a ſand-bath with good alcohol ſwimming above the powder to the depth of two inches, and cauſed to boil gently. The alcohol acquires a yellow colour, and appears to contain mercury from its

its communicating a white colour to a plate of copper. It appears, that in this operation the ammoniac is gradually diſengaged by the mercury, forming of conſequence ammoniaco-mercurial muriate, of which part is diſſolved by the alkali; and that the difference in the quantity of the mercury, and the gentle action which takes place during the maceration, are the cauſes why this experiment gives a reſult different from Bucquet's.

We know not in what manner hydrogenous gas acts upon mercury. Mercury combines very well with ſulphur. When one part of this metallic fluid is triturated with three parts of ſulphur, the mercury is by degrees confounded with the ſulphur; and the reſult is a black powder, black ſulphure of mercury, or *Æthiops mineral*, the colour of which deepens when it is ſuffered to lie aſide. This combination is produced more quickly when the mercury is mixed with melted ſulphur: on ſhaking that mixture it becomes black, and eaſily takes fire. In order to make it retain its black colour, it muſt be taken out of the fire, the flame muſt be quenched as ſoon as it appears, and the matter ſtirred till it become ſolid, and form into lumps. It is then reduced to powder, and paſſed through a fine ſieve. Black ſulphure of mercury is not the moſt intimate poſſible combination of ſulphur with mercury. When this compound is expoſed to an intenſe heat, it kindles, moſt of the ſulphur burns, and there remains, after that combuſtion, a matter which, when pulverized, takes a violet colour. This powder is put into a matraſs, which is heated till its bottom become red: it is kept for ſeveral hours in that ſtate till the matter be ſublimated. In the upper part of the matraſs there is found after the ſublimation a quantity of artificial cinnabar, or red ſulphure of mercury cryſtallized in needles of a brown red colour. Its colour is more lively, and not ſo deep when it is ſublimated in retorts. The Dutch prepare cinnabar for the arts in the great way. This compound is ſcarce volatile; and of conſequence a very intenſe heat is requiſite to ſublimate it. When much divided by levigation, it takes a bright red colour; and is then called *vermillion*. If heated in open veſſels, the ſulphur, which amounts to one-fourth of the whole quantity, burns by degrees, while the mercury is volatilized. Many ſubſtances have ſuch an affinity with ſulphur as to decompoſe red ſulphure of mercury. Lime and alkalis poſſeſs this property. When they are heated in a retort with this ſulphure, in the proportion of two parts of the ſulphure to one of the lime or alkali, running mercury is obtained, and the reſidue is alkaline or earthy ſulphure. M. Baumé has even obſerved this decompoſition to take place in the humid way, when red ſulphure of mercury is boiled with liquor of fixed alkali. It is remarkable, that the alkali which he employed was not effervefcent. Several of the ſemi-metals, ſuch as cobalt, biſmuth, and antimony, likewiſe poſſeſs the property of attracting ſulphur from mercury. We will ſee, that almoſt all the metals, lead, tin, iron, copper, and ſilver, have a greater affinity than mercury with ſulphur; and of conſequence decompoſe *cinnabar*: they may be therefore uſed indifferently to ſeparate the mercury of that compound. This metallic fluid, when obtained by ſuch a proceſs, is perfectly pure. It is diſtinguiſhed by the name of *mercury revivified from cinnabar*.

Mercury inſtantaneouſly decompoſes alkaline ſulphures; but the decompoſition is attended with different phænomena, according to the differences of the nature of thoſe compounds. With the alkaline ſulphures it forms black ſulphure of mercury, which at the end of ſeveral years is found to have changed its black colour for red. With ammoniacal ſulphure, it is very readily converted into black ſulphure of mercury, which in a few hours, or at moſt in a few days, takes a bright red colour. The yellow and the red oxide of mercury formed by fire or acids, exhibit ſooner or later the ſame phænomenon with ammoniacal ſulphure. It is produced alſo by pouring that liquor into ſolutions of mercury, and expoſing the black precipitate which reſults from the mixture to a new quantity of ammoniacal ſulphure.

I have diſcovered that running mercury ſhaken in water impregnated with hydrogenous gas, ſulphurated either naturally or artificially, decompoſes it very readily, and changes it into a black ſulphure.

We know not in what manner mercury acts upon arſenic. Cobalt does not combine with this metal. Biſmuth is eaſily diſſolved by mercury, and combines with it in any proportion. From this combination there reſults a bright friable matter, which is more or leſs ſolid, according to the quantity of the biſmuth. This amalgam cryſtallizes into four-ſided priſms, which ſometimes unite into octohædrons; but it is moſt frequently cryſtallized into thin plates of no regular form. This cryſtallization is effected by melting the combination, and ſuffering it to cool ſlowly. When heated in a retort, it gives out, but very refractorily, the mercury which ſerves as its ſolvent.

Mercury does not unite with either nickel or antimony. It combines with zinc by fuſion. The amalgam which it forms with that ſemi-metal is ſolid: it is rendered fluid by trituration. When it is melted and ſuffered

ſuffered to cool ſlowly, it cryſtallizes into plates, which appear to be ſquare and rounded on the edges.

Mercury is much uſed in the arts, ſuch as gilding, ſilvering of glaſs, the conſtruction of meteorological inſtruments, metallurgy, &c. This ſemi-metal is uſed in medicine almoſt under every form.

1. Crude mercury was formerly uſed in the volvulus or iliac paſſion. It is ſtill boiled in water, and is thought to communicate the properties of a vermifuge. It is mixed with fats, and applied as an ointment in venereal complaints.

2. *Turbith mineral,* or yellow oxide of mercury by the ſulphuric acid, has been recommended in the ſame caſes, in doſes of a few grains. This medicine is emetic and purgative, and often acts too powerfully in both ways.

3. Mercurial water, or its nitric ſolution, is uſed by ſurgeons as a powerful eſcharotic. Red precipitate, or red oxide by the nitric acid, ſerves the ſame purpoſe. There is a citron-coloured ointment made up of hog's-lard and the nitrous ſolution of mercury, which is an excellent cure for the itch.

4. Corroſive mercurial muriate has been recommended by Sanches and Van Swieten in venereal caſes. A few grains of it are diſſolved in *aquavitæ,* and the ſolution is taken by ſpoonfuls, diluted in a large quantity of ſome cooling drink. The ſtate of the breaſt ſhould be attended to when this medicine is adminiſtered, and it ought to be given with great caution. Mild mercurial muriate is given in doſes of twelve or fifteen grains as a purgative, and in doſes of three or four grains as an alterative. Phagedenic water is uſed in ſurgery, to corrode and deſtroy proud fleſh, &c.

5. Mercurial borate has been ſucceſsfully employed in

in venereal caſes by M. Chauſſier, the younger, of the Academy of Dijon.

6. *Cinnabar* has been undeſervedly conſidered as antiſpaſmodic and ſedative. It is one of the principles of Stahl's *pulvis temperans*, which, according to the pharmacopœia, is prepared by mixing exactly three drams of ſulphate of potaſh and nitre with two ſcruples of artificial *cinnabar*. This medicine is adminiſtered by expoſing the ſick perſon to its vapour; and this is one way of treating people ill with the venereal diſeaſe by fumigation.

All the preparations of mercury which are given internally, ſuit many other caſes beſides venereal complaints: Such are almoſt all cutaneous diſorders, a ſcrophulous habit, ſwellings of the lymphatics, &c. Yet we cannot avoid obſerving, that theſe medicines, and eſpecially all ſaline preparations of it, ought to be employed by none but ſkilful and cautious phyſicians; it is dangerous for the health, and even for the lives of mankind, that mercurial medicines ſhould be in the hands of ſuch a number of people who are deſtitute of the knowledge requiſite to adminiſter them; not only ſo as to be beneficial, but even ſo as not to do harm. I have oftener than once been witneſs of the unhappy effects produced by thoſe preparations, in conſequence of their having been adminiſtered by ignorant perſons, with that raſhneſs which uſually accompanies ignorance. We even think this an object of ſufficient importance to merit the attention of government.

CHAP. XVI.

Of Tin.

TIN, the *Jupiter* of the alchemiſts, is an imperfect metal of a white colour, brighter than lead, but darker than ſilver. It is very pliant, and when bent produces a crackling noiſe, called *the cry of tin.* We have already taken notice of the ſame phænomenon as belonging to zinc, though in a leſs eminent degree; a circumſtance which has induced Malouin to repreſent that ſemi-metal as nearly allied to tin.

This noiſe ſeems to be owing to the ſeparation or ſudden diviſion of the parts of the metal; and it ſeems to indicate a fracture; though tin, as we have already mentioned, makes ſcarce any reſiſtance to a force directed to bend it.

Tin is the lighteſt of all metals. It is ſo ſoft that it may be marked with the nail. In water, it loſes about a ſeventh part of its weight. It has a very diſcernible ſmell; and when it is rubbed, that property becomes ſtill more eminent. It has a diſagreeable taſte, peculiar

liar to itſelf; which is even ſo ſtrong, that ſome phyſicians aſcribe to this metal a pretty ſtrong power of action on the animal œconomy, and have recommended it for ſeveral diſeaſes. Being ſo exceſſively ſoft, it is ſcarcely ſonorous. Tin holds the ſecond place among metals, arranged according to their ductility; under the hammer it is reducible into plates thinner than leaves of paper, which are of great uſe in various arts. It is ſo tenacious that a tin thread, one-tenth of an inch in diameter, will ſuſtain without breaking a weight of forty-nine pounds and an half. M. Mongez could not accompliſh the cryſtallization of tin. M. de la Chenaye, a gentleman who ſtudied under me, has effected it by melting the metal for ſeveral times ſucceſſively. By this means he has obtained a rhomboidal aſſemblage of priſms or needles joined longitudinally.

Moſt mineralogiſts ſtill doubt the exiſtence of native tin. Several authors, however, aſſert, that it is found in Saxony, in Bohemia, and in Malacca. It even appears to be a ſufficiently atteſted fact, that there is native tin in the tin mines of Cornwall: and M. Sage has deſcribed a ſpecimen which he received from Mr Woulfe, a London chemiſt. The fracture of that piece is grey and ſparkling; when beaten on the anvil, it forms brilliant and flexible plates of tin. Tin is more commonly met with in a black oxide, ponderous, opaque, and cryſtallized in octohædrons, or pyramids with four faces. The texture of this ore is ſparry and lamellated. Bucquet thinks it to be a true carbonate of tin. M. Sage is of opinion that theſe cryſtals are mineralized by the muriatic acid. We may here recollect, that moſt of the white tin cryſtals in cabinets of natural hiſtory are native tunſtate of lime, which

which ought not to be confounded with oxide of tin, as the oxide does not become yellow when brought into contact with acids.

Thoſe matters which are denominated tin ores, are of a very deep red, violet, or black colour, and their ſpecific gravity is greater than that of any other mineral ſubſtance. Thoſe ores are ſometimes cryſtallized in irregular cubes; and they are then diſperſed in groupes in a gangue of quartz or fuſible ſpar. They are often in maſſes, not cryſtallized. Almoſt all naturaliſts agree in conſidering coloured tin ores as combinations of tin with arſenic, and aſcribe their uncommon ponderoſity to the want of ſulphur. Meſſrs Sage and Kirwan, however, think they contain no arſenic; and the former of theſe gentlemen affirms that they need not to be roaſted, unleſs they be mixed with arſenical pyrites; which is very common. Mr Kirwan ſays, black tin ore contains $\frac{80}{100}$ of tin and iron.

Bergman has found ſulphureous tin in nature among the minerals of Siberia. The ſpecimen of that ſulphureous ore which he examined, was externally of a golden colour, reſembling *aurum muſſivum:* within, it exhibited a maſs of radiated cryſtals, white, ſparkling, brittle, and changing its colour when expoſed to the air. He found it to contain a little copper.

We know of no tin ores any where in France. M. Baumé, however, ſuſpects that ſuch ores might be found in the neighbourhood of Alençon, and in ſome of the diſtricts of Brittany, becauſe there are rock cryſtals found there which appear to be coloured with this metal. The places where theſe ores abound, and are wrought in mines, are the counties of Cornwall and Devonſhire in England, Germany, Bohemia, Saxony, the iſland of Banca, and the peninſula of Malacca in in the Eaſt Indies. Many naturaliſts conſider garnets as a kind of tin ore, on account no doubt of their colour. They differ from tin ores, however, in tranſparency and in gravity; for they are much lighter. Beſides, Meſſrs Bucquet and Sage could find no tin in them.

Tin exiſts in nature but in a few different ſtates, which may be all reduced to the following varieties.

Varieties.

1. Native tin in leaves or plates.
2. White ſparry tin ore, in octohædral cryſtals.
3. Tin ore, of a yellowiſh white colour, often coloured and ſemi-tranſparent, like topazes.
4. Brown, reddiſh tin ore, in cubic cryſtals, more or leſs regular.
5. Tin ſtone, Swediſh *tinberg*. This is a ſtone or ſand, containing a mixture of oxide of tin; it is grey, blue, brown, or black.
6. Sulphureous tin ore, of a bright colour, reſembling zinc, or gilded over like *aurum muſſivum*.

In aſſaying tin ore, it muſt firſt be broken into lumps, then coarſely pounded, waſhed, and roaſted in a covered earthen capſule, in order that as little tin as poſſible may be loſt, care being taken, however, to uncover it from time to time; for as Cramer has remarked, a good deal of the metal is loſt when it is roaſted in a veſſel conſtantly open. It muſt likewiſe be quickly roaſted, that the tin may not be too much oxidated. M. Baumé propoſes to obviate theſe inconveniences

veniences by adding a portion of pitch, which reduces a part of the oxide formed in this operation. After the ore is roaſted, it is to be quickly melted in a crucible, with three parts of black flux and a little decrepitated marine ſalt. By comparing the three weights of the waſhed ore, the roaſted ore, and the metallic button, it may be eſtimated what quantity of extraneous matters the ore contains, and what quantity of tin it will yield in the hundred weight. Cramer propoſes a more expeditious way of making this aſſay,—by which, too, leſs of the ore is likely to be loſt,—by uſing two large pieces of charcoal burnt from linden or hazel wood. In one of theſe there muſt be a cavity to contain the tin ore with the pitch, inſtead of a crucible; the other muſt be pierced with a ſmall hole through which the vapours may eſcape. The latter of theſe covers the former; and they muſt firſt be luted, and afterwards bound together with iron wire. They are then ſet on fire before the nozzle of a forge bellows, and kept up againſt it by other pieces of coal placed around them. After they have got enough of the fire to melt the tin, they are quenched with water, and the tin is found in a metallic button.

Bergman propoſes to aſſay tin ores by diſſolving them in ſulphuric acid, mixing that with muriatic acid, and precipitating the mixture with fixed alkali. When the tin is pure, 131 grains of this precipitate are equal to 106 grains of tin. If it be mixed with copper and iron, theſe extraneous metals are ſeparated by the nitric and the muriatic acid.

The working of tin ores in the great way reſembles the foregoing proceſs. It is often neceſſary to make fires of wood in the mines, to calcine and ſoften the gangue, which is very hard. Theſe fires diſengage vapours that are very noxious. This proceſs is followed at the hills of Geyer. At other times thoſe ores are found in ſand, at no great depth beneath the ſurface of the earth, as at Eiberſtock. The ore is there pounded, and waſhed in boxes with ſmall partitions of cloth to retain the metallic particles. It is then roaſted in reverberating furnaces, with horizontal chimnies fitted to them, to collect the ſulphur and arſenic. It is then melted in a furnace with a ſleeve furnace, and poured into moulds which give it the form of blocks. In Germany and England tin ores are wrought nearly in the ſame way. In England, according to Geoffroy, the metal is always alloyed with lead and copper, and never exported pure. There comes too from England a ſtalactitical tin, which is called *tin in tears*, and is thought to be very pure; but Meſſrs Bayen and Charlard affirm, that it is ſometimes mixed with copper. The hardeſt tin of all is that which comes from Malacca and Banca. Malacca tin appears to have been run into moulds, which have given it the form of a truncated quadrangular pyramid, with a thin border round its baſe: this is ſaid to be in hats or ſtandiſhes: Each piece weighs about a pound. The tin of Banca is in oblong ingots of about forty-five or fifty pounds. Both theſe kinds of tin are covered with a dirty grey ruſt more or leſs thick.

The tin which we get from England, and which being cheaper, is much more uſed than pure Indian tin, is in large blocks, each weighing about three hundred pounds. It is alloyed with copper, either artificially, as Geoffroy tells us, or naturally, according to the Baron de Dietrich. That it may be more eaſily retailed, it is afterwards melted into ſmall ingots

gots or ſticks, about nine or ten inches in circumference, and a foot and an half long *.

When tin is expoſed to fire in cloſe veſſels, it melts very quickly. It is the moſt fuſible of all metals. If the fire be not increaſed it remains fixed; but its fixity appears to be only relative; for when expoſed to a conſiderable heat it is volatilized, as we are juſt about to relate. If heated in contact with air, there appears on its ſurface as ſoon as it is melted a dirty grey pellicle, which contracts into a ſhrivelled form. On taking it off, we behold the tin beneath, with its proper metallic luſtre, and not adhering to the pellicle: but it loſes this appearance, and a new pellicle is formed. The whole quantity of tin in fuſion may be in this manner carried off in pellicles, which are nothing but the oxide of the metal, or a combination of the metal with the oxigene of the atmoſphere. Tin, when reduced to oxide, becomes one-tenth heavier. When this metal is made red hot, Geoffroy has obſerved, that its oxide is gradually ſublimated by a very lively whitiſh flame, which he compares to the flame of zinc. This is actually an inflammation or rapid combuſtion of the metal: and the volatilized tin ariſes at the ſame time in a light ſmoke, which condenſes on cold bodies to a whitiſh oxide of tin in needles. The grey oxide of tin becomes white on being again expoſed to the action of fire; it then unites with a new portion of oxigene, and is more completely calcined. In this ſtate it is called *tin-putty*. When expoſed to a very intenſe heat,

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* It is not true that tin is never exported pure from England: But however pure it may be exported, foreign tin-founders uſually take care to alloy it, and aſcribe the alloy to the Engliſh. Neumann tells, that the Dutch keep Engliſh ſtamps for the purpoſe.

heat, like that of a porcelain furnace, it melts into a glaſs. Meſſrs Macquer and Baumé have obſerved, on treating tin in this way in a crucible, that a part of it was changed into a white, needled oxide; while another part under the former was hard, reddiſh, and half melted; a third was converted into ruby or hyacinth-coloured glaſs; and, laſtly, there remained in the bottom of the crucible a portion of the tin in its metallic ſtate. Notwithſtanding of this, oxide of tin is ſtill conſidered as infuſible; and it is at leaſt the moſt refractory of all oxides. This oxide may be decompoſed with the help of combuſtible animal or vegetable matters; which by detaching the oxigene enable the metal to reſume all its properties. It appears, however, that *tin putty*, when thoroughly calcined, retains, with no inconſiderable force, the oxigene with which it is united; for to reduce it is very difficult, and a great quantity of combuſtible matters muſt be employed for the purpoſe. This has led M. Baumé and ſeveral other chemiſts to think, that when tin ores are too much roaſted, a part is ſo changed as to be no longer ſuſceptible of reduction.

Tin does not ſuffer much alteration from air; when very pure, it is ſcarce liable even to loſe its luſtre. That which commonly paſſes in commerce is at length covered over with a grey duſt; but this duſt, according to Macquer, never penetrates deeper than the ſurface, as the ruſt of iron does.

Water does not diſſolve or calcine tin; yet a piece of tin expoſed to the action of water is at length tarniſhed, and ſeemingly calcined on its ſurface.

Earthy matters never contract any union with this metal; its oxide being ſo very infuſible, never forms either tranſparent or coloured glaſs with vitrifiable ſubſtances.

ſtances. But as it is ſo very white, it is capable of interpoſing itſelf among the particles of glaſs, ſo as to render it very opaque, and of a dead white colour. This ſort of vitreous frit is called *enamel.* The infuſibility of tin putty enables it to deſtroy the tranſparency of any kind of glaſs, and convert it into a coloured enamel.

We know not in what manner lime, magneſia, or alkalis act upon tin: but there can be no doubt that alkalis, with the help of water, may effect ſome alteration on this metal; for they in a very ſhort time cauſe it to aſſume the colours of the rainbow.

According to Kunckel, the concentrated ſulphuric acid diſſolves half its weight of tin; heat favours this ſolution. A very pungent ſulphureous gas is diſengaged from the matters, without any very diſcernible emotion or efferveſcence. In this operation, the tin ſeizes the oxigene of the ſulphuric acid; it is quickly oxidated, and the acid retains ſo much of it as to afford a precipitate by water. The ſulphuric acid, diluted in a little water, acts in the ſame manner on tin: but this ſolution is more permanent, and does not afford ſo copious a precipitate by water as the former. When the acid is very weak, it does not diſſolve tin at all. In this combination the tin attracts ſo much oxigene from the ſulphuric acid as to form ſulphur very quickly. The ſulphur communicates a brown colour to the ſolution when it is hot, and when it is cold ſubſides as a precipitate. Meſſrs Macquer and Baumé are convinced of the preſence of ſulphur in this combination. On continuing to heat the ſolution, the tin is precipitated in a white oxide. The ſame phænomenon will at length take place, even without the help of heat. The ſulphuric ſolution of tin is very cauſtic. M. Monnet obtained

obtained from it by cooling, cryſtals reſembling thoſe of calcareous ſulphate, or in fine needles intermixed and intwined with one another. The oxide of tin precipitated from this ſolution by reſt and heat, is ſoluble in the ſulphuric acid. If the ſulphuric ſolution of tin be evaporated to dryneſs, the oxide which it then affords is grey, ſcarce reducible, and not ſoluble in that acid. The alkalis precipitate tin diſſolved in the ſulphuric acid in a very white oxide.

Tin decompoſes the nitric acid, even cold, with amazing rapidity. This is one of the moſt aſtoniſhingly rapid ſolutions in all chemiſtry. Tin appears to have a very ſtrong tendency to combine with the oxigene of the nitric acid; and as the azotic principle does not adhere to the oxigenous with near the ſame obſtinacy as the ſulphur does in the ſulphuric acid, it is not at all ſurpriſing that the nitric acid ſhould be decompoſed by tin in a much more rapid and lively manner than the ſulphuric acid. M. de Morveau has obſerved, that in a ſolution of tin by the nitric acid, there was no gas diſengaged, but there was a portion of ammoniac formed. It appears then, that not only the nitric acid, but the water, is decompoſed by tin; for the ammoniac formed in this operation can only be formed by the union of the hydrogene of the water with the azote of the acid of nitre.

Tin is reduced into a white oxide, which Macquer ineffectually attempted to reduce to metal: this metal therefore appears to be ſuperſaturated with oxigene. The nitric acid retains only a little of it in ſolution; and when it is evaporated with a view to obtain nitrate of tin in cryſtals, the tin which was diſſolved in the acid is very ſoon precipitated, leaving the acid almoſt

pure.

pure. Bucquet, however, aſſerts, that a very deliqueſcent nitre of tin may be obtained from this ſolution; but he has not determined its form. He aſſerts likewiſe, that on waſhing calx of tin formed by the decompoſition of the nitric acid, the water diſſolves a little nitrate of tin, which may be obtained from it by evaporation. The nitric acid retains a little more tin diſſolved in it when it is diluted in a large proportion of water; but it precipitates the oxide which it has thus obtained either by heat or by reſt. Meſſrs Bayen and Charlard, in their valuable experiments on tin, have diſcovered, that when the nitric acid is impregnated with as much tin as it can reduce to oxide, and made ſo thick with it as to be unfit for acting on any other metal; the maſs, if copiouſly waſhed with diſtilled water, and evaporated to dryneſs, gives a *ſtanno-nitrous* ſalt, which detonizes by itſelf in a hot roaſting pot, and burns with a white thick flame like that of phoſphorus. Oxide of tin ſufficiently lixiviated, affords by exſiccation a ſemi-tranſparent maſs reſembling ſcales. The *ſtanno-nitrous* ſalt, when diſtilled in a retort, ſwells, boils up in bubbles, and on a ſudden fills the receiver with a white thick vapour of a nitrous ſmell.

The fuming muriatic acid acts with conſiderable ſtrength on tin: it diſſolves the metal with the help of heat, or even cold; but inſtantly loſes its colour and the property of fuming. The faint efferveſcence which takes place on this occaſion, diſengages from the mixture an inflammable fœtid gas, which, however, has no reſemblance to the fœtor of arſenic, notwithſtanding what ſome chemiſts have pretended to the contrary. Water is therefore decompoſed by tin, with the help of the muriatic acid. That acid diſſolves in this proceſs more than half its own weight of tin. The ſolution is yellowiſh, has a very fœtid ſmell, and affords not, like the preceding ſolutions of tin with acid, a precipitate of oxide of tin. When this ſolution is evaporated, it affords very regular brilliant needles, which attract a little moiſture from the air. M. Monnet ſays that thoſe needles, after falling into a deliquium, cryſtallize, and remain dry in the air. M. Baumé, who has prepared muriate of tin in the great way, with an hundred and fifty pounds of acid to twenty-five pounds of tin, for the manufacture of printed cloths, gives an accurate account of ſeveral of its properties. Of twelve pounds of tin diſſolved in forty-eight pounds of muriatic acid, there remained two ounces and ſix drams in a grey powder; which did not diſſolve in a pound of the acid, though digeſted in it for a number of days. Margraaf thinks it to be arſenic. M. Baumé has not examined it. He compares the ſmell of that ſolution concentrated to that of the black earths of old privies; and obſerves, that when it falls on the fingers, it is impoſſible to waſh or wipe away the metallic ſmell of tin which it communicates to them, but which goes off of itſelf in the courſe of four and-twenty hours. He obſerves, that the cryſtals of muriate of tin vary according to the ſtate of the acid: Sometimes they are little white needles. From the ſame ſolution he obtained both white and roſe-coloured needles. The roſe-coloured, when purified by ſolution and evaporation, afforded, by cooling, large cryſtals nearly like thoſe of ſulphate of ſoda. At other times, employing the common muriatic acid, he obtained the ſalt in ſmall pearl-white ſcales, like thoſe of the boracid acid. He does not mention the action of fire on this ſalt. M. Monnet, who diſtilled the muriatic ſolution of tin, affirms, that he he obtained from it a very fuſible unctuous matter,—in ſhort, a true butter of tin, and a fuming liquor like that of Libavius, which we ſhall hereafter mention. This fact agrees with what Macquer has obſerved concerning a ſolution of tin in the muriatic acid, which was almoſt entirely cryſtallized during winter, but became fluid again in ſummer; a property which is found to belong to ſublimated muriate of tin. That illuſtrious chemiſt has obſerved, that after a number of years there was a white ſediment formed in this ſolution. The combination of the muriatic acid with oxide of tin affords a much more copious precipitate than any of the other ſolutions of this metallic calx, by alkalis and lime. The alkalis again diſſolve a part of the precipitated oxide, and aſſume a brown yellow colour. By diſſolving large blocks of Engliſh tin, and in general all impure tin in this acid, Meſſrs Bayen and Charlard diſcovered at length that Engliſh tin contains ſome particles of arſenic. When tin contains arſenic, in proportion as the acid acts on the tin the metal aſſumes a black colour; and when it is totally diſſolved, there remains a blackiſh powder; which is pure arſenic, or arſenic combined with a ſmall portion of copper. This acid may therefore be employed to aſcertain the preſence of arſenic in tin, and determine its quantity.

The oxigenated muriatic acid diſſolves tin very readily, and without any diſcernible effervеſcence; for the metal quickly abſorbs the exceſs of oxigene in the acid, without decompoſing the water in order to unite with the oxigene which *it* contains. This ſolution poſſeſſes of conſequence all the properties of the foregoing ſolution.

The mixed nitro-muriatic acid, conſiſting of two parts of nitric acid and one of the muriatic, combines with tin with effervefcence. It produces a ſtrong heat, which ſhould be diminiſhed by immerſing the mixture in cold water. To compoſe a permanent ſolution of tin in this mixed acid, care muſt be taken to put the metal only by degrees into the acid, and to wait till the firſt portion be entirely diſſolved before putting in a ſecond. If a large quantity of the metal were put all at once into the acid, moſt of it would be oxidated. *Aqua-regia* is capable of diſſolving and holding in ſolution half its weight of tin. This ſolution is of a reddiſh brown colour; but its colour is very faint: it often forms in a few moments a tremulous jelly, of the appearance of roſin. This ſubſtance becomes in a few days more ſolid; at the end of which time it may be cut like a firm animal jelly. Some portions of it exhibit the ſemi-tranſparency and whiteneſs of the opal. It exhales a poignant ſmell of muriatic acid; but this ſmell is not fœtid like that of the muriatic ſolution of tin. I have preſerved ſome of it for ſeveral years in a bottle but indifferently ſtopped, and it loſt nothing of its tranſparency or ſolidity. In order that tin diſſolved in *aqua-regia* may form a jelly, the ſolution muſt contain a good deal of the metallic oxide. Sometimes, on adding to it half its weight of water, it becomes concrete, though not ſo before. But this jelly, formed by the help of water, is of an opal colour; becauſe, as has been remarked by Macquer, this ſolution being ſuſceptible of decompoſition by water, a portion of oxide is precipitated and deſtroys the tranſparency of the jelly. That ſkilful chemiſt has farther obſerved, that when the ſolution of tin in aqua-regia is heated, a lively effervefcence takes place, owing to the re-action of the mixed acid on the metal, on which it ſtill retains ſome power of acting. The ſolution then loſes its colour,

lour, and becomes fixed by cooling. The jelly new formed is beautifully tranſparent. By reſt, a liquid regaline ſolution of tin ſometimes depoſites ſmall needle cryſtals. Neither theſe, nor the gas diſengaged during the action of the nitro-muriatic acid on tin, have not yet been examined. Meſſrs Bayen and Charlard have found that this ſolvent might likewiſe be uſed to aſcertain the preſence of arſenic in tin; but that as it acts with conſiderable force on the ſemi-metal, it would not determine the quantity ſo preciſely as the muriatic acid itſelf is capable of doing.

We know not in what manner the other acids act upon tin. All ſulphuric neutral ſalts, eſpecially ſulphate of potaſh or ſoda, are liable to be decompoſed by tin. By heating in a crucible equal parts of ſulphate of potaſh and tin, I obtained a greeniſh melted maſs, which had no metallic properties, but was a true ſtannic ſulphure. Tin detaches the oxigene from the ſulphuric acid. The ſulphure ſeparated by this decompoſition combines with the potaſh; and that ſulphure diſſolves a portion of the oxide of tin. This is the third metallic ſubſtance which we have found to poſſeſs the property of decompoſing alkaline ſulphates. We will preſently ſee that Glauber had taken notice of this fact in regard to ammoniacal ſulphate.

This metal makes nitre detonize rapidly. It is melted and heated in a crucible till it aſſume a dark red colour, and the nitre then thrown on it in a powder. A white ſparkling flame accompanies the detonation. When more nitre is added, the detonation no longer takes place, the tin being entirely reduced to oxide. The white powder which remains contains alkali rendered cauſtic by the oxide of tin, and even combined with a certain quantity of that oxide. On forming it into a lixivium, the tin may be precipitated by an acid. If the grey oxide of tin melt with nitre, as Geoffroy has obſerved, the reaſon of this muſt be its ſtill containing a portion of tin not reduced to oxide; for when we take a perfect oxide of this metal, that for inſtance which has long been expoſed to heat, and is very white, or rather that which owes its formation to acids; neither of theſe exhibits any ſuch phænomenon.

Tin decompoſes ammoniacal muriate very readily: a quantity of ammoniac, ſtrongly cauſtic, and in a gazeous ſtate, is diſengaged. Bucquet, who made a ſeries of experiments on the decompoſition of ammoniacal ſalts by metallic matters and their oxides, obſerves, that a good deal of inflammable gas is diſengaged by the reaction of tin on ammoniacal muriate. According to the experiments of that ſkilful chemiſt, metals decompoſe this ſalt in conſequence of the muriatic acid acting upon them. As we have ſeen that the muriatic acid has a very conſiderable affinity with tin, we may conclude Bucquet's theory to be ſatisfactory and conſiſtent with facts. Glauber gave out, that his ſecret ammoniacal ſalt, or ammoniacal ſulphate, was decompoſed by tin; but according to Pott, who repeated Glauber's experiment, the decompoſition is not complete, doubtleſs becauſe the ſulphuric has not ſo ſtrong a tendency as the muriatic acid to combine with tin. Bucquet likewiſe obſerves, that as tin is very fuſible, it gathers into a button at the bottom of the retort; and that the ammoniacal muriate of conſequence is not ſo completely decompoſed by the metal as it might otherwiſe be. This is the reaſon why tin does not decompoſe this ſalt ſo completely as the leſs fuſible metals. The reſidue of this decompoſition is ſolid muriate of tin, decompoſable by water, and reſembling that formed by corroſive muriate of mercury with this metal; of which we will hereafter ſpeak.

Tin may be eaſily combined with ſulphur by caſting one or two parts of this combuſtible matter in powder upon five or ſix parts of tin melted in an iron ladle: this mixture, being ſtirred with an iron ſpatula, becomes black and kindles. When melted in a crucible, it forms a brittle maſs in flat bundled needles. This compoſition is much more difficult to melt than tin; and in the ſame manner all ſoft fuſible metals are leſs eaſily melted when mixed with ſulphur than when pure. But it is worthy of our notice, that though tin may be alloyed with ſulphur, yet this mixture is never found in nature. With zinc the caſe is directly oppoſite; for though in nature it be often found combined with ſulphur, yet in the laboratory we find it exceedingly difficult to effect ſuch an union. Nature often differs greatly in her operations from art: but if ſhe ſometimes effect combinations which art cannot imitate, art alſo forms combinations of which nature diſplays no pattern.

Arſenic ſcarce unites with tin by fuſion; being moſtly diſſipated by volatilization on ſuch an occaſion. Arſeniate of potaſh combines better with this metal; and M. Baumé has obſerved, that in this combination a part of the acid of arſenic forſakes the alkali, in order to unite with the tin, to which it yields a part of its oxigene, and the reſult is a brittle and very brilliant button with facets like antimony. Margraf's experiments on the union of tin with oxide of arſenic by diſtillation, ſhow, that a part of that oxide is reduced to arſenic, while, again, ſo much of the tin is oxidated: that when tin is once united with arſenic, it cannot be again ſeparated from it even by the moſt violent action of fire; and that tin probably retains always a certain portion of arſenic, which

which may render it dangerous in kitchen uſes. By diſtilling oxide of tin impregnated with arſenic, Margraf obtained a liquor of a phoſphoric ſmell. Meſſrs Bayen and Charlard have ſince examined the combination of arſenic with tin. They have obſerved, that the oxide of arſenic, ſimply called *white arſenic*, cannot combine with tin unleſs it be reduced to the metallic ſtate; and that the combination may be much better effected by a direct combination of *regulus* of arſenic with tin. If you put into a retort three ounces ſix drachms of tin, with two drachms of *regulus* of arſenic in coarſe powder, and after fitting a receiver to the retort, make it red hot, nearly two grains of arſenic riſe into the neck of the retort, and a metallic button, four ounces in weight, is found in its bottom. This mixture, which contains one ſixteenth of arſenic, is cryſtallized in large facets like biſmuth. It is more brittle than zinc, and more difficult to melt than tin. It becomes ſoft at firſt; and if it be touched while in this ſtate with an iron rod, a ſound is heard, produced by the friction of the plates againſt one another. It melts into a clammy paſte; and the arſenic goes then gradually off in a ſmoke.

Cobalt unites with tin by fuſion, forming a mixture with fine grains cloſely united, and of a light violet colour.

Tin and biſmuth form, according to Gellert, a brittle mixture with cubic facets. Workers in tin ſometimes mix it with biſmuth to render it white and hard. As it renders it much harder, and is dearer than zinc, which produces the ſame effects on tin, the workmen employ it only in the proportion of a pound, or a pound and an half of biſmuth to the hundred weight of tin: and we have nothing from its effect on the animal œconomy; effects which the ſtrong analogy between lead and biſmuth in all their properties might move us to fear, as likely to be no leſs fatal than thoſe of that metal. Biſmuth may be ſeparated from tin with the help of the muriatic acid; which diſſolves the tin, leaving the biſmuth ſeparate in the form of a white powder, provided the weak muriatic acid be employed. The nitro-muriatic acid, when diluted in water, produces the ſame effects.

Antimony combined with tin forms, according to Gellert, a very brittle white metal; the ſpecific gravity of which is leſs than that of the two metallic ſubſtances taken ſeparately.

Zinc is eaſily combined with tin; and the reſult is a hard metal with ſmall grains cloſely united; and the more ductile in proportion as the quantity of the tin is greater.

Cronſtedt aſſerts, that nickel combined with tin forms a white brilliant maſs; which, when calcined under a muffle, aſcends in the form of a vegetating ſubſtance.

Mercury diſſolves tin in any proportion with the greateſt facility. This combination is effected by pouring hot mercury into melted tin. The ſolidity of the amalgam thus produced varies with the proportions of the two metallic ſubſtances. Formerly there was an amalgam compoſed of four parts of tin and one of mercury, and run into balls, which, when they cooled, became ſolid. Thoſe balls were ſuſpended in water to purify it. The water was at the ſame time boiled; and the precipitation of the extraneous matter which altered it was entirely owing to ebullition. This amalgam of tin is ſuſceptible of cryſtallization. It forms little ſquare cryſtals, as M. Daubenton has obſerved of the amalgam of tin, which he uſed for ſtopping the mouths of veſſels containing preparations in the King's garden. Sage ſays, theſe cryſtals are grey and ſparkling, in foliated plates, thinner

thinner at the edges than in the middle, and the interſtices among them polygon figures.

Tin having a greater affinity than mercury with oxigene, decompoſes corroſive mercurial muriate. To effect this decompoſition, the tin is firſt divided by means of a little mercury: equal parts of this amalgam and corroſive mercurial muriate are then triturated together; and the mixture is diſtilled in a glaſs retort by a very moderate heat. There paſſes firſt into the receiver a colourleſs liquor; ſoon after this is followed by thick white vapour, which is forced up with a ſort of exploſion, and covers the ſides of the receiver with a very thin layer. This vapour is condenſed into a thick, white, and very copious ſmoke, known by the name of *Libavius's fuming liquor.* It is a combination of the muriatic acid with tin, in which the acid appears to become ſuperſaturated with oxigene. This liquor, when incloſed in a phial, does not diffuſe any viſible vapour. There is, however, a certain quantity diſengaged from it, which depoſites oxide of tin in needle cryſtals on the upper part of the phial; ſo that in a few months the lower end of the neck is entirely cloſed up. A little of this oxide is likewiſe precipitated to the bottom of the liquor in unequal leaves. Its ſmell is very pungent, and makes a perſon ſneeze. Its vapours are not viſible except when in contact with the air. They ſeem to conſiſt of a gas of a peculiar nature, which is decompoſable by air; and on coming into contact with air yields a precipitate of oxide of tin, in the ſame manner as the fluoric acid gas affords, on coming into contact with water, a precipitate of ſileceous earth, and as ſulphurated hydrogenous gas depoſites ſulphur when expoſed to the contact of air. Can this be a combination of oxigenated muriatic acid gas with oxide of tin?

Water

Water does not produce any diſcernible precipitate in *Libavius's fuming liquor:* but it appears to operate upon it a decompoſition which has not yet been properly examined. When a quantity of this liquor, newly prepared, is poured into diſtilled water, it produces a kind of hiſſing like that which the ſulphuric acid, highly concentrated, produces when mixed with water. It appears to ſeparate into a great many ſmall particles, which are tranſparent and irregular, and ſeem to have no adheſion to the water. On a near obſervation of what paſſes when this mixture is made, bubbles are perceived riſing from theſe particles to the ſurface of the water, where they are reduced to vapour, which is rendered white by the contact of air. When the water is ſtirred thoſe particles are quickly diſſolved; and the ſolution ceaſes to exhale vapour. Macquer affirms, that when this fuming liquor is diluted in a large quantity of water, it precipitates an oxide in light white flakes.

The gas of the fuming liquor is ſcarce elaſtic. It never puſhes out the ſtopper of the phial in which it is confined; as the nitric and the muriatic acids, ammoniac, and æther, &c. do.

M. Adet, who has read to the Academy a memoir on the *fuming liquor of Libavius*, has obſerved, 1. That the effervescence which takes place whenever it is mixed with water, depends on the diſengagement of an elaſtic fluid poſſeſſing all the properties of azotic gas: 2. That the fuming liquor, combined with water in the proportion of 7 to 22, forms a ſolid body which is melted by heat and congealed by cold, and appears to be ſubject to the ſame laws as oxigenated muriate of tin, or butter of tin. From his ſeveral experiments he concludes the fuming liquor to be nothing but a compound of muriatic acid in the æriform ſtate, with oxide of tin having an exceſs of oxigene. This ſalt, he thinks, bears the ſame relation to common muriate of tin which oxigenated muriate of mercury bears to common muriate of mercury, or *mercurius dulcis.*

The reſidue which remains after the diſtillation of the *fuming liquor of Libavius* exhibits as many intereſting phænomena as the liquor itſelf. The upper part and the neck of the retort are coated with a thin white or grey cruſt; which, according to the experiments of Rouelle the younger, contains a little of the *fuming liquor*, concrete muriate of tin, or corneous tin, mild mercurial muriate, and running mercury. The bottom of the veſſel diſplays an amalgam of mercury and tin, above which there is a little *corneous tin* of a grey white colour, ſolid and compact, and ſuſceptible of volatilization by a ſtronger heat. If this ſubſtance be put into a retort it melts, and divides into two ſtrata; the inferior ſtratum black, and the ſuperior white, and like the former, *corneous tin.* Rouelle appears to ſuſpect, that theſe two ſubſtances, thus different from each other and refuſing to mix, are owing to an alloy contained in the tin. According to that ingenious chemiſt, the more this metal is alloyed, the leſs *fuming liquor* does it afford. Solid muriate of tin attracts the moiſture of the atmoſphere, and is very readily diſſolved in water. M. Baumé has advanced a theory concerning the combination of tin with the muriatic acid, which is nearly the ſame with what Scheele and Bergman have advanced concerning what they call *dephlogiſticated marine acid.* He thinks that in this operation the acid loſes its *phlogiſton*, as thoſe chemiſts thought it did when diſtilled on oxide of manganeſe. He imagines that this acid might be obtained perfectly pure by a diſtillation of the *fuming liquor of Libavius*; from which it appears, that he conſiders the common muriatic acid as ſuperſaturated with *phlogiſton*. M. Baumé was therefore prior to Scheele in the diſcovery of the two ſtates of the muriatic acid; but he has not deſcribed the ſingular properties which that acid poſſeſſes when oxigenated, as has been done by the celebrated Swediſh chemiſt.

The uſes of tin are very many. It is employed in a great number of the arts. It is uſed for lining a great many veſſels, for organ pipes, for decorations, &c. An amalgam of tin is employed for ſilvering glaſſes. Copperſmiths tin copper by running a mixture of tin and lead upon it: A mixture of tin with copper is uſed for bells and ſtatues of bronze. Tin workers mix it with biſmuth, antimony, lead, and copper for utenſils of all kinds; which are very liable to alteration by the action of air. Tin putty is uſed in poliſhing hard bodies. It is melted with oxide of lead and ſand for enamel, as well as for glazing earthen ware, &c. Cryſtallized muriate of tin is uſed in printing cloth; a ſolution of this ſalt in *aqua regia*, or the nitro-muriatic acid, improves the dye of cochineal, gum lac, &c. ſo as to convert it to a lively fire colour. Dyers uſe this ſolution, calling it *a compoſition* for dyeing ſcarlet. When mixed on a bath with the above mentioned dyeing ſtuffs, it produces a precipitate which carries off the colouring particles, and fixes them on the cloth. We owe this obſervation to Macquer, whoſe labours have been very beneficial to the art of dyeing.

Some chemiſts have conſidered tin as very dangerous when uſed for kitchen utenſils. Navier, in his work on counterpoiſons, &c. relates, that a number of perſons have been poiſoned by *ragouts*, in which tin-ſpoons had been ſuffered to ſtand for a while, and by ſugar kept in tin canniſters. Theſe unhappy effects are uſually aſcribed to the arſenic, which Geoffroy in 1738 aſſerted that he had found to exiſt in tin, and which Margraf thought he found in the pureſt tins, and in no inconſiderable quantity.

But the fears thus excited have been diſpelled by the experiments of Meſſrs Bayen and Charlard, of which we have already had occaſion to take notice in the hiſtory of this metal. Thoſe chemiſts have proved by the moſt deciſive experiments, 1. That the arſenic obtained by Margraf from the tin of Morlaix, amounting to nearly ſix and thirty grains to an half ounce of tin, would have been much more than ſufficient to deſtroy the known ſoftneſs and flexibility of the metal, and render it as brittle as zinc. 2. That the tins of Banca and Malacca contain not a particle of that dangerous ſemi-metal. 3. That large blocks of Engliſh tin, when expoſed to the action of the muriatic acid, afford a ſmall quantity of a blackiſh powder, which is generally mixed with copper and arſenic; the arſenic, however, never amounting to more than three-fourths of a grain to the ounce of tin, and being often under that proportion. 4. That this ſmall proportion of arſenic is rendered ſtill leſs by the tin workers, who uſually mix Engliſh tin with the purer tins of Malacca or Banca. 5. That arſenic by combination with tin loſes a part of its properties and of its corroſive powers. 6. Laſtly, That the very ſmall quantity of alloyed tin which enters into the aliments prepared in tin-veſſels, cannot poſſibly have any influence on the animal œconomy; for, from the moſt accurate calculation of the loſs ſuffered by a tin-plate in two year's wear, it was fouud to have loſt not more than three grains a month; and of conſequence $\frac{1}{5700}$ of a grain of arſenic a day, ſuppoſing the

tin

tin work of Paris to contain as much of that poiſonous ſemi-metal as the tin-plate of London manufacture, on which M. Bayen made this obſervation.

We may obſerve, that if the chemiſts of Paris do not quite agree with Margraf, the difference may be occaſioned by the difference between the Saxon tin on which his experiments were made, and the Indian and Engliſh tins which they have examined.

Farther, many phyſicians who had ſtudied the medical powers of metallic matters had before pronounced tin perfectly harmleſs, and had even recommended the giving it in filings for diſorders affecting the liver, or the matrix, and for worms. Schulz, in his diſſertation on the uſe of metal veſſels in preparing aliments and medicines, thinks tin, when very pure, to be very ſafe. La Poterie uſes oxide of tin in preparing a medicine which he calls *anti-hectic*, and which is nothing but a lixivium of oxide of antimony and oxide of tin formed by the detonation of nitre.

Tin has been recommended as a vermifuge. At Edinburgh large dozes of it have been adminiſtered without ſucceſs. Some country people are in uſe to leave ſweet wine ſtanding for four and twenty hours in a tin veſſel, and to give that liquor by glaſſes to their children for the worms. Navier ſaw a girl of the age of fifteen or ſixteen diſcharge by ſtool fifteen or ſixteen large worms in a few hours after drinking a preparation of this kind. This medicine acts, therefore, as a violent purgative.

CHAP. XII.

Of Lead.

LEAD is an imperfect metal of a dark white colour, inclining ſomewhat to blue. The alchemiſts gave it the name of *Saturn*, becauſe, as we will afterwards ſee, it abſorbs and devours, ſo to ſpeak, all other imperfect metals in its ſcorification. It is the leaſt ductile, the leaſt ſonorous, and the leaſt elaſtic of all metals. It may be hammered into thin plates: it is rendered very little harder by this operation. There is no metallic matter leſs tenacious than lead, a leaden thread $\frac{1}{10}$ of an inch in diameter cannot ſuſtain more than 29$\frac{1}{4}$ pounds weight without breaking. In gravity it is the third metallic ſubſtance. A cubic foot of lead weighs 828 pounds: in water it loſes between $\frac{1}{11}$ and $\frac{1}{12}$ part of its weight: it is ſo very ſoft that it may be eaſily cut with a knife. It has a very diſcernible peculiar ſmell, which becomes ſtill more diſcernible when it is rubbed: its taſte is ſcarce ſenſible to the palate, but irritates the nerves of the ſtomach and the inteſtines, ſo as to produce, firſt pains and convulſions, and at length ſtupor and palſy. It may be cauſed to aſſume a regular form. The Abbé Mongez obtained it in quadrangular pyramids lying on their ſides in ſuch a form that one of the four ſides was always much larger than the other three. Each pyramid conſiſts of ſtrata, or zones of other ſmaller pyramids, terminating generally in one common acute pyramid.

Lead is ſcarce ever found pure in the earth. Wallerius and Linnæus admit its exiſtence in that ſtate; which is denied, however, by Meſſrs Cronſtedt, Juſti, Monnet, &c. It is moſt commonly in an earthy, ſaline ſtate, or mixed with ſulphur, ſo as to form what is called *Galena.* Lead mines are generally at a great depth under ground; and are ſituated either in hills or in plains. Naturaliſts have diſtinguiſhed a great many ſpecies of lead ore. The following are thoſe moſt worthy of notice.

1. Native oxide of lead. This muſt not be confounded with *ſparry lead* which contains carbonic acid. This oxide does not effervеſce with the nitric acid. It is uſually in white or grey ponderous ſolid maſſes, perhaps mixed with clay, ſand, and chalk. The colour of the clay, according as it is more or leſs ferruginous, gains it the name of native *maſſicot*, or *minium*, or yellow and red oxide. Native ceruſe of lead is often met with on the ſurface of galenas.

2. Carbonate of lead, or oxide of lead combined with the carbonic acid. This ore varies greatly in colour: it is either white, black, brown, yellow, or green, according to the ſtate of the iron by which it is altered. It bears the general name of *ſparry lead*, its contexture and cryſtallization being the ſame with thoſe of certain ſpars. It effervеſces with the nitric acid, which

diſengages the carbonic acid it contains. This ſpecies is diſtinguiſhed into the following varieties.

Varieties.

A. *White ſparry lead.* This is carbonate of lead ſlowly depoſited in cryſtals by waters. This lead is ſometimes ſemi-tranſparent like ſpar. Its cryſtals are uſually truncated hexahædral priſms, or ſtriated cylindric columns, which appear to conſiſt of a great number of filaments, or very ſlender ſmall needles. Some ſpecimens of this kind of lead are of a ſparkling white colour like *ſilky gypſum.* There are others of a yellowiſh white colour. There are generally ſome of theſe priſms fiſtulous. White ſparry lead is very plenteous in Low Brittany in the mines of Huelgoet and Poullaouen. M. Sage gave out, that white lead was mineralized by the muriatic acid. M. Laborié has affirmed it to be only a pure oxide of lead combined with fixed air, or carbonic acid, and mineralized by water. The Academy of Sciences at Paris having cauſed the experiments of both theſe chemiſts to be repeated, have adopted the opinion of M. Laborié; and Macquer has given it in his dictionary under the article *lead ores.* Sparry lead is always found in the ſame places with galena; and appears to be nothing but galena that has loſt its ſulphur, and of which the lead has been oxidated; for it is not uncommon to find galena beginning to paſs into the ſtate of white lead; as has been very well obſerved by M. Romé de Liſle.

B. Some naturaliſts admit the exiſtence of black lead; that is, white lead altered by a ſulphureous

reous

Varieties.

reous vapour, and reduced to the metallic ſtate: it may be conſidered as poſſeſſing a kind of middle nature between white lead and galena. It is cryſtallized in irregular maſſes.

C. Green ſparry lead. This mineral is more or leſs of a tranſparent green, moſt frequently yellowiſh, and always mixed with ochre and earthy iron. Sometimes it has no regular form, but reſembles a kind of moſs. Of this kind are moſt of the ſpecimens from Hoffsgrund, near Friburgh, in Briſgaw. Green lead is commonly cryſtallized in hexahædral priſms, either truncated, or terminating in hexahædral pyramids entire, or truncated near the baſe. A good deal of it is found at Sainte-Marie-aux-Mines, and at Tſchoppau in Saxony. It has been proved that lead owes its green colour to a mixture of iron, as iron is always found in the ores of this metal.

D. Reddiſh ſparry lead of the colour of peach flowers. M. Mongez has found this variety cryſtallized like white ſparry lead in the mines of Huelgoet.

E. Yellow ſparry lead. This variety, which is cryſtallized in tranſparent hexahædral plates, has been known only for theſe few years: the plates are from half a line to four or five lines in diameter: they reſemble glaſs of lead.

3. M. Monnet has diſcovered among lead ores ſome of the metal combined with the ſulphuric acid. It is commonly in a white maſs, ſoluble in eighteen parts of water: it is ſometimes blackiſh and cryſtallized in very long ſtriæ, or friable ſtalactites. This laſt variety effloreſces

floreſces in the air, and changes into a real ſulphate of lead. On account of this property, M. Monnet calls it *pyritous ore of lead.* Dr Withering ſays, there is in the iſle of Angleſey a great quantity of lead and iron mineralized together by the ſulphuric acid.

4. Lead ore appears to be combined with the arſenic acid in the red lead ore of Siberia; which was firſt deſcribed by M. Lehman in the year 1766. This ore is of a very fine red colour, and its duſt reſembles carmine powder. It is often cryſtallized in rhomboidal tetrahædral priſms, which are ſhort and obliquely truncated. M. Mongez, who thinks arſenic to be in the ſtate of acid in all red ores, has diſcovered another ore of a greeniſh yellow colour, which comes from Siberia, and like the laſt mentioned contains arſenic.

5. M. Gahn has recognized the exiſtence of the phoſphoric acid in a greeniſh lead ore: this ore is ſometimes, too, yellow and reddiſh; and on diſſolving it in the nitric acid, and precipitating the oxide of lead by the ſulphuric acid, the phoſphoric acid is obtained by evaporating the ſupernatant liquor. Meſſrs la Metherie and Tenant at Paris have confirmed Gahn's analyſis. M. de Laumont has written a memoir on native phoſphate of lead, which is very plenteous in Brittany.

6. Lead is ofteneſt found in combination with ſulphur: This ore bears the name of *galena;* in commerce it is alſo called *alquifoux.* This ſulphure of lead generally conſiſts of plates having nearly the colour and aſpect of lead; but more brilliant and very brittle. There are a great many diſtinct varieties of galena; namely:

Varieties.

A. Cubic Galena. Its cubes are of various ſizes, and either inſulated or in groupes. It is often found with truncated angles. It is common at Freyberg.

B. Maſſy Galena. This is in maſſes without any regular configuration. It abounds at Sainte Marie.

C. Galena with large facets. It appears not to form regular cryſtals, but is entirely compoſed of large plates.

D. Galena with ſmall facets. This galena appears to conſiſt like mica of ſmall and very bright white ſcales. It is called *white ſilver ore*, on account of its containing a large proportion of that metal. Of this kind is the galena of the mines of Pompéan in Brittany.

E. Galena with ſmall grains, ſo called becauſe its grains are very cloſe: this ore is likewiſe very rich in ſilver, and is found along with the laſt mentioned ore. Galenas in general contain ſilver: We know of none which does not contain ſilver but the galena of Carinthia. But it has been obſerved, that the galena with the ſmalleſt facets and cloſeſt grains affords moſt ſilver. It would appear, that ſilver being in ſome manner unfit for entering into the combination of galena, of conſequence deranges the regularity of its cryſtallization when it happens to enter into it.

F. Galena cryſtallized like ſparry lead in hexagonal priſms, or cylindric columns. It is found, as well as the laſt mentioned ore, in the mines of Huelgoet in Low Brittany. It is not rich in ſilver,

Varieties.

ſilver, and appears to be only ſpathoſe lead mineralized without having loſt its form. In fact we ſometimes obſerve in the ſame piece cryſtals of pure ſparry lead entirely covered with very fine galena, and others entirely changed into galena through the anterior parts of the priſms. M Romé de Liſle is in poſſeſſion of a number of ſuch ſpecimens. I have in my own cabinet a ſpecimen of white lead ore, the baſe of whoſe priſms is abſolutely in the ſtate of galena, and which diſplays the change of which I am ſpeaking.

Galena is generally found between two borders of blackiſh ochraceous quartz containing a good deal of ſilver, though that metal be not at the firſt obſervable. M. de Dolomieu, to whom we owe the obſervation of this fact, conjectures, that the lead might be at firſt mixed with this ſilver; and that the water carrying off the imperfect metal left the finer metal in the gangue. M. Monnet has diſcovered, that many galenas effloreſce like pyrites. He tells us, that he obtained true ſulphate of lead by waſhing one of thoſe ores, the ſurface of which was white, and bore the appearance of an efflореſcence.

7. Lead is ſometimes combined in nature with ſulphur, antimony, and ſilver. This ore is called *antimoniated galena*, and is of a needled ſtriated ſtructure like antimony: the preſence of the ſemi-metal is known by the aſcenſion of a white ſublimate when the ore is calcined. It is found at Salberg and Sainte-Marie-aux-Mines.

8. There is another ſort of galena, in which the lead is combined with ſulphur, ſilver, and iron. This martial

tial galena is harder and more ſolid than any of the foregoing. When ſcorified it affords yellow lead.

9. Laſtly, Lead is often met with in oxide and galena mixed in ſandy or calcareous earths and ſtones.

As almoſt all lead ores, and eſpecially galenas, contain a conſiderable proportion of ſilver, it requires to be carefully aſſayed. For this purpoſe, after pounding and waſhing a certain quantity of the ore, it is carefully put in a pot, which muſt be covered to prevent it from flying out. Galena ſuffers little loſs by roaſting. After having undergone this operation, it is weighed and melted with three times its own weight of black flux, and a little decrepitated marine ſalt. The fixed alkali of the black flux abſorbs the ſulphur from the lead: the coal of tartar, which is another part of the ſame flux, ſerves to reduce the metal from the ſtate of oxide, and the marine ſalt prevents the evaporation of a part of the metal contained in the crucible. After the melting, a button of lead is found in the crucible, and muſt be carefully weighed. The metallic button is in the next place *calcined*, and vitrified on a cupel, to ſeparate the ſilver which it contains. The reſult of this aſſay is not entirely to be truſted to; for the alkali uſed as a flux forms with the ſulphur of the galena *liver of ſulphur*, or ſulphure, which diſſolves a portion of the lead. Beſides, black flux is too expenſive a reductive matter to be uſed in labours of this kind in the great way. It may therefore be proper to attempt the fuſion of this ore on coals, in a reverberating furnace, either by itſelf, or with an addition of ſome cheap matters, ſuch as iron and glaſs-gall, in a ſmall proportion, to abſorb the ſulphur.

Bergman propoſes the uſe of the nitric acid for aſſaying lead ores. That acid diſſolves lead and oxide of iron, but produces no effect on ſulphur. The ſolution is precipitated by carbonate of ſoda; and 132 grains of this precipitate are equal to 100 grains of lead in a metallic ſtate. When the ore happens to contain ſilver; the oxide of ſilver is ſeparated by ammoniac, which has the power of diſſolving it.

At Pompéan, in working lead ore containing ſilver; after pounding it, and waſhing it with great care on tables, they carry it to the furnace, where they firſt roaſt it with a moderate heat, and afterwards melt it by increaſing the fire. The melted lead is taken out of the furnace by a hole, which correſponds to one ſide of the hearth, and is ſtopped with clay during the operation. The lead is moulded into pigs; and now acquires the name of *wrought lead.* It contains ſilver. To ſeparate the ſilver, the wrought lead is put into another furnace, the hearth of which is covered with aſhes that have been lixiviated, ſifted, and preſſed down upon it. On one ſide of the hearth of this furnace there are two large bellows, and oppoſite to them two gutters, called *the paſſages of the litharge.* When the furnace becomes hot, the lead is oxidated; a part of it is evaporated and ſublimated in ſmall chimnies over the paſſages of the litharge: another portion of the metal is abſorbed by the floor of the furnace; a third, and that the moſt conſiderable portion, is oxidated and partly vitrified; and this laſt portion receives the name of *litharge.* It is blown out of the furnace with the bellows; the action of which likewiſe contributes to the oxidation and vitrification of the lead, by pouring a copious ſtream of air on the metal when in fuſion. When litharge has been calcined by a moderate fire, it is in a red ſcaly powder; it is then called *merchant's litharge,* becauſe it is ſold in this ſtate, or *golden litharge;*

tharge, on account of its colour. If it has been expoſed to a ſtronger heat, it is then nearer a ſtate of vitrification, and of a pale colour: and it now bears the name of *ſilver litharge*. Laſtly, If the furnace be made very hot, the litharge is more completely melted, and runs into the form of irregular ſtalactites; it is now called *freſh litharge*. When the operation is finiſhed, the ſilver which was contained in the lead remains in the former. This ſilver muſt be refined in ſmall pieces, in order that it may throw off the lead which ſtill remains among its particles.

Lead, after being oxidated in the refining, is again melted on coals, after which it contains but a very few particles of ſilver. It is now run into pigs and ſold in this form. Sparry lead is melted among coals in the ſame way as the oxides.

When lead is expoſed to fire, it melts long before becoming red hot. The heat requiſite to maintain it in fuſion is ſo ſlight, that a perſon may put his hand into melted lead without feeling any pain; and in that ſtate it does not burn vegetable ſubſtances. It is ſcarce volatile; yet a very ſtrong heat *will* volatilize it; and it then gives out ſmoke, and is reduced to vapour like the more fixed metals. If it be left to cool very ſlowly when melted; and if after a part becomes ſolid, what ſtill remains fluid be decanted off; the ſolid part is found cryſtallized in quadrangular pyramids, the form of which we have already deſcribed.

Lead expoſed to the contact of air while it melts, is covered with a grey duſky pellicle. This pellicle is carefully taken off, and reduced by agitation into a greeniſh grey powder, inclining to yellow. When this oxide is ſeparated by a ſieve from the grains of lead which are ſtill intermixed with it, and again expoſed to a more intenſe heat ſufficient to make it red hot, it aſſumes

aſſumes a deep yellow colour. In this ſtate it is called *maſſicot*. *Maſſicot*, ſlowly heated by a moderate fire, takes a beautiful red colour, and obtains the name of *minium*. If expoſed to a ſtrong heat, *maſſicot* melts into a glaſs, and does not afford any minium.

Lead, by being oxidated, gains an increaſe of weight nearly in the proportion of ten pounds to the hundred weight. This increaſe of weight which lead gains when reduced to oxide, and the circumſtance of air's being neceſſary to this operation, led John Rey, a phyſician at Perigord, to conjecture, that air became fixed in this metal when it was *calcined*. Dr Prieſtley has confirmed John Rey's opinion by extracting vital air from minium. Oxide of lead, though very high coloured, may be entirely diveſted of its colour. Minium, if rather too much heated, becomes pale: when urged with fire, without having any other ſubſtance intermixed, it melts into a tranſparent glaſs, ſo fuſible as to penetrate and make its way through all crucibles, notwithſtanding whatever can be done to retain it. But a mixture of one part of ſand with three parts of oxide of lead melts into a beautiful amber-coloured glaſs, the oxide contributing to the fuſion of the ſand. The tincture of that glaſs is fainter, and reſembles the colour of topaz, when two parts of oxide of lead and one of ſand or pulverized flint are melted together. A ſmaller quantity of oxide of lead added to common glaſs does not alter its tranſparency, but increaſes its ſpecific gravity, and gives it a kind of unctuouſneſs, which renders it eaſier to be cut and poliſhed without breaking. This glaſs is the moſt proper for making achromatic lenſes, but is very liable to be ſtriated, and gelatinous in its appearance. The Engliſh call it *flint glaſs*. Our merchants have no ſmall difficulty to find any large pieces

pieces without ſtriæ in that which they import from England. This, which is a very conſiderable inconvenience, ariſes, as Macquer thinks, from the circumſtance of the principles of the glaſs not combining uniformly together. To make them combine uniformly, it would be neceſſary to keep them long in fuſion; but as the lead is volatilized, flint-glaſs then loſes part of its denſity, as well as that unctuouſneſs which conſtitutes its peculiar value.

Although all the phænomena which attend the oxidation and vitrification of lead, ſhow that it combines with the greateſt facility, and in a very rapid manner with the baſe of pure air, or oxigene; yet it is among thoſe metallic matters which have the leaſt tendency to remain in combination with the oxigenous principle; for, as has been proved by Dr Prieſtley, it may be ſeparated from it by the action of fire only. When minium is expoſed to an intenſe heat in a retort, vital air is obtained from it, and a part of it is reduced to lead. All the oxides, and even glaſſes of lead, are eaſily decompoſable by combuſtible matters: all that is neceſſary for this purpoſe is to mix them with charcoal, tallow, oils, reſin, or in ſhort any inflammable vegetable or animal ſubſtance; and to heat them till they afford a button of lead. This metal has therefore a weaker affinity than moſt other metallic ſubſtances with oxigene; and if it agrees with tin in ſome properties, in its oxidation and reduction it is ſubject to very different laws. Theſe phænomena afford a new proof in favour of what we have advanced as one of the laws of the affinity of compoſition; namely, that we are not to judge of the affinity ſubſiſting between any two bodies by the facility with which they combine, but rather by the obſtinacy with which they adhere together.

All the oxides of lead, and more eſpecially minium, abſorb a certain quantity of carbonic acid when expoſed to the air. And in order therefore to preſerve oxide of lead pure, it muſt be kept from the contact of air; or the carbonic acid, which it has abſorbed from the air, may be ſeparated by heating it before it be applied to any uſe.

Lead, when expoſed to the air, is tarniſhed; and the more moiſt the air, the ſooner does it produce this effect on the metal. A white duſt is formed, and gradually carried off by the water; that white duſt is not pure oxide of lead, but oxide of lead combined with carbonic acid abſorbed from the atmoſphere. The ſilver which is extracted from old lead that has been long expoſed to the air, is produced in conſequence of the lead not having been refined when it was firſt employed, and being in part oxidated by the action of the air of the atmoſphere. The ſilver not having been ſeparated from it at the firſt, has remained unaltered, and has even gradually increaſed in quantity as the imperfect metal has been deſtroyed by time.

Lead ſuffers no alteration from pure water; the metal does not ſeparate the component principles of the fluid; yet the ſides of leaden water-pipes are covered over with a whitiſh cruſt, or a kind of *ceruſe*, the production of which is owing, no doubt, to the action of the various matters contained in the water upon the metallic ſubſtance. M. Luzuriaga ſays, that on ſhaking lead in grains, in a little water, in contact with air, the metal is ſpeedily reduced to an oxide.

We know nothing of the action of ſalino-terreous ſubſtances and cauſtic alkalis on lead or its oxides.

This

This metal is ſoluble in all the acids. The concentrated ſulphuric acid acts upon it only when boiling; and it is likewiſe requiſite that the lead be in thin plates. Sulphureous gas eſcapes during the re-action of the metal and the acid. When the acid is moſtly decompoſed, the mixture becomes white and dry; when waſhed with diſtilled water it ſeparates into two portions. The moſt conſiderable of the two is inſoluble in water: it conſiſts of oxide of lead formed by the oxigene that the metal attracts from the ſulphuric acid, which has at the ſame time given out a good deal of ſulphureous gas. This oxide may be melted or reduced in the ſame way as that produced by the joint action of fire and air. The other portion, diſſolved by the water, is a combination of the ſulphuric acid with oxide of lead: this ſolution affords, when evaporated, ſmall needles of ſulphate of lead. M. Baumé and Bucquet have not deſcribed this ſalt as ſubſiſting in any other form but this. M. Monnet has ſometimes obtained it in ſhort priſmatic columns. M. Sage nearly agrees with M. Monnet, for he tells us, that ſulphate of lead affords cryſtals in tetrahædral priſms. This ſalt is very cauſtic, at leaſt 18 parts of water are requiſite to diſſolve it; it is decompoſed by fire, lime, or alkalis.

The nitric acid appears to act very ſtrongly on lead. When the acid is highly concentrated, and in no great quantity, the lead is ſpeedily reduced to a white oxide with the oxigene, which is diſengaged from the nitric acid at the ſame time when nitrous gas is diſengaged. But if the acid is weaker and in greater quantity, leſs of it is decompoſed, and there remains enough to diſſolve the oxide of lead. As the ſolution is effected, there is a grey powder precipitated, which M. Groſſe took for mercury; but M. Baumé affirms it to be oxide of lead. I have many times, but ſtill ineffectually, attempted to obtain mercury from it by ſublimation, as alſo by urging it with fire ſufficiently intenſe to reduce it to mercury if it were mercurial oxide. This ſolution gives no precipitate with water; by cooling, it affords cryſtals of a dead white colour, in a flat triangular form, with all their angles truncated. The ſame ſolution, ſubjected for ſeveral months to a ſlow evaporation, afforded cryſtals, the largeſt of which were about an inch in breadth, and their figure an hexahædral pyramid with three ſides, alternately ſmall and large, and its point truncated in ſuch a manner as to render it a ſolid octagon. Rouelle has given a good deſcription of this ſalt. Nitrate of lead decrepitates when expoſed to fire, and melts with a yellowiſh flame when laid on a burning coal; the oxide of lead, which is at firſt yellow, is very ſpeedily reduced to globules of lead. This ſalt is decompoſable by lime and alkalis. The ſulphuric acid, though it acts but very weakly on lead, has, however, a greater affinity than the nitric acid with the oxide of this metal. Pure ſulphuric acid, or even an earthy or alkaline ſulphate, poured into a nitric ſolution of lead, produces in a few moments a white precipitate. This precipitation takes place, becauſe the ſulphuric acid attracting the oxide of lead from the nitric acid, forms ſulphate of lead, not very ſoluble, and ſimilar to that which is prepared by an immediate combination of the ſulphuric acid with this metal.

The pure muriatic acid, with the affiſtance of heat, is capable of oxidating lead, and diſſolves a part of the oxide; but it is not eaſy to ſaturate it completely.

This ſolution contains always an exceſs of the acid: by a ſtrong evaporation, however, it affords fine, bright needled cryſtals, as has been obſerved by M. Monnet. Muriate of lead is ſomewhat, though but very little, liable to deliquiate. Lime and alkalis diſſolve this, as well as the foregoing ſalts. This metal may be more readily and more intimately combined with the muriatic acid, by pouring the acid either free or combined with an alkaline or earthy baſe into a ſolution of nitrate of lead: A white precipitate, much more copious than that formed by the ſulphuric acid, and reſembling a coagulum, is inſtantly produced. This precipitate is a combination of oxide of lead with the muriatic acid, which has ſeparated the metallic oxide from the nitric acid. This ſalt ſubſides to the bottom of the liquor, becauſe it is much leſs ſoluble in water than nitrate of lead. If expoſed to fire, it gives out vapours, and melts into a brown maſs, called *corneous lead*, on account of the reſemblance it bears to the ſilver which is diſtinguiſhed by the ſame epithet. It diſſolves well enough in thirty times its weight of boiling water. The ſolution of this ſalt when evaporated, cryſtallizes into ſmall ſlender brilliant needles bundled together, or joined at one end under an obtuſe angle. M. Sage ſays, this ſolution gives by very ſlow evaporation cryſtals in ſtriated hexahædral priſms. The ſolution of corneous lead is decompoſable by the ſulphuric acid, which cauſes it to yield, like the nitric ſolution of lead, a white precipitate. This diſcovery was made by Groſſe, and has been confirmed by M. Baumé, and all other chemiſts who have repeated the experiment. It contradicts the eighth column of Geoffroy's table, which repreſents lead as having a greater

affinity

affinity with the muriatic than with any of the other mineral acids.

All ſolutions of lead yield either black or brown precipitates when expoſed to the action of earthy or alkaline ſulphures; and the ſulphur then unites with the oxide of lead to form a ſort of galena: a circumſtance which ſeems to indicate, that the lead exiſts in this ore in the ſtate of oxide. In theſe operations there is a double decompoſition, though not a double elective attraction; for the alkaline baſe of the ſulphure is alone ſufficient to decompoſe ſulphate, nitrate, and muriate of lead.

All the oxides of lead are as eaſily decompoſed in acids as lead itſelf; nay, often eaſier than the metal. In theſe ſolutions minium loſes its colour. Lead does not act on ſulphuric neutral ſalts, nor does it decompoſe ſulphate of potaſh by heat, as tin, zinc, and antimony do.

Lead gives no ſenſible detonation with nitre. When the neutral ſalt is reduced to powder, and ſo caſt on the metal in a ſtate of fuſion and a little red, ſcarce any motion of the matters, and no diſcernible flame, follows. However, the lead is oxidated and vitrified by the alkali of the nitre, and is found after the operation in ſmall yellowiſh leaves like *litharge*.

Lead, with the help of heat, decompoſes ammoniacal muriate very readily. This property is common to it with many other metals. Any oxide of lead, triturated cold with this ſalt, makes it give out ammoniacal gas. But, when this mixture is heated in a retort, the decompoſition is very rapid. The ammoniac obtained, in conſequence, is very cauſtic and poignant. Some chemiſts have advanced, that volatile alkali extracted

tracted by *minium*, effervefces with acids, and have inferred that *minium* muſt therefore contain carbonic acid. Bucquet obſerved, that this effervefcence was often owing to a portion of the ammoniac gas volatilized by the heat produced by the combination of the alkali with the acid; and that it did not take place when the acids employed were concentrated. He made one ingenious and very deciſive experiment to determine this. Introducing into a bell-glaſs, over mercury, ammoniac obtained by *minium*, he conveyed into it a portion of ſulphuric acid pretty ſtrong, and ſufficient to ſaturate the alkalis. At the inſtant when the two ſubſtances were mixed, an ebullition was produced, and a quantity of gas diſengaged, and again rapidly abſorbed, which was nothing but ammoniac gas. However, ſince it is acknowledged that oxides of lead, and particularly red lead or *minium*, contain carbonic acid, in conſequence of having abſorbed it from the atmoſphere, it will be granted, that the ammoniac diſengaged by thoſe oxides muſt acquire a part of it. The maſs remaining in the retort, after the decompoſition of ſal ammoniac by *minium*, is muriate of lead, which melts by a moderate heat into corneous lead, and may be totally diſſolved in water. This is the melted maſs which Margraff made uſe of in compoſing phoſphorus of urine.

Hydrogenous gas alters lead in a very ſenſible manner; it colours its ſurface, and communicates to it changeable clouds, of the ſhades of the rainbow; it reduces oxide of lead. Minium, when brought into contact with this gas, becomes black, and takes the appearance of lead. Dr Prieſtley has obſerved, that a glaſs tube containing hydrogenous gas, and hermetically ſealed, on being expoſed for a number of days to the

heat

heat of a ſand-bath, becomes black within like ſoot, and a vacuum is at the ſame time formed, and drops of water are produced in the tube. This beautiful phænomenon is explained by conſidering that hydrogene has a greater affinity than lead with oxigene: a farther proof of which is, that this metal does not act at all upon water. Engliſh glaſs contains a good deal of oxide of lead: Hydrogenous gas, re-acting upon that oxide, gradually abſtracts from it the oxigene which it contains, and combines with it to form water, while the lead regains its metallic colour.

Sulphur eaſily unites with this metal. When theſe two ſubſtances are melted together, the product is a ſort of brittle mineral with facets, and of a deep grey ſparkling colour. Sulphure of lead is very like *galena*, and is much more difficult to melt than lead. This phænomenon is peculiar to the combinations of the metals with ſulphur. Very fuſible metals become difficult to melt when mixed with ſulphur; while again, ſuch metals as are difficult to melt, become very fuſible when united with this combuſtible matter.

We know nothing of the mixture of lead with arſenic. Neither nickel, manganeſe, cobalt, nor zinc, combines with this metal by fuſion. Antimony forms a brittle mixture with lead, with ſmall brilliant facets, in colour and contexture reſembling iron or ſteel, according to the proportions in which the principles of the mixture are combined together; the ſpecific gravity of this compound is greater than that of the two metallic ſubſtances taken ſeparately.

Lead unites with biſmuth, and forms by this combination a mixed metal of a fine cloſe grain, and very brittle. Mercury diſſolves lead with the greateſt facility.

cility. This amalgam is made up by pouring hot mercury into melted lead. It is white and ſparkling, and in a certain ſpace of time becomes ſolid: when triturated with amalgam of biſmuth, it becomes as fluid as running mercury. It is a circumſtance worthy of our notice, that this ſingular phænomenon takes place in the union of three metallic matters, which are very fuſible, very ponderous, and more or leſs volatile.

Lead combines readily with tin by fuſion. Two parts of lead and one of tin form a mixture more fuſible than either of the two metals ſeparate, and conſtitute the ſolder uſed by plumbers. Eight parts of biſmuth, five of lead, and three of tin, form a mixture which is ſo fuſible, that the heat of boiling water is ſufficient to melt it, as M. d'Arcet has diſcovered.

As a mixture of lead and tin is applied to many ordinary and domeſtic uſes; and as the firſt of theſe metals is capable of communicating ſome very noxious qualities to the utenſils formed of the ſecond, which are uſed in the kitchen and in the laboratory; it is of importance to know how to aſcertain the proportion of the lead in thoſe veſſels, for it is often above what the regulations of government allow. Meſſrs Bayen and Charlard have given a very good proceſs for determining what quantity of this dangerous metal may be contained in any given quantity of tin. It conſiſts in diſſolving two ounces of the tin in five ounces of very pure nitric acid, waſhing the oxide of tin thus obtained in four pounds of diſtilled water, and evaporating the water on a balneum-mariæ. This evaporation affords nitrate of lead, which muſt be calcined; and the reſidue is

weighed

weighed as the quantity of lead contianed in the two ounces of tin; allowing ſome grains for the additional weight which it muſt have acquired by oxidation, as well as for the other metallic ſubſtances, ſuch as zinc and copper, which may poſſibly be contained in the tin. Thoſe chemiſts thus aſcertained, that fine wrought tin contains about ten pounds of lead in the hundred weight; and that again, that which is ſold as common tin, contains generally twenty-five pounds of lead to the hundred weight. This is an enormous proportion of lead, and thoſe who uſe veſſels of common tin are certainly expoſed to no ſmall danger. It is almoſt continually met with in thoſe veſſels which are very much in common uſe; ſuch as meaſures for diſtributing fluids, particularly wine. It is eaſy to ſee, that a liquor which becomes ſo quickly ſour, muſt combine with the lead, and convey into the viſcera of the poor wretches compelled by neceſſity to drink it, the ſeeds of diſeaſe, which becomes the more afflictive and fatal becauſe its cauſe is often unknown. Pewterers have ſeveral ways of aſcertaining the fineneſs of tin and the quantity of the lead which it contains. Bare inſpection is often ſufficient to them; and when this is not ſufficient, the weight and the ſound of the metal are all that they require farther in order to judge of it. They have two methods of aſſaying. The one called *the aſſay by the ſtone,* is performed by running the melted tin into an hemiſpheric cavity, cut in a thunder-ſtone, and terminating in a gutter. The appearances which the tin exhibits as it cools, its colour, the roundneſs of its ſurface, the depreſſion of the middle part of its ſurface, the ſound which proceeds from that part of the metal contained in the gutter when twiſted backwards and forwards, are ſo many marks which the ſkilful workman carefully obſerves, and by which, from long habits of obſervation, he is enabled to determine exactly the quality of the metal under examination. However this be, the mode of aſſay employed by the Pariſian pewterers, does not appear to be ſo accurate as that uſed by the pewterers in the other parts of the kingdom. This ſecond eſſay is called the aſſay *by the ball*, or *by the medal;* becauſe it conſiſts in running the tin to be aſſayed in a mould which gives it the form either of a ball or of a flat maſs, in form like a medal. The weight of this moulded ſpecimen is then compared with a piece of fine tin, of equal bulk, run into the ſame mould. The more the tin examined exceeds in weight the ſpecimen of fine tin, the greater is the quantity of the lead with which it is alloyed. Meſſrs Bayen and Charlard, with good reaſon, prefer the latter of theſe modes of aſſaying, as its principles are ſurer and leſs liable to fallacy, than thoſe circumſtances on which the workman determines in the aſſay of the ſtone.

Lead is applied to a great many purpoſes. It enters into many mixtures; pipes for conveying water are formed of it. Its oxides are uſed in making glaſs and preparing enamels. It is uſed to imitate the colour of yellow precious ſtones, and to render fuſible the matters uſed for glazing earthen ware. Veſſels and other utenſils for many purpoſes in ordinary life are made of this metal, but the uſe of them is not without danger to the health. Water ſuffered to ſtand in leaden baſons or fountains, is liable to acquire noxious qualities from the lead. The vapour of this metal is dangerous to the workmen who melt it; and its duſt ſtill more ſo to thoſe who file or grate it down. This metal, by inſinuating itſelf into ſome corners of the ſtomach, and fixing there, occaſions the moſt painful colics, which are often

often attended with the vomiting of a green bile, and cauſe the belly to flatten, and contract the navel inwards. It has been obſerved, that antimonial emetics and purgatives are the happieſt medicines in ſuch caſes. Navier recommends various alkaline ſulphures for poiſoning by preparations of lead, as well as againſt the effects of arſenic and corroſive mercurial muriate. That phyſician praiſes alkaline ſulphure and ſulphureous waters, more eſpecially for their good effects in removing the palſy and tremulous motions, which uſually continue to effect patients after the painter's colic. The plain inference from theſe facts is, that we muſt ceaſe to employ preparations of lead internally, and make uſe of it only as an external medicine; and beſides, it ſhould not be uſed even externally but with all the precautions neceſſary when we employ a violent repercuſſive.

CHAP. XVIII.

Of Iron.

IRON, to which the alchemiſts gave the name of *Mars*, is an imperfect metal, of a livid white colour, inclining to grey, and diſpoſed in ſmall facets. It is ſuſceptible of a very fine poliſh, and may be made very brilliant. It is ſo hard and elaſtic as to be capable of deſtroying the aggregation of any other metal.

Iron emits a ſmell, eſpecially when it is rubbed or heated. It has likewiſe a very ſtrong ſtiptic taſte, which acts powerfully on the animal œconomy.

Iron is, next after tin, the lighteſt of all metallic ſubſtances. A cubic foot of forged iron weighs five hundred and forty-five pounds. It may be hammered into plates; but being very hard, and liable to become much harder under the hammer, it cannot be beat into leaves. Its ductility, when drawn into wire, is much more conſiderable: it is drawn into very fine threads, which are uſed as ſtrings to harpſichord keys. This property appears to depend on its tenacity. Iron is, in fact, the moſt tenacious of all metals next after gold. A thread of iron one-tenth of an inch in diameter is ſufficient to ſupport, without breaking, the weight of four hundred and fifty pounds.

Pure iron has a peculiar cryſtalline form. In furnaces in which iron has been ſlowly cooled, there are found quadrangular pyramids articulated and branched, and conſiſting of octohædrons inſerted one into another. We owe this obſervation to M. Grignon maſter of the forges at Bayard in Champagne. Laſtly, beſides all the properties which iron poſſeſſes in common with other metallic ſubſtances, this metal exhibits three properties which are entirely peculiar to itſelf. One of theſe is magnetiſm, or the property of being liable to be attracted by the loadſtone, and of acquiring the virtues of the loadſtone, either when it has remained long in an elevated ſituation, or in a direction between north and ſouth; or when it has been employed as a conductor to the electric fire of thunder, as is evinced by a variety of facts; or when two pieces of iron are ſmartly rubbed one upon another. The ſecond of the ſingular properties of iron is that of taking fire, and melting ſuddenly when ſtruck with a flint; a phænomenon to which the poets unanimouſly aſcribe the firſt diſcovery of fire. The third peculiar property by which it is diſtinguiſhed, is that of being found with manganeſe in plants and animals; the humours of animal bodies owe in part their colour to it: it is even probable that thoſe organic beings themſelves form the metal; for plants growing in pure water contain iron which may be obtained from their aſhes.

Iron is a metal which abounds very much in nature; for, independently of what plants and animals contain, it is found in almoſt all coloured ſtones, in bitumens, and in moſt metallic ores. But here we are to treat only of ſuch mineral matters as contain a great deal of iron, and are wrought for the purpoſe of extracting the metal from them. In thoſe ores, which are very numerous, iron exiſts either in a metallic ſtate, or in oxide, or mineralized by different ſubſtances.

1. Native iron is diſtinguiſhed by its colour and malleability. It is very rare, and is only found accidentally in iron ores. Margraf found it in a fibrous form at at Eibenſtock in Saxony: Dr Pallas has diſcovered in Siberia a maſs amounting to 1600 pounds; and M. Adanſon aſſerts, that it is common in Senegal. Some mineralogiſts think thoſe ſpecimens of native iron are products of art, and have been on different occaſions buried under ground.

2. Iron is very often in the ſtate of ruſt more or leſs oxidated. It then forms ochraceous iron ores. All earths coloured brown or red are of this kind.

3. We muſt beware of confounding with ochres thoſe iron ores which are called *bog ores*. They do, indeed, contain oxidated iron; but that oxide is combined with phoſphoric acid, which appears to have been produced by the decompoſition of vegetables. Bog irons are diſtinguiſhed into rich and poor, fuſible and dry. The rich is but very little ruſted, and contains but a very ſmall proportion of earth. Fuſible iron melts very eaſily, and affords caſt iron of a good quality; the metal being in it united only to ſome ſtones which eaſily melt. Dry iron is more calcined, and mixed with ſome very refractory ſubſtances. All bog iron, in general, is uſually arranged in layers like ſtones, and appears evidently to have been depoſited by water. It is often in the form of pebbles, or flat irregular ſpherical bodies. Organic matters, ſuch as wood, leaves,

leaves, barks, ſhells, are not unfrequently met with in the ſtate of bog iron. This kind of tranſmutation ſeems to ſuggeſt the idea, that there is analogy between iron and organic bodies. A portion of phoſphate of iron, contained in theſe, which abound more than any other iron ores, communicates to this metal the property of being more brittle when cold. Bergman, who was acquainted with iron in this ſtate, but did not determine its nature, called this phoſphate of iron *ſiderites;* ſome German chemiſts have ſince called it *water iron.* We will afterwards explain how this ſalt may be ſeparated from iron that is brittle when cold.

4. The eagle ſtone, or *ætites,* is a variety of bog iron. Eagle ſtones are bodies of various forms, commonly oval or polygonous, conſiſting of concentric layers, diſpoſed around a nucleus which is often moveable in the centre of the ſtone. The drying and contraction of theſe layers has formed a cavity in the middle, in which ſome fragments of various ſizes float at liberty. This ſtone has received its name from an opinion that eagles put it into their neſts, and that it helps them to lay their eggs more eaſily, and promote the effects of incubation. It has been hence inferred, that this ſtone would act powerfully on the fœtus in the mother's womb. Some authors go ſo far as to aſſert, that the pains of a lying-in woman may be brought ſooner on by binding an eagle ſtone to her thigh, and kept back by binding it to her arm.

5. The *hæmatites* is a kind of muddy iron ore, which appears to be formed in the ſame manner as ſtalactites. It derives its name from its colour, which is commonly red like blood, though ſubject to varieties. The hæmatites uſually conſiſts of layers covering one another, and compoſed of convergent needles. The ſuperficies of this

ore is covered over with tubercles. Hæmatites are diverſified, not only by colour but by form too. There is for inſtance the needled hæmatitis found in Lorraine; the tuberculated hæmatitis; the hæmatitis in bunches of grapes, or *hæmatitis botrytis*, &c. Theſe ores are pretty often found with muddy iron; and are depoſited on a great many different bodies.

6. The *loadſtone* is nothing elſe but an ochraceous iron ore, very hard and very refractory; which, however, ſome perſons think not very remote from the metallic ſtate. It is known by its property of attracting filings of ſteel. It is found in Auvergne and in Biſcay in Spain. It is diſtinguiſhed by the diverſities of its colour into ſeveral varieties.

7. *Emery*, *ſmyris*, is a grey or reddiſh iron ore, conſidered by a number of mineralogiſts as a kind of hæmatitis. It is very hard and refractory: great plenty of it is found in the iſles of Jerſey and Guernſey. It is ground in mills into a powder, and uſed in that form for poliſhing glaſs and metals.

8. *Sparry iron* is an oxide of iron in combination with carbonic acid, and worn by the action of water. It is uſually of a white colour; there is, however, of this ore ſtained with almoſt every different colour, grey, yellow, red. It is always in plates of various ſizes, and ſemi-tranſparent like ſpar. It is of conſiderable gravity, and is often regularly cryſtallized: it is found in conſiderable quarries, often mixed with pyrites, as for inſtance at Allevard in Dauphiny; ſometimes it is mixed with grey ſilver ore, as the iron of Baigorry; and ſometimes with manganeſe, as that of Styria. Some chemiſts think it to be a ſpar in which the metallic oxide has been depoſited. Sparry iron is decompoſed by itſelf in cloſe veſſels; and it then yields carbonic acid. What remains is iron in a black pow-

powder, which may be eaſily melted by the action of a ſtrong fire. The manganeſe which it frequently contains, renders it liable to be altered by the action of air, and makes it take a brown colour, when it loſes its form and conſiſtency.

9. Nature likewiſe preſents us with iron in a ſaline ſtate combined with the ſulphuric acid, and forming green ſulphate of iron or copperas. This ſalt is found in the galleries of iron mines, eſpecially in ſuch as contain *pyrites* among the iron ore. It is ſometimes found in green cryſtals, or in the form of beautiful ſtalactites: on other occaſions, again, it is not ſo pure, but appears to have ſuffered ſome alteration. If it has loſt only the water of its cryſtallization, it is of a white or a greyiſh colour: it is then called *ſori*. When ſomewhat more thoroughly calcined, it is yellow, and is called *miſſy*. If the calcination has been carried ſo far as to drive off a conſiderable part of the acid, the ſulphate of iron is then red, and bears the name of natural *colcothar*, or *chalcite;* when mixed with inflammable matters this ſalt is called *melanteri*, from its black colour. All theſe matters have received the common name of *atramentarious* ſtones, as being, no leſs than ſulphate of iron, good materials for making ink.

10. Iron is often found in combination with ſulphur; it then forms *martial pyrites*. This ore has received the name of pyrites, becauſe it is hard enough to afford a great abundance of ſparks when ſtruck with ſteel. We call this combination native ſulphure of iron. Martial pyrites are commonly in ſmall round maſſes, which are ſometimes regular. They are moſt generally ſpherical, cubic, or duodecahædral. Their form is ſubject to many varieties; a fact which the reader of Henckel's Pyritology cannot fail to be convinced of. Some of them are ex-

ternally brown and iron coloured; others yellowiſh, and even at the ſurface pretty much like copper ores. They are all yellow and of a copper appearance within; and they conſiſt moſtly of needles or pyramids of a number of ſides, with their ſummits converging towards a common centre. Pyrites are uſually diſperſed near beds of iron ore, and ſcattered among clays and through coal mines. The uppermoſt ſtratum of a coal mine is almoſt always pyritous. All pyrites are eaſily decompoſed. No ſtrong heat is requiſite to drive off the ſulphur which they contain. Almoſt all of them alter of themſelves when expoſed to the air, eſpecially if the ſituation be moiſt: they ſwell, break, loſe their luſtre, and are covered over with a greeniſh white effloreſcence, which is nothing elſe but ſulphate of iron. It appears that this alteration, which has been called the *vitriolization of pyrites*, depends on the joint action of air and water on the ſulphur. Sulphuric acid is thus formed; which, diſſolving the iron, riſes above the pyrite in a form reſembling vegetation, by ſeparating gradually the ſmall pyramids of which the mineral conſiſts. But all pyrites do not effloreſce with the ſame facility. The globolous pyrites, the colour of which is very pale, and the contexture not very cloſe, effloreſce the readieſt. Such as are of a bright copper yellow, and conſiſt of ſmall plates very neatly arranged one over another, effloreſce not without great difficulty, and ſhould be carefully diſtinguiſhed from the former, as they differ from them in colour, form, texture, and other properties.

11. Iron is likewiſe met with in combination with arſenic, and both of them in a metallic ſtate. This ore, which is true *miſpickel*, is white, ſparkling, granulated, or with facets, and does not, like the arſenical pyrites,

properly ſo called, contain any ſulphur. Wolfram was formerly thought to be arſenical iron ore; but is now known to be tungſten ore.

12. Black iron may be diſtinguiſhed by its colour, its being liable to be attracted by the loadſtone, and being inſoluble in acids. This iron is ſometimes cryſtallized in the form of polyhædrons, or round plates: it diſplays clouds of very bright rainbow colours; ſuch is that of the iſle of Elba. It there forms a conſiderable mountain which is wrought not by running ſhafts, but by cutting down the mountain. The Swediſh iron ore is likewiſe black but not cryſtallized: it is in maſſes more or leſs ſolid, and mixed with quartz, ſpar, aſbeſtos, &c. It is often hard enough to take a poliſh, and its ſurface then reflects images like a looking-glaſs. This, therefore, as well as the laſt mentioned, has received the name of *ferrum ſpeculare*: it is found in pretty large quarries. This iron is ſubject to varieties in colour; ſometimes it is perfectly black, and the black ore is the moſt ſubject to the attraction of the loadſtone; ſometimes bluiſh, and the loadſtone has then leſs influence upon it; it is at other times grey, and it then ſcarce obeys the attraction of the loadſtone. The iron of Norway is alſo black; but it is uſually in ſmall ſcales like mica, and often mixed with garnets and ſchorls. Black iron is ſometimes found in grains: it is alſo in cubic cryſtals; which circumſtance has cauſed ſome naturaliſts to give it the name of galena of iron, or *eiſen-glants*. When micaceous iron ore is black, it is called *eiſen-mann*; and it is thought to be more particularly worthy of that name when the ſcales are very large: when the ſcales are red, and covered with a duſt of the ſame colour, it is called *eiſen-ram*. The iron in black octohædral cryſtals, very regular, and ſcattered through a kind of hard ſchiſtus or ſteatites, which we get from Sweden, Corſica, &c. appears

pears to belong to this claſs of iron ores. It is attracted by the loadſtone, and very brittle. The lamellated briiliant iron of Framont is of the ſame kind.

Although the ſeveral kinds of black iron ore, which I have arranged together under this article, appear to have a ſtriking analogy with one another, yet many mineralogiſts conſider them as very different, and arrange them ſeparately, The cauſe of this diverſity of opinions concerning them, is our being as yet but very imperfectly acquainted with their nature. It appears that ſome among thoſe ores approach nearer to the metallic ſtate; ſuch as the octohædral iron of Corſica and Sweden, which M. Mongez compares to martial Æthiops. This ſpecies is very ſubject to the attraction of the loadſtone: others, again, are nearer the ſtate of oxide, ſuch as the iron of the iſle of Elba, and eſpecially the *eiſen-mann* and *eiſen-ram*, which refuſe to obey the loadſtone. All of theſe ores ſeem to be nothing but oxides of black iron, owing their formation to water, and in the ſtate of Æthiops more or leſs cryſtallized.

13. Iron is ſometimes found in the form of a blue duſt; ſometimes of a brighter, and ſometimes a deeper colour. In this ſtate it is called *native Pruſſian blue*. It is mixed with vegetable earths, particularly peat earth.

14. Laſtly, as iron is more plenteous than any other metal, it is often found mixed with ſand, clay, or chalk; and a great many earths and ſtones are coloured by it.

Iron ores are aſſayed in the dry way in the following manner: After being reduced to powder they are mixed with twice their own weight of pounded glaſs, one part of calcined borax, and a little powdered charcoal; this mixture is well triturated: it is then put into a crucible with a little marine ſalt added to cover the crucible, and urged with fire till it melt. When the whole becomes perfectly cool, it is found to contain a ſmall ſpherical button of iron often cryſtallized at the ſurface and more or leſs malleable.

Bergman propoſes the aſſaying of iron ores in the humid way. He employed the muriatic acid to diſſolve iron, and precipitated it by an alkaline pruſſiate. When there were other metals mixed with the iron, he calcined and ſeparated them by the nitric and the acetous acids; and after that diſſolved the iron by the muriatic acid.

The treatment of iron ores is varied according to the ſtate of the metal. Some ores need no preparation before they be melted; others muſt be pounded and waſhed, and ſometimes even roaſted, to render them ſoft and fuſible.

Muddy iron and ſparry iron are wrought in the ſame way; both being melted on coals. The furnaces uſed in melting iron vary in height from twelve to eighteen feet. Their cavity is in the form of two quadrelateral pyramids, with their baſes joined nearly at the middle of the height of the furnace: this cavity is called (in French) *etalage*. A hole, through which the metal may paſs when melted, is perforated through the bottom of the furnace; correſponding to this hole, which is ſtopped with earth, there is a triangular channel cut in the ſand to receive the metal. The operation begins with putting into the bottom of the furnace a few pieces of burning wood; coals are laid upon the wood; and upon the wood the ore with ſome matters to promote its fuſion. The matters employed for this purpoſe are uſually calcareous ſtones, called (in French) *caſtine*, with ſome argillaceous ſtones, under the name of *arbue*, and ſometimes quartz or flints. The ore, the ſtones, and the coal, are alternately put into the furnace, care being

being taken to cover over the whole maſs with a layer of coal, which muſt reach to a equal height with the upper opening of the furnace. Thus diſpoſed, the maſs is urged with two large bellows till it melt. When the iron melts, it paſſes through the coals, and is thus reduced to a metallic ſtate. The ſtony matters, as they melt and vitrify, contribute to the fuſion of the iron, which begins at the narroweſt part of the furnace. The melted metal is collected at the bottom of the furnace into a place called the *crucible;* from this it runs thro' the aperture in the bottom of the furnace into the reſervoir prepared for it in the ſand. It here forms what is called *caſt iron.* A vitreous matter called *ſlag* paſſes after the iron: it is formed by the vitrification of the gangue of the ore with the earths which were added to facilitate the fuſion of the iron. It is of a green whitiſh blue, or yellow colour, which is communicated to it by a part of the oxide of the melted iron.

The iron thus obtained is brittle, and without ductility. Metallurgiſts differ in opinion concerning the cauſe of this property of caſt iron: ſome have thought it to depend on the metal being intermixed with ſlag. Others have attributed it to the metal not being entirely reduced, but ſtill containing a portion of oxide. Brandt thought it to be arſenic; and M. Sage thinks it is zinc which renders caſt iron brittle. Bucquet conſidered caſt iron as iron imperfectly reduced, and ſtill containing an intermixture of oxide. Bergman, after examining this iron with great induſtry, concluded its fragility to depend on the intermixture of a certain quantity of an extraneous matter, which he thought to be a peculiar metal, and diſtinguiſhed by the name of *ſyderites:* that matter has been diſcovered to be a compound of iron with the phoſphoric acid. Syderites, as we ſhall hereafter ſhow, is likewiſe found in certain irons. The true cauſe of the fragility, fuſibility, granulated texture, and other peculiar properties of caſt iron, has been determined beyond a doubt by the ingenious reſearches of Meſſrs Vandermonde, Monge, and Berthollet. They have ſhown, that caſt iron contains both oxigene and coal: the laſt of which it has abſorbed when in fuſion in the high furnace. To the various proportions in which it contains theſe two extraneous bodies, caſt iron owes its peculiar properties, and the varieties by which theſe are diverſified.

Metallurgiſts diſtinguiſh various kinds of caſt iron; white, grey, black, &c. They give the name of ſpeckled iron to that which is variegated with blackiſh ſpots on a grey ground. White caſt iron is the worſt kind: it is almoſt a ſemi-metal. The grey is between the firſt mentioned and the black; which laſt is eſteemed the beſt, as it affords, the moſt eaſily, iron of a good quality. Theſe differences depend on the various proportions in which the oxigene, and ſtill more the coal, is intermixed with the iron. When the proportion of the charcoal is conſiderable, and it is uniformly intermixed, the caſt iron is then black: when the proportion of the charcoal is leſs, the caſt iron is grey. An imperfect mixture, too haſtily cooled, gives ſpeckled caſt iron. White caſt iron contains the ſmalleſt proportion poſſible of charcoal. The nature and the uſe of caſt iron, and the proceſs for converting it into iron, are affected by all of theſe qualities. The above-mentioned philoſophers have diſcovered, that when caſt iron is melted again, there is always ſeparated from it a portion of charcoal intimately combined with iron. This compound, which has been hitherto called *plumbago*, forms a cruſt on the ladles in which the caſt iron is taken out to be cooled.

In order to convert caſt-iron into iron, it muſt be purified from the coal and the oxigene which it contains. A ſtrong fire, which may penetrate through the whole maſs, is requiſite to effect this reduction. At an high temperature, the charcoal naturally attracts the oxigene, burns, and is diſengaged with effervеſcence, in the form of carbonic acid gas. To accompliſh this, the caſt iron is taken to a refining furnace. It is a forge furnace, with its hearth ſomewhat hollow; the caſt iron is put into it, and covered over with a good deal of charcoal. The fire is now blown till the caſt iron be melted; when brought into this ſtate, it is repeatedly ſtirred, with the heat ſtill continued. The ſtirring cauſes it to expoſe more ſurface to the heat; and by this means the charcoal ſeizes more of the oxigene, in conſequence of which it is more completely burnt, and diſengaged in carbonic acid gas. The metal appears alſo to detach from itſelf at the ſame time a portion of *ſyderite*, or phoſphate of iron. It is next to be hammered into bars. The hammering, by compreſſing the particles of the metals, contributes to the ſeparation of the carbure and oxide of iron which it ſtill contains; it conſequently effects what could not be effected by the fuſion from its being incomplete. The iron is repeatedly beaten and heated till it be brought to the deſired form and purity. Forged iron is either ſoft or brittle. Soft iron is very ductile; and when broken, which cannot be done without bending it, it appears to conſiſt of threads or fibres: this has gained it the name of *nervous iron.* But its nervous appearance is accidental; for even the ſofteſt iron, if broken ſmartly at a ſingle blow, does not appear nervous. The grain of this metal affords a better criterion of its quality. The other ſpecies of forged iron is more brittle: it has coarſe

coarſe grains, and appears to conſiſt of ſmall ſcales; This, again, is either brittle when hot, or brittle when cold. The cauſe of its fragility is now known. That which is ſo brittle when cold is known to contain much more ſyderite or phoſphate of iron than what is contained in any other ſort of iron: ſtill as iron is more ductile, it is found to contain leſs ſyderite; and the ſofteſt iron contains none at all. To ſeparate this ſalt from iron, and to determine its quantity, the metal may be diſſolved in ſulphuric acid, diluted in water; the ſolution when ſuffered to ſettle, by degrees depoſites the phoſphate of iron in a white precipitate, which may be taken up and weighed.

Iron is artificially converted into ſteel. For this purpoſe, ſhorts bars of iron are incloſed in an earthen box, filled with a cement, which is uſually made up of very combuſtible matters; ſuch as ſoot from chimnies, or coals of animal matters: ſometimes aſhes, calcined bones, marine ſalt, or ammoniac are added; but theſe matters are often more hurtful than ſerviceable. The box is now ſhut, and expoſed to heat for ten or twelve hours, till the bars become pretty white, and begin to ſoften. In this operation the iron is purified, and completely reduced by means of the combuſtible matters with which it is cloſely ſurrounded. Such parts of it as were not perfectly in a metallic ſtate, are now enabled to return to that ſtate: and the phoſphate of iron, if any yet remains, appears to be now entirely decompoſed. The iron, being thus ſoftened and dilated, abſorbs part of the ſurrounding charcoal; and cemented ſteel appears therefore to be a preparation of pure iron completely reduced with charcoal. It differs from iron, as containing charcoal; and from caſt or crude iron, as not containing, like it, any oxigene together with

with the charcoal. If caſt iron be deprived of its oxigene, and yet ſuffered to retain its charcoal, it will become ſteel; and again, if you add charcoal to pure iron, without adding to it any oxigene, it will likewiſe be converted into ſteel. Steel is much more fuſible than iron: and therefore bars of iron, converted by cementation into ſteel, are ſoftened to ſuch a degree that the carbonic acid, which is diſengaged in bubbles, ſwells the ſurface of the metal into ſmall cavities, which are ſufficiently diſcernible. The ſteel which exhibits theſe appearances is called *hen-ſteel* *. The differences of ſteel depend on the iron's having been more or leſs completely reduced, on the quantity of the charcoal contained in it, and on its being ſlowly or quickly cooled; tempering compreſſes its particles more cloſely upon each other, and renders it very hard, dry, and brittle.

It is plain, that what renders all theſe preparations neceſſary is, becauſe this metal is more difficult to melt than any other, adheres much more obſtinately to the oxigenous principle, and has a ſtronger tendency to combine with it.

There are ores, eſpecially black iron ores, ſuch as that of the iſle of Elba, in which the metal is ſo plenteous, and ſo little altered, that there is no occaſion for converting it firſt into caſt iron. It is only ſoftened in a refining furnace, and immediately ſubmitted to the hammer. This is called the *Catalan method.* It cannot be uſed except with ores which contain but a ſmall portion of extraneous matters that can run into *ſlag*.

Sparry iron ores afford iron ſo pure, and ſo eaſily reducible, that they melt very readily, and greedily abſorb

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* *Acier poule.*

abſorb charcoal as they are reduced. They are on this account called *ores of ſteel.*

A very intenſe heat is requiſite to melt iron. Iron filings caſt into the midſt of a pan with burning coals, or even againſt the flame of a taper, inſtantly kindle, and produce very lively ſparks; ſuch too are the ſparks which iſſue from a piece of ſteel when ſtruck againſt ſtones. When theſe ſparks are collected upon white paper, they are found to be melted into a kind of droſs or ſcoriæ. This metal, when expoſed to the focus of Trudaine's burning-glaſs, ſuddenly emits flaming and burning ſparks. Macquer, who melted both ſteel and iron in that lens, obſerved ſteel to be the moſt fuſible of the two; which is owing to its being combined with charcoal. When melted iron is ſlowly cooled, it takes, as we have already obſerved, a peculiar cryſtalline form. M. Mongez deſcribes it as a pyramid with three or four ſides.

A ſtream of vital air poured on iron in filings, cauſes it to burn with as much rapidity as the heat of the focus of the lentile in the garden *de l'Infante.* If into a bottle filled with vital air you immerſe a piece of iron wire, twiſted into a ſpiral line, with a ſmall bit of lighted tinder at one end, the metal ſuddenly takes fire, and burns with a rapidity and a flame which are very remarkable. As in all theſe inſtances of fuſion the iron becomes brittle, is reduced to oxide, and at the ſame time takes a black colour, iron-ſmiths, and all who have any occaſion to work the metal, conſider it as not being fuſible; and with them it is a maxim that iron is abſolutely infuſible. This opinion, however, proves, when ſtrictly examined, to be erroneous; for when ſubmitted to the action of a very ſtrong fire, without being at the ſame time expoſed to the action of air, iron

iron melts almoſt without alteration. In our accurate experiments we obtain ſmall buttons of ſoft ductile iron.

Iron, though ſo very hard and refractory, is very eaſily calcined or reduced to oxide. As ſoon as it begins to turn red hot, it combines with oxigene, and burns without any diſcernible flame. A bar of iron, after being kept red hot for a conſiderable time, exhibits on its ſurface ſcales which may be beaten off with the hammer, (and are called by the French workmen *bătitures de fer.*) The metal of theſe ſcales is but oxidated in part, for they are ſtill liable to be attracted by the loadſtone. A more perfect oxide of iron may be obtained by expoſing filings of ſteel under a muffle; and the ſcales may by this means be ſtill ſooner formed. Theſe are converted into a reddiſh brown powder, not liable to be attracted by the loadſtone, which is called *aſtringent ſaffron.* We call it *red oxide of iron;* and the ſcales we called *black oxide.* The black oxide contains from 20 to 25 parts of oxigene to the hundred; the red oxide contains from 32 to 34 of the ſame principle. The oxides of iron differ according as they approach nearer to the one or the other of theſe two degrees. Some are of a yellow brown colour; others cheſnut; and others again of the moſt beautiful red, like carmine. All of theſe oxides when mixed with earthy matters and expoſed to a very ſtrong heat, melt into a blackiſh porous glaſs. They are in part reduced when heated ſlowly in cloſe veſſels: However ſhort the time during which they have been expoſed to the air, they give out when reduced a certain quantity of carbonic acid; a circumſtance which proves that they attract this acid from the atmoſphere. This acid may be alſo produced from the charcoal which the iron contains, and

and which becomes acid by abſorbing the oxigene diſengaged from them as they are reduced.

Red oxide of iron is very eaſily reduced with the help of combuſtible matters. On being mixed with a little oil and heated ſlightly in a crucible, they become black, and very ſubject to the attraction of the loadſtone: But in this operation they loſe not all the oxigene which they contain; they only paſs into the ſtate of black oxide.

The pureſt iron ſoon loſes its metallic luſtre when expoſed to humid air: it is then covered over with a pulverulent brown yellow cruſt. This matter is called *ruſt*. Common iron is much more liable to ruſt than ſteel. The more the particles of the metal are attenuated and divided, the more rapid is the alteration which it ſuffers from air. On this principle is prepared the medicine known in pharmacy under the name of *aperient ſaffron of Mars*. To produce it, iron filings are expoſed to the air and watered; and by this means they come to ruſt very ſpeedily. It is formed ſtill more quickly of iron in the ſtate of *Æthiops*, or black oxide, treated in the ſame manner. In this alteration the metal is agglutinated into maſſes, which are levigated before being employed in medicine. The formation of the ruſt of iron was thought to be owing to the action of the air; but it is now known to be water which calcines the metal in this manner. Some experiments peculiar to myſelf lead me to conſider *aperient ſaffron of Mars* as a combination of oxide of iron with carbonic acid. I have diſtilled *this ſaffron of Mars* in a pneumato-chemical apparatus, and obtained from it a large proportion of this acid. The iron was then changed into a black powder, very ſubject to the attraction of the loadſtone. M. Joſſe, apothecary at Paris, has communicated to the Royal Society of Medicine a ſimilar proceſs for obtaining ſpeedily *martial Æthiops*. He adviſes the making the *aperient ſaffron of Mars* red hot in a retort with a balloon perforated with a ſmall hole, fitted, but not luted, to it. By this means the heat diſengages the carbonic acid, which M. Joſſe ſuffers to eſcape thro' the hole perforated in the balloon; and the iron then remains in the ſtate of black oxide in powder or *martial Æthiops*. I have by this means often cryſtallized cauſtic potaſh and ſoda, rubbed over the ſides of the balloon fitted to the retort, In conſequence of the carbonic acid from the iron uniting with the alkali, that neutral ſalt is formed to which we have given the name of carbonate of potaſh or ſoda. I have made many other experiments, and have given an account of them in a particular Memoir, (*Chem. Mem. & Obſerv.* 1784). From all of them I am convinced that this matter is a true neutral ſalt formed by oxide of iron with the carbonic acid. Ruſt ſhould therefore be called *carbonate of iron*, to diſtinguiſh it from the genuine oxides of this metal. This ſalt is preciſely the ſame with what Bergman calls *aerated iron*. This theory, too, has been adopted by Macquer. It explains very naturally how iron comes to contract ruſt ſo ſpeedily in humid and impure air; how it comes to be altered ſo quickly and ſo entirely in places where the air is corrupted by the reſpiration of animals, by combuſtion, or by vapours proceeding from animal matters; as, for inſtance, in ſtables, ſtalls, and houſes of office, &c. Iron is of all metals the moſt liable to alteration from the contact of air, and the alteration is not confined to its ſurface. Very thick bars of iron are often ruſted half way through.

Water acts powerfully on iron when cold. It divides it, it, and even diſſolves a part of it, according to the experiments of M. Monnet. The purer the iron is, and the more air it contains, ſo much the more of it does water diſſolve. When iron is for ſome time ſtirred about in water, it appears to be divided into very minute parts; and on decanting the water, which is a little turbid, it depoſites a very fine black powder, which has received the name of *Lemery's martial Æthiops*. This powder muſt be carefully dried by a moderate heat, and in a cloſe veſſel, ſuch as an alembic, leſt the contact of the air ſhould ruſt it. This martial Æthiops is very ſubject to the attraction of the loadſtone; it is a black oxide of iron formed by water. As this operation is very tedious and delicate, various chemiſts have attempted to ſimplify it. Rouelle, in making up this preparation, made uſe of the *mouſſoirs de la Garaye*, and by that means obtained a very fine *Æthiops* in much leſs time than what is conſumed in Lemery's proceſs. I believe M. Joſſe's method, which is much more expeditious, might be advantageouſly ſubſtituted in its place. We will hereafter give ſome other proceſſes for preparing *martial Æthiops*. Lemery's is effected by an actual decompoſition of water; the hydrogenous gas is diſengaged, and the iron is oxidated by abſorbing twenty-five parts of oxigene to a hundred. We will very ſoon treat more at length of this decompoſition of iron by water.

We have already mentioned, that when ſteel in bars is heated to a certain degree, and ſuddenly immerſed into cold water, it becomes very hard and very brittle. The hotter the ſteel, and the colder the liquor into which it is immerſed, ſo much the more eminent do theſe qualities become. This operation is called *tempering*. Steel may at pleaſure be cauſed to aſſume any degree of hardneſs. We can alſo deprive it of its *temper*, by heating it to the ſame temperature at which it was tempered, and ſuffering it to cool ſlowly. This effect of water on ſteel appears to depend on the ſudden cooling producing a change on the diſpoſition of its parts, and injuring its cryſtallization. All metals admit of being hardened by tempering; but the more infuſible the metal, ſo much the more eminent the degree in which it acquires this quality. Iron therefore is more ſuſceptible of it than any other.

About two years ſince a much ſtronger re-action was diſcovered to take place between water and iron. M. Lavoiſier putting iron and water together into a bell-glaſs above mercury, obſerved that the iron ruſted, and the water decreaſed in quantity in proportion as an elaſtic fluid which filled the upper part of the apparatus was diſengaged. The fluid diſengaged proved to be *inflammable gas*. The iron had gained an additional weight, and was oxidated. M. Lavoiſier conjectured that the water might contain oxigene, and that the inflammable gas, the other principle of the water, might be diſengaged, in conſequence of the oxigene uniting with the iron. He afterwards made a more deciſive experiment, in conjunction with M. Meuſnier: in that experiment, water in vapour introduced into a gun-barrel made red hot, afforded a large proportion of *inflammable gas:* The inner part of the gun was found to have acquired additional bulk, and was become black, brittle, and lamellated, much like the iron ore of the iſle of Elba. The metal was found to have gained an increaſe of weight; and the additional weight which it had acquired, taken together with the weight of the *inflammable gas*, correſponded preciſely to that of the water decompoſed. The portion of iron oxidated by this means was found ſeparate from that which had not undergone the ſame alteration. It formed an interior cylinder, thicker than the exterior part; and differing greatly from it in texture, colour, conſiſtency, and form. In order to ſucceed in this experiment, it is requiſite to make the iron fully red hot; for heat contributes greatly to the ſeparation of the principles of the water. And when the gun-barrel is not thoroughly red hot, and the water not in an highly elaſtic ſtate when it paſſes through it, no *inflammable* gas is diſengaged, nor is the water decompoſed. This has happened with various philoſophers; who not making the iron hot enough, and introducing the water into it in a liquid ſtate, have not obtained the ſame reſults as M. Lavoiſier, and have of conſequence denied water to be decompoſable, though Syntheſis concurs to juſtify M. Lavoiſier's inferences from analyſis, as has been incontrovertibly ſhown by the ſame gentleman and M. Mongez. There are many other occaſions on which water is, in like manner, ſeparated into its conſtituent principles, and gives riſe to many very important phænomena, of which we will hereafter have occaſion to take notice. Such is the experiment by which water was diſcovered to be a compound conſiſting of 0,14 of hydrogene with 0,86 of oxigene.

Iron does not combine in its metallic ſtate with earthy or ſtony matters; but oxide of iron facilitates the fuſion of all kinds of glaſs, communicating to it a green or brown colour. The colours which oxide of iron communicates to other bodies are various, according as it is more or leſs completely oxidated. This oxide poſſeſſes likewiſe the property of aſſuming and communicating more or leſs conſiſtency to thoſe ſtones with which

which it is naturally or artificially mixed, and of making them liable to dilution in water.

Neither barytes, magneſia, nor lime, acts obſervably upon iron.

The pure fixed alkalis and ammoniac, when diſſolved in water act in a ſenſible manner on this metal. In the courſe of a few days digeſtion on it, the liquors become foul, and give a precipitate of a ſmall portion of *Æthiops* or black oxide of iron: And, as has been obſerved by the chemiſts of the Academy of Dijon, a certain quantity of hydrogenous gas is diſengaged during the reaction of theſe ſubſtances; a circumſtance which proves that the water contributes to it, as the hydrogenous gas can be given out only in conſequence of its decompoſition; to which no doubt the alkalis contribute.

Iron may be diſſolved in any of the acids. M. Monnet has obſerved, that the concentrated ſulphuric acid cannot act on this metal, unleſs it be boiling. On diſtilling this mixture to dryneſs, there are found in the retort ſublimated flowers of ſulphur, and ſulphate of iron in a white maſs, which may be diſſolved in one part of water, but being decompoſed by the heat, affords no cryſtals. The ſulphuric acid diluted in two parts of water readily diſſolves iron filings cold; at the ſame time when the metal is diſſolved, a conſiderable quantity of hydrogenous gas is diſengaged. By putting a lighted taper to the mouth of the matraſs, after keeping it ſtopped for ſome time with the hand, it may be made to detonize with a conſiderable noiſe. This gas burns with a reddiſh flame, ſometimes emitting very ſmall ſparks, like thoſe of iron filings. Macquer, Bergman, and Mr Kirwan, think that in this inſtance of combination the ſulphuric acid diſengages a

great

great part of the phlogiſton of the iron, and that the *inflammable* gas belongs ſolely to this metal. This opinion appears to have been built on the belief that *inflammable* gas might be extracted from iron alone, without any intermedium, merely by the action of fire. But it is at preſent a well eſtabliſhed fact, that the hydrogenous gas diſengaged from iron by heat is always in ſtrict proportion to the water which it contains; and it is no leſs certain that the water added to the ſulphuric acid gives out, in conſequence of being decompoſed, hydrogenous gas. 1. Becauſe the concentrated ſulphuric acid affords only ſulphureous gas. 2. Becauſe in this ſtate it cannot act upon iron without the aid of heat, and even then acts upon it but very faintly. 3. Becauſe, whenever water is added, the reaction becomes more rapid, and hydrogenous gas is produced. 4. Laſtly, becauſe the concentrated ſulphuric acid is in part decompoſed by the iron when there is no water added; whereas when water is added to the ſolution, the acid remains without diminution, and only combines with the oxide of iron. The proof of this laſt fact is, that the ſame quantity of alkali is required to ſaturate this acid after it has acted on iron as before. In this operation, therefore, it is the water which oxidates the iron, as was long ſince conjectured by M. de la Place; and has been fully proved by Meſſrs Lavoiſier and Meuſnier.

While the ſulphuric acid diluted in water acts upon iron, a portion of the metal is precipitated in a black powder, which was taken by Stahl for ſulphur, and has been found by M. Monnet to be *martial Æthiops.* That black oxide appears to be more than ſufficient for the ſaturation of the acid. As ſoon as one part of the iron is combined with one of the acid, although the

the acid be not nearly ſaturated, yet the ſolution ceaſes, and it no longer acts upon the metal. M. Monnet, who firſt made this obſervation, remarks, that when water is poured into the mixture, the acid begins again to act upon the metal. The cauſe of this phænomenon is, that the water which was united with the ſulphuric acid has been abſorbed by the ſulphate of iron which is already formed, while the acid which remains unſaturated cannot act upon the iron, till by the addition of a new quantity of water more of the metal be reduced to oxide. The ſulphuric acid diſſolves more than half its own weight of iron. That ſolution, after being filtered and evaporated, affords by cooling a tranſparent ſalt, of a beautiful green colour, in rhombic cryſtals. This is the *martial vitriol,* or *green copperas* of commerce. We call it ſulphate of iron.

People do not take the trouble of making up this ſalt artificially, becauſe nature ſupplies it in abundance, and it is eaſily extracted from *martial pyrites.* All that is requiſite is, to leave thoſe ſulphures expoſed for ſome time to the air. The moiſture of the atmoſphere contributes to their decompoſition; they become covered with a white efflореſcence, which needs to be diſſolved in water and cryſtallized before it can afford ſulphate of iron. This decompoſition of pyrites depends, according to Stahl, on a double affinity. Sulphur is with him a compound of *phlogiſton* and *vitriolic* acid. Neither water or iron, when taken each by itſelf, can decompoſe ſulphur: But when theſe two ſubſtances are made to act upon it together, the iron detaches and attracts to itſelf the phlogiſton of the ſulphur, and the *vitriolic* acid combines with the water to diſſolve the metal. Such of the pyrites as are leſs diſpoſed to effloreſce, among which are the brilliant pyrites, effloreſce readily after being deprived by roaſting of a part of the ſulphur

phur which they naturally contain. The *vitriol* is ſeparated from it by waſhing. The ſolution of this ſalt depoſites at firſt a certain quantity of iron in the ſtate of ochre. The liquor is not evaporated and cryſtallized till after this depoſitum be precipitated. The modern opinion concerning the efflореſcence of pyrites is, that the ſulphur, which in them is divided as in its combinations with alkaline ſubſtances, combines with a portion of oxigene to form ſulphuric acid, which being diluted by the water of the atmoſphere, enters into union with the iron, not without exciting heat, and diſſolves it. What adds a very conſiderable weight to this opinion is, that the contact of air is neceſſary to the efflореſcence of pyrites, and that moiſture which contributes greatly to their *vitriolization*, acts in this inſtance in the ſame manner as in the ſolution of iron. Such is the origin of the hydrogenous gas, which is diſengaged in this operation when performed *in vacuo*.

Sulphate of iron has a green emerald colour, and a very aſtringent taſte. It ſometimes reddens ſyrup of violets; but it does not uniformly produce this effect. From the experiments of Kunckel and M. Monnet, it appears that theſe cryſtals contain a quantity of water equal to more than half the weight of the ſalt. If this ſalt be ſuddenly expoſed to a pretty ſtrong heat, it becomes liquid, like any of the other ſalts which are more ſoluble in heat than in cold; when dried, its colour is a whitiſh grey. If it be heated at a more intenſe fire, it gives out ſo much of its acid in the form of ſulphureous gas, and becomes red; in this ſtate it is called *colcothar*. Sulphate of iron, when calcined till it becomes red, attracts the moiſture of the atmoſphere in a very ſenſible manner by means of the ſulphuric acid which it contains. When diſtilled in a retort, and in a reverberating furnace, this ſalt affords at firſt a water which is faintly acid, and is called *dew of vitriol.* The balloon muſt be changed when we wiſh to obtain the concentrated ſulphuric acid ſeparately; which, when the heat is very intenſe, appears black as it paſſes into the receiver, and exhales a ſuffocating ſmell of volatile ſulphureous acid. What enables it to diſplay theſe phænomena is, according to the pneumatic theory, its having loſt a part of its oxigene, which has become fixed in the iron. Towards the end of the operation, the acid diſtilled aſſumes a concrete cryſtalline form, and it is now called *glacial ſulphuric acid.* This experiment, which is deſcribed by Hellot, did not ſucceed with M. Baumé; but among chemiſts in general it is conſidered as certain and infallible. The glacial ſulphuric acid, when diſtilled in a ſmall retort, gives out ſulphureous gas, and becomes white and fluid. It owes its concrete ſtate to the preſence of this gas. It combines with water with hiſſing and heat, and on this occaſion too, gives out ſulphureous gas. Such is Northaauſen's fuming *oil of vitriol,* and the concrete ſalt obtained from it by a moderate heat, of which I have given an analyſis in a Memoir publiſhed among the Memoirs of the Academy for the year 1785.

The reſidue remaining after the diſtillation of ſulphate of iron is red, and reſembles colcothar. When waſhed with water, there is ſeparated from it a white ſalt but little known, and called *colcothar ſalt,* or *fixed ſalt of vitriol.* What remains is a red inſipid earth, which is pure oxide of iron, and is called *mild earth of vitriol.*

Sulphate of iron, when expoſed to the air, becomes a little yellow, and is gradually covered with ruſt, by abſorbing oxigene from the atmoſphere. By this abſorption of oxigene, it is by degrees more and more calcined, till it become incapable of remaining united with the ſulphuric acid. A ſolution of this ſalt exhibits

bits the ſame phenomenon when brought into contact with the atmoſphere; and either the one or the other may be uſed as an eudiometer.

Cold water diſſolves a quantity of this ſalt equal to half its own weight: hot water diſſolves ſtill more of it; but when ſufficiently impregnated, it appears to be rendered turbid by a quantity of ochre more or leſs conſiderable. This ochre is ſeparated from it by filtration; and the ſolution, when cooled, gives pale green tranſparent rhomboidal cryſtals. The ſupernatant liquor affords by evaporation a new parcel of cryſtals: and after it is deprived of all that it can afford by cryſtallization, there remains a blackiſh brown, or a brown yellow mother water, not ſuſceptible of cryſtallization. When evaporated by a ſtrong heat, and ſuffered to cool, this mother water forms a ſoft unctuous maſs, which powerfully attracts the moiſture of the atmoſphere. When this maſs is thoroughly dry, it affords a greeniſh yellow powder. According to M. Monnet, the mother water of ſulphate of iron contains iron in the ſtate of a perfect oxide. He made himſelf certain of this fact, by forming directly, with the help of heat, a ſolution of genuine oxide of iron in this acid. The ſolution is brown, and not ſuſceptible of cryſtallization.

The oxide of iron may be ſeparated from the mother water, not only by aluminous earth, but alſo by copper and iron filings, to which perfect ſulphate of iron is not liable.—A ſtrongly ſaturated ſolution of this perfect ſalt, if expoſed to the air, changes in a certain ſpace of time into a mother water of the ſame nature with the two laſt-mentioned, by attracting oxigene from the atmoſphere.

Sulphate of iron is decompoſable by lime and alkalis. Lime-water poured into a ſolution of this ſalt produces a precipitate in flakes of a deep olive green colour; a portion of the precipitate is again diſſolved in the water, and communicates to it a reddiſh tinge. In the years 1777 and 1778 I preſented to the Academy two memoirs on precipitates of iron obtained by cauſtic alkalis, or by alkalis not cauſtic, in which I have accurately deſcribed the phænomena which attend thoſe precipitations, and the ſtate of the iron in theſe different circumſtances: I ſhall here give the chief facts which they afford in relation to ſulphate of iron. Cauſtic fixed alkali precipitates the ſulphuric ſolution of iron in dark green flakes, which are again diſſolved in the alkali, forming a kind of martial tincture of a very beautiful red colour. When a ſmaller portion of the alkali is put into the ſolution, the precipitate may be taken up and converted into blackiſh *Æthiops*, or black oxide of iron, by drying it rapidly and in cloſe veſſels. If theſe two precautions were neglected, the iron would very ſoon become oxide, on account of its being moiſt and divided. Potaſh, ſaturated with carbonic acid, or carbonate of potaſh, forms a greeniſh white precipitate which does not diſſolve again in the alkali. This difference is owing to the carbonic acid, which unites with the iron as faſt as it is ſeparated from the alkali by the ſulphuric acid. The precipitate formed by concrete ammoniac, or ammoniacal carbonate, is of a greeniſh grey colour: a part of it is again diſſolved in the ſalt, and communicates to it a red tinge: ſo that the phænomena which ammoniac produces in this ſolution are in one reſpect directly oppoſite to thoſe of the fixed alkalis: cauſtic fixed alkali diſſolves the precipitated iron very readily; carbonated potaſh not without the greateſt difficulty.

Aſtringent vegetable matters, ſuch as nut-galls, ſumac, huſks of nuts and pomegranates, quinquina, cypreſs

preſs nuts, logwood, tea, &c. cauſe ſulphate of iron to yield a black precipitate. That precipitate, which cannot be miſtaken for iron, is ſo much attenuated as to remain ſuſpended in the liquor. On adding to this mixture a little gum arabic, the iron precipitate is permanently ſuſpended, and the compoſition forms the black liquor known under the name of ink. We do not yet certainly know what paſſes on this occaſion. Macquer, M. Monnet, and many other chemiſts, think the precipitate of ink to be combined with ſome principle of the nut-gall which diſengages it from the acid. They appear with ſome reaſon to think that principle in an oily ſtate. M. Guanetti, a phyſician at Turin, has made a number of experiments on iron precipitated by aſtringents from its ſolutions. The reſult of his reſearches, which he has given in his analyſis of the waters of St Vincent, proves that this precipitate is not liable to be attracted by the loadſtone; that it becomes ſo, however, when heated in a very cloſe veſſel; that it is ſoluble in acids without effervеſcence; and that the ſolution no longer receives a black tincture from nut galls: from which facts it may be inferred, that the iron is combined with the aſtringent principle, and that they exiſt together ſomewhat in the ſtate of a neutral ſalt. In the third volume of the Elements of Chemiſtry by the Academy of Dijon, there is a ſeries of experiments on the aſtringent vegetable principle, which ſeem to repreſent that ſubſtance as of a ſimilar nature with acids. According to thoſe chemiſts it reddens vegetable blue colours; combines with alkalis; decompoſes ſulphures; diſſolves, and appears to neutralize metals; decompoſes all ſolutions of metals with peculiar phænomena; aſcends in diſtillation without loſing its power of acting on metals, and diſplays a vaſt number of other properties which we have not here room to enlarge upon.

The experiments and inductions of the academicians of Dijon have ſince been confirmed by the reſearches of Scheele. That celebrated chemiſt has diſcovered, that the ſimple infuſion of nut-galls in water ſeparates from it a peculiar acid, ſuſceptible of cryſtallization, which detaches iron from any other acids, and communicates to it a black colour, by bringing it nearer to a metallic ſtate. We call this ſalt the *acid of galls*, or the *gallic acid.* Its hiſtory will occur in the vegetable kingdom.

A phænomenon ſtill more difficult to underſtand than the action of nut-gall on ſulphate of iron, is the decompoſition of this ſalt by an alkali calcined with bullock's blood. By this means we obtain a precipitate of a beautiful blue colour, and inſoluble in acids. This precipitate is called *Berlin*, or *Pruſſian blue*, becauſe it was firſt diſcovered in the city of Berlin. Stahl relates, that a chemiſt, of the name of Dieſbach, happening to borrow from Dippel a quantity of fixed alkali to precipitate a ſolution of cochineal, Dippel gave him alkali on which he had diſtilled animal oil. The ſalt cauſed Dieſbach's ſolution to yield a blue precipitate. Dippel inquired into the cauſe, and prepared by a ſimple proceſs the Pruſſian blue, which was made known to the world in the year 1710, in the Miſcellanies of the Academy of Berlin; but the mode of preparation was not communicated. Chemiſts laboured eagerly to diſcover the proceſs for preparing it, and at length ſucceeded. In the year 1724 Woodward publiſhed in the Philoſophical Tranſactions a proceſs for preparing this colouring ſubſtance.

To make Pruſſian blue, mix four ounces of nitre fixed by tartar with as much dried bullock's blood. Calcine this mixture in a crucible till it be reduced to a coal and ceaſe to emit flame. Waſh it with as much water

water as may be requiſite to diſſolve the whole of the ſaline matter, which is called *phlogiſticated alkali*, or *colouring lixivium ;* and let this lixivium be concentrated by evaporation. Next diſſolve two ounces of ſulphate of iron and four ounces of aluminous ſulphate in a pint of water. Mix this ſolution with the alkaline lixivium; a greeniſh depoſitum is produced, which muſt be ſeparated by the filter and muriatic acid poured upon it. The depoſitum then takes a darker and more beautiful blue colour ; and is to be dried by a moderate heat, or in the air.

Many chemiſts have ſince attempted both to prepare and to form a theory of Pruſſian blue. As to its preparation, it is at preſent known that many other ſubſtances render alkali capable of producing a blue precipitate of iron.

Geoffroy, in the Memoirs of the Academy for the year 1725, ſays, that he found all coals of animal matters capable of communicating this property to alkalis. M. Baumé aſſerts, that *phlogiſticated alkali* may be prepared with the coals of vegetable ſubſtances by a ſtronger heat. Spielman has made it with bitumens ; Brandt with ſoot. The manufactories of Pruſſian blue are very numerous ; and in each of them, it would appear different methods are employed in the preparations. M. Baunach informs us, that in Germany the hooves, horns, and hides of cattle are uſed for this purpoſe. All animal matters, however, do not appear equally proper for the Pruſſian lixivium. I have attempted ineffectually to prepare it with the bile in the ſame manner as with the blood of bullocks. What I obtained was an alkali which produced in a ſolution of vitriol a greeniſh white precipitate ; and the precipitate was entirely diſſolved in the muriatic acid.

Chemiſts differ greatly concerning the theory of

Pruſſian blue. Brown and Geoffroy thought it to be the *phlogiſtic* part of iron extricated by the lixivium of the blood, and united with the aluminous earth. Abbé Menon thought it to be alkali. Macquer, in a memoir which has deſervedly been conſidered as a maſter-piece by every chemiſt, and is inſerted among the Memoirs of the Academy for the year 1752, has refuted the opinions of thoſe chemiſts. He thinks Pruſſian blue to be nothing but iron combined with an exceſs of the inflammable principle which it receives from the *phlogiſticated* alkali, and the alkali from the bullock's blood. He obſerves, 1. That Pruſſian blue, when expoſed to heat, loſes its colour and becomes ſimply iron again. 2. That this blue is inſoluble even by the ſtrongeſt acids: 3. That alkalis are capable of diſſolving the colouring matter of Pruſſian blue and abſorbing it till it be ſaturated. For this it is ſufficient to heat an alkaline lixivium upon Pruſſian blue till the alkali become unfit to diſcolour it. Alkali, when thus ſaturated with the colouring matter of Pruſſian blue, is found to have loſt moſt of its properties. It is no longer cauſtic; it does not efferveſce with acids; it does not decompoſe barytic ſalts; it precipitates all metallic ſalts; and this precipitation appears to take place by virtue of a double affinity, the affinity of the acid with the alkali, and the affinity of the metallic oxide with the colouring part of that ſalt. Alkali is thus capable of deſtroying the colour of a twentieth part of its weight of Pruſſian blue; and is then ſaturated with colouring matter. The acids diſengage from it a ſmall quantity of blue ſediment; and the ſulphate of iron is then inſtantly precipitated in perfect Pruſſian blue.

In regard to alkali prepared in the common way, Macquer obſerves, that it is far from being completely ſaturated with colouring matter; and that, from this circumſtance,

circumſtance, it produces at firſt a green precipitate from the ſolution of ſulphate of iron. In fact, the portion of the alkali which is ſaturated does give a blue precipitate; but the portion which is not ſaturated precipitates iron in the ſtate of ochre, which gives a green tinge to the blue precipitate by intermixing the blue with yellow. According to this ingenious theory, the acid poured on the precipitate ſerves to diſſolve that portion of it which is not in the ſtate of Pruſſian blue, and to improve the colour of that which is. The alum, which is added to the ſolution of ſulphate of iron, ſaturates the alkali which is not already ſaturated with colouring matter; and the earth of this laſt added ſalt, being precipitated with the Pruſſian blue, brightens its dye. As it is neceſſary to pour acid on the precipitate of ſulphate of iron, in order to brighten Pruſſian blue, that acid may be added to the alkali before it be employed to precipitate the iron; for while the acid ſaturates the pure part of the alkali, it does not combine with that which is impregnated with colouring matter, and is capable of inſtantaneouſly forming fine Pruſſian blue. This *phlogiſticated* alkali may be alſo ſaturated with bullock's blood, by digeſting it over Pruſſian blue till it ceaſe to diſcolour it. Macquer has recommended this alkali ſaturated with acid as a good teſt for determining the preſence of iron in mineral waters: but M. Baumé has obſerved, that this liquor itſelf contains a certain quantity of Pruſſian blue, by which it may occaſion miſtakes when applied to this purpoſe. He propoſes, therefore, to digeſt it for ſome time with a little vinegar by a moderate heat, in order that it may depoſite the blue matter which it contains. Such were the reſults of Macquer's ingenious experiments on Pruſſian blue; but that celebrated chemiſt was himſelf very ſenſible

ſible of what was wanting, more eſpecially to explain the nature of the colouring ſubſtance. He could not be perſuaded to conſider that ſubſtance as pure phlogiſton; for he could not conceive how, as is pretended in this hypotheſis, iron ſuperſaturated with the phlogiſtic principle could all at once loſe both the property of obeying the attraction of the loadſtone, and that of being ſoluble in acids, which, according to Stahl, this metal owes to its containing phlogiſton. M. de Morveau, in his excellent diſſertation on phlogiſton, has made the firſt attempt to determine the nature of the colouring part of Pruſſian blue. He obtained, by diſtilling two drachms of this compound, twenty-two grains of a yellow empyreumatic liquor, which effervеſced with alkaline carbonates, and communicated an high red colour to blue paper, but has not been once mentioned by Geoffroy or Macquer, though they likewiſe diſtilled Pruſſian blue.

M. Sage, in the year 1772, ſent to the Electoral Academy of Mayence a memoir on *phlogiſticated alkali*, in which he calls it animal ſalt. The lixivium of fixed alkali, treated with blood and ſaturated by digeſtion on Pruſſian blue, as directed by Macquer, is, according to M. Sage, a neutral ſalt formed by the animal acid with fixed alkali. It affords, by inſenſible evaporation, cubic cryſtals, either octohædral or in priſms with four faces, terminating in pyramids having the ſame number of ſides. This ſalt decrepitates on coals: by a violent heat it melts into a ſemi-tranſparent maſs ſoluble in water, and proper for making Pruſſian blue. M. Sage thinks that it is the phoſphoric acid which neutralizes the alkali in this neutral ſalt; becauſe when the mixture of alkali with bullock's blood is made very hot, it melts, and exhales an acrid vapour attended with white brilliant ſparks, which in his opinion are nothing

thing but phoſphorus in flame. This opinion concerning the nature of the acid of the Pruſſian alkali would be eſtabliſhed as a certain truth, if on the one hand it afforded phoſphorous when diſtilled with coal, a phænomenon which in that caſe Pruſſian blue might likewiſe exhibit; and if, on the other hand, Pruſſian blue could be formed by combining phoſphate of potaſh or ſoda with a ſolution of iron. But, as M. Sage has given no experiments to this purpoſe in his memoir, his theory cannot be admitted:

The chemiſts of the academy of Dijon have in their Elements adopted a part of this laſt doctrine: They conſider the *phlogiſticated* lixivium as a neutral ſalt. They recommend cryſtallizing it by evaporation in preference to purifying it by vinegar, as has been propoſed by M. Baumé. This ſalt, according to them, is very pure; when caſt on nitre in fuſion, it cauſes it to detonize. They ſay nothing of its decompoſition, or the nature of its principles; they call it cryſtallized Pruſſian alkali.

Bucquet, on precipitating with muriatic acid, and afterwards filtrating a lixivium prepared for Pruſſian blue, obſerved, that the alkali, tho' apparently pure after this operation, and without any appearance of Pruſſian blue, yet depoſited a blue powder. After filtrating it above twenty times in the ſpace of two years, in order to ſeparate the blue precipitated after each filtration, he at length found the liquor to be no longer capable of forming Pruſſian blue with the ſolution of ſulphate of iron. I have kept by me for more than eight years a ſmall portion of this lixivium; during the two laſt of theſe years it has given no precipitate, but has depoſited a light bluiſh coating on the ſides of the phial, and has maintained the ſame colour. I have had occaſion to obſerve

obſerve this phænomenon twice ſince I heard Bucquet mention it in his lectures; and I believe it to be invariable. The Duke de Chaulnes ſhowed Macquer a colouring lixivium, which, on being previouſly mixed with an acid, became incapable of affording Pruſſian blue. That chemiſt thinks, that the lixivium which exhibited this phænomenon muſt have been prepared in metal veſſels. Bucquet concluded from the facts which he is above mentioned to have obſerved, 1. That the Pruſſian blue is entirely contained in the alkali employed to precipitate the ſulphate of iron: 2. That acids alone are ſufficient to ſeparate the alkali: 3. That when this alkali has, in the courſe of a certain time, depoſited all the colouring matter which it contained, it is no longer fit for affording Pruſſian blue.

The *Journal de Phyſique* for the month of April 1778, contains obſervations on Pruſſian blue by M. Baunach apothecary at Metz, which contribute greatly to ſupport Bucquet's opinion. After deſcribing the proceſs of the German manufactories for preparing Pruſſian blue, M. Baunach affirms, that the lixivium prepared in thoſe manufactories by the fuſion of alkali, and the hoofs, horns, and hides of cattle, cauſes all metals, and even calcareous earth, to yield a blue precipitate. This alkali, after precipitating metals, diſſolves them; and they may be ſeparated by the muriatic acid, when they will diſplay a very beautiful blue colour. The ſingular facts related in that memoir, ſuch as the diſtillation of the Pruſſian blue produced by this lixivium, which affords neither oil nor ammoniac; the ſolubility of the blue precipitate formed when muriatic acid is poured on this lixivium in nitric acid; the circumſtance of calcareous earth being found in the nitric acid which has deſtroyed the blue; and the exiſtence of a peculiar phlogiſticated earth in it which he could not diſſolve: theſe facts taken together ſeem to ſuggeſt, that this blue is not of the ſame nature with that which is precipitated from the common phlogiſticated lixivium which Macquer found to contain, and which can be produced only from blood.

Since theſe experiments on Pruſſian blue, Scheele has made a new ſeries of reſearches on the nature of this compoſition, which, together with ſome obſervations of which I have not yet ſpoken, throw much new light on its nature.

1. Common Pruſſian blue, diſtilled by naked fire, affords a very large quantity of hydrogenous gas, together with oil, ammoniacal carbonate, and a little acid phlegm. This gas burns with a blue colour like that which riſes from marſhes; its ſmell is empyreumatic; lime-water communicates to it the property of burning with a red flame and detonizing in the air, for it abſorbs from the lime-water a part of its carbonic acid. M. de Laſſone has conſidered the gas of Pruſſian blue as a peculiar inflammable gas. Pruſſian blue, after this analyſis, is in the form of a blackiſh powder, ſubject to the attraction of the loadſtone. M. de Morveau has obſerved, that it becomes orange before taking this colour. He is even of opinion, that Pruſſian blue converted by heat to orange might be advantageouſly employed in painting.

2. Ammoniac heated above Pruſſian blue decompoſes it by ſeizing on the colouring matter, and leaving the iron in the ſtate of brown oxide. Macquer made this fact known in the year 1752. Meyer, following him, has given the name of *tinging* liquor to this volatile alkali ſaturated with blue colouring matter, and recommends the uſe of it in analyſing mineral waters.

I have obſerved, that when cauſtic ammoniac is diſtilled on Pruſſian blue, the liquor which paſſes does not give a blue colour to ſolutions of iron; from which it follows, that the colouring matter is not ſo volatile as ammoniac. When only a part of this ſalt is extracted by diſtillation, the reſidue is of an olive green colour: on diluting it in diſtilled water and filtrating the liquor, it is found to have impregnated the water with colouring matter; and it accordingly affords a very lively Pruſſian blue with ſulphate of iron.

3. In the year 1780 I diſcovered, that when lime-water is digeſted on Pruſſian blue, it diſſolves the colouring matter, if aſſiſted with a little heat. The combination is very rapid: the lime-water acquires a colour, and the Pruſſian blue takes the appearance of ruſt. Filtrated lime-water is of a fine bright yellow colour: It does not turn ſyrup of violets green; it has not an alkaline taſte, and is not precipitated by the carbonic acid; it does not combine with other acids: in a word, it is neutralized by the Pruſſian colouring matter; and when poured on a ſolution of ſulphate of iron, it affords a deep blue, which needs to be brightened by an acid. Scheele has mentioned this Pruſſian lime-water, without knowing any thing of my experiments; notwithſtanding of my having given an account of the reſult in my Elements of Chemiſtry, printed in the year 1781. He is of the ſame opinion with me, that this combination is the very beſt that has been propoſed for determining the preſence of iron; becauſe it contains either none, or at leaſt very little, Pruſſian blue completely formed.

5. The cauſtic fixed alkalis inſtantaneouſly deſtroy the colour of Pruſſian blue with cold. I have obſerved that a pretty lively heat is produced on this occaſion;

that

that the alkalis, when pure, diſcolour much more Pruſſian blue than when ſaturated with carbonic acid; and that they afford much more blue with ſolutions of iron when pure than when carbonated.

6. I found magneſia likewiſe to poſſeſs the property of diſcolouring Pruſſian blue, but not in ſo eminent a degree as lime.

7. Pruſſian blue in powder, if caſt on nitre in fuſion, produces ſome ſparks; from which we may infer, that it contains a combuſtible matter.

8. Pruſſian blue, prepared without alum, becomes very ſubject to the attraction of the loadſtone on being ſlightly calcined; but common Pruſſian blue never acquires this property by the action of fire.

9. Pruſſian blue diſcoloured by alkaline matters, and in the ſtate of oxide of iron, regains a part of its blue colour if an acid be poured into it. The cauſe of this phænomenon ſeems to be, that all the colouring matter has not been carried off by the firſt action of the alkalis; and a portion is ſtill retained among the particles of the oxide of iron.

All theſe facts ſhow, that the colouring part of Pruſſian blue acts as a peculiar acid which ſaturates alkalis, thereby forming neutral ſalts. This is the opinion of a great many chemiſts, particularly of Scheele; whoſe reſearches on this matter I am now to give ſome account of. That celebrated chemiſt has ſhown by his experiments, 1. That the lixivium of blood, or phlogiſticated alkali, is decompoſed by the carbonic acid of the atmoſphere; and that all other acids ſeparate from it the colouring part. 2. That this colouring part is fixed, and retained in the lixivium by a ſmall quantity of pure iron, or ſulphate of iron. 3. That when it is diſengaged by acids, by means of diſtillation, it fills the balloons with a vapour which

which makes ſolutions of iron to yield a blue precipitate. 4. That when Pruſſian blue, or the lixivium of blood, is diſtilled entirely, it affords, together with the colouring matter, other products which alter that matter, ſuch as ſulphur; and that therefore the colouring matter cannot be obtained pure by this proceſs. 5. That Pruſſian alkalis, diſtilled with ſulphuric acid, precipitate a good deal of Pruſſian blue, and afford a liquor impregnated with the colouring matter: the blue precipitated in this operation depends on the iron diſſolved in theſe triple ſalts or compounds of alkali, colouring matter, and iron. 6. That oxide of mercury, or red precipitate, carries off the colouring matter of Pruſſian blue by ebullition, in a quantity of water equal to twice the weight of the two ſubſtances; and that by diſtilling this mercurial Pruſſian lixivium with iron and ſulphuric acid, the iron reduces the mercury after the acid has diſengaged the colouring part: the colouring matter being diſſolved in the water of the receiver as faſt as it is diſengaged, retains a portion of ſulphuric acid: to ſeparate it Scheele mixes a little chalk with the colour, and diſtills it by a moderate fire; the colouring matter then paſſes very pure into the receiver: and as it is diſengaged in the ſtate of an elaſtic fluid, according to what has been obſerved by M. Monge, it may be received and diſſolved in water with the tubes and the apparatus which we have already repeatedly deſcribed.

After theſe experiments on the affinities of the Pruſſian colouring matter, its obſtinate adheſion to alkalis, and the means for obtaining it perfectly pure, Scheele in a ſecond memoir examines into the nature of this ſubſtance and its combinations with alkalis and metallic oxides. Although his experiments are numerous and very accurate, Scheele does not prove in this memoir that the Pruſſian colouring matter is a peculiar acid.

acid. On the contrary, he endeavours to ſhow, that it contains inflammable gas, ammoniac, and a carbonaceous principle. He acknowledges, however, that it renders a ſolution of ſoap turbid, and precipitates *hepars* or alkaline ſulphures; and in a letter to M. Crell, he calls it the colouring acid. We give this ſubſtance the name of the *Pruſſic acid*, and call its ſaline combinations *Pruſſiates* of potaſh, ſoda, ammoniac, &c. In a note by the tranſlator of Scheele, this acid is ſaid to be decompoſable by the acid of nitre; and a proceſs of M. Weſtrumb's is likewiſe given for obtaining Pruſſiate of potaſh very pure. It conſiſts in ſaturating cauſtic potaſh with colouring matter, digeſting it over white lead to purify it from any hepatic gas which it may contain, mixing it with diſtilled vinegar, expoſing it to the ſun, as directed by M. Scopoli and Father Bercia, in order to precipitate the iron entirely, and adding to it two parts of rectified alcohol. The Pruſſiate of potaſh is then depoſited in bright lamellated flakes, waſhed with a new quantity of ſpirit of wine, dried, and diſſolved in diſtilled water. Dr Crell ſays, that Scheele ſent him, three months after M. Weſtrumb, an analagous proceſs for obtaining a teſt liquor, the purity of which might be depended upon, to aſcertain the preſence of iron on any occaſion.

The Pruſſic acid, or the colouring matter of Pruſſian blue, has likewiſe engaged M. Berthollet's attention, who has made ſtill later experiments upon it than any of the above mentioned chemiſts. Though that able phloſopher is not yet fully ſatisfied with his reſearches on this matter; they contain, however, a good many new facts and experiments of ſuch conſequence, as to render it proper for us to give here an extract from his memoir, which he has obligingly communicated.

M. Berthollet firſt obſerves, that there are two kinds of Pruſſiate of iron; the one common Pruſſian blue, the other Pruſſian blue that has loſt a part of the acid which it poſſeſſes in its ordinary ſtate. The laſt of theſe he calls *Pruſſiate of iron with exceſs of oxide.* Pruſſian blue is in this ſtate, after being diſcoloured by an alkali. To ſeparate this exceſs of oxide, he employs the muriatic acid, which diſſolves it, leaving the Pruſſiate of iron in a neutral ſtate. He obſerves, with M. Landriani, that when alkali is digeſted hot on Pruſſian blue, the alkaline Pruſſiate then formed diſſolves more oxide of iron than if the digeſtion had been performed with cold. Both of theſe chemiſts are of opinion, that an acid added to this triple combination combines with the exceſs of oxide of iron, and produces a precipitate of Pruſſian blue, juſt as when Pruſſiate of potaſh is mixed with a ſolution of iron. They ſay alſo, that heat cauſes this combination to yield a yellow Pruſſiate of iron, that is, with exceſs of oxide of iron. According to them the acid added ſeizes the exceſs of oxide of iron, and the Pruſſian blue becoming then leſs ſoluble in the alkaline Pruſſiate, is of conſequence precipitated. When the Pruſſiate of potaſh, prepared by a moderate heat, has depoſited the Pruſſiate of iron with exceſs of oxide of iron, by ebullition, it may then be evaporated to dryneſs, diſſolved again in water and mixed with acids; but will not, by any of theſe expedients, be brought to depoſite Pruſſian blue. M. Berthollet ſays, that by evaporating the ſolution of Pruſſiate of potaſh thus purified, octahædral cryſtals are obtained with two pyramids truncated, ſo as to repreſent ſquare plates with their edges cut ſloping.

This chemiſt, on mixing a ſolution of theſe cryſtals with ſulphuric acid, and expoſing the mixture in a phial to the rays of the ſun, obſerved, that in a ſhort time a blue colouring matter began to appear, and was gradually precipitated till the mixture was entirely decompoſed. A mixture of the ſame kind, preſerved in a dark place, does not become blue, nor yield a precipitate, even tho' ſuffered to ſtand untouched for a number of months. A ſtrong heat produces abſolutely the ſame effect. From theſe experiments, M. Berthollet ſhows, how inaccurate the principles on which the proceſſes recommended for purifying alkaline Pruſſiates were founded. For, ſays he, inſtead of purifying them of a portion of Pruſſian blue, which chemiſts pretended to be only accidentally mixed in them, they decompoſed moſt part of the matter which they attempted to purify. As Pruſſiate of potaſh is a triple ſalt, the Pruſſic acid has but a very faint diſpoſition to adhere with potaſh, and may be ſeparated from it by any other acid. When the extraneous acid combines with the potaſh, one part of the Pruſſic acid combines with the oxide of iron to form Pruſſian blue, and the other is either volatilized in the ſtate of acid, or reduced to its principles.

The iron precipitated by alkaline Pruſſiates retains, according to M. Berthollet, no ſmall portion of thoſe ſalts; by repeated waſhing it may be purified of them; theſe lixiviums contain alkalis combined with a ſmall portion of Pruſſic acid; and the Pruſſiates with exceſs of alkali are not ſeparated till after the exceſs of acid contained in the ſolution of iron is carried off by the firſt waſhings; for the latter waſhings precipitate the iron in the ſtate of blue from its ſolutions, which the firſt do not.

The only diſcernible difference which he has found between Pruſſiate of potaſh and Pruſſiate of ſoda is, that

that the latter cryſtallizes differently from the former. Mineral acids diſengage the Pruſſic acid, which is in part fixed in the Pruſſian blue that is precipitated. This led Scheele to think of another combination, from which he might, with greater facility, obtain this acid pure, on which M. Berthollet has made ſome obſervations. This proceſs, as we have already mentioned, conſiſts in boiling red oxide of mercury with Pruſſian blue and diſtilled water. The Pruſſic acid then forſakes the oxide of iron to unite with the oxide of mercury, with which it has a ſtronger affinity, and forms a ſoluble ſalt which cryſtallizes in tetrahædral priſms, terminating in quadrangular pyramids, the ſides of which correſpond to thoſe of the priſms. To this lixivium, after filtrating it, iron and concentrated ſulphuric acid are to be added; the iron unites with the oxigene of the mercury, and afterwards combines with the ſulphuric acid; the mercury is precipitated in a metallic ſtate, as appears from its luſtre. Scheele next diſtilled this mixture by a moderate heat, to avoid volatilizing the Pruſſic acid; but he obſerved that, however moderate the heat which he employed, the Pruſſic was always mixed with a little ſulphuric acid. To prevent this, he added to the mixture a certain quantity of chalk to fix the ſulphuric acid. Concerning this addition, M. Berthollet has obſerved, that, as Scheele has not ſpecified the quantity, this operation might very eaſily miſcarry, if the chalk were ever ſo little above what is ſufficient to ſaturate the ſulphuric acid: for calcareous Pruſſiate muſt then be formed, which, by the law of double affinities, would decompoſe the ſulphate of iron.

M. Berthollet has obſerved, that the ſulphuric acid diſengages but a ſmall portion of acid from Pruſſiate of

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mercury; and that it combines with the greateſt part of that ſalt without decompoſing it, thus forming a triple ſalt which cryſtallizes in ſmall needles. According to his experiments, the muriatic acid diſengages more of the acid of Pruſſiate of mercury than the ſulphuric acid does; forming like it a triple ſalt cryſtallizable in needles, and much more ſoluble than corroſive mercurial muriate. Alkalis and lime cauſe this triple ſalt to yield a white precipitate. M. Berthollet proves, that alkaline Pruſſiates do not precipitate barytes from its ſolutions, as Bergman thought, but join with the ſolution to form triple ſalts: he ſhows that they precipitate aluminous earth. The precipitate which they form with this ſubſtance ſuffers no alteration from the ſulphuric acid; but when digeſted with ſulphate of iron, it forms Pruſſian blue.

The Pruſſic acid decompoſes the oxigenated muriatic acid, and by abſorbing its oxigene, becomes odorate. In this ſtate it does not ſeem to have any great tendency to unite with alkaline ſubſtances; for they ſcarce render its ſmell any thing weaker. It no longer cauſes ſolutions of iron to yield a blue, but a green, precipitate. The contact of the rays of the ſun renders it blue again; iron and ſulphureous acid produce the ſame effect upon it The phænomena appear when oxigenated muriatic acid, ſulphate of iron, and Pruſſiate of potaſh, are mixed together. M. Berthollet concludes from this, that Pruſſian blue is liable to no alteration either from light or from the ſulphureous acid, and that it owes its green colour, ſolubility in acids, &c. to its having abſorbed oxigene.

If the Pruſſic acid be ſuperſaturated with oxigenated muriatic acid, and after that expoſed to the rays of light, it aſſumes new characteriſtic properties. It no longer

longer combines either with oxide of iron, or with water; but is found precipitated to the bottom of either of theſe liquors, in the form of oil, with an aromatic ſmell. If more oxigene be added to it when in this ſtate, and it be now left expoſed to the ſun, it cryſtallizes in ſmall white needles. This acid thus oxigenated is reduced to vapours by a moderate heat; theſe vapours are neither ſoluble in water nor combuſtible. M. Berthollet has not yet been able to determine what paſſes in this operation. Is the Pruſſic acid ſimply united with oxigene, without ſuffering any alteration? or is there one of it principles burnt? I am rather inclined to agree with him in adopting the laſt of theſe ideas: For though oxigene appears very little diſpoſed to combine with the Pruſſic acid; yet the Pruſſic acid can no longer be reſtored to its oxiginal ſtate, after being treated in this manner with the oxigenated muriatic acid.

The Pruſſic acid prepared for forming a green precipitate with iron, by means of the oxigenated muriatic acid, forms ammoniac whenever lime or an alkali is mixed with it. Though an acid be poured into this laſt mixture, yet it does not regain the peculiar odour of the Pruſſic acid; from which M. Berthollet concludes it to have been deſtroyed by the mixture of the alkaline or calcareous ſubſtance. Although the potaſh employed were perfectly pure, yet an acid poured in after it, produces an effervеſcence, and diſengages carbonic acid.

From all theſe experiments, M. Berthollet concludes, that azote, hydrogene, and the pure coaly principle, combined in proportions, and condenſed to a degree ſtill unknown, form what is called the *Pruſſic acid.* The knowledge of this compoſition enables us to underſtand

derſtand how the Pruſſic acid comes to be formed in animal matters, in certain vegetable ſubſtances, and in ammoniacal muriate contaminated with charcoal. It explains likewiſe the reaſon why this acid is ſo combuſtible and detonizes with ſuch force with various nitrates, why it affords ammoniacal carbonate by diſtillation, and why the ſame ſalt is formed in it on the addition of oxigenated muriatic acid. M. Berthollet doubts if this ſingular combination contain oxigene. At leaſt, ſays he, if the Pruſſic acid *do* contain oxigene, it contains ſo very little that the carbonaceous matter is not entirely reduced by it to carbonic acid; for Pruſſian blue affords, by diſtillation, a good deal of carbonated hydrogenous gas.

Such are the facts diſcovered by M. Berthollet. By aſcertaining the nature of the colouring matter of Pruſſian blue, he has proved it not to be a genuine acid, however it may act as an acid in all its combinations. M. Veſtrumb and M. Haſſenfratz have found in Pruſſian blue a little phoſphoric acid. But the laſt of theſe gentlemen ſhows that acid not to be eſſential to its nature.

Sulphate of iron very eaſily decompoſes nitre. The decompoſition is partly owing to the ſulphuric acid, which by combining with the alkali of the nitre, expels the nitric acid; but it is likewiſe owing in a great meaſure to the reaction of the iron on the laſt mentioned acid. If the ſulphate of iron employed to decompoſe nitre be ſcarcely dry, a large quantity of nitrous acid is then obtained, very red and fuming: the reſidue, on being lixiviated, affords ſulphate of potaſh, fixed alkali, and red oxide of iron remaining on the filters. But if the ſulphate of iron have been well calcined, and the nitre melted, the product obtained will then be very ſcanty.

This

This product conſiſts of two liquors; one of which being of a dark colour, almoſt black indeed, ſwims on the ſurface of the other, which is red and ponderous, like oil above water. Accordingly, M. Baumé conſiders this liquor as a kind of oil. There afterwards paſſes into the neck of the retort a white ſaline maſs, which attracts the moiſture of the atmoſphere, and is ſpeedily diſſolved in water with heat, exhaling at the time a ſtrong ſmell of ſpirit of nitre, and very thick red vapours. This ſolution, when ſaturated with potaſh, affords ſulphate of potaſh. The white maſs is therefore nothing but ſulphuric acid rendered concrete by a portion of nitrous gas.

There appears to be no difference between the heavy liquor in the balloon and ſpirit of nitre obtained in Glauber's way. But the light liquor that ſwims above, on being mixed with ſulphuric acid, produces a lively effervеſcence; and even a dangerous exploſion. Almoſt the whole of the nitrous acid is diſſipated, and the ſulphuric acid takes a concrete cryſtalline form. Bucquet, who communicated this diſcovery to the Academy, had at firſt obſerved, that this concrete acid, obtained by diſtillation, exhales red nitrous vapours when diſſolved in water. He inferred, that the ſolidity of the acid muſt be owing to its containing nitrous gas. But to determine this with greater certainty, he attempted to mix the blackiſh brown nitrous acid, which ſwims above the red, with ſulphuric acid highly concentrated. But at the very inſtant of the mixture, ſo rapid a motion took place, that the ſpirit of nitre poured on the ſulphuric acid was expelled with noiſe to a great diſtance; and the perſon who made the mixture was covered all over with ſulphuric acid; and there immediately appeared on his countenance a great many red inflamed

inflamed pimples, which ſuppurated like the ſmall-pox. The ſulphuric acid became ſoon after concrete preciſely like that obtained by diſtillation, of which we have given the hiſtory. From this fact it appears that this acid may be rendered concrete as well by nitrous as by ſulphureous gas.

The reſidue remaining after the diſtillation of nitre by ſulphate of iron calcined to redneſs, is nothing but ſcoriæ of iron, from which but very little ſulphate of potaſh can be extracted by waſhing.

The ſolution of ſulphate of iron ſuffers no alteration from hydrogenous gas. But though the baſe of this elaſtic fluid appears to have leſs affinity than iron with oxigene, as has been ſhown in the hiſtory of the decompoſition of water; yet M. Monnet has obſerved, that hepatic gas communicates to ſulphuric mother water the property of affording cryſtals: And Dr Prieſtley has reduced brown oxides of iron by the contact of hydrogenous gas. Theſe facts do not contradict our doctrine; they rather confirm it. In fact, iron may be deprived of whatever oxigene it contains above the proportion of 0,28 by the action of hydrogene; but this proportion it obſtinately retains, however attacked by that principle. Such is the reaſon why in theſe inſtances of reduction nothing is ever obtained but a black oxide, or martial Æthiops, and why iron oxidated by water is always black.

Alkaline ſulphures precipitate ſulphate of iron with a blackiſh colour. This precipitate is a kind of martial pyrites, or ſulphure of iron.

The nitric acid is rapidly decompoſed by iron, which diſengages from it a good deal of nitrous gas, eſpecially if the acid employed be concentrated, and the iron in a ſtate of diviſion. The metal is ſpeedily calcined by the

the oxigene which it attracts from the acid of nitre; the ſolution is of a brown red colour; at the end of a certain time it is found to have depoſited oxide of iron, eſpecially if it have been expoſed to the contact of air. On immerſing into it a new quantity of iron, the acid, as has been obſerved by Stahl, is diſſolved, and the oxide of iron which it held in ſolution inſtantaneouſly precipitated. Yet by employing weak nitric acid and iron in ſmall pieces, a more permanent ſolution may be obtained, in which the metal adheres with more obſtinacy to the acid. This laſt combination is greeniſh, and ſometimes of a bright yellow colour. Both theſe ſolutions, when evaporated, become turbid, and depoſit a brown red martial ochre. But if the latter be highly concentrated, inſtead of affording cryſtals, it takes the conſiſtency of a reddiſh jelly, in part ſoluble in water, the greateſt part, however, being precipitated on ſuch an occaſion. On continuing to heat nitrate of iron, it gives out a good deal of red vapours; and the magma, becoming dry, affords a brick-coloured oxide. This magma, when diſtilled in a retort, affords a ſmall quantity of fuming nitrous acid, a good deal of nitrous acid, a good deal of nitrous gas, and ſome azotic gas. There can be no vital air obtained from it, becauſe the iron retains all the oxigene of the acid. The oxide which remains after the diſtillation of nitrate of iron is of a lively red colour, and would make a fine colouring matter for painters, &c. The nitrous ſolution of iron, however highly ſaturated, has never, on any occaſion, appeared to me liable to be precipitated by diſtilled water. The alkalis decompoſe it with phænomena diverſified according to their different natures. Cauſtic potaſh makes it yield a bright brown precipitate: the mixture aſſumes very ſpeedily a blackiſh brown colour, much deeper than that of the former ſolution. The cauſe of this phænomena is, that a portion, though a very ſmall one indeed, of the precipitate is diſſolved by the alkali. Carbonate of potaſh ſeparates from it a yellowiſh oxide, which very ſoon takes a beautiful orange red colour. If this mixture be ſtirred in proportion as the efferveſcence takes place, the precipitate is again diſſolved in much greater abundance than that which is produced by cauſtic potaſh. M. Monnet has accurately obſerved this phænomenon, and he aſcribes it with good reaſon to the gas which is diſengaged. This ſolution of iron by fixed alkali bears the name of *Stahl's alkaline martial tincture*. Its colour is a very beautiful red. M. Baumé adviſes to prepare it with a nitrous ſolution of iron containing but a ſmall portion of the metal. Stahl again recommended an highly ſaturated ſolution. M. Monnet has obſerved, that a yellow ſolution affords a copious precipitate, which is ſcarce diſſolved again in alkali, and does not colour it like martial tincture; whereas a very red ſolution inſtantaneouſly forms a martial tincture with the ſame alkali. Stahl's martial tincture loſes its colour in a certain time, and depoſites the oxide of iron which it contains. It may be decompoſed with the help of an acid. The acid of nitre ſeparates from it a red brick-coloured oxide, which is ſoluble in acids, and is called *Stahl's aperient ſaffron of Mars*. Either pure or cauſtic ammoniac cauſes the nitric ſolution of iron to yield an almoſt blackiſh deep green precipitate. Ammoniacal carbonate diſſolves again the iron which it ſeparates from the acid, and takes a red colour ſtill more lively than that of Stahl's tincture. This ſolution of iron by ammoniacal carbonate might be of great uſe in caſes in which

which there is need both of a powerful tonic and an active diſcuſſive.

I have never been able to obtain more than a very ſmall quantity of genuine Pruſſian blue from the red, ſaturated, nitric ſolution of iron, by alkali ſaturated with the colouring matter of that compoſition. I could never obtain any thing but a blackiſh precipitate, liable to be again diſſolved by the muriatic acid: the liquor, on this laſt event, aſſumed a green colour.

M. Maret, ſecretary to the Academy of Dijon, has ſent to the Royal Society of Medicine a proceſs for making *martial Æthiops* very quickly. It conſiſts in precipitating the nitric ſolution of iron by cauſtic ammoniac, and in waſhing and drying the precipitate without loſs of time. M. d'Arcet, who was employed by the Society to examine M. Maret's proceſs, did not uniformly obtain the ſame reſult. In my Memoirs on Precipitates of Iron, I have determined in what caſes M. Maret's proceſs muſt ſucceed, and when it is likely to fail. To obtain this Æthiops, it is requiſite, 1. That the ſolution of iron have been lately formed, and that very ſlowly, of weak nitric acid, and iron ſomewhat divided, both cold. 2. That the ammoniac be recently prepared, very cauſtic, and, above all, have loſt by ſtanding undiſturbed for ſome time the ſmall portion of calcareous earth and blackiſh combuſtible matters with which it uſually carries up from the ſal ammoniac and lime, not extracted in Woulfe's apparatus. 3. That the precipitate be inſtantly ſeparated from the liquor, and ſpeedily dried in cloſe veſſels. Even when all theſe precautions are carefully taken, the precipitate is ſometimes not very black, but rather of a light brown colour. It riſes in ſcales, the under ſurface of which is blackiſh; a circumſtance which proves that the contact of air ſlightly ruſts its upper ſurface. I have obtained a more beautiful and permanent *Æthiops* by precipitating muriatic and acetous ſolutions of iron with fixed alkali and cauſtic ammoniac; waſhing theſe precipitates ſufficiently, and then drying them ſpeedily in cloſe veſſels. Yet I am of opinion, that theſe *Æthiops*, however pure they may be ſuppoſed to be, ſtill retain a ſmall portion of their precipitants and firſt ſolvents; as has been obſerved by M. Bayen of the precipitates of mercury; and they cannot therefore be employed in medicine with ſo much certainty as thoſe which I have above-mentioned. M. d'Arcet, in his report to the Royal Society of Medicine concerning M. Maret's proceſs, has communicated a proceſs of M. Crohare's for making *martial Æthiops*. This apothecary, who is known by a number of judicious chemical operations, prepares *martial Æthiops*, by boiling water acidulated with a little nitric acid, upon iron filings. The metal is immediately ſlightly oxidated, and affords a good deal of black oxide, or *martial Æthiops*. But in my opinion, M. Joſſe's proceſs is preferable to all of theſe; it is eaſily performed, and is attended with no danger.

As iron is often uſed in procuring nitrous gas, it cannot be improper to obſerve here, that the nature of this gas is never preciſely the ſame on two occaſions; it varies amazingly, according as the circumſtances of the ſolution are diverſified, as the acid contains more or leſs azote and oxigene, as the iron is more or leſs diſpoſed to abſorb oxigene, as the temperature of the matters is hotter or colder, &c. Gas prepared by this proceſs generally contains more or leſs azote; for as iron abſorbs a greater proportion of oxigene than moſt other

other bodies, and abſorbs different quantities of it according as it is more or leſs completely in a metallic ſtate; the effects of nitrous gas diſengaged by this metal are therefore more or leſs uncertain in eudiometric experiments. This truth, which is applicable to all bodies that ſeparate nitrous gas from the acid of nitre, ſhows how little the aſſays of eudiometers with nitrous gas are to be depended upon. Alkaline ſulphures are therefore much preferable as teſts for determining the purity of air.

The muriatic acid diluted in water diſſolves iron rapidly. A large quantity of hydrogenous gas is diſengaged from this ſolution, the production of which muſt be owing to the decompoſition of water, in the ſame manner as when the metal is diſſolved in the ſulphuric acid. The hydrogenous gas produced by the action of iron on the muriatic acid was formerly thought to be different in nature from that which is diſengaged from the ſulphuric ſolution of iron. This elaſtic fluid was then thought to be one of the principles of the muriatic acid. But ſince the diſcovery of the decompoſition of water by iron, it has been proved, that the water, and not the muriatic acid, the nature of which is ſtill unknown, gives riſe to the hydrogenous gas diſengaged from the muriatic ſolution of iron; for the acid remains undiminiſhed and unaltered after the exhalation of this gas, and the ſame quantity of alkali is neceſſary to ſaturate it which it would have required before. This ſolution of iron by the muriatic acid produces a conſiderable heat; which continues to be felt till the acid be ſaturated: a portion of the iron is precipitated in real *Æthiops*, in this as well as in all its other ſolutions When filtrated, it is of a green colour, inclining to yellow: It is much more permanent than either of the two former: when incloſed in a phial properly ſtopped, it depoſites no oxide. I have kept by me ſome of it for eight years; in all which time it has depoſited nothing but a very light pale yellow duſt. But, again, when it is left expoſed to the air, it depoſites in a few weeks almoſt all the air that it contains; and the more it has been brought into contact with air, the brighter is the colour of the precipitate. It is at preſent known as a certain fact, that this precipitation, which is in the ſame manner produced in all the other ſolutions of iron, is owing to the metal abſorbing the oxigene of the atmoſphere; as I conjectured and ſuggeſted to the public in the year 1777. (See *my Memoirs on Chemiſtry.*)

Stahl announced to the world, that in the combination of iron with the muriatic acid, the muriatic acquired the characteriſtic properties of the nitric acid. But this fact has not been obſerved by any other chemiſt. It appears that Stahl attended only to the yellow-colour of this ſolution, and the ſmell which it diffuſes: a ſmell in fact but little different from that of ſpirit of ſalt, and much the ſame with that of the oxigenated muriatic acid.

The ſolution of iron by the muriatic acid does not cryſtallize regularly when evaporated. M. Monnet has obſerved, that if left to cool, when its conſiſtency is that of a ſyrup, it forms a kind of magma, in which flat needled cryſtals are obſerved, which are liable to deliquiate. This magma melts by a very moderate heat; when a ſtronger heat is applied, it is decompoſed, but not ſo eaſily as nitrate of iron; and when dry, it takes the colour of ruſt. There is diſengaged from it a portion of muriatic acid, which may be obtained by diſtillation;

ſtillation; and which, as has been remarked by Brandt, carries off with it a little oxide of iron.

The Duke d'Ayen, in four excellent Memoirs on the combinations of iron with acids, which he has given the Academy, has entered into a minute examination of what paſſes when muriate of iron is decompoſed in a retort. He obtained from this operation three very ſingular products: He firſt obtained, by a moderate heat, a phlegm ſlightly acidulated: the muriatic acid was then concentrated; and its gas, though much more volatile than water, was in part fixed by the iron. By a much ſtronger heat, a part of the acid was volatilized with a little iron, and ſome cryſtals, not diſpoſed to deliquiate, were formed in the balloon. At the ſame time, there were ſublimed to the upper part of the retort a number of very tranſparent cryſtals, reſembling razor-blades, which decompoſed the light like the moſt beautiful priſms, diſplaying very beautiful ſhades of red, yellow, green, and blue. There remained at the bottom of the retort a ſtiptic, deliquiating ſalt, of a brilliant colour and a foliated form, preciſely like that ſpecies of talc in large plates, which is improperly called *Muſcovy glaſs.* This laſt ſalt, when expoſed to a violent heat in a ſtone retort, was decompoſed, and afforded a ſublimated product of a ſtill more ſurpriſing nature than any of the former products. It was an opaque matter, truly metallic in its nature, and when examined by the microſcope, it exhibited regular cryſtals, or ſections of hexagonal priſms, which the Duke d'Ayen compares to the ſquare pieces of wood uſed in flooring rooms. Thoſe cryſtals were as brilliant as the beſt poliſhed ſteel, and equally ſubject to the attraction of the loadſtone; this was iron partly reduced and

and ſublimated *. Art ſeems, in this inſtance, to effect an imitation of nature, which ſublimes black oxides of iron by the fire of volcanoes, in the form of bright poliſhed plates like ſteel. Such at leaſt appears to be the origin of the ſpecular iron of Mont d'Or and of Volvic; which, according to the accurate obſervations of M. de l'Arbre, phyſician at Riom, is always in the chinks of lavas.

From theſe particulars, it appears what ſingular phænomena the ſcience of chemiſtry offers to our obſervation, and what valuable diſcoveries it promiſes to ſuch as ſhall purſue a train of experiments with the accuracy and perſeverance of the Duke d'Ayen. Let it not eſcape us, that this reduction of iron favours the doctrine of gaſes, and that ſimilar products might be obtained by the ſame proceſs from many other ſolutions of metals.

The muriatic ſolution of iron is decompoſed by lime and alkalis, like all martial ſolutions; but theſe precipitates are not ſo much altered, and may be very eaſily reduced, eſpecially ſuch as are produced by cauſtic alkalis. I have already obſerved, that this combination affords by precipitation the pureſt *Æthiops*, or black oxide of iron, that can poſſibly be obtained. Alkaline ſulphures, ſulphurated hydrogenous gas, and aſtringents, decompoſe this ſolution

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* I have in my cabinet a black iron ore, with ſmall and very brilliant laminæ, half a line in breadth, the form of which nearly reſembles that of the cryſtals obtained by the Duke d'Ayen. They are very thin ſmall ſcales, of a very ſparkling grey iron-colour, diſpoſed ſlopewiſe, ſo as to interſect each other in all directions, and diſperſed in a reddiſh opaque quartz, or a kind of coarſe jaſper. This beautiful ſpecimen comes from Lorraine. The iron of Framont is of the ſame nature. A.

ſolution as well as the other two: laſtly, Pruſſian alkalis, or alkaline Pruſſiates, cauſe it to yield a very beautiful blue precipitate.

Water impregnated with carbonic acid eaſily diſſolves iron: all that is neceſſary in order to accompliſh this combination is to put iron filings into the acidulated liquid, and to leave the mixture to digeſt during a few hours. This liquor, after being filtrated, has a pungent and ſomewhat ſtyptic taſte. Meſſrs Lane and Rouelle have obſerved the carbonic acid to poſſeſs this property. Bergman calls this combination *aerated iron*, and ſays, that when expoſed to the open air it acquires a rainbow-coloured pellicle; that it is decompoſable by pure alkalis; but that alkalis ſaturated with carbonic acid produce not the ſame effect upon it. This ſolution gives a green tinge to ſyrup of violets, and affords with calcareous Pruſſiate a very brilliant Pruſſian blue. When expoſed to the air or heated, it precipitates brown oxide of iron. The name which we give to this combination is *carbonate of iron*. Iron has a ſtrong tendency to combine with the carbonic acid. In nature we often find it in this ſtate. Muddy iron ores and ſparry iron appear to conſiſt moſtly of this combination. Ferruginous mineral waters often contain iron in the ſtate of carbonate of iron. This ſalt, when ſeparated from the water, and dried, is ſcarce ſoluble in that fluid. But it diſſolves plentifully in liquid carbonic acid, ſubſiding, however, in a precipitate when the acid is volatilized. We know not in what manner the fluoric and the boracic acids act upon iron.

This metal very readily decompoſes ſulphuric ſalts, particularly ſulphate of potaſh or ſoda. I have treated thoſe ſalts with iron in a crucible, and have found them reduced by ſuch treatment to the ſtate of ſulphures.

phures. The lixivium of a ſulphure of this kind is of a very deep green colour. A few drops of acid very ſpeedily deſtroy the colour of this metallic tincture. The greateſt part of the iron, oxidated by the oxigene of the ſulphuric acid, remains undiſſolved in the water of the lixivium; and acids diſengage from it a large quantity of ſulphurated hydrogenous gas.

Iron cauſes nitre to detonize. On throwing into a red hot crucible a mixture conſiſting of equal parts of iron filings and dry nitre, in a certain time a very rapid motion is excited, and a great many bright ſparks fly out of the crucible. When the detonation is over, the crucible contains a reddiſh oxide of iron, of which a ſmall part is combined with the alkali; when this matter is waſhed, the water diſſolves the alkali, and the oxide of iron remains on the filter. This oxide was formerly called *Zwelfer's ſaffron of Mars.* It is of a reddiſh yellow colour, and is ſcarce ſoluble in acids. The alkali ſeparated from it by waſhing is cauſtic, according to moſt chemiſts; for it is generally thought that metallic oxides act like pure lime on this ſalt, thus ſaturated with carbonic acid *.

Iron eaſily decompoſes ammoniacal muriate. Two drachms of iron-filings, triturated with a drachm of this ſalt, give out no ammoniac gas. Bucquet, who diſtilled this mixture in a pneumato-chemical apparatus with mercury, obtained from it fifty-four cubic inches of aeriform fluid; one half of which was ammoniac gas, and the other half hydrogenous gas. Four ounces of the ſame

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* It is to be obſerved, that ſince Black's theory, concerning the cauſticity of lime and alkalis, has been received, the proper experiments have not yet been made to determine whether metallic oxides and lime, properly ſo called, agree in their phænomena in this reſpect. And, till experiment determine, we can ſay nothing certain on this head. A.

ſame filings, with two ounces of ammoniacal muriate, afford, when diſtilled in a retort with a common receiver, about two drachms of liquid ammoniac, impregnated with a little iron, which it ſoon depoſites in the ſtate of oxide of iron. The reſidue of theſe operations is muriate of iron. What occaſions the decompoſition of ammoniacal muriate by iron is, that the metal eagerly combines with muriatic acid: a proof of which is the diſengagement of hydrogenous gas, obſerved to take place during the operation. In pharmacy, there is a medicine prepared of ammoniacal muriate and iron, which is called *martial flowers of ſal ammoniac*, or *ens martis*. A pound of ammoniacal muriate in powder is mixed with an ounce of iron-filings: this mixture is expoſed in an earthen pot covered with another veſſel of the ſame kind to a fire ſufficient to make the under part of the apparatus red hot. In five or ſix hours there is a yellow matter ſublimated, which is to be preſerved in a phial: this matter is the *martial flowers*. This ſubſtance conſiſts chiefly of ſublimated ammoniacal muriate with a little oxide of iron. As the metal very readily decompoſes this ſalt, only a very ſmall quantity of it muſt be employed, in order that the greateſt part of the ſalt may be ſublimed in its natural ſtate. That portion of the oxide of iron which is volatilized, communicates a colour to the ammoniacal muriate, which is at the ſame time ſublimated.

Oxide of iron decompoſes this ſalt better than the metal itſelf; for it diſengages the ammoniac with cold. That which is obtained by diſtillation is very fluid and ſufficiently cauſtic. I have obtained ammoniac, which gave a ſlight efferveſcence with acids, by diſtilling ammoniacal muriate with half its weight of *aperitive ſaffron of Mars*, or oxide of iron prepared with acceſs of air,

air, and of conſequence containing carbonic acid. In this inſtance, the carbonic acid diſengaged from the iron combined with the ammoniac, and ſo rendered it effervefcent.

Iron is altered in its colour by hydrogenous gas; but the alteration which it ſuffers has not been yet ſufficiently examined. Black oxide of iron is not decompoſed by this gas; but the brown or the red oxide eaſily are, and they then paſs into the ſtate of black oxide; for hydrogene robs them of all the oxigene they contain, more than what is requiſite to maintain them in the ſtate of black oxide, Sulphur combines rapidly with iron. A mixture, conſiſting of iron-filings and ſulphur in powder, and moiſtened with a little water, becomes hot in a few hours. It then ſwells, acquires conſiſtency, abſorbs the water, burſts with a diſcernible crackling, and exhales a good deal of aqueous vapour, accompanied with a fœtid odour, very like that of ſulphurated hydrogenous gas. When the mixture is a large maſs, it takes fire in the ſpace of four and twenty or thirty hours, and as ſoon as ever the aqueous vapours ceaſe to ariſe from it. When ſubſtances have nearly ceaſed to act on each other, the heat rapidly increaſes, and inflammation takes place. The ſmell then becomes much ſtronger; it ſeems to be owing to the hydrogenous gas produced by the action of the ſulphur and iron on the water. This ſmell is mixed with another, that of alkaline ſulphures and pure hydrogenous gas: the inflammation obſerved in this experiment is, no doubt, owing to a copious diſengagement of hydrogenous gas; for the flame is more lively than that of ſulphur. It riſes a foot high, according to M. Baumé's account, who obſerved this phænomenon on a mixture conſiſting of an hundred pounds of iron-filings and as much

much ſulphur in powder: it laſts only for two or three minutes; the mixture continued red and burning for forty. M. Baumé explains this inflammation into the diſengagement of the phlogiſton of the ſulphur into the ſtate of fire at liberty. Lemery, the father, has given the name of artificial volcano to this experiment. He imagined the fires which kindle in the interior parts of our globe, and by forcing their way to the ſurface produce earthquakes and volcanoes, to ariſe from a ſimilar combuſtion of pyrites piled on each other, and moiſtened by water. In his opinion, theſe awful phænomena might be imitated, by burying in the earth a mixture of ſulphur in powder and iron-filings reduced to a paſte with water, and covering it over with earth preſſed cloſely down upon it. This experiment did not ſucceed with Bucquet, who repeated it with the greateſt exactneſs. Dr Prieſtley ſeemed to ſhow the reaſon why it failed. That philoſopher obſerved, that the moiſtened mixture of ſulphur and iron abſorbed a certain quantity of air, which might be thought neceſſary to its inflammation. But, notwithſtanding this, the inflammation takes place without the contact of air. It appears, in fact, that the iron being very much divided, reacts on the fluid, and ſeizes its oxigene; in conſequence of which it is calcined, and gives out hydrogenous gas, which takes an elaſtic form by means of the heat ſeparated from the water. This gas alſo diſſolves a portion of the ſulphur, and thus becomes ſulphurated hydrogenous gas.

There is a ſtrong analogy between this combination of iron and ſulphur by the humid way and the efflo-reſcence of *pyrites;* which, when they are moiſtened by water, produces ſulphurated hydrogenous gas.

Sulphur combines very eaſily with iron by fuſion; the reſult is a ſulphure of iron, or pyrites, arranged in needles,

needles. As in this caſe the ſulphur increaſes greatly the fuſibility of iron, the metal may be inſtantaneouſly melted with the help of this combuſtible body. In order to this, a ſmall bar of iron heated to whiteneſs, may be applied to a roll of ſulphur, and the melted matter which runs from them received into water. It will be found in the fluid in brittle blackiſh globules, reſembling *pyrites*, and, like them, in the form of ſmall ſlender concentric pyramids.

Iron with arſenic affords a brittle mixture, which is but very little known.

This ſemi-metal appears to exiſt in many iron ores; and it is in conſequence of being intermixed with it that iron is brittle when hot.

With cobalt, iron forms a ſemi-metal, with ſmall cloſe grains, hard, and not eaſily broken.

It does not appear capable of combining with biſmuth.

In combination with antimony, it forms a brittle alloy with ſmall facets, which yields but very little to the hammer. Iron has more affinity than antimony with ſulphur; and is of conſequence capable of decompoſing ſulphure of antimony. To effect this decompoſition, make five ounces of the points of horſe-ſhoe nails red hot in a crucible; throw upon them a pound of pulverized ſulphure of antimony; and apply ſpeedily to this mixture a heat ſufficiently ſtrong to melt it: when it is pretty well melted, add an ounce of nitre in powder, to promote by a thorough fuſion the ſeparation of the ſcoriæ from the ſemi-metal; let the mixture be now left to cool, and the antimony will be found by itſelf not impregnated with any iron. If the mixture employed conſiſt of one part of iron with two of ſulphure of antimony, the ſemi-metal will be alloyed with iron. The ſcoriæ which are found above antimony alloyed with iron,

and

and prepared with nitre and tartar, are of a yellowiſh colour like amber, which they owe to the iron contained in them. Stahl has, on this account, called them *ſuccinated ſcoriæ.* He directs to reduce them to powder; then boil the powder in water, which mixes intimately with the moſt ſubtle part of it; decant off the liquor; filtrate it; and detonize the powder remaining on the filter three times with nitre; then waſh and dry it: and the matter thus prepared is Stahl's *aperitive ſaffron of antimoniated Mars.*

It is ſtill uncertain whether zinc be capable of entering into union with iron. Malouin, in his Memoir on Zinc (*Academy*, 1742), has ſhown, that this ſemi-metal may be applied like tin to the ſurface of a piece of iron, ſo as to ſecure it from the contact of air; a circumſtance which ſhows, that theſe two metallic matters are capable of entering into combination with one another.

It appears that nickel enters into a very intimate union with iron; for, as Bergman has ſhown, theſe two metallic ſubſtances can never be entirely ſeparated.

Mercury can contract no union with iron in its metallic ſtate. Ineffectual attempts have been made to produce a direct combination of theſe two ſubſtances; but their oxides have been combined. Navier has obſerved, that a ſnowy white precipitate may be obtained by mixing together a ſolution of iron and a ſolution of mercury, both made by the ſulphuric acid; and on evaporating this mixture, ſmall flat cryſtals are formed in it, very thin, and reſembling the boracic acid. Navier is convinced that theſe cryſtals are a combination of iron with mercury.

Lead cannot enter into union with iron.

It appears that iron and tin may be combined by fuſion.

ſion. That art which conſiſts in coating the ſurface of iron with tin, or preparing white iron, ſhows this combination to be poſſible. The ſurface of iron to be tinned muſt be ſmooth and ſparkling. For this end, it is ſometimes cleared with an acid, ſometimes filed, and ſometimes coated with ſal ammoniac: when prepared in this manner, it is immerſed vertically into a veſſel full of melted tin; its poſition in the veſſel is repeatedly changed, in order to bring it more completely in contact with the tin; and when it is thought to be ſufficiently tinned, it is taken out and rubbed with ſawduſt or bran, to clear it from the tallow or pitch with which the ſurface of the melted tin is covered, and which of conſequence ſticks to the ſurface of the tinned iron. If the iron ſubjected to this proceſs be in very thin plates, the tin will not barely adhere to its ſurface, but penetrate through it, and combine with all its parts: and on cutting or breaking it, the ſame white colour will appear in the midſt as on the ſurface of the plate: From which it appears, that white iron, properly prepared, is actually a chemical combination. Beſides, it is more malleable than iron, and is wrought into veſſels of a form which it would be impoſſible to make the pure metal take with the hammer.

We have ſeen in the beginning of this chapter, that iron eaſily abſorbs coal by heat; forming by its union with that combuſtible body caſt iron and ſteel; with this difference between theſe two compounds, that in the former it contains oxigene, but not in the latter. In both, the quantity of the iron is much above that of the coal. Scheele, who has applied chemical analyſis to ſo many happy purpoſes, found, on inveſtigating by this method the nature of *plumbago*, a ſpecies of mineral, the rank and character of which naturaliſts were long at a loſs to determine, that it is nothing but a natural combination, conſiſting of a large quantity of coal, with a very ſmall proportion of iron.

Plumbago has been long confounded with *molybdena* *. Pott was the firſt who proved that neither of theſe ſubſtances contains lead, as they were anciently thought to do. The names beſtowed on *molybdena* and *plumbago* were formed to perpetuate the error. They were both indifferently called *lead ore, Engliſh pencil, marine lead, black ceruſe, painter's mica, lead pencil, falſe galena, talc, blende, potelot.*

Native *carbure of iron* (a name which, as expreſſive of the nature of the compound, we have ſubſtituted inſtead of *plumbago*) is found in mountains, frequently among beds of quartz, feldt-ſpar, clay, or chalk, in the form of irregular round lumps, or balls, like the teſticles of animals of various ſizes; the largeſt weighing from eight to ten or eleven pounds; ſometimes, too, it is ſcattered in much ſmaller fragments; and ſometimes even in ſtrata or layers. The inhabitants of Bleoux, a hamlet near Curban, in the higher part of Provence, work *native carbure of iron*, or plumbago, which is found in ſtrata of the thickneſs of four feet, between two beds of clay; the matter is ſold at Marſeilles. M. de la Peyroux reckons carbure of iron among the minerals of the Pyrenees: it is found in Spain and in Germany; in the Duchy of Cumberland in England there is a very rich mine of it; it is made into pencils which are much eſteemed. North America, and the Cape of Good Hope likewiſe afford ſpecimens of this ſubſtance. *Plumbago* has for ſome time been found in octohædral cryſtals.

Carbure of iron is of a gliſtering blackiſh blue colour;

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* It is now agreed, that the ſubſtance called *molybdena*, is the oxide of a certain acidifiable ſemi-metal. Its hiſtory has been given among the ſemi-metals.

lour; it feels greaſy, and its fracture is tuberculous; whereas *molybdena* has a lamellated fracture. Its being of an unctuous ſoapy nature, has induced ſome chemiſts to conſider it as a kind of impure clay. It ſpots the hands; and the *black pencil* leaves, as every body knows, a blackiſh mark on paper.

Carbure of iron ſuffers no alteration from heat in cloſe veſſels. M. Pelletier, who has made a ſeries of experiments on this ſubſtance, ſince Scheele, without obtaining, however, any different reſult, expoſed 200 grains of it in a well-ſtopped crucible of porcelain to the heat of the fire uſed in the Sêves manufactory for porcelain; the mineral loſt only 10 grains: But when heated in contact with air, it burns and is oxidated ſo as to leave ſcarce any reſidue. Meſſrs Quiſt, Gahn, and Hielm, obſerved, that 100 grains, treated in this manner in a capſule under a muffle, left only ten grains of ferruginous oxide. This oxidation is a ſlow combuſtion, very difficult to bring about. It does not ſucceed in a common crucible; but to effect it, a thin piece of carbure of iron muſt be expoſed in a broad flat veſſel to the action of a ſtrong fire, and the ſurfaces often cleared, and its poſition changed.

Neither air, water, nor any earthy ſubſtance, acts on carbure of iron. The alkalis act powerfully on this ſubſtance. If one part of carbure of iron with two of dry cauſtic fixed alkali, or the *lapis cauſticus*, be heated together in a retort with a pneumato-chemical apparatus, the ſmall quantity of water ſtill contained in the ſalt contributes to the combuſtion of this ſubſtance; a product of carbonated hydrogenous gas is obtained; the alkali is found to be ſaturated with carbonic acid; and there remains ſcarce any of the carbure of iron. The reſult of this experiment, and the detonation of carbure of iron with nitre, which will hereafter come under our notice, led Scheele to conſider this matter as a kind of ſulphur formed of *aerial* or carbonic acid and phlogiſton. We will examine this theory, after having conſidered the other phenomena which this combuſtible body diſplays when expoſed to the action of acids and neutral ſalts.

The ſulphuric acid, according to Scheele, is incapable of acting on carbure of iron. M. Pelletier has obſerved, that when 100 grains of this ſubſtance and four ounces of concentrated ſulphuric acid are digeſted together cold for ſeveral months, the acid acquires a green colour, and becomes liable to congeal by a very moderate degree of cold. This acid, when diſtilled on carbure of iron, paſſes into the ſtate of ſulphureous acid in conſequence of the combuſtion of a part of that ſubſtance.

The nitric acid produces no alteration upon it. The muriatic acid diſſolves the aluminous earth and the iron, and ſerves to purify it, according to M. Berthollet. M. Pelletier has made uſe of the ſame proceſs in order to obtain pure carbure of iron. With reſpect to the aluminous earth which the muriatic acid carries off from carbure of iron, Scheele remarks, that the aluminous earth ſeparated in his analyſis belonged to the crucible in which he had before treated it.

Carbure of iron, when melted with four parts of ſulphate of potaſh or ſulphate of ſoda, affords alkaline ſulphures, and is entirely decompoſed.

Nitre detonates with the help of this ſubſtance; ten parts of that ſalt are requiſite to burn one of carbure of iron. The fixed alkali which remains after this operation gives a lively effervefcence with acids, and is found to be mixed with a ſmall quantity of oxide of

iron.

iron. The ſame effect takes place with nitrate of ſoda and ammoniacal nitrate. M. Pelletier has obſerved, that in this laſt operation there is ammoniac diſengaged in combination with a portion of carbonic acid.

Carbure of iron acts neither on muriate of potaſh nor muriate of ſoda.

When diſtilled with ammoniacal muriate, it gives *martial ammoniacal flowers.* When it is heated with ſulphur in a retort, the ſulphur is ſublimed by itſelf, without producing any alteration on the carbure of iron.

All theſe facts concur to prove, that this ſubſtance is neither earth nor lead ore, as it was thought to be. But Scheel's theory again, who conſiders it as a combination of carbonic acid with phlogiſton, cannot be admitted, 1. Becauſe that chemiſt has not informed us what quantity of the acid he obtained; 2. Becauſe he could not compoſe *plumbago* artificially, by combining carbonic acid with a combuſtible matter. Beſides, the two ſubſtances with which Scheele changed carbure of iron into carbonic acid, effect the change by affording vital air, which combines with the inflammable matter of this ſubſtance, and gives riſe to that acid by the fixation of oxigene; for in this manner does the nitric acid convert tungſten, arſenic, and ſugar, into acids. With regard to cauſtic fixed alkali, which likewiſe changes carbure of iron into carbonic acid, this effect is plainly owing to the water which that alkali always contains, and which burns the combuſtible matter in the ſame manner as it conſumes zinc and iron; the hydrogenous gas obtained during the reaction of the alkali and the carbure of iron adds confirmation to this theory.

ry. It might be ſtill farther confirmed by paſſing water in vapours upon this ſubſtance made red hot in a copper or porcelain tube, as is done with iron and zinc. Although this experiment has not been yet made, I believe I may venture to advance, that the whole of the carbure of iron would be deſtroyed and converted into carbonic acid, and that the product of the operation would be carbonated hydrogenous gas, mixed with a large proportion of carbonic acid. It would then ſeem a natural inference, that the carbonic acid is a compound of plumbago and oxigene: but as we know from many other experiments, that this acid cannot be formed unleſs when a combination of coal with oxigene takes place; we muſt infer, in this inſtance, that *plumbago* contains a large proportion of coal, and even conſiſts almoſt entirely of that combuſtible body. A few facts concerning the properties of coal, here thrown together, will farther confirm this aſſertion.

The coal of various vegetable matters is brilliant, and has a metallic aſpect, like carbure of iron: it ſoils the hands, and marks paper like that matter; and its texture too is granulated and brittle. The moſt brilliant coals, ſuch as thoſe of ſome animal ſubſtances, are as difficult to burn as carbure of iron, which needs to be much ſtirred, expoſed to an intenſe heat, and brought as much as poſſible into contact with air, in order that it may be conſumed: iron is found in both: And laſtly, theſe two ſubſtances are both liable to be changed into carbonic acid by combuſtion. After conſidering theſe facts, may we not regard *plumbago* as coal formed in the interior parts of the globe, or buried in the earth? May we not even conclude, that this matter is formed by the combination of ſome mineral prin-

ciples?

ciples? though almoſt all chemiſts be of opinion that nothing but organic matters can be converted into coal. But this notion can be confirmed or refuted only by a regular inquiry into the ſtate of carbure of iron in nature, the circumſtances of its formation, and the alteration which it ſuffers. Since the reſearches of Meſſrs Vandermonde, Monge, and Berthollet, into the ſeveral ſtates in which iron ſubſiſts, diſcovered theſe facts concerning carbure of iron, they have farther diſcovered, that there is conſtantly formed, on the fuſion of caſt iron, a ſubſtance preciſely ſimilar to native carbure of iron. The ladles with which the caſt iron is taken out to cool are uſually coated with it. Maſſes of it are likewiſe found in cryſtals in repairing the upper parts of the furnaces. We may venture to hope that it will be one day artificially prepared for the ſervice of the arts.

Carbure of iron is a good deal uſed. It is made into pencils; the moſt eſteemed of which come from England. Reſwick, in the Duchy of Cumberland, is the place where that uſed for pencils is found. The native lumps are ſawed into ſmall ſlender pieces; which are put into wooden cylinders with grooves, ſo cut that the cavity of the cylinder may be entirely filled. The duſt produced from the ſawing and cutting of the pieces inſerted into the cylinders is uſed for pencils of an inferior quality, a great many of which are ſold at Paris. It is mixed with a gum paſte, or melted with ſulphur. Theſe baſe pencils are known in England, either by their melting and burning at the flame of a taper, or by their ſeparating into bits, and even falling into powder when ſteeped in water. The German carbure of iron is likewiſe uſed for pencils: in making them

them ſeveral extraneous matters are added; ſuch as coal, ſulphur, &c. In England the fineſt duſt of carbure of iron is uſed for coating the wheel-work of ſome inſtruments; and it facilitates their motions by its greaſy unctuous nature.

One of the moſt important uſes to which this ſubſtance is applied is to coat iron, in order to preſerve it from ruſting; the pipes of ſtoves, the back parts of grates, and other utenſils expoſed to the action of fire and air are coated with powder of carbure of iron, which is applied to their ſurface by ſimply rubbing with a bruſh. Homberg, in the year 1699, deſcribed a proceſs for giving a leaden colour to utenſils of iron. It conſiſts in mixing eight pounds of melted animal fat with four ounces of camphire, and a ſufficient quantity of carbure of iron, and laying this compoſition on iron ſo hot that it can ſcarce be held in the hand: theſe utenſils muſt be carefully wiped with a cloth, after being covered with this ſort of varniſh.

The workmen who manufacture lead for hunting-ſhot, ſoften and blacken its ſurface at the ſame time by rolling it in powder of carbure of iron. It is likewiſe a part of the compoſition put upon the pieces of leather uſed for ſtrapping razors. Laſtly, it is uſed in the manufacture of ſeveral black Engliſh earthen wares; and in that of the crucibles which are made at Paſſaw in Saxony.

M. Pelletier, who has given a good account of the various uſes to which carbure of iron is applied, found it to anſwer very well in a luting which he prepared after Pott, with one part of this ſubſtance, three of common clay, and a little cow-dung reduced very ſmall. This luting ſupports glaſs retorts well enough: they even melt ſometimes without its ſuffering any change of form.

The principal uſes of iron are ſo extenſive, and beſides ſo well known, that it is unneceſſary to inſiſt on them here; only we may mention, that no art can do entirely without it, and that it is, as Macquer ſays, the ſoul of all arts. The various modifications of which it is ſuſceptible, render it very ſuitable for all the purpoſes to which it is applied. Caſt iron is run into utenſils more or leſs ſolid, and capable of reſiſtance, according to the purpoſes for which they are deſigned. The tenacity and hardneſs of the ſeveral ſpecies of forged iron render it very ſuitable for all the purpoſes to which it is applied. The ſame is the caſe with the ſeveral kinds of ſteel. The fineneſs of the grain and the temper vary ſo as to divide it into a great many ſpecies, each of which is better fitted than any of the reſt to ſome purpoſe or other in the circle of the arts. Oxides of iron ſerve for giving a red or brown colour to porcelain, pottery, enamels, &c. They are likewiſe employed in the preparation of artificial precious ſtones; and mixed with oil for painting colours.

Iron affords a remedy of great uſe in medicine; to which indeed the art is indebted for moſt part of its ſucceſs. This is the only metal that has no noxious quality whatever, and of the good effects of which there can be no doubt. There is even, as we have ſeen, ſuch an analogy between iron and organic matters, that it ſeems to compoſe a part of them, and to be often produced by the operation of the vital powers of animals and by vegetation. The effects of iron on the animal œconomy are various. It ſtimulates the fibres of the membraneous viſcera, and appears to act more eſpecially on thoſe of the muſcles, which it affects as a tonic. It fortifies the nerves, and communicates to the animal, when enfeebled and languid, new force and vigour in a remarkable degree. It excites many ſecretions, eſpecially ſuch as take place by evacuations of blood or urine. It contributes to bring on natural hæmorrhages, ſuch as the menſtrual flux and the hæmorrhoids. It increaſes and multiplies the contractions of the heart; and of conſequence renders the pulſe quicker and ſtronger. It acts with no leſs energy on the fluids. It paſſes eaſily into the channels through which the blood circulates, combines with it, and thus gives it new denſity, conſiſtency, and colour, and renders it more liable to concretion. It at the ſame time communicates to it ſuch activity, that it paſſes without difficulty into the ſmalleſt veſſels, ſtimulates of itſelf the ſides of the ducts through which it flows; and thus conveys life and vigour through the whole ſyſtem. The valuable experiments of M. Menghini, publiſhed among the Memoirs of the Inſtitution of Berlin, prove, that the blood of people who make uſe of iron is higher coloured, and contains more than the natural quantity of this metal. Lorry, who in the practice of medicine has diſplayed that nice acuteneſs of obſervation, and that extenſion of views which diſtinguiſh the profound and philoſophical phyſician; obſerved the urine of a ſick perſon to whom he had adminiſtered iron reduced to powder, to have the colour of nut-gall. This metal is therefore tonic, ſtrengthening, ſtomachic, diuretic, alterative, inciſive, and to it a great many medicines owes thoſe properties which render them uſeful. It contracts the fibres like aſtringents, it increaſes their oſcillation; and it has the ſuperiority over many of the other medicines which poſſeſs the ſame virtues, as being more conſtant and durable in its effects; for it combines with the organs themſelves, by means of the fluids by which theſe are nouriſhed. It may be uſefully adminiſtered therefore in all caſes in which the action of the fibres of the viſcera of the muſcles, or even of the nerves, is very feeble; when the ſtomach and inteſtines are ſo languid as to refuſe their functions; and in the caſe of weakneſs ariſing from ſuch a cauſe: in ſhort, whenever the conſiſtency of the fluids is diminiſhed, and they are become too thin, as in the green ſickneſs, and in tendency to dropſy, &c. It is uſed under many different forms; ſuch as levigated filings, martial Æthiops, aſtringent and aperitive ſaffron of Mars, Stahl's alkaline martial tincture, martial flowers of ſal ammoniac, &c. To theſe medicines there might perhaps be added iron precipitated from acids, and again diſſolved by ammoniac. Pruſſian blue, the uſe of which as a medicine is propoſed by the chemiſts of the Academy of Dijon, &c. Sulphate of iron is applied externally to ſtop hæmorrhages, &c.

Iron, endowed with magnetic qualities, or artificial loadſtone, has been thought to produce ſome very ſingular effects on the animal œconomy. According to many modern authors, when laid upon the ſkin, it eaſes pain, ſtops convulſions, occaſions redneſs, ſweating, and often too the eruption of ſmall pimples; it likewiſe renders epileptic fits leſs frequent. We are even aſſured, that in the ſpace of twelve hours it communicates to water a purgative quality. Theſe aſſertions, which are juſtified by facts, afford ſo many proofs to enlightened philoſophers of the difficulties with which the ſtudy of animal phyſics is attended. As no body is liable to be affected by the magnetic powers of other bodies which is not itſelf capable of acquiring ſuch powers, it muſt therefore be impoſſible for the loadſtone to act by virtue of its magnetic powers upon the animal œconomy.

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The phyſicians who aſcribe to it ſuch eminent effects and ſuch energetic medicinal powers, have been miſled and deceived by the changes, more or leſs ſenſible, which have taken place about the time of the application of the magnetic body, and have been owing to the circumſtances of the caſe and the happy exertions of nature. This opinion is farther enforced by conſidering, that nature ſeems to act with more irregularity and inconſtancy in removing pains and convulſions than in any other inſtance; and that the medicinal virtues of the loadſtone are chiefly inferred from the effects which have followed after applying it in caſes of this kind.

CHAP. XIX.

Of Copper.

COPPER is an imperfect metal, of a very brilliant red colour, to which the alchemiſts gave the name of *Venus*, on account of the readineſs with which it combines ſo as to ſuffer alteration from a vaſt variety of other bodies. It has a diſagreeable ſmell, which is felt when it is rubbed or heated. Its taſte is ſtiptic and nauſeous, but leſs ſenſible than that of iron. It is hard, very elaſtic, and very ſonorous. Its ductility is conſiderable: it is reducible into very thin plates and very ſlender threads. In the hydroſtatic balance, it loſes about an eighth or a ninth part of its weight. Such is its tenacity, that a thread of copper, one-tenth of an inch in diameter, ſupports 299$\frac{1}{4}$ pounds weight without breaking. Its fracture appears as if it were compoſed of ſmall grains. It is ſuſceptible of a regular form. The Abbé Mongez defines its cryſtals to be quadrangular pyramids, ſometimes ſolid,

lid, and ſometimes conſiſting of other ſmaller pyramids inſerted laterally.

Copper is found in various ſtates in the earth. Its ores are very numerous; but they may be all reduced to the following.

1. Native copper of a red colour, malleable, and poſſeſſed of all the other properties of the metal. It is diſtinguiſhed into two ſorts; copper of the firſt formation, and copper of a ſecondary formation or cementation. The copper of the firſt formation is diſperſed in plates or filaments within a gangue, which is almoſt always of a quartzoſe nature. It is ſometimes found in octahædral cryſtals, one above another, reſembling a kind of vegetation. There are other ſpecimens in maſſes and grains. Copper of cementation is commonly in grains, or in thin laminæ on the ſurfaces of ſtones or iron. That which is found on iron appears to have been depoſited in waters containing ſulphate of copper, and precipitated by iron. Native copper is found in many places over Europe: At St Bel, in the neighbourhood of Lyons, at Norberg in Sweden, at Newfol in Hungary, and in ſeveral parts of America *.

2. Copper oxidated and mineralized by the carbonic acid. There are ſeveral varieties of native carbonate of copper.

Varieties.

A. Red copper, or *hepatic copper ore.* This ore is diſtinguiſhed by its dark red colour, like the colour of the ſcales which fall off from copper made red hot, and then ſtruck with a hammer. M. Monnet conſiders this ore as a na-

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* Alſo in different places in England, Scotland, and Wales.

Varieties.

natural oxide of copper. It is generally mixed with native copper and *mountain green:* it is not very plenteous; ſometimes it is found in octahædral cryſtals, or ſilky fibres called *flowers of copper.*

B. *Earthy copper, mountain green,* or *green chryſocolla.* This ore is a genuine oxide of copper, of a lighter or a deeper green, not heavy, and unequally diſperſed within its gangue. It appears from the analyſis of the malachite, made by the Abbé Fontana, to be combined with carbonic acid. This ore is ſometimes very pure. It may be conſidered as exiſting in three different ſtates.

Simple *mountain green,* earthy or impure, called alſo *green chryſocolla.*

Mountain green in cryſtals, or *ſilky copper* of China. This ore, which is common enough in Voſges and Hartz, is likewiſe found in China. It is pure, and cryſtallized in long ſilky bundles of no ſmall ſolidity.

Mountain green in ſtalactites, or *malachite.* This ſubſtance, which is found in conſiderable abundance in Siberia, conſiſts of layers in the form of nipples, of various ſizes: ſome of the ſpecimens conſiſt of needles converging towards a common centre. The different layers have not all preciſely the ſame ſhade of green. The malachite is hard enough to take a fine poliſh; and various toys are made out of it; but as it is often porous, and full of unequal cavities, the ſolid pieces are always

Varieties.

the moſt valuable when they come up to a certain ſize.

C. *Mountain blue*, or *blue chryſocolla*. This is an oxide of copper of a deep blue colour; it is ſometimes in a regular form, and in rhomboidal priſmatic cryſtals of a very beautiful blue. It is then called *copper azure*. At other times it is found in ſmall grains depoſited in the cavities of different gangues, more eſpecially in quartz. Generally, however, it is in thin layers, in the cavities of grey and yellow copper ores. It appears that all theſe oxides of copper have been precipitated from ſulphuric ſolutions of this metal by the intermedium of calcareous earths, through which the waters containing them flow. M. Sage conſiders theſe blue copper ores as combinations of copper with ammoniac; and ſays that they differ from it only in being inſoluble. He likewiſe thinks that the malachite is nothing but this blue, which he calls tranſparent azure copper ore, with a ſmall alteration. But this opinion is not generally received among mineralogiſts. M. de Morveau thinks that the blue differs from the green oxide of copper only in containing a ſmaller proportion of oxigene.

The blue oxide of copper ſeems to be the matter which colours certain ſtones; the turquois ſtone particularly, in which Reamur found copper, appears to owe its colour to this cauſe, as well as the Armenian ſtone, the baſe of which is calcareous carbonate, or

ſulphate

Varieties.

ſulphate of lime. Mr Kirwan makes a ſpecies of copper ore of theſe blue ſtones. The turquois is formed of animal bones, coloured by copper. According to Reaumur, the Perſian turquois is not liable to ſuffer from the attacks of the nitric acid. The ſame acid entirely diſſolves the turquois of Languedoc.

3. Copper mineralized by the muriatic acid and combined with clay. M. Werner ſpeaks of this ore in his tranſlation of Cronſtedt. It has been confounded with talc ; and a perſon of the name of *Dans* expoſed it to ſale at Paris in the year 1784, under the name of *green mica*. It is in ſmall cryſtals of a beautiful green colour, or in ſmall ſparkling ſcales. Mr Forſter found ſpecimens of this in the mines of Johan Georgenſtadt. The green copper ſand brought from Peru by M. Dombey ſeems to belong to this ſpecies of copper ore : on analyſing it, I have found it to contain a little muriatic acid.

4. Copper mineralized by ſulphur almoſt without iron. It is called *vitreous copper ore ;* but the name is very improper. It is dark grey, violet, brown, greeniſh, or entirely brown and liver-coloured. A very moderate heat melts it. It is ponderous, ſometimes flexible, and always of ſuch a conſiſtency that it may be cut with a knife. In its fracture it appears brilliant like gold. It is one of the richeſt copper ores ; for it affords no leſs than 90 pounds of copper in the hundred weight.

5. Copper mineralized by ſulphur with more iron than is contained in the ſpecies immediately preceding ; azure copper ore. It differs from the laſt only in containing

taining about 30 pounds to the hundred weight: it affords only from 50 to 60 pounds of copper in the hundred weight; the reſt is ſulphur. Theſe two ores may be aſſayed by acids.

6. Copper mineralized by ſulphur with a good deal of iron; brilliant or yellow golden pyrites. The quantity of the ſulphur and the copper varies greatly in this ore; the iron is always in a very conſiderable proportion. It exiſts in the earth in veins more or leſs conſiderable. This ore is ſometimes maſſy and dark, often ſcaly, and ſeemingly micacious. Such is the form of that of Denmark, Norway, Sweden, and St Marie-aux-Mines. On other occaſions this ore is diſperſed in its gangue, as the copper of Alſace; it is then called *ſpeckled copper ore.* This variety is often mixed with a little azure; coppery pyrites exhibit very brilliant colours on their ſurface, either blue or violet, which are owing to the decompoſition of their principles. They are then called *copper with a waving light*, or *peacock-tail copper ores.* They uſually contain a great quantity of ſulphur, a little iron, and in copper they are not very rich. When theſe ores are only ſuperficially diſperſed on the gangue, they are more particularly diſtinguiſhed by the name of *copper pyrites:* Of which kind are the ores of Derbyſhire in England, ſome of thoſe of St Bel in the Lyonnois, and a number in the mines of Alſace, as at Caulenbach and Feldens. They are beſides found adhering to gangues of all ſorts, rock cryſtal, quartz, ſpar, ſchiſtus, and mica, &c.

7. Copper united with ſulphur, iron, and a little ſilver. This ore is called *arſenical copper ore*, or *fahlertz*, and bears a great reſemblance to the grey ſilver ore; only it is not juſt ſo brilliant; the only difference is, that this copper ore contains leſs ſilver than the other.

other. M. Romé de Lille takes notice likewiſe of a white copper ore, which according to him contains a little more ſilver than the grey: but that is a true ſilver ore. Fahlertz affords from 35 to 60 pounds of copper in the hundred weight.

8. Copper mineralized by ſulphur and arſenic, with zinc and iron. *Brown,* or *blendy copper ore.* M. Monnet found this ore no where but at Catharineberg in Bohemia: it is brown, granulated, and very hard. It contains from 18 to 30 pounds of copper in the hundred weight.

9. Schiſtous copper ore. This is *vitreous copper* very intimately mixed with brown or black ſchiſtus. It affords from 6 to 10 pounds in the hundred weight: chalk muſt be added when it is melted.

10. Bituminous copper ore. This is copper mixed with a kind of coal of Swediſh earth.

11. Black, or pitch-coloured copper ore. M. Gellert calls it *copper ore in ſcoriæ*: it is a reſidue, remaining after the decompoſition of yellow and grey copper ores, which contains neither ſulphur nor arſenic, and is nearly in the ſtate of *malachite.* It is of a gliſtering black colour like pitch.

12. Copper combined with ſulphur and arſenic, containing antimony. Antimonial copper ore. M. Sage mentions this ore in his Elements of Mineralogy. It is grey and brilliant in its fracture like antimony. It contains from 14 to 20 pounds of copper in the hundred weight.

To aſſay a copper ore, after being pounded and waſhed, it muſt be ſubjected to long roaſting by an intenſe heat, and melted with four times its own weight of black flux and marine ſalt. The button thus obtained, which is often blackened with a reſidue of the ſulphur, is is next to be melted with four parts of lead; and paſſed into a cupel, where the ſilver and gold which it contains may be ſeparated; for there is but very little copper which does not contain ſome portions of theſe precious metals. M. Tillet's flux, which is a mixture of two parts of pounded glaſs with one of calcined borax, and an eighth of coal, ſucceeds better in reducing this metal than black flux; for the black flux forms an alkaline ſulphure, which diſſolves a part of the oxide of copper.

Bergman recommends the ſulphuric and the nitric acids for aſſaying copper ores in the humid way. When the copper is diſſolved by the acids, it is then precipitated by iron.

In working copper ores in the great way, they are firſt pounded and waſhed: they are then roaſted at the firſt in the open air, and almoſt without wood; for when the ſulphur which they contain is once kindled, it burns away of itſelf. When it ceaſes to burn, the ore is then roaſted anew, and even twice ſucceſſively on wood, in order to obtain what is called *the mat of copper*. This is the ore after it has loſt only a portion of the ſulphur which it contained. The fuſion to which it is ſubjected ſerves to make it expoſe its ſurfaces more entirely to the heat; in conſequence of which it is more thoroughly roaſted. It is expoſed to ſix or ſeven ſucceſſive roaſtings, according as it contains more or leſs ſulphur, and is then melted into *black copper*. This copper is malleable: ſtill, however, there is ſo much copper united with it, which cannot be ſeparated without extracting at the ſame time the imperfect metals which it contains. The black copper is melted with three times its quantity of lead, which is called *refreſhing the copper*; and this mixture is moulded into the form of loaves, which are called loaves of *eliquation*. Theſe are inſtantly placed on two plates of iron, inclined ſo as to leave a gutter between them. They terminate immediately over the furnace of eliquation; the under part of which ſlopes forward. The fire under the plates heats the loaves: the lead melts, and runs under the coals, carrying with it the ſilver and the gold, with which it has a greater affinity than with copper. After this operation, the cakes are found to be conſiderably diminiſhed, and to have loſt their ſhape. They are now expoſed to a ſtronger fire; the heat of which is ſo intenſe as to melt the copper ſo far that it may be entirely ſeparated from the lead. This third operation is called (in French) *reſſuage*. The lead, with the perfect metals, is taken to the cupel. As to the copper, it is refined by melting it in a crucible, and ſuffering it to ſtand ſo long melted that it may throw up in a ſcum any extraneous matters which it contains. It is aſſayed by dipping into it iron rods, which take up a little copper; and from its being more or leſs of a bright red colour, a judgment is formed of the purity of the metal. Copper thus refined is run into plates, or divided into *roſettes*. To form a *roſette*, the ſcoriæ with which copper in fuſion is covered are carefully taken off. The ſurface of the metal is ſuffered to ſettle and fix: when it ceaſes to be fluid, it is ſweeped over with a beſom: The impreſſion of cold contracts it. The portion congealed ſeparates not only from the edges of the crucible, but likewiſe from the reſt of the melted metal, and is taken off with pincers. Moſt part of the copper in the crucible is thus taken off in *roſettes*. What remains at the bottom is called *the king*.

Cupreous pyrites, containing but little of the metal, are

are wrought ſolely for the ſulphur and the vitriol. At St Bell, and in many other places, they are roaſted and diſtilled, in order to ſeparate the ſulphur. During the roaſting a portion of the ſulphuric acid acts on the metal, diſſolves it, and thus begins to form ſulphate of copper. The roaſted pyrites are next expoſed to the air; and when the *vitriolization* is ended, the pyritous efflorеſcence is lixiviated, the lixivium filtrated and evaporated, in order that it may afford a blue rhomboidal ſalt in cryſtals, called *vitriol of copper, blue vitriol, blue copperas*, or *vitriol of Cyprus*. We will ſpeak of it when we come to examine the combinations of this metal, under the name of ſulphate of copper.

Copper, when expoſed to fire, takes nearly the ſame colours with ſteel: it becomes firſt blue, then yellow, and at laſt violet. It does not melt unleſs when very red. When fully in fuſion, it appears covered over with a green flame: it boils, and is capable of volatilization, as may be obſerved in the chimnies of founders. There are alſo found flowers of copper in the crucibles in which it is melted. Small filings of this metal, when thrown into the flames, give them a blue and green colour. It is uſed in artificial fire-works, on account of this property. If this melted metal be ſlowly cooled, and the fluid portion decanted off, that which adheres to the ſides of the crucible or roaſting pot employed in the experiment is found in pyramidal cryſtals; which are larger and more regular in proportion as the fuſion of the metal is more complete, and its cooling more ſlowly brought on. The pyramids are quadrangular, and appear to conſiſt of a number of octahædrons diſpoſed one over another.

Copper heated in contact with air, burns at the ſurface, and changes into a blackiſh red oxide, as it abſorbs the baſe of vital air. This oxide may be eaſily obtained by making a copper plate red hot, and then ſtriking it with a hammer; the oxide comes off in ſcales. The ſame thing takes place when a copper plate is dipped in cold water after being made red hot. The ſudden contraction of the parts of the metal contributes to the ſeparation of the oxide which covers its ſurface. The oxide falls to the bottom of the water; it is called *ſcales of copper*. As the copper is not completely oxidated, it may be burnt anew under the muffle of a cupelling furnace; it then takes a pretty deep brown colour; when urged with a violent heat, it melts into a blackiſh or brown cheſnut-coloured glaſs. Oxide of copper may be decompoſed and deprived of its oxigene which deſtroys its metallic properties, by oils, reſins, &c. The ſcales are in part reducible by themſelves; for founders buy them from copperſmiths, and uſe no means for their reduction but throwing them into large crucibles above melted copper, with which, as they melt, they enter into union. The filings of this metal are melted in the ſame way. Oxide of copper appears to poſſeſs ſome ſaline properties; but its nature, as a ſalt, has not yet been the ſubject of examination.

Air acts upon copper; and the more eaſily the more it is loaded with, and altered by moiſture. It converts it into a ruſt or green oxide, which appears to have ſome ſaline properties: it has a taſte, and is liable to be acted upon by water. Such was the reaſon which induced the ancient chemiſts to conſider copper as containing a ſalt. One thing remarkable with regard to this ſalt is, that it never penetrates deeper than the ſurface, and ſeems to contribute to the preſervation of the interior parts of a maſs of this metal; as may be inferred from

from the ſtate of ancient medals and ſtatues, which are well preſerved under the coat of ruſt with which they are covered. Antiquaries call that ruſt *patina,* and ſet an high value on it; becauſe it is a proof of the antiquity of thoſe pieces which are covered with it. There are many artiſts, eſpecially Italians, who know how to imitate this ruſt on copper; and thus counterfeit ancient pieces of bronze.

The oxidation of copper by humid air appears to be owing to water in a ſtate of extreme diviſion. This fluid, however, does not appear to attack copper in the ſame manner as iron at an high temperature. It would rather ſeem, that cold water oxidates the metal; for it is known to be more dangerous to leave liquors to cool, than to boil them in copper veſſels. When the liquor is boiling, and the veſſel hot, the aqueous vapour does not attack the ſurface of the metal; but when the liquor is cold, the drops which adhere to the ſides of the veſſel appear to reduce the copper to green oxide. This oxidation may be therefore aſcribed, with great probability, to the operation of the air, and the carbonic acid diffuſed through it: for, on diſtilling this ruſt of copper in a pneumato-chemical apparatus, I obtained from it carbonic acid.

Copper does not combine with earthy matters. Its oxide, however, contributes to their fuſion, and combines with them to form brown glaſſes of a lighter or a deeper ſhade.

Barytes, magneſia, and lime, act not in a diſcernible manner on copper: we know not how they act on the oxide of this metal.

Cauſtic fixed alkali, digeſted cold with filings of copper, aſſumes in a certain time a very light blue ſhade; and the copper is covered over with a duſt of the ſame colour. According to M. Monnet, theſe ſolutions are better effected in cold than in heat. It is, however, of importance to obſerve, that he made the combination with carbonate of potaſh, not with pure fixed alkali. Pure fixed alkali ſeems to have much more influence on copper: But neither of theſe ſalts does any thing more than promote and haſten the precipitation of the oxigene of the atmoſphere into copper; for the oxidation never takes place without the concourſe of air.

This phænomenon is more eſpecially remarkable when ammoniac is brought into contact with copper; on which occaſion the metal is pretty ſoon diſſolved. When ammoniac is digeſted on filings of copper, with concourſe of air, it takes, in a few hours, a very beautiful deep blue colour; there is not, however, much of the copper diſſolved. I have for a year obſerved the phænomena of this ſolution. I put into a ſmall phial a portion of cauſtic ammoniac with copper filings; the phial was often unſtopped. At the end of ſome months I found the ſurface of the metal covered with a blue oxide: its ſides were coated with a pale blue oxide; and the under part of the phial, containing the copper, diſplayed at the ſurface of the glaſs a brown oxide, the upper part of which was yellowiſh. When the phial containing this liquor is cloſely ſtopped, the liquor loſes its colour almoſt entirely; but whenever the phial is unſtopped, it appears again. It does not exhibit this phænomenon in an eminent degree, except in the beginning of the operation, and when it is decanted from above. If the ſolution be not newly made, and ſtill contain copper, it is of a beautiful blue colour, even in cloſe veſſels: however, when expoſed to the air, its colour becomes ſtill deeper. Theſe phænomena ſhow the influence of the oxigene of the atmoſphere.

When the ſolution of copper by ammoniac is ſlowly evaporated, moſt part of the ſalt is diſſipated; a portion, however, remains fixed with the oxide of the metal, and is depoſited in ſoft cryſtals; as has been obſerved by M. Monnet. M. Sage aſſerts, that very beautiful cryſtals may be obtained from this ſolution by ſlow evaporation; and compares them to natural azure of copper. This laſt ſubſtance, however, affords no ammoniac when heated; is not ſoluble in water; and does not effloreſce in the air, like that which is artificially prepared. M. Baumé ſays, this compound forms very brilliant cryſtals of a very beautiful blue colour. This ſolution, when expoſed to the air, becomes very ſoon dry; and what remains is a matter of a graſs-green colour, which can be nothing but a green oxide of copper. M. Sage thinks this the origin of the malachite: but this oxide does not afford near ſo much carbonic acid as the malachite. An acid poured into the ſolution of copper by liquid ammoniac produces ſcarce any precipitate, but changes the blue colour of the ſolution into a very light pale green. This phænomenon, which has been obſerved by Meſſrs Pott and Monnet, ſhows that there is but very little oxide of copper in the ammoniac, and that it is again diſſolved by the acid, or by the ammoniacal ſalt, formed by the addition of the acid. By adding ammoniac to the mixture, however, it may be made to reſume its blue colour. Both the oxide of copper reduced to that ſtate by fire, and all the other oxides of this metal, are inſtantaneouſly diſſolved in pure ammoniac; and the ſalt may be thus impregnated with a conſiderable portion of the metal. It takes immediately a very beautiful blue colour: and, on this account, it has been propoſed to uſe it as a teſt for aſcertaining the preſence or abſence of copper in ſubſtances in which it may be ſuſpected to exiſt.

The ſulphuric acid does not act on copper except when concentrated and boiling: a good deal of ſulphureous gas is diſengaged while this ſolution takes place. When the ſolution is completed, the two ſubſtances are found to have formed a matter of the conſiſtency of jelly, containing oxide of copper by itſelf, and a portion of that oxide in combination with ſulphuric acid. By lixiviating this matter and filtrating the lixivium, a blue ſolution is obtained: when evaporated to a certain point, and ſuffered to cool, this ſolution affords oblong rhomboidal cryſtals of a beautiful blue colour, which are ſulphate of copper. If, inſtead of being evaporated, this ſolution be left for a long time expoſed to the air, it affords cryſtals; but it likewiſe precipitates a green oxide,—the colour which all oxides of copper take that are either formed or dried in the air.

Sulphate of copper has a very ſtrong ſtiptic taſte; it is even cauſtic. When expoſed to fire it melts very quickly: it loſes its water of cryſtallization, and takes a bluiſh white colour. A very ſtrong heat is requiſite to ſeparate the ſulphuric acid, which adheres much more obſtinately to oxide of copper than to oxide of iron. Sulphate of copper is decompoſed by magneſia and lime: the precipitate formed by either of theſe ſubſtances is of a bluiſh white colour: when dried in the air it becomes green; on this account chemiſts deſcribe the precipitates of ſulphate of copper as green. The caſe is abſolutely the ſame with thoſe which are obtained by fixed alkalis in different ſtates; they are at firſt bluiſh, and take a green colour when dried: perhaps *mountain green* may be formed in this manner. It is of conſequence to obſerve, that when ſulphate of copper is precipitated by a ſolution of carbonate of pot-

aſh

aſh, there is no efferveſcence excited; a circumſtance which proves that the carbonic acid unites very readily with oxide of copper. This phænomenon is not common to all ſolutions of metals. Ammoniac in the ſame manner cauſes ſulphate of copper to yield a bluiſh white ſolution; but the mixture ſoon takes a very deep blue colour; for the ammoniac diſſolves in ſome meaſure the precipitated copper: and a very little of that ſalt is ſufficient to diſſolve again the whole of the copper ſeparated from the ſulphuric acid.

The nitric acid diſſolves copper cold, and with rapidity. A good deal of very high-coloured nitrous gas is diſengaged from this ſolution. This method Dr Prieſtley employed in order to obtain this gas very ſtrong. A portion of the metal reduced to oxide is precipitated in a brown powder, and ſeparated from the ſolution by filtration, This ſolution, after being filtrated, appears of a much deeper blue colour than the ſolution of copper by the ſulphuric acid; which ſhows that the copper is here more completely oxidated. This ſolution, carefully evaporated, cryſtallizes by cooling. Macquer, in his memoir on the ſolubility of ſalts in alcohol, is one of the firſt chemiſts who obſerved this fact. If the cryſtals are very ſlowly formed, they become oblong parallelograms; if depoſited more quickly, hexahædral priſms, the point of which is obtuſe and irregularly formed, and which appear like bundles of divergent needles. Laſtly, when this ſolution is too quickly evaporated, it affords only a magma of no regular form. This, no doubt, is what has made chemiſts ſay, that the ſolution is not ſuſceptible of cryſtallization. Nitrate of copper is of a very bright blue colour. It is ſo cauſtic, that it may be applied to corrode excreſcences growing on the ſkin. It melts, according to M. Sage, at a temperature of twenty degrees of Reaumur's thermometer.

thermometer. It detonizes on burning coals; but as it contains a good deal of water, the phænomenon is not very diſcernible. When melted in a crucible it exhales a good deal of nitrous vapour, which may be collected by diſtilling it: when dried, its colour is green: when ſtill farther urged with heat, it becomes brown: it is now nothing but pure oxide of copper. I have diſtilled a quantity of it in a pneumato-chemical apparatus, and it afforded a good deal of nitrous gas, a little carbonic acid, and a little vital air: by this operation it was reduced into the ſtate of brown oxide. Nitrate of copper attracts the moiſture of the atmoſphere. It may, however, be preſerved for a long time in cloſe veſſels. When expoſed to a hot dry air, it is covered over with a green effloreſcence. It is very ſoluble in water, and rather more ſoluble in hot than in cold water. The ſolution, if expoſed to the air in flat veſſels, or haſtily evaporated in dry warm weather, leaves a green oxide, ſuch as the cryſtals of the ſalt leave on a ſimilar occaſion. Lime makes it yield a pale blue precipitate; fixed alkali, a bluiſh white precipitate; by ammoniac it yields flakes of the ſame colour, which are very quickly diſſolved, and communicate to the liquor a very bright deep blue tincture. Its precipitate by alkaline ſulphures is of a browniſh red colour, without a fœtid ſmell; with the tincture of nutgall it gives an olive green precipitate. The ſulphuric acid likewiſe decompoſes nitrate of copper; and if it be employed in an highly concentrated ſtate, cryſtals of ſulphate of copper are obtained. Stahl firſt took notice of this decompoſition; M. Monnet has ſince confirmed the fact related by Stahl; and I have ſeveral times had occaſion to obſerve it. Iron has a greater affinity than copper with moſt of the acids. When a plate of this metal is immerſed into a ſolution of copper by the nitric acid, the copper is precipitated in a metallic form, and colours the ſurface of the iron: the iron effects this precipitation in conſequence of its having a ſtronger affinity than copper with oxigene. Sulphate of copper diſplays the ſame phænomenon; and jugglers, by this proceſs, make ignorant people believe that they can change iron into copper.

The muriatic acid diſſolves copper only when concentrated and boiling: only a very little hydrogenous gas is diſengaged when this ſolution takes place. The muriatic acid takes a very deep green, almoſt a brown colour. This combination forms a magma, which diſſolves readily enough in water: if this magma be lixiviated, the water is of a beautiful green colour; a circumſtance which ſerves to diſtinguiſh this from the two preceding ſolutions. On evaporating it ſlowly, and ſuffering it to cool, it depoſites priſmatic cryſtals ſufficiently regular, if the evaporation have been cautiouſly managed; but if the evaporation have been too quick, and the cooling too ſudden, they then appear under the form of very ſmall ſharp needles. Muriate of copper is of a graſs green colour, very pleaſing to behold: its taſte is cauſtic and very aſtringent; it melts by a very moderate heat, and when ſuffered to cool, congeals into a maſs. M. Monnet affirms, that the muriatic acid adheres to it with great obſtinacy, and that a very conſiderable heat muſt be applied to volatilize it: it powerfully attracts the moiſture of the atmoſphere; it is decompoſable by the ſame intermedia which decompoſe the preceding ſalts of copper. I have obſerved, that ammoniac does not diſſolve the oxide which it ſeparates from the muriatic acid ſo readily as that which it ſeparates from the ſulphuric and the nitric acids. The blue then formed is not ſo lively, and there remains

mains a portion of the oxide which the ammoniac does not thoroughly diſſolve. Neither the ſulphuric nor the nitric acid decompoſes muriate of copper. The nitric ſolutions of mercury and ſilver decompoſe it, and are themſelves decompoſed at the inſtant of the mixture. A white precipitate is formed in conſequence of the muriatic acid uniting with the oxide of mercury or ſilver; and the oxide of copper combines with the nitric acid. I have however obſerved, that this liquor does not aſſume the blue colour which a ſolution of copper by the acid of nitre ought to have; and that in general, the oxide of copper formed by the muriatic acid, does not aſſume this colour but with great difficulty, as we have already ſeen with regard to ammoniac. I have found, that in general oxides of copper paſs very eaſily from blue to green, and with very great difficulty from green to blue. The muriatic acid diſſolves oxide of copper much eaſier than copper itſelf. This has been obſerved by Brandt. The colour of the ſolution is a beautiful green; and it cryſtallizes as the former: a circumſtance which proves, that in ſaline metallic combinations the metals are always in the ſtate of oxides, as we have already obſerved.

Nitre detonizes with difficulty by copper. The ſalt muſt be in fuſion, and the copper very hot, in order that the deflagration may take place: ſtill, however, it is but very weak. This operation is performed by caſting copper filings on nitre in fuſion into a large crucible, in order that their parts may be as much as poſſible in contact with each other. When the metal becomes very hot, a ſlight motion is obſerved with faint ſparklings. The reſidue is a browniſh grey oxide mixed with potaſh; it is waſhed; the water takes up the alkali, which ſtill retains a little copper, and the oxide of the

metal

metal remains pure. It melts all alone into a deep brown opaque glaſs; it is uſed to colour enamels. It is thought that the alkali is rendered cauſtic; but more experiments are neceſſary to aſcertain this.

Copper very readily decompoſes ammoniacal muriate. Bucquet, who examined this decompoſition with very great care, obtained, on making the experiment in a pneumato-chemical apparatus with mercury, from two drams of copper filings and a dram of ammoniacal muriate, fifty-eight inches of elaſtic fluid; of which twenty-ſix inches were very pure ammoniac, twenty-ſix inches detonating inflammable gas, and the remaining ſix inches a mephitic gas, which extinguiſhed lights, without being abſorbed by water, or precipitating lime-water; and was conſequently azotic gas produced by the decompoſition of a part of the ammoniac. There was a little liquid ammoniac diſengaged, of a fine colour, which ſtood immediately over the mercury. The reſidue was a blackiſh green maſs, one half of which was diſſolved in the water, and communicated to it a fine colour, the diſtinguiſhing characteriſtic of muriate of copper: the other half was a kind of brown oxide of copper, formed by the water of the ammoniacal muriate. On repeating this decompoſition on four ounces of copper to two of ammoniacal muriate, with the common apparatus of a balloon, Bucquet obtained two drams and eighteen grains of blue liquid ammoniac, which gave a ſlight efferveſcence with acids, and contained about an inch of carbonic acid to the dram. He knew not how to account for the appearance of this laſt gas: but I ſuppſe it might proceed from ſome impurities of the ſal ammoniac; for on repeating the experiment with ammoniacal muriate, previouſly purified by ſublimation, the ammoniac which I obtained was very cauſtic, and did not effervefce in the leaſt degree with acids. Oxide of copper likewiſe decompoſes ammoniacal muriate, and communicates to the ammoniac which it diſengages a portion of carbonic acid that renders it effervefcent. This alkali is always blue, becauſe it takes off with it a ſmall portion of oxide of copper which colours it. Acids, however, do not precipitate an atom of the metal. There are two medicines prepared in pharmacy with ammoniacal muriate and copper; the former of which has received the name of *cupreous ammoniacal flowers*, or *ens veneris*. This is nothing but ammoniacal muriate coloured by a little oxide of copper. A mixture conſiſting of eight ounces of this ſalt with a dram of oxide of copper, is ſublimated in two earthen pots, the one placed over the other. All the ammoniacal muriate is volatilized without being decompoſed; and it carries off with it a little oxide of copper which communicates to it a bluiſh colour. The ſecond, called *celeſtial water*, is prepared by putting an ounce of ammoniacal muriate with a pound of lime-water into a copper baſon, and ſuffering the mixture to ſtand in it for ten or twelve hours. The lime diſengages the ammoniac, which diſſolves a little of the copper of the baſon; and by that means acquires a blue colour. Celeſtial water may be made in a glaſs or an earthen veſſel, by adding a ſmall quantity of filings or oxide of copper to the lime-water and ammoniacal muriate.

It appears that copper decompoſes aluminous ſulphate; for when a ſolution of this ſalt is boiled in a copper veſſel, there is a little aluminous earth precipitated: And when this alum is precipitated by ammoniac, the earth aſſumes a blue colour, which indicates the preſence of copper. This effect may be likewiſe aſcribed to the exceſs of acid which aluminous ſulphate always contains.

Hydrogenous gas does not act upon copper, but reduces the oxides of copper, by robbing them of their oxigene; with which principle hydrogene has a greater affinity than copper has.

This metal combines very readily with ſulphur. The combination may be effected in the humid way; that is, by mixing flowers of ſulphur with copper filings moiſtened with water; but it ſucceeds much ſooner in the dry way. To accompliſh it in this way, a mixture, conſiſting of equal parts of ſulphur in powder and copper filings, is expoſed to fire in a crucible, which is gradually heated till it become red hot; from this combination there reſults a blackiſh grey maſs, a ſort of *mat* of copper, which is brittle and more fuſible than copper. This compound is prepared for a tincture, and for painting Indian ſtuffs, by laying in a crucible alternate ſtrata of copper and ſulphur in powder, and heating the crucible in the manner above mentioned. The mat thus formed is pulverized, and receives the name of *æs veneris*. Alkaline ſulphures and ſulphurated hydrogenous gas act in a ſufficiently eminent manner on copper. The former ſubſtances diſſolve this metal either by the dry or by the humid way: the latter communicates an high colour to its ſurface; but the mutual effects of theſe ſubſtances and copper have not been farther examined.

Copper forms an alloy with various metals: with arſenic it becomes white and brittle, and ſo forms *white tombac.*

It combines with biſmuth; forming with it, according to Gellert, a reddiſh white alloy with cubic facets.

It

It enters very readily into union with antimony, forming with it the *cupreous regulus* diſtinguiſhed by a beautiful violet colour. It decompoſes ſulphure of antimony, and combines with the ſulphur which it detaches from the ſemi-metal.

With zinc it combines very readily. This combination may be effected in two ways; 1. By fuſion, a metal is obtained of the colour of gold, much leſs liable to ruſt than pure copper; but at the ſame time leſs ductile. The more this metal reſembles gold, the brittler it is: beſides, its nature varies according to the proportion in which the two ſubſtances are mixed together and the precautions taken in melting them: its varieties are ſimilor, pinchbeck, Prince Robert's metal, and Manheim gold. 2. By cementing plates of copper with native carbonate of zinc, or lapis calaminaris reduced to powder, and mixed with coal, and making the crucible in which they are contained red-hot, the copper then forms *yellow braſs*. This laſt compound is not ſo liable to ruſt as copper: it is equally malleable and more fuſible; but if expoſed for ever ſo ſhort a time to a ſtrong heat, it loſes its zinc and becomes red copper again.

Copper combines with mercury, but not readily; yet by triturating very thin leaves of copper with mercury, theſe metals may be formed into a ſort of amalgam. A plate of this metal immerſed into a ſolution of mercury by an acid, takes a fine ſilver colour, owing to the mercury being reduced and precipitated by the copper, which has a greater affinity than that ſemi-metal with oxigene.

Copper and lead combine very well by fuſion; as appears by the formation of the loaves of eliquation.

It is combined with tin in two ways; either by pouring

ing melted tin on the ſurface of a plate of copper, or by melting the two metals together. The former operation is uſed in tinning copper; the latter forms bronze. Copper veſſels to be tinned are firſt well ſcoured, to render the ſurface on which the tin is to be applied ſmooth and bright. They are next rubbed with ammoniacal muriate, to make them perfectly clear. They are then made hot, and powdered roſin is caſt upon them. This ſubſtance covers the ſurface of the copper ſo as to prevent it from being oxidated At laſt the melted tin is poured on, and ſpread over it. Complaints have been made, and with good reaſon, that the tinning of copper-veſſels is not ſufficient to defend them from the action of air, of moiſture, and of ſalts; becauſe ſuch veſſels are often obſerved to be covered with verdigris. This might be effectually remedied by laying on a thicker coat of tin, were there not reaſon to fear that when ſuch veſſels are expoſed to any degree of heat above that of boiling water, the tin is then liable to be melted, and thus to expoſe the ſurface of the copper uncovered. To prevent ſuch an accident, the tin may be alloyed with iron, ſilver, or platina, to render it harder and leſs fuſible, in order that it may be laid in thicker layers on the copper. Mixtures of this kind are already made uſe of in ſeveral manufactories. It is amazing how ſmall a quantity of tin is ſufficient to tin copper; for Meſſrs Bayen and Charlard have aſcertained, that a pan nine inches in diameter and three lines in depth, gained only an additional weight of one and twenty grains by being tinned. This trifling quantity, however, is ſufficient to prevent the danger which might otherwiſe ariſe from the uſe of copper-veſſels, when care is taken not to ſuffer ſubſtances capable of diſſolving tin to remain too long in ſuch veſſels, and eſpecially

ſpecially to renew the tinning frequently, as friction, heat, and the action of the ſpoons uſed in ſtirring ſubſtances boiled in them, very ſoon deſtroy the tinning. There is one thing, however, reſpecting the tin uſed by copperſmiths for tinning pans which we cannot be too much on our guard againſt. It is often alloyed with one-fourth part of lead; the bad effects of which are to be feared, as it is well known in fats and acids. Government ſhould therefore take meaſures to prevent copperſmiths from being cheated when they purchaſe their tin, and from employing the tin of Malacca or Banca in any other ſtate but as it comes from the Eaſt-Indies, before being melted again, and having its purity debaſed by our tin-workers.

M. de la Folie, a citizen of Rouen, who merits the reſpect of the public for thoſe chemical reſearches which he has proſecuted on matters relative to the arts, and for the uſeful diſcoveries with which he has enriched dyeing, pottery, and many other of the manufactures carried on at Rouen, has propoſed, in order that the inconveniences and dangers attending the uſe of tinned copper may be avoided, to employ in its ſtead iron plated with zinc; which, as we have already ſeen, is productive of no dangerous effects. Many people have already adopted the uſe of ſuch veſſels with advantage; and it is to be wiſhed that they were in general uſe.

Tin melted with copper gives a metal, the ſpecific gravity of which is greater than that of either of the two metals of which it is made up, in conſequence of their mutually penetrating each other in a very intimate manner. The greater the proportion of tin in this mixture, ſo much the more white, brittle, and ſonorous is the mixture. When very white, it is called *bell-metal:* when

when it contains more than an equal proportion of copper, it is yellow, and bears the name of *bronze*, or *braſs*. It is moulded into ſtatues and into cannons, which muſt be ſo ſolid as not to burſt by a moderate force; and at the ſame time not ſo ductile as to loſe their form by the impulſe of bullets.

Copper and iron may be united by fuſion or by ſoldering. This combination, however, does not very eaſily ſucceed. When a mixture of theſe two metals is melted in a crucible, the iron is found to be intermixed, but not perfectly united with the copper. Copper decompoſes the mother water of ſulphate of iron; and yet iron has a greater affinity than acids with copper.

The uſes to which copper is applied are very various and very well known. A great variety of utenſils are made out of it. Yellow copper, or an alloy of copper with zinc, is principally employed for ſuch purpoſes, on account of its ſuperior ductility and beauty. Copper being a very violent poiſon, ſhould never be adminiſtered as a medicine. The remedies moſt uſually applied in the caſe of poiſoning by copper reduced to oxide or verdigris, are emetics, water drunk in large quantities, alkaline ſulphures, alkalis, &c.

CHAP. XX.

Of Silver.

SILVER, called *Luna*, or *Diana*, by the alchemiſts, is a perfect metal of a white colour and the moſt lively brilliancy. It has neither taſte nor ſmell. Its ſpecific gravity is ſuch, that it loſes in the hydroſtatic balance about one-eleventh part of its weight. A cubic foot of this metal weighs ſeven hundred and twenty pounds. So great is the ductility of ſilver, that it may be reduced to leaves as thin as paper, and to threads finer than hairs. A grain of ſilver may be extended ſo as to contain an ounce of water. Its tenacity is ſo conſiderable, that a thread of ſilver, one-tenth of an inch in diameter, is ſufficient to ſupport the weight of two hundred and ſeventy pounds without breaking. It poſſeſſes hardneſs and elaſticity in an inferior degree to that in which copper poſſeſſes theſe qualities ; it is next after copper the moſt ſonorous of all metals. It becomes hard under the hammer, but may be eaſily deprived by heating of the hardneſs which it thus acquires.

quires. Meſſrs Tillet and Mongez have cryſtallized ſilver. They obtained it in quadrilateral pyramids, ſometimes ſolitary on the edges of the crucible, at other times laterally united in groups.

Silver is found in various ſtates in nature. The following are the ſilver ores moſt ſtrikingly diſtinguiſhed from each other.

1. Native, or virgin ſilver. It is known by its luſtre and ductility. It appears under an amazing variety of forms. It is frequently in irregular maſſes, the ſize of which is more or leſs conſiderable. It is ſometimes in capillary threads twiſted round; its formation then appears to be owing to the decompoſition of a red ſilver ore, as has been obſerved by Henckel and M. Romé de Liſle. It is likewiſe found in plates, or in pieces of net-work reſembling ſpider's webs, which the Spaniards on this account call *arané;* ſometimes again in a vegetable form, or in branches conſiſting of octohædrons riſing one over another. Some of theſe ſpecimens reſemble the fern leaf, others are in ſeparate cubes and octohædrons, with truncated angles; but theſe laſt are rare. Native ſilver is often diſperſed in a quartzoſe gangue; it is ſometimes found in fat earths. It is found in Peru, in Mexico, at Konſberg in Norway, at Johan Georgenſtadt and Ehrenfriederſdorf in Saxony, at St Marie, at Allemont in Dauphiny, &c. This metal is not known to exiſt in nature in the ſtate of oxide.

2. Native ſilver, in union with gold, copper, iron, antimony, or with gold and copper together, or with arſenic and iron together. Theſe various native combinations of ſilver are found at Freyberg in Saxony, and in the mines of Guadal-Canal in Spain. But it is

to be obſerved, that the proportion of the extraneous ſubſtances is very trifling.

3. *Vitreous ſilver ore* conſiſts, according to moſt mineralogiſts, of ſilver and ſulphur. It is of a blackiſh grey colour like lead; it is alſo brown, greeniſh, yellowiſh, &c. and it may be cut with the knife as well as that metal. It is frequently irregularly ſhaped, ſometimes in octohædral cryſtals, the angles of which are truncated. M. Monnet takes notice of a variety, which, inſtead of being diviſible by the knife, falls into powder. This ore affords from ſeventy-two to eighty-four pounds of ſilver in the hundred weight. It melts very eaſily: when expoſed to a heat ſo moderate as not to melt it, the ſulphur is diſſipated, and leaves the virgin ſilver in a vegetative form, or in filaments.

4. *Red ſilver ore* is often of a deep colour, ſometimes tranſparent, and cryſtallized in cubes with their edges truncated, or in hexahædral priſms terminating in trihædral pyramids: at Potoſi this is called *roſſi-clero.* The ſilver is combined in it with ſulphur and arſenic. When it is broken, its colour is lighter within, and it appears to conſiſt of ſmall needles or priſms converging like ſtalactites. If expoſed, with proper management, to a fire ſtrong enough to make it red hot, the ſilver is reduced, and takes a capillary vegetative form like native ſilver. It affords from fifty-eight to ſixty-two pounds of ſilver in the hundred weight. This ſpecies is diverſified into varieties by the properties of colour, form, and gravity, &c. It is generally found in all ſuch places as contain the other ſilver ores.

5. Silver with arſenic, cobalt, and iron mineralized by

by ſulphur. Bergman ſays, that in this ore the ſilver is ſometimes above the proportion of $\frac{50}{100}$. This ore is ſometimes grey and ſparkling, ſometimes of a dark and duſky appearance; efflor eſcences of cobalt are obſervable upon it. The ſilver ore called *gooſe-dung* belongs to this ſpecies.

6. The grey ſilver ore; which differs from the copper ore called *Fablertz* only in containing a larger proportion of this precious metal. It is either in maſſes or in triangular cryſtals, with their ſides cut ſloping. The largeſt of theſe cryſtals are not of a very bright colour; the ſmall, being diſperſed over a ſmooth gangue, are of ſo lively a luſtre as to afford a very pleaſing ſpectacle when light falls upon them. Grey ſilver affords from two to five marks of ſilver in the hundred weight. Grey ſilver is ſometimes introduced into organic matters, and moulded into an exact imitation of their form. It is then called *figured ſilver ore.* Of this kind is that reſembling blades of corn, and that which M. Romé de Liſle has obſerved in the form of the cones and ſcales of the pine-tree. This ore contains ſilver, copper, iron, arſenic, and ſulphur. When the proportion of the iron is very ſmall, it is then called *white ſilver ore.* This latter ore is not to be confounded with galena containing ſilver, which is ſometimes called by the workmen *ſilver ore.*

7. Black ſilver ore, called by the Spaniards *nigrillo*, is, according to Meſſrs Lehman and Romé de Liſle, nothing but red or grey ſilver ore decompoſed and brought into a kind of middle ſtate between its original ſtate and that of native ſilver: it is ſometimes found to contain native ſilver. The latter of theſe two mineralogiſts has obſerved, that when ſolid, ſpongy, or worm-eaten, it may be conſidered as produced from the red and

vitreous ores, and is then richer than when friable and pitch-coloured; when it may be conſidered as originating from the alteration of grey or white ſilver ores. It therefore affords various products. In general, it affords from ſix or ſeven to nearly ſixty pounds of ſilver in the hundred weight.

8. *Corneous ſilver ore*, or the natural combination of ſilver with muriatic acid, and a little ſulphuric acid, is of a dirty yellowiſh grey colour: it ſometimes inclines to a grizelin colour; ſometimes, tho' but ſeldom, it is ſemi-tranſparent: it is ſoft, and may be eaſily cruſhed or cut: it melts at the flame of a taper. It is found in cubic cryſtals, but ofteneſt in irregular maſſes. It frequently contains lumps of native ſilver. It was formerly thought to contain ſulphur and arſenic; but mineralogiſts are now agreed in reſpect to its nature. Meſſrs Cronſtedt, Lehman, and Sage, Woulfe, Lommer, and Bergman, have found it to contain muriatic acid, which is diſengaged by heat. Woulfe has beſides aſcertained it to contain ſulphuric acid. It is found at Saxony, at St Marie, at Guadal Canal in Spain, and at Allemont in Dauphiny.

9. *The ſoft ſilver ore* of Wallerius, is ſilver either native or mineralized, and intermixed with more or leſs coloured earth. Earths containing ſilver vary in colour from a dirty grey to a deep brown.

10. Laſtly, Silver is often found in combination with other metallic matters in ores, the hiſtory of which we have already given. Such are miſpickel, the grey cobalt ore, kupfernickel, or nickel ore, ſulphure of antimony, which often affords the variety called *ſilver ore in feathers*, *blende*, *galena*, *martial pyrites*, and *white copper ores:* the latter are only grey ſilver ores. All of theſe ſubſtances, many times, contain ſo much ſilver, as

renders

renders the working them for the ſake of this precious metal profitable. But it is eaſy to ſee, that they cannot, with any propriety, be deſcribed as peculiar ſilver ores; and deſerve only to be mentioned as containing ſilver.

Silver ores are aſſayed in various ways, according to the nature of the ore. All that is ſtrictly requiſite in aſſaying ſuch as contain native ſilver, is to pound and waſh them. In order to ſeparate the metal entirely from extraneous ſubſtances altering it, after being waſhed, it may be triturated with running mercury. The mercury diſſolves the ſilver, and being then volatilized by fire, leaves the perfect metal ſeparate. Sulphureous ſilver ores need to be roaſted, and afterwards melted with a greater or a leſs quantity of flux. The ſilver obtained by this melting is commonly alloyed with lead, copper, iron, &c. To ſeparate it, and to aſcertain exactly what quantity of the precious metal this mixture contains, a proceſs entirely chemical, and founded on the conſideration of the properties of the imperfect metals, is employed. As lead is ſuſceptible of vitrification, and acts in the quality of a flux on the imperfect metals, ſuch as iron and copper, but is incapable of affecting ſilver in the ſame manner; lead is therefore employed to ſeparate the perfect metal from ſuch imperfect metals as alter it. The greater the proportion of the extraneous matters by which the ſilver is altered, ſo much the more lead muſt be made uſe of to ſeparate them This alloy is put into flat porous veſſels, made of calcined bones and water. Theſe roaſting pots, which are called *cupels*, as being in the form of ſmall cups, are proper for abſorbing the lead-glaſs formed in this operation The ſilver after this remains pure. In order to determine what quantity of the

the imperfect metals any maſs of ſilver contains, it is conſidered as conſiſting of twelve parts, which are called *penny-weights;* and each of theſe conſiſts of twenty-four grains. If the maſs of ſilver under examination has loſt in the cupels only a twelfth-part of its weight, it is called *ſilver of eleven penny-weights:* if it has loſt but a twenty-fourth part of its weight, it is *ſilver eleven penny-weights and twelve grains fine*, and ſo on. The cupel is found, after this operation, to have acquired a conſiderable addition of weight: it contains vitreous oxide of lead, and of the other imperfect metals, which were in combination with the ſilver, and have been ſeparated by the lead. As the lead almoſt always contains a little ſilver, it muſt be at firſt cupelled by itſelf, in order to aſcertain what quantity of ſilver it contains: from the button of fine ſilver obtained, a deduction muſt be made for the ſmall portion known to be contained in the lead which is employed, and is called a *witneſs*. The cupellation exhibits a phænomenon from which the artiſt underſtands the ſtate of his operation. As the ſilver becomes pure by vitrification and the ſeparation of the lead, it aſſumes a much more brilliant appearance than that with which the lead is ſtill intermixed. The luſtre by degrees increaſes; and when the whole ſurface of the metal becomes pure and of a dazzling brightneſs,—at the very inſtant when the whole aſſumes ſuch an appearance, the operation is finiſhed. The ſilver, after being thus cupelled, is entirely purified from the imperfect metals which it before contained: but it may ſtill contain gold; and a new proceſs muſt be employed to ſeparate the two perfect metals. As gold is much leſs liable than ſilver to be altered by a great many menſtrua, the ſilver is diſſolved by the nitric or the muriatic acid and by ſulphur; and the

the gold, which is ſcarce liable to be affected by theſe ſolvents, remains pure. This way of ſeparating ſilver from gold is called *parting*. We will ſpeak of the various ways of parting theſe metals, after deſcribing in what manner the ſeveral ſolvents which are uſed for this purpoſe act upon the ſilver, and when we treat of the alloy of ſilver with gold.

The proceſſes, in the great way, for extracting ſilver from its ores, and obtaining it pure, are nearly the ſame with thoſe which we have deſcribed as proper for aſſaying the ores of this metal. There are, in general, three ways of treating ſilver in the great way. The firſt conſiſts in triturating virgin ſilver with mercury: this amalgam is waſhed to purify it entirely from earth: it is then ſtrained through goat-ſkin, and diſtilled in an iron retort; after which the ſilver is melted, and run into ingots. This proceſs cannot be applied to ſilver ores containing ſulphur. Theſe muſt be roaſted and mixed with lead, in order to refine the precious metal by cupellation. This is the proceſs to which rich ſilver ores are ſubjected. As to ſuch as are pure, the method employed upon them is different from either of theſe two. They are melted without being previouſly roaſted with a certain quantity of pyrites. This is called *crude fuſion*, and affords a mat of copper containing ſilver, which is treated with lead by eliquation. The lead which takes up the ſilver as it melts, is afterwards ſcorified in the cupel, and then leaves the perfect metal pure. Cupellation in the great way differs from that which is performed in the ſmall way; for, whereas in the former the ſcorified lead is blown over the edges of the cupel with blow-pipes, in the aſſay the vitrified oxide of lead is abſorbed by the cupel.

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The ſilver obtained by the proceſſes which we have diſcribed is, in general, much leſs liable to alteration than any of the other metals of which we have given the hiſtory. The contact of light, however long the metal remain expoſed to it, produces no change of its properties. Heat melts it, makes it boil, and volatilizes it, but without altering its nature. An heat ſufficient to make it become firſt red, and afterwards white, is requiſite to melt it: it is more fuſible than copper. After being kept for ſome time in fuſion, it ſwell and exhales vapours which are nothing but ſilver volatilized. What puts this fact beyond doubt is, that portions of the metal are found in the funnels of chimnies in which it is melted in large quantities. It is confirmed by a fine experiment of the Academicians of Paris; they expoſed very pure ſilver to the focus of M. de Trudaine's lens, and obſerved the melted metal to diffuſe a thick ſmoke, which being intercepted by a plate of gold, was fixed upon it, and whitened its ſurface.

Silver when ſlowly cooled, is ſuſceptible of a regular form, and cryſtallizes in quadrangular pyramids. M. Baumé obſerved, that this metal takes, as it cools, a regular form; which appears from its ſurface being covered over with filaments reſembling the threads of a feather. I have remarked, that the button of fine ſilver obtained by cupellation, often exhibits on its ſurface ſmall ſpaces with five or ſix ſides, arranged like the flags of a pavement. But its cryſtallization in tetrahædral pyramids has not been carefully examined by any but Meſſrs Tillet and the Abbé Mongez.

It was long imagined, and many chemiſts are ſtill of opinion, that ſilver is ſecure againſt the joint action of heat

heat and air. It is certain that this metal ſuffers no apparent alteration when held for ſome time in fuſion, and in contact with air. Juncker, however, related, that on treating ſilver for a conſiderable time by reverberation, in the way of Iſaac of Holland, he found it to change into a vitreous oxide. This fact has been confirmed by Macquer. He expoſed ſilver twenty times ſucceſſively in a porcelain crucible, to the heat of the porcelain furnace at Seves, and obtained, by the twentieth fuſion, a vitreous matter, of an olive green colour, which he conſidered as a true vitreous oxide of ſilver. When this metal is heated in the focus of a burning-glaſs, its ſurface is always covered with a white pulverulent matter, and a greeniſh incruſtation is formed on the body on which it reſts. Theſe facts remove every doubt that could be reaſonably entertained of the alteration of ſilver in ſuch circumſtances. Tho' much more refractory againſt all attempts to reduce it to an oxide than any other metal; yet is it liable to be at length changed into a white oxide, which when treated in a very ſtrong fire takes an olive green colour. It might perhaps be poſſible to obtain an oxide of ſilver, by reducing the metal to very thin plates or leaves, and heating it for a conſiderable time in a matraſs, in the ſame way as is done with mercury. The electric ſpark appears likewiſe to oxidate ſilver. It is certain, at leaſt, that this metal has but a very faint tendency to combine with the baſe of vital air, and that heat does not contribute to this combination ſo much as in the caſe of any of the other metals; but on the other hand, deſtroys it by a very ſlight effort; for all the oxides of ſilver may be eaſily reduced without addition; and oxigene muſt therefore be but very imperfectly

fectly combined with the metal, ſince it can be detached from it ſo as to form vital air, by the action of light and heat alone.

Silver is liable to no alteration from air; its ſurface in a long ſpace of time is a very little ſullied by the action of the atmoſphere. Water acts not upon it: earthy matters do not combine with this metal: Its oxide, if melted with glaſſes, would probably communicate to them an olive green colour.

Neither the alkalis nor the ſalino-terreous ſubſtances act in a ſenſible degree on ſilver. The ſulphuric acid, when highly concentrated and boiling, and when the metal is preſented in a ſtate of extreme diviſion, diſſolves it. A conſiderable quantity of ſulphureous acid gas is diſengaged from this ſolution; and the ſilver is reduced to a white matter, on which a new quantity of ſulphuric acid muſt be poured, in order to diſſolve it. By evaporating this liquor, ſulphate of ſilver is obtained in ſmall needles. I have ſeveral times obtained this ſalt in plates, formed by the longitudinal junction of a number of theſe needles. This ſalt melts when expoſed to fire, and is of a very fixed nature. It is decompoſable by alkalis, iron, copper, zinc, mercury, &c. All the precipitates obtained by alkalis may be reduced without addition to fine ſilver, in cloſe veſſels.

The nitric acid oxidates and diſſolves ſilver rapidly, even without the help of heat. This ſolution even takes place at times ſo quickly, that to prevent the inconveniences ariſing from this circumſtance, it is found expedient to have the ſilver in lumps when expoſed to the acid. A conſiderable quantity of nitrous gas is diſengaged on the occaſion, and a white precipitate is produced, more or leſs in quantity, if the acid of nitre have been mixed with any portion of ſulphuric or muriatic acid. The nitric

nitric acid uſually gives it a blue or a green colour. If the ſilver be pure it loſes that colour, and becomes tranſparent as ſoon as the ſolution is fully accompliſhed: but if the ſilver happen to contain copper, the ſolution retains a lighter or deeper greeniſh ſhade. The pureſt ſilver that can be obtained often contains gold. In that caſe, as the nitric acid is ſcarce capable of acting on that metal, when it acts on the ſilver it ſeparates ſmall blackiſh flakes, which fall to the bottom of the veſſel, and prove to be gold. It is in conſequence of the nitric acid acting in ſo different a manner on theſe two metals, that it is happily employed to ſeparate them in the operation of parting by aquafortis. The nitric acid diſſolves a quantity of ſilver equal to half its own weight. This ſolution is exceedingly cauſtic; ſo much ſo, that it produces black ſpots on the epidermis, and eats entirely through it. When ſtrongly concentrated, it depoſites thin bright cryſtals like the boracic acid: when half the quantity is evaporated, it affords, by cooling, flat cryſtals, which are either hexagonal, or triangular, or ſquare, and appear to conſiſt of a great many ſmall needles joined laterally. Theſe flat cryſtals are obliquely arranged one over another. They are tranſparent and very cauſtic. They are called *Lunar cryſtals:* their proper name is nitrate of ſilver. This ſalt is ſpeedily altered by the contact of light, and rendered black by combuſtible vapours. When placed on a burning coal it readily detonizes, leaving after the detonation a white powder, which conſiſts of pure ſilver: it is very fuſible. If expoſed to fire in a crucible, it ſwells at firſt as it loſes the water of its cryſtallization; and after that remains in fuſion without motion. If ſuffered to cool in this ſtate, it becomes a grey maſs, ſlightly needled; a preparation which is known in ſurgery

gery under the name of the *infernal ſtone.* But there is no occaſion to make uſe of cryſtallized nitrate of ſilver when we wiſh to obtain this medicine; the proceſs by which it is made up is too tedious and too expenſive. It is ſufficient to evaporate to dryneſs a ſolution of ſilver by the nitric acid, to put the reſidue in a ſilver crucible or ladle, as M. Baumé adviſes, and to heat it ſlowly till it melt; it may be then run into a mould to give it the form of ſmall cylinders. When theſe cylinders are broken, they appear to conſiſt of needles diverging in radii from the centre of the cylinder, and terminating at its circumference. In compoſing the *infernal ſtone* of nitrate of ſilver, we muſt beware of heating it too long; otherwiſe a part of the ſalt will be decompoſed and formed into a button at the bottom of the crucible. In order to have an opportunity of obſerving what paſſes in this operation, I diſtilled this ſalt in a pneumato-chemical apparatus; I obtained nitrous gas and vital air, mixed with azotic gas. In my matraſs I found the ſilver entirely reduced; the glaſs was become opaque, like enamel, and was of a beautiful cheſnut-brown colour. The brown colour which the glaſs takes on this occaſion muſt, no doubt, be owing to oxide of manganeſe, or ſome other ſubſtance contained in it; for the colour of glaſs formed of oxide of ſilver is nearly an olive green, as we have already obſerved.

Nitrate of ſilver does not attract moiſture when expoſed to the air; it diſſolves very readily in water; and may be cryſtallized from the ſolution by a ſlow evaporation of the fluid.

The nitric ſolution of ſilver is decompoſed by ſalino-terreous ſubſtances and alkalis; but the phænomena vary greatly, according to the ſtate of the matters. Lime-water

water produces a very copious olive-coloured precipitate. Fixed alkali, ſaturated with carbonic acid, makes it yield a white precipitate: cauſtic ammoniac cauſes it to afford a grey precipitate, inclining to olive green. This precipitation does not take place till a conſiderable time after the two ſubſtances have been mixed.

Although the nitric acid act with a ſtronger energy on ſilver than any of the other acids, there are, however, others which have a greater affinity with its oxide, and adhere to it with more obſtinacy: the ſulphuric and the muriatic acids detach the oxide from the nitric acid. For this reaſon, when a few drops of either of theſe acids are poured into a nitric ſolution of ſilver, a precipitate is produced; which, when the ſulphuric acid is employed, is a white powder; and when it owes its origin to the muriatic acid, in thick flakes like a *coagulum*. In the former caſe the precipitate is ſulphate of ſilver; in the latter, muriate of ſilver. As neither of theſe two ſalts is very liable to ſolution, they therefore ſubſide in a precipitate. It is not neceſſary that the acids be in a ſtate of liberty when applied to this purpoſe; the neutral ſalts which are formed by their combinations with alkalis and ſalino terreous ſubſtances ſerve the purpoſe equally well. A double decompoſition and a double combination then take place; for the nitric acid, ſeparated from the ſilver, enters into combination with the baſe of the ſulphuric or muriatic ſalt.

On this difference among the acids, in reſpect to the manner in which they act upon ſilver, there is founded a proceſs which is employed to procure the nitric acid in an high ſtate of purity, and unmixed with any other acid: in a word, in that ſtate in which it is requiſite to have it for many operations in metallurgy, and for moſt

chemical

chemical experiments. Diſtilled ſpirit of nitre is generally mixed with a certain quantity of ſulphuric or muriatic acid; and chemiſts have therefore induſtriouſly ſought to ſeparate theſe extraneous fluids, and have found no happier expedient than the uſe of the nitric ſolution of ſilver. This ſolution is poured into the impure nitric acid till it ceaſe to produce a precipitate; the ſediment of ſulphate or muriate of ſilver is ſuffered to ſettle; the acid is decanted off, and diſtilled by a moderate heat to ſeparate from it that ſmall quantity of ſalts of ſilver which may ſtill be contained in it. The product of this diſtillation is very pure nitric acid: in the arts it is called precipitated aquafortis.

Moſt metallic matters are capable of decompoſing the nitric ſolution of ſilver, as they have in general a greater affinity than that metal with the nitric acid. Arſeniate of potaſh, diſſolved in water, produces in the nitric ſolution a reddiſh precipitate, which originates from the union of the ſilver with the arſenic. This precipitate reſembles red ſilver ore. The ſilver may be obtained in its metallic ſtate, as a precipitate from this ſolution by moſt of the metals and the ſemi-metals. But the ſeparation of this perfect metal by mercury and copper is particularly worthy of our notice, on account of the phænomena which attend the firſt of theſe metallic ſubſtances as it acts on ſilver, and the uſeful purpoſes which are ſerved by bringing the ſecond to act upon it.

Silver, when ſeparated from the nitric acid by mercury, is in a metallic ſtate; and the precipitate ſubſiding ſlowly, produces, as it ſubſides, a regular figure, known by the name of *Diana's tree*, or *the philoſophic tree*. This ſpecies of cryſtallization may be obtained by ſeveral different proceſſes. Lemery directed to take an an ounce of fine ſilver, to diſſolve it in nitric acid moderately ſtrong, and to dilute the ſolution with about twenty ounces of diſtilled water, adding two ounces of mercury. In the ſpace of 40 days a very beautiful vegetative form is produced. Homberg gives another proceſs much ſhorter than this. His proceſs is, to make a cold amalgam of four drachms of ſilver in leaves with two drachms of mercury: this amalgam is to be diſſolved in a ſufficient quantity of nitric acid, and a pound and an half of diſtilled water to be added to the ſolution: into an ounce of this liquor put a ſmall ball of a ſoft amalgam of ſilver, and the precipitation of the ſilver will immediately take place. The ſilver being precipitated and combined with a part of the mercury, is depoſited in a kind of priſmatic filaments on the ſurface of the amalgam. Other filaments riſe above the firſt, till we behold the form of a vegetable buſh. Laſtly, M. Baumé has deſcribed a way of obtaining the tree of Diana, a little different from Homberg's proceſs, and more infallibly attended with ſucceſs. He directs to mix ſix drachms of the ſolution of ſilver and four drachms of a ſolution of mercury by the nitric acid, both fully ſaturated; to add to the mixture five ounces of diſtilled water; and then to pour it into an earthen veſſel upon ſix drachms of an amalgam made up of ſeven parts of mercury with one of ſilver. Either of theſe proceſſes ſucceeds in a much ſhorter time than Lemery's, in conſequence of the relation ſubſiſting between the metallic matters and their mutual action. In fact, the mercury contained in the ſolution attracts the mercury of the amalgam; the ſilver of the amalgam acts in the ſame way on the ſilver of the ſolution: and, of conſequence, the ſilver is more ſpeedily precipitated. The mercury of the amalgam, being more than what is requiſite to precipitate the ſilver of the ſolution, produces a third effect, which we muſt not ſuffer to eſcape unnoticed: It attracts the ſilver by its affinity and tendency to combine with that metal: a combination is actually effected between them; for the vegetation of the tree of Diana is a real amalgam, brittle and cryſtallized. This cryſtallization ſucceeds much better in conical veſſels, ſuch as glaſſes, than in round or wide veſſels like the cucurbite recommended by M. Baumé. It is almoſt unneceſſary to mention, that the veſſel muſt not be moved, nor expoſed to any impulſe which might hinder the regular ſymmetrical arrangement of the amalgam.

Copper immerſed into a ſolution of ſilver likewiſe precipitates it in a bright metallic form. This is the proceſs uſually employed to ſeparate ſilver from its ſolvent, after the operation of parting. Plates of copper are dipped into the ſolution, or rather the ſolution is put into a copper veſſel; the ſilver is immediately ſeparated in whitiſh grey flakes. When the liquor becomes blue, and ceaſes to precipitate ſilver, it is decanted off. The ſilver precipitated is repeatedly waſhed, then melted in crucibles, and paſſed with lead into a cupel, to ſeparate from it a portion of copper which became united with it in the precipitation. The ſilver which paſſes through this operation is purer than any other kind: it is no leſs than twelve penny-weights fine. From theſe two caſes of the precipitation of ſilver by mercury and by copper, it appears that metals ſeparated from their ſolvents by metallic matters, are precipitated with all their properties. This phænomenon, as we have ſhown in the hiſtory of copper, takes place in conſequence of the metals immerſed into the ſolution of ſilver, robbing it of its oxigene, with which they have a greater affinity.

The muriatic acid does not diſſolve ſilver immediately; but it diſſolves its oxide readily enough. This acid ſuperſaturated with oxigene eaſily oxidates the metal. Such, no doubt, is the reaſon of what happens in the *concentrated parting*. This operation conſiſts in expoſing to fire plates of gold alloyed with ſilver, cemented with a mixture of ſulphate of iron and muriate of ſoda: The ſulphuric acid diſengaging the muriatic, communicates to it a portion of its own oxigene; and the muriatic acid then acts upon the ſilver, and diſſolves it.

There is a much eaſier and more expeditious proceſs for combining the muriatic acid with oxide of ſilver. The acid is poured into a nitric ſolution of the metal: a very copious precipitate is inſtantaneouſly formed, and proves to be a combination of the muriatic acid with ſilver; for the metal has a greater affinity with the muriatic than with the nitric acid, and of conſequence forſakes the latter to combine with the former. The ſame combination may be obtained by pouring muriatic acid into a ſolution of ſulphate of ſilver; for this acid has likewiſe a greater affinity than the ſulphuric with the metal. The muriatic acid may alſo be combined with ſilver, by heating the acid with oxide of the metal precipitated from the nitric acid by fixed alkali.

Muriate of ſilver poſſeſſes various properties worthy of notice. It is remarkably fuſible. When expoſed in a phial to a moderate heat, ſuch as that of hot aſhes, it melts into a grey ſemi-tranſparent ſubſtance, bearing no ſmall reſemblance to horn; and for this reaſon called *corneous luna*. If run upon a ſurface of porphry, it fixes into a friable matter, appearing to be cryſtallized in fine ſilver needles. When long heated in contact with air, it is decompoſed; it paſſes eaſily thro' the crucibles; one part of it is volatilized, and another re-

reduced to metal; ſo that it now takes the form of ſilver globules diſperſed through muriate of ſilver; a portion of the ſalt remaining not decompoſed. This ſalt, when expoſed to light, loſes its whiteneſs, and becomes ſpeedily brown. It diſſolves in water; but, according to an experiment of M. Monnet's, a pound of diſtilled water diſſolves only three or four grains. Alkalis are capable of decompoſing muriate of ſilver, when it is either diſſolved in water or expoſed to fire together with any of theſe ſalts. This is one way of obtaining the fineſt and pureſt ſilver poſſible. Mix, for this purpoſe, four parts of potaſh, or carbonate of potaſh, with one of muriate of ſilver: Put the mixture into a crucible and melt it; when it is completely melted, take it out of the fire; ſuffer it to cool, and then break it: ſeparate the ſilver; which is found under the muriate of potaſh formed during this operation and the exceſs of alkali. M. Baumé, to whom we owe this proceſs, aſſerts, that the quantity of alkali which he directs to be employed hinders the muriate of ſilver from paſſing through the crucible, by acting on all its parts, and decompoſing them at once. Margraff has given another proceſs for reducing this ſalt, and obtaining from it ſilver perfectly pure. Triturate in a mortar five drachms and ſixteen grains of muriate of ſilver with an ounce and an half of ammoniacal carbonate; add as much diſtilled water as may be ſufficient for making it into a paſte: ſtir this mixture till the ſwelling and effervescence which at firſt take place in it ceaſe: then add three ounces of pure mercury, and triturate the whole till it be formed into a beautiful amalgam of ſilver: waſh it with a good quantity of water; continue the trituration, and repeat the waſhing till the water run off very clear, and the amalgam become very bright: then dry the amalgam, and diſtil it in a retort till the veſſel take a white red colour: the mercury now paſſes into the receiver, and the ſilver is found in an high ſtate of the retort. In this manner the metal may be obtained of the higheſt purity poſſible, and without any ſenſible loſs. This ſort of ſilver ſhould be uſed in nice chemical experiments. The water employed to waſh this mixture carries off two ſubſtances; a certain quantity of ammoniacal muriate, which it holds in ſolution, and a white powder not ſoluble in water. When the white powder is ſublimated, there is a ſmall quantity of ſilver found at the bottom of the ſublimatory veſſel. This experiment proves, that muriate of ſilver cannot be completely decompoſed otherwiſe than by double affinity. In fact, in Margraff's proceſs, the cauſe of the ammoniac combining with the muriatic acid is, that the ſilver is firſt detached from the acid by the mercury, and the alkali then becomes capable of effecting an event which it could not otherwiſe have produced. But this tedious and expenſive operation can only be employed in the ſmall way and in the laboratory. To reduce a great quantity of muriate of ſilver at once, either fixed alkali, or ſome metallic ſubſtance having a greater affinity than ſilver with the muriatic acid, muſt be employed. Such, among others, are antimony, lead, tin, iron, &c. One part of muriate of ſilver melted in a crucible with three parts of any of theſe matters, affords, at the bottom of the crucible, the ſilver reduced and ſeparate; while the metal employed to produce the ſeparation appears in union with the muriatic acid. The ſilver precipitated in this manner is very impure; it always contains more or leſs of the metal employed to ſeparate it: and as, in compliance with the advice of Kunckel, lead is moſt commonly employed for the purpoſe, this ſilver needs to be cupelled; nor can it even be rendered equally pure with that which is reduced by alkalis, or by Margraff's proceſs.

The nitro-muriatic acid acts with conſiderable force on ſilver; and as it diſſolves it, cauſes it to precipitate. The manner in which this effect takes place may be eaſily underſtood: the nitric acid diſſolves the metal at the firſt, and the muriatic acid detaching itſelf from the nitric forms a neutral ſalt with the ſilver; which, having no great tendency to ſolution, is depoſited in ſediment. This proceſs may be uſed to ſeparate ſilver from gold.

We know but little about the manner in which the other acids act upon ſilver; only, a ſolution of borax produces in the nitric ſolution of this metal a very copious white precipitate; which precipitate conſiſts of boracic acid in union with oxide of ſilver.

This metal does not appear liable to be altered by neutral ſalts. It is certain, at leaſt, that it does not detonize with nitre, nor decompoſe ammoniacal muriate. Silver, in conſequence of its being unalterable by nitre, may be eaſily ſeparated from imperfect metals, ſuch as copper, lead, &c. by detonizing them with that ſalt. This metal, alloyed above the juſt proportion with ſome of the baſer metals, is melted with nitre: the ſalt detonizing burns the imperfect metal; and the ſilver falls to the bottom of the crucible in a ſtate of much higher purity.

Almoſt all combuſtible matters act with more or leſs force on ſilver. No metal is ſooner tarniſhed or coloured by inflammable matters. Sulphurated hydrogenous gas, from whatever ſubſtance diſengaged, communicates to ſilver the inſtant it comes into contact with it a blue or violet colour, inclining to black, and conſiderably diminiſhes

miniſhes its ductility. It is known that fœtid animal vapours, ſuch as proceed from houſes of office, from putrefied urine, and from hot eggs, produce the ſame effect on this metal. The mutual action of theſe bodies, and the combination which takes place on the occaſion, have not yet been examined.

Sulphur combines very readily with ſilver. This combination is uſually effected by ſtratifying on a crucible plates of the metal with flowers of ſulphur, and melting the mixture haſtily: the reſult is a violet black maſs, much more fuſible than ſilver, brittle, and needled: in a word, a true artificial ore. This compoſition is eaſily decompoſed by the action of fire, on account of the volatility of ſulphur and the fixity of ſilver: the ſulphur is conſumed and diſſipated, leaving the ſilver pure. Alkaline ſulphure diſſolves this metal in the dry way: on melting one part of ſilver with three of ſulphure of potaſh, the metal diſappears, and may be diſſolved in water together with the ſulphure. An acid poured into the ſolution produces a black precipitate of ſulphurated ſilver. Leaves of ſilver put into a ſolution of ſulphure of potaſh ſpeedily take a black colour; and it appears that the ſulphur forſakes the alkali to unite with the metal and mineralize it; as we have already obſerved of mercury,

Arſenic combines with ſilver and renders it brittle. We know not yet how the acid of arſenic affects this metal.

It combines, but not without great difficulty, with cobalt.

It enters readily enough into an alloy with biſmuth, forming with it a brittle mixed metal, the ſpecific gravity of which is greater than that of either of the two metals taken ſeparately. According to Cronſtedt, ſil-

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ver does not unite with nickel. Theſe metals, when melted together, are diſpoſed ſeparately, one beſide the other, as if their ſpecific gravities were preciſely equal.

It melts with antimony into a very brittle alloy. It appears to be capable of decompoſing ſulphure of antimony, by combining with the ſulphur of that mineral, with which it has a greater affinity than antimony has.

Silver eaſily combines with zinc by fuſion. From this combination there reſults an alloy granulated at the ſurface, and very brittle.

In mercury, even cold, it is completely diſſolved. All that is neceſſary to effect this ſolution, is to malaxate leaves of ſilver with this metallic fluid: an amalgam is by this means inſtantaneouſly produced; the conſiſtency of which varies with the reſpective quantities of the two ſubſtances. This amalgam may be brought into a regular form by fuſion and ſlow evaporation: it affords tetrahædral priſmatic cryſtals terminating in pyramids of the ſame form. The mercury becomes in ſome degree fixed in this combination: for, to ſeparate it from the ſilver, a ſtronger heat is required than what is ſufficient to volatilize it when taken by itſelf. Silver decompoſes corroſive mercurial muriate either in the dry or in the humid way.

It unites perfectly with tin; but entirely loſes its ductility when alloyed with ever ſo ſmall a proportion of that metal.

It enters readily into union with lead, which renders it very fuſible, and deſtroys its elaſticity and ſonorouſneſs.

It forms an alloy with iron, which might be very advantageouſly employed in the arts.

Laſtly, it melts and combines in any proportion with copper. Copper does not deſtroy its ductility; but renders

renders it harder and more ſonorous; and the alloy is often employed in the arts.

Silver, on account of its ductility, and its being proof againſt the attacks of fire and air, is a metal ſingularly uſeful. Its luſtre recommends it for an ornament: it is laid on the ſurfaces of various bodies, and even of copper: it is wrought into ſtuffs, and adds conſiderably to their beauty. But the moſt important uſe for which it ſerves, is that of a good material out of which veſſels of all kinds may be made; and its hardneſs and ductility render it peculiarly ſuitable for this purpoſe. The ſilver wrought into plate is commonly alloyed with $\frac{1}{24}$ of copper, which improves its hardneſs and coheſion, without rendering it in any degree dangerous to the health of thoſe who uſe it; for twenty-three parts of ſilver are ſufficient to deſtroy all the noxious qualities of one part of copper.

Laſtly, ſilver is coined into money, and uſed as a ſign of value for all ſorts of commodities; but in this caſe it is alloyed with $\frac{1}{12}$ of copper, and is, of conſequence, only eleven pennyweights fine.

CHAP. XXI.

Of Gold.

GOLD, the ſun of the alchemiſts, is of all known metals the moſt perfect, and the leaſt liable to alteration: its colour is a bright yellow. It is next after platina the moſt ponderous body in nature: in water it loſes only between a nineteenth and a twentieth part of its weight: neither its hardneſs nor its elaſticity is very conſiderable. Its ductility, of which gilding and gold wire afford ſuch amazing proofs, is ſo great, that an ounce of gold is ſufficient to give a ſilver thread four hundred and forty-four leagues in length; and it is reducible into leaves that may be carried about before the wind. It is calculated by Lewis, that a grain of gold will cover an area more than four hundred inches ſquare. It is the moſt tenacious of all metals; for a thread of gold one-tenth of an inch in diameter, is ſufficient to ſupport five hundred pounds weight without breaking. Gold ſoon becomes hard and brittle under the hammer; but heat reſtores its ductility.

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The colour of gold is ſubject to a good many varieties. It is ſometimes more or leſs yellow or pale, and ſometimes almoſt white: theſe differences, however, appear to be owing to ſome mixture. Gold has neither taſte nor ſmell: It cryſtallizes by cooling into ſhort quadrangular pyramids. Meſſrs Tillet and Mongez obtained it in this form.

Gold is found in nature almoſt in a pure and virgin ſtate. It is ſometimes met with in ſmall maſſes, either ſolitary or continuous, and in a bed of quartz: At other times it is in ſmall ſpangles, among ſand under water: Laſtly, It is extracted from various ores, into the compoſition of which it enters; ſuch as galena, blende, red ſilver ore, and virgin ſilver. It is almoſt always united with a certain quantity of ſilver, or ſome other metal, forming thus a natural alloy.

There are ſeveral varieties of native gold. It exiſts in plates, in grains, in cryſtals; which are either octahædral, in priſms of four faces, or ſtriated in filaments, and in irregular maſſes. M. Sage thinks, that native gold in priſms is combined with a certain quantity of mercury, which renders it brittle.

Modern mineralogiſts reckon up various ſpecies of gold.

1. Native gold in union with ſilver, copper, iron, &c. It is found in Peru, Mexico, Hungary, Tranſilvania, &c.

2. Auriferous pyrites: It is not eaſily diſtinguiſhed from other pyrites by the eye: we diſcover the gold by diſſolving it in the nitric acid, and waſhing the reſidue. Gold is only mixed, not combined, in martial pyrites. Some arſenical pyrites, particularly thoſe of Saltzbergh in Tyrol, contain likewiſe a little gold.

3. Gold mixed with ſilver, lead, and iron mineralized

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by ſulphur. This auriferous ore is of a very mixed nature. According to M. Sage, it is found to contain blende, galena, ſpecular antimony, copper, ſilver, and iron; the gold melts and drops out with the lead when the maſs is expoſed to heat. It comes from Naggyac in Tranſilvania.

Gold ore is aſſayed in different ways, according to its nature; pulverization and waſhing are ſufficient with native gold. Gold alloyed with other metals muſt be roaſted, melted, and cupelled with lead, and parted.

It is very eaſy to conceive in what way gold is extracted from its ores, after what has been already ſaid on metallurgy in this work. Native gold needs only to be ſeparated from its gangue. For this purpoſe, it is firſt pounded; then waſhed, to ſeparate the powder of the gangue; then triturated in a mortar full of water, with 10 or 12 parts of mercury; the water being poured off after this operation, waſhes away every earthy particle from the metallic ſubſtance. When the amalgam thus formed appears to be ſufficiently purified from earth, it is ſtrained through goat ſkins. Great part of the mercury paſſes through; a certain quantity remains ſtill united with the gold. The amalgam is next heated, and the mercury ſeparated from it by diſtillation; the pure gold obtained by this diſtillation is then melted, and run into bars or ingots. With reſpect to the gold that is found in combination in the ores of other metals, ſuch as lead, copper, ſilver; it is extracted by eliquation, cupellation, and parting. The lead which runs down from the eliquation of copper carries with it the ſilver and the gold. It is then cupelled, to ſeparate the lead; and the ſilver, as we ſhall hereafter mention, is ſeparated by parting.

Gold expoſed to fire, becomes red hot before it melts. When very red, it aſſumes a dazzling luſtre, and a clear green colour, like that of the aqua-marina. It does not melt till its colour change to a white red; when cooled ſlowly it cryſtallizes. It ſuffers no alteration, however long it be expoſed to fire, and however intenſe the heat; for Kunckel and Boyle found gold to have undergone no alteration by being expoſed for ſeveral months to the fire of a glaſs-houſe. This inalterability of nature is only relative however to the degrees of heat which we are capable of applying to it by the uſe of combuſtible matters; for it appears that a much more intenſe and active heat, ſuch as that of glaſs lenſes, deſtroys the metallic properties of gold. Homberg obſerved, on expoſing this metal to the focus of a lens of Tſchirnhauſen's, that it ſmoked, became volatile, and was even vitrified. Macquer obſerved, on expoſing gold to the focus of M. Trudaine's lens, that it melted and exhaled a ſmoke which gilded ſilver, and could therefore be nothing but gold volatilized; that the globule of melted gold was agitated by a rapid internal motion, and became covered with a rough pellicle, ſhrivelled, and ſeemingly earthy; and that a violet coloured vitrification was at length formed in the middle of the gold. The vitrified part was by degrees enlarged, till it formed a kind of cap of a larger curvature than the globule of gold, and cloſely fixed on the gold, in the ſame manner as the tranſparent cornea appears fixed on the ſclerotica of the eye. The extent of the glaſs became gradually larger, and the gold was diminiſhed. The ſurface on which it reſts is always coloured with a purple tinge, which ſeems to be owing to the glaſs which it has abſorbed.

Time did not allow Macquer to vitrify a given quantity of gold completely. He obſerved that it would be neceſſary to reduce the violet glaſs with combuſtible matters, in order to know whether it would afford gold, and whether it were oxide of that perfect metal. At any rate, we are of opinion, that vitrified gold may be conſidered as a true oxide of gold; and we are the rather induced to adopt this opinion, becauſe in a number of operations, which we will immediately proceed to deſcribe, it invariably takes a purple colour, and ſeveral preparations of it are uſed for colouring enamel and porcelain. Gold then, like other metallic matters, may be reduced to calx; only, like ſilver, it requires a more intenſe heat and longer time to make it combine with the baſe of vital air than any other metallic matter: theſe circumſtances no doubt bear a near relation to its extraordinary denſity, and its faint tendency or averſion to combine with oxigene. It is reduced to a purpliſh oxide by electrifying it violently.

Gold ſuffers no alteration from the action of air. Its ſurface is only tarniſhed by the extraneous bodies which are continually floating in the atmoſphere. Water does not alter it in any way; from the experiments of Garaye, however, it appears that this ſubſtance gradually divides it in the ſame manner as iron.

Gold in its metallic ſtate does not combine with earths or ſalino-terreous ſubſtances. Its oxide enters into the compoſition of glaſſes, and communicates to them a violet or purple colour.

Gold is not liable to ſuffer from the attacks of the ſulphuric acid, however highly concentrated, and even aſſiſted by heat.

The nitric acid diſſolves a few particles of this metal;

tal; but it is perhaps rather mechanically than by a true combination. Brandt was among the firſt chemiſts who aſſerted gold to be ſoluble in the nitric acid: the fact has been ſince confirmed by the experiments of Scheffer and Bergman. But we muſt obſerve, that according to experiments made by the whole chemiſts of the Academy of Paris, the nitric acid produces this effect only in certain circumſtances, which thoſe philoſophers have not particularly mentioned. M. Deyeux, member of the College of Pharmacy, has remarked, that the acid of nitre diſſolves gold only when it is ruddy, and contains nitrous gas. According to him, the acid is not pure in this ſtate: he calls it *acid impregnated with gas*, and deſcribes it as a kind of *aqua-regia*. We have elſewhere ſhown in what conſiſts the difference between the nitrous and the nitric acid.

The muriatic acid alone, and in a ſtate of purity, acts not upon gold in any ſenſible degree. Scheele and Bergman have diſcovered, that the oxigenated muriatic acid diſſolves gold in the ſame way as *aqua-regia;* and forms alſo with the metal the ſame ſalt which it forms with the mixed acid uſually employed to diſſolve it. It is the exceſs of oxigene united with the muriatic acid which cauſes the ſolution to take place: it is accompanied with no ſenſible efferveſcence, like the other ſolutions of metals, by the oxigenated muriatic acid.

Aqua-regia has been conſidered as the true ſolvent of gold. It diſſolves it, however, no better than the oxigenated muriatic acid. As it would be improper to repeat here what we have elſewhere ſaid concerning the nature and properties of this mixed acid, and the varieties to which it is liable, according as the proportions of the two acids by the combination of which it is formed vary, we ſhall ſpeak only of the manner in which it acts upon gold. Aſſoon as the nitro-muriatic acid comes into contact with this metal, it attacks it with an efferveſcence; which the more concentrated the acid the hotter the temperature, and the more divided the integrant parts of the gold, is ſo much the more lively. This operation may be more ſpeedily effected by a moderate heat; at leaſt a moderate heat is favourable in the beginning of the proceſs. Bubbles then riſe in conſtant ſucceſſion till a part of the metal be diſſolved. This action by degrees ceaſes; ſtirring or heat is requiſite to make it continue. Nitrous gas is diſengaged while the ſolution is taking place. The nitro-muriatic acid, when ſaturated with the full quantity of gold which it is capable of diſſolving, takes a yellow colour of a lighter or a deeper ſhade. It is conſiderably cauſtic; it tinges animal matters with a deep purple colour, and corrodes them. When evaporated with proper management, it affords cryſtals of a beautiful golden colour reſembling topazes, and appearing to be truncated octahædrons, and ſometimes tetrahædral priſms. It is difficult enough to obtain this cryſtallization. M. Monnet thinks it owing to a neutral ſalt ready formed in the nitro-muriatic acid; and aſſerts, that in order to obtain it, the *aqua-regia* made uſe of ſhould be compoſed of nitric acid with ammoniacal muriate, or muriate of ſoda. A mixed acid prepared in this manner cannot but contain nitrate of ſoda or ammoniacal nitrate. It is either the one or the other of theſe neutral ſalts, according to the chemiſt whoſe opinion we are mentioning, which occaſions the cryſtallization of gold. It appears, however, that a ſolution of gold in nitro-muriatic acid made up of pure acids, is capable of affording cryſtals; and Bergman conſiders the ſalt as muriate

riate of gold. Theſe cryſtals when heated melt and take a red colour. This ſalt powerfully attracts the moiſture of the atmoſphere. A ſolution of gold gives, by diſtillation, a beautiful red colour, which is nothing but muriatic acid impregnated with a little gold. The alchemiſts who have laboured ſo much upon gold, called this liquor *red lion.* A few golden cryſtals are likewiſe ſublimated, the colour of which is a reddiſh yellow. Moſt part of the metal remains at the bottom of the crucible; and fuſion purifies it ſo that it again diſplays all its properties.

The ſolution of gold may be decompoſed by a great many intermedia. Lime and magneſia precipitate the gold in the form of a yellowiſh powder. Fixed alkalis afford the ſame phænomenon. But it is to be obſerved, that the precipitate is but very ſlowly formed; and the ſolution takes a reddiſh colour, if more alkali be employed than what is abſolutely requiſite, for the exceſs of alkali again diſſolves the precipitated gold. The precipitate gold may be reduced by heat in cloſe veſſels; it is an oxide, and readily gives out its oxigene into the ſtate of vital air. This oxide, however, is fuſible with vitreous matters, and communicates to them a purple colour; for enamels and porcelain are coloured with a precipitate of gold, formed by mixing a ſolution of gold with liquor of flints.

Gold precipitated by fixed alkali exhibits likewiſe another property, very different from thoſe which gold poſſeſſes in its metallic ſtate: it is ſoluble in pure ſulphuric, nitric, or muriatic acid. All of theſe acids, when heated on the yellowiſh precipitate of gold, readily diſſolve it; but they do not take up ſo much of it as to afford cryſtals. When theſe ſolutions are evaporated, the gold is very quickly precipitated; the ſame thing happens by reſt. M. Monnet has obſerved a fact concerning the precipitation of gold by nut-gall *, which muſt not be forgotten; it is, that the precipitate which is reddiſh, diſſolves very well in the nitric acid, and communicates to it a beautiful blue colour.

Ammoniac precipitates the ſolution of gold in much greater abundance. This precipitate is of a brown yellow, and ſometimes of an orange colour: when expoſed even to a moderate heat, it detonizes with a conſiderable noiſe; it has been called *fulminating gold.* Ammoniac is indiſpenſibly neceſſary to its production. It may be formed, either by precipitating by fixed alkali a ſolution of gold made in nitro-muriatic acid, compoſed

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* As we have taken notice only of the precipitation of iron by nut-gall, we ſhall give a ſhort account of the phænomena which this aſtringent ſubſtance exhibit with moſt other metallic ſubſtances.

Nut-gall, with the ſolution of cobalt, gives a clear blue precipitate; with the ſolution of zinc, an aſh-green precipitate; with the ſolution of copper, a green precipitate, which becomes grey and reddiſh; with a ſolution of ſilver, it gives firſt reddiſh ſtriæ, which take afterwards the colour of burnt coffee; with the ſolution of gold, a purple precipitate. Theſe facts have been obſerved and deſcribed by M. Monnet; and he has obſerved farther, that theſe precipitates are ſoluble in acids; and that alkalis combine with the latter ſolutions without producing precipitates.

The academicians of Dijon have added to theſe facts the following new obſervations. 1. The ſolution of arſenic is not altered by nut-gall; with the ſolution of biſmuth nut-gall produces a greeniſh precipitate; with the ſolution of nickel a white precipitate; with the ſolution of antimony, a bluiſh grey precipitate; with lead, a ſlaty ſediment, the ſurface of which is covered with pellicles of a mixed green and red colour; laſtly, the ſolution of tin takes a dirty grey colour, by mixture with nut-gall and gives a copious precipitate, ſomewhat of a mucilaginous nature. Under the article of the Gallic Acid, or acid of galls, in the vegetable kingdoms, ſeveral of theſe facts will again draw our attention.

ſed with ammoniacal muriate; or rather, by precipitating by ammoniac a ſolution of gold made in aqua-regia, compoſed of pure nitric and muriatic acid. The fulminating gold thus obtained is always one-fourth more in quantity than the gold diſſolved in the *aqua-regia*. There are ſome precautions neceſſary to be taken in order to eſcape ſuffering from the terrible effects of fulminating gold. In the firſt place, it muſt be dried cautiouſly and in the open air, at a diſtance from any fire; for a very moderate degree of heat is ſufficient to make it fulminate. As friction alone would be enough to make it give an exploſion, the veſſels into which it is put muſt be ſtopped only with cork. Some unlucky accidents have ſhown, that cryſtal ſtoppers, by their friction on the necks of the bottles, may cauſe ſuch particles of the powder as adhere to that part of the bottle to fulminate; and by communication with the reſt of the powder, to produce the moſt dangerous effects. A terrible accident happened in M. Baumé's laboratory, of which he has given an account in his *Theory and Practice of Chemiſtry*.

Chemiſts have entertained various opinions concerning the cauſe of the detonation of fulminating gold. Baümé gave it as his opinion, that in this inſtance there was formed *nitrous ſulphur*, which he conſidered as the fulminating principle of the compound. But Bergman has proved his theory inadmiſſible, having formed fulminating gold without nitric acid, by diſſolving a precipitate of gold in ſulphuric acid, and precipitating it anew by ammoniac. Neither can the fulmination of this gold be owing to ammoniacal nitrate; for after being copiouſly waſhed in water, which would certainly carry off any portion of that ſalt which it might contain,

tain, it ſtill retained its fulminating powers. On examining attentively what paſſes in the detonation of fulminating gold, it is obſerved to take fire at the very inſtant when it ſhivers into pieces. When it is expoſed to the moderate heat of warm aſhes, it gives out, before the exploſion, ſparks like thoſe of electric fire: when expoſed to the ſpark produced by the Leyden bottle, it detonizes; a ſimple ſpark without motion does not kindle it: laſtly, after fulminating, it leaves the gold in a metallic ſtate. It appears, therefore, that the fulmination of this gold is owing to ſome combuſtible matter contained in the compound. And as ammoniacal gas is neceſſary to the production of fulminating gold, it is at preſent agreed, that the exploſion ought to be attributed to that ſubſtance. This theory is founded on the following facts.

1. M. Berthollet has obtained ammoniac gas by applying a gentle heat to copper tubes containing fulminating gold, and communicating at one end by means of a ſyphon, with a pneumato-chemical apparatus with mercury. The gold was now no longer fulminating, but was reduced to oxide.

2. Bergman expoſing fulminating gold to a degree of heat not ſufficient to make it fulminate, gradually deprived it of its fulminating powers, by volatilizing the ammoniac gas which it contained.

3. When a few grains of fulminating gold are made to detonize in copper tubes communicating with a pneumato-chemical apparatus with mercury, azotic gas, and a few drops of water, are obtained as products, and the gold is found to be reduced. M. Berthollet, to whom we owe this fact, thinks that in this inſtance ammoniac is decompoſed; that the hydrogene which it contains uniting with the oxigene of the oxide of gold, reduces

it by forming water; and that the azotic gas being thus ſet at liberty is conſequently diſengaged: the fulmination appears therefore to be owing to the combuſtion of hydrogene and the ſudden diſengagement of azotic gas.

4. The concentrated ſulphuric acid, melted ſulphur, fat oils, and æther, deprives this precipitate of its fulminating powers, by detaching its ammoniac.

A ſingular property of fulminating gold, which ſhows with what force it acts, is its making a mark or hole on any metal plate, ſuch as a plate of lead, tin, and even ſilver, on which it is fulminated. But it does not appear to be liable to take fire in a very cloſe veſſel; for Lewis relates, that it produced no exploſion when incloſed in an iron ball, and expoſed to an intenſe heat. The cauſe of this phænomenon ſeems to be, that there is not then room for the diſengagement of the azotic gas. Bergman, who did not well know the nature of the gas diſengaged during the fulmination of this precipitate, and conſidered it as pure air impregnated with a little ammoniac, has given a ſimilar explanation of the experiments made on this matter before the Royal Society of London. The reader may conſult his valuable Diſſertation *de calce auri fulminante*, in his *Opuſcula*. M. Berthollet diſcovered that oxide of ſilver, precipitated from nitric acid by lime, and digeſted with ammoniac till it take a black colour, acquires the property of detonizing not only by a heat a very little ſuperior to that of boiling water, but likewiſe by a ſlight friction againſt any body. Here, then, we have fulminating ſilver of a ſtill more ſingular nature than the gold ſo called; which, however, owes its fulminating properties to the ſame cauſe. The ammoniac decanted from above this oxide, depoſites, by ſlow evaporation, ſmall, bright, lamellated cryſtals, poſſeſſing the property of fulminating, even under water, by ſimple friction.

The ſolution of gold is precipitated by alkaline ſulphures. When the fixed alkali combines with the acid, the ſulphur that is precipitated unites with the gold; but this combination is not very permanent; it is enough to heat the gold, and the ſulphur is then volatilized, and the perfect metal left in a ſtate of purity. It is proper to obſerve, that the gold precipitated from a ſolution by an intermedium, is perfectly pure, even more ſo than gold obtained by parting, being ſeparated from the ſilver which it would otherwiſe have contained, in conſequence of that metal being precipitated into a muriate, even during the ſolution of the gold, as we have above obſerved.

Gold has not a greater affinity than all the other metals with the nitro-muriatic acid; on the contrary, almoſt any other metallic ſubſtance is capable of ſeparating it from its ſolvent. Biſmuth, zinc, and mercury, precipitate gold. A plate of tin immerſed into a ſolution of gold ſeparates this perfect metal into a powder of a deep violet colour, which is called purple precipitate of *Caſſius*. This precipitate, which is uſed for painting on enamels and porcelain, is prepared by diluting a ſolution of tin with nitro-muriatic acid, in a large quantity of diſtilled water, and pouring upon it a few drops of a ſolution of gold. When the ſolutions are pretty much concentrated, there is inſtantaneouſly formed a precipitate of red crimſon, which in a few days changes to purple: the precipitate is light and ſomewhat mucilaginous; the liquor is filtrated, and the precipitate waſhed and dried. This matter is a compound

pound of oxide of tin and oxide of gold; the preparation of it is one of the moſt ſingular operations of chemiſtry, on account of the variety and the inconſtancy of the phænomena which attend it. Sometimes it affords a beautiful red precipitate; ſometimes its colour is only a deep violet: and what is moſt ſurpriſing, it happens pretty often, that the mixture of theſe two ſolutions produces no precipitate. Macquer, to whom theſe varieties were very well known, obſerves, that they depend almoſt always on the ſtate of the ſolution of tin employed. If the ſolution have been haſtily effected, the metal is too much oxidated, and there is too little of it contained in the ſolution for the acid of the ſolution of gold to act upon it; for he attributes the formation of the purple precipitate of *Caſſius* to the action of that acid upon the tin. According to him, to ſucceed in this operation the ſolution employed muſt have been very ſlowly made, ſo as to contain as much tin as poſſible, without the metal being too much oxidated. He accordingly gives the following directions for preparing the purple precipitate. Diſſolve the tin, one part after another, in an acid conſiſting of two parts of nitric acid and one of muriatic acid, with an equal weight of diſtilled water; on the other hand, diſſolve with the help of heat a quantity of very pure gold in another mixed acid, conſiſting of three parts of nitric and one of muriatic acid. Dilute this ſolution of tin in an hundred parts of diſtilled water; divide it into two parts: add to one of them a new quantity of water, and try both of them with a drop of the ſolution of gold; obſerve then which of them affords the moſt beautiful red, and treat the other in the ſame manner with it; then pour in the ſolution of gold till it ceaſe to afford a precipitate.

Lead,

Lead, iron, copper, and ſilver poſſeſs likewiſe the property of ſeparating gold from its ſolution. Lead and ſilver ſeparate it into a dirty dark purple precipitate. By copper and iron it is precipitated with its metallic luſtre. The nitric ſolution of ſilver, and that of ſulphate of iron, produce likewiſe a red or brown in a ſolution of gold.

Neutral ſalts act not in a very conſpicuous manner on gold. Only it is obſerved, that melted borax poured on this metal alters its colour, and gives it a ſtrange paleneſs: but nitre and muriate of ſoda reſtore it to its former ſtate. A ſolution of borax poured into a ſolution of gold forms a precipitate of boracic acid impregnated with gold.

Sulphur is incapable of combining with gold; and this mineral is therefore employed to ſeparate ſuch other metals as happen to be united with gold, eſpecially ſilver. The alloy is melted in a crucible; when it is fully melted, flowers of ſulphur, or ſulphur in powder, are caſt on its ſurface: the ſulphur melting and combining with the ſilver thus forms a blackiſh ſcoria which ſwims above the gold. It is to be obſerved, that the two metals are never entirely ſeparated by this operation, which is called *dry parting;* and that it is applied only to lumps of ſilver containing too little gold to be worth the expence of parting by aquafortis.

Alkaline ſulphure diſſolves gold entirely. Stahl even thinks that it was by ſuch a proceſs that Moſes made the Iſraelites drink the golden calf that they had worſhipped. In making this combination, a mixture conſiſting of equal parts of ſulphur and potaſh is haſtily melted with a quantity of gold leaf, amounting to an eighth part of the weight of the whole maſs. This melted matter is poured upon a ſurface of porphyry, pulverized, and diluted with hot diſtilled water; it now forms a yellowiſh green ſolution, containing an auriferous ſulphure of potaſh. This metal may be precipitated by means of acids, and ſeparated from the ſulphur precipitated together with it by heating it in open veſſels.

Gold combines with moſt metallic matters; and in its combinations with them exhibits a number of important phænomena.

It unites with arſenic. This ſemi-metal renders its contexture brittle, and its colour very pale. It is ſcarce poſſible to ſeparate the arſenic entirely from this mixture; the gold ſeems to render it more fixed in its nature.

We are unacquainted with any alloy of this metal with cobalt. It combines with biſmuth, which renders it white and brittle; in the ſame manner with nickel and antimony. As theſe ſemi-metals are all eaſily oxidated, and moſtly fuſible, they are eaſily ſeparated from gold by the joint action of fire and air.

Sulphur of antimony has been loudly praiſed by the alchemiſts as a purifier of gold. When this metal is alloyed with any extraneous metallic ſubſtance, ſuch as copper, iron, or ſilver; on melting with it ſulphure of antimony, the ſulphure unites with theſe ſubſtances, and ſeparates them from the gold, which is found by itſelf at the bottom of the veſſel. This gold, however, is alloyed with antimony; it is purified by heating it to a white red. The antimony is then volatilized; a very intenſe fire, however, is requiſite to ſeparate it entirely; and it is obſerved the ſemi-metal carries with it ſome part of the gold. This proceſs, which was ſo famous

mous among the alchemiſts, is in no way preferable to that in which ſulphur alone is employed for the ſame purpoſe.

Gold eaſily unites with zinc: the mixed metal reſulting from this union is the whiter and the more brittle in proportion as the quantity in which the ſemi-metal enters into the mixture is greater. An alloy conſiſting of equal parts of theſe two ſubſtances is of a very fine grain; and takes ſo beautiful a poliſh, that it has been recommended by Hellot as proper for making mirrors to teleſcopes, not liable to loſe their luſtre. When the zinc is ſeparated from the gold by calcination, the oxide of the ſemi-metal is reddiſh, and carries with it a little gas, as mentioned by Stahl.

Gold has a greater affinity than any other metallic ſubſtance with mercury, and decompoſes amalgams of any other metal or ſemi-metal with mercury. It unites with mercury in all proportions, forming with it an amalgam; which the greater the proportion of the gold is, ſo much the more ſolid and the higher coloured. This amalgam is liquefied by heat, and cryſtallized by cooling, like almoſt all the other compounds of this kind. We know not well what regular form it takes. M. Sage ſays, that its cryſtals are like feathered ſilver; and that when viewed through the magnifier, they appear to be quadrangular priſms. He aſſerts likewiſe, that the mercury becomes fixed in this combination. This amalgam is uſed to gild painters gold.

Although gold cannot be oxidated by the joint action of the air and the fires of our furnaces, it ſuffers that change, however, when heated with mercury. Mercury, with a forty-eighth part of gold, heated in a flat-bottomed matraſs with a very narrow neck, on a ſand-

bath,

bath, in the ſame way as oxide of mercury is heated in preparing *precipitate per ſe*, is itſelf oxidated, and cauſes the ſame phænomenon to take place on the gold. The mixture is changed into a dark red powder; and this double oxide is obtained even much ſooner, according to M. Baumé, than oxide of mercury heated by itſelf.

Here, then, we have a metal which, though exceedingly difficult to oxidate by itſelf, haſtens and facilitates the oxidation of another metallic matter, which does not readily ſuffer ſuch a change by itſelf.

Gold enters very readily into union with tin and lead: either of theſe metals totally deſtroys its ductility. With iron it forms a very hard alloy, of which inſtruments for cutting may be formed much ſuperior to thoſe which are made of pure ſteel. This mixed metal is grey, and ſubject to the attraction of the magnet. Lewis propoſes the uſe of gold to ſolder ſmall pieces of ſteel neatly and in a very ſolid manner.

Gold combines with copper, which renders it red, hard, and more fuſible. This alloy is fixed at different proportions for pieces of money, veſſels, and toys.

Laſtly, Gold combines with ſilver, which changes its colour, and renders it very pale. A certain difficulty, however, attend this mixture, on account of the different gravities of the two metals; as has been obſerved by Homberg, who ſaw them ſeparate when melted together. The alloy of ſilver with gold forms the jeweller's green gold.

As the uſe of gold is very extenſive, and as men have agreed to uſe gold and ſilver as common ſigns to repreſent the value of all the other productions of nature

ture and art, it is of great importance to be able to diſtinguiſh the degree of the purity of any piece of this metal, in order to the prevention of fraud, and that all the gold which circulates in commerce may be nearly of the ſame intrinſic value. Juſt and ſevere laws have preſcribed the particular alloy of gold to be employed in making utenſils, and have pointed out the proportions requiſite to give it a due degree of hardneſs and inflexibility for that purpoſe. Chemiſtry affords means for diſtinguiſhing with what quantity of imperfect metal gold may be at any time alloyed. The operation by which this is accompliſhed is called *the aſſay of gold*: Twenty-four grains of the gold to be aſſayed are cupelled for this purpoſe, with forty-eight grains of ſilver and four drachms of pure lead. The lead as it vitrifies carries off with it the imperfect metals, ſuch as copper, &c. The gold remains, after the cupellation, in combination with the ſilver. Theſe two metals again are ſeparated by an operation which bears the name of *parting*. To part an alloy of gold and ſilver, is to ſeparate the two metals by a ſolvent which may act upon the ſilver without affecting the gold. Aquafortis is commonly uſed. The deſign in adding the ſilver to the gold was, that all the ſilver in the gold might be completely diſſolved by the nitric acid; for experience has ſhown that gold muſt contain at leaſt twice its weight of ſilver, before the nitric acid can act ſo as to diſſolve the ſilver totally. As three parts of ſilver are often added to the gold, this operation is called *quartation*, as the gold compoſes in fact but one-fourth part of the mixture. The following is the way of performing this proceſs of *parting*.

The cupelled alloy of gold and ſilver is firſt hammered flat, care being taken to heat and turn it frequently, that

that it may not ſplit, nor ſeparate into ſmall parts, in conſequence of becoming hard and brittle under the hammer; it is then rolled up in feathers in a ſpiral form; in this form it is put into a ſmall matraſs, and ſix drams of precipitated aquafortis, unmixed with muriatic acid, but diluted with half that quantity of water, are poured upon it. The veſſel is expoſed to a moderate heat, till the mixture begin to effervefce. The ſilver is ſoon after diſſolved, and the metallic coil takes a brown colour. When the acid ceaſes to act, it is then decanted off; and a new quantity is poured upon the metal, and boiled on it till the ſilver be entirely diſſolved. This ſecond operation is called a *repetition*. The acid is then decanted off, and the ſpiral piece of metal, now become very thin, and perforated with a great many holes, is waſhed; it is poured with water into a crucible; the water decanted off, the crucible made red hot, and the gold now diſplays all its properties. It is next weighed, and its weight ſhows the degree of the fineneſs of the gold. In order to know exactly what quantity of imperfect metals gold contains, any maſs of gold whatever is ſuppoſed to conſiſt of twenty-four parts, called *carats*; and to attain ſtill greater accuracy, each carrat is divided into two and thirty parts called *thirty-ſeconds of a carat*. If the gold thus aſſayed have loſt one grain in twenty-four, the maſs to which it belonged is conſidered as gold of twenty-three carats; if a grain and an half, it is then gold of twenty carats ſixteen thirty ſeconds, and ſo on. The weight made uſe of in aſſaying gold is called *ſole weight*, and conſiſts commonly of twenty-four grains; it is divided into twenty-four carats, which are again ſubdivided into thirty-two parts. There is alſo another weight uſed on the ſame

ſame occaſion, weighing twelve grains, but divided into twenty four carats, and the carat again into thirty-two parts.

There are two important obſervations to be made on this operation of parting.

1. It has been thought by ſome chemiſts, that the nitric acid diſſolves a little gold with the ſilver. M. Baumé has obſerved (*pages* 117 and 118. *of the third volume of his Chemiſtry*), that ſilver extracted from gold by parting retains in it a diſcernible quantity of the gold. From two pounds of fine-grain ſilver, which that chemiſt employed in making up the infernal ſtone, he ſays, that he uſually ſeparated about half a dram of gold in black powder. However, when the operation of parting is effected with an acid not too much concentrated, and the ſolution not carried too far, the gold then remains pure and uninjured, and there is none of it diſſolved with the ſilver. The chemical claſs of the academy have been employed by adminiſtration to examine whether the nitric acid diſſolves gold in the proceſs of parting. From a long train of experiments made for this purpoſe, they have concluded, that, "in the proceſs of parting, performed "according to the received rules and mode of operation, the gold can never ſuffer the ſmalleſt loſs; and "that the operation is to be regarded as carried to the "utmoſt perfection of which it is capable." This deciſion, which we have extracted from the Report publiſhed by the Academy on the occaſion, cannot but give full ſatisfaction to the public, and re-eſtabliſh their confidence in the proceſs in queſtion.

2. Many gentlemen, ſkilled in aſſaying, and among others Schindler and Schlutter, have been of opinion, that the gold after parting ſtill retains a little ſilver.

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That portion they call *ſurcharge*, or *inter-halt.* Meſſrs Hellot, Macquer, and Tillet, being employed to examine the operation of the money aſſayers, proved this aſſertion to be groundleſs. M. Sage, however, in his Work intitled, *The Art of Aſſaying Gold and Silver*, *page* 64, aſſerts, that the ſpiral piece of gold always retains a little ſilver, which may be proved to exiſt in it by diſſolving the ſuſpected gold in twelve parts of nitro-muriatic acid: the ſolution being cooled, depoſites in a certain ſpace of time, often twelve hours after it is made; a little muriate of ſilver, in the form of a white powder.

Gold is applied to a great many uſes. Its ſcarcity, and the high value ſet upon it, hinder it from being uſed for veſſels and other utenſils, like ſilver; but as its colour and luſtre are very pleaſing to the ſight, it is therefore applied as a gilding or plating to the ſurfaces of many bodies, which it at the ſame time defends from the impreſſion of the air.

The modes of gilding are very various. Gold leaf is ſometimes glued on pieces of wood. Powder of gold is prepared by braying clippings of gold leaf with honey, waſhing them with water, and drying the particles of gold that are precipitated. Shell gold is powdered gold diluted in a mucilaginous liquor, prepared by the ſolution of a gum in water. The name of gold in rags is given to the following preparation: Pieces of linen ſteeped in a ſolution of gold, dried, and burnt. In making uſe of them, a wet cork is dipped in theſe aſhes, and rubbed upon ſilver; on which the gold, being in a ſtate of extreme diviſion, readily fixes. We have already ſpoken of gilding with water gold. To make uſe of it, the piece of copper to be gilded muſt firſt be well ſcoured with ſand and

and a weak aquafortis, which the workmen call *ſecond water;* it is then immerſed into a very weak ſolution of mercury: the mercury being precipitated, cauſes the amalgam of gold, which is applied to the piece, after waſhing it with water to carry away the acid, to adhere. When the amalgam is uniformly extended over the copper, the piece is then heated on the coals to volatilize the mercury; the operation is concluded by rubbing upon the gold gilder's wax, which is compoſed of *red bole*, *verdigris*, *alum*, or *martial vitriol*, with yellow wax, and heating the gilt piece for the laſt time to burn the wax.

The other uſes of gold for toys and laces are ſufficiently known, ſo that it is unneceſſary for us to inſiſt on them here. With reſpect to the medicinal virtues which have been aſcribed to it; the beſt phyſicians, at preſent, agree in denying their exiſtence, and think that any effects produced by the ſeveral potable preparations of gold muſt have been owing not to the gold, but to other matters mixed with it in the ſolution.

CHAP. XXII.

Of Platina.

PLATINA; which has been known as a peculiar metal only during the laſt forty years, has not yet been found any where but in the gold mines of America, particularly in that of Santa Fé, near Carthagena, and in the bailiwick of Choco in Peru. The Spaniards have given it this name from *plata*, which in their language ſignifies ſilver; comparing it with that metal, of which it has in fact the colour: But the name of *white gold* appears to agree much better with its nature than that of *ſmall ſilver*; for in its properties it reſembles gold much more than ſilver.

Before the period which we have mentioned, there were ſome jewels of platina. But as this metal cannot be melted and wrought by itſelf, it is probable that the ſnuff-boxes, heads of canes, and other utenſils of that kind ſold under the name of *platina*, were mixtures of that metal with ſome other metallic ſubſtances;

which, as we ſhall ſee, are neceſſary to render it fuſible.

The platina in cabinets is in the form of ſmall grains or ſpangles of a livid white, inclining at once to the colour both of iron and of ſilver. Theſe grains are mixed with various extraneous ſubſtances; they are found to contain ſpangles of gold, blackiſh ferruginous ſand; grains which, when viewed with the magnifier, appear to be ſcarified like machefer, and ſome particles of mercury. The mercury is ſeparated from this mixture by heating it; waſhing carries off the ſand and the grains of iron; the iron may likewiſe be ſeparated by the magnet: after this there remains nothing but gold and platina, which may be eaſily ſeparated by picking, as Margraf did. The grains of platina, when examined with the microſcope, appear, ſome of them angular, others round and flat, like ſmall cakes. When hammered upon ſteel, moſt of them are found to be malleable and ductile: ſome of them break into pieces on ſuch an occaſion. Theſe, when narrowly examined, are found to be hollow, and to contain within iron and a white powder. It is, doubtleſs, on the principle of their containing ferruginous particles, that the property which ſome grains of platina poſſeſs of being ſubject to the attraction of the loadſtone, however purified from ferruginous ſand, is to be accounted for.

This metal is very nearly as hard as iron. The ſpecific gravity of platina mixed with the ſeveral extraneous matters which we have mentioned, is nearly equal to that of gold: in water it loſes from a ſixteenth to an eighteenth part of its weight. Buffon and M. Tillet, on comparing with a weight equal bulks of platina and gold reduced to grains, like thoſe of platina, found the ſpecific gravity of platina to be one-twelfth leſs

leſs than that of gold. It has been aſcertained by latter experiments, that platina, after being purified by a long fuſion, is ſuperior in ſpecific gravity to gold.

Probably platina is not found in the mines in the ſame form in which it is brought to us: it poſſibly owes its granulated form to the waters which carry it down from the hills into the plains. It is ſometimes found in pretty conſiderable pieces: the Society of Biſcay are in poſſeſſion of a piece as large as a pigeon's egg. Platina, being found in places adjacent to gold mines, always contains a certain quantity of that metal. As to the mercury mixed with it, that ſemi-metal has been employed in extracting the gold.

Though toys made of platina have long been ſold, yet the peculiar nature of the metal was unknown. Even the workers of mines had not paid any particular attention to it; but neglected a matter which had no very beautiful aſpect, and was beſides very difficult to work. For our firſt knowledge of platina, we are indebted to a Spaniſh mathematician, Don Antonio de Ulloa, who accompanied the French academicians that were ſent on the famous journey to Peru, to aſcertain the figure of the earth. In the account of his journey, publiſhed at Madrid in the year 1748, he makes mention of this metal. Charles Wood, an Engliſh metallurgiſt, had brought ſome of it from Jamaica in the year 1741. He then examined it, and gave an account of his experiments in the Philoſophical Tranſactions for the years 1749 and 1750. At that period, the greateſt chemiſts in Europe engaged eagerly in the examination of that new metal, the ſingular properties of which promiſed to render it ſo uſeful. Scheffer, a Swediſh chemiſt, publiſhed an account of his

his experiments on platina in the Memoirs of the academy of Stockholm for 1752. Lewis, an Engliſh chemiſt, made a ſeries of experiments, almoſt complete, upon this metal, which may be found in the Philoſophical Tranſactions for the year 1754. Margraff has given a detail of his experiments on this new metal in the Memoirs of the Academy of Berlin for 1757. Moſt of theſe ſeparate memoirs have been collected into one body by M. Morin, in a work intitled, *Platina, white gold*, or *the eighth metal, Paris* 1758. About the ſame time Meſſrs Macquer and Baumé jointly made a great many important experiments on platina; an account of which has been publiſhed in the Memoirs of the Academy for the year 1758. Buffon, in the firſt volume of the Supplement to his Natural Hiſtory, gives an account of a train of experiments on platina made by himſelf, M. de Morveau, and the Count de Milly. The baron de Sickengen likewiſe engaged in a ſeries of reſearches on the metal of which we are now ſpeaking; but his work has not yet been publiſhed in French. Macquer gives an extract from it in his Chemical Dictionary. M. de Lilly has given the Academy a paper on platina. The ſcarcity of the metal, and the difficulties attending the treatment of it, have retarded our progreſs towards a complete knowledge of its properties: but of late, the inquiries concerning it have been reſumed with new ardour. Bergman, M. Achard, and M. de Morveau, have examined this metal in reſpect to ſeveral of its properties, which were before but little known.

Platina, when purified and ſeparated by waſhing, picking, and muriatic acid, from the extraneous bodies which it contains, ſuffers no alteration of nature, only conglomerating a little more by expoſure to the moſt intenſe heat. All the chemiſts who have examined the metal

metal agree in this. Meſſrs Macquer and Baumé kept platina for a number of days expoſed to an unremitting fire in a glaſs houſe, without producing any other alteration on its grains but that of making them adhere ſlightly together; and they were even ſo feebly agglutinated as to be ſeparable barely by touching them. In theſe experiments they obſerved, that platina acquired a luſtre when heated to a red white; that when very long expoſed to heat, it took a dirty grey colour: and, laſtly, that, as Margraff had aſſerted, it conſtantly increaſed in weight; which could happen only in conſequence of its being reduced in part to oxide; a change which it appears liable to ſuffer from the action of fire. Thoſe chemiſts expoſed platina in the focus: it firſt ſmoked and gave out very red and lively ſparks; the portions of metal expoſed to the centre of the focus were next melted in about the ſpace of a minute: the melted parts were of a ſparkling white colour, and in the form of a button; they were diviſible into plates with a knife. One of theſe maſſes of melted platina being ſtruck upon ſteel, became flat, and was reduced into a plate without ſplitting or cracking: it became hard and brittle under the hammer. This fine experiment ſhows platina to be fuſible by extreme violence of fire; to be malleable like ſilver and gold; and to be liable to very little alteration from the action of fire: for in all of theſe experiments, moſt of which were performed in the open air, the platina exhibited no marks of being oxidated. M. de Morveau likewiſe effected the fuſion of platina by heating it in the wind furnace deſcribed by Macquer, with his reductive flux, conſiſting of eight parts of pounded glaſs, one part of calcined borax, and half a part of charcoal in powder. At preſent it is very eaſily melted in ſmall portions,

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without the addition of any other ſubſtance, by heating it on a burning coal with a ſtream of vital air: but the globules, thus melted, are ſo very ſmall, that they can anſwer no purpoſe.

Platina ſuffers no alteration from expoſure to the air: we know not, however, what might happen if it were heated red hot in contact with air: perhaps it would be oxidated, as Juncker aſſerts that ſilver and gold are when heated in this way.

This metal ſuffers no alteration from water, earthy matters, ſalino-terreous ſubſtances, or alkalis.

Neither the ſulphuric acid, however highly concentrated, the nitric, nor the muriatic acid, however ſtrong and fuming, act at all on platina, even though aſſiſted by ebullition. Diſtillation, a method which chemiſts have always found very effectual in promoting the action of acids on metallic matters, does not effect any ſolution or alteration of theſe mixtures; only the ſulphuric acid has been obſerved by Meſſrs Lewis and Baumé to tarniſh the colour of grains of platina. The nitric acid again improves their luſtre. Margraff ſays, that he obtained, by diſtilling this acid with platina, towards the end of the operation, a little arſenic; which phænomenon has not been obſerved by any other chemiſt. The muriatic acid produces no change on platina. Margraff likewiſe obtained, by diſtilling this acid on the metal, a white ſublimate which appeared to him to be arſenic, and a reddiſh ſublimate, the quantity of which was ſo ſmall, that he could not examine its properties. All of theſe ſubſtances are evidently extraneous to platina. This metal, therefore, reſembles gold in being but little ſubject to be affected by the action of ſimple acids; but ſtill more in being ſoluble in the oxigenated muriatic and in the nitro-muriatic acid.

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The firſt of theſe acids diſſolve platina with eaſe, and without requiring the aſſiſtance of any conſiderable heat: Fifteen or twenty degrees of heat in the atmoſphere are ſufficient to promote this ſolution: it takes place without any ſenſible efferveſcence; and, in other reſpects, perfectly reſembles the following ſolution.

The nitro-muriatic acid, which is the moſt powerful ſolvent of platina, is that conſiſting of equal parts of nitric and muriatic acid. To effect this ſolution, which is generally more difficult than that of gold, an ounce of platina muſt be put into a retort, and a pound of nitro-muriatic acid, conſiſting of the above-mentioned proportions, mixed with it: the retort muſt then be put on a ſand-bath and a receiver fitted to it. As ſoon as the acid becomes hot, there iſſues from it ſome bubbles of nitrous gas not in great plenty. The mixed acid acts calmly and ſlowly: this acid, however, takes at firſt a yellow colour, which changes to an orange, and becomes gradually deeper till it be changed into a very dark brown red. When the ſolution is ended, particles of reddiſh and black ſand are found at the bottom of the retort, and ſeparated by decanting off the liquor; the ſaturated liquor gradually depoſites ſmall irregular cryſtals of a duſky colour, which are a combination of the acid with platina. The ſolution of platina is among the higheſt coloured of metallic ſolutions. Though it appears to be of a deep brown colour, yet when it is diluted in water, the fluid takes at firſt an orange colour, which in a ſhort time becomes yellow and very like the ſolution of gold: it communicates to animal matters a blackiſh brown tinge; which, however, is by no means purple. M. Baumé ſays, that platina, melted in the focus of a burning-glaſs and diſſolved in aqua regia, never takes a brown colour, like that of platina in in grains; and that the ſolution is of a deep orange yellow.

Macquer aſſerts, that on evaporating the ſolution of platina, and ſuffering it to cool, cryſtals are obtained from it much larger and much more beautiful than thoſe which it depoſites of itſelf when ſaturated. Lewis, on ſuffering this ſolution to evaporate in the open air, obtained cryſtals of a deep red colour tolerably large, of an irregular form, and pretty like the acid of benzoin, but thicker. Bergman deſcribes them as having an octohædral form. This ſalt is tart, but not very cauſtic; it melts with heat, gives out its acid, and leaves, as a reſidue, a dark grey oxide. The concentrated ſulphuric acid produces in it a dark-coloured precipitate, which is no doubt ſulphate of platina. The muriatic likewiſe produces in it, in the courſe of time, a yellowiſh ſediment.

Alkalis and ſalino-terreous matters decompoſe the ſolution of platina, and precipitate the metal in the ſtate of oxide. Carbonate of potaſh produces an orange precipitate in the ſolution of platina. This precipitate is not oxide of pure platina. Meſſrs Macquer and Baumé have obſerved, that it owes its colour to its containing a certain quantity of acid. It is therefore to be conſidered as a mixture of oxide of platina with muriate of potaſh, or a kind of triple ſalt. A proof of this opinion is, that when this precipitate is waſhed with hot water, the fluid acquires a colour by diſſolving the ſalt of platina, and the reſidue is pure oxide of platina of a grey colour. Fixed alkali, boiled on this precipitate, inſtantly deprives it of its colour, leaving an oxide of platina of a grey white pearl colour, according to the experiments of M. Baumé. That chemiſt made himſelf certain, that the precipitate of platina is ſoluble in alkali;

for on pouring a ſolution of the metal into a hot ſolution of carbonate of potaſh, he found no precipitate produced: and this ſolution, precipitated by fixed alkali, always retains, on this account, a deep colour: and platina may be eaſily obtained by evaporating it to dryneſs. Margraff diſcovered, that ſoda does not precipitate the ſolution of platina: but Bergman has obſerved, that, on putting into it a great quantity of this alkali, there is a precipitate ſpeedily enough produced.

The alkaline Pruſſiates form a copious blue precipitate, which, according to M. Baumé, is owing to the iron contained in the alkali; for if the Pruſſiate of potaſh be purified, by the proceſs which that chemiſt deſcribes for the purpoſe, from the iron which it contains, it no longer affords any more than a few particles of blue, which are owing to the metal's ſtill retaining a ſmall portion of iron. Bergman aſſerts, that an alkaline Pruſſiate, highly ſaturated and very pure, does not precipitate the ſolution of platina; and that this metal is the only one not liable to be precipitated by this reagent; and therefore propoſes it for ſeparating the iron, which is always in union with platina.

Cauſtic ammoniac produces an orange precipitate in the ſolution of platina. This precipitate is almoſt entirely ſaline; for water diſſolves moſt part of it, taking a colour like that of the ſolution of gold. After the water has acted on this precipitate, there remains a blackiſh ſubſtance, which appears to be ferruginous. One eſſential difference between the precipitate of platina and that of gold by ammoniac, is, that the former is not fulminating like the latter.

Nutgall, or rather the gallic acid, produces, in the ſolution of platina, a deep green precipitate, which becomes gradually pale by reſt.

All precipitates of the ſolution of platina obtained by alka-

alkaline matters, are unfit for vitrifying and colouring glaſs by furnace fires. In the attempts made by Meſſrs Lewis and Baumé to accompliſh this, the platina was always reduced to grains, which were arranged in ramifications, or a kind of chequer work. Platina may be obtained in a ſort of button, by expoſing theſe precipitates to heat, together with ſome reductive fluxes, ſuch as borax, cream of tartar, glaſs, &c. Meſſrs Macquer and Baumé melted in five and thirty minutes, at a forge fire blown by two ſtrong bellows, a precipitate of platina mixed with theſe fluxes. They obtained in a hard blackiſh glaſs, like bottle-glaſs, a brilliant button of platina, which appeared to have been in fuſion. This button was not ductile: it broke into two pieces; in conſequence of which it was obſerved to be hollow within. It was nearly of the ſame hardneſs with forged iron, and made deep ſcratches in gold, in copper, and even in iron. Notwithſtanding what we have obſerved of precipitates of platina, as not being liable to vitrify or mix with glaſs, Baumé melted them into a vitriform matter by two different proceſſes. The precipitate of platina, mixed with calcined borax and a very fuſible white glaſs, and expoſed for ſix and thirty hours to the heat of the hotteſt place of a furnace for pottery, afforded him a greeniſh glaſs, inclining to yellow, and containing no globules of reduced metal. This glaſs being treated anew with cream of tartar, gypſum, and potaſh, was thoroughly melted, but contained ſmall globules of platina diſperſed through it. M. Baumé ſeparated them by waſhing, and found them to be ductile. He then, in conjunction with M. Macquer, expoſed precipitate of platina in the focus of the ſame burning-glaſs with which they had melted the metal. The precipitate emitted a very thick luminous ſmoke, which

which diffuſed a ſtrong ſmell of nitro-muriatic acid: it loſt its red colour, and reſumed the natural colour of platina; and it melted into a gloſſy ſparkling button: which button was an opaque vitreſcent matter of an hyacinth colour on the ſurface, and blackiſh internally, and may be conſidered as a real glaſs of platina. It is, however, neceſſary for us to obſerve, that the ſaline matters with which it was impregnated, muſt, without doubt, have contributed to its vitrification.

The precipitate of platina does not appear to be ſoluble in ſimple acids; but it diſſolves readily in the nitro-muriatic acid, to which it communicates only an orange colour; never a brown like platina in grains.

The ſolution of platina is not precipitated by alkaline or perfect neutral ſalts; but ammoniacal muriate produces in it a copious precipitate. We know not yet well what paſſes on this occaſion. It appears, that the orange colour obtained by pouring a ſolution of ammoniacal muriate into a ſolution of platina, is a true ſaline ſubſtance entirely ſoluble in water. This precipitate poſſeſſes one property of no ſmall importance, which was firſt obſerved by M. de Liſle: it melts alone without any addition in a good ſtrong furnace fire, or in the fire of a common forge. The platina melted by this proceſs is a ſparkling button of conſiderable denſity and cloſeneſs of grain, but not malleable, and not liable to become ductile unleſs when expoſed to a pretty ſtrong heat. Macquer is of opinion, that the ſame thing takes place in this inſtance of fuſion, as when grains of platina are expoſed by themſelves to the action of a ſtrong fire; and that what is effected is nothing but an agglutination of the particles ſoftened by the heat; which being much more minute than grains of platina, are brought more completely into contact with

with each other than thoſe grains can be; in conſequence of which, though no real fuſion take place, yet the grain of the metal is much cloſer in this than in the former caſe. It appears, however, that as platina in grains is liable to melt in a burning-glaſs, and acquires, by that means, conſiderable ductility; ſo the precipitate of this metal produced by ammoniacal muriate, being in a ſtate of extreme diviſion, may be alſo melted; and if the precipitate acquire not by fuſion the ſame ductility with platina melted by the rays of the ſun, this is perhaps owing to its ſtill retaining ſome matter which intermixed with it when it was precipitated; but may be ſeparated from it by the action of fire.

Margraff diſſolved platina in *aqua regia*, conſiſting of ſixteen parts of nitric acid with one of ammoniacal muriate. On diſtilling this ſolution to dryneſs, and even till the retort became red hot, a dark ſalt was ſublimated, and the reſidue was a reddiſh powder. It is not known whether the ſolution of platina in ſimple *aqua regia*, that is, *aqua regia* conſiſting of nitric and muriatic acid, would afford the ſame ſublimate by diſtillation.

Meſſrs Margraff, Baumé, and Lewis, mixed the ſolution of platina with ſolutions of the other metallic ſubſtances. From theſe experiments it appears, that almoſt all metals precipitate platina in a brick-red or a brown powder; and that, agreeably to what happens to moſt other metals, none of theſe precipitates poſſeſſes the properties of a metal. In this there is an analogy between gold and platina: with tin, however, platina does not give a purple, but a brown precipitate, inclining to red. With reſpect to the effects which the ſeveral metallic ſolutions produce on the ſolution of platina, we ſhall only obſerve, that ſolutions of biſmuth and lead by the

the nitric acid, of iron and copper by any of the acids, and of gold by aqua regia, produce, none of them, any precipitate in the ſolution of platina, according to Margraff: but again, ſolutions of arſeniate of potaſh, of nitrate of zinc, and nitrate of ſilver, are capable of precipitating the ſolution of platina: with the firſt it yields a ſcanty cryſtallized precipitate of a beautiful golden colour; with the ſecond, an orange-red matter; and with the third, a yellow matter. Theſe different precipitates have not been yet carefully examined, nor is it known by what decompoſition they are produced.

Scarce any of the neutral ſalts acts upon platina. Margraff heated platina with ſulphate of potaſh and ſulphate of ſoda at a ſtrong fire. The ſalts were melted, but the platina remained in grains without alteration; only it communicated a faint reddiſh colour to the ſaline matters, which it was enabled to do, no doubt, by means of the iron mixed with it.

Nitre, according to the experiments of Lewis and Margraff, alters platina in a ſingular manner. No detonation takes place when a mixture of theſe two ſubſtances is caſt into a crucible; but when a mixture, conſiſting of one part of platina and two of nitre, is expoſed for a conſiderable time to an intenſe heat, as Lewis expoſed it for three days and three nights ſucceſſively, the metal takes a ruſty appearance. If this mixture be boiled in water, the fluid diſſolves the alkali, which carries with it a browniſh powder; and the platina ſeparated by this waſhing is found to be one-third leſs than the original quantity. The brown powder may be ſeparated from the alkali by filtration. This powder appears to be a kind of oxide of platina mixed with a little oxide of iron. Lewis cauſed it to take a whitiſh grey colour, by diſtilling it many times ſuc-

ſucceſſively with ammoniacal muriate. Margraff repeated this valuable experiment, and has added two important facts; platina combined with alkali of nitre, and diluted in a certain quantity of water, forms a jelly: A portion of the metal ſeparated from this jelly by dilution in water and filtration takes a black colour like pitch. From theſe circumſtances it appears that the platina ſuffers in this proceſs ſome great alteration: and it is to be wiſhed that theſe experiments were farther proſecuted, in order to determine whether by repeated oxidation with nitre, this metal might be wholly reduced to a brown powder; as alſo to aſcertain the ſtate of the platina thus oxidated.

Muriate of potaſh or ſoda, borax or earthy ſalts, produce, none of them, any alteration on platina, nor contribute in any degree to its fuſion. Ammoniacal muriate ſublimated with this metal affords a ſmall quantity of martial flowers, on account of the iron contained in the platina.

Chemiſts are not agreed with regard to the mutual action of arſenic and platina. Scheffer firſt gave out that arſenic acted as a flux to platina; but the experiment ſucceeded only in part with Lewis, and did not ſucceed at all with Margraff, Macquer, and M. Baumé. This experiment has been ſince repeated; and it is now eſtabliſhed as a fact, that arſenic does cauſe platina to melt very readily; and that the mixture produced by this fuſion is exceedingly brittle. When the arſenic is ſeparated by roaſting, and the perfect metal expoſed to a continued heat, the latter becomes ductile. By this proceſs M. Achard and M. Morveau have accompliſhed the making of crucibles of platina, by melting it a ſecond time in moulds.

No attempt has yet been made to combine cobalt, nickel, or manganeſe with platina.

This perfect metal enters readily enough into combination with biſmuth; which renders it fuſible, and the more ſo the greater the quantity of the biſmuth. This mixture is brittle; it becomes yellow, purple, and blackiſh in the air; it cannot be cupelled without the greateſt difficulty; the maſs has alway very little ductility.

Platina eaſily melts with antimony: the product is a brittle metal with facets, from which the antimony cannot be ſeparated by the action of fire, and which ſtill retains, whatever means may be uſed for its ſeparation, ſo much of the ſemi-metal as is ſufficient to deſtroy the gravity and ductility of the platina.

Zinc renders platina very fuſible, and combines very eaſily with it; the mixture is brittle, and reſiſts the file: it inclines to blue in colour, when the platina is more copious than the zinc. Theſe two metallic matters are ſeparable by the action of fire which volatilizes the zinc; platina, however, always retains a little of it.

Platina does not combine with mercury; and though triturated together for hours, theſe two metallic matters cannot be formed into an amalgam. It is alſo known, that in America, mercury is employed to ſeparate platina from gold. Various intermedia, ſuch as water, which Meſſrs Lewis and Baumé made uſe of, and nitro-muriatic acid which M. Scheffer employed, contribute nothing to the union of platina with mercury. It reſembles iron in this property, as alſo in colour and hardneſs.

Platina readily combines with tin. The mixture is very fuſible, and melts into a flowing liquid. It is ſo brittle as to break even by a blow, when the two metals are united in equal parts. When tin is in the proportion of twelve or more parts to one of the platina, the mixed metal is then ſufficiently ductile; but its grain is coarſe, and it becomes yellow in the air. The platina diminiſhes the ductility of the tin in an amazing degree, and it does not appear that it can be ſeparated from this mixture. However, when well poliſhed, it remains long in the air without ſuffering alteration. Lewis, to whom we owe moſt of our knowledge concerning the mixtures of platina, oxidated the metal, and diſſolved it in muriatic acid by means of tin.

Lead and platina combine very well by fuſion; but a ſtronger fire is requiſite to melt them than to melt the foregoing mixture. The platina deſtroys the ductility of the lead. From the combination of theſe two metals there reſults a mixed metal, nearly of a purple colour, more or leſs brittle according to the proportions of the platina, ſtriated and granulated in its fracture, and liable to alter very readily in the air. Cupellation of lead was one of the moſt important experiments to be made on platina; for this was the only operation that could be expected to ſeparate from it ſuch extraneous matters as it might contain. Lewis and ſeveral other chemiſts in vain attempted to cupel platina in common cupelling furnaces, whatever the degree of the heat employed in thoſe furnaces. On account of the exceſs of the lead, it is vitrified and abſorbed in the beginning of the operation; but the platina ſoon becomes fixed, and the progreſs of the operation ſtops; the perfect metal remains in union with a portion of the lead, and is without ductility. Meſſrs Macquer and Baumé effected the complete cupellation of platina by expoſing an ounce of of this metal with two ounces of lead to the heat of the hotteſt place of the porcelain furnace at Seves. The wood fire which they kindled in it burnt for fifty hours uninterruptedly. At the end of that time the platina lay flat upon the cupel: its upper ſurface was dark and ſhrivelled, and was eaſily ſeparable from the reſt; its under ſurface was brilliant; and what is of moſt importance, it was now ſufficiently malleable. Theſe chemiſts aſcertained, by every poſſible means, the platina to be very pure, and unmixed with lead. M. de Morveau likewiſe ſucceeded in cupelling a mixture of a dram of platina with two drams of lead in Macquer's wind furnace. This operation, which was four times repeated, laſted eleven hours. M. de Morveau obtained a button of platina, not adheſive, uniform, coloured like tin, ſomewhat rough, weighing exactly a dram, and not ſubject to the attraction of the magnet. This is therefore a convenient proceſs, by which platina may be melted into plates that may be wrought in the forge; and of conſequence made into various utenſils of great value for their hardneſs and unalterability. M. Baumé likewiſe obſerved it to poſſeſs this valuable property, that different pieces of it may be ſoldered and wrought together like iron, without the intervention of a third metal. After heating two pieces of platina that had been cupelled in the furnace of Seves to a white red, he put the one upon the other, and ſtruck them with a hammer; and by this management the two pieces were as ſufficiently and ſolidly ſoldered as any two pieces of iron could have been. It is not neceſſary that we ſhould inſiſt long on this experiment, to ſhow what advantages the arts may derive from it.

Lewis could not obtain a mixture of forged iron and platina. A mixed metal of this kind would poſſeſs at once the hardneſs of tempered ſteel, and a conſiderable degree of ductility; it would not at leaſt be ſo brittle as ſteel. The Engliſh, whom we have cited, melted a mixture of caſt iron and platina. The alloy was ſo hard that the file could make no impreſſion upon it: it had little ductility; but when red hot, it broke with a ſmooth fracture.

Platina communicates hardneſs to copper, and melts with it eaſily enough. This mixture is ductile when the proportion of the copper is three or four more than that of the platina. It takes a fine poliſh, and is not liable to be tarniſhed in the courſe of ten years.

Platina deſtroys in part the ductility of ſilver, increaſes its hardneſs, and tarniſhes its colour. The mixture is very difficult to melt. The two metals are ſeparable by fuſion and reſt. Lewis obſerved, that the ſilver melted with platina is daſhed with a kind of exploſion againſt the ſides of the veſſel. This phænomenon ſeems to be effected ſolely by the ſilver; for M. d'Arcet ſaw that metal burſt bowls of porcelain in which it was incloſed, and ſpring out of thoſe veſſels in conſequence of the action of fire upon it.

A very ſtrong heat is requiſite to make platina combine properly with gold. It greatly alters the colour of that metal, at leaſt if its quantity be not very ſmall; for inſtance, a forty-ſeventh part of platina, and all proportions under that, produce but little alteration on the colour of gold. Platina ſcarce diminiſhes the ductility of gold; it is even one of thoſe metals which have the leaſt influence on gold this way. The gravity of platina being greater than that of gold, might be an encouragement to fraud; and the Spaniſh miniſtry have therefore prohibited the exportation of the metal.

metal. However, ſince chemical methods of diſtinguiſhing when gold is alloyed with platina have been diſcovered, theſe fears are now vain; and it is much to be wiſhed that platina were permitted to be an article of commerce, that ſo we might obtain the uſe of a new metal which promiſes to be ſo ſerviceable.

The ſolution of ammoniacal muriate poſſeſſes, as we have obſerved, the property of precipitating platina. When therefore gold is ſuſpected to be alloyed with platina, a ſolution of it in *aqua-regia* may be aſſayed with a ſolution of ammoniacal muriate. If it contain any platina, however little, an orange or reddiſh precipitate will be produced: if there is no precipitate produced, that circumſtance is a proof that the gold contains no ammoniac. If the valuable properties of platina ſhould one day render it more ſcarce and more eſteemed than gold, neither will we then be in danger of having alloys of gold with platina impoſed on us for pure platina; for a ſolution of ſulphate of iron, which poſſeſſes the property of precipitating a ſolution of gold without affecting platina, might be uſed as a teſt to prevent ſuch impoſition. A plate of tin immerſed into a ſolution of platina alloyed with gold, would likewiſe detect the preſence of the latter metal, by becoming coated with a purple precipitate; whereas platina, by itſelf, gives it only a dirty brown colour inclining to red. Beſides, the precipitate of platina does not colour glaſs, whereas the precipitate of gold gives it a purple colour.

All thoſe properties of platina which we have examined prove it to be a peculiar metal. Its poſſeſſing in ſo low a degree the properties of ductility and fuſibility, which has been conſidered by ſome perſons as a ſtrong objection againſt this opinion, is not ſufficient to juſtify

juſtify

juſtify the refuſing it that character which we have aſcribed to it: for perhaps the difference between the fuſibility of platina and that of forged iron, is not ſo conſiderable as the difference between the fuſibility of forged iron and that of lead: and its inductility may be conſidered as owing to its having never yet been completely melted. With reſpect to the opinion of thoſe philoſophers who think platina a natural alloy of gold with iron, however ingenious and ſatisfactory it may appear, cannot be admitted till ſuch time as platina ſhall be ſeparated by an exact analyſis into theſe two metals, and till it be better imitated than at preſent by an artificial mixture of gold with iron. Laſtly, Macquer has urged a very ſtrong objection againſt this laſt opinion, by obſerving that the more thoroughly platina is purified from iron, the more remote does it appear in its exterior characteriſtics and properties from the nature of gold.

It may be eaſily conceived with what advantages the uſe of this precious metal in commerce would be attended, as it poſſeſſes, with the durability of gold, nearly the hardneſs of iron, and is proof againſt the action of the moſt violent fire, and the moſt concentrated acids. It would, doubtleſs, be of the higheſt utility both to chemiſtry and to the arts.

CHAP. XXIII.

Genus VI. *Bitumens in general**.

BITUMENS are combuſtible matters, either ſolid, ſoft, or fluid, of a ſtrong, acrid, aromatic ſmell, and apparently of a much more compound nature than any of the bodies belonging to the mineral kingdom which we have yet examined. They are found either in ſtrata in the bowels of the earth, or dropping from rocks, or ſwimming on the ſurface of waters. They generally burn with a rapid flame when heated in contact with air, like thoſe matters formed from the organs of animals and vegetables, which are called *oils*. They admit of being much more exactly analyſed than earthy, ſaline, or metallic matters; for the action of fire alters them in a ſingular manner, extracting their principles, which as they are volatilized react on each other.

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* The reader may here recollect that we divided combuſtible mineral matters into five genera; diamond, hydrogenous gas, ſulphur, metals, and bitumens. A.

other. In this reſpect there is an analogy between bitumens and vegetable ſubſtances They afford by diſtillation an odorate water or phlegm, more or leſs coloured and ſaline; an acid generally concrete; ſometimes ammoniac; and oils which, tho' at firſt light, become more and more thick and coloured as the diſtillation is continued, and the ſtrength of the fire increaſed. After this analyſis, there remains a coal of a greater or a leſs bulk, denſe, light, porous, brilliant, or compact, according to the particular nature of the bitumen. This analyſis is a proof that theſe inflammable bodies have originated from animal or vegetable matters; as we ſhall relate more at large when we give the hiſtory of their properties.

Bitumens ſuffer ſome alterations from light; when fluid, their colour is rendered deeper, and their ſmell modified in tranſparent veſſels. The air renders them thicker by a gradual evaporation of the moiſture which they contain; and the drier the atmoſphere, ſo much the ſpeedier is this evaporation. Their odorous principle, or ſpiritus rector, is at the ſame time gradually diſſipated; and from fluid they become by degrees tenacious and ſolid. But this latter alteration requires a long ſeries of years.

When bitumens are boiled in water, the water does not diſſolve them, but extracts their ſpiritus rector, and afterwards that odour which is peculiar to them. It would therefore appear that water has a greater affinity with their odorous principle than the oily matter of the bitumen; and perhaps theſe bodies might thus be entirely deprived of ſmell.

No experiments have been made to determine in what manner the ſalino-terreous ſubſtances act upon on bitumens. Both lime and pure alkalis, however, appear capable of combining with theſe combuſtible matters, and forming with them compounds ſoluble in water, which are called *ſoaps*.

We know not in what manner the mineral acids are capable of acting on bitumens. Probably they would either diſſolve or burn them like oils, according to the ſtate of concentration in which they happened to be.

Neither has the action of neutral ſalts, hydrogenous gas, ſulphur, or metals on bitumens, been examined; and the chemical properties of theſe bodies are in general but very little known. This is an unbeaten path; and very uſeful diſcoveries might here be made.

Naturaliſts have been at much more pains in ſtudying the origin and formation of bitumens than chemiſts in analyſing them. Several different opinions have been entertained on that head. Some have thought combuſtible bodies to belong properly to the mineral kingdom, and to hold in it the ſame rank which oils and reſins hold among organic matters. But this fancied analogy, however plauſible, does not agree with facts; for we know of no ſubſtance in the mineral kingdom of an oily nature. And that opinion which aſcribes the origin of bitumens to vegetable matters buried under ground, and altered by the action of mineral acids, has been much more generally received than the former. Every fact indeed concerning bitumens, concurs to prove that they have been produced from organic matters. Near them are found a great many matters ſtill retaining an organical form. Beſides, their chemical properties are thoſe of ſubſtances formed by the action of vital powers;

ers; and they have been imitated to a certain degree by the combination of oils with concentrated ſulphuric acid. In the chemical hiſtory of vegetable matters, we ſhall ſee, that this acid brought into contact with eſſential oils renders them hard and black, and communicates to them a ſtrong pungent ſmell like that of bitumens. But are theſe bodies formed ſolely from vegetables buried under ground, as has been aſſerted by moſt naturaliſts? Do animal matters in the ſame ſituation never contribute to the formation of bitumens? One objection which may be urged againſt the opinion that repreſents bitumens as originating ſolely from particular vegetable bodies, is the great diſproportion between the maſſes of bitumen found in the earth and the wood or trees found near them, and ſtill more the trifling quantity of oily matters contained in thoſe vegetable ſubſtances. And farther, the abundance of theſe combuſtible bodies in places where ſcarce any remains of vegetable matters appear but the exuviæ of animals, are found in heaps above the bitumens, lead us to think that theſe latter organic beings have contributed greatly, perhaps more than vegetables, to the formation of certain bituminous ſubſtances. We may likewiſe obſerve, that the ſucceſſive ſtrata, in which ſome continuous maſſes of bitumen are found arranged in the interior parts of the globe, indicate thoſe maſſes to have been depoſited ſlowly, and by water; and that the date of their formation correſponds to the period in which ſuch immenſe maſſes of ſhells and other marine bodies would be formed by the ſea. They have therefore been in a fluid ſtate, and have become hard in the courſe of time, in conſequence of being expoſed to the action of ſaline or other ſubſtances abounding in the interior parts of the earth. Such is the opinion which M. Parmentier, member of the College of Pharmacy, has embraced concerning the origin of mineral coal, in a Memoir which he read before that Society at the opening of their courſe of lectures. The oils and fats of marine animals appear therefore to be part of the materials which nature employs in the formation of certain bitumens: and there are others again, the origin of which is evidently from vegetables, and which have been produced from reſins or eſſential oils, buried and altered in the earth.

The number of bitumens is very conſiderable. Naturaliſts have arranged them under various genera. Conſidered chemically, they merit rather to be conſidered as ſo many ſpecies; for the ſame chemical characteriſtics are common to them all. Some of them are liquid; others of a ſoft conſiſtency: there are others ſolid, and among theſe ſome ſo hard as to be ſuſceptible of poliſh; others friable. We know of five ſpecies, conſiderably diſtinct from one another. Theſe are amber, the aſphaltes or bitumen of Judæa, jet, pit-coal, and petroleum; and we are to give their hiſtory. Ambergris we do not conſider as a bitumen, but as an animal product.

CHAP. XIV.

Species I. *Of Amber, and its Acid.*

THIS ſubſtance is, in external appearance, one of the moſt beautiful of bituminous matters: it exiſts in irregular fragments of a yellow or a brown colour, either tranſparent or opaque, and compoſed of layers or ſcales. It takes a very fine poliſh. After being rubbed for ſome time, it becomes electric, and attracts ſtraws. The ancients, who knew amber to poſſeſs this property, gave it the name of *electrum;* and hence the word *electricity.*

The conſiſtency of this bitumen is pretty hard, nearly equal to that of certain ſtones: which has induced ſeveral authors, particularly Hartman a naturaliſt, who lived about the end of the laſt century, to rank it among precious ſtones. It is, however, brittle and friable. When pulverized, it diffuſes an agreeable enough ſmell. It is often found to contain inſects in a good ſtate of preſervation; a circumſtance which proves

proves that it has been in a liquid ſtate, and in that ſtate has incloſed theſe bodies. It is uſually buried under ground at various dephths; it is found under coloured ſand, in ſmall incoherent maſſes, on beds of pyritous earth; above it is found wood containing a blackiſh bituminous matter. From theſe circumſtances it is thought to be formed from a reſinous ſubſtance altered by the ſulphuric acid of the pyrites. It alſo floats on ſea-coaſts. It is gathered on the ſhores of the Baltic in Ducal Prüſſia. The hills of Provence, near the town of Siſteron, the Marquiſate of Ancona, and the Duchy of Spoletto, in Italy, Sicily, Poland, Sweden, and various other countries, likewiſe afford this ſubſtance. This bituminous ſubſtance is diſtinguiſhed into a good many varieties, by its colour, contexture, tranſparency, or opacity. Wallerius reduces them to the following

Varieties.

1. White tranſparent amber.
2. Pale yellow tranſparent amber.
3. Citron yellow tranſparent amber.
4. Tranſparent amber of a golden yellow colour. *Chryſo-electrum* of the ancients.
5. Dark red tranſparent amber.
6. White opaque amber. *Leucelectrum.*
7. Yellow opaque amber.
8. Brown opaque amber.
9. Amber coloured green or blue by extraneous matters.
10. Veined.

Were we to take notice of all the accidental appearances which are obſerved in the interior parts of pieces of of amber, we might extend theſe varieties to a much more conſiderable number. But, in regard to the price demanded for pieces of amber, on account of their ſize, their tranſparency, and their containing inſects in a fine ſtate of preſervation, it is proper to warn people that they may be impoſed upon, as many perſons know how to render it tranſparent or colour it at pleaſure, as well as to ſoften it to ſuch a degree, that extraneous bodies may be introduced into it. Wallerius informs us, that gold-coloured amber always owes its tranſparency to nature; and that amber made tranſparent by art is always of a pale colour.

Although it be highly probable that this bitumen originates from reſinous vegetable matters; yet ſeveral naturaliſts have entertained different opinions concerning its formation. Some have thought it to be urine of certain quadrupeds congealed and hardened; others have imagined it a juice of the earth extracted and carried off by the ſea, which being driven by the waters on the ſhore, is there dried and hardened by the rays of the ſun. This claſs of naturaliſts call it a peculiar mineral juice. Such was the opinion of an ancient naturaliſt of the name of Philemon, quoted by Pliny. It has been in modern times revived by George Agricola. Frederic Hoffman thought it to conſiſt of a light oil, ſeparated by heat from bituminous wood, and thickened with the acid of vitriol. This opinion of Hoffman's, however, cannot be admitted: it is not eaſy to imagine how an oil ſeparated in the bowels of the earth could happen to contain animals that are known to live only on the ſurface. Till of late, amber was thought to be a reſinous juice which dropped at firſt in a fluid ſtate from certain trees: this juice, it was thought, having been, by ſome convulſion of the earth, buried

buried under ground, had been there hardened and impregnated with ſaline mineral vapours. But there is no appearance of its having been altered by concentrated acids; for experience ſhows, that ſuch acids would have blackened it, and reduced it to a carbonaceous ſtate. Pliny thought amber to be nothing but the reſin of the pine tree condenſed by cold. M. Girtanner thinks it to be a vegetable oil concreted by the acid of ants. The *formica rufa* of Linnæus is, according to this author, the ſpecies which prepares it. Theſe inſects inhabit old foreſts of fir trees, where there is foſſile amber found, which is ductile, like liquid wax, but becomes dry in the air.

A conſiderable degree of heat is neceſſary to liquefy amber: it becomes ſoft and ſwells a good deal. When heated in contact with air it takes fire, and diffuſes a very thick and ſtrong ſmelling ſmoke. Its flame is yellowiſh, variegated with green and blue. After its combuſtion there remains a ſparkling black coal, which affords, by incineration, a very ſmall quantity of brown earth. Bourdelin, in his Memoir on Amber (*Academy*, 1742), relates, that he obtained only eighteen grains of this earth from two pounds of amber burnt in a roaſting pot. Half a pound of the ſame bitumen, burnt and calcined in a crucible, afforded, in a ſecond operation, twelve grains of earthy reſidue; from which, by means of the magnet, he extracted iron.

Amber diſtilled in a retort, by a fire gradually applied, gives at firſt a phlegm which takes a red colour, and is plainly of an acid nature. This acid ſpirit retains a ſtrong ſmell of amber; there paſſes next a volatile acid ſalt, which cryſtallizes in the neck of the retort into ſmall white or yellowiſh needles; next after this ſalt there comes a white light oil of a very lively ſmell.

ſmell. This oil gradually takes a colour as the fire becomes ſtronger; and at length becomes brown, blackiſh, thick, and viſcid, like empyreumatic oils. While theſe two oils are paſſing, there is a certain quantity of volatile ſalt ſublimated, which becomes gradually more and more coloured. After the operation, there remains in the retort a black maſs fixed on its bottom, brittle, and ſimilar to the bitumen of Judæa. George Agricola made this obſervation three centuries ago on the reſidue of diſtilled amber. When the operation is conducted with a moderate fire, judiciouſly applied, and the quantity of the amber not inconſiderable, theſe products may be obtained by changing the receiver. They are commonly received all in one receiver, and afterwards rectified by a moderate heat. The ſpirit loſes its colour in part by this rectification. The oil, the reaſon of which becoming black towards the end of the operation is becauſe it carries with it a portion of carbonaceous matter, and the acid reacts on its principles, may be rendered very white and very light by repeated diſtillation. Rouelle, the elder, has given a very good proceſs for obtaining it in this ſtate by one operation. Put the oil with water into a glaſs alembic, and diſtil it by the heat of boiling water; the pureſt portion, being the only part of the oil volatile at ſuch a degree of heat, on account of its levity paſſes with the water, and is collected above it. To preſerve it in this ſtate, it muſt be put up in ſtone-veſſels; for in glaſs veſſels, the rays of light which paſs through that matter, give it, in a certain time, a yellow, or even a brown colour.

This analyſis proves amber to conſiſt of a great quantity of oil rendered concrete by an acid It contains likewiſe a very ſmall quantity of earth, the nature of which

which has not yet been examined, and a few particles of iron.

The oil of amber appears to be much of the ſame nature with eſſential oils. It is equally volatile, and has the ſame ſmell. It is very inflammable; and appears to be fit for forming ſoaps with alkalis.

The volatile ſalt of amber was for ſome time conſidered as an alkaline ſalt. Glaſer, Le Fevre, Charas, and John-Maurice Hoffman, profeſſor at Altdorf, were of this opinion. Barchuſen, and Boulduc the father, both in the laſt century, were the firſt who aſcertained the nature of this ſalt to be acid. Their diſcovery has been unanimouſly received by ſucceeding chemiſts; who have not agreed, however, concerning the particular nature of that acid. Frederick Hoffman, becauſe amber is found in Pruſſia upon ſtrata of matters among which pyrites are copiouſly intermixed, has inferred its ſalt to be vitriolic acid. Neumann appears to be of the ſame opinion. Bourdelin, in the memoir above quoted, relates ſeveral experiments by which he ſought to aſcertain the nature of this ſalt. He firſt obſerves, that the ſalt of amber, extracted by diſtillation, however white and pure it may appear, always contains an oily matter; to this oily ſubſtance, no doubt, it owes its ſmell, and that kind of combuſtibility which it conſtantly exhibits when caſt on burning coals. He attempted by various means to ſeparate that ſubſtance. We will have occaſion to ſee, when we come to examine the nature and properties of the ardent ſpirit, that *it* could not ſerve his purpoſe. He ſucceeded no better by digeſting fixed alkali over amber, with a view to ſeparate from it this oily matter; the alkali only diſſolved a little of the bitumen, and acquired a ſaltiſh lixivial taſte like that of ſea-ſalt. Laſtly, the beſt means which Bourdelin could find for combining the acid of amber entirely purified from oily matters with fixed alkali, was to detonize a mixture, conſiſting of two parts of nitre with one of the bitumen. The reſidue after this detonation he lixiviated with diſtilled water. The lixivium was of an amber colour: it produced in the ſolution of ſilver a white curdled precipitate; in the ſolution of mercury, a precipitate of the ſame colour. It decompoſed, in like manner, ſeveral other metallic ſolutions; but Bourdelin conſidered only theſe two precipitations as conclusive facts. He underſtood them as indicating the acid of amber to be the ſame with that of marine ſalt; for theſe phænomena are preciſely the ſame with thoſe which the acid of marine ſalt produces in the nitric ſolutions of mercury and ſilver. The lixivium of the reſidue which remained after the detonation of amber with nitre being evaporated in the air, afforded a mucilaginous matter, in the middle of which oblong ſquare cryſtals were by degrees depoſited; which, by their form, their ſaltiſh taſte, their decrepitation on burning coals, and ſtill more their effervеſcence, which was conſiderable, and the ſmell of muriatic acid which exhaled from them when concentrated ſulphuric acid was poured upon them, indicated, in his opinion, that they conſiſted of muriatic acid with a baſe of nitre. Notwithſtanding this analyſis, which, conſidering the time when Bourdelin made his experiments, is very accurate; the chemiſts, who have ſince examined the ſalt of amber, have not found it to bear any reſemblance to the muriatic acid. Bergman, who ſeems to have adopted this opinion, gives the following account of the properties and the elective affinities of this ſalt. The ſuccinic acid, or acid of amber, extracted by diſtillation, and purified by repeated ſolutions and cryſtallizations, forms, with potaſh

potaſh and ammoniac, cryſtallizable and deliqueſcent neutral ſalts. With ſoda, it affords a ſalt which does not attract the moiſture of the atmoſphere: with barytes and lime it forms ſalts that are ſcarce ſoluble: with magneſia, a thick gum-like matter. It diſſolves metallic oxides; and the ſuccinates produced by theſe ſolutions are moſtly cryſtallizable and permanent.

Barytes, lime, and magneſia, according to him, ſeparate the acid of amber from alkalis. Barytes decompoſes ſuccinates of lime and magneſia; and lime-water precipitates magneſia from its combination with this acid.

The chemical properties of this bitumen have been no farther examined. We know not even how the acids would act upon it. Frederick Hoffman affirms, that it may be entirely diſſolved in a lixivium of cauſtic alkali and in ſulphuric acid. We know too, that the eſſential oil of amber combines with cauſtic ammoniac, and forms with it, ſimply by mixture and ſhaking, a ſort of liquid ſoap of a milk-white colour and of a very pungent ſmell, known in pharmacy by the name of *Eau de luce:* and laſtly, this ſame oil is known to diſſolve ſulphur by the heat of a ſand bath, thus compoſing a medicine, called *ſuccinated balſam of ſulphur.*

Amber is uſed in medicine as an antiſpaſmodic: it has been recommended for hyſteric and hypochondriac caſes, a ſuppreſſion of the *menſes*, gonorrhœa, fluor albus, &c. It is made uſe of after being waſhed with warm water, and levigated to a fine powder. It is uſed in fortifying and reſolvent fumigations, by throwing the powder on a hot brick, and directing the ſmoke to the place upon which you wiſh it to act. The volatile ſpirit and the ſalt of amber are conſidered as inciſive, cordial, and antiſeptic; they are alſo adminiſtered as powerful diuretics. Oil of amber is applied both externally and internally for the ſame purpoſes as amber itſelf: it is adminiſtered in ſmaller dozes, on account of its acting with more energy. The ſuccinated balſam of ſulphur is given in dozes of a few drops in certain drinks, or mixed with other ſubſtances in pills, and is ſucceſsful in pituitous affections or defluxions of the breaſt and veins, &c. A ſyrup, called ſyrup of amber, is made up of ſpirit of amber and opium, and is ſucceſsfully uſed as a calming, an anodyne, and an antiſpaſmodic medicine. *Eau de luce* is prepared by pouring a few drops of oil of amber into a phial full of cauſtic ammoniac, and ſhaking the mixture till it take a milk-white colour. It has been long uſed in fainting fits as a powerful ſtimulant: it is put to the noſtrils, and it then ſtimulates the nerves; and, by the ſneezing which it excites, the fluids are again put into motion, and the patient reſtored.

The moſt beautiful pieces of amber are cut and poliſhed into veſſels, heads of canes, necklaces, bracelets, ſnuff-boxes, &c. But this ſpecies of toys is no longer valued among us, ſince diamonds and cut ſtones have been known and brought into uſe. They are ſent, however, to Perſia and China, and to other foreign countries, where they are ſtill valued as the greateſt curioſities. Wallerius ſays, that the moſt tranſparent pieces may be uſed for microſcopes, burning glaſſes, priſms, &c. It is affirmed, that the late King of Pruſſia was poſſeſſed of an amber burning-glaſs a foot in diameter; and that in the cabinet of the Duke of Tuſcany there is a column of amber ten feet high, and of a moſt beautiful luſtre. Two pieces of this bituminous ſubſtance may be joined together, by dipping them into a ſolution of potaſh, heating them, and applying them to each other.

C H A P. XXV.

Species II. *Of Aſphaltus.*

ASPHALTUS, or *bitumen of Judea*, called alſo *funeral gum*, *amber of Sodom*, *mountain-pitch*, *balm of mummies*, &c. is a black bituminous ſubſtance, ponderous, ſolid, and conſiderably brilliant. It breaks eaſily, and its fracture is vitreous. A thin plate of this bitumen appears red between the eye and the light. Aſphaltus, when cold, has no ſmell; when rubbed, it emits a faint ſmell. It is found on the waters of the lake Aſphaltites, or the Dead Sea, in Judea, near which ſtood the ancient cities of Sodom and Gomorrha. The inhabitants of the adjacent country finding the ſmell of the bitumen which gather on the waters of that lake troubleſome, and the bitumen itſelf a profitable article of commerce, collect and expoſe it to ſale. Lemery, in his Dictionary of Drugs, ſays that aſphaltus ſweats like liquid pitch out of the earth covered by the Dead Sea; and riſing above the waters, is there condenſed by the heat of the ſun, and the action of a ſalt which abounds in thoſe waters. It is alſo found on many lakes in China.

The aſphaltus of commerce, M. Valmont de Bomare tells us, is obtained from the mines of Daunemore, and eſpecially in the principality of Neufchatel and Wallengin. According to that naturaliſt, it is of two colours, either blackiſh or greyiſh. But ſuch aſphaltus is far from being pure; it ſeems to be only earth hardened and intermixed with bitumen which has penetrated through it.

Naturaliſts are divided concerning the origin of aſphaltus, as well as concerning the other bitumens. Some think it a mineral product, formed of an acid united in the interior parts of the earth, with ſome fat matter. Others think it a reſinous vegetable matter, that has been buried under ground and altered by mineral acids. The moſt general and probable opinion is, that it has been produced in the ſame way as amber, and is actually nothing but amber altered by the action of ſubterraneous fire. The ground of this opinion is, that amber, when melted and deprived of a part of its oil, becomes black, dry, brittle, and in all reſpects like aſphaltus. But it can be finally eſtabliſhed only by a comparative analyſis of this reſidue of amber and aſphaltus. Aſphaltus has not yet been examined with ſuch exactneſs as will allow us to preſume on the analogy between them.

Aſphaltus, when expoſed to fire, becomes liquid, ſwells, and burns with a thick flame and ſmoke; the ſmell of which is ſtrong, acrid, and diſagreeable. By diſtillation, it affords a coloured oil, like brown petroleum, and an acid phlegm.

Aſphaltus is uſed by the Arabians and Indians in the ſame way as pitch for coating their veſſels. It enters into the compoſition of the black varniſhes which we get from China, and of thoſe artificial fires which burn on water. The Egyptians uſed it in embalming dead bodies; but it was employed for that purpoſe only by the poor, who could not afford to purchaſe dearer antiſeptic matters. Wallerius aſſerts, that the merchants prepare a ſort of aſphaltus of thick pitch, or by mixing and melting pitch with aſphaltus from Judea. But the fraud may be detected by means of alcohol, which entirely diſſolves pitch, but produces no change on aſphaltus, only taking itſelf from it a pale yellow colour.

CHAP. XXVI.

Species III. *Of Jet.*

JET, in Latin *gagas*, called by Pliny *black amber*, by Strabo, &c. *pangitis*, is a black bituminous ſubſtance, compact, hard like ſome ſtones, brilliant and vitreous in its fracture, and ſuſceptible of a fine poliſh. After being rubbed for ſome time, it attracts hard bodies, and, like amber, appears to be electric. It has no ſmell: when heated, it acquires a ſmell nearly the ſame with that of the bitumen of Judea.

Jet is found in France, in Provence, and in the county of Foix. There is alſo a quarry of it which is wrought at Beleſtat in the Pyrenees. It is found too in Sweden, in Germany, and in Ireland. The quarries of jet are in ſtrata; they likewiſe contain pyrites and pitcoal, and moſt of the other bitumens.

This bitumen, when expoſed to a ſtrong heat, becomes ſoft and melts; it burns with a fœtid odour. By diſtillation it affords oil and an acid liquor.

Of the ſeveral opinions which have been advanced concerning the formation of jet, the moſt probable is that which repreſents it as aſphaltus condenſed and hardened by length of time. It has been adopted by the learned Wallerius.

Jet is uſed for mourning toys. At Wirtemberg it is wrought into bracelets, buttons, boxes, &c.

CHAP. XXVII.

Species IV. *Of Pit-coal.*

THE name of *foſſil coal, pit coal, ſtone coal, lithantrax*, &c. is given to a black bituminous matter, foliated, either gliſtering or dull, brittle, and inferior in conſiſtency and purity to the bitumens which we have been deſcribing.

This bitumen derives its name from its combuſtibility, and the uſe to which it is in many countries applied. It is found in the interior parts of the earth, under ſtones of various degrees of hardneſs, and under aluminous and pyritous ſchiſti. Theſe ſchiſti always bear impreſſions of vegetables belonging to the fern tribe, which have been obſerved by Bernard de Juſſieu to be moſtly exotics. Pit-coal is ſometimes nearer to, ſometimes more remote from, the ſurface of the earth. Its diſpoſition is always in horizontal or inclined layers; ofteneſt in inclined. The beds or ſtrata which it compoſes, differ from each other in conſiſtency, colour, gravity, &c. Over this bitumen, ſtrata of of foſſil ſhells and madrepores, varying in extent, are often obſerved; a circumſtance which has led ſome moderns, particularly M. Parmentier, to think that it has been formed in the ſea by the depoſition and alteration of the oily or fat matters of marine animals. Moſt naturaliſts think it the reſidue of wood depoſited in the ground, and altered by acids.

Quarries of foſſil coal are wrought like mines of metal by digging into them pits and galleries, and hewing down the coal with a ſort of pickaxes. The colliers are often in danger of loſing their lives by the elaſtic fluids diſengaged. This mephitis, which they call *choak damp*, puts out their lights, and ſeems to be carbonic acid gas. There likewiſe gathers in theſe mines a kind of inflammable gas, the effects of which are very noxious, and which ſometimes produces very dangerous exploſions.

Foſſil coal is very plentiful in nature. It is found in England, Scotland, Ireland, Hainault, the territory of Liege, Sweden, Bohemia, Saxony, &c. Several provinces of France afford great quantities, particularly Burgundy, the diſtrict of Lyons, Forez, Auvergne, Normandy, &c.

Foſſil coal is diſtinguiſhed by its hardneſs or friability into ſtone-coal or earth-coal. The manner of its burning, and the phenomena which it exhibits during combuſtion, afford the beſt characteriſtics for diſtinguiſhing it into different ſpecies. Wallerius arranges foſſil coals, conſidered in this point of view, under three ſpecies. 1. The ſcaly coal, which remains black after combuſtion. 2. The compact foliated coal, which affords, after being burnt, a ſpongy matter like ſcoriæ. 3. Fibrous pit-coal, reſembling wood, which is reduced to aſhes by combuſtion.

This

This bitumen, when heated in contact with a burning body and air, takes fire; the more ſlowly, and with the greater difficulty, the more ponderous and compact it is: when it has once taken fire, it diffuſes a lively laſting heat, and burns long before being conſumed. It may be quenched and burnt again, for a number of times ſucceſſively. The inflammable matter contained in it appears to be very denſe, and in a manner fixed in ſome other incombuſtible ſubſtance which oppoſes its combuſtion. It exhales as it burns a peculiar odour; which, however, is no way ſulphureous, if the coal be very pure, and contain no pyritous matter. The combuſtion of this bitumen ſeems very analogous to that of organic matters, as it may be ſtopped and afterwards renewed. The moſt volatile part of the oily combuſtible matter contained in pit-coal is indeed burnt and diſſipated when it is firſt expoſed to the action of heat; and if, after the whole of that principle is diſſipated, the combuſtion be ſtopped, the bitumen retains only the moſt fixed and the leaſt inflammable part of its oil, in a truly carbonaceous ſtate, and combined with an earthy baſe. It is by a proceſs of this nature that the Engliſh prepare their *coaks*, which are nothing but pit-coals deprived by the action of fire of the fluid part of their oil.

We may eaſily obſerve what happens in this operation, by heating this bitumen in cloſe veſſels, and in a diſtillatory apparatus. It affords in this way an alkaline phlegm, concrete ammoniacal carbonate, and an oil which, as the diſtillation proceeds, takes a deeper colour, and becomes more ponderous. There paſſes at the ſame time a large quantity of an elaſtic inflammable fluid, which is commonly thought to be oil in vapours, but is properly hydrogenous gas, mixed with azotic gas,

gas, with carbonaceous matter diſſolved in it, and with carbonic acid gas. There remains in the retort a ſcorified carbonaceous matter, which is ſtill ſuſceptible of combuſtion, and is the ſame with the Engliſh *coak*. Obſerving carefully the action of fire on pure pit-coal, we perceive the coal to be firſt ſoftened, and in a manner half melted; but as this property might render it unſuitable for the melting of ores, it muſt be deprived of it before it be applied to that purpoſe. After taking from it the principle which renders it liable to ſoften, that is the oil which it contains in great abundance, and thus reducing it to a ſtate nearly the ſame with that of vegetable coal, it then becomes ſuitable for the fuſion of ores. Let us not forget to obſerve, that the ammoniac which pit-coal affords in ſuch conſiderable quantity, affords an argument in favour of that opinion which repreſents this bitumen as produced from animal matters; for, as we ſhall hereafter ſee, bodies belonging to the animal kingdom always afford this ſalt when diſtilled. This analyſis is performed in the great way in various places in England; and the ſeveral products are collected in a peculiar diſtillatory apparatus. The oil is uſed for pitch; the ammoniac is uſed in the compoſition of ammoniacal muriate; and the reſidue is a very good *coak*. M. Faujas de Saint Fond has imported this uſeful art into France; and the trials which he has made in the king's garden have ſucceeded very well in the ſmall way: We have as yet no eſtabliſhment for carrying it on in the great way *.

Pit-

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* The Engliſh reader will here recollect the patriotic exertions of the Earl of Dundonald to eſtabliſh works of this kind in Britain.

Pit-coal is highly uſeful in countries deſtitute of wood. It is uſed as a combuſtible matter; and the dangerous effects which have been aſcribed to it are quite imaginary. The ſulphureous vapour which it has been ſaid to diffuſe has no exiſtence; for chemiſts have univerſally found, by the moſt exact analyſis, that pure mineral coal contains not an atom of ſulphur. From this we ſee the ignorance and impoſture of ſome people who have pretended to give proceſſes for purifying coals of ſulphur. Another conſideration which ſhould induce us to make as much uſe as poſſible of coals in France is, that ſuch enormous quantities of charcoal are conſumed in the working of ores, that our wood is likely to fail one day or another; it is eſpecially in works of that kind we ſhould try the uſe of pit-coal, as the Engliſh have long done. It is already beginning to be uſed in various manufactories among us; and in the famous founderies of iron at Creuſot, near Montcenis in Burgundy, there is a great inſtance of its application to theſe purpoſes, highly worthy of imitation.

Purified pit-coal is nothing but that which has been deprived of its oil by the action of fire. This ſort of coal burns without ſmoke, without ſoftening, and without diffuſing any ſtrong ſmell; in a word, it is a true coak; and is, on account of theſe properties, preferred for fires in rooms.

Another inconvenience, beſides the copious dark ſmoke proceeding from it, which attends the burning of pit-coal, is, that the copious and rapid ſtream of air requiſite to maintain it in combuſtion, carries before it, and volatilizes, a part of the aſhes. But both theſe inconveniences may be in a great meaſure remedied by a judicious conſtruction of chimneys; ſo that the current of air, and whatever matters mix with it, may be entirely carried up, and diſcharged in the air, and no part of it returned and diſperſed through the room.

This combuſtible matter will in France be applied with moſt advantage for the ſervice of arts and manufactures of all kinds; in conſequence of which wood may be greatly ſaved for kitchen and room fires, and for building.

CHAP. XXVIII.

Species. V. *Of Petroleum.*

THE name of *petroleum*, or *oil of ſtone*, has been given to a liquid bitumenous ſubſtance, which runs between ſtones upon beds of rocks, or in various places on the ſurface of the earth. This oil is of various degrees of levity, ſmell, conſiſtency, and inflammability. Authors take notice of a great many varieties of it. The lighteſt, the moſt tranſparent, and the moſt inflammable petroleum, they have diſtinguiſhed by the name of *naphtha*. *Petroleum*, properly ſo called, is a liquid bitumen, ſomewhat thick, and of a deep brown colour: mineral pitch, again, is a black bitumen, thick, ſcarce liquid, tenacious, and adheſive to the fingers. The following varieties have been deſcribed by Wallerius and ſeveral other naturaliſts.

Varieties.

1. White naphtha.
2. Red naphtha.

Varieties.

3. Green or dark naphtha.
4. Petroleum mixed with earth.
5. Petroleum trickling through ſtones.
6. Petroleum ſwimming on waters.
7. Mineral pitch, or *maltha.*
8. Piſſaſphaltus. It is of a middle conſiſtency between that of common petroleum and that of aſphaltus or bitumen of Judea.

The ſeveral ſorts of naphtha are found in Italy, in the Duchy of Modena, and on Mount Chiaro, about twelve leagues from Placentia. Kempfer, in his *Amœnitates Exoticæ*, relates, that great quantities of it are gathered in many places in Perſia. Petroleum runs in Sicily, and in many places of Italy; in France, at the village of Gabian, in Languedoc; in Alſace, at Neufchatel in Switzerland; in Scotland, &c. Piſſaſphaltus and mineral pitch were formerly obtained from Babylon, in the building of the walls of which they had been employed; from Raguſa in Greece, and from the pond of Samoſata, the capital of Comagena in Syria. It is at preſent obtained from the principality of Neufchatel and Wallengin from the Well de la Page, a league from Clermont-Ferrand in Auvergne, and from various other places.

With regard to theſe ſeveral varieties, it is to be obſerved, that they ſeem to be all produced from one common origin, and to be but different modifications of the ſame ſubſtance. Moſt naturaliſts and chemiſts aſcribe the formation of petrolea to the decompoſition of ſolid bitumens by the action of ſubterraneous fires. Naphtha, they obſerve, appears to be the light oil which is firſt diſengaged by fire: that which follows after it having colour and conſiſtency, forms the ſeveral ſorts of petroleum: And, laſtly, petrolea, united with earthy ſubſtances, or altered by acids, acquire the characteriſtics of mineral pitch or piſſaſphaltus The phenomena of the diſtillation of amber favour this opinion: It affords actually a ſort of naphtha, and a petroleum too of a higher or a lighter brown colour, according to the degree of heat employed, and the length of time ſpent in the operation. Laſtly, They obſerve, that nature often affords all the different ſorts of petroleum in the ſame place, from the lighteſt naphtha to mineral pitch. Such are the fluid bitumens from Mount Feſtin, in the Duchy of Modena. Altho' this opinion be very probable, yet other authors think petroleum an oily mineral combination, formed by the ſulphuric acid with ſome fat matters. But even ſuch a combination muſt ſtill be allowed to originate from organic beings; as fat matters are always formed by thoſe beings.

The chemical properties of petroleum have not yet been examined. We know only that naphtha is very volatile, and ſo combuſtible that it takes fire when brought near any burning body; it even appears by its volatility to attract the flame. From brown petroleum there is obtained an acid phlegm, and an oil which at the firſt reſembles naphtha, but acquires a colour as the diſtillation proceeds. There remains in the retort a thick matter like piſſaſphaltus, which by greater activity of fire may be rendered dry and brittle like aſphaltus, and entirely reduced to a carbonaceous ſtate. Alkalis ſcarce act upon petroleum: the ſulphuric acid colours and thickens it; the nitric acid kindles it in the ſame

ſame manner as eſſential oils: it eaſily diſſolves ſulphur; it is coloured by metallic oxides; and it combines with amber, and with the help of heat ſoftens and diſſolves a part of it.

The ſeveral kinds of petroleum are uſed for various purpoſes in the countries in which they abound. Kempfer tells us they are uſed in Perſia, to give light, and burnt in lamps with wicks. They may alſo be uſed for common fires. Lehman ſays, that for this end the naphtha is poured on a few handfuls of earth, and kindled with paper: it takes fire and burns with great activity, but diffuſes a ſmoke in great abundance, which ſticks to all bodies that come in its way, and has a very diſagreeable ſmell. Petroleum is likewiſe thought to make part of the Greek fire. Thick petroleum makes alſo a very ſolid and durable mortar. By the decoction of piſſaſphaltus with water, an oil is obtained, which is uſed for pitching veſſels.

Laſtly, Some phyſicians have preſcribed petroleum with ſucceſs in diſorders affecting the muſcles, palſy, weakneſs, &c. by rubbing the ſkin with it, or expoſing it to its ſmoke. Vanhelmont thought friction with petroleum an excellent cure for frozen limbs, and recommends it as a good preſervative againſt the effects of cold.

[End of the Third Volume of the Original.]

PART THIRD.

The VEGETABLE KINGDOM.

CHAP. I.

Of the Structure of Vegetables.

VEGETABLES are organized beings, confined to the ſurface of the earth, without ſenſibility or power of motion. They are known by their appearance, and the conformation of their parts. They are diſtinguiſhed from minerals, as being capable of receiving nouriſhment internally, and elaborating the juices to which they owe their growth. They diſplay to our obſervation phænomena which depend on their organization, and are called *functions;* the chief of theſe is that of reproducing themſelves by ſeeds or *ova* like animals.

Vegetables differ from one another, 1. In ſize; they are divided into trees, ſhrubs, herbs, moſſes, &c. 2. In local

local ſituation; ſome grow in dry grounds, others thrive in a moiſt ſoil; ſome, again, in ſand, clay, water, on the ſurfaces of ſtones, or on other vegetables, &c. 3. In ſmell, taſte, colour, &c. 4. In duration; plants either live for a number of years, or only for one year, or are produced and die twice a year, &c. 5. In the uſes to which they are applicable; they are uſed either as aliments, or as medicines. A great many of them are made uſe of in the arts, for dyeing, &c. others for adorning gardens, &c.

Vegetables, conſidered with reſpect to the external conformation of their parts, conſiſt of ſix parts or organs, deſtined each to a peculiar function: theſe parts are the root, the ſtem, the leaf, the flower, the fruit, and the ſeed. Theſe again differ in different plants, in form, contexture, bulk, number, colour, hardneſs, taſte, &c.

1. The root is concealed in the ground, in water, or in the bark of ſome other vegetable. It is either tuberous, or fibrous, or bulbous. Its direction is either perpendicular or horizontal. Both its form and conſiſtency are ſubject to great varieties. Botaniſts divide the roots of plants into many ſpecies; which diſtinctions they ſometimes make uſe of to determine the ſpecific characters of the plants themſelves.

2. The ſtem proceeds from the root, and ſupports the other parts of the plant. It is either ſolid or hollow, ligneous or herbaceous, round, ſquare, triangular, or with two very acute angles, &c. The ſtem conſiſts of wood and bark. The wood is diſtinguiſhed into wood properly ſo called, and ſap: the bark conſiſts of the epidermis, the veſicular part or pulp, and the cortical ſtrata or inner rind. The ſtem divides into

branches,

branches, the ſtructure of which is preciſely the ſame with its ſtructure. This part, too, is liable to ſuch diverſities as enable botaniſts to eſtabliſh upon it the diſtinctive characters of ſpecies, and ſtill oftener of varieties.

3. The leaves of vegetables are extremely various: A. in form; they are oval, round, linear, ſagittated, haſtate, oblong, elliptical, cuneiform, &c.: B. in their poſition on the ſtem; they are ſeſſile, petiolate, oppoſite, alternate, ſtellate, perfoliate, vaginal, &c.: C. in their margins; they are uniform, dentate, crenate, ſerrate, repand, undulated, laciniated, truncated: D. in ſimplicity or compoſition; compound leaves are formed by the inſertion of foliolæ, or ſmaller leaves; they are then either digitate or conjugate, with either an even or an odd number of leaves: E. in place or ſituation; they are radical, cauline, or floral: F. in colour, ſmell, taſte, conſiſtency, &c. they ſeem deſigned to abſorb elaſtic fluids from the atmoſphere, and to pour others into it, according to circumſtances.

4. The flowers are thoſe parts which nature has deſigned to contain the organs of generation, and to preſerve them from injury till the fecundation is accompliſhed; at which time they fall off. A flower conſiſts of two parts; the exterior, deſigned to cover and protect the interior; the uſe of which is to re-produce the plant. The former comprehends the calix and the corolla; the calix is exterior, and of a green colour.

Linnæus divides the calices of plants into ſeven ſpecies; namely, the perianthium, the ſpartha or ſheath, the huſk, the involucrum, the amentum or catkin, the calyptra or veil, and the volva. The corolla is the coloured part, commonly

monly called the *flower:* it is either a ſingle piece, and monopetalous, or conſiſting of ſeveral pieces, polypetalous. Tournefort's ſyſtem is founded on the corolla. The pieces of the corolla are called *petals.* The organs incloſed, and often entirely concealed in the corolla, are the ſtamina and piſtils or ſtyles. The ſtamina are the male or fecundating parts; and are almoſt always more numerous than the piſtils. They conſiſt of the filament and the anthera. The anthera, placed at the extremity of the filament, is a ſmall bag, containing fecundating powder. The piſtil ſtands in the middle of the ſtamina; it is ſometimes on another flower, or even on another plant: this circumſtance has cauſed ſome plants to be diſtinguiſhed into male and female. The piſtil conſiſts of three parts; the inferior part or ovarium, which contains the embryo, and is called in Latin *germen;* the filament, which riſes out of the ovarium or ſtyle; and its extremity, which is more or leſs dilated, and is called *ſtigma.* The ſexual ſyſtem of Linnæus is founded on the number, and the relative poſitions of the ſtamina, and the piſtils. M. de Juſſieu has formed a ſyſtem in the inſertion of the ſtamina, above or under the germen, &c.

5. Flowers are ſucceeded by fruits. Botaniſts diſtinguiſh fruits into ſeven ſpecies; the capſule; the ſiliqua; the legumen; the conceptaculum, which becomes dry; fruits having kernels; fruits having pippins and berries, which remain ſucculent. The purpoſe of theſe organs is to incloſe the ſeeds, and to protect them from ſuffering by the action of external bodies.

6. The ſeeds of plants differ greatly in form, magnitude, appendices, &c. The ſeed contains the plumula or ſmall plant, the radicula, and the cotyledons. There are two of theſe latter in moſt vegetables; yet many

families of plants have but one cotyledon. This part is to the grain what the yellow and white of an egg are to the embryo bird; it contains a ſubſtance intended for nutriment to the young plant during the germination. Beſides, the cotyledons of many ſeeds contain fleſhy and farinaceous bodies, &c.

Vegetables, conſidered as to their internal ſtructure, contain five ſpecies of veſſels or organs which exiſt through all their parts, 1. The common veſſels which convey the ſap. Theſe are placed in the middle of plants and trees; they riſe perpendicularly, but bend laterally, ſo as to form ſmall vacancies between them. 2. The peculiar veſſels which ſecrete and convey the juices peculiar to each vegetable, oils, reſins, gums, &c. Theſe are placed under the bark; they are often dilated into cavities, or reſervoirs; they ſeem to be excretory ducts. 3. The tracheæ, through which the air that vegetables take in from the atmoſphere circulates. When a young and green branch is broken, theſe may be obſerved, and known from their ſpiral form, reſembling a cork-ſcrew. They are often full of ſap. 4. The utricles, which are ſmall veſſels containing a ſecreted juice, and frequently colouring matter. They are placed in the middle of the ſtem. 5. The veſicular tiſſue, exhibiting a ſeries of ſmall cells, leading horizontally from the pith, croſſing the ſap-veſſels, filling up the vacuities among them, and ſpreading over the epidermis, where they form a ſoft covering like the ſkins of animals. The veſicular tiſſue of vegetables ſeems to correſpond to the cellular membrane of animals.

All parts of vegetables conſiſt of an aſſemblage of theſe five kinds of veſſels; which are, each of them, more or fewer in number, dilated, contracted, &c. On this diverſity in point of number and diſpoſition depend the differences in the form and texture of the roots, ſtems, leaves, &c. of plants.

Malphigi, Grew, and Duhamel, are the three naturaliſts who have ſtudied the anatomy of vegetables with the greateſt ſucceſs; and their works will be conſulted with the greateſt advantage, concerning the internal ſtructure of the ſeveral parts of vegetable bodies.

CHAP. II.

Of the Natural Philoſophy of Vegetables.

ALL theſe organs of vegetables, of which we have given the above brief account, are deſigned for the performance of the various motions called *functions.* Theſe functions are,

1. The motion of the fluids, which is a ſort of circulation.

2. The alterations or changes produced on thoſe fluids, which are effected in their ſecretion.

3. The growth of the vegetable and the developement of its parts by nutrition.

4. The exhalation of the ſeveral fluids elaborated by the organs of vegetables, and the receiving of ſeveral principles from the atmoſphere by the ſame organs.

5. The action of air, and the employment of that fluid in the veſſels of vegetables.

6. The motion performed by ſome of their parts.

7. That

7. That ſort of ſenſibility by which they court the contact of bodies that may be uſeful to them, ſuch as light, &c.

8. Laſtly, The ſeveral phænomena, by which plants are generated, and ſpecies reproduced. Let us conſider each of theſe functions more particularly.

The principal fluid in vegetables, which is called the *ſap*, is contained in certain ducts, which are known by the name of *common veſſels*. Theſe veſſels, ſituated in the centre of the ſtem, and under the bark, extend from the root all the way to the leaves and flowers. The ſap which they convey is a colourleſs fluid, more or leſs inſipid in taſte, and intended, like the blood of animals, to be ſeparated into different juices for the nouriſhment and ſuſtenance of the various organs. In ſpring it flows very copiouſly, cauſing the plant to diſplay leaves and flowers. By applying ligatures, and by all the phænomena of vegetation, it has been proved, we think in a ſatisfactory manner, that the ſap aſcends from the root through the ſtem and the branches. We are not ſo certain whether it be true, as ſome naturaliſts have thought, that it deſcends again towards the root. The exiſtence of thoſe valves, which ſome botaniſts have repreſented as belonging to the common veſſels of plants, has not yet been demonſtrated; not at leaſt unleſs we give the name to certain filaments or hairs with which Tournefort and Duhamel have obſerved their interior ſides to be lined. There is a vaſt difference between this irregular motion and the circulation of the fluids in animals.

The ſap being conveyed into the utricles, and thence into the proper veſſels, is there elaborated in a peculiar manner. By this elaboration it is wrought into different fluids, ſaccharine, oily, or mucilaginous, which

which are diſcharged by an organic excretion; and of which the evacuation ſeems to be an advantage to the vegetable, as it does not appear to ſuffer even from a conſiderable loſs of theſe matters. This alteration of the fluids, which may be diſtinctly obſerved as it takes place in ſeveral of the organs, in the nectarium, for inſtance, at the extremity of the piſtil, in the pulp of fruits, at the baſe of the calices, and of many of the leaves, is entirely effected by a function ſimilar to that which in animals bears the name of *ſecretion.* Guettard has carried this analogy ſo far as to deſcribe glands of various forms, at the baſes of the leaves of fruit-trees, and towards the inner extremity of the petals of certain flowers. This ſecretion ſeparates the odorous principle, the colouring matter, the combuſtible ſubſtance, &c. but it differs from animal ſecretion, as animal ſecretion is entirely owing to the organization of the glands which elaborate the animal fluids: whereas in vegetables, the juices conveyed through the common veſſels are in the proper veſſels more expoſed to the contact of air and light and the action of heat; and their ſituation renders them liable to paſs, by the operation of theſe agents, through a proceſs of fermentation, by which only they can be altered.

The ſap in the cavities of the utricles and the veſicular tiſſue, becomes thick, and acquires more or leſs conſiſtency. In conſequence of this alteration, it adheres to the ſides of the fibres, and incorporates with them gradually, ſo as to increaſe their dimenſions. Such is the mechaniſm by which vegetables are nouriſhed and grow, and unfold their parts. It bears a great reſemblance to the nutrition of animals. The veſicular tiſſue of vegetables and the cellular membrane of animals, are formed with a ſimilar ſtructure, and intended to ſerve ſimilar purpoſes. They paſs in the ſame manner through all the organs of the bodies to which they reſpectively belong; they eſtabliſh a direct communication among theſe organs; and both may be ſaid to be the ſeats of nutrition.

Philoſophical botaniſts have long been convinced, that plants exhale effluvia from the ſurfaces, which are diffuſed through the air. The odorate ſpirit of leaves and flowers forms round vegetables an atmoſphere which affects the ſenſes in a lively manner; and which, as has been obſerved with regard to the fraxinella, the contact of a burning body will ſometimes ſet on fire. This effluvia appears to be an inflammable gas of a peculiar nature. Mankind have alſo learned from fatal experience, that ſome vegetables exhale vapours, noxious to ſuch animals as approach them. The walnut, the yew, and many other trees, natives of warm climates, are of this kind.

M. Ingenhouſz has diſcovered by experiment, that the leaves of all plants, when expoſed to the ſun and to light, pour into the atmoſphere an inviſible fluid, which is vital air of the ſame qualities with that obtained from oxide of mangancſe, mercury, &c. But in the ſhade they no longer exert ſuch a property; inſtead of vital air, they give out carbonic acid gas, when deprived of the contact of light. This valuable diſcovery, which was firſt communicated to the world by Dr Prieſtley, ſhows vegetables to poſſeſs a property that was not before attributed to them, and to be capable of purifying and renovating the air, by pouring into it a portion of that vivifying fluid which is conſtantly conſumed by combuſtion, reſpiration, &c. But if vegetables are continually diffuſing vaporous fluids through the atmoſphere, produced by the laſt proceſſes of of vegetation, they likewiſe abſorb ſeveral of the principles of the atmoſphere. The experiments of Bonnet ſhow, that the under ſurface of the leaves abſorbs moiſture from the dew. Dr Prieſtley has proved, by his reſearches, that vegetables abſorb the gazeous reſidues of combuſtion and reſpiration; for vegetation is more ſpeedy and vigorous in air altered by theſe phænomena. Exhalation and inhalation are therefore much more conſiderable and important phænomena of the vegetable kingdom than they were known to be before the modern diſcoveries. It even appears, that the water abſorbed by the under part of the leaves is decompoſed by their organs, its hydrogenous gas abſorbed, and its oxigene converted into the vital air which is diſengaged from the upper ſurfaces of the leaves. The rays of the ſun contribute greatly to this decompoſition; for it does not take place in the ſhade. The water being then not decompoſed, but entirely abſorbed, renders the plants white, inſipid, ſoft, and in a word *ætiolated;* and in ſuch caſes, much leſs colouring, combuſtible, or oily matter, is formed than when the plant is expoſed to the action of light.

The gaſes abſorbed by vegetables are conveyed thro' all their organs by veſſels known under the name of *tracheæ*, which in their uſe and ſtructure bear a reſemblance to thoſe of inſects and worms. But the conveyance of this fluid is not the only purpoſe for which theſe tracheæ are intended. They are obſerved to be filled with ſap in the ſeaſon when that fluid flows in greateſt abundance; a circumſtance which diſtinguiſhes them widely from thoſe organs of reſpiration which belong to ſo great a number of animals, and are ſo eſſentially neceſſary. From the theory of reſpiration which we have laid down in the hiſtory of air, it is eaſy to explain

explain why vegetables poſſeſs not free heat in a degree of temperature ſuperior to that of the atmoſphere.

Several parts of vegetables have, no doubt, an internal principle of motion. In ſome plants this motion is ſo conſiderable as to be obſervable by the eye. Such is the motion of the ſenſitive plant, of the ſtamina of the Indian fig, of pellitory, &c. This motion ſeems to correſpond to that function of animal organs which is called *irritability;* for it is effected by the action of a ſtimulus, and by peculiar organs, which are by ſome botaniſts compared to the muſcular fibres.

Can we deny plants to poſſeſs a ſort of ſenſibility, when we ſee them turn their leaves and flowers towards the ſun; when we obſerve, that, if incloſed in boxes of wood, with glaſs on one ſide, or perforated with an open hole, or ſimply thinner on that ſide than on the other, they conſtantly turn towards the tranſparent body, or the aperture through which light is permitted to enter, or the ſide which, being thinner, is nearer to that fluid than the other? Or, is this appearance of ſenſibility rather to be conſidered as an effect of the power of affinity, of the tendency of vegetables to combine with light? It has been fully proved, that, either by percuſſion or combination, this ſubſtance produces in plants the properties of colour, taſte, and combuſtibility; in the ſhade even the talleſt plants are white, inſipid, aqueous, and deſtitute of any inflammable principle: but, again, vegetables expoſed to the rays of the ſun, in the torrid climates of the ſouth, are very high-coloured, contain bitter and reſinous parts, and are very combuſtible. However ſtrong this affinity be allowed to be, yet it is hard to imagine how it could excite ſuch a motion in the branches and leaves of vegetables.

getables. We muſt therefore grant them a peculiar ſenſation, a ſort of feeling very different indeed from that of animals, by which they are enabled to diſtinguiſh and prefer ſuch ſituations as are moſt expoſed to light.

The methods which nature uſes for the reproduction of ſpecies of vegetables are ſtrongly analogous to thoſe by which the generations of animals are perpetuated. The greateſt number of the ſpecies of plants are propagated by ſexual coition. The labours of the celebrated Linnæus have diſcovered a ſtriking reſemblance between the organs deſigned for this purpoſe in theſe two claſſes of organic beings. The ſtamina of plants correſpond to the genital parts of male animals, and the piſtils conſiſts of three parts, which bear an equal reſemblance to the ſame organs of female animals. The embryo is developed by the action of the fecundating powder, without which a new individual could not be produced from it; agreeably to what is daily obſerved of birds. But beſides this analogy, which it would be needleſs to trace farther, as vegetables are of a much ſimpler ſtructure than animals, and their parts conſiſt all of the ſame organs, any of them is capable of producing a new individual ſimilar to that to which it belonged. This is the reaſon of the reproduction of plants by means of ſcions or ſlips, as well as of the alteration of their fluids by grafting, whether natural or artificial. Here, therefore, is another analogy between vegetables and that claſs of animals which are reproduced by diviſion into pieces, as polypi, cruſtaceous inſects, certain worms, &c.

All theſe functions of vegetables, which bear ſo ſtriking an analogy to thoſe of animals, are liable to alterations, by which the vegetable is brought into a diſeaſed

ſtate.

ſtate. Theſe diſeaſes to which plants are liable, depend commonly either on ſuperfluity or defect of ſap, as well as on the bad qualities which the ſap may happen to acquire; and they bear therefore no ſmall reſemblance to thoſe with which animals are affected. Their cauſes, ſymptoms, and cure, come under the general principles of medicine; and form a branch of agricultural knowledge, in which it muſt be confeſſed little progreſs has yet been made; but which may be greatly advanced by following the directions of ſome celebrated modern writers on the ſubject.

CHAP. III.

Of Juices and Extracts.

THE fluids contained in vegetables are of two kinds, the common and the proper juices. The firſt of theſe conſtitute the ſap, which is found in all plants. This fluid ſeems to perform the ſame functions in vegetable which the blood does in animal bodies. It is contained in the common veſſels: It runs naturally from their ſurface; but may be extracted in greater abundance by inciſion. The ſap is not an aqueous fluid, but contains ſalts, extracts, and mucilages. When a certain quantity of it is wanted, in order to an examination of its properties, or for medical uſes, the plant is brayed in a mortar, and ſqueezed through a linen cloth: if the plant does not readily yield its juice, it is put into a preſs.

Succulent vegetables give out their juice by ſimple expreſſion. Thoſe whoſe juices are viſcid, or not very copious, muſt be treated with water to ſwell and dilute them; ſuch are borage and the dry aromatic plants. This fluid, when extracted by the force of preſſure, is found

found to contain a portion of the ſolids of the vegetable, which were bruiſed with the peſtle: it muſt then be purified. Juices of plants are purified, 1. Simply by reſt, or by filtration, when they are very fluid: in this way, for inſtance, are the juices of purſlain and the houſe-leek purified. 2. By the white of eggs, which collects the impure parts by coagulation; it is uſed with borage, nettles, &c. 3. By the ſimple application of heat, which coagulates and precipitates the parenchyma. M. Baumé recommends this as the beſt way for purifying thoſe vegetable juices which contain volatile principles, ſuch as that of cochlearia, creſſes, &c. The phial containing the juice is immerſed in boiling water, care having been taken to cover it with a piece of paper perforated with a hole; when the juice becomes pure it is taken out; it is then immerſed in cold water, and the juice filtrated. 4. By alcohol, which coagulates the feculent part. 5. By vegetable acids, which the London pharmacopœia preſcribes for the juices of cruciform plants.

There are matters diſſolved in the juices of plants which, when ſeparated from the aqueous vehicle, form what is called in pharmacy the *extract*. Theſe matters are diſtinguiſhed into three ſpecies, mucilaginous, ſaponaceous, and gum-reſinous extracts.

Thoſe are called *mucilaginous extracts* which diſſolve eaſily in water, are ſcarce ſoluble in alcohol, and undergo ſpirituous fermentation; ſuch is the rob of the gooſeberry, which is prepared by evaporating the juice.

Saponaceous extracts diſſolve in water, are partly ſoluble in alcohol, and rather mould than paſs into a ſtate of ſpirituous fermention. Such is the juice of borage when reduced to an extract. Theſe are extracts properly ſo called.

Gum-reſins are ſoluble both in water and in alcohol. They are inflammable, as containing a reſinous principle, and are not liable to ſuffer any alteration from air. The concentrated juice of wild cucumber, called *elaterium*, is of this ſort. Inciſions are made in the fruit of this plant; and the juice ſqueezed out, ſuffered to clarify of itſelf, and evaporated to dryneſs on a water-bath.

Theſe three different ſorts of extracts are prepared in the great way for commerce by the evaporation of the juice of various plants. Of theſe, among others, are,

1. The juice of acacia; which is prepared in Egypt by pounding the fruit of that tree, preſſing out the juice, and evaporating it by the ſun: the juice of acacia from Germany is prepared from the juice of ſloes by a ſimilar proceſs.

2. That of hypociſtis, which is prepared like the above, from the fruits of this paraſitical plant.

3. Opium, a medicine of great importance, the nature of which ſhould be very well known. It is extracted from the white poppy in Perſia, &c. There flows out by inciſions made in the green capſules of that plant, a white juice, which is dried into brown tears; this is the true opium. The opium which is commonly ſold, is prepared by firſt ſoaking the capſules in water, and then ſqueezing them; this juice is dried, and formed into flat circular cakes, covered with leaves, and mixed with a good deal of impurities. To purify it, it is diſſolved by the help of heat, with as ſmall a quantity of water as poſſible; the liquor is filtered or ſtrained by ſtrong preſſure, and evaporated on a balneum mariæ. This

This is the extract of opium. This ſubſtance contains a ſaponaceous extract, a reſin, a ſolid eſſential oil, an odorous principle, which is poiſonous and narcotic, an eſſential ſalt, and a glutinous matter. As the odorous, poiſonous, and narcotic principle is often noxious, attempts have been made to obtain the extract of opium without that principle. M. Baumé, who has examined this medicine with much care, volatilized that principle, together with the eſſential oil, and in conſequence of that ſeparated the reſin by digeſtion, for ſix months. Bucquet has diſcovered, that this extract may be obtained in ſuch a ſtate as to be ſedative, and not narcotic, by diſſolving opium in cold water, and evaporating the ſolution in a balneum mariæ. Lorry, who has made ſome very valuable experiments on this matter, has diſcovered, that fermented opium affords by diſtillation a ſedative water which has no poiſonous qualities, and has preſcribed it with great ſucceſs. He obſerves, that the odorous principle of this medicine cannot be deſtroyed by any proceſs.

To obtain the extracts of dry ligneous plants, we muſt employ maceration, infuſion, or decoction in water, according to the particular ſtate and nature of the matter from which the extract is deſired; maceration is often ſufficient. Odorous plants can only be treated by infuſion. Decoction carries off too much of their ſubſtance, and ſeparates the reſinous part: it forms an highly concentrated thick fluid, which becomes turbid by cooling. Infuſion will be ſufficient in any caſe. Such is the opinion of the greateſt chemiſts and the moſt celebrated phyſicians.

By water various products can be extracted from ſeveral plants. Thus juniper-berries afford with water a mucilaginous extract; quinquina affords a ſaponaceous

ceous extract, which is obtained in ſmall tranſparent ſcales of a ſaline appearance, if the ſolution be evaporated in broad flat veſſels; rhubarb affords in the ſame manner a gum-reſinous ſubſtance.

The chemical extract, properly ſo called, or the ſaponaceous extract, ſeems to be a compound of oil with fixed vegetable alkali. The extracts prepared in pharmacy are far from being all of the ſame nature; they are mixed with mucilage, eſſential ſalt, ſaccharine juice, and reſin. For this reaſon, Rouelle, with a view to throw new light on this part of medical chemiſtry, has diſtinguiſhed them, as above mentioned, into three genera. But the pure extract, reckoned among the immediate principles of vegetables, is to be conſidered as a ſaponaceous compound poſſeſſed of peculiar properties.

There are extracts prepared in the great way for commerce by water. Such are,

1. The juice of liquorice, which is yellow by the firſt infuſion, and black by a powerful decoction. The black juice is burnt, and actually contains coal. It is purified by melting it in water, filtering and evaporating the ſolution, which is rendered aromatic by the addition of eſſential oil, of anniſeed, cinnamon, &c.

2. The cachou, which is obtained in the Eaſt Indies from an infuſion of the ſeed of a certain palm-tree, called the *areca*. This ſolution is evaporated, and the matter obtained formed into broad cakes. The cachou is purified for medical purpoſes by ſolution in water and evaporation. It is ſeaſoned with aromatics like liquorice juice.

Among the extracts which are prepared for medical purpoſes, Rouelle has taken particular notice of thoſe mixed with reſin, by the name of *extracto-reſinous*, or *reſino-extractive matter*.

Extracta-reſinous matter does not burn till after it be dried: it ſeems to contain more extract, properly ſo called, than reſin. *Reſino-extractive matter* burns much better than the former: it ſeems to contain a greater proportion of reſin than of the extractive matter. This diſtinction proves theſe two ſpecies to be nothing but mixtures of extract in various proportions with a reſinous principle. They are not, therefore, extracts properly ſo called; and the name can be with propriety applied only to the ſaponaceous matter; which is therefore the ſubſtance whoſe properties we ought to examine.

The pure extract differs from thoſe above-mentioned. Taking all its properties together, we may conſider it as a dry ſolid ſubſtance, of a brown red colour, tranſparent, not capable of burning by itſelf, but which exhales a good deal of ſmoke, and is found to contain more or leſs eſſential ſalt. Its taſte is almoſt always bitter, it affords by diſtillation an inſipid phlegm; expoſed to a moderate fire, the phlegm by degrees takes a colour, and becomes of an alkaline nature, which is obſerved of elaterium, the extract of borage, &c. The ammoniac of the product is formed by the heat: there paſſes, next, a little empyreumatic oil; the coal is light, contains potaſh, and almoſt always neutral ſalts. The extract, when expoſed to the air, acquires a kind of moulding all over its ſurface, and attracts moiſture; and the ſalts mixed with it cryſtallize and ſeparate from the extractive part. They are often entirely altered and decompoſed on this occaſion. It diſſolves in water, and is then like a ſtrong infuſion. Acids decompoſe this ſolution like ſoaps. Metallic ſolutions likewiſe precipitate it; and the ſubſtances are, on this

occaſion,

occaſion, mutually decompoſed. The chemical properties of the extract have not been farther examined: on account of theſe which it is known to poſſeſs, it is, with good reaſon, conſidered as a kind of ſoap.

Extracts are employed in medicine as aperitives, diſcuſſives, diuretics, ſtomachics, and almoſt always with great ſucceſs.

CHAP. IV.

Of the eſſential Salts of Vegetables; and of thoſe in particular which are analagous to Mineral Salts.

THE ſaline ſubſtances held in ſolution in the juices of plants, or in water in which they have been infuſed, are called their *eſſential ſalts*. They are extracted by ſuffering theſe fluids to cool, after they have been evaporated to the conſiſtency of a ſyrup. As theſe ſalts are impregnated with extracts and fat matters, they need to be purified with lime and the white of eggs. When the ſalts are acid, lime muſt not be uſed, as it would neutralize them, but pure white clay in powder. After this firſt extraction they are ſtill very impure. They are diſſolved in diſtilled water, and repeatedly cryſtallized till they become white. This proceſs can be employed only on thoſe eſſential ſalts of vegetables which are cryſtallizable; but there have been ſome vegetable ſalts diſcovered which are not cryſtallizable, and which, on account of their mixture or combination with other principles, cannot be extracted by ſuch a ſimple proceſs. In giving an account of the ſalts contained in vege-

vegetables, or at leaſt obtained from them, we ſhall diſtinguiſh them into the following ſix genera.

The firſt genus comprehends all ſuch vegetable ſalts as are analogous to thoſe with which we are acquainted in the mineral kingdom.

The ſecond conſiſts of the pure acid ſalts of plants.

In the third we ſhall rank acid ſalts combined with a certain quantity of potaſh, under the generic name of *acidulæ*.

To the fourth genus we may refer ſuch as are formed by the action of the nitric acid on ſome vegetable matter.

The fifth may contain ſuch as owe their formation to heat.

Laſtly, Under the ſixth we include vegetable acids produced by a particular fermentation.

Firſt Genus of Vegetable Salts. Salts analogous to thoſe of the Mineral Kingdom.

The firſt genus of the eſſential ſalts of vegetables comprehends neutral ſalts extracted from their juices by evaporation, which are analogous to thoſe of the mineral kingdom. The principal ſpecies of thoſe ſalts are, 1. Fixed alkalis in combination with carbonic acid, which are obtained from almoſt all plants, by macerating them in acids, as has been ſhown by Margraaff and Rouelle the younger; potaſh is moſt commonly obtained; ſoda exiſts in ſome marine plants. 2. Sulphate of potaſh, in millefoil, in old borage, in aſtringent and aromatic plants, in ſpurge flax, and in the mark of olives. 3. Sulphate of ſoda, from tamariſk, and from rotten

rotten wood. 4. Nitre, from borage, turnſole, tobacco, &c. 5. Muriate of potaſh, and muriate of ſoda, from marine plants. 6. Sulphate of lime, diſcovered by Model in rhubarb. The exiſtence of the laſt ſalt is doubtful; for Scheele ſuſpects that what Model took for ſulphate of lime was only calcareous oxalate, or ſalt of ſorrel.

By an accurate analyſis of a greater number of plants, many other ſalts might no doubt be found in vegetables, reſembling mineral ſalts. It was alſo thought that ammoniacal carbonate exiſted ready formed in ſome cruciform plants; becauſe thoſe plants, when diſtilled, afforded by the firſt impreſſion of the heat a phlegm, in which there was a little of this ſalt ſuſpended. The ancient chemiſts, on this account, called thoſe plants *animal plants.* But Rouelle the younger has ſhown, that the ſalt is not ready formed in the plant, but is produced in conſequence of the reaction of the principles of the plant occaſioned by heat. M. Baumé has repreſented this volatile principle of cruciform plants, as being nothing but ſulphur. The ammoniac obtained from thoſe plants has been fully proved by M. Berthollet, to proceed from the combination of the hydrogenous part of the oil with the azote contained in the vegetable.

Naturaliſts have been of different opinions concerning the mineral ſalts found in plants. Some think the ſalts to be conveyed from the earth into the vegetable by water, without alteration. Others think them to be formed by the act of vegetation. One thing certain is, that two very different plants, ſuch as borage and millefoil, growing on the ſame ſoil, afford each its peculiar acid; borage, nitre, and

and millefoil, ſulphate of potaſh. This doubtful queſtion might be determined by a ſingle experiment; of which much has been ſaid, but which has never been performed with ſufficient exactneſs. The experiment is, to raiſe from a previouſly lixiviated earth plants affording a kind of ſalt, like nitre, and to water them with water impregnated with muriate of ſoda, or ſome other ſalt. If they ſhould be ſtill found to afford nitre, and not muriate of ſoda, it might be inferred, that ſalt does not paſs from the earth into the plant unaltered, but that the proper ſalt is formed in the plant by the functions of vegetation. Whatever may be the reſult of this experiment, it will be proved, that a number of the ſalts which we examined in the mineral kingdom are immediately formed in vegetables.

CHAP. V.

Of the ſecond Genus of Eſſential Salts, or of the pure Acids of Vegetables.

IN the ſecoud genus of eſſential vegetable ſalts, we rank thoſe acids which are entirely formed in plants, and are extracted from them pure by very ſimple proceſſes. There are five acids of this genus, the citric, the gallic, the malic, and the benzoic.

§ 1. *Of the Citric Acid.*

WE give the name of *citric acid* to the pure acid which Scheele obtained from lemon juice.

Chemiſts formerly, without attending to the peculiar characteriſtics of this acid juice, compared it to that of tartar; and at that period all vegetable acids were thought to be of the ſame nature. Attempts have been

been made to concentrate and purify the acid juice of the lemon and the orange, in order to preſerve them for long voyages. The juice of the former of theſe fruits has ſuch an acid taſte, and produces ſuch an effectual alteration on blue colours, that there can be no doubt entertained concerning its nature, M. de Morveau has found the ſpecific gravity of this juice to be to that of diſtilled water as 1,860 to 1.

When this juice is kept for ſome time, it acquires a diſagreeable taſte, and is covered over with a mouldineſs: this alteration is owing to its containing a conſiderable proportion of mucilage, of which chemiſts have endeavoured to purify it. Before means were found out by which that might be accompliſhed, it was preſerved in glaſs bottles, and covered with oil. Some people propoſed to put ſand into the veſſels; others added a mineral acid; either of theſe proceſſes altered the nature of the juice. The firſt was ſuperior to the other, but even with it, the juice, in the ſpace of a few days, contracted a tart, oily, and diſagreeable taſte. M. Georgius in the year 1774, publiſhed, among the Acts of the Academy of Stockholm, a proceſs for concentrating the acid juice of citrons, and rendering it unalterable. He directs this juice to be kept for ſome time in the cellar, in inverted bottles, in order to ſeparate from it a part of the mucilage, and to expoſe it to a cold 3 or 4 degrees under 0 in Reamur's thermometer; the aqueous part freezes, carrying with it, as would appear, a portion of the mucilaginous matter: care muſt be taken, as the ice forms, to ſeparate the liquid from it; and the congelation muſt be carried on till the ice become acid. M. Georgius has found, that when the juice is reduced to an eighth part of its bulk, and is eight times as ſtrong as before, a drachm of citron juice,

juice, concentrated by congelation, will ſaturate thirty-ſix grains of potaſh, which would require to ſaturate it an ounce of the ſame juice before concentration. This acid, thus concentrated, may be employed for many œconomical purpoſes. Dry lemonade is prepared by mixing it with ſugar refined and reduced to powder, in the proportion of one part to ſix.

Citron, or lemon juice, if expoſed ſoon after its preparation to an atmoſphere above the temperature of 15° of Reaumur, depoſites a white ſemi-tranſparent, mucilaginous matter, of a gelatinous conſiſtency: this juice, when decanted and filtered, becomes leſs liable to alteration than before. The mucilaginous matter, when dried, does not diſſolve in boiling water: when treated with the acid of nitre, it affords azotic gas, and is converted into oxalic acid: this is not a gummy mucilage, but bears an analogy to the vegetable gluten, of which we ſpoke in the article farina.

M. Dubuiſſon has preſerved citron juice by a proceſs directly oppoſite to that of M. Georgius. On evaporating this juice by a moderate heat long continued, the mucilage becomes thick, and ſeparates in the form of a cruſt and glutinous flakes; the acid liquid is concentrated, and may be long kept in well ſtopped bottles without being liable to alteration. M. Dubuiſſon has obſerved, that the contact of the air which remains between the ſtopper and the ſurface of this acid liquor concentrated by evaporation, is ſufficient to ſeparate in a few weeks flakes of a white ſubſtance, which he thinks to be glutinous, and which collecting on the ſurface, form there an elaſtic conſiſtent body. The acid is not ſenſibly altered during this ſeparation.

Theſe are the ſeveral proceſſes which were propoſed and

and uſed, before Scheele's time, for purifying and preſerving citron juice. From them it appears indeed, that this acid has engaged the attention of chemiſts; but it was prepared only for the purpoſes of pharmacy; and ſo fully was every one perſuaded that its nature was the ſame with that of the acid of tartar, that no doubt was ever ſuggeſted of that being the caſe. Stahl had aſſerted, that lemon-juice, when ſaturated with the lobſter ſtone or with chalk, acquired the nature of vinegar. Several chemiſts had attempted to combine it with alkalis, without obtaining permanent cryſtals from the combination, on account no doubt of the mucilage ſo plentifully mixed with it. M. de Morveau, however, informs us, that by ſaturating lemon-juice with carbonate of potaſh, expoſing the ſolution to the air, and filtering it ſeveral times, he obtained from it a ſalt cryſtallized in ſmall opaque grains not liable to deliquiate.

Scheele, in Crell's Journal, in the year 1784, gave a proceſs for obtaining the acid of lemon very pure, ſeparated from the mucilage and the extractive matter by which it is altered in the juice as preſſed from the fruit, and in a concrete form. He firſt employed alcohol to ſeparate the mucilage by coagulation, and did not ſucceed; the liquor, when inſpiſſated, filtered, and evaporated, afforded no cryſtals. He tried the proceſs which he had ſeveral years before diſcovered for purifying the acid of tartar, and obtained the acid of lemon, pure and concreted. The proceſs is as follows: Saturate boiling lemon-juice with pulverized chalk. The acid forms with the lime a ſalt that is ſcarce ſoluble, and the mucilaginous and extractive ſubſtances remain diſſolved in the ſupernatant liquor; the precipitate is to be waſhed with lukewarm water, till it ceaſe to deepen in colour; it diſſolves nearly as well as ſulphate of lime: it is then treated with as much ſulphuric acid as is requiſite to ſaturate the chalk, diluted in ten parts of water; and the mixture is now boiled for a few minutes. Afterwards it muſt be cooled and filtered; the ſulphate of lime remains on the filter; and the liquor affords by evaporation a concrete cryſtallized acid. In this operation, it is better, as Scheele has remarked, to uſe an exceſs of ſulphuric acid, than to leave a little lime not ſaturated: as this would prevent the citric acid from cryſtallizing; whereas, when there is an exceſs of ſulphuric acid, it remains in the mother-water.

The citric acid thus prepared is very pure and highly concentrated: its taſte is ſtrongly acid; it reddens all blue vegetable colours that are ſuſceptible of ſuch a change. Fire decompoſes it, converting it into acidulous phlegm, gazeous carbonic acid, and carbonated hydrogenous gas: there remains in the retort a little coal: air effects no alteration on its cryſtals. It diſſolves eaſily enough in water. The ſolution is decompoſed by an actual putrefaction, which indeed takes place but very ſlowly. With earths and alkalis it forms citrates of aluminous earth, barytes, magneſia, lime, potaſh, ſoda, and ammoniac; the properties of which have not yet been examined, though they are known to differ from all other neutral ſalts. The nitric acid does not convert this, like ſeveral other vegetable acids, into oxalic acid: this appears indeed to be one of the moſt powerful of vegetable acids. It acts with the help of water on various metallic ſubſtances, chiefly on zinc, iron, copper, &c.

Bergman has repreſented its affinities in the following order; lime, barytes, magneſia, potaſh, ſoda, am-

ammoniac. M. de Breſſey of Dijon has an account of its affinities ſomewhat different from this. According to him, barytes holds the firſt place, lime the ſecond, and magneſia the third; the alkalis follow after theſe. It appars from the reſearches of both, that this acid prefers the three alkaline earths to the alkalis themſelves.

The uſes of the acid of lemon are various. With water and ſugar it compoſes a very pleaſant drink, known by the name of *lemonade*. It is uſed in medicine as cooling, temperating, antiſeptic, antiſcorbutic, diuretic; it is eſpecially efficacious in correcting the acridity of the bile. It is ſometimes applied as a gentle eſcharotic to ſcorbutic ulcers, eruptions of the itch, and ſpots on the ſkin. When concentrated by the proceſs of M. Georgius, or that of M. Dubuiſſon, it may be put up for long voyages by ſea; and it is found of great utility on ſuch occaſions.

§ II. *Of the Gallic Acid.*

WE give the name of *gallic acid* to that which is extracted from the nut-gall which grows on oaks in conſequence of the puncture of an inſect. This acid is generally found, either in a greater or a ſmaller quantity, in all ſour or aſtringent vegetable ſubſtances: Such are oak, aſh, willow, and the barks of theſe trees, quinquina, ſimarouba, pomegranate, ſumac, tormentillo, the cypreſs nut, the ſtalk and leaves of the marſh iris, of the ſtrawberry ſhrub, of the water lily, &c.

Chemiſtry formerly diſtinguiſhed this matter by the name

name of the *aſtringent principle:* and all that they knew of it was, that it poſſeſſed excluſively the property by which its character was very diſtinctly marked, of producing black precipitates in ſolutions of iron in acids, and thus making ink. Meſſrs Macquer, Monnet, Lewis, Cartheuſer, and Goanetti, ſought to determine by experiments, in what manner this principle acts upon the metal. M. Monnet remarked, that nut-gall and aſtringent vegetable juices acted immediately on iron, and gave it a black colour. M. Gioanneti obſerved, that the atramentarious precipitate or feculum was not ſubject to the attraction of the magnet, and that iron therefore did not exiſt in the precipitate in a metallic ſtate, as had been before thought. Theſe obſervations might lead to the concluſion, that the aſtringent principle of nut-gall muſt be an acid, or at leaſt performed the part of an acid in chemical operations. The Academicians of Dijon were, however, the firſt after theſe writers, who diſtinguiſhed, in their experiments, the aſtringent principle to be an acid. Theſe philoſophers have ſhown, 1. That the products of diſtilled nut-gall become black with the ſolution of ſulphate of iron. 2. That an ounce of this ſubſtance communicates to cold water a tincture, from which 3½ drachms of extract are obtained by evaporation. 3. That this infuſion reddens turnſol and blue paper. 4. That the ſame principle is ſoluble in oils, alcohol, and æther. 5. That acids diſſolve without altering it, and without depriving it of the property of producing a black precipitate of iron. 6. That its ſolution in water precipitates alkaline ſulphures. 7. That it entirely decompoſes all ſolutions of metals, and communicates a colour to the oxides by combining with them. 8. Laſtly, That it directly diſſolves iron, and precipitates ſilver and gold, after ſeparating them from their ſolvents.

Such are the important facts concerning this ſubſtance, which have been communicated to the world by the Academicians of Dijon. Several of them had indeed been before obſerved by different chemiſts, but none had before aſcertained the acidity of the principle.

Since they communicated theſe obſervations to the world, Scheele has not only obſerved, that all ſour, aſtringent plants exhibit marks of acidity, but has diſcovered and deſcribed a proceſs for obtaining this vegetable acid pure and cryſtallized.

Upon a pound of nut-gall in powder, pour ſix pounds of diſtilled water; leave this mixture to macerate for the ſpace of fifteen days, in the temperature of from 16 to 20 degrees; then filtrate the liquor, and put it in a ſtone pot, or a large capſule of glaſs; ſuffer it to evaporate ſlowly in the air; a mouldineſs, and a thick and ſeemingly glutinous pellicle is then formed upon it: mucilaginous flakes are firſt precipitated in great abundance; the ſolution has no longer a very aſtringent taſte, but is more ſenſibly acid than before. After it has been two or three months expoſed to the air, there is obſerved on the ſides of the veſſels, and adhering to them, a brown plate, covered with granulated cryſtals, ſparkling, and of a yellowiſh grey colour: the ſame cryſtals exiſt likewiſe in great abundance on the under ſide of the thick pellicle which covers the liquor: the liquor muſt now be decanted off; and hot alcohol is poured on the flaky ſediment, the pellicle, and the cryſtalline cruſt: this ſolvent takes up all the cryſtallized ſalt, but affects not the mucilage. This ſpirituous ſolution is then evaporated, and the gallic acid

cid is obtained from it pure, in ſmall granulated cryſtals, of a grey colour, inclining a little to yellow, and brilliant.

The gallic acid thus purified has a taſte ſomewhat ſour and aſtringent. It produces in ſolutions of ſulphate, and of other ſalts, of iron a very fine and brilliant black precipitate: it gives a high red colour to the tincture of turnſol; when heated in contact with air, it ſwells and kindles, diffuſing an agreeable enough ſmell; and leaves a coal, the incineration of which is very difficult: when diſtilled by a moderate fire, a part of it is diſſolved in the water of its cryſtals, and aſcends in that ſtate; another part is ſublimed, without being decompoſed, in ſmall ſilky cryſtals; a ſtrong fire ſeparates from it ſome drops of oil, carbonic acid gas, and carbonated hydrogenous gas. Nut-gall, when diſtilled entire, affords a ſmall portion of concrete ſalt, reſembling the ſublimated gallic acid.

The gallic acid requires 24 parts of cold water to diſſolve it; of boiling water only three parts. Repeated ſolution and cryſtallization do not whiten it in a ſenſible manner. Alcohol diſſolves it much more efficaciouſly: four parts of this liquid, when cold, are ſufficient to diſſolve one of gallic acid; when boiling, it diſſolves a quantity of the acid equal to itſelf in weight.

This acid diſengages the carbonic acid from earthy and alkaline baſes, when its action is aſſiſted by heat.

With barytes, magneſia, and lime, it forms ſalts ſoluble in water, and eſpecially when there is an exceſs of the baſe. Potaſh, ſoda, and ammoniac, combine very readily with it, forming *gallates*, the properties of of which are hitherto unknown. The nitric converts the gallic into oxalic acid.

The gallic acid precipitates gold in a brown powder, and cauſes a part of the metal to appear on the ſurface of its ſolution in a brilliant metallic pellicle. In the ſolution of ſilver it produces a brown precipitate; and ſoon after the precipitation, a plate of reduced ſilver appears on the ſurface of the liquor. From mercury it produces an orange yellow precipitate; from copper a brown precipitate; from iron a beautiful gliſtering black precipitate; from biſmuth a citron yellow precipitate. Solutions of platina, zinc, tin, cobalt, and manganeſe, ſuffer no alteration from this acid.

Such are the properties which Scheele allows to the gallic acid prepared by his proceſs. They are ſufficient to intitle it to the character of a peculiar acid, diſtinct from all others. Its intimate nature, and the proportion of its principles, have not yet been aſcertained. M. de Morveau obtained from it a reſin which he thinks to be the acidifiable baſe; by the union of which with oxigene the acid is formed.

The uſe of nut-gall for dyeing black is well enough known: we ſhall only add to what we have already ſaid of it in the article of iron, that when the pure gallic acid is uſed in the preparation of ink, the ink is very beautiful and very black, and remains long unaltered.

§ III. *Of the Malic Acid, or the Acid of Apples.*

WE give the name of *malic acid* to a peculiar vegetable acid which Scheele extracted from the juice of various fruits, and of which he found apples to contain a conſiderable quantity.

This acid is obtained by ſqueezing the juice from four apples, ſaturating it with potaſh, and mixing the liquor with a ſolution of acetite or ſugar of lead. A double decompoſition is thus effected; the acetous acid combines with the potaſh, and the malic with the oxide of lead; the malated lead is precipitated; that precipitate is waſhed; and, and on its being treated with ſulphuric acid, ſulphate of lead is produced, and the malic acid ſwims above. A ſufficient quantity of ſulphuric acid muſt be poured in to diſſolve all the malate of lead; which, when it takes place, will be known from the taſte of the ſupernatant liquor.

The following are the properties of this acid. It cannot be obtained in a concrete form; with the three alkalis it forms deliqueſcent neutral ſalts; with lime it produces a ſalt that affords ſmall irregular cryſtals, ſoluble in boiling water, in vinegar, and in the malic acid itſelf; with aluminous earth a ſalt that is ſcarce ſoluble; with magneſia, a deliquieſcent ſalt. It diſſolves iron, and the ſolution is brown and not ſuſceptible of cryſtallization; it diſſolves zinc readily, and produces with it a ſalt in very beautiful cryſtals: the nitric acid changes it into oxalic acid; it precipitates nitrate of mercury, lead, ſilver, and gold, in a metallic ſtate: calcareous malate decompoſes ammoniacal citrate, forming in conſequence of the decompoſition calcareous citrate, not ſoluble in boiling water or in vegetable acids. The ſolution of calcareous malate in water is precipitated by alcohol; laſtly, the malic acid is ſpeedily deſtroyed by fire, which changes it into carbonic acid: the carbonic acid thus formed, ſaturates in part the baſes of the malates decompoſed by heat. Such are the properties which form the peculiar character of this acid.

Scheele found it almoſt pure, or mixed with a little citric acid, in the juice of apples, of the barberry, of alder twigs, of the ſloe thorn, of the ſorb tree, and of the plum tree; in gooſeberries, cherries, ſtrawberries, raſp-berries, &c. Laſtly, He obtained it from ſugar by the nitric acid; and M. de Morveau remarks, that the malic is diſcovered before the oxalic.

When four fruits contain both citric and malic acid, the following is Scheele's proceſs for ſeparating them, in order to obtain the latter pure. The juice of gooſeberries ſaturated with chalk affords calcareous citrate, which, being inſoluble, is precipitated; the ſupernatant liquor holds in ſolution the calcareous malate, which is ſeparated by alcohol; but as it is ſtill in union with a mucilage, Scheele has had recourſe to another means for obtaining it pure. He evaporated the juice of gooſeberries to the conſiſtency of ſyrup; upon this ſyrup he poured alcohol, which diſſolved the acids without affecting the mucilage; he then filtrated the ſolution to ſeparate the mucilage; after the filtration of the liquor, he evaporated the alcohol; the acids he ſaturated with chalk. The citric acid, uniting with the chalk, was, of conſequence, depoſited in calcareous citrate; and the calcareous malate remained in ſolution.

A new addition of alcohol precipitated it from the liquor; and Scheele then obtained the malic acid by diſſolving this ſalt in water, precipitating the ſolution by acetite of lead, and decompoſing the malate of lead by the ſulphuric acid; the malic acid was then found ſeparate in the ſupernatant liquor.

§ IV. *Of the Benzoic Acid, or the Acid of Benzoin.*

SINCE the days of Blaiſe de Vigenere, who wrote in the beginning of the laſt century, benzoin has been known to afford, by diſtillation, an acid ſalt cryſtallized in ſtrong ſmelling needles, of an acrid taſte, which in pharmacy are called *flowers of benzoin*. Chemiſts formerly thought this to be a particular modification of a mineral acid; but its diſtinctive properties are now ſo well known, that we can no longer doubt of its being a peculiar vegetable acid.

This acid is found to exiſt in benzoin, balm of Peru and Tolu, ſtrorax, liquidambar, and vanilla around which it is cryſtallized. Scheele has found it likewiſe in the ſugar of milk and the extract of urine. It will be ſhown under the article of Benzoin, that the ſimple proceſs which was formerly employed to obtain it, conſiſted in ſublimation by a moderate fire. Geoffroy diſcovered in the year 1738, that it might be extracted by water, and that the ſaline ſubſtance was fully formed as it exiſted in benzoin; by the ſame proceſs I extracted it from Peruvian balm, ſtorax, and the huſks of vanilla. But this proceſs affords only a ſmall quantity; for the reſin of benzoin, not mixing with the water, covers and preſerves a great part of the acid ſalt.

Scheele, in the year 1776, gave, in the Memoirs of Stockholm, ſome important obſervations on the benzoic acid: from 96 parts of benzoin he obtained, by ſublimation, between 9 and 10 parts of this ſublimated ſalt, which was very far from what Spielman aſſerted that he obtained,—namely, a fourth part of the benzoin ſubmitted to diſtillation: it appears that the chemiſt of Straſburg had taken acid of benzoin mixed with empyreumatic oil for pure acid. Scheele, having reduced benzoin to powder and mixed it with chalk, boiled upon it a quantity of water, and then filtrated the liquor, which afforded no ſalt by cooling: ſulphuric acid, poured into this liquor, ſeparated the benzoic acid in powder, and ſhowed that acid to have been united with a baſe of chalk, with which it formed a neutral ſalt ſoluble in water: the quantity of concrete acid, however, precipitated by this proceſs was not more conſiderable than that which is obtained by ſimple lixiviation. Scheele thought that a greater quantity might be obtained by employing a matter capable of acting on the reſin, and facilitating the ſeparation of the ſalt. Potaſh did not ſerve his purpoſe; the reſin again collected on the ſurface of the liquor in a thick tenacious oil, on which account he could not expect the acid to be entirely ſeparated. With quicklime he was more ſucceſsful: According to him it is to be applied in the following manner. Take four ounces of quicklime; ſlake it with 12 ounces of water; add eight pounds more when the ebullition ceaſes; mix ſix ounces of this water with a pound of benzoin in powder; theſe ſubſtances need to be well ſtirred, in order that they may mix properly; pour in by degrees the remaining part of the lime-water; when the lime-water is thus gradually poured in, it hinders the benzoin from collecting into a maſs: this liquor muſt next be heated for half an hour by a moderate fire, and conſtantly ſtirred: it is then taken off the fire, and ſuffered to ſettle for ſeveral hours together: the clarified liquor is now decanted off; eight pounds of tartar are poured upon the reſidue; it is boiled for half an hour, and then mixed with the clarified liquor before poured off from it; the operation is finiſhed by putting the reſidue upon a filter, and pouring hot water upon it. Theſe lixivia are next reduced all to two pounds by evaporation; a little reſin is ſeparated: when the evaporated liquor is cooled, a quantity of muriatic acid is dropped upon it, till it ceaſe to produce a precipitate, and the liquor take a diſcernible acid taſte: the ſalt of benzoin is then precipitated in powder. It is to be edulcorated on the filter: when it is wanted in cryſtals, it is diſſolved in five or ſix times its weight of boiling water; it is then filtrated through a cloth, and the ſolution ſlowly cooled; the ſalt is depoſited in oblong compreſſed priſms. In this proceſs the lime abſorbs the benzoic acid, and forms with it calcareous benzoate, which is very ſoluble; and the reſin is ſeparated from that ſalt, which has but very little affinity with it. The muriatic acid which attracts lime with more force than the benzoic acid, ſeizes that earth, and ſeparates the vegetable acid. The liquor, when reduced to two pounds by evaporation, is no longer ſufficient to maintain the acid in ſolution, and it is therefore almoſt all depoſited. Calcareous benzoate has not the ſmell of benzoin; but as ſoon as the benzoin is ſeparated by the muriatic acid, it takes that lively ſmell which is peculiar to this balſamic ſubſtance. By this proceſs Scheele obtained 12 or 14 drachms of benzoic acid from the pound of benzoin; whereas ſublimation affords

affords only 9 or 10. He farther informs us, that the purification of this ſalt by hot water and by cryſtallization, cauſes a great quantity of it to be loſt, and is by no means neceſſary to prepare it for pharmaceutical purpoſes. In fact, this ſalt, when properly cryſtallized, is very difficult to be reduced to powder; and the deſign of the purification is to ſeparate only about two grains of reſin from the pound of benzoin. Laſtly, he remarks, that the filtration of this acid diſſolved in water, can be effected only through a linen cloth. The ſalt being ſeparated quickly, as the liquor cools, ſtops up the pores of paper, ſo that the filtration cannot take place.

Since theſe experiments of Scheele's were made known to the world, M. Lichtenſtein has publiſhed in Germany ſome obſervations on the benzoic acid; in which he aſſerts, that ſublimation affords more of this acid than the proceſs by lime water: but I agree with Scheele and Morveau, in thinking that this can be ſaid only of the purified acid.

The purified benzoic acid has a taſte ſomewhat ſour, pungent, hot, and acrid; its ſmell is only a little aromatic; it communicates an high red colour to the tincture of turnſol.

Heat, while it volatilizes this acid, increaſes its bulk amazingly. When expoſed in a ſilver ladle to the heat produced by the blow-pipe, it becomes liquid, as has been obſerved by M. Lichtenſtein, and evaporates without inflammation. When ſuffered to cool, it forms a ſolid cruſt, which exhibits on its ſurface ſome marks of cryſtallization in divergent radii. It does not burn with flame, unleſs when in contact with bodies that are burning with a ſtrong flame. Burning coal only ſublimates it rapidly.

Air appears to have no power of acting on this acid; for after being preſerved 20 years in a glaſs veſſel, a quantity of it was ſtill very pure, and had loſt nothing of its weight: it loſes its ſmell indeed; but that it regains by heat.

The benzoic acid is ſcarce ſoluble in cold water. It appears from the experiments of Meſſrs Wenzel and Lichtenſtein, that 480 grains of cold water diſſolve no more than one grain of this acid; but the ſame quantity of boiling water diſſolves 20 grains of it; 19 of which are ſeparated by cooling. Bergman ſays, that boiling water diſſolves $\frac{1}{24}$ of its own weight, and that water of a moderate temperature diſſolves nearly $\frac{1}{500}$ part.

The benzoic acid combines with all earthy and alkaline baſes, forming with them benzoates of aluminous earth, barytes, magneſia, lime, potaſh, ſoda, and ammoniac. We know not the particular characteriſtic properties of each of theſe combinations, nor the different affinities of the acid with each of theſe baſes. M. Lichtenſtein aſſerts, that it prefers the fixed alkalis, and even ammoniac, to aluminous, magneſian, or calcareous, earth; but a great many more experiments are neceſſary to determine exactly the order of theſe affinities: And theſe are the more neceſſary, becauſe Bergman has given a different account of them. According to him, lime ſeparates the alkaline baſes, and barytes ſeparates lime: it diſengages carbonic acid from all of theſe baſes.

The concentrated ſulphuric acid diſſolves it eaſily without either noiſe or heat, according to the ſame chemiſt; but paſſes in conſequence of effecting this ſolution into the ſtate of ſulphureous acid; the benzoic acid may be ſeparated from it unaltered by water.

The nitric acid likewiſe diſſolves it, and gives it up in in the ſame manner to water without alteration. M. de Morveau has cauſed theſe two bodies to re-act on each other with additional force by the application of heat. The nitrous gas was not diſengaged till the end of the operation; and the benzoic acid was ſeparated without loſs, and without alteration. M. Hermſtadt, however, ſays, that when the concentrated nitrous acid is employed, the benzoic acid becomes fluid, and more fixed in its nature, and loſes the characteriſtics of the tartareous or oxalic acid; but new reſearches are neceſſary to eſtabliſh the truth of this reſult, to which little confidence can at preſent be given. That which appears to be moſt certain concerning this acid is, that it differs in its nature and properties from all other vegetable acids, and retains in it an eſſential oil, to which it owes its ſmell, volatility, combuſtibility, and ſolubility, in alcohol.

CHAP. VI.

Of Vegetable Acids, partly ſaturated with Potaſh, and of the ſame Acids pure.

IN the fourth chapter, we mentioned a particular claſs of vegetable acids; which, we ſaid, were in part combined with potaſh. We know of two acids of this character, the acid of tartar, and the acid of ſorrel. We call theſe acids which are partly neutralized, *acidulæ;* the one is the tartareous, the other the oxalic.

§ I. *Of the Tartareous Acidula, or Tartar, and of the pure Tartareous Acid.*

THE tartar ſold in the ſhops is an eſſential acid ſalt combined with a portion of potaſh and of oil, which is depoſited on the ſides of hogſheads containing wine, during the inſenſible fermentation of the wine. It is not, as ſome chemiſts have thought, a product of vinous fermentation; for Rouelle the younger has found it fully formed in muſt and in verjuice. Many other chemiſts have ſince found it fully formed in various fruits.

It is in the form of irregular plates, arranged in ſtrata, often full of brilliant cryſtals, and of an acid vinous taſte. It is diſtinguiſhed into white and red tartar; the latter of which differs from the former only in containing a greater quantity of colouring extractive matter.

Crude tartar, when expoſed to fire in cloſe veſſels, affords a reddiſh acid phlegm, an oil that is at firſt light, but afterwards ponderous, coloured, and empyreumatic, a little ammoniac, and a great quantity of carbonic acid, which Hales, Boerhaave, and many other chemiſts have taken for air. There remains a coal which contains a good deal of carbonate of potaſh, and is eaſily incinerated. By the combuſtion and incineration of tartar, fixed alkali is obtained in a ſtate of conſiderable purity. For this end, the tartar reduced to powder is put into rolls of paper ſteeped in water; they are then put into a furnace between two layers of coal; the coal is kindled, and the tartar is then burnt and calcined: when the fire is extinguiſhed, the rolls are taken out, and are found to retain their form; the matter which they contain is lixiviated with cold diſtilled water: This lixivium is filtered, and evaporated to a pellicle; it is ſuffered to cool, in order to ſeparate from it the ſulphate of potaſh, which is formed by reſt; the water is decanted from above this ſalt, and it is evaporated and cryſtallized anew, till it ceaſe to yield ſulphate of potaſh; it is then evaporated to dryneſs, and by this means affords potaſh, partly cauſtic and partly combined with carbonic acid.

It is very difficult to diſſolve tartar in water; for an ounce of water, 65 degrees above the freezing point, diſſolves only four grains of tartar. As it contains a good deal of oily colouring matter, it is purified by ſolution and cryſtallization at Aniane and Calviſſon, in the neighbourhood of Montpelier. Doctor Fizes favoured the public with an account of this purification, in a Memoir printed among the Memoirs of the Academy for the year 1725.

The tartar is boiled in water; the boiling ſolution is filtrated; as it cools it becomes turbid, and depoſites irregular cryſtals, which form a paſte. This paſte is boiled in copper veſſels with water, in which there is a mixture of clayey earth, which comes from the village of Merviel, two leagues diſtant from Montpelier. A froth gathers on the ſurface of the liquor, which is carefully ſkimmed off, and is ſucceeded by a ſaline pellicle. The fire is then abated; and the pellicle being broken, mixes with the cryſtals which are precipitated from the ſolution: theſe cryſtals are waſhed with water, to purify them entirely from a mixture of earth with which they are contaminated, and ſold under the name of *cream* or *cryſtals of tartar;* the only difference between the cream and the cryſtals being, that the cream is cryſtallized on the ſurface, whereas the cryſtals are depoſited at the bottom of the liquor. The white clay appears to ſerve the purpoſe of ſeparating from the tartar the ſuperfluous oily and extractive matter, which it contains.

At Venice, tartar is purified in a way ſomewhat different from this, according to M. Deſmaret's account. The ſalt is reduced to powder, and diſſolved in boiling water; it is ſuffered to depoſite any impure matters which it contains; and theſe are carefully taken out: the liquor then

then affords cryſtals by reſt and cooling. Theſe cryſtals are again diſſolved in water, which is expoſed to a gentle heat: when this new ſolution is heated to ebullition, beaten whites of eggs and aſhes, previouſly paſſed through a ſieve, are put into it. This mixture of aſhes is repeated 14 or 15 times; the ſcum produced by the effervefcence of the liquor is taken off; and it is then ſuffered to ſettle. A pretty white pellicle, and ſaline cryſtals of the ſame colour, are ſoon formed: the water is then decanted off, and the ſalt dried. By this method the nature of the tartareous acidulum is in ſome degree altered, and a part of it is changed into tartarite of potaſh. The cream of tartar, or purified tartar of Montpelier, muſt be the ſubject of our examination, in order that we may underſtand the nature of the pure tartareous *acidulum.*

The tartareous acidulum, when very pure, is cryſtallized, but in an irregular manner. Its taſte is ſour, and not ſo vinous as that of crude tartar. When it is put on a burning coal, it diffuſes a good deal of ſmoke of a pungent empyreumatic ſmell; and becomes black and carbonaceous. When this ſubſtance is ſubmitted to diſtillation in an earthen retort, with a balloon terminating in a tube, entering a bell glaſs full of water, it affords, if the fire be gradually applied to it, a phlegm, which is at firſt a little coloured, and ſomewhat acid: there paſſes after this an acid which is ſtronger and of a deeper colour; an oil which by degrees acquires colour and conſiſtency, and has an empyreumatic ſmell; ammoniacal carbonate; and a large quantity of carbonic acid. In the retort there remains a good deal of coal, which, when lixiviated without incineration, affords a large proportion of potaſh. All of theſe products may be rectified by a new diſtillation at a moderate

derate fire. The phlegm paſſes almoſt colourleſs; the oil, by this rectification, becomes very white and volatile; the ammoniac is in part combined with the acid, and can only be obtained ſeparate and pure by diſtilling the laſt portions of the phlegm with an addition of potaſh. With reſpect to the coal; the potaſh which it contains is not produced in the courſe of the operation, as has been thought by ſome chemiſts not well acquainted with the nature of *cream of tartar;* but exiſts in it ready formed before the operation. The production of the ammoniac is owing to the re-action of this alkali on the oil. A ſtill greater quantity of the volatile ſalt may be obtained by diſtilling the oil obtained from the tartareous acidulum upon the coal which it leaves, when analyſed in the retort. The proximate cauſe of the formation of the ammoniac is the combination of the azote of the potaſh with the hydrogene diſengaged from the oil.

The tartareous acidulum ſuffers no alteration from air. It diſſolves in twenty-eight parts of boiling water, and cryſtallizes by cooling, but in a very confuſed manner. There is a certain quantity of earth ſeparated from the ſolution of this ſalt, which, no doubt, is a part of the earth that was employed to purify it. This ſolution reddens the tincture of turnſol, and has an acid taſte. When left expoſed to the air, it becomes turbid, and, after ſome time, depoſites mucilaginous flakes: the acid is then decompoſed, and the liquor is, after this, found to contain nothing but carbonate of potaſh. M. de Machy was the firſt who obſerved this decompoſition. Meſſrs Spielman and Corvinus likewiſe attended to it; but M. Berthollet has obſerved it with ſtill greater accuracy than any former philoſopher. He has obſerved, that two ounces of tartareous acidulum require 18 months before they can be entirely decompoſed; that theſe two ounces will afford, in that time, 6½ drachms of carbonate of potaſh, ſtill oily, and mixed with a ſmall quantity of carbonaceous matter; and that, therefore, the quantity of alkali obtained by this means from the tartareous acidulum is preciſely the ſame which it would afford by combuſtion and calcination. The alkaline reſidue which remains after the diſtillation of this acidulum, and this ſpontaneous decompoſition, prove, therefore, that it contains a proportion of potaſh, nearly equal to one-fourth of its weight.

We know nothing of the action of ſiliceous, and very little of the action of aluminous, earth and barytes on the tartareous acidulum. The chemiſts of the Academy of Dijon have obſerved, that magneſia forms with this acidulum a ſoluble ſalt, liable to be decompoſed by fixed alkali; the ſolution of which affords, by evaporation, in the open air, ſmall priſmatic radiated cryſtals. When expoſed to fire, this tartarited magneſia emits bubbles, and is converted into a light coal. M. Poulletier de la Salle obtained from this combination a gelatinous maſs, perfectly like a mucilage. Theſe phænomena depend on the particular ſtate of the tartareous acidulum, which is in part ſaturated in this acidulated vegetable acid.

A number of chemiſts have given very good deſcriptions of the manner in which lime and chalk affect the tartareous acidulum. When chalk is caſt into a ſolution of this acidulum, an efferveſcence takes place, owing to the diſengagement of the carbonic acid, and a very copious precipitate is formed; the precipitate is a combination of lime with the tartareous acidulum. The ſupernatant liquor contains a neutral ſalt ready formed in the acidulum, or *cream of tartar*, which

confiſts

conſiſts of the pure acid in union with potaſh: This ſalt, as we will hereafter ſee, has been improperly called *ſoluble tartar*. We are indebted to Rouelle the younger for this analyſis of the tartareous acidulum by chalk. It proves, 1. That this ſubſtance conſiſts of an exceſs of oily acid, and a certain quantity of the ſame acid, united with potaſh in the ſtate of a neutral ſalt. 2. That the combination of the tartareous acid with lime, forms a neutral ſalt which is ſcarcely ſoluble. M. Prouſt has diſcovered, that calcareous tartarite, diſtilled in a retort, leaves a reſidue that takes fire in the air like the pyrophorus.

The tartareous acidulum very readily combines with the different alkalis. Put into a ſolution of carbonate of potaſh a quantity of tartareous acidulum in powder; a lively effervefcence is produced by the diſengagement of the carbonic acid: let acidulum be added till the alkali be ſaturated; after boiling this liquor for half an hour, filtrate it, evaporate the filtrated liquor to a pellicle, and ſuffer it to cool ſlowly; oblong ſquare cryſtals, terminating ſlopewiſe at two of their extremities, will be formed. This ſalt has been called *vegetable ſalt, ſoluble tartar, tartarized tartar;* but it ought to be called *tartarite of potaſh*. Its taſte is bitter; when expoſed to a ſtrong heat, it becomes carbonaceous: it may be decompoſed in a retort; and it then affords an acid phlegm, oil, a good deal of carbonic acid, and a little ammoniacal carbonate. It attracts, in ſome degree, the moiſture of the atmoſphere. It diſſolves in four parts of water heated to the temperature of 40°. This ſolution is decompoſed of itſelf in a few months; and it then leaves tartareous acidulum in combination with carbonic acid. The mineral acids decompoſe it, and precipitate the tarta-

tartareous acidulum. It is alſo decompoſed by moſt metallic ſolutions.

The tartareous acidulum, combined with ſulphur, forms the *ſalt of Seignette*, who was an apothecary of Rochelle, and the firſt that made up this combination; we give it the name of *tartarite of ſoda*. To prepare it, put 20 ounces of the acidulum of tartar into four pounds of boiling water; add by degrees very pure cryſtallized carbonate of ſoda, till the acidulum be ſaturated; that is, till the addition of the alkaline ſalt no longer produce any effervefcence. This combination renders the tartareous acidulum ſoluble. Evaporate the liquor almoſt to the conſiſtency of ſyrup; and you then obtain from it by cooling very beautiful and regular cryſtals, often of a conſiderable ſize. Theſe are priſms with ſix, eight, or ten, unequal ſides, with their extremities truncated at right angles. Theſe priſms are generally divided longitudinally into two; and the baſe on which they ſtand is marked with two diagonal lines, which croſs each other ſo as to divide it into four triangles. Tartarite of ſoda, which was at firſt ſold as a ſecret, and which was diſcovered at the ſame time by both Boulduc and Geoffroy in the year 1731, has a bitter taſte. It is decompoſable by fire, like tartarite of potaſh; it effloreſces in the air, on account of its containing a good deal of water in its cryſtals: it is almoſt as ſoluble as tartarite of potaſh; and is, like it, decompoſable by air, by mineral acids, and by metallic ſolutions. The mother-water of this ſalt contains that portion of tartarite of potaſh which entered into the compoſition of the tartareous acidulum.

Ammoniac forms with the acidulum of tartar an ammoniacal tartarite, which cryſtallizes very well by evaporation

poration and cooling. Bucquet ſays, that its cryſtals are rhomboidal pyramids. Macquer ſaw ſome of them in large priſms, of four, five, or ſix ſides; others ſwelled in the middle, and terminating in very acute points; and the Academicians of Dijon obtained this ſalt in parallelopipeds with two alternate ſloping ſides. This ſalt, ammoniacal tartarite, has a freſh taſte, and is decompoſable by fire: it effloreſces in the air; it is more ſoluble in hot than in cold water; and it cryſtallizes by cooling: lime and the fixed alkalis diſengage the ammoniac; the contact of air, mineral acids, and metallic ſolutions, decompoſe it. It appears, that when this ſalt is prepared, the tartarite of potaſh, which, in union with the tartareous acid, conſtituted the acidulum, or *cream of tartar*, remains in the mother-water.

Pott and Margraaff have treated the tartareous acidulum with mineral acids; and the latter obtained neutral ſalts, the ſame with thoſe which the ſame acids form with potaſh: from which he he has inferred, that potaſh exiſts ready formed in the acidulum. Rouelle the younger, who proſecuted a ſimilar train of experiments, obtained the ſame reſults. On throwing a pound of concentrated ſulphuric acid on an equal weight of tartareous acidulum in a very fine powder, the mixture becomes hot; the reciprocal action of the two ſubſtances may be promoted by the heat of a *balneum mariæ*, and by ſtirring them with a ſpatula of glaſs: let the heat be continued for ten or twelve hours; the mixture will then become thick like a jelly: then pour upon it two or three ounces of boiling diſtilled water to render it fluid; and leave it on the *balneum-mariæ* for about two hours; then take off the fire, and add three pints of boiling diſtilled water: the ſolution is now

now coloured and opaque ; it contains naked ſulphuric acid, a portion of tartareous acidulum, not decompoſed, and ſulphate of potaſh. Saturate the exceſs of ſulphuric acid with chalk ; a precipitate of ſulphate of lime, with a ſmall portion of tartareous acidulum, is then produced : filtrate the mixture, and evaporate the filtrated liquor ; it now affords ſo much tartareous acidulum and ſulphate of lime, that it is reduced to eighteen or twenty ounces. It is next decanted and evaporated anew ; and it affords, by reſt, cryſtals of ſulphate of potaſh ; which may be thus obtained by repeated evaporation and cryſtallization till the whole ſolution be exhauſted. This ſalt is always mixed with a little of the tartareous acidulum, and it burns upon red iron ; but when lixiviated with a ſufficient quantity of diſtilled water, it is diſſolved, and the acidulum remains on the bottom of the veſſel. This proceſs has been deſcribed, and ſucceſsfully repeated, by M. Bemiard, after Rouelle.

The nitric and the muriatic acids, when treated in the ſame manner with the tartareous acidulum, afford nitrate and muriate of potaſh ; which proves incontrovertibly the exiſtence of potaſh in that ſubſtance.

The tartareous acidulum acquires ſolubility by union with borax and the boracic acid. According to the experiments of M. de Laſſone, one part of the latter ſalt will render four parts of the tartareous acidulum ſoluble. This mixed ſolution affords, by evaporation, a greeniſh gummy ſalt, which is very acid.

The tartareous acidulum appears to be capable of uniting, without decompoſition, with moſt metallic ſubſtances ; as has been ſhown by M. Monnet and the chemiſts of the academy of Dijon. But as all of theſe combinations have been but very little examined, we ſhall here ſpeak only of thoſe in which the acidulum is combined with antimony, mercury, lead, and iron; becauſe theſe compounds are better known, and much more employed in medicine, than the others.

The combination of the tartareous acidulum with antimony bears the name of *ſtibiated*, or *antimoniated tartar*. It conſiſts of tartarite of antimony and potaſh. As it is one of the moſt valuable medicines which chemiſtry can ſupply, we may examine its properties with care. Since the time of Adrian, who firſt made it known to the world in the year 1631, the method of preparing it has been much varied. All the pharmacopœiæ, as well as the works of chemiſts, differ, either in reſpect to the antimonial ſubſtances to be employed in this preparation, or in reſpect to the proportions in which theſe, the water, and the tartareous acidulum, are to be mixed; or laſtly, in reſpect to the proceſs by which theſe ſubſtances are to be united in ſtibiated tartar. In Bergman's Diſſertation on this medicine, there is an excellent table of the various proceſſes which have been given for the preparation of tartarite of antimony. The ſublimated vitreous white oxide, the brown, and the orange-coloured oxide of antimony, have been ſucceſſively recommended for this purpoſe. Some have directed to boil theſe ſubſtances with the tartareous acidulum, and a greater or a leſs proportion of water, for ten or twelve hours; others think half an hour's boiling ſufficient: laſtly, ſome writers prefer the evaporation of the filtrated lixivium to dryneſs; while others would have it to be cryſtallized, and only the cryſtals uſed in medicine. From theſe various modes of preparation, it happens, that tartarite of antimony can ſcarce ever be purchaſed twice preciſely of the ſame ſtrength and nature; and its effects can never be depended upon. Geoffroy, who had examined ſeveral ſorts of *ſtibiated tartar* of different degrees of ſtrength, found by analyſis, that the weakeſt *ſtibiated tartar* contains in the ounce from thirty grains to a dram and eighteen grains of oxide of antimony: that which is moderately emetic, a dram and a half; and that which acts with moſt energy, no leſs than two drams and ten grains. The vitreous oxide of antimony has been preferred to other antimonial ſubſtances for this preparation; becauſe it diſſolves eaſily by the acidulum of tartar: but this metallic glaſs may happen to be more or leſs oxidated; and according as it is more or leſs oxidated, it will be more or leſs emetic. However, a tranſparent vitreous oxide of antimony, levigated and boiled in water with an equal quantity of tartareous acidulum, till the latter be completely ſaturated, then filtrated and evaporated by a moderate heat; affords by reſt and cooling, cryſtals of antimoniated tartarite; the effects of which, as emetics, may be ſafely depended upon. Decant the liquor, evaporate it, and you obtain by ſucceſſive evaporation a new quantity of cryſtals. The mother-water contains ſulphur and tartarite of potaſh, with a certain quantity of antimoniated alkaline ſulphure. When the mixture of tartareous acidulum, vitreous oxide of antimony, and water, which were boiled for the preparation of antimoniated tartarite, is filtrated, there remains on the filtre a ſeemingly gelatinous, yellow, or brown matter, of which Rouelle has taken notice. According to M. Prouſt, this jelly, when diſtilled, affords a very inflammable pyrophorus.

Macquer has propoſed the uſe of white oxide, precipitated from muriate of antimony by water, inſtead of the vitreous

vitreous oxide of antimony. That oxide is a violent emetic, and Macquer thought it conſtant in its effects. Bergman has adopted Macquer's opinion; and in the laboratory of the Academy of Dijon, tartarite of antimony has been ſince prepared, according to the method of that chemiſt and M. de Laſſone. This preparation has been very ſucceſsfully employed: the requiſite doſe is three grains; and this quantity does not affect the ſtomach or the inteſtines too violently.

Tartarite of antimony cryſtallizes in trihædral pyramids. It is very tranſparent; it is decompoſed, and rendered carbonaceous by fire; in the air, it effloreſces, takes a dead white colour, and becomes farinaceous. It diſſolves in ſixty parts of cold water, and in a much ſmaller proportion of boiling water; it cryſtallizes by cooling; alkalis and lime decompoſe it. Calcareous and pure water, in large proportions, are capable of decompoſing it; and it ſhould therefore be adminiſtered only in diſtilled water. Alkaline ſulphures, and ſulphurated hydrogenous gas, produce in its ſolution a precipitate of a red powder, which is a kind of ſulphurated oxide of antimony; and may be employed to aſcertain the preſence of this ſalt in any liquor with which it may happen to be mixed. Iron ſeizes the tartareous acid, and ſeparates the oxide of antimony: ſtibiated tartar, therefore, ſhould not be prepared in iron veſſels. M. Durande, a phyſician and profeſſor at Dijon, has propoſed, that this medicine ſhould be publicly prepared by one uniform proceſs, in the ſame manner as theriaca. Such a method could not but be very advantageous; the phyſicians might then all depend on the effects of this medicine. It appears that tartarite of antimony contains that portion of tartarite

tartarite of potaſh which entered into the compoſition of the tartareous acidulum; and is therefore a ſort of triple ſalt. The tartareous acid may be combined with mercury in two ways. The one, which is mentioned by M. Monnet, conſiſts in diſſolving in boiling water ſix parts of the tartareous acidulum with one part of oxide of mercury, precipitated from the nitric acid by carbonate of potaſh. This liquor, by filtration and evaporation, afforded him cryſtals, which were decompoſed by pure water. The ſecond method of combining mercury with the tartareous acidulum, is, by pouring a nitric ſolution of the metal into a ſolution of tartarite of potaſh or ſoda; a precipitate is thus obtained, which conſiſts of mercurial tartarite; and the nitrate of potaſh or ſoda remains diſſolved in the liquor.

The tartareous acidulum acts in a ſenſible manner upon oxide of lead. Rouelle the younger obſerved, that the tartarite of lead formed in this operation, does not remain diſſolved in the liquor; and that the liquor, when evaporated, affords only pure tartarite of potaſh, which exiſted, ready formed, in the tartareous acidulum. This is one of the proceſſes which he employed to aſcertain the preſence of potaſh in tartar.

Copper and its oxides are eaſily acted upon by the tartareous acidulum: the reſult is a beautiful green ſalt, ſuſceptible of cryſtallization; but it has not hitherto been carefully examined.

Iron is one of thoſe metals on which the tartareous acidulum acts with the greateſt efficacy. A medicine, called *chalybeate tartar*, is prepared by boiling four ounces of levigated iron filings with a pound of white tartar, in twelve pounds of water. When the tartar is diſſolved, the liquor is filtrated: it depoſites cryſtals;

ſtals; and theſe may be repeatedly obtained by evaporating the mother-water. To prepare *tartarized tincture of Mars;* make a paſte of ſix ounces of iron filings, a pound of white tartar in powder, and a ſufficient quantity of water: let this mixture ſtand undiſturbed for twenty-four hours; next, dilute it in twelve pounds of water, and boil the whole for two hours, adding water to ſupply the room of that which is evaporated; decant off the liquor, filtrate it, and concentrate it to the conſiſtency of a ſyrup, adding an ounce of alcohol. Rouelle obſerved, that the potaſh exiſts at liberty in this tincture; and that, by treating it with acids, neutral ſalts are obtained; which demonſtrate beyond a doubt the preſence of the alkali. There are two other medicines formed by the combination of the tartareous acid with iron; one of theſe is *ſoluble martial tartar*, which is a mixture conſiſting of a pound of *tartarized tincture of Mars*, with four ounces of tartarite of potáſh, evaporated to dryneſs. The other is known by the name of *balls of Mars*. Theſe are prepared by putting one part of filings of ſteel with two parts of white tartar in powder, into a glaſs veſſel, with a certain quantity of brandy: when the liquor is evaporated, pulverize the maſs, and add more brandy, which evaporate again as before; repeat this proceſs till the mixture become greaſy and tenacious; then make it up into balls.

Crude tartar is of great uſe in dyeing; hat-makers likewiſe make uſe of it.

The ſeveral preparations of the tartareous acidulum, which we have here enumerated, are chiefly employed in medicine. The pure tartareous acidulum is thought to be refreſhing and antiſeptic; in doſes of half an ounce, or an ounce, it acts as a gentle purge and puke.

puke. Tartarite both of potaſh and ſoda, is frequently taken in doſes of a few drams, to aſſiſt the action of other purgative medicines. Tartarite of antimony is one of the moſt uſeful and moſt powerful medicines which chemiſtry affords. This ſalt is emetic, purgative, diuretic, diaphoretic, or diſcuſſive, according to the dozes and the circumſtances in which it is adminiſtered. It often produces even all theſe effects at once. It may be conſidered as a powerful alterative, happily qualified to remove obſtructions in the viſcera, when adminiſtered in ſmall and repeated doſes. It is given as a vomit in doſes of from one to four grains, diſſolved in a few glaſſes of water. A grain of it is ſometimes mixed with other medicines to aſſiſt their action: laſtly, it acts as an alterative when taken, half a grain at a time, diluted in a large proportion of water. M. de Laſſone has diſcovered, that tartarite of antimony is rendered very ſoluble in water, by mixing with it ammoniacal muriate; and that there reſults from this mixture a ſalt of a nature ſimilar to that of ammoniaco-mercurial muriate. This new triple ſalt cannot but produce very powerful effects on the animal œconomy. *Chalybeated tartar*, *ſoluble martial tartar*, and the *tartarized tincture of Mars*, are employed as tonics and aperitives.

Such are the properties of the native tartareous acidulum, or of the tartareous acid, combined by nature with a certain quantity of potaſh. It was requiſite to examine it with care, as it is ſo very uſeful, and ſo very much employed. But this is not the pure tartareous acid; and it is of no leſs importance to know the characteriſtic properties of that ſubſtance. M. Retzius has publiſhed, in the Memoirs of Stockholm for the year 1770, a proceſs invented by Scheele for extracting and purifying

purifying this acid. Into a ſolution of two pounds of the tartareous acidulum, in boiling water, put waſhed chalk, till ſuch time as it ceaſe to produce effervescence, and there be no longer any of the acid in a ſtate of liberty: the quantity requiſite is ſomewhat more than a fourth part of the weight of the acidulum: take out the precipitate of calcareous tartarite which is now formed, place it on a filtre, and waſh it with cold water; there are uſually thirty-two or thirty-three ounces of it, on account of its containing water. The liquor decanted from above the precipitate, affords by evaporation a quantity of tartarite of potaſh, which has not been decompoſed, equal nearly to half the acidulum employed. Pour upon the calcareous tartarite, in powder, nine and a half ounces of concentrated ſulphuric acid, diluted in five pounds five ounces of water; leave this mixture to digeſt for twelve hours, ſtirring it from time to time. Decant the liquor from above the ſulphate of lime; evaporate it, after aſcertaining that it contains no ſulphuric acid. In order to that, pour into it a few drops of acetite of lead, or ſalt of Saturn: if the precipitate thus produced be ſoluble in vinegar, the lixivium may be inferred to contain no ſulphuric acid; but if the precipitate cannot be diſſolved in that fermented acid, the lixivium ſtill contains ſulphuric acid; which may be ſeparated by digeſting it on a certain quantity of calcareous tartarite. Lime may be uſed inſtead of chalk, in the proceſs for obtaining the tartareous acid: But as that alkaline earth decompoſes the tartarite of potaſh contained in the tartareous acidulum, the lixivium, when lime is uſed, contains only alkali inſtead of tartarite of potaſh, as in the former proceſs. The uſe of quicklime in this decompoſition affords more of the acid, becauſe

cauſe lime decompoſes twice its weight of tartareous acidulum.

The pure tartareous acidulum obtained in a liquid ſtate by either of theſe proceſſes, muſt be evaporated to dryneſs; then diſſolved again, and cryſtallized either by ſlow evaporation, according to M. Pæcken; or by cooling the evaporated liquor to the conſiſtency of a clear ſyrup, according to Bergman. It is obtained in the form of ſmall ſharp pointed needles, or minute priſms; the form of which it is ſcarce poſſible to determine. Bergman deſcribes them as divergent leaves; M. Retzius compares them to hairs intwined together: They are at firſt very white; thoſe obtained towards the end of the operation are yellow.

The cryſtallized tartareous acid melts, fumes, becomes black, and even takes fire, when brought into contact with burning bodies. When diſtilled, it affords, like the tartareous acidulum, only an acid phlegm, a little oil, and a good deal of gazeous carbonic acid mixed with carbonated hydrogenous gas. The coal which remains contains neither acid nor alkali: which proves that no alkali is formed in conſequence of the decompoſition of the tartareous acid by fire: this acid, however pure, is always oily. For this reaſon it is called the *tartareous acid*, and its ſalts *tartarites*.

It is not liable to alteration in the air: It is much more ſoluble than the tartareous acidulum: Its taſte is very pungent: It reddens the tincture of violets, as well as that of turnſole. It diſſolves aluminous earth, and forms with it an aluminous tartarite, which takes only a gummy or mucilaginous conſiſtency by evaporation.

In combination with magneſia, the pure tartareous acid forms a ſalt; which alſo, inſtead of cryſtallizing, gives a ſort of gelatinous matter.

By combination with lime, it affords an almoſt inſoluble ſalt.

A little potaſh poured into this ſolution, precipitates the tartareous acidulum, or *cream of tartar*, in cryſtals. This diſcovery, made by Scheele and Bergman, throws more light than any other facts known, on the nature of this vegetable ſalt. No farther proofs are requiſite, as M. de Morveau ſays, to determine the principles of which the tartareous acidulum conſiſts: we know it to conſiſt of tartarite of potaſh with exceſs of acid; but, what is very ſingular, this acid, naturally very ſoluble, ſuddenly loſes that property when about half ſaturated with potaſh; which, however, is very ſoluble by itſelf. This fine experiment alſo proves, that the tartareous acid is not in any manner altered by Scheele's proceſs; for with about one-fourth or one-third of its own weight of potaſh, it forms an acidulous ſalt, ſimilar in nature to the acidulum from which it was obtained. With a greater proportion of potaſh, it forms a neutral ſalt, completely ſaturated and ſoluble, which is tartarite of potaſh, or *vegetable ſalt.*

The tartareous acid with ſoda forms a cryſtallizable neutral ſalt, or tartarite of ſoda (*ſalt of Seignette*), which is very pure. With ammoniac it affords a cryſtallizable ammoniacal tartarite. M. Retzius informs us, that the tartareous acid, when combined with a quantity of ammoniac conſiderably leſs than what is required to ſaturate it, forms a ſcarce ſoluble ammoniacal tartareous acidulum, which cryſtallizes like the common cream of tartar, or tartareous acidulum of potaſh.

Although the tartareous have not ſo ſtrong an affinity

nity with the alkalis as the mineral acids; yet theſe latter ſalts, when they decompoſe tartarite of potaſh or ſoda, do not completely ſeparate the baſe, but diſengage the tartareous acid into the ſtate of acidulum, of potaſh, or of ſoda The pure tartareous acid does itſelf partly decompoſe ſulphate, nitrate, and muriate of potaſh, and ſeparates ſo much of the alkali as is requiſite to bring it into the ſtate of tartareous acidulum, or acidulated tartarite of potaſh. It does not produce the ſame effect on nitrate and muriate of potaſh.

M. Hermſtadt aſſerts, that the tartareous becomes oxalic acid by means of the nitrous acid. Bergman could not effect this change; but he failed probably on account of employing too little of the nitrous acid. As the nitrous acid gives out nitrous gas, when it accompliſhes the tranſmutation of the tartareous acid; the only difference between the tartareous and oxalic acids would appear to be, that the latter contains a greater quantity of oxigene.

The tartareous acid is incapable of acting on ſilver, gold, or platina; it diſſolves their oxides. Its action on copper, lead, and tin, is imperceptible; it diſſolves the oxides of theſe metals, and deſtroys the red colour of oxide of lead.

It diſſolves iron with a very gentle efferveſcence.

It produces no alteration on antimony in a metallic ſtate, but acts with ſufficient force to diſſolve its oxides.

It ſeparates lime from the nitric, the muriatic, the acetous, the formic, and the phoſphoric, acids.

It precipitates the nitric ſolution of mercury, the muriatic ſolution of lead, &c.

Its attractions are repreſented by Bergman in the following order: lime, barytes, magneſia, potaſh, ſoda, ammoniac, aluminous earth; oxide of zinc, iron, mangaueſe, cobalt, nickel, lead, tin, copper, biſmuth, antimony, arſenic, ſilver, mercury, gold, platina, water, and alcohol.

§ II. *Of the Oxalic Acidulum, or Salt of Sorrel, that is ſold in commerce, and of the pure Oxalic Acid.*

THE ſalt of ſorrel ſold in the ſhops, or the oxalic acidulum, is extracted in great quantities at Hartz, in Thuringia and Swabia, from the juice of ſorrel, called by Linnæus *oxalis acetoſella*. An hundred pounds of this plant, cut down in a ſtate of vigorous vegetation, afford, according to M. Savary, fifty pounds of expreſſed juice; which fifty pounds of juice afford only five ounces of concrete ſalt by evaporation and cryſtallization. The ſalt of ſorrel that comes from Switzerland, is diſtinguiſhed in commerce as the moſt beautiful and the whiteſt: that from Forets in Thuringia is dirty and yellowiſh.

The juice of ſorrel has been long known to afford a neutral ſalt by evaporation. Duclos mentions it in the Memoirs of the Academy for 1668; Juncker likewiſe ſpeaks of it. Boerhaave, who compares this ſalt to tartar, has given a very accurate deſcription of the proceſs for obtaining it. M. Margraaf diſcovered, that potaſh entered into the oxalic, as well as into the tartareous acidulum. But the nature of this ſalt was by no means exactly known, till the experiments of

Meſſrs Savary, Wenzel, Wiegleb, Scheele, and Bergman, were communicated to the world.

The oxalic acidulum exiſts in ſmall white cryſtals, opaque, and needled or lamellated. Their form has not been yet fully aſcertained; although Capeller and Ledermuller have deſcribed them as they appeared through the microſcope. M. de Liſle repreſents them as very oblong parallelopipeds. They conſiſt of collections of long thin leaves, joining at one end, but ſeparate at the other. The taſte of this ſalt is ſour, poignant, and at the ſame time bitter. It communicates a deep red colour to tincture of turnſole and blue paper. Four hundred and eighty grains of this acidulum, diſtilled in a retort by a fire, the heat of which was properly regulated, afforded M Wiegleb one hundred and fifty grains of phlegm ſtrongly acid, without either ſmell or colour. There remained one hundred and ſixty grains of grey ſalt, from which one hundred and fifty-ſix grains of vegetable alkali were obtained. About four grains of concrete acid ſalt were likewiſe ſublimed into the neck of the retort: not a drop of oil paſſed. In this proceſs of diſtillation there were one hundred and ſixty-ſix grains of loſs. But as M. Wiegleb does not mention what elaſtic fluids were diſengaged in this analyſis, the loſs was probably owing to the diſengagement of water in vapours, and of carbonic acid gas mixed with a little hydrogenous gas and carbonaceous matter. By comparing this analyſis with that of the tartareous acid, we perceive the oxalic acidulum to be leſs oily than the other. The liquid acid, therefore, obtained by this diſtillation, is pure oxalic acid; whereas the tartareous acidulum, when treated with fire, affords an altered acid, different in nature from the tartareous acid, which we call the *pyro-tartareous*

tareous acid. It is becauſe the acid of ſorrel contains ſo little oil, that we call it the *oxalic acidulum* and *acid;* while to the more oily acid of tartar, the rules of our methodical nomenclature require us to give the name of the *tartareous acid.*

The oxalic acidulum, when pure, ſuffers no alteration by expoſure to air; it is more ſoluble than the tartareous acidulum. According to M. Wiegleb, a drachm of oxalic acidulum from Switzerland requires to diſſolve it only ſix drachms of boiling water; but though other ſix drachms of boiling water be added, it is entirely precipitated by cooling. According to M. Wenzel, it is even much more ſoluble than M. Wiegleb repreſents it; for he found, by experiment, nine hundred and ſixty parts of boiling water to take up ſix hundred and ſeventy-five parts of this ſalt: but its ſolubility varies, according as it is more or leſs acid; which again depends on the quality of the plant from which it is extracted.

The oxalic acidulum combines with barytes, magneſia, ſoda, ammoniac, with which it forms triple ſalt (or *triſules.*) Lime decompoſes, by detaching its acid, both that part which is in a ſtate of liberty, and that which is in combination with the potaſh. One hundred grains of chalk decompoſe one hundred and thirty-ſeven grains of the oxalic acidulum. The precipitate of calcareous oxalate that is depoſited, weighs one hundred and ſeventy-five grains; the ſupernatant liquor affords by evaporation thirty-two grains of carbonate of potaſh. This proceſs cannot be uſed in preparing the pure oxalic acid, though the tartareous acid be obtained pure by it: for calcareous oxalate is not decompoſable by ſulphuric acid, like calcareous tartarite: on the contrary, the oxalic acid has ſo ſtrong an affinity with lime, that it attracts this earth from all other acids; and one certain teſt of the purity of the oxalic acidulum, or ſalt of ſorrel, is, to pour a ſolution of it into water impregnated with calcareous ſulphate: when the acidulum has been really extracted from ſorrel, it produces in the water a copious precipitate.

The ſulphuric acid contributes to the diſengagement of the oxalic acid from the acidulum by means of heat, according to M. Wiegleb. The nitric acid decompoſes the acidulum, and ſeparates the alkali; but it has much more difficulty to accompliſh this on the oxalic than on the tartareous acidulum, according to Margraaff's experiments.

The oxalic acidulum acts upon iron, zinc, tin, antimony, and lead. It diſſolves the oxides of all the other metals, forming with them triple cryſtallizable ſalts, which are not deliqueſcent, and in which the potaſh always remains in union with the acid; it precipitates the nitric ſolutions of mercury and ſilver. M. Bayen, by evaporating the ſupernatant liquor from above theſe precipitates, obtained nitrate of potaſh, and thus eſtabliſhed more certainly the exiſtence of alkali in this acidulum.

To prepare the oxalic acid by ſeparating the potaſh of the acidulum, diſtillation, as we have already ſeen, may be employed: but this proceſs affords only a ſmall quantity; and that which Scheele has recommended, being eaſier performed, and more certain in its reſults, is therefore preferable. Saturate the oxalic acid with ammoniac; pour into this triple ſolution, conſiſting of oxalic acid, with ammoniac and potaſh, a quantity of barytic nitrate. A precipitate of barytic oxalate is thus produced, and the nitric acid retains the potaſh and

and ammoniac; After waſhing the barytic oxalate, decompoſe it with ſulphuric acid. The ſulphate of barytes that is now formed, remains inſoluble at the bottom of the liquor. Decant off the liquor; ſeparate the portion of ſulphuric acid which may ſtill be contained in it by barytic oxalate, diſſolved in boiling water; and when it ceaſes to afford a precipitate, the liquid may be conſidered as containing pure oxalic acid, and decanted off from above the precipitate. It is next to be evaporated with proper care; and it now affords the ſalt, by cooling, in quadrilateral priſms, with their ſides alternately broad and narrow, and terminating in dihædral ſummits. Theſe cryſtals are often in the form of ſquare or rhomboidal plates.

This concrete acid has a very ſtrong ſour taſte; ſeven grains communicate a ſenſible acidity to two pounds of water. It reddens all blue vegetable colours. A grain of this ſalt communicates to 3600 grains of water the property of reddening paper tinctured with turnſole.

The concrete oxalic acid, when expoſed to a moderate fire, becomes dry, and is covered over with a thick cruſt; it is in a ſhort time reduced to powder, and loſes .3 of its weight. When diſtilled in a retort, by a ſtronger fire, which muſt not, however, be violent, it liquefies, becomes brown with ebullition, affords an acidulated phlegm, and is partly ſublimated, without alteration. There is at the ſame time diſengaged from it a gas mixed with carbonic acid, and hydrogenous gas. When expoſed to a violent heat, it affords more gas, leſs ſublimated concrete acid, and more acidulated phlegm, that is not liable to cryſtallization; at the bottom of the retort there remains only a grey or brown

brown maſs, amounting to one-fiftieth part of the acid employed. When put upon a coal burning in the air, it emits a very acrid white ſmoke, which irritates the lungs in a very lively manner: the reſidue which it leaves is white, without any mixture of carbonaceous matter. Such is the reſult of the decompoſition of the oxalic acid by fire that was obſerved by Bergman. The Abbé Fontana has obtained near double the quantity of gas; but that, as we have already ſhown, depends on his having applied a ſtronger heat, with a view to effect a thorough decompoſition of the acid.

When expoſed to moiſt air, the concrete oxalic acid remains deliquieſcent, but in hot air it rather becomes dry. Cold water diſſolves a quantity of it equal to one-half of its own weight. When cryſtals of this acid are caſt into cold water, a faint noiſe is heard, which muſt be produced by a ſudden breaking of their particles. The ſpecific gravity of this cold ſolution is 1.0593, according to M. de Morveau. No acid vapour riſes with the water of the ſolution when evaporated, not even by ebullition. Boiling water diſſolves a quantity of this concrete acid ſalt equal to itſelf in weight: One half is precipitated in cryſtals by cooling.

The oxalic acid diſſolves aluminous earth. This ſolution affords, by evaporation, a yellowiſh maſs, tranſparent, ſoft, and aſtringent; which attracts moiſture from the atmoſphere, and reddens turnſole. This ſalt ſwells in the fire: it then loſes its acid, and the aluminous earth remains a little coloured. It is decompoſable by mineral acids.

In combination with barytes, it forms a ſcarce ſoluble ſalt; which, with an exceſs of the acid, affords angular cryſtals. Hot water, by depriving them of that

that exceſs, renders them opaque, pulverulent, and inſoluble.

With magneſia, it affords a white ſalt in powder, which is decompoſable by the fluoric acid and barytes.

The oxalic acid, ſaturated with lime, forms a ſalt inſoluble in water, pulverulent, and not decompoſable by fire; for ſo ſtrong is the affinity between this acid and lime, that it detaches this baſe from every other acid. On account of this property Bergman has propoſed the uſe of the oxalic acid for aſcertaining the preſence and the proportion of lime in mineral waters, or in any combination with other acids. Calcareous oxalate gives a green tinge to ſyrup of violets.

The oxalic acid combines with potaſh; and the neutral ſalt, with an exceſs of either of the two principles, is ſuſceptible of cryſtallization. Oxalate of potaſh is very ſoluble in water, and decompoſable by the action of fire and of mineral acids. Pure oxalate acid, added in drops to a ſolution of this ſalt, ſoon produces a precipitate, which appears to be oxalic acidulum, the ſame as the common *ſalt of ſorrel.*

With two-thirds of ſoda the oxalic acid forms a ſalt which is ſcarce ſoluble, but diſſolves beſt in hot water, and turns ſyrup of violets green. An exceſs of the acid forms acidulous oxalate of ſoda, which is ſcarce ſoluble.

With ammoniac, the oxalic acid affords ammoniacal oxalate, which cryſtallizes, by ſlow evaporation, into quadrilateral priſms. By fire this ſalt is decompoſed; and then it yields ammoniacal carbonate, formed by the deſtruction of the oxalic acidulum. An exceſs of the acid poured into a ſolution of this ſalt, precipitates from

from it an ammoniacal oxalic acidulum, in cryſtals much leſs ſoluble in water than the pure neutral ſalt.

The oxalic acid is ſoluble in mineral acids. It imbrowns the concentrated ſulphuric acid; it is decompoſed by the nitrous acid, and reduced into carbonic acid in conſequence of the decompoſition. This acid generally combines much eaſier with metallic oxides than with the metals themſelves.

1. With oxide of arſenic, it forms priſmatic cryſtals, very fuſible, very volatile, and decompoſable by heat.

2. With oxide of cobalt, a pulveriſed ſalt, of a bright roſe colour, and ſcarce ſoluble.

3. With oxide of biſmuth, a white ſalt in powder, very little ſoluble in water.

4. With oxide of antimony, a ſalt in cryſtalline grains.

5. With oxide of nickel, a ſalt, of a white or greeniſh yellow colour, and ſcarce ſoluble.

6. With oxide of manganeſe, a ſalt in a white powder, which becomes black in the fire.

7. With zinc, the ſolution of which is attended with effervеſcence, a pulverulent white ſalt.

8. It diſſolves oxide of mercury, and reduces it to a white powder, which is rendered black by the contact of light. This acid decompoſes mercurial ſulphate and mercurial nitrate.

9. Tin, by its action, is firſt rendered black, and afterwards covered with a white powder. The ſalt which it forms with this metal is of an harſh taſte. It cryſtallizes into priſms by evaporation judiciouſly conducted; when evaporated by an intenſe heat, it leaves a tranſparent maſs, reſembling horn.

10. It tarniſhes lead, but diſſolves its oxide better. The

The ſaturated liquor depoſites ſmall cryſtals, which may alſo be obtained by pouring oxalic acid into a ſolution of nitrate or muriate of lead, or into acetite of the ſame metal.

11. It acts on iron filings; and as there is water decompoſed in this ſolution, there is, of conſequence, hydrogenous gas diſengaged. Oxalate of iron is ſtiptic: it affords greeniſh-yellow priſmatic cryſtals, decompoſable by heat.

Yellowiſh oxide of iron, in combination with this acid, affords a yellow ſalt, ſimilar to that which is obtained by pouring liquid oxalic acid into a ſolution of ſulphate of iron.

12. It acts on copper, and entirely diſſolves the oxides of this metal. The ſalt thus formed is of a clear blue colour, and ſcarce ſoluble. This ſalt may be likewiſe obtained by precipitating ſulphuric, nitric, muriatic, and acetous ſolutions of copper with oxalic acid.

13. Oxide of ſilver precipitated by potaſh, diſſolves in a ſmall proportion in this acid. The beſt way of obtaining this ſalt is by precipitating the nitric ſolution of ſilver with oxalic acid: a white ſediment is produced, ſcarce ſoluble in water, and liable to become brown by the contact of light.

14. This acid ſcarce acts on oxide of gold.

15. Laſtly, it diſſolves the precipitate of platina produced with ſoda. This ſolution is ſomewhat yellow, and affords cryſtals of the ſame colour.

Such are the phænomena of the combinations of the oxalic acid, as deſcribed by Bergman.

That celebrated chemiſt accompliſhed all theſe combinations with artificial oxalic acid, prepared from ſugar and nitric acid. Sugar, as well as all mucilages, ex-

extracts, ſweet oils, and farina, affords, when treated with nitrous acid, an acid perfectly the ſame with pure oxalic acid, as has been aſcertained by Scheele. All theſe matters, and even a great many animal ſubſtances, as has been diſcovered by M. Berthollet, contain therefore the radical principle of the oxalic acid, wanting nothing but oxigene to complete the acid.

Bergman was the firſt who diſcovered that ſugar, treated with nitrous acid, formed a peculiar acid: he gave it the name of the *acid of ſugar*, or *ſaccharine acid;* which it retained for ſeveral years, till Scheele ſhowed it to be preciſely of the ſame nature with the oxalic acid, extracted from *ſalt or ſorrel* by the proceſs above deſcribed. He ſhowed the identity of theſe acids, by forming the ſcarce ſoluble oxalic acidulum, or *ſalt of ſorrel*, from a combination of a ſmall quantity of ſoda with the ſaccharine acid. Here then is a vegetable acid which exiſts in an acid ſtate in but few vegetable matters, but of which the baſe is exceedingly copious in thoſe matters, and appears to paſs unaltered into animal bodies. In the following chapters, we ſhall ſee that this acid is probably, like all other vegetable acids, a compound of hydrogene, carbone, and oxigene; and that the only difference between it and the other vegetable acids is in the proportions of their principles.

The baſe or radical principle of the oxalic acid appears to exiſt in greater plenty in inſipid matters than in ſugar; though it was once believed, that ſaccharine bodies afforded moſt of it. From ſugar, Bergman obtained only a third part of its weight of oxalic acid: and from wool M. Berthollet has obtained a quantity equal to more than half the weight of the wool.

The

The pure oxalic acid is uſed no where but in the laboratory; the chief uſe to which it is there applied, is to aſcertain the preſence of lime. The oxalic acidulum, or ſalt of ſorrel, is uſed to efface ſtains of ink from white ſtuffs, wood, ivory, &c. on account of its having ſo ſtrong an affinity with iron; but the pure oxalic acid being more ſoluble, might be more advantageouſly uſed for ſuch purpoſes.

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