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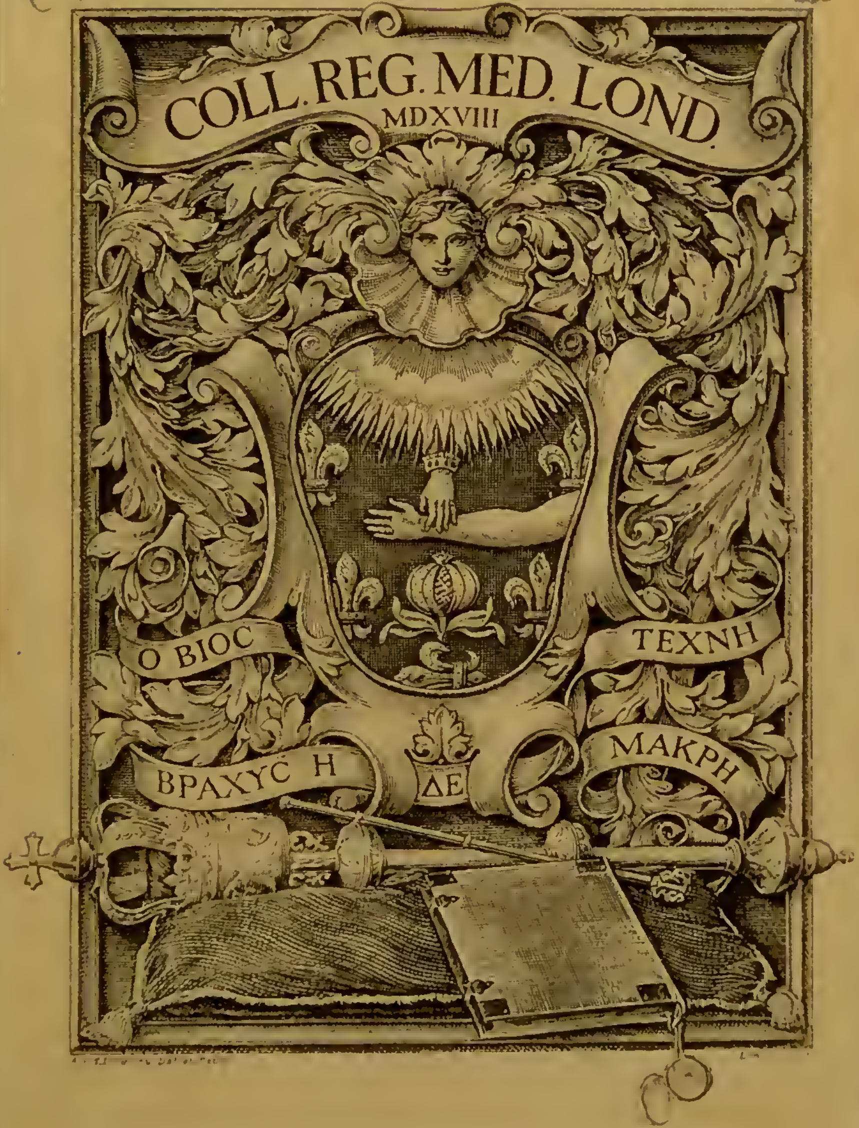

THE

CHEMICAL ESSAYS

OF

CHARLES-WILLIAM SCHEELE.

TRANSLATED FROM THE

TRANSACTIONS

OF THE

ACADEMY OF SCIENCES AT STOCKHOLM.

WITH ADDITIONS.

LONDON.

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M,DCC,LXXXVI.

TO

CHARLES-WILLIAM SCHEELE,

APOTHECARY AT KÖPING

EDEN,

TTEMPT

O

EXTEND THE KNOWLEDGE

OF HIS DISCOVERIES

IS RESPECTFULLY INSCRIBED.

PREFACE.

I Happened to be converfing, a few months ago, with a foreign gentleman of diftinguifhed knowledge and abilities, on a circumftance which is obferved by every foreigner, who is capable of making obfervations, and of which every native, whofe information extends beyond the productions of his own country and one or two among the fwarm of Parifian journals, muft be fufficiently fenfible: I mean, on the very flow and imperfect manner in which the improvements of literature and fcience, that are made in feveral countries abroad, become generally known in England; and to the accidental occurrence of this fubject, the prefent publica-

 tion

tion entirely owes its riſe. The train of ſuch a converſation would naturally lead us to recollect many names, among the philoſophers of Germany and Sweden in particular, of whom it may be ſaid, almoſt in the ſtrict acceptation of the terms,

Ἡμεῖς δὲ κλέος οἶον ἀκούομεν, οὐδέ τι ἴδμεν·

with whoſe contributions to the ſum of human knowledge, the Authors and Profeſſors of Britain, how confident ſoever of their own ſuperiority, might find it no diſadvantage to be better acquainted than they in general appear to be.

In a review of this kind, it was impoſſible to leave, unnoticed, the merits of that original genius, whoſe eſſays are collected into this volume, and concerning whom it was well obſerved to me by a near relation of Bergmann, *that the greateſt of* BERGMANN's *diſcoveries was the diſcovery of* SCHEELE. It was not long before I learned, during a continuance of our converſation, that my friend had, lying among his papers, moſt of the following eſſays, which he had been induced to tranſlate,

at

at different periods, in confequence of the folicitations of different perfons, who were eager to obtain fuller information concerning them than could be had from any Englifh book. I was no fooner apprifed of this treafure, than I became defirous of laying it open to public accefs; and accordingly offered, when he hefitated, becaufe the tranflation was, for the moft part, written when his acquaintance with our language was very imperfect, and muft therefore be altogether unfit for the prefs, to revife and correct it as well as circumftances would permit. And in performing this tafk of minute diligence, I have not contented myfelf with a bare perufal of the manufcript, but have almoft conftantly compared it with two German tranflations, one by Profeffor KAESTNER of Gottingen, which is by no means free from inaccuracies and miftakes, and the other by Dr CRELL or fome of his coadjutors, which, though for the fake of brevity, fome parts of different papers are omitted, and others abridged, I have found very exactly to

 convey

convey the author's ſenſe. Hence, although the moſt careleſs reader of the following pages will undoubtedly be offended with many harſh conſtructions, and many phraſes of foreign growth, yet I hope with ſome confidence, that few obſcure paſſages will occur, and ſtill fewer in which the meaning of the original has been miſrepreſented. The aids which I have juſt mentioned, have enabled me to exhibit a faithful tranſlation; but in order to have ſtood any chance for attaining correctneſs of language, I muſt have tranſcribed the whole manuſcript, a labour to which I would never have ſubmitted, even if the various engagements which occupied my time had not rendered it impoſſible.

I have juſt alluded to the Swediſh eſſays, as the original; but the truth is, as I have been credibly informed, and it is a curious circumſtance, that Mr Scheele tranſmits his communications to the Stockholm Academy of Sciences, not in Swediſh, but in German, his native language,

guage, from which they are tranſlated by ſome Member, in order to be inſerted in the Tranſactions. This may perhaps account for the obſcurity of one or two paſſages of no great moment, which I am obliged to leave as I found them, not being able to clear them up by the help either of the German or the French tranſlation, as it occurs in the *Journal de Phyſique*. Theſe paſſages, which are, I think, not above two in number, I intended to point out to the reader; but I neglected to note them, and cannot now diſcover them.

I have, moreover, made ſome additions, ſuch as the papers of Mr Wiegleb and Mr Meyer, together with thoſe both of the author and of Dr Crell, which occur at the end of the volume, and are chiefly taken from the moſt excellent of modern journals. Other ſources, too, would perhaps have afforded other additions to the author's diſcoveries and corrections of his opinions; but having ſo lately annexed to BERGMANN'S DISSERTATION ON E-

LECTIVE

lective Attractions, much of what it would have been proper to obſerve concerning Mr Scheele's experiments and deductions, as far as I am acquainted with it, I chuſe rather to refer to that publication, than repeat the ſame things in the preſent. I know not whether it can now be neceſſary to put any reader on his guard againſt the notions concerning the compoſition of heat which run through moſt of the eſſays, and are employed to explain the phænomena of phlogiſtic proceſſes, as they have been denominated—phænomena, perpetually recurring in the operations of chemiſtry. Yet erroneous as this theory certainly is, it required for its formation no common talents; it is among the moſt ſtriking proofs of a genius for diſcovery, and implies nothing leſs than accuracy of obſervation, and equal ſagacity and boldneſs in deducing concluſions. The neceſſity of ſome body, which ſhould ſupply both pure air and phlogiſton, had never been ſo clearly ſtated, nor had this principle been applied in a ſyſtematical manner.

manner, to account for the appearances. The reader needs only to ſubſtitute WATER for HEAT, and all will be conformable to the moſt accurate experiments with which we are even yet acquainted. Had the author but fortunately fixed upon another element, as it was ſuppoſed to be, his view of chemiſtry would perhaps have been as juſt as it was extenſive. But what analogy led to this? and who, without the moſt direct experiments, would have allowed himſelf to imagine, that water was more nearly allied to phlogiſton than heat? I know indeed, that this great diſcovery, confirmed as it has been by ſeveral philoſophers*, countenanced by all the phænomena which appear in the leaſt connected with it, and, with a fate very different from that of moſt of the great advances in ſcience, ſeeming at once likely to meet with univerſal reception, without cavil or contradiction, has been lately called in queſtion. But if the

* WATT, PRIESTLY, LAVOISIER, even Mr KIRWAN, while he maintains an hypotheſis ſeemingly quite inconſiſtent with it, ſeems to admit it.

the account of Mr Fontana's experiments, which has lately been given in a French Journal (*Journ. de Phyſ. Septembre* 1785) be not exceedingly defective, it is certain that they do not in the ſmalleſt degree tend to invalidate the concluſions of Mr Cavendiſh. They only ſhew, that Mr Lavoiſier has formed ſome opinions with too much precipitancy.

The printer's mark ſufficiently intimates the deſign of continuing this collection. At preſent, there are but few materials for a ſecond volume. The continuation of the experiments on Pruſſian blue, and a few other papers of very recent date, being, I believe, all that the author has publiſhed, except the contents of this volume, and the *Treatiſe on Air and Fire.* I can only therefore promiſe to gratify the impatience of the public as ſoon as poſſible, and ſhall be willing to publiſh the ſecond volume in three or four different parts, of which the firſt ſhall appear, as ſoon as the author himſelf ſhall have ſupplied materials for a few ſheets.

The

The eſſays of Mr Scheele have been lately publiſhed in France, with notes by Mr Morveau; but as I have not hitherto been able to procure that tranſlation, I could not borrow any aſſiſtance from it; but whatever it contains, more than the preſent, of uſeful or curious matter, ſhall be added in the ſecond volume.

THOMAS BEDDOES.

EDINBURGH, *Feb.* 12. 1786.

P. S. Having fortunately procured the ſecond part of the paper on Pruſſian blue ſince this preface went to the preſs, I have ſubjoined it at the end of the preſent volume, that the reader might not be left in a diſagreeable ſtate of ſuſpenſe by the half-finiſhed diſcuſſion of ſo intereſting a ſubject.

CON-

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ESSAY

CHEMICAL ESSAYS.

ESSAY I.

On Fluor Mineral, and its Acid. 1771.

§ I.

FLUOR mineral is a kind of ſtone, eſpecially remarkable on account of the beautiful phoſphoric light which it yields in a dark place, when it has been heated. But its conſtituent parts are as yet little known. In order to diſcover them, I made ſeveral experiments with this ſubſtance. I made uſe of two ſorts, one of a green colour, found at Garpenberg, and a white ſpecies from Giſlof in Scania.

§ II.

It is well known, that fluor mineral, after having been once thoroughly heated, loſes its power of becoming phoſphoric for ever after. In order to find out whether it thus loſes any of its conſtituent parts, I expoſed three ounces in a covered crucible to a ſtrong fire, ſo that it was thoroughly heated. It decrepitated, as ſoon as it grew red hot, with a loud noiſe, very like common ſalt. I took it out of the furnace, and found, after it was cooled, that it had loſt hardly any of its weight, and that it appeared in every reſpect like fluor mineral which had not been burnt, only that it, 1*ſt*, Neither ſhowed any ſigns of decrepitation nor phoſphoreſcence, on being heated anew; 2*dly*, That it was more friable than before; and 3*dly*, That the green ſort had become reddiſh, and the white had loſt its tranſparency.

§ III.

I put a piece of fluor heated to phoſphoreſcence, into cold water: It immediately loſt a great part of its light, retaining, however, ſome glimmering for very near an hour. The ſame thing happened when it was put into acids, inſtead of water; but the ſolution of fluor in acids, though made by boiling, ſhewed no kind of phoſphoreſcence. A piece of fluor, in its luminous ſtate, ſuſpended by means of a braſs wire in the vacuum of an air-pump, continued to emit light for about an hour, but it was faint during the laſt half hour.

§ IV.

§ IV.

The following experiments were made, in order to find whether the property of becoming phoſphoric could be reſtored to the fluor, after it had been once loſt.

Fluor mineral that had been thoroughly heated, was ſtratified with powder of charcoal in a crucible, which, after being well cloſed, was kept hot for two hours. It was then taken out of the fire, cooled and heated again, but no light appeared. Burnt fluor was expoſed to the ſunſhine for a whole day, and afterwards heated, with as little ſucceſs. I therefore conclude, that its phoſphoreſcence does not depend upon a ſubtile inflammable matter.

§ V. *Effects of Acids on Fluor.*

I poured two ounces of concentrated vitriolic acid upon the ſame quantity of fluor, which had been previouſly powdered in a glaſs mortar, and then put into a retort, to which a receiver was adapted, and the juncture well cloſed with gray blotting paper: A gentle fire was then applied; the maſs began immediately to efferveſce and ſwell; inviſible vapours penetrated every where through the joining of the veſſels; and, towards the end of the

the procefs, white vapours rofe, and formed a white matter on the whole internal furface of the receiver. The lute was fo much corroded as to be quite friable between the fingers, but its colour was unchanged. The mafs remaining in the retort was as hard as ftone, and could not be taken out without breaking the veffel.

§ VI.

The procefs (v.) was repeated exactly in the fame manner, excepting only, that a quantity of diftilled water was put into the receiver before the operation. When the mafs began to grow warm, and to fwell, a vapour rofe, which was condenfed upon the furface of the water in the receiver, and formed juft in the center of it, immediately under the mouth of the retort, a white round fpot: This fpot continually increafed, till it at laft occupied the whole furface of the water, forming a pretty thick cruft, which prevented the communication of the water with the new vapours that came over; I therefore gently agitated the receiver, upon which this cruft burft and fell to the bottom, and foon after a new cruft like the former was produced. At laft the receiver, and foon after likewife the retort, were become white in the infide. As foon as the vapours ceafed to rife with a gentle fire,

fire, the veſſels were permitted to cool. Their internal ſurface was found much corroded. The liquid in the receiver was a mixture of water, and of an acid, which the vitriolic acid had expelled from the fluor. The great quantity of white matter which had ſettled at the bottom during the proceſs, was ſeparated from it by filtration.

§ VII.

The maſs remaining in the retort was reduced to a fine powder, and edulcorated with diſtilled water, till no veſtige of acid appeared. This lixivium was filtered, and a little evaporated by boiling. In a few days time ſelenite was depoſited, with a little alum, weighing about two ſcruples. The lixivium was then evaporated anew, and its ſuperfluous acid ſaturated with vegetable alkali; but no more cryſtals were depoſited.

§ VIII.

The lixivium, thus inſpiſſated by evaporation, became blue on the addition of phlogiſticated alkali. In both proceſſes, (V. VI.) I uſed the green fluor. In order to know whether the ſolutions of every kind of fluor mineral ſhewed ſigns of iron, I made an experiment with the white ſpecies, previouſly calcined with concentrated vitriolic acid in a crucible; but no Pruſſian blue was obtained by means of the ſame phlogiſticated alkali; the green colour therefore is owing to iron.

§ IX.

The remaining reſiduum of the former diſtillation, after being perfectly edulcorated by means of diſtilled water, was boiled repeatedly with rain-water, until ſeven kannes of water were uſed, whereby every thing ſoluble in water was diſſolved, ſince nothing was precipitated from the laſt water employed, by adding alkali of tartar. The maſs now remaining was $\frac{1}{4}$ of the whole employed. It was reduced to fine powder, and calcined with acid of vitriol to dryneſs. In the beginning of this operation, a quantity of corroſive vapours were ſeparated from the maſs, which at the ſame time ſwelled conſiderably. After the veſſel was cooled, I reduced the maſs to a very fine powder, boiled it in pure water, and found it entirely diſſolved. On part of this ſolution I poured ſome cauſtic volatile alkali, which produced no precipitation; but, by means of alkali of tartar, true calcareous earth was precipitated. A kanne of the liquor, from which the precipitation was obtained, yielded upon evaporation vitriolated vegetable alkali. The alkali, at the ſame time,

time, decompoſed an earthy ſalt, (ſelenite,) which was diſſolved in the water. The remaining fourth part, not ſoluble in water, was powder of fluor undecompoſed.

§ X.

Fluor, therefore, conſiſts principally of calcareous earth, ſaturated with a peculiar acid; the nature of which we ſhall inveſtigate hereafter. Pure clay, or, as it is generally called, earth of alum and iron ſeem to be accidental ingredients. The following experiments will prove this ſynthetically.

I mixed diluted acid of fluor, obtained as in par. VI. with lime-water, upon which a white powder was immediately precipitated. When nothing more would precipitate, the water was found perfectly pure. The precipitate itſelf, though not of a cryſtalline form, proved however to be the ſame as fluor. It yielded phoſphoric light when put upon a red hot ſtone in the dark, melted by means of the blowpipe, and ſtill more readily by adding ſome gypſum. And when this fluor, thus artificially produced, was again decompoſed by means of vitriolic acid, it ſhewed itſelf to be the ſame as the native.

§ XI.

The white matter, which, during the

processes, (No. v. vi.) was deposited in the receivers, after being well edulcorated and dried, shewed the following properties: 1. It was rare, friable, and white. 2. It was not sensibly soluble in acids. 3. It did not make a tough paste with water, but was loose and incoherent after being dried. 4. It dissolved by boiling in lixivium tartari, and the solution on cooling assumed a gelatinous consistence. 5. In its pure state it suffered no change in the strongest heat; but, 6. When mixed with a little alkali of tartar, it frothed and boiled in a melting heat, and formed a glass. 7. This glass, with three parts of fixed alkali melted in the fire to a bluish mass, which, when powdered and put into a cellar, first deliquiated, and then became gelatinous. The acids precipitated a powder from it. 8. It dissolved in borax without any intumescence. These several properties shew it to be siliceous earth.

§ XII.

That this siliceous earth was formed during the processes themselves, appears from several experiments.

(A) I poured vitriolic acid upon powdered fluor in a cylinder of brass, which was closed by an exact cover, after having suspended over the mixture an iron nail and a bit of charcoal. Two hours afterwards I opened the

the veſſel, and found the nail and charcoal unchanged. I now moiſtened them, and ſuſpended them as before. The cover was put on again, and, being removed in two hours, I found the nail, as well as the coal, covered with a white powder, which had all the properties of ſiliceous earth. In this experiment I made no uſe of glaſs veſſels. The ſiliceous earth, therefore, obtained in the experiments (V. VI.) was not the earth of the glaſs diſſolved by the acid of fluor, and afterwards precipitated, as one might otherwiſe ſuſpect, from the internal ſurface of the glaſs being ſo much corroded.

(B) The artificial fluor (X.) was treated in the ſame manner, by means of vitriolic acid, as the native, (VI.) and diſtilled water was poured into the receiver for the condenſation of the acid. As ſoon as the fumes reached the ſurface of the water, a white cruſt of ſiliceous earth was formed. When no more acid came over, I filtered the liquor contained in the receiver, and found it to be fluor acid diluted with water. By means of lime-water, I obtained a precipitate, which, like the former, was an artificial fluor, and its acid was extricated by the vitriolic, with the ſame phænomena as in the former experiment. Upon repeating this experiment five times in the ſame manner, I conſtantly found the

the ſiliceous earth and the acid diminiſh conſiderably, ſo that, after the laſt eſſay, the water had hardly any mark of acidity.

Thence I conclude, that all the fluor acid united itſelf by degrees with the vapours of water, and thus formed the ſiliceous earth. It may be objected, that the fluor acid is perhaps already united, by nature, with a fine ſiliceous powder, which it volatiliſes and carries over in diſtillation, but leaves it as ſoon as it finds water to unite with, juſt as muriatic acid parts from the regulus of antimony, when butter of antimony is dropped into water. But if this was the caſe, the fluor acid would leave the whole quantity of ſiliceous earth thus combined with it in the firſt diſtillation, and therefore ſhow no mark of its preſence in the following proceſſes.

(c) When I put ſpirit of wine into the receiver inſtead of water, no ſiliceous earth was produced; but the alcohol became ſour.

(d) When I put an unctuous oil into the receiver, all the fluor acid penetrated through the crevices of the lute, and did neither unite with the oil, nor produce a ſiliceous earth.

(e) This alſo happened when acid of vitriol was put into the receiver. If, therefore, the ſiliceous earth was not a product of of each diſtillation, but, being previouſly contained in the acid, was only depoſited from it, in conſequence of the union of the acid with a third ſubſtance, I think the ſiliceous earth ought equally to appear when alcohol was put into the receiver, with which it unites, as well as with water; but as this does not happen, I conclude, that not all the ſiliceous earth, which is depoſited upon the ſurface of water during the diſtillation of the fluor acid, was previouſly diſſolved in this acid.

§ XIII.

I diſtilled one part of powdered fluor with two parts of concentrated nitrous acid, one part of which went over, together with the fluor acid, and upon the water of the receiver there was a thick cruſt formed. The maſs remaining in the retort was calcareous earth, ſaturated with nitrous acid, of a porous texture and reddiſh colour, which attracted moiſture from the atmoſphere.

§ XIV.

Two parts of concentrated muriatic acid being diſtilled with one part of the ſpar, the fluor acid paſſed over into the receiver with a large quantity of the muriatic. The internal ſurface of the receiver, as well as the ſurface of the water

ter contained in it, was covered with a white cruſt. The reſiduum in the retort was reddiſh, attracted moiſture from the air, and exhibited the properties of muriated lime, (fixed ſal ammoniac).

§ XV.

If there had appeared no ſiliceous earth, except when vitriolic acid was employed for expelling the fluor acid, it might ſeem as if this earth owed its generation to the vitriolic acid. (Becher and Stahl pretend, that acid of vitriol contains ſiliceous earth). The fluor acid, reduced into vapours, might be ſuppoſed, in this caſe, to deprive the vitriolic acid of this earth, and to loſe that power again in proportion as its vapours are condenſed and unite with water; but as there is ſiliceous earth likewiſe produced, when no vitriolic acid has been employed, it is evident that this earth has not been ſeparated from the acid of vitriol during the diſtillation.

§ XVI.

I diſſolved ſome ſpar in the nitrous and in the muriatic acid, in a ſand bath. From theſe ſolutions, a calcareous earth, capable of effervescing with acids, was precipitated, by aerated or common fixed alkali. But if the precipitation was performed

formed with caustic fixed, or with volatile alkali, the precipitate was fluor in fine powder. The same thing happened with aerated volatile alkali. When vitriolic acid was added to the above solutions, a precipitation took place immediately, and the precipitate was vitriolated lime. The same thing happens if vitriolated magnesia, (Epsom salt), vitriolated vegetable alkali, (vitriolated tartar), or vitriolated volatile alkali, (Glauber's sal ammoniac), were mixed with the above solutions.

§ XVII.

I digested powdered fluor with phosphoric acid, which dissolved a good deal of it. On distilling this solution, the fluor acid went over, together with the watery particles of the mixture; but the remaining mass in the retort had the properties of ashes of bones.

It has been lately discovered, that the earth of bones or horns is calcareous earth combined with phosphoric acid.

Distilled vinegar and acid of tartar had no effect in decomposing the fluor.

§ XVIII. *With Alkalis.*

I melted one part of fluor with four parts of caustic fixed alkali in a crucible, upon which I afterwards poured water,

water, in order to diſſolve all the ſoluble parts. I found the alkali had not in the leaſt united with the fluor; this latter remaining unchanged after the water had diſſolved the alkali.

§ XIX.

I melted one part of powdered fluor with four parts of aerated fixed alkali, and then poured water upon it, which diſſolved all that was ſoluble; there remained at the bottom calcareous earth, which efferveſced with acids. The liquor before mentioned was evaporated, and contained fixed alkali united with fluor acid, which remained dry in the air.

§ XX. *With neutral Salts.*

I diſtilled one part of powdered fluor with two parts of muriated volatile alkali (ſal ammoniac). At firſt, cauſtic volatile alkali paſſed over, then ſal ammoniac, at laſt yellow flowers, which attached themſelves to the internal ſurface of the veſſel with the ſal ammoniac. The reſiduum in the retort was fluor unchanged.

The iron contained in the fluor was moſt probably the cauſe of the ſmall decompoſition of the ſal ammoniac, which took place at firſt.

§ XXI.

§ XXI.

I ſublimed one part of powdered fluor with two parts of vitriolated volatile alkali, (ſecret ammoniac of Glauber); and obtained, firſt, ſome cauſtic volatile alkali, then a kind of ſal ammoniac. The reſiduum in the retort was vitriolated lime (ſelenite); the acid of fluor conſequently united in this proceſs with the volatile alkali, forming a kind of ſal ammoniac; and its earth remaining in the retort, united with the vitriolic acid of the vitriolated volatile alkali. I diſſolved this kind of ſal ammoniac in lime-water, and obtained a precipitate, which was regenerated fluor. On mixing ſome of the ſame ſal ammoniac with a ſolution of vitriolated magneſia, a precipitation likewiſe took place.

§ XXII.

I expoſed equal quantities of powdered fluor and corroſive ſublimate to ſublimation. The mercurial ſalt roſe unaltered; but a ſmall quantity of muriatic acid went over towards the end of the proceſs. The reſiduum in the retort was fluor unchanged. The muriatic acid obtained in the receiver had been probably firſt diſengaged from the corroſive ſublimate by the iron contained in the fluor; but was afterwards again ſeparated from it by the

too

too great degree of heat, and was thus carried over into the receiver.

§ XXIII.

I expoſed equal quantities of powdered fluor and vitriolated mercury in a cloſe veſſel to the fire, and obtained firſt a liquid; but ſoon after, when the retort became red hot, ſome fluor acid went over, and ſome globules of quickſilver adhered to the neck of the retort. The reſiduum was of a reddiſh colour. The ſmall decompoſition, which took place here, was likewiſe owing to the iron contained in the fluor; for, after the iron had united with a part of the acid of the vitriolated mercury, ſome quickſilver was neceſſarily diſengaged, and roſe; but, on increaſing the heat, the vitriolated iron was again decompoſed, and its acid left at liberty to unite with the calcareous earth of the fluor, and thus expel the acid of fluor.

§ XXIV. *With Sulphur and Arſenic.*

Fluor expoſed to fire in cloſe veſſels, with an equal quantity of arſenic, ſuffered no change. The ſame thing happened with ſulphur.

§ XXV. *On the Acid of Fluor.*

The effects produced by fluor acid upon other

other bodies is very remarkable. By the ſmell alone it is not diſtinguiſhable from the muriatic acid; but the experiment in XIV. evidently ſhows, that theſe two acids are very different. Beſides this, the fluor could not be fixed, permanent, and of a tranſparent and cryſtalline appearance, but would be conſtantly liquid, like muriated lime. The fluor acid, in ſome experiments, acts like muriatic acid; in others like acid of tartar; but in others it ſhows phænomena peculiar to itſelf.

§ XXVI.

The fluor acid, obtained in the manner deſcribed in VI. was filtered, and rectified in a glaſs retort, by means of a gentle fire. The whole liquor which aſcended at firſt was of a ſouriſh taſte; at the end of the proceſs the vapours were concentrated fluor acid; they formed a white cruſt upon the more diluted acid which came over firſt. After thoſe vapours had done riſing, I found the internal ſurface of the retort much corroded by the concentrated acid, and, at the bottom of the retort, ſome ſiliceous earth was left behind, which had been before diſſolved in fluor acid, and may be ſeparated from it beſides by another method, of which I ſhall ſpeak hereafter.

The ſiliceous earth thus produced towards the end of the proceſs, was ſeparated by filtration from the rectified acid, with which I then repeated the ſame proceſs. At the end of it I again found ſiliceous earth in the retort, as well as in the receiver. After a third rectification, I obtained the ſame. Thence it ſeems to follow with certainty, that the acid alſo, by itſelf, might be changed entirely, with vapours of water, into ſiliceous earth, if the diſtillation was repeated with water always in the receiver.

§ XXVII. *Effects produced by this Acid on Alkalis.*

The ſolution of alkali of tartar in fluor acid immediately formed a gelatinous maſs, almoſt without taſte. I filtered and evaporated it, but was not able to bring it to cryſtalliſation. I evaporated it then to dryneſs, and obtained a ſaline maſs, which only was in weight the ſixth part of the fixed alkali diſſolved; did not change the colour of ſyrup of violets, but precipitated lime-water. The liquid above this precipitate was a ſolution of pure alkali in water. The ſame ſalt likewiſe precipitated the ſolutions both of muriated lime, and vitriolated magneſia. The precipitate obtained from the lime-water

water and ſolution of muriated lime, was regenerated fluor.

The gelatinous ſolution of fixed alkali in fluor acid was well edulcorated, dried, and expoſed to the fire in a cloſe covered crucible. It melted without any ebullition. I then took it out and powdered it. The taſte was cauſtic. Expoſed in a cellar, it deliqueſced, and ſhowed itſelf in every reſpect to reſemble the liquor ſilicum.

§ XXVIII.

With mineral alkali fluor acid yielded exactly the ſame products as with the vegetable.

§ XXIX.

Volatile alkali diſſolved in fluor acid likewiſe formed a jelly, which, when it was ſeparated from the liquid, and well edulcorated, I found to be real ſiliceous earth. The ſupernatant liquid had a taſte reſembling that of the vitriolated volatile alkali, and yielded cryſtals, though indeed very ſmall, with which I tried the following experiments:

(A) By ſublimation, I at firſt obtained a little volatile alkali, and afterwards ſal ammoniac, of a taſte rather acid.

(B) Upon diſtillation, with a mixture of of powdered chalk and water, all the volatile alkali came over immediately.

(C) On the addition of lime-water, regenerated fluor was inſtantly precipitated.

(D) A precipitate of the ſame nature as the former was obtained, when the compound of fluor acid and volatile alkali was put into a ſolution of muriated lime. The liquor was a ſolution of common ſal ammoniac.

(E) Regenerated fluor was likewiſe precipitated by a ſolution of lime in nitrous acid.

(F) A powder was precipitated from the ſolution of ſilver, which, by means of the blowpipe, was reduced to ſilver, loſing, at the ſame time, its acid, which partly flew off, and in part uniting with the watery particles of the flame, generated ſiliceous earth, which appeared in the form of a white circular ſpot upon the charcoal, round the reduced ſilver.

(G) A maſs was precipitated from the ſolution of quickſilver in nitrous acid, entirely volatile in heat; but a ſolution of corroſive ſublimate remained unchanged.

(H) All the lead was precipitated from its ſolution in nitrous acid.

(I) A ſolution of vitriolated magneſia became turbid.

(K) Vitriolic

(K) Vitriolic acid, mixed with the ſolution of this kind of ſal ammoniac, and diſtilled in cloſe veſſels, yielded pure fluor acid, which formed, at the ſame time, a thick cruſt upon the water in the receiver.

Regenerated fluor, obtained in the manner as mentioned C, D, E, is decompoſed by digeſtion with aerated vegetable alkali. The acid of fluor unites with the alkali; but the calcareous earth, thus freed, uniting, at the ſame time, with the aerial acid, falls to the bottom of the veſſel.

When the experiment was made with aerated volatile alkali, no decompoſition enſued.

§ XXX. *On Abſorbent Earths.*

(A) A ſolution of lime in fluor acid remained clear till the acid was ſaturated; but then the whole quantity of diſſolved earth united with the acid into a maſs, which partly precipitated and partly congealed with the liquid into a jelly in the open air, and proved to be regenerated fluor.

(B) Magneſia, diſſolved in the fluor acid, partly precipitated immediately with it, and in part formed a jelly.

(C) Pure clay, or earth of alum, formed with the fluor acid a ſweet ſolution, which alſo formed a jelly.

§ XXXI. *On Metals.*

The under mentioned metals were digested with fluor acid in separate glass vessels for six hours. The liquor was made to boil towards the end. They shewed the following phænomena:

(A) Gold was not attacked. The fluor acid shewing in some particulars a resemblance with muriatic acid, I was induced to try whether it would dissolve gold, when mixed with nitrous acid, as muriatic acid does; but without success.

(B) Neither did silver undergo any change. The calx of silver, precipitated by an alkali, was partly dissolved; but the remainder united with the fluor acid into an insoluble mass, which lay at the bottom of the vessel. On pouring vitriolic acid upon it, the fluor acid was expelled, under its common form of a corrosive vapour.

(C) Quicksilver was not dissolved; but the calx of quicksilver, precipitated from nitrous acid by fixed alkali, was dissolved in part. The remaining insoluble part united with the acid, and formed a white powder, from which the vitriolic expelled the fluor acid in the form of vapour. The same powder formed, by means of the blowpipe, a yellowish glass, which, however, evaporated by degrees, leaving

at

at the end a ſmall globule of fixed glaſs behind.

(D) Lead was not diſſolved; but with its calx the acid formed a ſweet ſolution, from which the calx could be precipitated by vitriolic or muriatic acid, as alſo by ſal ammoniac. After digeſting a quantity of acid with calx of lead, which having been previouſly digeſted with the ſame calx, of courſe held ſome of it already diſſolved, a ſpontaneous precipitation took place. The vitriolic acid expelled that of fluor from the precipitate, in the form of corroſive vapours. It was eaſily brought into fuſion by means of the blowpipe, when the acid flew off, and the calx of lead was reduced. Part, however, of the glaſs remained fixed in the fire.

(E) Copper was partly diſſolved; for the acid, after digeſtion with this metal, grew bluiſh, on the addition of volatile alkali. The calx of copper was readily ſoluble. This ſolution was gelatinous; yielding, however, blue cryſtals, partly of a cubic, partly of an oblong form, from which the acid could not be ſeparated but by heat.

(F) Iron was attacked with violence. The vapours which aroſe during the ſolution were inflammable. The ſolution had a taſte like vitriol of iron; it congealed during the evaporation, but was not reducible into cryſtals, forming only a hard maſs,

maſs, after all the liquid was evaporated. Vitriolic acid expelled from this maſs the fluor acid under the form of vapours. The ſame effect was likewiſe produced by ſimple heat; and in this caſe a red ochre or calx of iron was left behind. The calx of iron was likewiſe ſoluble in this acid; the ſolution had a taſte like alum; it could not be reduced to cryſtals; upon the addition of alkali, it was decompoſed, and the calx precipitated.

(G) Tin was not ſoluble; but the calx was eaſily diſſolved; the ſolution became gelatinous; it had a nauſeous taſte.

(H) Biſmuth was not diſſolved; but its calx was diſſolved by the acid, with the very ſame phænomena as the calx of lead.

(I) Zinc produced the ſame effects as iron with the fluor acid, excepting that the ſolution ſeemed to be more inclined to cryſtalliſe.

(K) The regulus of cobalt was not ſoluble; but its calx diſſolved and formed a yellow gelatinous matter.

(L) The regulus of antimony was not attacked; neither was powdered crude antimony *(antimonium ſulphuratum)* ſenſibly diſſolved.

§ XXXII. *With Solutions of Salts.*

(A) Fluor acid precipitated ſomething from a ſolution of ſilver. The ſmall quantity

tity of precipitate, thus obtained, neither melted nor evaporated under the blowpipe.

(B) Quickſilver, diſſolved in nitrous acid, yielded precipitate, which melted upon the charcoal under the blowpipe, and was afterwards evaporated. The ſolution of corroſive ſublimate was not changed by the fluor acid.

(C) The ſolution of lead in nitrous acid was not changed; but, from the ſolution of this metal in vinegar, all the lead was precipitated by the fluor acid. Upon adding more of this acid than was neceſſary for precipitating the calx of lead, the calx was diſſolved, and found to be ſoluble afterwards in diſtilled vinegar.

(D) The ſolutions of vitriolated iron, copper, and zinc, of alum and vitriolated magneſia, were but little affected by the fluor acid.

§ XXXIII.

From what has been ſaid of the fluor acid hitherto, it follows:

(A) That it diſſolves ſiliceous earth, (XXVI.)

(B) That it parts from this earth as ſoon as it finds ſome other ſubſtance, alkali, (XXVII, XXVIII, XXIX,) abſorbent earths, (XXX.) metals, (XXXI.) to unite with.

(C) That

(c) That the fluor, produced by art, (x.) was not quite pure, but mixed with ſiliceous earth; which however does not militate againſt the aſſertion mentioned in that paragraph; for the ſiliceous earth is obliged to remain always behind when it is decompoſed, together with the gypſum that is formed at the ſame time.

(D) That the fluor acid will hardly ever be obtained pure, but always combined with ſome ſiliceous earth, which may be ſeparated from it by volatile alkali.

(E) That if pure fluor acid is to be combined with ſome other ſubſtance, the ſureſt way to effectuate this, is to make firſt a kind of ſal ammoniac by uniting it with volatile alkali.

(F) A compound of fixed alkali and fluor acid is capable of combining with finely divided ſiliceous earth, *via humida*, (XXVII.)

ESSAY

ESSAY II.

On Fluor Mineral. 1771.

§ I.

IN the year 1771, I had the honour to preſent to the Royal Society ſome experiments made with fluor mineral, which were inſerted the ſame year in the Tranſactions, and by which I proved, that the conſtituent parts of this foſſil are calcareous earth, and a peculiar acid, to which I gave the name fluor acid. Two years afterwards, Mr *Boullanger* *, in a little Treatiſe, endeavoured to ſhew, that this acid was nothing elſe than muriatic acid, intimately combined with ſome earthy ſubſtance. A ſhort time after this again Mr *Monnet* † brought forward ſome experiments, made by himſelf upon the ſame ſubſtance. He maintains, that the acid, which I obtained from fluor mineral, is only vitriolic acid volatiliſed by means of ſome extraordinary combination with fluor.

§ II.

* Experiénces et obſervations ſur le ſpath vitreux, ou fluor ſpathique, par M. Boullanger, 1773.

† Obſervations de phyſ. de M. l'Abbé Rozier, tom. x. p. 106.

§ II.

Thus we have three different opinions on the origin of this acid. A natural philosopher, who seeks for truth, will naturally wish to know which of these opinions he is to follow. Far from adhering tenaciously to the propositions advanced in my former paper, I shall shortly examine the arguments adduced by both these Chemists in favour of their respective opinions.

§ III.

Mr Boullanger maintains, that fluor acid precipitates the solutions of silver and quicksilver, yielding with the former muriated silver, (*vulgo luna cornua*); and he asserts, that, by subliming half an ounce of the second precipitate, he obtained *mercurius dulcis*. It is indeed true, that the fluor acid precipitates silver and quicksilver, as I mentioned likewise in my Dissertation on the fluor mineral; but the precipitate obtained is in very small quantity; (for the fluor mineral, as well as all other mineral substances of a calcareous nature, is adulterated with a small quantity of muriatic acid); but the greatest abundance of the remaining acid will not precipitate the above mentioned metallic solutions; which however should happen,

happen, if Mr Boullanger's opinion was true. He muſt have alſo made uſe of a very large quantity of fluor acid, in order to obtain ſuch a conſiderable precipitate: For, from the quantity of acid, which I obtained from two ounces of perfectly pure fluor, I procured only half a drachm of luna cornua: But I ſhall ſhew how to ſeparate this ſmall quantity of muriatic acid from that of the fluor. A ſolution of ſilver made with nitrous acid is to be precipitated with alkali of tartar; and upon the precipitate, after being edulcorated, ſo much acid of fluor is to be poured as is requiſite for giving an exceſs of acid, and then the ſolution is to be filtered. Of this ſolution of ſilver, ſo much is dropped into the fluor acid, till no more precipitation enſues, then the acid is filtered through gray paper, and afterwards evaporated to dryneſs in a glaſs retort. Water firſt comes over into the receiver; this is followed by fluor acid, which covers the inſide of both the veſſels, together with the ſurface of the water in the receiver, with a thick ſiliceous cruſt. The acid, thus rectified, does not precipitate the ſolution of ſilver, and ſhews not the leaſt mark of muriatic acid. Were Mr Boullanger's opinion juſt, the acid, notwithſtanding it has been thus purified, ſhould ſtill precipitate the ſolution of ſilver, becauſe he maintains, that, if the

the terreſtrial part can but be ſeparated from the acid, we ſhould have nothing left but pure muriatic acid *. Now we know that this terreſtrial part of fluor acid is a ſiliceous powder; if therefore Mr Boullanger is able to compoſe fluor acid with this powder, or any other ſiliceous ſubſtance and muriatic acid, I ſhall immediately give my aſſent to his opinion, but not before. Why does not fluor acid mixed with nitrous acid diſſolve gold? Why is no corroſive ſublimate produced when fluor acid is diſtilled with vitriolated mercury? Why do we not obtain plumbum cornuum on dropping this acid into a ſolution of lead made with nitrous acid? *&c.* Would not all this happen, if muriatic acid was contained in pure fluor acid? I readily believe that Mr Boullanger was not able to expel the fluor acid from the ſpar by the ſtrong concentrated nitrous and muriatic acid. Had he made uſe of thoſe acids a little leſs concentrated, or diluted as they commonly are, he would have ſurely ſeen the fluor mineral decompoſed, as well as it was in my experiment; for theſe acids have not ſo ſtrong an elective attraction for lime as vitriolic acid has; a ſmall quantity of water is therefore required, and then the fluor is decompoſed by means of a double elective attraction.

§ IV.

* Exp. & Obſ. par M. Boullanger, p. 29.

§ IV.

I now come to Mr Monnet's Eſſay, who maintains, in oppoſition as well to mine as to Mr Boullanger's experiments, that fluor mineral contains neither acid nor lime, but that this ſubſtance, being volatiliſed when united with a ſufficient quantity of vitriolic acid, forms the acid called fluor acid. The reſiduum in the retort, or the cryſtalliſed ſalt which I and Mr Boullanger call ſelenite, is in his opinion quite a different ſubſtance, ſince both this ſalt, and the cruſt which is ſublimed, want only a ſmall quantity of vitriolic acid, in order to be changed into fluor acid. Such are the concluſions of Mr Monnet. Thus we have a new kind of earth hitherto unknown to Chemiſts, and which will probably remain unknown to them to all eternity. It muſt be a curious kind of earth which is fixed by itſelf, but notwithſtanding is able, without the aſſiſtance of fire, to volatiliſe the vitriolic acid; ſo that both united together form a kind of air, which even retains its elaſticity in the cold. If I juſtly think that fluor acid contains not the leaſt veſtige of vitriolic acid, and if all the vitriolic acid, made uſe of for the proceſs, is found in the retort, after the diſtillation, united with the baſis of the fluor; and if this baſis is lime or

pure

pure calcareous earth;—if I ſhall be able to prove this, I ſay, Mr Monnet's theory muſt fall of itſelf.

§ V.

Upon one ounce of pure levigated fluor with alcohol, I poured three ounces of concentrated acid of vitriol, and diſtilled the mixture in a ſand-bath, having previouſly put twelve ounces of diſtilled water into the receiver. Then I took three other ounces (as exactly weighed as the former) of the ſame acid of vitriol, diluted with four-and-twenty ounces of water, to which I afterwards added lixivium tartari (liquid fixed alkali) previouſly weighed, till I attained the exact point of ſaturation; then I weighed again the remaining lixivium tartari, after the end of the diſtillation, which was continued for eight hours with ſuch a degree of heat, that none of the vitriolic acid was carried over; I carefully broke the retort, took out the maſs, and reduced it to powder in a glaſs mortar; it was then boiled in a glaſs veſſel with four-and-twenty ounces of water, for ſome minutes; after which, I added juſt as much lixivium tartari as I had found before to be requiſite for the ſaturation of three ounces of the vitriolic acid, and continued the boiling for a few minutes longer. When I at laſt came to examine

examine the ſolution, I found it to be perfectly neutraliſed, neither the acid nor alkali prevailing. It was a perfect vitriolated vegetable alkali, (vitriolated tartar) and conſequently not a drop of the vitriolic acid had paſſed over into the receiver. I afterwards lixiviated all the ſaline matter with hot water, dried the lime, and found it to weigh 9½ drachms. I diſſolved two drachms of this lime in diluted muriatic acid; there remained ſomething which was inſoluble, and ſeemed to be undecompoſed fluor; it weighed, after being dried, nine grains. Upon one part of this ſolution I poured ſome acid of ſugar, which immediately produced a precipitation of ſaccharated calcareous earth. To another part I added vitriolic acid, upon which ſmall cryſtals immediately precipitated, which were found to be vitriolated lime or gypſum. The third part of the ſolution was evaporated to dryneſs, whence a ſalt was obtained, which was deliqueſcent in the air. The remaining part of the aerated lime being put into a crucible, and burned in a ſtrong fire, I obtained a real quicklime, which made with water a perfect lime-water; and, when it was boiled with ſulphur, diſſolved it. It is probably unneceſſary to adduce any more arguments, in order to prove that lime is the baſis of fluor. After having thus ſhown, that the

 whole

whole quantity of vitriolic acid employed was retained by the lime, it would appear unneceſſary to mention all the experiments which I made, in order to aſcertain, whether, 1. fluor really contains vitriolic acid. But, in order to ſhow the falſehood of Mr Monnet's aſſertion on this ſide alſo, I ſhall relate a few of them. 1. Pure acid of fluor does not precipitate the ſolution of the terra ponderoſa. 2. Neither does it precipitate the ſolution of lead in nitrous acid. 3. Acid of fluor, ſaturated with alkali of tartar, and evaporated to dryneſs, then mixed with charcoal-powder, and melted, does not yield hepar ſulphuris. Not to mention, that ſeveral other acids have the power of expelling the acid from fluor. Mr Monnet, however, might very eaſily ſay, in anſwer to this, that fluor mineral has the property of volatiliſing all acids, the fixed acids of phoſphorus and of arſenic not even excepted. But no good chemiſt can poſſibly allow, that the cruſt, ſublimed into the neck of the retort, and into the receiver, as likewiſe the ſelenitic maſs remaining in the retort, diſtilled anew with vitriolic acid, is altogether converted into acid of fluor.

§ VI.

Mr Monnet, in order to give farther proof that fluor contains no calcareous earth, adduces the following experiments: He

He melts equal quantities of alkali and fluor together, and obſerves, that this mineral is thereby little or not at all changed; for, after having lixiviated the alkali employed, he diſſolved the fluor remaining in the filter in nitrous acid; and to the ſolution he added vitriolic acid: and becauſe he obtained no precipitate, he thinks it fully proved that fluor contains no lime. I maintain, on the contrary, that all ſolutions of fluor yield a precipitate of gypſum whenever vitriolic acid is added to them.

Was I to attempt an explication of Mr Monnet's experiment, I ſhould be induced to think, that he diluted his ſolution with too great a quantity of water. But why does he take equal quantities of alkali and fluor, whereas, in my Diſſertation on fluor, I ſay, that I took four parts of alkali to one part of fluor? I likewiſe mentioned in the ſame Diſſertation, that fluor, melted with cauſtic alkali, undergoes no change. Now, Mr Monnet undoubtedly knows, that alkali, when expoſed to a ſtrong fire, without fuſing, becomes cauſtic, the very thing which happens in his experiment. The reſult is quite different, if the experiment be made with four parts of alkali, here the fluor is decompoſed by means of a double elective attraction; and this is the reaſon that Mr Monnet obtains pure lime in the fil-

 ter.

ter. Mr Monnet is farther of opinion, that fluor may be precipitated by the phlogiſticated alkali, becauſe he obtained from its ſolution a much larger quantity of Pruſſian blue, though of a paler colour than was to be expected from the ſmall quantity of iron contained in the fluor. Thus we ſhould have, according to Mr Monnet's idea, a new diſcovery concerning the conſtituent parts of the fluor, *viz.* a new metallic earth, quite different from all others, ſince metallic calces alone have the property of being precipitated by phlogiſticated alkali. If a chemiſt, however, ſpeaks of the lixivium ſanguinis, or phlogiſticated alkali, he always underſtands a lixivium where the alkali does not predominate, but where it is perfectly neutraliſed; but of ſuch an alkali Mr Monnet probably did not make uſe in this experiment; for I can affirm with certainty, that phlogiſticated alkali does not precipitate the fluor. *Laſtly*, Mr Monnet pretends, in contradiction to all thoſe who have diſtilled the acid of fluor, that he has never obſerved the glaſs attacked by this acid. Every chemiſt, who has any fluor acid ſtanding in a glaſs veſſel, muſt be convinced of the contrary by his own ocular teſtimony: And thus, I hope, I have demonſtrated, that the acid of fluor is and remains entirely a mineral acid ſui generis.

ESSAY

ESSAY III.

Chemical Investigation of Fluor Acid, with a View to the Earth which it yields, by Mr Wiegleb.

§ I.

THE obſervation communicated by Mr Margraaf to the Academy of Sciences at Berlin in 1768 *, that a peculiar volatile earth might be obtained by diſtillation from fluor, to which vitriolic acid had been added, probably gave occaſion to Mr Scheele to make ſome experiments with a view to this. They have ſerved to ſhew the truth of what Margraaf had ſaid concerning the volatile earth. But Mr Scheele has attempted to advance farther, and to explain the ſingular phænomenon which this earth exhibits.

§ II.

It appears from his Eſſay, that he does not conſider the earthy matter as coming from the fluor, from which there is only a very peculiar acid ſui generis expelled by the vitriolic acid. He ſuppoſes that the fluor acid, which ariſes in the form of

 vapour,

* Memoires, tom. xxv. for 1768.

vapour, combines with the water as ſoon as it reaches its ſurface, and thus changes it into earth, conſtituting the cruſt which appears on the ſurface of the water during the operation. At the ſame time, he takes it for granted, without expreſsly mentioning it, that another portion of the acid is condenſed, and forms with the water an acid liquor.

§ III.

Having moreover obſerved, that the liquor ſeparated by filtration from the earthy cruſt, coagulated on the addition of alkaline ſalts, and, when it was more diluted, yielded a ſemitranſparent, gelatinous, and viſcid precipitate, he conſidered the coagulation as a property of the acid itſelf, not imagining that there took place a ſeparation of any earthy ſubſtance that was combined with the proper acid: He therefore looked upon the gelatinous matter, which, after edulcoration and deſiccation, was found to poſſeſs the moſt diſtinguiſhing properties of ſiliceous earth, as newly formed from the water and acid. In ſhort, Mr Scheele conſiders both the cruſt which forms upon the water during the diſtillation of the ſpar, and the ſiliceous earth obtained by precipitation, as an earthy ſubſtance originating from the acid of fluor and water.

§ IV.

§ IV.

Since the appearance of Mr Scheele's Eſſay, many hands have been ſet in motion by the ſingular phænomena related in it. Boullanger was probably led by the volatility of this acid, and the ſtrong ſmell of pure marine acid, which the liquor emits after diſtillation, to look upon the acid of fluor as an acid of ſea-ſalt. Monnet and Prieſtley, on the other hand, declared in favour of the vitriolic acid. With reſpect to the earth, Margraaf and Achard ſuppoſed that it muſt proceed from the fluor itſelf, and conſtitute an unknown ſpecies. Profeſſor Weigel maintains, that it has its origin in a decompoſition of the acid. Such are the principal opinions hitherto formed concerning the earthy matter which appears on this occaſion.

§ V.

Mr Scheele's explanation of the phænomena appeared to me, on the firſt reading of his Eſſay, ſomewhat bold and improbable: For we are not acquainted with any inſtance in which water is thus changed into an earth by an acid, and ſtill leſs with a tranſmutation of this liquid into ſiliceous earth. I endeavoured, therefore, to diſcover its origin by experiment. Having therefore firſt repeated ſeveral experiments in the way defcribed by Mr Scheele, accurately obferved all the phænomena that occurred, and thus fallen upon a track which promifed to lead to the folution of the whole problem, I proceeded to fomething which Mr Scheele had neglected, and from which I hoped that it might be ultimately determined whether the earth proceeded from the fluor, or was formed of the acid and water.

§ VI.

For this purpofe, I firft weighed the retort deftined for the experiment in a very accurate manner, and found that its weight was two ounces and five drachms. I then put into it two ounces of calcined fluor in powder, and added, by means of a glafs tube, $2\frac{1}{2}$ ounces of oil of vitriol. The retort was then placed on the furnace, and a receiver, which, when empty, weighed two ounces, two drachms, and thirty grains, and now contained two ounces of diftilled water, luted to it. The diftillation was conducted with all poffible care, and at laft pufhed till the retort grew red hot. A few vapours could not be prevented from penetrating through the lute. The next day, the retort being feparated from the receiver, was found to weigh, together with its contents, five ounces, five drachms, and thirty grains; it it had therefore loſt one ounce, three drachms, and thirty grains. The receiver, which, with the water, had originally weighed four ounces, two drachms, and thirty grains, now weighed five ounces and three drachms, and had therefore gained one ounce and thirty grains. This gain, compared with the loſs of the retort, ſhews, that the retort loſt more by three drachms than the receiver gained. Theſe three drachms muſt have inevitably paſſed out of the veſſels in the form of vapour.

§ VII.

But, from this inference, we can deduce nothing towards the determination of the point in diſpute; it was neceſſary to examine more narrowly what had happened in the veſſels. But, before I give any account of that, I ſhall, for the ſake of perſpicuity, briefly ſtate what has been juſt ſaid.

	Oz.	dr.	gr.
The empty retort weighed	2	5	0
The calcined fluor -	2	0	0
The oil of vitriol - -	2	4	0
Total weight before diſtillation,	7	1	0
After it, - -	5	5	30
Loſs, - - -	1	3	30

The

	Oz.	dr.	gr.
The empty receiver weighed	2	2	30
The water put into it -	2	0	0
Total weight, - -	4	2	30
Weight after diſtillation, -	5	3	0
Gain, - - - -	1	0	30

If we now deduct this gain from the above loſs, three drachms will be miſſing; and they muſt have been diſſipated in the form of vapour.

§ VIII.

I now broke the retort, and, in the firſt place, ſeparated, as accurately as poſſible, the dry earth, both in the neck and arch of the retort; it weighed three drachms. Then the reſiduum in the retort was tried, and found to weigh three ounces, two drachms, and forty grains. Now, as the maſs in the retort had originally weighed four ounces and four drachms, it appears, by deducting the reſiduum, to have ſuffered, upon the whole, a loſs of one ounce, one drachm, and twenty grains.

§ IX.

In order to determine the loſs more accurately, I made the following calculation:

(A) The

	Oz.	dr.	gr.
(A) The white earth, ſeparated from the neck and arch of the retort, amounted to -	0	3	0
(B) The gain of the receiver,	1	0	30
(C) Loſt in vapour, -	0	3	0
Total	1	6	30

Here, to my great aſtoniſhment, the matter that had come from the retort amounted to more by five drachms, ten grains, than the maſs in the retort had loſt of its original weight (VIII). Now, nothing remained for the illuſtration of this circumſtance but to weigh the retort and receiver themſelves. The retort, or, more properly ſpeaking, the pieces of it, which had been carefully preſerved, weighed an ounce, ſeven drachms, and fifty grains; whereas, before the proceſs, the weight of the retort was two ounces, five drachms; and hence it was obvious, that it had loſt five drachms, ten grains, the preciſe quantity which the products of the whole operation had gained, and by which they exceeded the loſs of the matter in the retort.

§ X.

This began at once to throw light on the controverted point. For where are the five drachms, ten grains, which the glaſs of the retort had loſt, but in the products

products obtained out of the retort? In order to examine these, the fluid in the receiver was diluted with four ounces of diſtilled water, and poured on a filter, that the clear liquor might be ſeparated from the earthy cruſt which floated in it; freſh water was poured on the filter as long as the earth retained any ſour taſte. The empty receiver was found, upon weighing, to have loſt no ſenſible part of its original weight. The earth remaining on the filter, weighed, after it had been dried, fifty-ſeven grains.

§ XI.

The clear liquor was then diluted with more diſtilled water, and afterwards precipitated with ſpirit of ſal ammoniac, prepared with fixed alkali and water, which was added till the ſmell of volatile alkali indicated the point of ſaturation. Before any precipitate began to fall, there was a briſk efferveſcence, that continued for ſome time. The precipitation itſelf took place without efferveſcence: There was preſent, therefore, a quantity of unſaturated acid. The ſemitranſparent gelatinous precipitate not having quite reached the bottom the next day, the whole was poured upon a filter, and when the liquor had paſſed through, freſh water poured upon the precipitate as long as it retained

any

any ſaline taſte. After drying, it weighed exactly two drachms.

§ XII.

If we add together the three kinds of earth obtained in the above proceſs, *viz.*

	Oz.	dr.	gr.
(1.) The earth in the neck, and arch of the retort, -	0	3	0
(2.) The earth that had formed a cruſt on the water,	0	0	57
(3.) The earth that was precipitated out of the fluor acid,	0	2	0
It amounts upon the whole to	0	5	57

and therefore only to forty-ſeven grains more than the retort had loſt of its weight; which ſmall exceſs is to be attributed in part to the acid inhering in it, and partly to ſome moiſture attracted by it. To aſcertain this, I made each by itſelf red hot in a ſmall crucible, after which

	Oz.	dr.	gr.
(1.) Weighed - -	0	2	36
(2.) - - -	0	0	21
(3.) - - - -	0	1	55
In all	0	4	52

which is leſs by eighteen grains than the loſs of the ſubſtance of the retort (IX); they

they muſt certainly have eſcaped in the three drachms of vapour.

§ XIII.

Hence, I think, the origin of the earth which makes its appearance during the diſtillation of fluor, rendered quite evident. It proceeds neither from the ſpar itſelf, and ſtill leſs, as Mr Scheele ſuppoſes, from the fluor acid and water *, nor does it originate in any other way but from the ſolution of the glaſs.

§ XIV.

Hence the idea of the fluor acid aſſumes a totally different form. It is true, that fluor contains an acid before unknown, and

* To this I am induced, by my own experience, to accede. In diſtilling fluor with oil of vitriol, I have found the retort, as well as the receiver, very much corroded. I poured the acid obtained by the proceſs into a phial furniſhed with a glaſs ſtopple, and obſerved, after ſome time, a conſiderable depoſition. I then poured the liquor into another phial like the former; and that it might neither, on the one hand, attack the glaſs, nor, on the other, compoſe ſiliceous earth with the particles of water, according to Mr Scheele's hypotheſis, I added highly rectified ſpirit of wine. I ſaw, however, after ſome time, another conſiderable depoſition. This ſeemed alſo to proceed from the glaſs that had been before diſſolved, which the acid let fall in conſequence of the gradual combination with the ſpirit of wine; otherwiſe we muſt ſuppoſe, what to me appears incredible, that the acid decompoſes the ſpirit, attracts the water, and forms the earth. Crell.

and totally different from every other, which has the fingular property not only of diffolving glafs, but of carrying it off in the form of vapour: And moreover, that this acid forms, with all the alkaline falts, very peculiar neutral falts, of which the ammoniacal falt arifing from the precipitation (XII. & XVI.) furnifhes an inftance.

§ XV.

I cannot leave untouched the fingular property of this laft falt, in which the fluor acid, though in the form of a perfect neutral falt, yet retains its power of diffolving glafs unchanged: For, upon evaporating to drynefs in a cup of Mifnia porcelain, the liquor of § XII. which, by its fmell, fhewed an excefs of volatile alkali, I obtained four drachms forty grains of an ammoniacal falt in thin prifmatic cryftals; but, upon examining the cup, I found all the glazing corroded, and the bottom as rough as a file. During the evaporation, the cup was covered with white paper, which, when dry, appeared full of fmall cryftals of an acid tafte, eafily diftinguifhable with the naked eye. Thefe, as well as the ammoniacal falt, forcibly attracted moifture from the air.

§ XVI.

§ XVI.

From the properties of fluor acid, with which we are now become acquainted, all Mr Scheele's other obſervations may be quite naturally explained; as, for inſtance, that regenerated fluor ſtill continues to yield ſiliceous earth when it is diſtilled with vitriolic acid: That fluor acid, by being merely rectified, always leaves behind ſiliceous earth, and yet paſſes over ſtill loaded with that earth: That the ammoniacal ſalt, in the formation of which the ſiliceous earth is ſeparated by volatile alkali, yet yields an acid, when it is mixed with vitriolic acid, and diſtilled, that contains this earth. But the knowledge of ſo ſingular an acid may lead to much farther inſtruction, as we are already certain, that it completely and abundantly diſſolves flint, quarz, and glaſs, the only refractory bodies. From this quality, it muſt alſo be apparent to every one, that the preſent can neither be the acid of ſalt nor of vitriol, but one totally different from all before known, and peculiar to fluor.

At the ſame time, we muſt perceive the almoſt inſuperable difficulty of obtaining it pure, and aſcertaining its effects on other bodies.

Additional

ESSAY IV.

Additional Information concerning Fluor Mineral. By Mr* MEYER.

§ 1.

IT is always of advantage to chemiſtry, when new and important experiments are controverted ſoon after their publication. If any miſtakes, as ſo eaſily happens in chemical reſearches, be committed in the experiments themſelves, or if a falſe theory be founded upon them, the error is not continued half a century, nor does it paſs from one elementary book into another, till at laſt ſome ſceptic thinks of enquiring more narrowly into the matter.

If the experiments be exact, and the theory founded on them true, ſuch a controverſy commonly gives occaſion to new reſearches which otherwiſe would not have been made, and the ſubject is placed in a clearer point of view.

It were indeed to be wiſhed that both parties held truth ſtrictly in view; that they brought no falſe experiments into the diſpute, and obſerved and explained the phænomena

* *Meyers Beytraage zur Kenntniſs des fluſspaths.* Schriften der Berliniſcher Geſellſchaft Natur-forſcher-der Freunde. B. 2. t. 319.

phænomena no otherwiſe than a friend to truth, unintereſted in the controverſy, would do, and advanced contradictory aſſertions with as much caution as poſſible. It is, by no means, rare, for a man, eager to convict his adverſary of a miſtake, to commit another in the very ſame experiment by which he thinks to attain his purpoſe.

Truth, however, let the diſpute be carried on in whatever manner, is commonly a gainer; and this is no ſmall advantage.

§ II.

This has been the fate of the fluor acid, a ſubſtance made publicly known by that excellent chemiſt Mr Scheele, in the Swediſh Tranſactions.

Many doubted concerning it, but its moſt zealous avowed oppoſers were, as far as I know, Mr Boullanger and Mr Monnet. Though I had made but few experiments with it when I read Mr Monnet's eſſay, yet I eaſily perceived, that, while he charged Mr Scheele with having obſerved wrongly, his own obſervation had been ſtill more faulty.

I reſolved to defend my friend; but learning that he was himſelf making experiments in order to refute his adverſaries, I willingly relinquiſhed the taſk to his

his maſterly hand. I read with ſatisfaction the experiments publiſhed by him with this view, in the firſt quarter of the Swediſh Tranſactions for 1780; and moreover, tranſlated them, in order to communicate them to my countrymen in ſome journal.

Hence I was led to repeat a few experiments, and theſe again ſuggeſted others; and, as I think them likely to contribute ſomewhat to a more intimate knowledge of this remarkable ſtone, I lay them before the Society.

§ III.

Among Mr Scheele's experiments, I was particularly ſtruck by one in which he obtained no earthy cruſt on diſtilling fluor with vitriolic acid, when he had put ſpirit of wine into the receiver. I repeated this experiment, in hopes, that, by putting but little ſpirit into the receiver, I might procure a new kind of æther.

With this view, I put an ounce of finely powdered fluor, that had been before heated red hot, into a glaſs retort, and added three ounces of white Engliſh oil of vitriol; the receiver contained three ounces of highly rectified French brandy.

I had continued the diſtillation for three hours in a gentle heat, when the acid, having made its way through the bottom of of the retort, put a ſtop to the proceſs, part of the mixture running into the ſand.

On the ſurface of the ſpirit, I could not obſerve the leaſt trace of any cruſt; but in the place where the receiver had been in contact with it, there was a thin ring of tranſparent jelly.

The ſame mixture of fluor and oil of vitriol was again put into a retort of very ſtrong glaſs, and the ſame ſpirit, as in the former experiment, ſet in the receiver. The diſtillation was continued in a ſand-bath for two hours, at firſt with a gentle, but afterwards with a ſtronger heat. When the diſtillation was half over, the ſpirit of wine began to change into a thin jelly; and, at the end of the proceſs, I found ſome firmer pieces at the bottom. Theſe I waſhed with ſome ſpirit of wine; and, in order to obtain the ſpirit, together with the acid, in a pure ſtate, I poured it into a large retort; as the retort grew warm, the opal-coloured ſpirit grew clear and ſwelled; what paſſed over became again gelatinous. A good deal of earth remained behind, but did not adhere firmly to the retort, which was ſmooth in the inſide, and yet full of broad ſhallow excavations: And it was evident, that it is not a mere cruſt which fixes itſelf to the glaſs, in treating fluor mineral with oil of vitriol, but that the glaſs is actually cor-

roded,

roded, which Mr Monnet, contrary to all experience, denies.

§ IV.

I gave over my attempt to procure æther, thoroughly edulcorated the jelly and the earth that remained in the retort after the rectification, and precipitated the earth that was diſſolved by the water with ſpirit of ſal ammoniac. The quantity of earth amounted in all to two drachms, and that which had ſeparated ſpontaneouſly from the ſpirit was ſemi-tranſparent.

Neither of theſe earths ſuffered any change under the blowpipe, but they both flowed on the addition of a little ſalt of tartar.

This was a large quantity of earth from two ounces of fluor; and it could not be eſtimated as the whole, ſince the firſt proceſs was cut ſhort before it was completed.

As this earth ſhewed the properties of ſiliceous earth, and the glaſs, which was ſo much corroded, conſiſts in great meaſure of it, the greateſt part might come from the glaſs, and the reſt perhaps be a conſtituent part of the fluor itſelf.

§ V.

In order to aſcertain this, it was neceſſary to obtain the fluor acid quite free from

from ſiliceous earth. I therefore expoſed the ley, which I had procured by the precipitation of the earth with ſal ammoniac, to a gentle evaporation in a ſlightly covered glaſs veſſel. The product was one drachm fifty-ſix grains of an ammoniacal ſalt; the glaſs did not appear to have been attacked.

I ſublimed half a drachm of this ſalt in a ſmall retort, which, towards the end of the operation, I laid upon the bare fire. No cruſt appeared upon the ſurface of the water in the cover. At the bottom of the retort lay a little flocculent earth, of a light grey colour, above which the internal ſurface was covered with a white pellicle that reflected various colours, and in the neck there was a ſublimate.

The thin pellicle eaſily ſeparated in many places from the glaſs, which was quite ſmooth beneath, though it was not without ſmall furrows.

I poured water both upon the ammoniacal ſalt and the cruſt, in conſequence of which it acquired a very ſour taſte, and coloured the tincture of turnſol red.

The white cruſt that was left undiſſolved behind, weighed five grains, and under the blowpipe ran without addition into a green glaſs. This was nothing but the glaſs that had been corroded by the fluor acid; but, as this acid can be ſet looſe only

only by a ſtrong heat, it had done no more than corrode the glaſs, without paſſing over along with it in the form of vapour, and then depoſiting it again on the water. For, upon pouring two drachms of oil of vitriol upon half a drachm of this ammoniacal ſalt, a little moiſtened, and placed in a glaſs retort, a great foam aroſe, and the thick vapours that aſcended covered the water in the receiver with a white cruſt.

A ſcruple of the ſalt on ſolution left behind a grain of earth, which, as I conjecture, it had taken up during the evaporation in the glaſs veſſel.

§ VI.

In order to prevent this, I diſtilled half an ounce of fluor with an ounce of oil of vitriol for five hours. The cruſts were ſeparated from the water; they weighed, after being well waſhed and dried, eleven grains; they were white and very flocculent; thirty-two grains of ſiliceous earth were precipitated from the filtered water; the ley was then evaporated in a leaden veſſel, and yielded eighty grains of ſalt.

Glaſs veſſels were no longer to be truſted; a piece of a gun-barrel furniſhed with a cover and terminated by a bent tube, intended to ſerve inſtead of the neck of a retort, was uſed in the following experiments,

ments, and the diſtillation was performed in a ſand-bath. In this apparatus, to half a drachm of the newly procured ammoniacal ſalt I added two drachms of oil of vitriol, and diſtilled for two hours into a glaſs receiver, containing an ounce of water.

No veſtige of a cruſt could be perceived on the water; but I ſaw ſome earth in the receiver, where the vapours having aſcended through the tube came into contact with the wet glaſs; and here the ſurface was become ſenſibly rough.

On the addition of volatile alkali, a few flocculi of ſiliceous earth, amounting only to one-fourth of a grain, were thrown down out of the water.

Again, I added a drachm of oil of vitriol to $1\frac{1}{2}$ drachm of the ſalt in the ſame apparatus; but I now uſed a receiver of lead, containing an ounce of water.

At the cloſe of the diſtillation, I found no cruſt on the water which had an unpleaſant ſmell; and, on the addition of ſpirit of ſal ammoniac, let fall a little grey earth that weighed half a grain.

A ſcruple of this ſalt, mixed with an equal quantity of white ſand in fine powder, and diſtilled in the iron apparatus with $1\frac{1}{2}$ drachm of oil of vitriol, an ounce of water being put into the leaden receiver,

ver, ſhewed no veſtige of a cruſt. The water had a putrid ſmell, and left on the filter $2\frac{1}{2}$ grains of grey earth, which ran under the blowpipe into a grain of lead; and, by volatile alkali, five grains of grey earth were precipitated, which melted on the addition of a little ſalt of tartar into a black globule, though the blowpipe alone produced no change on it. This probably aroſe from ſome diſſolved lead; but as there was a more copious precipitate here than in the preparation of the ammoniacal ſalt without ſiliceous earth, it muſt unqueſtionably have ariſen from a portion of that earth being diſſolved and carried over by the fluor acid.

My ammoniacal ſalt being expended, I prepared more from a weaker acid, which I had remaining from another experiment, in a leaden veſſel, but procured only thirteen grains.

To this quantity I added a drachm of oil of vitriol in the above deſcribed apparatus, putting in moreover two ſcruples of green glaſs in ſmall pieces. Scarce had the iron tube grown warm, when I perceived on the water in the leaden receiver a great ſpot of ſiliceous cruſt; and I ſaw the ſame appearance on the moiſt ſides of the veſſel. I continued the diſtillation for two hours; but there did not ſeem to be any increaſe of the ſiliceous cruſt; $1\frac{1}{4}$ grain

grain remained on the filter, partly consisting of grey earth, partly of white films, which ran under the blowpipe into a greenish glass.

It seems therefore certain, that the earth which passed over in these experiments comes not from the stone, as any constituent part of it, but that it is siliceous earth dissolved by the acid. Did the stone contain an earth which so wonderfully altered acids, it must be thrown down by the volatile ley.

§ VII.

To set the matter in a still clearer light, I used a different species. Some yellow cubical fluor from Saxony being heated and pounded, and then distilled in the iron tube, with a double quantity of oil of vitriol, and with a drachm of water in the leaden receiver, yielded a thin pellicle, of the appearance of lead, but no siliceous crust. By precipitation with volatile alkali I got $2\frac{1}{4}$ grains of grey earth.

A drachm mixed with the same quantity of pulverized sand afforded a pellicle of lead, interspersed with a few particles of white crust, which ran into glass under the blowpipe. Volatile alkali precipitated eight grains, a striking difference.

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A drachm mixed with an equal quantity of green glaſs, reduced to powder, ſwelled a good deal, and yielded a thick ſiliceous cruſt.

§ VIII.

Not yet ſatisfied with theſe experiments, I added to a drachm of green fluor, that had been heated and pounded, two drachms of oil of vitriol, ſtill employing the iron tube. I alſo ſuſpended a piece of wet charcoal in the inſide, fixed a cover upon the tube, heated it in a ſand-bath, and found, upon taking off the cover, in the ſpace of fifteen minutes, that the charcoal was dry, and had no earth upon it. I now added a ſcruple of ſand in fine powder, wetted the charcoal, and replaced it; but found after the ſame time nothing more than at firſt.

Some bits of green glaſs were now thrown into the mixture, when it began to foam ſo vehemently, that it ran over; and I did not now hang the charcoal in the tube, as it was no longer clean, nor was this at all neceſſary; for, after I had held it a few ſeconds over the orifice, it was covered with a white powder.

Mr Scheele, in his firſt Eſſay, ſays, That he obſerved the white powder on a piece of charcoal that had been moiſtened and ſuſpended over fluor, to which vitriolic acid

acid was added. As this experiment was made in metallic veſſels, I conjecture that the mortar uſed for reducing the fluor to powder was of ſoft glaſs, and that ſome particles being abraded by the trituration, had occaſioned the phænomenon.

The GLASS was therefore the chief cauſe of the production of the ſiliceous pellicle on the ſurface of the water in the receiver.

§ IX.

In order to aſcertain whether, when a quantity of glaſs ſufficient for the ſaturation of the acid is added to it, it can carry over much more along with it, to half an ounce of fluor, 1½ ounce of white oil of vitriol was added in a retort of glaſs, and three ounces of water put into the receiver. The retort was corroded through in an hour's time, and the cruſt on the water weighed ten grains. The water was filtered and divided into two equal parts, of which the one being precipitated with cauſtic volatile alkali, afforded twenty-five grains of ſiliceous earth, and the other with aerated vegetable alkali yielded ſixty-eight grains of a precipitate which flowed under the blowpipe, ran into the pores of the charcoal, and gave out ſtrong vapours of fluor acid.

In this caſe, therefore, the ſiliceous earth was precipitated in a ſtate of purity by the volatile

volatile alkali; but the precipitate by fixed alkali was a mixture of ſiliceous earth, fluor acid, and alkali, as Profeſſor Bergmann has already obſerved.

§ x.

To a mixture of half an ounce of fluor, and the ſame quantity of glaſs in powder, 1½ ounce of oil of vitriol being added in a retort that was thus half filled, the ingredients acted ſo violently on each other, that in a ſhort time the mixture roſe to the neck of the retort. It was left expoſed to the open air on account of the vapour, and the next day I found the rim of the retort covered with faſciculated cryſtals as with hoarfroſt.

The ſame mixture being on another occaſion made in a capacious retort, and thoroughly blended by agitation, became a thick maſs, and ſwelled like dough in fermentation; the bottom of the retort grew very hot, and the ſiliceous cruſt appeared, on three ounces of water, which had been put into the receiver.

At the end of the diſtillation, which was continued three hours, I found ſixteen grains of ſiliceous earth on the ſurface of the water, and the precipitate by volatile alkali weighed fifty-ſix grains. The retort was not nearly ſo much corroded as uſual.

On

On diftilling thirty grains of this precipitate in a glafs retort, with $1\frac{1}{2}$ drachm of oil of vitriol, I faw no filiceous earth on the water in the receiver, nor fublimate, nor did fpirit of fal ammoniac throw down any thing, either out of the water in the receiver, or that with which the earth was edulcorated. I mixed the ley of fluorated volatile alkali with a folution of chalk in nitrous acid, till no more precipitation took place. The mixture was paffed through nitrous acid, and the precipitate edulcorated; it weighed, when dry, two drachms thirty-fix grains.

Two drachms of oil of vitriol being added to a drachm of this precipitate contained in a glafs retort, the precipitate was attacked in the cold, yet no cruft appeared; but heat was fcarce applied, when the whole furface of the water was covered, and all the phænomena which the natural exhibits were fhewn by this regenerated fluor.

This fhews, that Mr Scheele's theory of fluor acid is true, and that fuch an acid actually exifts.

§ XI.

My firft experiments were communicated to Mr Scheele, with a requeft that he would repeat them; by which means I hoped to guard againft any new miftake.

That

That worthy philoſopher informed me, that he had long obſerved, that a mixture of fluor, as tranſparent as mountain cryſtal, and of oil of vitriol in a metallic cylinder, produced no appearance of ſiliceous earth on a wet ſponge ſuſpended in the inſide.

At my requeſt he made a new experiment, which conſiſted in adding oil of vitriol to portions of fluor of this tranſparent kind that were placed in two tin cylinders; ſome ſiliceous earth was put into one, a wet ſponge ſuſpended in both, and a cover fixed on them. The next morning the ſponge that was ſuſpended over the mixture to which ſiliceous earth had been added, was covered with that earth, while the other exhibited no ſuch appearance.

However contrary this may appear to my experiment (§ VIII.), I have no doubt of the fact, having often experienced my friend's accuracy; I might have committed a miſtake before.

§ XII.

The experiment was therefore repeated, but no heat was applied to the mixtures in the tin cylinders. After the expiration of fifteen minutes, neither ſponge had any earth adhering to it; but after continuing ſuſpended for a whole night, the reſult refult was exactly fuch as Mr Scheele defcribed.

Here, therefore, the filiceous earth alone, on mixture with fluor, had yielded the dry filiceous earth which I obferved only when I added glafs. Hence it became neceffary to attempt a few more experiments.

§ XIII.

A drachm of fluor, mixed with a double quantity of oil of vitriol in the iron apparatus, afforded, after a diftillation of two hours, a thin film of lead on the furface of the water in the receiver, but no filiceous earth. While I was wafhing it out, I perceived fome few particles, which were like the filiceous cruft, but they were too inconfiderable to be weighed. If the mixture had been treated in glafs veffels, the filiceous earth would have amounted to 2½ grains, which, on account of its rarity, makes a tolerable bulk. In order to be better able to obferve it, the fame mixture was difpofed in the fame manner, except that, inftead of the leaden receiver, one of glafs, with 3½ ounces of water, was fo applied, that the mouth of the iron retort nearly touched the furface of the water. In the beginning of the diftillation, a fmall fpot appeared under the neck of the retort, and the mouth itfelf ſelf was covered with white powder. But it all ſoon diſappeared, and I ſaw no more of it, though the proceſs was long continued.

The empty part of the receiver was corroded, yet I procured, after edulcoration, but half a grain of earth.

This ſeems further to ſhew, that nothing but the glaſs has any ſhare in the production of the ſiliceous earth.

§ XIV.

It follows from theſe experiments, that uncombined fluor acid diſſolves ſiliceous earth, and carries it up into the water in the receiver. If no water be preſent, it aſcends in the form of a dry vapour; a remarkable fact, conſidering the fixity of this earth. May not this ſerve to illuſtrate the volatility of the diamond? I think it probable that fluor acid is a conſtituent part of this gem.

The origin of the ſiliceous cruſt on the ſurface of the water may be explained, by ſuppoſing, either that the acid diſſolves an exceſs of the earth which is preſent in the glaſs, and already half prepared for ſolution, and that being over-ſaturated, it lets fall a part which it cannot retain when mixed with water, or that the alkali in the glaſs comes into action.

 In

In Mr Scheele's experiment, the ſiliceous earth was depoſited on the ſponge, without any other circumſtance to promote the volatilization. But it is, at the ſame time, to be noticed, how ſlowly this happened; for it, doubtleſs, did not begin to take place till the ſmall quantity of water contained in the ſponge was ſaturated with the ſiliceous earth diſſolved in the acid. Fluor acid, which I have kept above a year in a phial, has corroded the glaſs in many points, which are ſurrounded with concentric circles, and depoſited a powder that adheres to the bottom.

This remarkable foſſil may ſtill furniſh a ſubject for many experiments. Golden veſſels would, in my opinion, be the moſt convenient in ſuch an undertaking, as alſo for keeping the acid *.

ESSAY

* Theſe experiments ſo clearly point out the origin of the ſiliceous cruſt, that Bergmann, who had adopted Mr Scheele's opinion concerning its formation during the proceſs, candidly deſerted it (Opuſc. vol. iii. p. 397.). That this ſubject might not remain in obſcurity for want of inveſtigation, Mr Wenzel of Dreſden likewiſe made a number of experiments on fluor, which coincide in every eſſential point with thoſe of Mr Meyer, though they differ in a few particulars. The title of his pamphlet is, G. WENZELS *Chymiſche Unterſuchung des Fluſs-ſpaths. Dreſden bey Gerlach*, 1783. 4to.

Mr Wenzel, in order to obtain the fluor acid free from ſiliceous earth, performed the diſtillation in a leaden retort, provided with a glaſs receiver; there appeared,

ESSAY V.

ON MANGANESE, MANGANESIUM, OR MAGNESIA VITRARIORUM. 1774.

§ I.

THOUGH the different ſpecies of manganeſe have attracted the attention of chemiſts of late years, the reſult of

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appeared, however, upon the water in the receiver a variegated cruſt, and the acid, with fixed alkali, yielded a gelatinous precipitate. Upon examining the receiver, he found that the vapours had corroded its internal ſurface, ſo that it appeared as if it had been rubbed with coarſe ſand. Mr Wenzel, however, accompliſhed his purpoſe, by ſubſtituting a balloon of lead in the place of a glaſs receiver, and by diſtilling with a gentle heat. At the end of the operation, there was no appearance of any earthy cruſt, either in the retort, or on the ſurface of the water in the receiver: The acid liquor gave no jelly on the addition of alkali, though there was a precipitation of iron and earth of alum.

To complete his proof of the origin of the ſiliceous earth, he mixed fluor, quarz, and vitriolic acid, and performed the diſtillation in his apparatus of lead. But he now found the uſual cruſt upon the acid liquor, and obtained a gelatinous precipitate on the addition of alkali.

Moreover, Mr Wenzel obſerved, that two ounces of fluor loſt upon calcination in open veſſels only two grains. When this experiment was performed in an air-apparatus, ſome inflammable air was obtained, and a very ſmall quantity of fluor acid, which attacked the glaſs.

their experiments has gone no further than to difclofe fuch of their qualities as ferve to diftinguifh them from other minerals; at leaft nothing has been publifhed to elucidate their nature any further, except a differtation by Mr Weftfeld, in the year 1767, in which this author firft examined their conftituent parts. My experiments, however, will fhew, that his conclufions were too haftily made. I think it unneceffary to enumerate all the different kinds of manganefe which I have examined, as they all agree in their principal qualities.

§ II. *Effects of Vitriolic Acid on Manganefe.*

(A) Two drachms of manganefe, levigated in a glafs mortar, were digefted with an

glafs. Fixed alkali threw down a precipitate, amounting, after proper edulcoration, to one ounce, twenty-two grains, from the acid expelled by oil of vitriol from two ounces of fluor. This precipitate was very fufible, and yielded fluor acid with oil of vitriol. Both fire alone and vitriolic acid expelled a little acid of fluor from the earthy cruft. When the precipitation from the fame quantity of acid was made by volatile alkali, two drachms and fifty-three grains of an infufible fubftance were obtained, which likewife, on addition of vitriolic acid, yielded fome fluor acid. It appears then, that a portion of it is contained in the earthy cruft, and that even fixed alkali is not capable of feparating it completely from filiceous earth, but it remains united with fome filiceous earth and alkali after precipitation.

The refiduum, after diftillation, contains calcareous and aluminous earth; this, at leaft, was the cafe with the German fpecies examined by Mr Wenzel.

an ounce of diluted acid of vitriol for ſeveral days. No effervefcence enſued, neither had the acid loſt any of its taſte, nor was the manganeſe diminiſhed in quantity. I notwithſtanding filtered the liquor, and ſaturated the acid with alkali of tartar, whence I obtained a yellowiſh white precipitate. (B) Upon the remaining manganeſe I poured another ounce of diluted acid of vitriol; which, however, appearing to have no action upon it, I put another half ounce of levigated manganeſe into the mixture, and boiled it. The ſolution ſtill retained ſome acid taſte; but on adding two drachms more of levigated manganeſe its taſte grew bitter.

(C) I expoſed an ounce of powdered manganeſe, mixed with as much concentrated acid of vitriol as to reduce the maſs to the conſiſtence of honey, in a glaſs retort to the fire, till it became red hot, during which operation ſome vitriolic acid mixed with water came over in the receiver. After breaking the retort, the maſs was found hard, white in the inſide, and red on the ſurface; it weighed 12½ drachms. This maſs was reduced to powder, and diſtilled water poured upon it; in conſequence of which a great heat was generated, and a great deal of it diſſolved. The ſolution, after being filtered, was edulcorated. Afterwards, when it was dry, it appeared of a dark grey colour, and weighed one drachm and a half. This reſiduum was calcined in an open crucible with concentrated vitriolic acid, till no more vapours aroſe; then it was put into water, when one drachm remained undiſſolved, which was again calcined with concentrated vitriolic acid, and the undiſſolved reſiduum was a white powder, weighing half a drachm. (D) This white reſiduum was further inſoluble in the vitriolic acid. During its fuſion with borax, it made an efferveſcence, and yielded a tranſparent brown glaſs; it likewiſe efferveſced with fixed alkali, changing into a brown máſs, which yielded an hepatic ſmell with acids, becoming, at the ſame time, a gelatinous maſs. (E) The ſolution of mangameſe obtained by calcination was evaporated, and, in the firſt place, a few ſmall cryſtals were depoſited, which were nothing but vitriolated lime (ſelenite). Afterwards, ſome very fine large cryſtals, of an oblique parallelopiped form, were depoſited, which increaſed in number as long as there was any liquid remaining. Their taſte was very much like the taſte of vitriolated magneſia (Epſom ſalt). Mr Weſtfeld pretends that they are alum; but they reſemble alum in no other reſpect, except in containing the ſame acid.

§ III.

§ III. *Effects of phlogisticated Vitriolic Acid.*

I dipped, according to Stahl's prescription, some rags into a solution of fixed alkali of tartar, and, after saturating them with the acid of burning brimstone, I put them into a retort, poured some acid of tartar upon them, and luted on a receiver which contained water and levigated manganese. The retort was put into a sand-bath, and, after a warm digestion of one day, the liquid of the receiver had become as clear as water, and a little fine powder was precipitated to the bottom, consisting, for the most part, of siliceous earth.

§ IV. *Effects of pure Nitrous Acid*.*

(A) I poured one ounce of pure colourless nitrous acid upon two drachms of levigated manganese. After this compound had been kept in a heat of digestion for several days, the menstruum was found to have lost nothing of its acidity, nor was there any appearance of effervescence. I abstracted the acid by distillation, poured the distilled liquor again upon the residuum

* Under the name of pure nitrous acid I understand colourless nitrous acid—the fuming acid distilled in a gentle heat, till the mass remaining in the retort appears colourless, and yields white vapours when heated. Nitrous acid of this quality must be preserved in a glass vessel furnished with a ground stopple, in a dark room.

ſiduum, and diſtilled it over again, but very ſlowly. The reſiduum was but very little diſſolved. I again poured the diſtilled acid upon it, and afterwards added as much powdered mangane ſe as was neceſſary for the perfect ſaturation of the acid, and found that nine drachms were required for this purpoſe. (B) The ſolution of mangane ſe being by theſe means ſaturated, was filtered and divided into two equal portions. Into one of theſe I poured ſome drops of vitriolic acid, whereby a fine powder was precipitated, which, however, did not ſettle at the bottom till after ſome hours had elapſed. This powder was neither ſoluble in boiling water nor in acids. The limpid ſolution, after being evaporated, yielded ſome ſmall cryſtals of ſelenite or gypſum; but would afford no others. (C) From the other half of this ſolution, after it had been evaporated in a gentle heat, I obtained ſmall ſhining cryſtals, which, as well as the ſolution itſelf, were of a bitter taſte, and weighed about ten grains. On pouring ſome drops of vitriolic acid into this ſolution, inſpiſſated by a gentle heat, no precipitation enſued, except of a little ſelenite; but as ſoon as it was inſpiſſated to the conſiſtency of honey, ſome fine acicular cryſtals, verging towards the ſame centre, began to form, but they grew

grew ſoft and deliqueſced in a few days afterwards.

§ v. *Effects of phlogiſticated Nitrous Acid.*

As this acid ſhews, in ſeveral experiments, quite different phænomena from thoſe which the pure nitrous acid ſhews, I purpoſed to try its effects alſo upon manganeſe. I therefore put a little levigated manganeſe, mixed with ſome water, into a large receiver, to which I luted a tubulated retort, and poured through the opening ſome ounces of common nitrous acid, and added, at ſeveral different times, ſome iron filings, taking care to cloſe the veſſel always with a glaſs ſtopple. The nitrous acid thus combined with the phlogiſton of the iron went over into the receiver, and there united with the black maſs above mentioned. The manganeſe was thus entirely diſſolved in a few hours time; the ſolution was as limpid as water, a little fine earth excepted, which was ſiliceous. There began now to precipitate a white earth, of the ſame kind as that mentioned in § iv. (b). In other reſpects, this ſolution agreed with that made in pure nitrous acid, as it is deſcribed in the preceding paragraph.

§ vi. *Effects of common Muriatic Acid.*

(a) I poured an ounce of purified muriatic

riatic acid upon half an ounce of levigated manganefe. This acid, after ftanding quiet for an hour's time, grew dark brown. A portion of this folution was digefted in an open glafs veffel in heat. It yielded a fmell like warm aqua regia. In a quarter of an hour, the fmell was gone, and the folution became clear and colourlefs. (B) The reft of the brown folution was digefted, with a view to fee whether the muriatic acid would be faturated with manganefe. As foon as it grew warm, the fmell of aqua regia was confiderably ftronger, and an effervefcence enfued, which lafted till the next day, when the folution was found faturated. Upon the refiduum, which was not diffolved, I poured another ounce of muriatic acid, which was followed by the very fame phænomena, and the manganefe was entirely diffolved, a fmall quantity of filiceous earth remaining. (C) This yellow folution was divided into two portions. Into the one I poured fome drops of vitriolic acid, and the folution in a few minutes turned white, and a fine powder was precipitated, which was not foluble in water. After the folution was evaporated, fome fmall felenitic cryftals formed, and the refiduum exhibited the fame phænomena as are defcribed above, with the mixture of nitrous acid and manganefe.

(D) The

(D) The other half was evaporated, and ſome ſmall angular ſhining cryſtals were obtained, which, with regard to their cryſtalliſation, agreed with thoſe obtained by the nitrous acid.

§ VII. *Effects of Fluor Acid.*

But very little of the manganeſe, after being digeſted with this acid for ſeveral days, was diſſolved; and it was neceſſary to add a very large quantity of levigated manganeſe before the acid was ſaturated. The ſolution had hardly any ſenſible taſte; a little precipitation took place on adding alkali. But if a neutral ſalt, compoſed of this acid and volatile alkali, be added to the ſolution of manganeſe in any one of the above mentioned acids, a double decompoſition takes place, and the manganeſe uniting with the fluor acid is precipitated.

§ VIII. *Effects of Phoſphoric Acid.*

One drachm of phoſphoric acid being boiled with half a drachm of powdered manganeſe, diſſolved but little of it; and, though evaporated to dryneſs, the remainder had a very ſour taſte. At laſt, however, by adding more manganeſe, the acid was ſaturated. On adding microſmic ſalt to a ſolution of manganeſe, a decompoſition follows, like that effected by the fluor acid.

§ IX.

§ IX. *Effects of Acid of Tartar.*

Pure acid of tartar, digested in the cold with manganese, produced a brown solution; but, on digesting in heat, more was dissolved with a kind of effervescence; the whole quantity, however, was not dissolved, but the acid was at last saturated by the addition of more manganese. On adding tartarized fixed alkali to a solution of manganese, a double decomposition happens, as § VII. VIII. IX.

§ X. *Effects of distilled Vinegar.*

In a boiling heat little of the manganese was dissolved by vinegar; but, after distilling the spirit of verdigrease several times from manganese, the acid was saturated. On adding vitriolic acid, I obtained a little white precipitate, (§ IV. B). Of the remaining manganese hardly any sensible quantity was dissolved by concentrated vinegar, though repeatedly distilled over it. The product of the solution upon evaporation to dryness was deliquescent in the open air.

§ XI. *Effects of Acid of Lemon.*

Two drachms of levigated manganese were digested with an ounce of the acid of lemon. The mixture, when cold, acquired a brown colour; but, on the application

application of heat, the liquid began to effervefce, which continued till the acid was faturated, when it had loft its brown colour. In the fame manner the remaining manganefe was diffolved. More acid was poured upon it, and thus the whole was in a few hours diffolved, a white earth excepted.

§ XII. *Effects of Aerial Acid.*

I faturated cold water, which contained a little fnow unmelted, with aerial acid, and then put a little levigated manganefe into it. The phial which contained this mixture was carefully clofed, and left for feveral days in the cold, during which time it was now and then agitated. The liquor was afterwards filtered, and alkali added to it, upon which a white powder precipitated. The manganefe likewife feparated from its folution, on ftanding a few days in the open air.

§ XIII.

Such are the effects of acids upon manganefe. What is moft remarkable in them is, that fome of the acids, fuch as the volatile fulphureous, the phlogifticated nitrous, the common muriatic acids, and the acid of lemon, completely diffolve it. Others during the folution caufe a confiderable effervefcence; others again produce

duce the ſolution quietly, and others diſſolve a part of the manganeſe only. Before I enter upon any explication of theſe ſingular phænomena, it will be neceſſary to point out the general properties of manganeſe.

§ XIV.

(1.) Manganeſe has a ſtrong elective attraction for all phlogiſtic ſubſtances. (2.) This attraction becomes ſtronger, if there be a menſtruum preſent which at the ſame time can unite with the phlogiſticated manganeſe. In this ſituation the manganeſe is able to attract phlogiſton more ſtrongly than the nitrous acid does *viâ humidâ*. (3.) When manganeſe is ſaturated with phlogiſton, it loſes its black and aſſumes a white colour, which however diſappears as ſoon as the phlogiſton is ſeparated from it again. (4.) Without combining it with phlogiſton, there is no way of producing a colourleſs ſolution of manganeſe in any acid; and, whenever phlogiſton is wanting, the ſolution becomes blue or red. By means of theſe four general qualities of manganeſe, diſcovered by a train of experiments, all its known effects are eaſily explicable, as will appear from the following obſervations.

§ XV.

§ XV.

Diluted vitriolic acid diſſolves manganeſe only in part, whether digeſted or boiled with it, (§ II. A). This part therefore ought to be ſeparated from the reſt, becauſe the ſolution of manganeſe is never colourleſs, except when combined with phlogiſton, (§ XIV. No. 4.) Whence it follows, that this ſoluble part of it is united with phlogiſton. That manganeſe naturally contains but little phlogiſton, has been ſome time ago taught by Mr Weſtfeld; but the cauſe he aſſigns is not to be admitted, till it is confirmed by other arguments, eſpecially as nitre, without the addition of phlogiſton, may become alkaleſcent, and that the ſooner, if there be a body preſent which is capable of uniting with the alkali, in which caſe a heat only half as ſtrong is requiſite. This happens in the calcination of manganeſe with nitre; for if the mixture is diſtilled, nitrous acid is obtained in the receiver: But that ſome phlogiſton really enters into the compoſition of manganeſe, the following experiments will ſhew: (A) If the ſolution of manganeſe in vitriolic acid (§ II. A, B) be evaporated to dryneſs, and then the reſiduum diſtilled in the open fire in a glaſs retort, with a receiver applied to it, the vitriolic acid does not ſeparate from the manganeſe

manganese till the retort begins to melt; but it is then changed into volatile sulphureous acid. The residuum is black, and nothing but common manganese. (B) Let the solution of manganese in nitrous acid (§ IV. A) be put into a glass retort, all the liquid abstracted, and, when it begins to foam, let a receiver, with some water in it, be applied. By a slow fire, the nitrous acid, employed for the solution, will be driven over in the form of blood-red vapours, and yield green volatile nitrous acid. In the retort there will remain likewise real black manganese. (C) A solution of manganese in vitriolic or pure nitrous acid, (§ II. IV. B, A) precipitated by alkali of tartar, retains its colour; but, when calcined in the open air, grows black (§ XIV. No. 3.). Hence it follows, that manganese contains phlogiston; and, since the residuums in the retort have lost their phlogiston, by means of which they were united with the acids, they are no longer soluble in pure acids. If therefore vitriolic acid be poured upon the residuum (A), little or nothing of it will be dissolved; but if the volatile vitriolic acid, which was driven over into the receiver, be poured upon it, it will again dissolve it, a small portion excepted, for want of a sufficient quantity of acid; for there is some of the acid

acid loſt during the diſtillation through the lute. The ſame thing happens with the diſtillation and ſolution of manganeſe in nitrous acid, (B).

§ XVI.

Now, ſince only a part of this mineral is diſſolved by the vitriolic acid, it may be aſked, Why the remainder does not diſſolve? To this I anſwer, The undiſſolved portion has parted with the little phlogiſton it naturally poſſeſſed, to that portion of manganeſe which is taken up by the vitriolic acid during the firſt digeſtion; for, without that principle, manganeſe is inſoluble. That the remaining manganeſe loſes its phlogiſton, is evident from this, that if nitrous acid be abſtracted from it, there appears little or no red vapour. That manganeſe, according to its ſecond general property, attracts phlogiſton more ſtrongly when it is combined with ſome acid, the following experiments will ſhew: (A) Levigated manganeſe digeſted or boiled with a ſolution of ſugar, honey, gum Arabic, hartſhorn, jelly, undergoes no change. But on mixing the manganeſe with ſome diluted vitriolic or pure nitrous acid firſt, afterwards adding ſome of theſe ſubſtances, and expoſing the whole to digeſtion, you perceive with admiration how the black colour vanifhes by degrees, and the folution becomes as limpid as water. During this phænomenon, a quantity of air-bubbles is difcharged with a violent effervefcence; they are found to be aerial acid. Nay, manganefe, in fuch a combination, fhews fuch a ftrong attraction for phlogifton, that metals, not even the noble ones excepted, render it foluble in thefe acids in a limpid form; and what is ftill more remarkable, the volatile alkali, as well as the above mentioned vegetable and animal fubftances, is entirely deftroyed. But of this I fhall fpeak more fully hereafter. At prefent I conclude from thefe experiments, that the fuperficial particles of levigated manganefe, on touching an acid, acquire a great attraction for phlogifton; and if fuch an acid contains no phlogifton, nor the manganefe fo much as is requifite for its entire folution (§ II. IV. A, A), thofe fuperficial particles attract as much of the phlogifton as is required from the particles next adjacent to them, which have not yet come in contact with the acid. This is the reafon why the external particles diffolve in vitriolic or nitrous acid; and the internal, or thofe lying neareft under the external ones, having been deprived of their phlogifton, remain undiffolved; but thefe likewife diffolve as foon as the requifite phlogifton is communicated

municated to them from the above mentioned ſubſtances, ſuch as ſugar, &c.

§ XVII.

We now come to ſpeak of the effects of concentrated vitriolic acid on mangaueſe, (§ II. c). It is remarkable, that this acid diſſolves the manganeſe entirely without the addition of any phlogiſton. It would be difficult to comprehend whence the phlogiſton in this caſe ſhould come, if we were not certain that ſeveral ſubſtances, which have a great attraction for phlogiſton, can attract it in a red heat. Quickſilver, and ſilver when diſſolved in the pureſt nitrous acid, really loſe the phlogiſton (§ IV.), which is a conſtituent part of theſe metals. This appears from the red vapours, under the form of which the nitrous acid ariſes; and the diſſolved metallic earth cannot be again reduced to its metallic form, till it has again acquired the loſt phlogiſton, which is effected either by precipitation with complete metals, or elſe by means of heat alone. It is known, that nitrous acid, when combined with a little phlogiſton, adheres afterwards to abſorbent bodies ſo looſely, that it may be expelled from them by vegetable acids. If a ſmall glaſs retort, filled with nitre, is kept upon the fire, till the nitre ſhall

 have

have been in a red fuſion for half an hour, it is found, after cooling, to have acquired ſome phlogiſton. For, when rubbed with tamarinds, a ſtrong ſmell of aquafortis riſes; and it likewiſe deliqueſces in the open air, though there is no mark of any ſuperabundant alkali. And what elſe can be the cauſe, that fuming nitrous acid, when diſtilled, riſes at laſt, when the retort is nearly of a white heat, in blood-red vapours, whereas it aſcends during the diſtillation in a limpid form like water? I could adduce many more experiments to prove, that phlogiſton is contained in fire, if I was not afraid of rendering this diſſertation too long. This, however, I may add, that the following objection is void of foundation: Why, if what I aſſert was really the caſe, the calces of the ignoble metals are not equally reducible by heat? ſince all bodies have not an equal degree of attraction to phlogiſton.

Thus manganeſe can attract the quantity of phlogiſton neceſſary for its ſolution, by means of concentrated vitriolic acid, from heat. It is not probable, that the concentrated acid undergoes a decompoſition in this degree of fire; for if you ſaturate half an ounce of this acid with alkali of tartar, and afterwards calcine in a retort, with a receiver applied, an ounce and

and a half of powdered manganefe, with an equal quantity of the fame vitriolic acid, then diffolve the calcined mafs in diftilled water, and likewife wafh well the receiver, which contains fome drops of vitriolic acid, which are alfo to be added to the folution; and laftly, add the fame quantity of alkali, there will be no mark either of abundant alkali or acid. Thence it may be concluded, that the phlogifton in the vitriolic acid (if there really exifts any in it) contributes nothing to the folution. But the manganefe, precipitated with alkali, contains a confiderable quantity of it; in confequence of which, it is afterwards entirely foluble in acids, without the addition of any phlogifton.

§ XVIII.

Manganefe is often mixed with heterogeneous earths, which are not to be reckoned as its conftituent parts. Among thefe are, (1.) a little iron ochre. This was the reafon why the mafs in the retort, after diftillation, was red on the outfide (§ II. c), becaufe it was there expofed to the greateft heat; whence the vitriolic acid, that was combined with the iron, quitted it. Calx of iron is befides eafily obtained from the folutions of manganefe in acids. If a few drops of a folution of alkali are

 dropped

dropped in, the iron will be precipitated firſt, becauſe it has leſs attraction for the acid than the phlogiſticated mangaueſe has. That this ſmall quantity of calx of iron is only mechanically mixed with manganeſe, has been proved by Mr Pott, and afterwards by Mr Rinman, though Mr Weſtfeld looks upon it as a conſtituent part of manganeſe. (2.) Some ſiliceous earth is likewiſe found mixed with manganeſe, but it does not enter into the ſolution, (§ II. D). That the ſiliceous earth is not pure, appears from experiment; but it may be obtained quite pure by means of proper acids. (3.) A little calcareous earth, which, as far as I know, has not hitherto been taken notice of. It is this with which the ſeparated ſiliceous earth is mixed, (§ II. D); and, in conſequence of its abſorbent nature combining with the vitriolic acid, it forms a neutral ſalt, which is ſoluble in water, and forms with borax a brown glaſs (§ II. D), on account of the ſulphur produced during the fuſion; of which I ſhall ſpeak more particularly hereafter, § XXXII.

§ XIX.

If the ſalt, conſiſting of vitriolic acid and manganeſe (§ II. C), be again diſſolved in diſtilled water, and afterwards cryſtalliſed, it will be obtained in a ſtate of

purity,

purity, containing nothing of the admixtures, mentioned in the preceding paragraph. From it manganefe, faturated with phlogifton, may be precipitated by alkali of tartar. That this manganefe is really faturated with phlogifton, appears from this, that it cannot be united with more phlogifton, fo as to yield any metallic fubftance. If Mr Weftfeld had examined this precipitate a little more, he certainly would not have pronounced it to be the earth of alum. The earth, thus obtained, is without the leaft particle of iron, and is befides endowed with all the properties which mineralogifts afcribe to manganefe, after the phlogifton has been feparated from it by calcination in the open air, (§ xv. c). Thence I infer, that Mr Weftfeld's Differtation affords no inftruction whatfoever.

§ xx.

The effects of volatile fulphureous acid on manganefe clearly prove what has been afferted (§ iii.). The manganefe attracts the phlogifton contained in this acid, which is the caufe of its great volatility, and which renders the manganefe foluble in the now pure vitriolic acid. If this folution be mixed with concentrated vitriolic acid, and diftilled, no volatile fulphureous acid is obtained; and if it be precipitated by means of fixed vegetable alkali, vitriolated tartar is obtained. This proves that manganeſe has a ſtronger attraction for phlogiſton than for vitriolic acid in the moiſt way.

§ XXI.

The effects of nitrous acid on manganeſe coincide, upon the whole, with thoſe of vitriolic acid. If this acid could ſupport ſuch a degree of heat as the other in a ſtate of concentration, it would alſo entirely diſſolve the manganeſe without the addition of any phlogiſton. But as this is not the caſe, it is neceſſary to ſupply the defect of phlogiſton. The extraneous ſubſtances mixed with it appear in this proceſs more clearly, (§ XVIII.). Here the pure ſiliceous earth remains undiſſolved at the bottom; but another unknown earth unites with the nitrous acid, and yields cryſtals, (§ IV. C). It likewiſe may be precipitated by the vitriolic acid; and this is the precipitate mentioned in the ſame place (H), as inſoluble in water. The calcareous earth, with vitriolic acid, forms gypſum, and the ſmall portion of iron is readily ſeparated, by means of a few drops of alkali of tartar, (§ XVIII. No. I.).

§ XXII.

§ XXII.

All this appears ſtill more clearly with phlogiſticated nitrous acid. The mangaeſe decompoſes this acid for the ſame reaſon as it does the volatile ſulphureous acid (§ XX.). That the phlogiſton of the acid really combines with the manganeſe, appears from this, that on adding to ſuch a ſolution ſome vegetable acid, there is no ſmell of aquafortis obſerved, (§ XVII.) and the diſtillation with pure vitriolic acid yields limpid, by no means yellow, nitrous acid. There appears no effervеſcence here, as happens with the ſolution in pure nitrous or vitriolic acids, on adding a little gum or ſugar (§ XVI. A). It is well known, that a great quantity of aerial acid is conſtantly developed in the decompoſition of any animal or vegetable ſubſtance. Now, ſince manganeſe, aſſiſted by acids, has the ſame effect upon thoſe ſubſtances as air and other bodies have, which extract from them their phlogiſton, there muſt neceſſarily be, in this proceſs, a ſeparation, or perhaps a generation of aerial acid. But, in the preſent caſe, with phlogiſticated nitrous acid, no ſuch effervеſcence can take place, becauſe it is combined with pure phlogiſton; and if this be again ſeparated, I do not ſee why aerial acid ſhould be extricated. Moreover, manganeſe,

ganeſe, when united with nitrous acid and metals, arſenic or oil of turpentine, is entirely diſſolved without ſhewing any effervefcence.

§ XXIII.

The VIth paragraph ſhews the effects of muriatic acid. In this caſe, perhaps, it does not immediately appear whence manganeſe ſhould obtain its phlogiſton; no phlogiſton being added here, and the entire ſolution taking place without heat. There occurs, indeed, here a circumſtance, which certainly proves that muriatic acid contains ſome phlogiſton; a property which one ſhould have attributed to the nitrous acid, chemiſts having been of opinion that this principle was preſent in a pretty large quantity, as one of its conſtituent parts. But this we now reverſe, and attribute phlogiſton to the muriatic acid.

Muriatic acid, when digeſted in the cold with manganeſe, aſſumes a dark-brown colour (§ VI. A); for, ſince this ſubſtance never affords a colourleſs ſolution without phlogiſton, the preſent ſolution will be either blue or red (§ XIV. IV.), though the muriatic acid is capable of diſſolving manganeſe, without the addition of the inflammable principle. In this caſe, the colour has more of brown than red, on account of the fine particles of the manganeſe nefe floating in the folution, and not eafily finking to the bottom; for, without thefe particles, the folution is red; and red mixed with black yields a brown colour. Manganefe adheres here loofely to the muriatic acid; fo that it may be precipitated by water; and the precipitate fhews the fame properties as common manganefe. Whenever I expofed the mixture of manganefe and muriatic acid to digeftion, an effervefcence enfued with a fmell of aqua regia, (§ VI. B).

In order to fet this new difcovery in a clear light, I tied to the neck of a retort, which contained a mixture of manganefe and muriatic acid, an empty bladder, and put it into hot fand. An effervefcence enfuing, the bladder was filled. When the acid no longer occafioned any effervefcence, which was a fign of its faturation, I took the bladder off, and found that the air had rendered the bladder yellow, as nitrous acid would have done; but there was not the leaft mark of aerial acid, only a very fenfible pungent fmell, highly oppreffive to the lungs, and refembling the fmell of warm aqua regia. The folution in the retort was clear, and of a yellowifh hue, which was owing to the iron contained in it. If you wifh to be convinced, that the manganefe, thus diffolved, likewife contains phlogifton, you fhould precipitate the folution with alkali

of

of tartar, edulcorate the precipitate, and treat it in the manner above mentioned, (§ XVI. A, B, C). But whence did it acquire its phlogiston? From the muriatic acid. The matter of heat has no share here, because the solution becomes limpid without it, if it be only exposed to the air for a few hours. The following is the theory of the solution: The manganese is first attacked by the acid, and thus we have a brown solution. The manganese, when dissolved, acquires, by means of the acid, a strong attraction for phlogiston, (§ XIV. No. 2.) and really attracts it from the particles with which it is combined. These particles having thus lost one of their constituent parts, and being but very loosely combined with the phlogisticated manganese, are expelled from it by the remaining muriatic acid, which has not yet suffered any decomposition, and now appear with an effervescence, as an highly elastic air; the brown colour has now disappeared, and the solution is become limpid.

§ XXIV.

The marine acid separated from phlogiston, one of its constituent parts, unites with water in a very small quantity only, and gives it a slight acid taste: But, whenever it is enabled to combine with phlogiston,

giſton, it aſſumes its former nature, and again becomes a true muriatic acid. In order to diſcover the properties of this aerial fluid, it is beſt to examine it in its elaſtic ſtate. Common muriatic acid is to be mixed with levigated mangaueſe in any quantity in a glaſs retort, which is to be put into warm ſand, and a glaſs receiver applied, capable of containing about twelve ounces of water. Into the receiver put about two drachms of water; the joints are to be luted only with a piece of blotting paper tied round them. In a quarter of an hour, or a little longer, a quantity of elaſtic acid, going over into the receiver, gives the air contained in it a yellow colour, and then it is to be ſeparated from the retort. At this time, if the paper has been cloſely applied, a portion of the aerial fluid will ruſh out with ſome force; and you therefore muſt have a cork ready to cloſe it immediately; and then another receiver, with two drachms of water in it, ſhould be applied to the retort as before; and thus ſeveral ſuch veſſels may be filled with dephlogiſticated muriatic acid. In the proceſs care ſhould be taken, that the retort be fixed in ſuch a poſture, that if a few drops ſhould riſe into its neck, they may run back into the body. The water put into the receivers ſerves to condenſe the vapours of

marine

marine acid, ſhould any go over. I fill ſeveral glaſſes at once, in order to get a good quantity, and to avoid the trouble of repeating the proceſs as often as I want ſome of the fluid for my experiments. It is better to make uſe of ſmall veſſels for receivers, becauſe a great part of the acid is loſt every time the cork is taken out.

§ XXV.

The bodies which I wiſhed to expoſe to the action of this dephlogiſticated aerial fluid were fixed in a glaſs tube, which paſſed through the cork of the receiver. I obſerved that the corks (A) became yellow within the receiver, as from aquafortis, and the lute was likewiſe corroded during the diſtillation. (B) Paper coloured with lacmus became nearly white; all vegetable red, blue, and yellow flowers, grew likewiſe white in a ſhort time; the ſame thing happened to green vegetables: Meanwhile, the water in the veſſel was changed into a weak but pure muriatic acid. (C) The former colour of the flowers, or of the green vegetables, could not be recovered either by alkalis or acids, (D), expreſſed oils and animal fat, whether dropped into the tube, or ſmeared upon it, grew in a ſhort time as tenacious as turpentine. (E) Cinnabar grew white upon the ſurface, and, when it was

waſhed

waſhed in water, a pure ſolution of corroſive ſublimate was obtained; but ſulphur was not changed; (F) vitriol of iron grew red and deliqueſcent; vitriol of copper and zinc remained unchanged; (G) iron filings, put into the tube, were diſſolved. The ſolution, after being evaporated to dryneſs, and then diſtilled with the addition of ſome concentrated vitriolic acid, again yielded pure marine acid, in which gold remained undiſſolved. (H) All the metals were attacked; and, with regard to gold, it is remarkable that its ſolution in this dephlogiſticated muriatic acid yields with volatile alkali aurum fulminans. (I) When ſome volatile alkali, prepared from ſal ammoniac and quicklime, was dropped upon the tube, a white cloud was produced, and a great number of air-bubbles were diſcharged from them, which, on burſting, yielded a vapour. (K) Fixed alkali was changed into common ſalt, which decrepitated, but did not detonate in the fire. (L) Arſenic became deliqueſcent in this vapour; (M) inſects inſtantly died in it; (N) and fire was inſtantaneouſly extinguiſhed.

§ XXVI.

This ſufficiently ſhews how ſtrong an attraction dephlogiſticated muriatic acid has for phlogiſton. Perhaps STAHL obtained

tained fuch a dephlogifticated muriatic acid by means of iron, and, from the yellow colour of the cork, was led to fuppofe that the muriatic had been changed into the nitrous acid. If you make a mixture of manganefe, muriatic acid, or diluted vitriolic acid and alcohol, and, after digefting it in a well clofed phial for fome days, diftil it by a gentle fire, no effervefcence enfues; but the fpirit of wine goes over, and, what is very remarkable, has a ftrong fmell of nitrous æther. The remainder in the retort will have loft its acidity, and be faturated with manganefe. If metals, fugar, linfeed, or oil of turpentine, be combined with a mixture of pulverized manganefe and muriatic acid, no fuch dephlogifticated muriatic acid is produced; becaufe, in this cafe, a fufficient quantity of phlogifton is prefent for the elaftic acid to unite with. It is remarkable of quickfilver, that a great part of it enters into the folution, and may be afterwards again obtained by cryftallifation with all the properties of corrofive fublimate. If plates of pure gold be put into a mixture of pulverized manganefe and pure muriatic acid, it will afterwards appear that gold as well as manganefe is contained in the folution.

§ XXVII.

§ XXVII.

As fluor acid yields a precipitate with manganefe, (§ VII.), it is eafily underftood why it diffolves fo little; for the falt forms a fine pellicle round the particles of the manganefe, and thus prevents the acid from penetrating any further. The fame thing happens with the acid of phofphorus, (§ VIII.); for microcofmic falt likewife produces a precipitation.

§ XXVIII.

The effects produced on manganefe by the acid of tartar are remarkable, on account of the effervefcence. Manganefe does not enter with any acid into a colourlefs combination, without being firft united with phlogifton. The fmall portion of phlogifton, which it naturally contains (§ XV. A, B, C), may ferve to render it foluble in all acids; but this only in very fmall quantity. The effervefcence which happens in the prefent cafe fhews, that a part of the acid of tartar is entirely deftroyed, in confequence of the combination of its phlogiftic part with the manganefe, as is explained in § XXII. in which the deftruction of animal and vegetable fubftances is defcribed. To this it may be added, that if you make the folution with a proper proportion of fugar, gum,

 &c.

&c. there will not remain the leaſt mark of thoſe ſubſtances, (§ XVI. A). This is eaſily proved; for, if ſuch a ſolution be filtered, inſpiſſated, and ſlowly calcined with concentrated vitriolic acid, there ſhould neceſſarily appear ſome blackneſs from the burned ſugar, which however does not take place. During this decompoſition of ſugar or gum, there ariſes a vapour that vellicates the noſe; and, if it be collected in a receiver, it appears to be pure vinegar. From diluted vitriolic acid, ſugar and mangeneſe, this acid is obtained in its pureſt ſtate.

§ XXIX.

Among the vegetable acids, diſtilled vinegar combines moſt looſely with abſorbents; for the acids of lemon and tamarinds expel it from its union with fixed alkali in acetated vegetable alkali, (*terra foliata tartari*). Its inflammable part is more cloſely united than in the reſt of the vegetable acids, ſince it ariſes with it into the receiver, which is not the caſe with the other acids which are deſtroyed, except the volatile dry acids of benzoin and amber. Hence it appears, that vinegar acts upon manganeſe in no other manner than diluted nitrous and vitriolic acid do, (§ XV—XXI). If this acid had a greater attraction for phlogiſticated manganeſe, nefe, or if its phlogifton was not fo clofely combined, the manganefe would decompofe it, as really happens with phlogifticated vitriolic acid, with volatile nitrous acid, and the acids of tartar and lemon.

§ XXX.

The acid of lemon is likewife decompofed by manganefe, as well as that of amber. During putrefaction and combuftion the acid of lemon alfo yields a great deal of aerial acid, which is here the real caufe of the effervefcence during the folution. The brown colour affumed at firft by the folution, is a proof that the acid of lemon can diffolve the manganefe, without its being firft united with phlogifton. The acid of tartar produces likewife in the beginning a folution of a fomewhat brown colour. The caufe of this colour is the very fame with that affigned with refpect to the muriatic acid.

§ XXXI.

The XIIth paragraph fhews that aerial acid too has fome effect upon manganefe. I have related this experiment to fhew, that, from a folution in any acid, if there be an excefs of the acid, all the manganefe is not precipitated by vegetable alkali, though it be added till the acid is completely

pletely ſaturated; for the aerial acid, which is extricated from the alkali, diſſolves part of the mangaueſe.

§ XXXII.

The peculiar kind of earth found in all the limpid ſolutions of manganeſe, and mentioned § XVIII. No. 4. remains to be more carefully examined. I ſhall here ſpeak of a few particulars in which it differs from others.

(A) The ſmall cryſtals which appear on the evaporation of the ſolution of manganeſe in nitrous and muriatic acids, § IV. C, § VI. D, conſiſt of this earth combined with thoſe acids. They are eaſily ſoluble in water, and may be freed from the adhering ſolution of manganeſe, by repeated evaporation and cryſtalliſation. They are inſoluble in ſpirit of wine, have an auſtere taſte, and do not attract moiſture from the atmoſphere. (B) Diſſolved in water, they are neither precipitated by fixed nor volatile cauſtic alkalis, nor by lime-water; but, on addition of the mild, fixed and volatile alkalis, an earthy precipitation takes place. (C) This precipitate, after being edulcorated and dried, is white, and effervesces with all the acids. If calcined, it grows a little bluiſh, and produces no effervefcence with acids, but is diſſolved by them when heat is applied. It is not ſoluble

ſoluble in water, but expels the volatile alkali from ſal ammoniac. (D) Expoſed to the blowpipe, it is at laſt changed into an opal-coloured glaſs, which is again ſoluble in acids. (E) With fixed alkali it undergoes no change. (F) Borax diſſolves it with effervеſcence, and thus forms a glaſs, which is colourleſs and tranſparent as long as it continues hot, but opaque when cold. (G) The ſolution of this earth in nitrous or muriatic acids is not precipitated either by phoſphoric, tartar, or fluor acid, though it is by all ammoniacal ſalts containing theſe acids. (H) This ſolution is precipitated by vitriolic acid, and the precipitate is inſoluble in water (§ IV. VI. B, C). It is likewiſe precipitated by vitriolated vegetable, foſſil, volatile alkalis, and lime; as alſo by iron, copper, and zinc, combined with the ſame acid. (I) The vitriolic acid is not ſeparable from this earth, either by alkali, lime, or ſolution of ſilver or quickſilver. The only means to effect this ſeparation is to convert the acid into ſulphur. This may be done, by mixing the edulcorated precipitate with alkali of tartar, and a little charcoal powder, fuſing the mixture, afterwards diſſolving the maſs in water, and edulcorating the powder that lies at the bottom, which then may be again diſſolved in nitrous acid, and thus purified from the charcoal. (K)

 By

By fuſing it with black flux and powder of charcoal I obtained no metallic ſubſtance.

Hence it appears, that this earth differs from all other earths hitherto known. But I am alſo convinced from experiments, that this earth is not found in manganeſe alone: For, when you lixiviate potaſhes made of trees, or other ſmaller vegetables, in order to free them from vitriolated tartar, and afterwards diſſolve them in pure nitrous or muriatic acid, filter the ſolution, and dilute it with water; then, on pouring into it ſome drops of vitriolic acid, you obtain, in a quarter of an hour's time, a fine white precipitate, which conſiſts of this earth and vitriolic acid, and is exactly the ſame with the precipitate of (B).

§ XXXIII. *Manganeſe united with Phlogiſton.*

In order to obtain the manganeſe in this ſtate pure, it ought to be precipitated from limpid colourleſs ſolutions by alkali of tartar. The ſhorteſt way to obtain it in this manner has been already mentioned § XIX. It is white like chalk, and I ſhall call it for the future *phlogiſticated manganeſe.* That this precipitate contains phlogiſton, has been already evinced by ſeveral experiments; and it has been likewiſe mentioned, that it loſes its white colour by calcination in an open fire. The

ſame

ſame circumſtance is obſerved when the ſolution of manganeſe is precipitated by fixed or volatile cauſtic alkalis: For thus a white precipitate is obtained, which, when expoſed to the air, ſoon grows dark-brown, but retains its colour when kept in a cloſe glaſs veſſel. The manganeſe, however, precipitated by fixed vegetable alkali, retains its white colour in the open air. The reaſon of this is, becauſe it is united not only with phlogiſton, but likewiſe with aerial acid; the precipitate is conſequently, properly ſpeaking, a ſalt. No ſolution of manganeſe in acids is decompoſed by air alone; whence it appears, that the acids enhance the attraction of manganeſe for phlogiſton. The manganeſe, therefore, of which Mr Rinman ſpeaks in his Eſſay, muſt be a white manganeſe prepared by art.

§ XXXIV.

(A) If you dilute a ſolution of manganeſe with a good deal of water, and afterwards precipitate it with cauſtic alkali, the precipitate from the very beginning is brown, and has all the properties of pure manganeſe. Here it evidently appears, that the air contained in the water is ſufficient to attract the phlogiſton of the manganeſe as ſoon as it is ſeparated from the acid. For the ſame reaſon, manganeſe precipitated from its ſolution by lime-water, is brown; but, on adding more of a concentrated ſolution of mangaueſe, and afterwards ſome cauſtic alkali, the precipitate is white; becauſe the air contained in the water, being already ſaturated with phlogiſton, is not able to combine with any more.

(B) On diſtilling an ounce and an half of phlogiſticated mangaueſe in a glaſs retort with a ſtrong fire, a great quantity of aerial acid, with ſome drops of water, came over. The retort being ſtill warm, I poured the manganeſe out upon a piece of paper, when it immediately grew red hot, and ſet the paper on fire.

(C) The ſame experiment was repeated with a drachm; and an empty bladder was tied to the neck of the retort; the diſtillation was continued with a ſtrong fire as long as the bladder was diſtended by the air.

This air occupied the ſpace of three ounces of water. The reſiduum in the retort afterwards weighed thirty-five grains, was of a light grey colour, diſſolved in acids, without the addition of phlogiſton, with a great heat. At that degree of heat, at which ſulphur ſmokes, but does not take fire, it grew black, and began to turn red hot. From theſe experiments, it follows, that, in cloſe veſſels, phlogiſton does

does not ſeparate from mangaueſe, if the acceſs of air be prevented, (§ XIV. No. 3.)

§ XXXV.

In § XV. I obſerved that manganeſe decompounds nitre, and that the acid paſſes over. This does not happen till the mixture grows red hot. (A) If phlogiſticated manganeſe be mixed with an equal quantity of pure nitre, and diſtilled in a glaſs retort provided with a receiver, it is obſervable, that the mixture begins to grow black before the retort becomes red hot, but no nitrous acid goes over. If it be afterwards lixiviated, there appears no mark of any uncombined alkali in the lixivium; but, on mixing the ſolution with tamarinds, an odour of aquafortis immediately ariſes. (B) If three parts of phlogiſticated manganeſe, mixed with one part of finely powdered nitre, be diſtilled in the ſame manner, but the diſtillation be ſtopped as ſoon as the mixture grows black, the nitre is found to be alkalized; no nitrous acid, however, is found in the receiver. All this proves clearly, that phlogiſton is contained in manganeſe.

§ XXXVI.

I likewiſe examined the effects produced on manganeſe by unctuous oils, and inflammable bodies.

(A)

(A) One part of finely powdered manganefe, digefted with four parts of olive oil, underwent no change; but as foon as the oil grew hotter, the mafs began to effervefce violently, which is owing to the extrication of aerial acid. After the mafs was become cold, the manganefe was found to be diffolved, and had the confiftence of falve. (B) A mixture of finely powdered manganefe and charcoal was diftilled in a fmall glafs retort, to which an empty bladder was tied. When the retort began to melt, a quantity of aerial acid was extricated, and filled the bladder (§ XXII.). The remainder in the retort was for the greateft part foluble in fpirit of vitriol, without the addition of any phlogifton. Spirit of wine, æther, oil of turpentine, produced no change upon manganefe by themfelves.

§ XXXVII.

(A) Half an ounce of powdered manganefe mixed with two drachms of pounded fulphur were expofed to diftillation in a glafs retort. A part of the fulphur rofe to the neck of the retort, and fome of the volatile acid penetrated through the lute; at laft the retort melted. After the refiduum was cold, it weighed $5\frac{1}{2}$ drachms, and appeared of a yellowifh grey colour. It diffolved in fpirit of vitriol with effervefcence, vescence, and with an hepatic smell; when it was filtered, some sulphur remained on the filter. It is insoluble in water. Upon calcination in the open air, the sulphur was volatilised, and the mass assumed a brown colour. After this process a good deal of the mass dissolved in water, and shot into crystals, which were exactly like those of parag. XXII. The insoluble residuum being calcined with more sulphur in the same manner, was at last entirely reduced to such crystals. This has also been observed by Mr Westfeld; but he supposed them to be alum, to which I can by no means assent.

§ XXXVIII. *With Nitre and fixed Alkali.*

(A) Nitre triturated with manganese to a fine powder, and strongly calcined in a crucible, loses its acid, and the manganese combines with the alkali, forming a dark-green mass, which is soluble in water, communicating to it a green colour. The colour is in reality blue (§ XIV. No. 4.); for, after the solution has been kept for a few days in close vessels, a fine yellow powder precipitates by degrees, which for the greatest part is nothing but crocus martis, and the solution afterwards turns blue. (B) In such a solution, the manganese is very loosely combined with the alkali; for it can be separated from it by water

water alone. This mixture is at firſt of a violet colour, grows afterwards red, and when the red particles come into cloſer contact with one another, the red colour diſappears, and the powder precipitated has the natural colour of manganeſe. (c) The ſame thing happens if the blue ſolution of manganeſe be mixed with a few drops of an acid, or if the ſolution has been expoſed for a few days to the open air; the cauſtic alkali, in this caſe, unites with the aerial acid, which is preſent in large quantity in the atmoſphere, and for this reaſon the manganeſe muſt alſo fall down. (D) Probably the fine particles of manganeſe have naturally a dark-red colour, which becomes viſible when they are ſeparated from one another, without, however, being perfectly diſſolved in a menſtruum. (E) The precipitate, produced by an acid, is ſtill real manganeſe, a part of which is ſoluble in acid of vitriol, but not the whole (§ II. A), unleſs there be added ſome phlogiſton. Hence it follows, that nitre is not capable of depriving the manganeſe of its natural ſmall quantity of phlogiſton (§ XV.); conſequently the alkaliſation of nitre cannot be aſcribed to the natural phlogiſton of the manganeſe. (F) If the ſolution (A) be mixed with diluted vitriolic acid to ſaturation, the red colour diſappears, and the ſolution grows colourleſs.

colourleſs. The reaſon of this is, becauſe there is always ſome undecompoſed nitre in the alkali of nitre, the acid of which has taken ſome phlogiſton from the red heat (§ VII.). This phlogiſticated nitrous acid is in the preſent caſe ſeparated from its alkali by the vitriolic acid, and diſſolves the mangneſe according to the reaſons mentioned in § XX. XXII. (G) Manganeſe fuſed with alkali of tartar has nearly the ſame properties with that treated with nitre, the laſt excepted from the want of ſulphur. (H) If charcoal in powder be mixed with the melted green maſs, an effervеſcence enſues (§ XXXVI. B), and the maſs aſſumes a light grey colour; it likewiſe yields a white ſolution with water; what remains on the filter is phlogiſticated manganeſe. (I) If finely powdered arſenic be added to ſuch an alkaline ſolution of manganeſe during its ſtate of fuſion, the green colour alſo diſappears, and a white one is produced. If the maſs be diſſolved in water, phlogiſticated manganeſe is precipitated. This is certainly a very remarkable phænomenon. I here ſee, that phlogiſton actually enters into the compoſition of arſenic. The ſame thing likewiſe follows from par. XXII. in which I mentioned, that arſenic is capable of rendering the ſolution of manganeſe in acids limpid. I here alſo recollected the volatile

volatile nitrous acid that is produced by means of arſenic. I thought, if the arſenic could be deprived of its phlogiſton, quite different properties would appear. The experiments which I made according to this conjecture were crowned with ſucceſs, and I found out two ways of reſolving arſenic into its conſtituent parts, which are a peculiar acid, and the univerſal inflammable principle.

§ XXXIX. *Effects of Sal Ammoniac.*

(A) Half an ounce of phlogiſticated mangaueſe, mixed with an equal quantity of powdered ſal ammoniac, was diſtilled in a glaſs retort. I obtained in the receiver dry volatile alkali, and towards the end ſal ammoniac in the neck of the retort. (B) Half an ounce of pure phlogiſticated mangaueſe (§ XXIV. B, C), mixed with two drachms of pounded ſal ammoniac, were expoſed to diſtillation, and I obtained cauſtic liquid volatile alkali. Both the reſiduums in the retort were fuſed; they were ſoluble in water. (C) An ounce of well triturated manganeſe was diſtilled with half an ounce of ſal ammoniac, when a liquid volatile alkali came over, the ſame as that which is prepared by means of quicklime. There likewiſe ſublimed a little ſal ammoniac; the reſiduum was put into water, but there remained

mained a good deal of manganeſe undiſſolved. As manganeſe is not ſoluble in acids without being combined with phlogiſton, a queſtion ariſes, Whence the manganeſe obtains the phlogiſton in this proceſs? (D) If finely pounded manganeſe be expoſed with pure nitrous acid and ſome volatile alkali to digeſtion for ſeveral weeks, you will obſerve a great number of air-bubbles riſe to its ſurface. This kind of air, collected in a bladder tied to the neck of the flaſk, is not aerial acid, but of a quite different nature. During the digeſtion, the volatile alkali is entirely decompoſed; for if the ſolution be mixed and diſtilled with a ſufficient quantity of quicklime, not the leaſt ſmell of volatile alkali appears in the receiver. In this proceſs, the phlogiſton, one of the conſtituent parts of volatile alkali, has combined with the manganeſe, and thus rendered the acid of nitre capable of acting upon the manganeſe. The elaſtic fluid, collected in the bladder, has been either ſeparated from the volatile alkali, and is then its other conſtituent part, or it is a product ariſing from its decompoſition. That the nitrous acid has no ſhare here, is clearly proved by the following proceſs: (E) I repeated the very ſame diſtillation with manganeſe and ſal ammoniac, as in C; but, inſtead of the receiver, I applied

plied an empty bladder, which in theſe experiments is always to be faſtened very exactly to the neck of the retort. It happened here as I expected; I obtained the ſame kind of air in the bladder as in the preceding experiment; and now I underſtand the nature of the proceſs in E, and how this proceſs is to be explained. The mangaueſe had combined with the phlogiſton of the ſal ammoniac (reſolved by the heat into vapours), that is, the phlogiſton of the volatile alkali; and thence aroſe the elaſtic fluid; and the muriatic acid, which was before united with the volatile alkali, could not now but unite with the phlogiſticated manganeſe. But ſince this alkali contains more phlogiſton than the manganeſe requires to be combined with, in order to be ſoluble in muriatic acid (for *nitrum flammans* will deflagrate, but not a ſolution of phlogiſticated manganeſe in nitrous acid, after being evaporated to dryneſs), the reſt of it combines with another portion of the manganeſe, which being thus phlogiſticated, cauſes the alkali to go over in a cauſtic ſtate, for the reaſon aſſigned in par. XXXIX. B; and thus it likewiſe appears whence the air-bubbles come, which are obtained from cauſtic volatile alkali (§ XXV. I.), *viz.* the dephlogiſticated marine acid in this proceſs combines, in conſequence of its great attraction

attraction for phlogiston, with that of the volatile alkali, and thus a part of this salt is necessarily decomposed.

§ XL. *Effects of Arsenic, Orpiment, and Antimony.*

(A) Powdered manganese, mixed with an equal quantity of arsenic, was distilled, when all the arsenic came over, and the manganese remained behind unchanged. (B) Manganese, distilled with an equal quantity of orpiment, yielded some volatile sulphureous acid, which was followed by a small portion of yellow sublimate, and at last a little red sublimate. I increased the fire by degrees, till the retort began to melt; but the orpiment remained attached to the manganese. (C) The same thing happened when manganese was treated with an equal quantity of antimony, which likewise yielded a pungent sulphureous acid, but no sublimate. In this process, as well as when united with sulphur alone § XXXVII., the manganese bears a very strong resemblance to a metallic substance. It seems as if it cannot combine with sulphur before it is united with phlogiston; it therefore first attracts the phlogiston of the sulphur, and the vitriolic acid, still retaining some of this principle, goes over in the form of volatile sulphureous acid, and the remaining

 sulphur

ſulphur is afterwards fixed by the phlogiſticated mangaueſe. By calcination in the open air, this is decompoſed, as well as the compounds with orpiment and antimony, and the vitriolic acid unites with the phlogiſticated manganeſe § XXXVII.

§ XLI. *With Cinnabar and corroſive Sublimate.*

(A) A portion of finely pounded manganeſe was mixed and diſtilled with an equal quantity of powdered cinnabar. A penetrating volatile ſulphureous acid came over, and a little cinnabar was ſublimed into the neck of the retort, which was followed by quickſilver. The reſiduum ſhewed the ſame properties as that mentioned § XXXVII. (B) Manganeſe, diſtilled with an equal quantity of corroſive ſublimate, underwent no change; (C) but mixed with an equal quantity of mercurius dulcis and ſublimed, there aroſe firſt corroſive ſublimate, and then mercurius dulcis, into the neck of the retort. Now, as mercurius dulcis contains crude mercury united with phlogiſton, but corroſive ſublimate conſiſts of calx of mercury and muriatic acid, it follows, that if part of the phlogiſton of the mercurius dulcis is taken away, a kind of corroſive ſublimate will be produced; and this portion of phlogiſton is taken away in the preſent caſe by the manganeſe.

§ XLII.

§ XLII. *With Glaſs Fluxes.*

All the phænomena hitherto obſerved with manganeſe I have explained from the four general properties laid down in § XIV.; and, from the ſame principles, I think the phænomena it ſhews with glaſs fluxes may be deduced. A colourleſs glaſs flux becomes conſtantly more or leſs red, on addition of manganeſe, according to the quantity (§ XXXVIII. D). If the flux be a little alkaline, the colour will approach to violet (§ XXXVIII. A). It is well known, that arſenic, gypſum, and calx of tin, deſtroy the red colour in thoſe glaſſes, and thus render them clear and colourleſs. As to the arſenic, the reaſon appears from its conſtituent parts § XXXVIII. I.; for in this caſe the phlogiſton of the arſenic unites with the manganeſe that is diſſolved in the red glaſs, and thus takes away the colour; and the acid of arſenic unites with the alkali of the glaſs, (§ XIV. No. 3.). It is to be obſerved here, that the experiment likewiſe ſucceeds in a covered crucible, but it never ſucceeded with me when it was made in that way with gypſum and calx of tin; but, on adding powdered charcoal, an efferveſcence enſues, the red colour diſappears, and the glaſs becomes colourleſs. Thence it may be concluded, that the experiments made with a view to

 change

change the red colour were made upon charcoal with the blowpipe; and the phlogiston of the charcoal is therefore the cause of the destruction of the colour. The preceding effervescence is a necessary consequence of the separation of the phlogiston from the charcoal (§ XXII.).

(A) If glass coloured red by manganese be mixed with charcoal powder in a crucible, and fused, the colour disappears during the effervescence, without the addition of gypsum or calx of tin. (B) But on keeping the glass for a long time in fusion upon charcoal, by means of the blowpipe, the colour does not disappear. Nay, if the colourless glass (A) is kept in this state for a short time upon charcoal, by means of the blowpipe, it grows red again. (C) If to such a red glass globule a little sulphur be added, the colour disappears. The same thing happens on adding a little of any metallic calx, and any neutral salt containing vitriolic acid. Here it is to be observed, that all metals of which the calces colour glass, as, for instance, copper, iron, cobalt, give their peculiar colour to the glass, while they deprive it of the red colour communicated by manganese. (D) If to such a colourless glass nitre be added, though even in the smallest quantity, it immediately grows red again. The same thing happens

pens if ſuch a colourleſs glaſs globule is kept in fuſion upon an iron plate for a few minutes. (E) The appearance and diſappearance of the red colour may be produced at pleaſure: By only keeping the colourleſs glaſs apart from all phlogiſtic matter, and in fuſion, for a few minutes, it will grow red; and then, by ſetting it upon charcoal, it will efferveſce and grow colourleſs again. Theſe laſt phænomena, however, will not ſucceed if the glaſs (A) be made uſe of.

From theſe experiments the following queſtions may be anſwered. Whence does it happen, that the additions, mentioned at letter E, ſo ſuddenly deſtroy the natural red colour of the manganeſe, ſince, ſulphur excepted, they do not contain any conſiderable portion of phlogiſton that can be ſeparated from them, which, however, is neceſſary for the deſtruction of the colour? And why does not the red glaſs upon the charcoal become colourleſs by itſelf under the blowpipe, as happens on the addition of charcoal in the crucible?

Without contact the manganeſe cannot combine with the phlogiſton of the charcoal, and the glaſs globule touches the coal only in one point, and thus takes the phlogiſton only from that point; all the remaining points are in contact with the

 ſurrounding

ſurrounding atmoſphere, which deprives it of much more phlogiſton (§ xv. c) than it is able to get from a ſingle point of the charcoal, and thus the natural colour of the manganeſe muſt remain (B). The caſe is quite different in a crucible (A); for here the atmoſphere touches only a part of the globule, and the whole maſs receives a ſufficient quantity of phlogiſton from the ſurrounding charcoal powder to repair the loſs, whence a colourleſs glaſs flux is produced. The ſame is the caſe when any vitriolic ſalt or metallic calx is added to a borax-glaſs globule in fuſion under the blowpipe, and coloured red by manganeſe (C). For, ſince theſe ſubſtances attract the phlogiſton with ſufficient force from the charcoal, though they are diſſolved in the glaſs, as is well known from the converſion of the vitriolic acid into ſulphur, and the reduction of the metallic calces, and ſince manganeſe is able to ſeparate the phlogiſton from metals (§ xvi. xxxvii.), it follows, that in ſuch a glaſs globule there is much more matter preſent which attracts the phlogiſton from the point of the charcoal, upon which the globule reſts, as is likewiſe ſufficiently evident from the effervеſcence that takes place. If manganeſe comes into contact with any ſuch ſubſtance when it is on the point of being converted into

ſulphur,

ſulphur, or reduced, it is in the ſame circumſtances as if it were in contact with an equal quantity of charcoal powder. Hence, therefore, the glaſs muſt become colourleſs; and though the air every moment takes away phlogiſton from the ſurface of the globule that is expoſed to its action, the manganeſe will have, notwithſtanding, a ſufficient number of points through which the want of phlogiſton is conſtantly ſupplied. This is proved by the conſtant effervеſcence which takes place as long as the glaſs globule remains in a liquid ſtate upon the charcoal (§ XXII.).

§ XLIII.

From this explanation it plainly appears how manganeſe purifies glaſs. If the colour of the glaſs were to depend on a kind of carbonaceous matter, it would be imprudent to add more of the manganeſe than is required to ſaturate the phlogiſton of that matter, for the natural colour of the manganeſe would certainly be produced. With regard to the green colour of the common bottle-glaſs, I was not yet fully convinced that it depended upon iron, and I therefore took this opportunity to examine whether I could ſeparate iron from it. (A) I melted green glaſs with alkali of tartar by the blowpipe upon a piece of the ſame ſubſtance, (for in uſing a crucible one may be deceived by the iron it contains). Upon this maſs I poured a large quantity of pure muriatic acid, and added ſome drops of lixivium ſanguinis, when the mixture grew a little bluiſh, and there is conſequently ſome iron in the green glaſs. (B) This iron muſt be preſent nearly in a metallic form; for the calx of iron renders glaſs always yellowiſh. It is, therefore, the phlogiſton to which the green colour is owing. As long as the iron retains part of its phlogiſton, it alſo gives ſuch a green colour to its ſolution in acids. But if manganeſe be added to ſuch a ſolution, the green colour diſappears during digeſtion, and a yellowiſh one is ſeen in its place. Nitrous acid likewiſe takes away this green colour during digeſtion. (C) If nitre be added to green glaſs in fuſion, the green colour alſo diſappears. Manganeſe added in due proportion produces the ſame effect. If Mr Weſtfeld had not added nitre in his experiment, by which the green colour of the glaſs was deſtroyed, he certainly never would have effected any change of the glaſs, nor would he have aſcribed this property to the earth of alum. (D) But ſuch a glaſs purified by manganeſe ſhould have become ſomewhat yellowiſh; for manganeſe was incapable,

pable, in my experiment, of taking away the colour of glaſs tinged by calx of iron; and that a real calx of iron is preſent in this glaſs, though to all appearance pure, I have already ſhewn by the above experiment (A). I performed the fuſion upon a plate of colourleſs glaſs. What can be the cauſe that it becomes clear and colourleſs under theſe circumſtances? I believe, that the too ſmall quantity of the calx of iron is the reaſon why its natural yellow colour cannot be diſtinguiſhed. It is remarkable, that the rays of light paſſing through ſuch an uncoloured glaſs when it is heated nearly red hot, appear yellow. Something like this is obſerved in red colours that are not changeable by fire; ſuch as minium, crocus martis, cinnabar, red precipitate, which, during the time they are heated, appear of a black colour. Before I conclude, the following obſervations may deſerve a place.

§ XLIV. *Preſence of Mangane*ſ*e in Pota*ſ*hes.*

Chemiſts have often obſerved, that alkaline ſalts, when calcined, aſſume a bluiſh or greeniſh colour. The cauſe of this has been ſaid to be phlogiſton preſent in the alkali; but I have conſtantly found ſome nitre in the fixed nitre which was prepared with charcoal powder by a ſtrong fire.

fire. Its preſence was immediately diſcovered by the aquafortis ſmell that enſued on pouring ſome vitriolic acid upon the maſs. To the common opinion, therefore, there ariſes an immediate objection; which is, that the green colour in this caſe ſhould have been deſtroyed by the nitre ſtill remaining. I obſerved, that ſuch a green alkali fuſed with nitre did not, however, loſe its colour. When fixed alkali is made to run over the crucible by a ſtrong fire, the part that attaches itſelf to the outſide acquires a dark green colour, in conſequence of the aſhes uniting with it. If one part of alkali of tartar be mixed with one-fourth of fine ſifted aſhes, and one-eighth of nitre, a dark green maſs is obtained, which, when diſſolved in water, yields a beautiful green ſolution, and, when filtered, turns red on adding a few drops of vitriolic acid (§ XXXVIII. B, C). Some days afterwards I found a brown powder precipitated, which, though in a ſmall quantity, appeared, on experiment, to be preciſely the ſame ſubſtance as manganeſe.

A ſufficient quantity of ſifted aſhes were diſſolved in muriatic acid in a ſand-heat. During the digeſtion, the ſame ſmell of aqua regia that ariſes from manganeſe and muriatic acid was perceptible. Some hours after I mixed a certain quantity of vitriolic

vitriolic acid with this ſolution, in order to precipitate the greater part of the calcareous earth that was preſent. The ſecond day I filtered it, and what paſſed through the filter had a yellow colour, and with alkali of tartar afforded a yellowiſh precipitate. This powder being edulcorated, dried, and calcined in the open air upon an iron plate placed on burning charcoal, aſſumed a dark grey colour. It ſhould have been quite black like manganeſe if an extraneous earth had not ſtill been mixed with it (§ XV. c). This calcined powder was not entirely ſoluble in pure nitrous acid; but, on adding a little ſugar, a clear ſolution was inſtantly procured. When mixed with alkali it yielded a green maſs before the blowpipe; with glaſs of borax it aſſumed a yellow colour. From this latter phænomenon, however, it does not follow that it contains no manganeſe; the yellowneſs of the glaſs is a ſign that iron is at the ſame time preſent, which is likewiſe confirmed by the yellow colour of the ſolution in muriatic acid: Now, ſince the calx of iron has the ſame property as gypſum and calx of tin (§ XLII. c), the red colour muſt alſo here diſappear. If only a little nitre be added to the yellow glaſs, it becomes immediately dark red (§ XLII. D). Thence it is evident, that manganeſe really

really enters into the compoſition of pot-aſhes. In the aſhes of thyme, (thymus ſerpillum), however, I have obſerved very little; aſhes from wood yield more.

§ XLV.

I ſhall now conclude with an account of ſome experiments which I made with a view to diſcover the conſtituent parts of manganeſe. But not having yet been able to produce manganeſe by art, or to confirm by ſynthesis what I have learnt by analyſis, I am uncertain whether my concluſions, though founded on experiments, are juſt. I have obſerved, that from phlogiſticated manganeſe, diſſolved by vitriolic acid, there ſeparates, after every calcination in the open fire, a quantity of gypſum. The gypſum is indeed in very ſmall quantity; but I was curious to know whether the manganeſe loſes of its weight in proportion? This led me to make the following tedious and troubleſome experiments with the utmoſt accuracy: I calcined half an ounce of phlogiſticated manganeſe, purified from all foreign particles, as deſcribed § XIX, upon a finely poliſhed iron plate till it grew quite black. I then diſſolved it in diluted vitriolic acid, with the addition of a little ſugar, in a ſand-heat, till the ſolution became limpid. After it was cooled, a fine ſhining powder precipitated, which proved

proved to be felenite; this I feparated by filtration; then diluted the folution with fix ounces of diftilled water, and precipitated it with purified alkali of tartar; but as in this procefs there is always a certain quantity of aerial acid expelled from the alkali by the acid, which may diffolve fome manganefe (§ XXXI.), it was neceffary to place the whole mixture, with its precipitate, in an open veffel upon hot fand, in order to expel the aerial acid. In the fpace of a few hours it was filtered, and what remained in the filter was edulcorated with hot diftilled water. This phlogifticated manganefe was afterwards dried, and expofed again to calcination in the fame manner. All this was done with proper care not to lofe any thing; on which account the draught of air was carefully avoided. The manganefe, when deprived of its phlogifton, was again diffolved in diluted vitriolic acid, with the addition of a little fugar, by which means I obtained as much felenite as before; the folution was then made to pafs through the fame filter, on which the felenite remained behind mixed with that of the preceding operation. The filtered folution was precipitated by alkali of tartar, and, by means of heat, deprived of the aerial acid; it was afterwards purified, as before, from the vitriolated tartar, by means

means of the ſame filter, edulcorated, then dried, and again deprived of its phlogiſton by a new calcination. This operation I repeated eleven times, till I grew tired of it. I dried the phlogiſticated manganeſe which was laſt obtained upon the ſame blotting paper which had ſerved as a filter, then ſubtracting the weight of this paper, which I had aſcertained before the experiments were begun, I found the weight of the manganeſe to be three drachms and five grains, the ſelenite obtained forty-nine grains. It is impoſſible to avoid ſome loſs in the edulcoration. The phlogiſticated manganeſe thus obtained had the ſame property as in the beginning, and yielded, after the laſt calcination and ſolution, as much ſelenite as after the firſt. It therefore ſeems as if it was entirely changeable into calcareous earth, if the ſame operation was long enough continued. Mr Weſtfeld found it eaſy to fix his opinion about the conſtituent parts of manganeſe; but how near he advanced to the truth, thoſe may determine who ſhall make experiments in the method juſt deſcribed. How this change of manganeſe into calcareous earth is produced, I dare not undertake to explain, having been, notwithſtanding all poſſible trouble, never able to unite phlogiſton with calcareous earth. I ſhall add but one obſervation,

vation, really remarkable in itſelf, and very well adapted to be inſerted here. Having once abſtracted muriatic acid from minium, I found that the acid had not only the ſmell of aqua regia, but that it alſo was capable of diſſolving gold. If finely pounded minium be diſſolved in pure nitrous acid, diluted with a triple quantity of water, a black powder remains, which is not ſoluble without the addition of a little ſugar, upon which a clear ſolution is immediately obtained. If this black powder be digeſted with diluted vitriolic acid, no change happens; but, on adding ſome ſugar, the powder grows white, and contributes to produce vitriol of lead. If muriatic acid be poured upon the black powder, an efferveſcence ariſes in a warm place, and the acid grows yellowiſh; the colour afterwards diſappears, and a ſtrong ſmell of aqua regia riſes; but the black powder grows white, and is changed into muriated lead (*plumbum corneum*). If the black powder be diſtilled by itſelf in a glaſs retort, it grows yellow again, but not till it comes near the degree of heat at which it melts. This yellow powder ſhews in every reſpect the ſame properties as common yellow calx of lead, is entirely ſoluble in nitrous acid, and, on being mixed with muriatic acid, yields no further ſmell of aqua regia;

gia ;—a proof of the preſence of phlogiſton in heat (§ XVII.). It ſeems as if the black powder was nothing elſe but calx of lead, which having loſt its phlogiſton entirely, or for the moſt part, during a gentle and ſlow calcination, has thus acquired ſuch a ſtrong tendency to unite again with it, as to be able to decompoſe muriatic acid.

Supplement

Supplement to the foregoing Differtation on Manganefe. *By* T. BERGMAN.

Mr Scheele, after having examined the compofition of fluor, undertook, at my requeft, the examination of manganefe, and has offered to the Society what he has learned upon the fubject by his numerous and ingenious experiments, which were continued during the fpace of three years. After he had finifhed thefe experiments, I informed him that Mr Sage fuppofes manganefe to be nothing elfe than a mineralifed mixture of cobalt and zinc. He immediately made feveral experiments for this purpofe, but found not the leaft mark of either of thofe metals.

Manganefe has been claffed by all mineralogifts among the iron-ores. Mr Pott, however, thought the iron to be mixed only accidentally; and at laft Mr Cronftedt, in his Effay on mineralogy 1758, placed it among the earths. For my part, however, I muft own there are feveral circumftances which make me think that it is a metallic fubftance.

No pure earth colours glafs; but all metallic calces have this property. Manganefe, therefore, in this refpect, fhews a great refemblance to the latter, which is further increafed by its fpecific gravity, and its ftrong attraction for phlogifton. But what principally confirms me in my conjecture, is the following experiment, which I made with a view to determine its nature more particularly. It is well known, that fixed alkali, by a certain treatment with dried blood, *viâ ficcâ*, or, what is more convenient, with Berlin blue in the moift way, may be almoft completely neutralifed. Phlogifton, it is true, is generally affigned as the caufe of this change; but, in all probability, the whole depends principally on an animal acid. There appears at leaft on the addition of Berlin blue an evident effervefcence, and the folution may be reduced to cryftals. Alkali, thus changed and diffolved in water, is generally called *lixivium fanguinis*, and precipitates all metals diffolved in acids; but does not precipitate in the leaft any of the earths, except as far as there is any fuperfluous alkali prefent, which may be eafily avoided by adding fome diftilled vinegar. Now, if a quantity of this alkali be added to a folution of manganefe, a light yellowifh grey earth immediately precipitates, which is not foluble in any of the mineral acids: Both which circumftances happen only with metals, and thus clearly fhew the nature of the precipitate. But what kind of metal it is which manganefe contains,

contains, is not ſo eaſily aſcertained. The ſolution of cobalt does not loſe its colour on adding ſugar, or any other phlogiſtic ſubſtance; and zinc does not impart any colour to acids; theſe two ſubſtances conſequently differ from manganeſe, which does not, indeed, entirely agree with any other of the known metallic earths. I have, however, great reaſon to conjecture that it muſt be platina, the earth of which is not yet known; or a new metal, which at leaſt would agree with platina in the great difficulty with which it fuſes. To aſcertain this, a ſeries of experiments is begun, which, if they ſhall confirm my conjecture, will make manganeſe a ſtill more remarkable ſubſtance.

Additional Remarks upon Mr SCHEELE's *Analyſis of Mangareſe, by* GUSTAVUS v. ENGESTROM.

The experiments I made on manganeſe and its colour ſeem to differ in ſome meaſure from Mr Scheele's. Hence it will perhaps appear how difficult it is to meaſure the degree of fire in experiments with the blowpipe.

I melted manganeſe and borax together upon charcoal by means of the blowpipe. The glaſs at firſt aſſumed the common colour of manganeſe; but this colour I deſtroyed without any addition, and imparted it again to the glaſs; and this I did repeatedly to the ſame globule without adding any thing. During the operation I obſerved the following phænomena.

1. If I took a ſmall quantity of manganeſe, the colour was light; if a larger portion, it became ſo dark as to appear black. This dark or light colour, which manifeſted itſelf during the firſt melting, appeared again in a ſecond operation upon the ſame maſs.

2. Manganeſe, on being melted with borax, unites with a violent effervescence, which, however, ceaſes as ſoon as the manganeſe is diſſolved.

3. If

3. If the glaſs of borax was coloured by manganeſe, and I wiſhed to make the colour diſappear, I always directed the blue flame of the candle upon the glaſs, and that equally and conſtantly, but not very violently. As ſoon as I blew more faintly, and allowed the brown flame to touch the place, the glaſs grew dark again. According as the globule was larger or ſmaller, more or leſs coloured, it required a longer time to make the colour diſappear. About the time when the glaſs becomes colourleſs, a kind of a ſection or partition is obſerved in it; and, as ſoon as the colour diſappears, the blowing muſt be immediately diſcontinued, in ſuch a manner that the brown flame ſhall not touch the glaſs. When it is afterwards taken out with the forceps, it appears perfectly colourleſs.

4. This deſtruction of the colour does not ſeem to happen ſuddenly and at once, but by degrees: For when I now and then diſcontinued the blowing, before the true mark had appeared, I found the glaſs generally lighter than it was before, and this more or leſs according as I had blown longer or ſhorter time.

5. After putting this colourleſs glaſs again upon the charcoal, and melting it by the brown flame of the candle, it again aſſumed its former colour, though I

 kept

kept it melted for a long time in the brown flame.

This change of colour I have effected several times with the same glafs, always with the same fuccefs; but I cannot fay whether it may be repeated often: Such an experiment would be too difficult to make. There is fome room to doubt of this;—at leaft if the phænomenon in the following experiment was not owing to fome accident.

6. Having already twice difcharged the colour, I forced the blue flame with violence againft the glafs, in order to make the colour of the manganefe the fooner difappear. I obferved fome little veficles to rife in the glafs, which afterwards burft, and at the fame time difperfed a number of very fmall glafs globules around. I had now continued the blowing for a whole hour, and had been blowing very violently, I therefore was obliged, after a fhort blaft, to defift for two or three minutes.

I found the glafs fomewhat lighter than it was before; but on continuing the blowing with equal force, I found it impoffible to expel the colour from the glafs. After I had given over blowing, the mafs appeared to be fomewhat diminifhed, and was as dark as at firft; but of the fmall globules difperfed around upon the charcoal fome were clear and colourlefs, others were white and opaque.

I

I attempted to give them colour by means of the blowpipe alone, but without ſucceſs.

7. In one experiment I had taken a much larger quantity of mangaueſe in proportion to the borax, and happening to give it a very violent heat, ſo as to cauſe an exploſion of ſmall particles, I found that the larger globule conſtantly retained a red colour, till at laſt it likewiſe grew clear and tranſparent during the blowing. On ſtopping ſuddenly, the glaſs was clear as long as it remained warm; but as ſoon as it began to grow cold, a dark cloud made its appearance upon the ſurface, which by degrees ſpread over the whole. On melting it ſuddenly anew, it recovered its tranſparency; but, as it grew cold, the ſame phænomenon as before appeared; and the oftener I repeated this, the more cloudy appeared the globule. As ſoon as it had become cold, I obſerved that it had loſt its glaſſy ſplendour, and had aſſumed a very dry appearance, and was of a greyiſh red colour. The ſame thing happens likewiſe with glaſs of borax and lime, if the latter be added in too large quantity, the glaſs of borax loſes its glaſſy appearance nearly in the ſame manner.

That the ſmall globules ſeparated by the violent heat (6.) remained colourleſs, though the great globule became red, ſeems to ſhew, that manganeſe, or at leaſt its colouring part, has a ſtrong attraction for a ſmall portion only of borax; and that, by means of a violent heat, the ſuperfluous part may be ſeparated, and the reſt unite more cloſely with the earthy particles. The ſame thing happened likewiſe with the ſmall globules which ſometimes remained, after the maſs was taken away, fixed to the charcoal by the violence of the flame. If this is really the caſe, it would follow, that, by repeating the experiment, ſome of theſe particles would always ſeparate, if a ſufficiently ſtrong flame was applied, and it would be impoſſible to expel the red colour afterwards. I dare not, however, advance this conjecture, though it is grounded on ſome experiments, as a matter of certainty. Accidents may ſometimes make a thing appear in a quite different light from what it really is, eſpecially in experiments upon ſuch a ſmall ſcale, where one cannot be careful enough in forming concluſions.

More experiments would elucidate this point; but it would perhaps hardly be worth while to make them, ſince they ſeem to be more curious than uſeful.

Quite different is the caſe with regard to the deſtruction and reſtoration of the colour of manganeſe itſelf, by means of the

the ſimple flame; for the ſeveral experiments I made all agreed in the ſame reſult. In order to confirm them the more, I have made experiments lately with manganeſe, from Upton Pine, near Exeter, in England, and have obſerved no difference.

The brown flame of the candle has probably more phlogiſtic particles than the blue one.

The preſence of phlogiſton ſeems in moſt caſes to communicate colour. Mineral ſubſtances, which contain little phlogiſton, are often with great difficulty deprived of it; a violent and long continued heat is frequently required for this purpoſe; ſometimes, however, we ſucceed on adding more phlogiſton, and by means of certain management with regard to the fire itſelf.

Deſcription of a new ſpathiform Species of Mangancſe from the Iron Mines of Klapperud in the Pariſh of Freſko in Dahlland. *By* Seven Riuman.

This ſpecies was ſent me by Baron Hermelin. It is not, as far as I know, mentioned in any ſyſtem of mineralogy, unleſs that of Baron Born, entitled, *Magneſia texturâ lamelloſâ, lamellis nitentibus*, from Hirſchberg (Index Foſſ. p. 47.), belong to it. The preſent ſpecies, at firſt view, reſembles a brown blend, or an impure calcareous ſpar: It conſiſts of irregular cubes of the colour of colophony, or common reſin; the thin lamellæ are ſemitranſparent, and of a browniſh-red colour; the ſurface has more ſplendour than that of blend or calcareous ſpar, and in this reſpect it is moſt like mountain-pitch. The ſpecimens that I received were diſtinguiſhable, with reſpect to external appearance, into two varieties.

1. Sparry, ſhining, of the colour of colophony.

2. Compact, irregular in the fracture, with a duller ſurface, and of a darker colour.

The following general properties might moreover be diſtinguiſhed:

(A) The

(A) The ſmooth ſurface, already deſcribed, is a ſufficient intimation that it does not ſoil the hands; but, upon a part of the foſſil, there appears a dark-brown calciform powder, ſeemingly produced by expoſure to the atmoſphere, which *does* ſoil the hands.

(B) Between the diviſions of this ſparry mangáneſe, there are a few calcareous particles of a bright yellow.

(C) Againſt ſteel or the knife, it has no more hardneſs than common looſe calcareous ſpar, and, when pulverized, affords a bright brown powder.

(D) Placed on a piece of charcoal, and heated with the blowpipe, it at firſt reſembles zeolite, fuſing with ſome efferveſcence and intumeſcence of the particles, which afterwards coagulate into a light-grey porous ſcoria, that is not fuſible of itſelf by means of the blowpipe.

(E) It fuſes eaſily with borax into a dark-red or garnet-coloured glaſs, and the fuſion is accompanied with a briſk efferveſcence; but, in order to be tranſparent, it muſt be diluted with a good deal of borax, and it then appears of a beautiful red oppoſite the light.

(F) When heated red-hot in a teſt in an aſſay-furnace, it turns black with ſmall ſhining ſcales; but in a ſtronger heat the black

black colour paſſes away in part, and the powder becomes brown.

(G) The magnet does not attract any ſenſible quantity, either before or after roaſting.

(H) This ſpecies of manganeſe in its crude ſtate, and reduced to a fine powder, does not make any efferveſcence with ſtrong aquafortis; but, in a gentle heat, it is almoſt entirely diſſolved without imparting any colour to the ſolution.

(I) Fixed vegetable alkali precipitated a white powder out of this ſolution, which, when waſhed and dried, efferveſced a little with acids, turned black upon being heated red-hot; and, when treated by the blowpipe upon charcoal with glaſs of borax, gave it a red colour.

(K) The roaſted powder (F) efferveſced ſtill leſs with aquafortis; a great part of it, however, by gentle boiling, was diſſolved, and yielded in like manner a white precipitate on the addition of vegetable alkali. This precipitate, when heated moderately red-hot, grows as black as ſoot, and gives a garnet colour to borax. The reſiduum, which did not diſſolve in aquafortis, was as black as before.

(L) When mixed with a large quantity of common enamel, conſiſting of ſiliceous powder and litharge fuſed together, ſo as to form a clear yellow glaſs, and expoſed to a

ſtream

ſtream of air in a cloſe crucible for a quarter of an hour, the roaſted powder (F) yielded only a clear olive-coloured glaſs, in which many little grains of reduced lead were to be obſerved. That it did not aſſume a garnet colour,—I aſcribe to the too great violence of the heat. The reduction of ſome of the lead indicates the preſence of phlogiſton in the pulverized manganeſe.

(M) Some of this roaſted manganeſe was rubbed in a glaſs mortar with a quantity of the above mentioned enamel, to which a little more ſiliceous powder and ſome fixed alkali were added. With this mixture a piece of Cologne clay burnt white was covered, then placed in an heated aſſay-furnace, and taken out as ſoon as the enamel began to melt. It had acquired a clear and more beautiful colour than I could have produced with other manganeſe.

(N) One part of the roaſted powder, mixed with two of ſiliceous powder, and four of white potaſhes, fuſed in a crucible, placed before the bellows, in ſeven minutes. It effervеſced at firſt with violence, and afterwards yielded a clear violet-coloured glaſs, with which the crucible was likewiſe glazed.

The ſmall quantity of which I was poſſeſſed, and the ſhortneſs of the time, would

not

not permit me to make any more experiments. From thoſe which I have related, it appears that this ſpecies has nearly the ſame properties with that examined by Mr Scheele. There are, however, ſome points of difference to be noticed ; as its ſhewing the ſame phænomena as zeolite under the blowpipe without addition, its containing in all probability but little iron, and its yielding a very beautiful violet-coloured enamel, for which, and eſpecially for painting upon porcelain, it will be of great uſe, ſince, according to my information, the mine will yield a ſufficiently large quantity.

It is to be obſerved of every ſpecies of manganeſe, that the colour is the deeper, the more violently it is roaſted or calcined. Hence that which is uſed for enamel or glazing ſhould be expoſed for a long time to a ſtrong heat.

ESSAY

ESSAY VI.

On Arsenic and its Acid. 1775.

§ I.

AFTER I had found, by my experiments on manganeſe, that the inflammable principle is not only preſent in arſenic, but that it may really be ſeparated from it, I aſked myſelf, What were the other conſtituent part or parts of arſenic? I found that it was an acid. Mr Macquer has given us ſome very ſatisfactory information concerning the properties of this mineral; but whether any one elſe has ſince made any experiments upon it, I know not.

§ II. *Analyſis of the White Arſenic.*

Firſt Method.

Put two ounces of arſenic, reduced to a fine powder in a glaſs mortar, into a retort of the ſame matter; pour ſeven ounces of pure muriatic acid * upon it, and lute on a receiver. The mixture is immediately

* The ſpecific gravity of this acid to water is as 10 : 8. If a bottle of water weighs one ounce, a quantity of muriatic acid occupying the ſame ſpace will weigh ten drachms.

immediately to be made to boil, and kept in this ſtate till the arſenic is diſſolved; then, while the ſolution is ſtill warm, three ounces and an half of pure nitrous acid * are to be added to it, together with the acid which has already gone over into the receiver. The receiver is then to be applied again, but not luted. The mixture ſoon begins to foam, and volatile red nitrous acid goes over. Meanwhile the diſtillation is to be continued till no more red vapours appear, when again an ounce of finely powdered arſenic is to be added, the receiver applied as before, and a gentle ebullition continued, till this be likewiſe diſſolved; and afterwards an ounce and a half of nitrous acid is to be added, whereupon a new effervefcence and red vapours will ariſe; the recipient is to be applied, and the whole diſtilled to dryneſs; there will remain a white maſs; —and, laſtly, the fire is to be increaſed ſo far as to make this maſs thoroughly red hot. The acid obtained in the receiver during the operation may ſerve for the ſame purpoſe ſeveral times. After the retort has grown cold, it is to be broken, and the white maſs is to be put into a cloſed veſſel, with this ſignature, *Dry acid of arſenic*; or, if you pleaſe, you may reduce

* Of the ſame ſpecific gravity as the muriatic acid above mentioned.

duce it to coarſe powder in a glaſs mortar, put it into a glaſs retort, pouring a double quantity of diſtilled water upon it, apply a receiver, and boil it for a few minutes till the acid is diſſolved; the water that goes over is to be poured back into the retort. The ſolution is then to be filtered through blotting paper, which has been previouſly waſhed in hot water, and then to be preſerved in a phial with a glaſs ſtopple, under the name of *Liquid acid of arſenic.*

It is to be obſerved, that arſenic muſt neceſſarily be deprived of its phlogiſton before the acid can be obtained; this is principally effected by the nitrous acid. It may ſeem as if it ſhould be ſufficient to diſtil the nitrous acid from the arſenic, after which the acid of arſenic would remain behind; but in this manner only a very ſmall portion of arſenic will be decompounded; for this ſalt requires firſt to be diſſolved in water, in order that the nitrous acid may act upon it in all its points; but nitrous acid diſſolves only a ſmall quantity of arſenic, and that only in proportion to the water contained in the acid; the fuming nitrous acid diſſolves ſtill leſs; but muriatic acid has a ſtrong attraction for arſenic, and the leſs water it contains the more it diſſolves and carries over into the receiver. The above

 mentioned

mentioned quantity of muriatic acid is neceſſary, in order to keep the arſenic diſſolved with the aid of heat. Now, if to ſuch a ſolution nitrous acid be added, the arſenic will be calcined, becauſe its phlogiſton is taken away by that acid, as ſufficiently appears from the red elaſtic vapours; whence likewiſe the attraction of the muriatic acid, for the now dephlogiſticated arſenic is diminiſhed, ſo that it is capable of diſſolving more arſenic. Aqua regia might be poured upon arſenic at firſt, but then the great efferveſcence carries the arſenic up to the ſurface, and thus prevents it from being perfectly attacked by the menſtruum. After all the acid has been diſtilled over, the fire ought to be increaſed, in order, if there ſhould be any aqua regia remaining in the maſs, to expel it entirely; the remaining acid weighs nearly as much as the arſenic employed for the experiment. One would hardly believe that it was an acid, becauſe it has no taſte; but after ſome days it grows moiſt in the air, and at laſt deliqueſces, and then it has the appearance of vitriolic acid. As the deliqueſcency of this acid is very ſlow, I diſſolve it in a certain quantity of water, when a ſmall quantity of white powder remains undiſſolved, which comes from the retort, which is found much corroded after the proceſs, and is therefore

therefore nothing but ſiliceous powder. This powder ought to be carefully ſeparated from the acid, which may be effected by filtration; and in order to prevent the glue of the blotting paper from mixing with the acid, which might lead to a different reſult, the paper ought to be, as I ſaid above, previouſly lixiviated with hot water.

§ III. *Another Method.*

A ſecond method of decompoſing arſenic is by means of manganeſe. Take one part of powdered manganeſe, and mix it in a tubulated retort with three parts of the above deſcribed muriatic acid. This mixture ſhould fill one-fourth of the retort; a receiver containing one-fourth of white powdered arſenic, diluted with one-eighth of diſtilled water, is to be luted on, and the retort put into a ſand-bath. The dephlogiſticated muriatic acid going over into the receiver is immediately abſorbed by the arſenic. Some hours afterwards the arſenic will be diſſolved, and two different liquid ſtrata, which will not mix together, be perceived in the receiver. This ſolution is now to be put into a clean glaſs retort, and diſtilled to dryneſs, and the fire at the end ſo much increaſed that the whole remaining maſs may be perfectly red-hot. In this proceſs alſo two different liquids go over into the receiver, which do not unite together.

Of this operation it is to be remarked, that the muriatic acid yields its phlogifton to the manganefe ; and as the dephlogifticated acid attracts the phlogifton again, wherever it meets with it, very powerfully, it deprives the arfenic of its phlogifton, and hence it reaffumes the nature of common muriatic acid. This acid diffolves a portion of the arfenic, and thus forms with it a liquor, called *butter of arfenic* ; but the other portion of the arfenic, that has been decompofed, remains diffolved in the water, which was placed in the receiver, together with a little muriatic acid, and forms a liquid fpecifically lighter than the butter, which remains at the bottom. If thefe two liquids be now rectified, the undecompofed portion of the arfenic rifes along with the muriatic acid, and goes over into the receiver in the form of an heavy oil, while the acid of arfenic remains behind in the retort. The acid obtained in this way has precifely the fame qualities with that obtained by the former procefs. It is, however, remarkable, that the butter of arfenic does not combine with the muriatic acid when it is fomewhat concentrated.

§ IV.

§ IV.

Before I ſubjected this acid to my experiments, I was curious to know whether it is as fatal as arſenic itſelf. I therefore mixed a little of it with honey, and expoſed it to the flies, when I found that it killed them in an hour. I gave eight grains of the powdered acid, incloſed in a piece of meat, to a cat, which, two hours afterwards, ſeemed to be at the point of death; I then gave it ſome milk, upon which it vomited violently, and afterwards ran away.

§ V. *Effects of the Acid of Arſenic upon inflammable Subſtances.*

(A) If one ounce of dry acid of arſenic be expoſed by itſelf in a ſmall glaſs retort to ſuch a degree of heat that it becomes nearly red-hot, it flows into a clear liquid, which, when cold, is of a milky colour; but if the heat be increaſed to ſuch a degree that the retort begins to melt, the acid begins to boil, and a little arſenic riſes into the neck of the retort. The longer the boiling is continued, the more arſenic is obtained. After I had kept up this degree of heat for an hour, the retort melted, and the acid ran into the fire. After the whole was cooled, I found that the acid had riſen up the ſide of the retort as high as the neck. (B) The ſame quantity of dry acid of arſenic, melted in a cloſe crucible in a ſtrong fire, boils violently, and diſappears in the form of vapours in a quarter of an hour; if the crucible, during the time the acid is evaporating, be put under a convex glaſs veſſel, the inſide will be covered with a white powder, which is arſenic, and not acid of arſenic. In the crucible there remains a little clear and difficultly fuſible glaſs, with which the crucible is likewiſe covered; it conſiſts of clay and acid of arſenic. (C) Acid of arſenic digeſted with charcoal powder undergoes no change; but if this mixture be put into a retort, the moiſture all driven off, a receiver then luted on, and the heat increaſed till the bottom of the retort begins to grow red-hot, the whole maſs takes fire with violence, and all the acid is reduced and ſublimed into the neck of the retort; a ſhining regulus is obtained, mixed with a little arſenic and charcoal duſt. A few drops of water are found in the receiver, but they do not contain a particle of acid. The ſame thing happens when the acid of arſenic has been prepared with mangane'ſe. (D) The acid, after ſome days digeſtion with oil of turpentine, unctuous oil, and ſugar, becomes thick and black. If ſome muriatic acid be abſtracted with a gentle heat

heat from this maſs, and then a few drops of nitrous acid dropped into it, and the abſtraction repeated, a little arſenical acid will remain behind. It appears from this, that the arſenical acid attracts a little phlogiſton from theſe oils, in conſequence of which ſome arſenic is regenerated and carried over by the muriatic acid into the receiver. Spirit of wine undergoes no change, whether it be digeſted or diſtilled with arſenical acid. (E) Six parts of the acid, digeſted with one of ſulphur, ſuffer no change; but when the mixture is evaporated to dryneſs, and diſtilled from a glaſs retort provided with a receiver, a violent combination takes place, as ſoon as the mixture is heated to that degree at which ſulphur melts. The whole maſs riſes almoſt at the ſame inſtant, in the form of a red ſublimate; and in the receiver there is found a penetrating volatile ſulphureous acid.

It follows from theſe experiments, that the acid of arſenic has conſiderable fixity (A), and a ſtrong attraction for phlogiſton, without which it cannot be reduced to arſenic; whence it follows, that heat muſt neceſſarily contain phlogiſton, ſince it is capable of reducing the arſenical acid (B). That it reſembles metallic calces in this reſpect, that it is incapable of uniting with ſulphur, except in a reguline ſtate, appears from the volatile-ſulphureous acid found in the receiver (c); for when the arſenic has attracted as much phlogiſton as is neceſſary to that ſtate, the vitriolic acid, that is extricated, retains ſo much of this principle as to form volatile ſulphureous acid. That this is really the caſe, appears moreover from the ſulphureous acid which arſenic, changed by ſublimation with ſulphur into red arſenic, affords.

§ VI. *Effects of ſaline Subſtances on Arſenic.*

Fixed vegetable Alkali.

(A) When acid of arſenic is ſaturated with alkali of tartar, a neutral ſalt is obtained, which cannot be reduced to cryſtals; but, after being evaporated to dryneſs, and expoſed to the open air, deliqueſces. This neutral ſalt turns ſyrup of violets green, but produces no change on the ſolution of lacmus. (B) But if as much acid be added as ſhall produce no change on ſyrup of violets, and yet redden lacmus, the ſolution will afford fine cryſtals, reſembling Macquer's arſenical neutral ſalt, both in form and other properties. (C) I have kept this ſalt in fuſion for an hour in a crucible, expoſed to a ſtrong heat, upon which another was luted; after the whole had grown cold, the crucible was found to be covered in the inſide with a white glazing; a ſalt ſtill remained,

remained, which, after being diſſolved in water, and evaporated, appeared to be the ſame ſalt, with exceſs of acid, as before. (D) This neutral ſalt, as it is called, was mixed with one-eighth of charcoal powder, and diſtilled in a glaſs retort. When it began to grow red-hot, it ſet to boil violently, without taking fire, and a very fine regulus of arſenic was ſublimed. The black reſiduum, when diſſolved in water, proved to be of an alkaline nature, and ſhewed no veſtige of the acid of arſenic. Mr Macquer thinks, that his neutral ſalt is an alkali mixed with arſenic in ſome peculiar manner; but it now appears, that it is only one of the conſtituent parts of arſenic with which the alkali is combined: And this is likewiſe the reaſon why acids do not precipitate any arſenic from this ſalt.

§ VII. *Mineral Alkali.*

(A) If mineral alkali be ſaturated with the acid of arſenic, cryſtals are obtained, the form of which is entirely the ſame with that of thoſe juſt mentioned; but they do not change lacmus, and they make ſyrup of violets green. (B) If acid of arſenic be added, no cryſtalliſation enſues, but the maſs, after being evaporated to dryneſs, grows moiſt again in the air.

§ VIII.

§ VIII. *Volatile Alkali.*

(A) Volatile alkali, ſaturated with the acid of arſenic, affords, upon evaporation in the open air, an arſenical ſal ammoniac, which, in its form, is very like the foregoing ſalts. This ſalt does not change lacmus, but turns the ſyrup of violets green; it loſes its tranſparency when expoſed to a gentle heat, and a part of the volatile alkali flying off, it afterwards ſhews a ſuperabundance of acid. (B) When it is thus ſuperſaturated with acid, it forms long radiated acid cryſtals, but deliqueſces again in the air. (C) Arſenical ſal ammoniac, when diſtilled, yields a liquid volatile alkali; it then flows, and arſenic is ſublimed: A white maſs remains, which likewiſe melts in a ſtronger heat, and proves to be the acid of arſenic. Since the acid of arſenic cannot be converted into arſenic without phlogiſton, and ſuch a change during the diſtillation cannot be aſcribed to the heat, becauſe the arſenic is ſublimed before the reſiduum or acid begins to flow, it follows, that the acid of arſenic muſt decompound part of the volatile alkali during the proceſs. In my experiments on mangancſe, I obſerved that a peculiar kind of air is obtained whenever volatile alkali is decompounded. (See Diſſ. on manganeſe, § XXXIX.).

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The ſame thing happens here :—I diſtilled an ounce of arſenical ſal ammoniac in a ſmall retort, and applied a dry bladder inſtead of a receiver. Immediately as the arſenic roſe into the neck of the retort, the bladder was filled. This air is perfectly the ſame with that which is obtained from manganeſe and ſal ammoniac.

§ IX. *Vitriolated vegetable and foſſil Alkali.*

(A) I diſſolved one part of finely powdered vitriolated vegetable alkali, by boiling it in a retort in three parts of acid of arſenic; the liquid was firſt diſtilled off, then a dry receiver was applied, and the fire increaſed. When the retort grew red-hot, the maſs melted into a tranſparent liquor, but no acid went over into the receiver; however, on increaſing the fire ſtill further, till the retort began to melt, the maſs began to boil, and concentrated acid of vitriol went over. It had the ſmell of volatile ſulphureous acid; no arſenic was ſublimed. (B) Vitriolated foſſil alkali, or Glauber's ſalt, was likewiſe decompoſed, but ſeems not to require ſo much heat as vitriolated vegetable alkali.

§ X. *Nitre.*

I diſtilled a mixture of one part of purified nitre, and three parts of acid of arſenic. As long as there remained any humidity

midity in the acid, pure water went over into the receiver; but when the maſs grew dry, nitrous acid roſe, and the matter in the retort flowed clear. When no more acid came over with this degree of heat, I let the retort cool. The nitrous acid I obtained was not ſo volatile as that which is obtained from arſenic and nitre. The reſiduum, diſſolved in water and evaporated, yielded cryſtals, perfectly agreeing with the neutral ſalt obtained by Macquer, together with a little undecompoſed nitre.

Arſenic certainly could not decompoſe nitre, except by the power of a double elective attraction, *viz.* in conſequence of the alkali of the nitre uniting with the acid of arſenic, and the acid combining with the phlogiſton of the arſenic, by which this acid is rendered very volatile. If muriatic acid had a greater affinity with phlogiſton, arſenic would likewiſe decompoſe common ſalt, as really happens with cubic nitre. Macquer obtained no neutral ſalt in the crucible, but alkali of nitre containing a little arſenic. I have found that this ſalt may likewiſe be prepared in a crucible. Let nitre be melted for this purpoſe in a crucible, which is to be red-hot only at the bottom, then let as much as will ſtand on the point of a knife of powdered arſenic be added, and, after the

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red vapours and effervefcence are over, as much more arfenic is to be added, and fo on, till the nitre begins to grow thick, and will no longer flow in the fame degree of heat. If a part of the mafs, thus obtained, be diffolved in water, it will redden paper ftained with lacmus. After evaporating the folution, a quantity of arfenical neutral falt is obtained with a little nitre. But if the fire is a little increafed, the mafs begins to boil, and yield red vapours. When it grows thick, and the boiling with this degree of fire is over, a folution of it in water will not change paper coloured by lacmus, but fyrup of violets will be turned green; yet no alkaline tafte will be perceived. This folution does not fhoot into cryftals (§ VI. A).

If at laft the fire be increafed to fuch a degree, that the crucible and the faline mafs are perfectly red-hot, a new ebullition begins, and a fmell of aquafortis is perceived; at laft the whole melts into a tranfparent mafs. If this be diffolved in water, it proves to be ftrongly alkaline; but it contains as much acid of arfenic as the firft folution. If one part of arfenic be expofed with two parts of nitre in a glafs retort, to fuch a degree of heat as melts the retort, no neutral arfenical falt is obtained, but an alkaline mafs mixed with fome acid of arfenic. From this experiment

periment it appears, that Mr Macquer applied too ſtrong a heat, and obtained, therefore, no neutral arſenical ſalt in the crucible. But it will be aſked, Why a greater degree of heat alkaliſes the maſs, whereas nitre in an equal degree of heat, or neutral arſenical ſalt in a ſtill greater, is not alkaliſed (§ VI. c)? The following experiment gives the ſolution of this problem. If acid of arſenic be ſaturated with alkali of tartar, till the ſolution of lacmus is no longer reddened, and the ſolution be afterwards evaporated to dryneſs, and then diſtilled with double the quantity of nitre in a glaſs retort furniſhed with a receiver, the nitrous acid will be expelled as ſoon as the maſs enters into fuſion: This acid will be very volatile. If the diſtillation be continued with a ſtrong fire till no more acid goes over, the reſiduum in the retort proves to be very alkaline. If a ſolution of hepar ſulphuris be mixed with this imperfect neutral ſalt, the ſulphur will be precipitated; in like manner, a ſolution of ſoap is rendered turbid by it. It is hence evident, that the acid of arſenic may be combined with a greater quantity of alkali than is neceſſary to its ſaturation; and that, in conſequence of this, the nitrous acid is expelled, whence an arſenical ſalt, with a ſuperabundance of alkali, ariſes. This attraction, however, has

has likewiſe its limits; for when a mixture of one part of acid of arſenic and ſix parts of nitre is melted in a covered crucible in a ſtrong fire till all ebullition ceaſes, there will be found, beſides the arſenical ſalt, a conſiderable quantity of undecompounded nitre. But concerning the alkaliſation of nitre with arſenic, there is one principal point to be noticed, *viz.* that nitre always attracts a certain ſmall quantity of phlogiſton from the heat itſelf, and that this phlogiſticated nitrous acid forms with the alkali but a looſe union, ſo that vegetable acids are able to expel it from its baſis. This property of nitre is the reaſon why acid of arſenic, by virtue of its attraction for the ſuperfluous alkali, expels the nitrous acid phlogiſticated by heat; whence it likewiſe follows, that, ſince common ſalt undergoes no change in the fire, the acid of arſenic is not able to alkaliſe it, as will appear from the following paragraph.

§ XI. *Muriated foſſil Alkali, or common Salt.*

One part of common ſalt was diſtilled with three parts of acid of arſenic. Water firſt went over; when the maſs was dry, I changed the receiver, and increaſed the fire till the retort grew red-hot, when the maſs began to flow and to boil. This degree of heat was continued till the ebullition,

lition was over, when I found that ſome fuming muriatic acid had gone over into the receiver. After the reſiduum in the retort was cool, I diſſolved it in water; the ſolution being filtered and evaporated, yielded cryſtals of common ſalt; but there remained a thick maſs, which changed the colour of lacmus to red, and would not cryſtalliſe. In § VII. it has been obſerved, that mineral alkali, ſuperſaturated with acid of arſenic, will not cryſtalliſe; wherefore I diluted this magma with diſtilled water, adding finely powdered chalk, till the ſolution ſhewed no more mark of acidity; I then filtered it. After evaporation in the open air, cryſtals were obtained, perfectly agreeing with the neutral ſalt § VII.

§ XII. *Upon Sal Ammoniac.*

One part of ſal ammoniac was diſtilled with three parts of acid of arſenic. A portion of muriatic acid went over with the water; I then changed the receiver, and increaſed the heat, when fuming muriatic acid came over, and the maſs entered into fuſion. Immediately after this, the receiver was filled with a white ſmoke, and a white powder was ſublimed into the neck of the retort; at laſt a pungent volatile alkali paſſed over into the receiver; and a reſiduum remained in the retort, which

which was acid of arſenic. The powder ſublimed into the neck of the retort was diſſolved in water, and the ſolution was filtered, when there remained a white powder, which proved to be arſenic. The liquor which paſſed through the filter contained ſal ammoniac.

I repeated the ſame experiment, applying only a bladder inſtead of the receiver. When the heat became ſo ſtrong as to drive the white powder into the neck of the retort, the bladder was diſtended. The air it contained is entirely the ſame with that of which I ſpoke § VIII. c. Hence it follows, that part of the arſenical acid has combined with a portion of the phlogiſton of the volatile alkali, and that the arſenic ſublimed into the neck of the receiver has been thus produced. Hence, too, the bladder was neceſſarily filled at the ſame inſtant with that air which ariſes from the decompoſition of volatile alkali. Heat expels the volatile alkali from arſenical ſal ammoniac § VIII. c; and as any acid converted into vapour, when it meets with volatile alkali, always produces a ſmoke, it is evident why the bladder at the end of the proceſs was filled with it.

§ XIII. *Vitriolated Lime, (Gypſum), and Spathum Ponderoſum.*

One part of powdered gypſum was mixed with two parts of dry acid of arſenic, and expoſed to a red heat, when ſome vitriolic acid came over, with a ſtrong ſmell of volatile ſulphureous acid, and the maſs entered into fuſion. After the diſtillation was over, it had the appearance of a milky glaſs. (B) Spathum ponderoſum produced the ſame phænomena, only the vitriolic acid was not expelled till the retort melted. The reſiduum was a little reddiſh. See § XX.

§ XIV. *Upon Fluor Mineral.*

One part of powdered fluor was mixed with four parts of acid of arſenic, and diſtilled, a little water being put into the receiver. When the retort grew red-hot, firſt a yellow, and afterwards a red ſubſtance, was ſublimed. Volatile ſulphureous acid went over, but no acid of fluor. The reſiduum, which was of a grey colour, was divided into two equal parts. Of theſe one was mixed with charcoal-powder, and diſtilled with a ſtrong fire; but neither arſenic nor regulus was ſublimed: Whence it appears, that I took too ſmall a quantity of acid of arſenic to decompoſe

compoſe this fluor, which contained a ſmall quantity of pyrites (§ v. c). The other half was mixed with four parts of acid of arſenic, and the mixture was diſtilled. When the maſs grew dry, a little yellow ſal ammoniac was ſublimed, whereupon the water in the receiver was covered with a white cruſt. I frequently ſhook the receiver, in order to make this cruſt fall to the bottom, and continued the diſtillation as long as any cruſt formed upon the water. This cruſt was ſiliceous earth, and the water contained acid of fluor.

§ xv. *Effects of the Acid of Arſenic upon Earths.*

Lime.

(A) When acid of arſenic is dropped into lime-water, the lime precipitates, in combination with the acid of arſenic. If more acid be dropped in, the precipitate is again diſſolved. If the ſolution be evaporated, ſmall cryſtals ſhoot. If theſe be diſſolved in a little water, and ſome vitriolic acid dropped into the ſolution, a precipitation of vitriolated lime takes place. (B) If the acid of arſenic be diluted with water, and ſome powdered chalk added, it will at firſt diſſolve; but, on adding more chalk, the whole ſolution will coagulate into ſmall cryſtals. (C) The acid of arſenic does not precipitate the ſolutions of nitrated, muriated,

 and

and acetated lime; neither are theſe ſolutions precipitated by the neutral arſenical ſalt of Mr Macquer; but the arſenical ſalts (§ VI. VII. VIII. A, A, A,) decompoſe theſe ſolutions, and form a precipitate which is not ſoluble in water, though it is of eaſy ſolubility in acids. (D) If the precipitate of lime, combined with acid of arſenic, be edulcorated, and afterwards ſtrongly calcined for an hour in a cloſe crucible, it will form a thick flux; but it ſtill retains the acid of arſenic. (E) If it be mixed with the ſame quantity (in meaſure) of charcoal-powder, and expoſed to a ſtrong fire in a retort, a ſhining regulus of arſenic will be ſublimed. The reſiduum is quicklime, mixed with charcoal, ſtill however containing ſome arſenic.

§ XVI. *Upon Magneſia.*

(A) Magneſia diſſolves in acid of arſenic; but, when the ſolution comes to the point of ſaturation, the maſs coagulates. This coagulum being diſſolved in a larger quantity of acid of arſenic, and evaporated, the ſolution grows gelatinous; if the jelly be lixiviated with water, filtered and evaporated, a viſcid maſs remains, which will not cryſtalliſe. (B) The ſolutions of magneſia in vitriolic, nitrous, muriatic, and acetous acids, are not precipitated by the acid of arſenic, but very readily by the

the neutral arſenical ſalts § VI. VII. VIII. A, A, A. The precipitate is eaſily ſoluble in acids, but not in water. (C) Expoſed to the fire in a crucible with charcoal, it ſhews the ſame phænomena as the precipitate of lime § XV. D, E.

§ XVII. *Upon Earth of Alum.*

(A) The earth, which is precipitated from a ſolution of alum by alkali of tartar, after being waſhed with boiling water, is eaſily ſoluble in the acid of arſenic, till it becomes quite dry. The ſolution coagulates as ſoon as it arrives at the point of ſaturation. (B) Diſſolved in the vitriolic, nitrous, and muriatic acids, it is not precipitated by the acid of arſenic, but it is, when diſſolved in vinegar. The above ſolutions are precipitated by neutral arſenical ſalts; the precipitate eaſily diſſolves in acids, but not in water. (C) Treated in the crucible, it ſhews the ſame phænomena as the precipitate of lime § XV. D. (D) If the ſolution (A) be evaporated to dryneſs, and then mixed with a little charcoal-powder, and expoſed to diſtillation with a ſtrong fire, a little yellow ſublimate riſes into the neck of the retort, as likewiſe ſome ſhining regulus; volatile ſulphureous acid paſſes over into the receiver. The reſiduum diſſolves with difficulty in vitriolic acid; ſome cryſtals of

 alum,

alum, however, will form in the ſpace of two months.

§ XVIII. *Upon white Clay.*

One part of white clay reduced to powder was mixed with four parts of acid of arſenic, and digeſted for a fortnight; but the acid would not diſſolve any part of it. The maſs was put into a retort, and diſtilled to dryneſs, and the fire increaſed till the retort began to melt. It was converted into a thick flux, and a little arſenic was ſublimed. The reſiduum, powdered and mixed with a little charcoal-powder, was expoſed to diſtillation in the ſame degree of heat when a ſhining regulus was ſublimed.

§ XIX. *Upon Silex.*

Liquor ſilicum was precipitated by vitriolic acid, and lixiviated with boiling water. While it was ſtill moiſt, acid of arſenic was added, and the maſs was expoſed to digeſtion for fourteen days, but no ſolution enſued. I afterwards evaporated it, and calcined the product, till the retort which I uſed began to melt. A little arſenic roſe into the neck of the retort: Then the reſiduum was boiled in water, upon which the acid diſſolved, but the ſilex remained at the bottom unchanged.

§ XX. *Upon Terra Ponderoſa.*

The earth in the ponderous ſpar is not lime, as is generally believed, but a peculiar kind of earth: It is the ſame with that of which I related ſome experiments in my Diſſertation on manganeſe. Mr I. G. Gahn afterwards informed me, that he found that this earth was the baſis of the ponderous ſpar. Incited by this, I procured a larger quantity of it, in order to make more experiments. I ſhall here only mention the effects of acid of arſenic. (A) Terra ponderoſa diſſolves readily in the acid of arſenic; but, as ſoon as it has obtained its point of ſaturation, it again precipitates, combined with the arſenical acid. (B) Neither is its ſolution in nitrous, muriatic acetous acid, precipitated by the acid of arſenic; but the arſenical neutral ſalts (§ VI. VII. VIII. A, A, A,) precipitate theſe ſolutions. (C) In the crucible, this precipitate ſhews the ſame phænomena as the precipitate of lime; as alſo when treated with charcoal-powder. (D) The ſolution of ponderous earth in acid of arſenic is again precipitated by the acid of vitriol, in the form of a ſalt inſoluble in water, *viz.* regenerated ponderous ſpar.

§ XXI. *The Effects of the Acid of Arſenic upon Metals.*

As the acid of arſenic cannot be kept long in the crucible without being converted into arſenic, in which ſtate it ſublimes (§ V. B); and as in a retort it continues long unchanged, and conſequently acts longer upon metals, I rather choſe to conduct my experiments in the latter way.

In long necked flaſks I added four parts of the acid of arſenic to one part of filings of metals. After the water was evaporated, I poured freſh upon the mixture. This method I purſued in all the following experiments.

§ XXII. *Upon Gold.*

(A) The acid of arſenic has no effect upon gold in the heat of digeſtion. I put the maſs into a retort, and abſtracted all the liquid, then increaſed the heat till the acid flowed, and continued the ſame degree of heat for half an hour, during which time a ſmall quantity of arſenic was ſublimed. When the retort was grown cool, I poured a little water into it, and placed it in ſand. The acid was diſſolved; but the remaining gold being waſhed and dried, was found to be nearly of the ſame weight as at firſt. The retort was marked with red and yellow ſpots, which could not

not be taken off by any menſtruum. (B) The ſolution of gold was mixed with acid of arſenic, but no precipitation enſued; the maſs was then abſtracted in a retort to dryneſs, and the fire increaſed till it was in a perfectly fluid ſtate; the gold was reduced, and ſome dephlogiſticated muriatic acid came over into the receiver. The retort was ſpotted red and yellow. (C) The mixture of acid of arſenic and muriatic acid has no effect upon gold, neither has a mixture of acid of arſenic and nitrous acid.

§ XXIII. *Upon Platina.*

(A) Platina digeſted in the acid of arſenic is not attacked. After all the humidity was abſtracted, I increaſed the fire till the retort melted. The platina lay at the bottom in the fuſed acid; a little arſenic was ſublimed. After it was cool, I poured ſome water into the retort, which diſſolved the acid. This acid was rendered opaque by a white powder, which was afterwards lixiviated with water, and then dried. It grew black upon charcoal before the blowpipe, had a ſmell like arſenic, and was attracted by the loadſtone. The platina, after it was dried, had hardly loſt any thing of its weight. Pure platina, conſequently, is not attacked by the acid of arſenic. (B) The ſolution of platina

tina in aqua regia is not precipitated by the acid of arſenic, but readily by the arſenical neutral ſalts. The precipitate in this caſe is yellow; it is ſoluble in a large quantity of water; but it contains no mark of acid of arſenic. A mixture of acid of arſenic and muriatic acid has no effect upon platina, neither has a mixture of nitrous acid and the acid of arſenic.

§ XXIV. *Upon Silver.*

(A) Pure ſilver is not attacked by the acid of arſenic in digeſtion. After the whole of the liquid was abſtracted, I increaſed the fire till the acid came into fuſion. Here more arſenic was ſublimed than in the foregoing experiments with gold and platina. This degree of heat being continued for half an hour, the ſilver diſſolved. After the retort was grown cold, I broke it, and found that it contained a colourleſs glaſſy maſs, nearly tranſparent. The retort was covered with a glazing of a flame-colour, which could not be ſeparated from the glaſs by any ſolvent. (B) Upon the vitreous maſs, after it was pounded, I poured ſome diſtilled water, and expoſed it to a ſand-heat, upon which it immediately loſt its tranſparency, and aſſumed a brown-red colour; the acid of arſenic was diſſolved, and a brown

brown powder remained at the bottom. The acid contained a little of the ſilver in ſolution; for, on adding muriatic acid, ſome luna cornua was precipitated. (C) The brown powder was dried, and expoſed to ſuch a degree of heat that the retort melted. The powder entered into fuſion, but no arſenic was ſublimed. When the retort was cooled, I broke it, and, upon taking the maſs out, I found it tranſparent at the margin. (D) As calx of ſilver is reducible without the addition of phlogiſton, as is likewiſe the caſe with acid of arſenic (§ V. B), I tried what a greater degree of heat would effect. I therefore put the glaſſy maſs into a crucible, over which I luted another, and afterwards applied as ſtrong a heat as ſilver requires for being melted. After the apparatus was cooled, the ſilver was found reduced, and ſurrounded with a little white glaſs. (E) The ſolution of ſilver is precipitated by acid of arſenic, but not entirely; the precipitate is of a brown colour. More is precipitated by the neutral arſenical ſalt of Mr Macquer; but as this ſalt is ſuperſaturated with acid, ſome ſilver is retained in the ſolution. The neutral arſenical ſalts (§ VI. VII. VIII. A, A, A,) decompoſe the ſolution entirely. (F) If this precipitate of ſilver be digeſted in muriatic acid, the acid of arſenic is expelled

pelled, and it is changed into muriated silver. In the same manner, this brown precipitate is soluble in spirit of sal ammoniac, prepared with lime. (G) Though neither the acid of arsenic nor the muriatic acid alone attack silver, a mixture of them has considerable action upon this metal. If the solution of silver in nitrous acid be precipitated by copper, and the precipitate well-washed with hot water, and afterwards digested for fourteen days in a close vessel, with two parts of acid of arsenic, and two parts of muriatic acid, the silver is changed into a white powder, which, after being edulcorated and dried, is found to be muriated silver. If the acid liquor be then distilled off, muriatic acid goes over, which contains arsenic; for, when mixed with a little nitrous acid, and again abstracted, a little acid of arsenic remains behind. Hence it follows, that the muriatic acid attacked the earth of silver during the digestion, while the acid of arsenic attacked its phlogiston; whence the arsenic was produced, which the muriatic acid afterwards took over with it into the receiver.

§ XXV. *Upon Quicksilver.*

(A) Quicksilver was not acted upon by the acid of arsenic during digestion. I next put the mixture into a retort, abstracted

ſtracted all the watery part, and then increaſed the fire. The maſs grew yellow, quickſilver roſe into the neck, with a little arſenic, and a little yellow ſublimate. The fire was then increaſed till the retort was near melting, but the maſs would not enter into fuſion. Of ſix drachms of quickſilver which I took for this experiment, I obtained three drachms and a half in the receiver. Thus the acid of arſenic contained $2\frac{1}{2}$ of fixed quickſilver. (B) After the retort was cold, I took the maſs, which was a little yellow, out of it, and divided it into two parts. One I boiled in diſtilled water, but none of it was diſſolved. Diluted nitrous and vitriolic acids had hardly any effect upon it, but muriatic acid diſſolved it very readily. This ſolution being evaporated to dryneſs, then put into a retort, and diſtilled, corroſive ſublimate roſe into the neck. The reſiduum flowed upon applying a ſtrong fire, and proved to be acid of arſenic. The other portion I mixed with two parts of common ſalt, and diſtilled it. Corroſive ſublimate roſe into the neck of the retort. (C) Calcined quickſilver and arſenical acid being reducible by heat without any addition of phlogiſton, this reſiduum (A) muſt likewiſe be reducible by a ſufficient degree of heat alone. One part of quickſilver was mixed with ſix parts of acid of

arſenic,

arſenic, and after all the humidity was driven off, the fire was increaſed, and though the maſs was heated white, it, however, lay unchanged in the retort; but when the retort melted, it ran likewiſe into fuſion; the quickſilver was reduced, and roſe, together with the arſenic, into the neck of the retort, a little quickſilver remaining behind. (D) It is known, that quickſilver, digeſted with muriatic acid is not attacked. But if two parts of muriatic acid, two parts of acid of arſenic, and one part of quickſilver, be expoſed to digeſtion in a cloſe phial for fourteen days, the acid acquires the taſte of quickſilver, and that metal is changed into a yellow powder. If the acid be now diſtilled, muriatic acid impregnated with arſenic goes over. If the reſiduum in the retort be urged by a ſtrong heat, corroſive ſublimate riſes, and the ſuperabundant acid of arſenic remains behind in the retort. The yellow powder is turned black by lime-water and alkalis; if ſublimed, it is changed into mercurius dulcis. (E) The ſolutions of quickſilver in vitriolic and nitrous acids are precipitated by the acid of arſenic in the form of a yellow powder; but the ſolution of corroſive ſublimate is neither precipitated by the acid of arſenic, nor by any of the neutral arſenical ſalts; but arſenicated volatile

latile alkali (§ VIII.) precipitates the ſolution in the form of a white powder. (F) The acid of arſenic, when ſublimed with corroſive ſublimate, undergoes no change. But if, inſtead of corroſive ſublimate, mercurius dulcis is employed, corroſive ſublimate riſes, and the reſiduum is the ſame as that of letter A. Some writers aſſert, that arſenic, diſtilled with corroſive ſublimate, yields butter of arſenic; but they are miſtaken. I have diſtilled ſuch a mixture in different proportions, but have always obtained at firſt corroſive ſublimate in the neck of the retort, and afterwards arſenic. Hence it would follow, that as the quickſilver in the corroſive ſublimate is calcined, the muriatic acid has a ſtronger attraction for arſenic than for the calx of quickſilver. In order to aſcertain this point, I mixed butter of arſenic with calcined quickſilver, and diſtilled the mixture. I firſt obtained ſome drops of the butter in the receiver, then corroſive ſublimate roſe into the neck of the retort, which was at laſt followed by arſenic. But the caſe is quite different with the regulus of arſenic; for if it be mixed with an equal quantity of corroſive ſublimate and diſtilled, ſmoking butter of arſenic, mercurius dulcis, and a little quickſilver, are obtained. Hence it follows, that mercurius dulcis is decompoſed

poſed by a double elective attraction, that of the phlogiſton of the regulus for the calx of mercury, and that of the muriatic acid for the calcined regulus of arſenic, whence the quickſilver is reduced, and butter of arſenic is produced. The ſame thing happens with a mixture of orpiment and corroſive ſublimate.

§ XXVI. *Upon Copper.*

Copper is attacked by the acid of arſenic during digeſtion. The ſolution is of a green colour. A quantity of light blue powder is depoſited, and attaches itſelf to the copper. This powder conſiſts of acid of arſenic and calcined copper. (B) One part of filings of copper was mixed with two parts of dry acid of arſenic, reduced to a fine powder. The mixture was expoſed to diſtillation, and the fire increaſed till the retort melted. Here ſome arſenic roſe into the neck, the maſs entered into fuſion, and turned blue. After the retort was cooled, I poured ſome water upon it and boiled it; the ſolution was like that of letter A. In the retort there remained a little copper which was not diſſolved, and the bottom of the retort was tinged with brown, red, and yellow ſpots, which were inſoluble in any menſtruum. (E) Copper diſſolved in mineral acids was not precipitated by the acid of arſenic;

arſenic; but when it is diſſolved in vinegar, a precipitation enſues. Neutral arſenical ſalts precipitate the ſolution of copper in the form of a blue powder, which I edulcorated, dried, and expoſed to a ſtrong fire for an hour. After the maſs was cooled, the powder appeared to be changed into a brown ſcoria, which had covered the whole internal ſurface of the crucible with a yellow enamel. (D) The ſcoria was finely powdered, mixed with a little lamp-black, and expoſed in a ſmall glaſs retort to the fire till it melted, when a fine regulus of arſenic was ſublimed, and the copper in the reſiduum was found to be reduced.

§ XXVII. *Upon Iron.*

(A) Iron is attacked by the acid of arſenic during digeſtion, and at laſt the whole ſolution grows gelatinous. (B) But if the digeſtion be performed in a cloſe phial, ſo that the air has no acceſs to it, it does not grow gelatinous. One portion being expoſed to the open air, in a couple of hours afterwards the ſolution was grown ſo gelatinous upon its ſurface, that the phial might be inverted without any thing running out of it. Another portion was mixed with alkali of tartar, whence a quantity of a whitiſh green powder was precipitated, which being edulcorated and

 diſtilled

diſtilled in a glaſs retort by a gentle fire, ſome arſenic was ſublimed, and the reſiduum was red ochre. (C) One part of iron-filings was diſtilled with four parts of acid of arſenic. The maſs made a great efferveſcence towards the end, and, when it became dry, it took fire in the retort upon increaſing the heat, and then both arſenic and regulus of arſenic were ſublimed. After it was grown cool, the reſiduum was found to be black; it was friable, and contained but little acid of arſenic. The retort was covered with yellowiſh-brown ſpots. (D) Solutions of iron in mineral acids are not precipitated by the acid of arſenic, but iron diſſolved in vinegar is precipitated in the form of a dark-brown powder. Neutral arſenical ſalts precipitate all ſolutions of iron. The precipitated powders, if expoſed to a ſtrong fire, enter into fuſion with an arſenical ſmell, and are changed into black ſcoriæ, which, when mixed with charcoal-powder, and calcined, yield copious vapours of arſenic, and are afterwards attracted by the loadſtone.

§ XXVIII. *Upon Lead.*

(A) Lead digeſted with acid of arſenic turned black at firſt. Some days afterwards it was ſurrounded with a light-greyiſh powder, which is mixed with a little arſenic,

ſenic, but this may be ſublimed by a gentle fire. The acid contains no lead diſſolved. (B) One part of ſhavings of lead was diſtilled with two parts of dry acid of arſenic reduced to powder. The lead was diſſolved, and the maſs flowed clear, a little arſenic riſing into the neck of the retort. After the retort was grown cold, I found a milky glaſs in it, which I boiled in diſtilled water, and thus a quantity of white powder was ſeparated; the ſuperfluous acid of arſenic was diſſolved in the water. (C) This powder was edulcorated, then put into a little retort, and kept in fuſion for half an hour, but no arſenic was ſublimed. I put ſome ſmall pieces of charcoal into the retort, upon which a violent ebullition took place, and ſome regulus of arſenic was ſublimed. (D) Lead diſſolved in nitrous or muriatic acid or vinegar is precipitated by the acid of arſenic. This precipitate ſhews the phænomena mentioned at C.

§ XXIX. *Upon Tin.*

(A) Tin digeſted with acid of arſenic grows at firſt black, and is afterwards covered with a white powder; at laſt the whole maſs grows gelatinous. (B) One part of tin-filings was mixed with two parts of acid of arſenic, and diſtilled. When the maſs became red-hot, it took

 fire

fire in the retort, and immediately after both arſenic and a little regulus of arſenic were ſublimed. The tin was diſſolved, and formed a limpid flux, which, after growing cold, was of a milky colour. Upon this maſs I poured water, and expoſed it to heat, in order to diſſolve the acid. A quantity of white powder was ſeparated, which was inſoluble in any acid, and contained very little acid of arſenic. (c) The ſolutions of tin in mineral acids are not precipitated by the acid of arſenic, but its ſolution in vinegar is. Neutral arſenical ſalts precipitate the ſolutions of tin. This precipitate is very difficult of fuſion. When it is mixed with charcoal-powder, regulus of arſenic is ſublimed.

§ XXX. *Upon Zinc.*

This is the only one of all the metals and ſemimetals that efferveſces when digeſted with acid of arſenic. The zinc grows black, and the tranſparency of the acid is deſtroyed by a quantity of black powder. If this powder be ſeparated, edulcorated, and dried, and then put upon an iron plate, heated nearly red-hot, in a dark place, it burns with a blue flame and a white arſenical ſmoke, and leaves a white powder behind; it is conſequently for the moſt part regulus of arſenic. The efferveſcence ſoon ceaſes, becauſe each

each particle of zinc is ſurrounded with the regulus, which hinders the acid from having any effect upon it. (B) In order to aſcertain what kind of air it is which riſes during the ſolution, I tied an empty bladder to the phial in which the maſs was contained. The air which I obtained had the following properties: 1. It would not unite with water, nor did it precipitate lime-water. 2. Mixed in a glaſs-veſſel with two-thirds of common air, it was not abſorbed. 3. When a burning candle was brought to the mouth of the veſſel, the air in the veſſel was inflamed with detonation; the flame took its direction towards the hand, which was thereby coloured brown: The matter that produced this colour proved to be regulus of arſenic, and left a diſagreeable arſenical ſmell behind; the internal ſurface of the veſſel too was covered with a brown pellicle. The air, therefore, which holds the regulus of arſenic in ſolution is of the inflammable kind. (C) One part of filings of zinc was mixed with two parts of dry and finely powdered acid of arſenic, and diſtilled. When the bottom of the retort began to be red-hot, a violent inflammation, accompanied with a very bright light, took place in the retort, which burſt with an exploſion. In the neck were found regulus of arſenic and flowers of zinc.

(D) Zinc diſſolved in mineral acids is not precipitated by the acid of arſenic, but its ſolution in vinegar is precipitated. Neutral arſenical ſalts decompoſe all the ſolutions, and a white precipitate is obtained, which, when well edulcorated, fuſes in a retort on the application of a ſtrong heat, and, when mixed with charcoal-powder, yields regulus of arſenic.

§ XXXI. *Upon Biſmuth.*

(A) Biſmuth, during digeſtion with acid of arſenic, is covered with a white powder; water precipitates the ſolution. The powder conſiſts of calcined biſmuth and acid of arſenic. (B) One part of biſmuth was diſtilled with three parts of dry acid of arſenic. The maſs entered into fuſion, the biſmuth was calcined, but remained at the bottom undiſſolved; a little arſenic roſe into the neck; after the retort became cool, water was poured upon the reſiduum, which diſſolved the acid, but the calx of biſmuth remained unchanged. (C) Biſmuth diſſolved in nitrous acid was precipitated by the acid of arſenic. This precipitate, as well as the calx (B), are very difficult of fuſion; but on adding a little charcoal-powder, they melt immediately; the arſenic goes off in vapours, and the biſmuth is reduced.

§ XXXII.

§ XXXII. *Upon Regulus of Antimony.*

(A) During its digeſtion with the acid of arſenic, a quantity of white powder is ſeparated from the regulus of antimony. If a little of the clear ſolution be dropped into water, a white powder is likewiſe precipitated, which conſiſts of calcined regulus of antimony, and of acid of arſenic. It is ſoluble only in muriatic acid, and may be again precipitated by water. (B) One part of regulus of antimony was diſtilled with three parts of arſenical acid; as ſoon as the maſs entered into fuſion, an inflammation enſued, and regulus of arſenic and a little red ſublimate were ſublimed. A little volatile ſulphureous acid came over into the receiver. The reſiduum was boiled in water, upon which the acid was diſſolved; a white ſhining powder remained behind, which was mixed with charcoal-powder and diſtilled. An ebullition took place, ſome regulus of arſenic roſe into the neck of the retort, and the antimony was reduced. (c) Butter of antimony was not precipitated by the acid of arſenic, but readily by the neutral arſenical ſalts. The ſolutions of glaſs of antimony in vinegar and cream of tartar are precipitated by the acid of arſenic.

§ XXXIII. *Upon Cobalt.*

(A) The acid of arſenic digeſted with cobalt aſſumed a roſe-colour, but a great deal of the cobalt remained undiſſolved. (B) I put the whole maſs into a retort, and abſtracted it to dryneſs; then, on increaſing the heat, it entered into fuſion, and a little arſenic was ſublimed. After the maſs was grown cool, it had a ſemitranſparent violet-colour. I then poured water upon it, and put it into hot ſand; the acid was diſſolved, the violet-colour diſappeared, and the ſolution turned dark-red. The bottom of the retort was blue, and no menſtruum was capable of taking this colour out of the glaſs. (C) Neither the ſolutions of cobalt, in mineral acids nor vinegar, are precipitated by the acid of arſenic; but the arſenical neutral ſalts produce a precipitation of a roſe-colour. This precipitate is difficult of fuſion in the crucible, and has the appearance of a dark-blue ſcoria.

§ XXXIV. *Upon Nickle.*

(A) The acid of arſenic digeſted with nickle aſſumes a green colour; a quantity of green powder mixed with arſenic is precipitated. The arſenic may be ſeparated from it by a gentle heat. (B) One part of nickle was mixed with two parts of of dry acid of arſenic, and diſtilled by a ſtrong fire. The maſs melted with an appearance of inflammation, and ſome arſenic was ſublimed. After it was grown cool, it proved to be a yellow maſs, upon which a number of grey elevated ſtreaks appeared; they were like a vegetation, and were formed during the diſtillation. This yellow maſs was boiled in water, when the acid diſſolved, and a yellow powder remained behind, which, when treated with charcoal-powder, yielded a regulus of arſenic, but was not reduced itſelf. (c) The ſolutions of nickle in acids are not precipitated by the acid of arſenic, neither is there any precipitation from its ſolution in vinegar; but the neutral arſenical ſalts precipitate a whitiſh-green powder.

§ XXXV. *Upon Manganeſe.*

(A) The acid of arſenic diſſolves a little manganeſe during digeſtion; fixed alkalis precipitate a white powder from it. (B) When diſtilled with acid of arſenic, a little arſenic was ſublimed. The maſs entered into a kind of fuſion, but the acid contained no more of the manganeſe than it did before. (c) Phlogiſticated manganeſe diſſolves readily in acid of arſenic; but whenever the acid arrives at the point of ſaturation, the ſolution coagulates into to little cryſtals. (D) The ſolutions of manganeſe in the mineral acids are not precipitated by the acid of arſenic, though they readily are by the neutral arſenical ſalts. Manganeſe diſſolved in vinegar is precipitated by the acid of arſenic. (E) Theſe precipitates, which conſiſt of phlogiſticated manganeſe and of acid of arſenic, were diſtilled in ſuch a heat that the retort at laſt melted, but no arſenic was ſublimed, nor would they enter into fuſion, but retained their white colour; however, when mixed with charcoal-powder in a crucible, they flowed, and regulus of arſenic aroſe in the form of vapour, while the manganeſe remained behind.

§ XXXVI. *Upon Regulus of Arſenic.*

(A) The regulus of arſenic digeſted with acid of arſenic, was covered with a white powder, which proved to be arſenic. (B) One part of the regulus was mixed with two parts of dry acid of arſenic, and diſtilled. The regulus roſe into the neck, and the acid entered into fuſion. (C) If ſmall pieces of regulus of arſenic be put, one after another, into a retort where the acid of arſenic is in a ſtate of fuſion, an inflammation takes place, and arſenic is ſublimed. (D) The regulus of arſenic is diſſolved by unctuous oils in a boiling heat; the ſolution is black, and, after it grows cold, of the conſiſtence of ſalve.

ESSAY

ESSAY VII.

REMARKS UPON SALT OF BENZOIN. 1775.

THE common way to obtain the ſalt from benzoin is by ſublimation. This ſalt is ſold in the ſhops under the name of flowers of benzoin. I propoſed to determine with exactneſs how much ſalt a given proportion of benzoin yields by ſublimation. For this purpoſe, I diſtilled a pound of benzoin in a retort, and, after having perfectly ſeparated the empyreumatic oil by lixiviation, I obtained between nine and twelve drachms of flowers. This ſalt may be likewiſe obtained by ſimply lixiviating the benzoin with water; but the ſalt thus obtained is leſs in quantity, and if the ley be made too hot, the reſin eaſily runs together, and the whole labour is loſt. The reaſon why ſimple lixiviation yields ſo little ſalt is eaſily aſſigned. The reſinous particles of the benzoin do not tranſmit the water; the ſolution, therefore, takes place only on the ſurface of the particles of the powdered benzoin.

I further boiled pounded chalk and benzoin in water, and then filtered the decoction, but, on its cooling, obtained no no cryſtals; but on pouring ſome drops of vitriolic acid into this liquor, the ſalt of benzoin ſoon afterwards precipitated; for this ſalt, which is an acid, was united with the chalk. The quantity of ſalt obtained, however, was not greater than that obtained by lixiviation. I then fell upon the idea of communicating to the water the power of acting upon the reſinous particles of the benzoin, and thought thus to extract all the ſalt exiſting in this reſin. I therefore boiled pounded benzoin with alkaline ley, and afterwards ſaturated it with an acid. I thus obtained the ſalt of benzoin by precipitation; but I here likewiſe met with this inconvenience, that the powder of benzoin ran together during the boiling and floated on the ſurface in the form of a tenacious reſin.

There remained one way more to be tried, *viz.* To boil the benzoin with quicklime. As the particles of the lime, by interpoſing themſelves between the particles of the benzoin, might prevent their running together, and as lime has likewiſe the property of acting upon the reſinous particles, this promiſed to be a good way of extracting the ſalt from the benzoin. The ſalt thus obtained is perfectly free from empyreumatic oil, with which the flowers of benzoin are commonly contaminated, it is conſequently alſo free from the ſmell

ſmell which they otherwiſe yield. An equal, if not a greater quantity of ſalt, is obtained by this proceſs than by diſtillation. A pound of the reſin yielded from twelve to fourteen drachms of ſalt by this new method, which is as follows:

Upon four ounces of unſlaked lime pour twelve ounces of water, and, after the ebullition is over, add eight pounds more (the pound twelve ounces) of water; then put a pound of finely pounded reſin of benzoin into a tinned pan, pour upon it firſt about ſix ounces of the above lime-water, mix them well together, and thus ſucceſſively add the reſt of the lime-water. If it be poured in all at once, it will not mix with the benzoin, which will likewiſe coagulate, and run together into a maſs. This mixture ought to be boiled over a gentle fire for half an hour with conſtant agitation; then take it from the fire, let it ſtand quiet for an hour, in order that it may ſettle; pour off the ſupernatant limpid liquor into a glaſs veſſel. Upon the remainder in the pan pour eight pounds more of lime-water; boil them together for half an hour, then take it from the fire and let it ſettle; add the ſupernatant liquor to the former; pour upon the reſiduum ſome more lime-water, boil it as aforeſaid, and repeat the ſame proceſs once more. At laſt, put all the reſiduum

ſiduum upon a filter, and pour hot water ſeveral times upon it. During this proceſs, the calcareous earth combines with the acid of benzoin, and ſeparates it from the reſinous particles of this ſubſtance. A ſmall quantity of the reſin is diſſolved by the lime-water, whence it acquires a yellow colour. All theſe yellow leys and decoctions are to be mixed together, and boiled down to two pounds, which are then to be ſtrained into another glaſs veſſel.

Theſe lixivia are inſpiſſated thus much, becauſe ſuperfluous water would hold much ſalt in ſolution, which muſt afterwards be precipitated. Beſides, a ſmall quantity of the reſin, ſuſpended by the lime-water, likewiſe ſeparates during the evaporation, not being ſoluble in a ſmall quantity of water; it therefore remains in the ſtrainer. After the two pounds of the evaporated leys are grown cold, muriatic acid is to be added, with conſtant ſtirring, till there be no further precipitation, or till the maſs taſtes a little ſouriſh. As vegetable acids have in general a weaker attraction for abſorbent earths than mineral acids, the muriatic acid combines with the calcareous earth, and the acid of benzoin, which requires a large quantity of water to its ſolution, muſt fall down; the ſolution, which had before but a very

weak

weak ſmell of flowers of benzoin, acquires, by this precipitation, a very ſtrong one.

The precipitated coagulum is then to be put into a filter, and, after being well dried, it is to be edulcorated ſufficiently, by repeatedly pouring cold water upon it; it ſhould be dried afterwards in a gentle heat. But as the water made uſe of for the edulcoration contains a little of the ſalt of benzoin diſſolved, it ought to be evaporated, and afterwards ſet by to cryſtalliſe. If you wiſh to give this ſalt a ſhining appearance, diſſolve it in a ſufficient quantity—in ſix ounces, for inſtance, of water, by gentle boiling, then ſtrain it immediately, while it is yet warm, through a cloth, into a glaſs veſſel which has been heated before; you will thus have the ſatisfaction to ſee a number of fine cryſtals ſhoot as ſoon as the ſolution is grown cold. The water is then to be ſtrained from the cryſtals, and the reſt of the ſalt, ſtill ſuſpended in this water, is obtained by repeated evaporation and cryſtalliſation. But as the flowers of benzoin are, on account of their lightneſs, not eaſily pulverized, it may be beſt to keep the ſalt in the form of a precipitate, which is always the fineſt powder. To this conſideration it may be added, that, during the cryſtalliſation, a great deal of ſalt is loſt.

I have recommended cloth for filtering the warm ſolution, becauſe I found it anſwer beſt. If blotting paper be uſed, the ſalt ſometimes cryſtalliſes in the filter itſelf, and obſtructs it. The filtration itſelf might be omitted, if it were not unavoidable, in order to purify the ſalt from about two grains of reſinous ſubſtance, which, having been mixed with it during the preceding boilings, remain united with it during the reſt of the proceſs.

ESSAY

ESSAY VIII.

On Silex, Clay, and Alum. 1776.

FROM the writings of Mr Baumé, it appears that he takes the earth of alum to be nothing elſe than ſilex, and common clay to be ſiliceous earth, combined with a little vitriolic acid. Alum he ſuppoſes to be the ſame earth, ſuperſaturated with vitriolic acid. With regard to chemical opinions, it is my cuſtom not to credit any, till I have brought them to the teſt of experiment. I therefore was obliged to try Mr Baumé's aſſertion, that ſilex is ſoluble in vitriolic acid, by this teſt. I took an ounce of mountain cryſtal reduced to powder, mixed it with three ounces of alkali of tartar, and fuſed the mixture by a ſtrong fire. This alkaline maſs I afterwards diſſolved in twenty ounces of water, and poured as much diluted vitriolic acid to it, as was more than ſufficient to ſaturate it; I then filtered the liquor, collected, edulcorated and dried, the precipitated ſilex which remained on the filter. From the filtered liquor, after it was evaporated, I obtained, beſides a ſubacid vitriolated tartar, about 1 $\frac{1}{2}$ drachm of alum. The queſtion now was, Whether the precipitated ſilex, repeatedly fuſed with alkali, would ſtill yield alum? If this was the caſe, Mr Baumé's ſyſtem would gain a ſtrong confirmation; but, if it did not, a ſuſpicion would ariſe, that ſome clay was mixed with the mountain cryſtal; I therefore dried the precipitate, and mixed it with a triple quantity of alkali; and, proceeding in the ſame manner as in the foregoing experiment, again obtained alum. This laborious experiment I repeated ſeven times, and always obtained alum; I now thought it reaſonable to believe that Baumé was right. But, behold! on examining the crucibles, employed for theſe repeated fuſions, I found them every where uneven in the inſide, and full of little excavations, which they had not before the experiment. This created a ſuſpicion that the alkali had perhaps diſſolved part of the clay of theſe crucibles, and thus, with the ſuperfluous vitriolic acid, produced alum; I therefore now took an iron crucible, and prepared the liquor ſilicum, which I treated in the ſame manner as before, and obtained no alum. How eaſily may one err in making experiments! Thus, all the alum, I obtained, came from my crucibles, and I was in a fair way to obtain conviction of a falſehood: Undoubtedly the ſame thing led Mr Baumé into the miſtake. I afterwards

wards took precipitated ſiliceous earth while it was moiſt, and digeſted it for a fortnight with diluted vitriolic acid, in order to find out whether, as Mr Baumé aſſerts, any thing is diſſolved, but could find not the leaſt mark of ſolution.

The ſiliceous earth, therefore, ſtill remains a peculiar earth. Mr Baumé pretends, that clay contains a little vitriolic acid, and is on this account ſoluble in a large quantity of boiling water. I likewiſe tried this experiment, but found, that of ſeveral kinds of pure argillaceous earth not the ſmalleſt quantity was diſſolved, which is eaſily aſcertained by means of alkali of tartar. I here likewiſe made different experiments, in order to obtain vitriolic acid from pure argilla, but without ſucceſs. I could never obtain any hepar by means of alkali of tartar, nor by means of powder of charcoal; neither have I obtained with clay a vitriolic neutral ſalt from the reſiduum of the diſtillation of muriatic and nitrous acid.

I have made ſeveral experiments with alum, in order to aſcertain its effects when mixed with other ſubſtances. A ſolution of alum is decompoſed (A) by lime-water. If no more lime-water be added than is exactly requiſite for the precipitation, the earth of alum forms a tranſparent precipitate, of the appearance

 of

of boiled ſtarch. If the clear water is filtered, it proves to be a ſolution of gypſum. (B) If more lime-water be added to the ſolution of alum than is requiſite for its precipitation, a white precipitate is formed, but nothing gelatinous, as in the foregoing experiment. If the whole be left together for a quarter of an hour, and frequently agitated during this time; and if it then be filtered, no gypſum, nay, not even lime, is found in the ſupernatant water, unleſs there has been added too much lime-water; but it will be found to be pure water. I was at firſt at a loſs to imagine what was become of the gypſum. (C) On examining the precipitate, I found it to conſiſt of earth of alum, ſelenite, and lime; for, after putting it to diſſolve in muriatic acid, the gypſum, which is not ſo eaſily ſoluble, remained behind. The clear ſolution being ſaturated with cauſtic volatile alkali, a tranſparent gelatinous earth, which was the earth of alum, was precipitated. Upon ſtraining it again, and pouring lixivium tartari to it, I obtained a precipitate, which was lime. Hence I ſaw that the lime and gypſum had ſeparated from the water, and united with the earth of alum.

In order to acquire a more diſtinct idea of this phænomenon (D), I precipitated a ſolution of alum with a quantity of cauſtic volatile

volatile alkali, more than ſufficient to ſaturate the acid, in order that I might be quite certain of ſeparating all the vitriolic acid, which might perhaps ſtill adhere to the precipitate. The precipitated earth was edulcorated, and mixed with a ſolution of gypſum, that I might ſee whether the gypſum would ſeparate from the water and precipitate with the ſolution of alum; but this did not happen. (E) I further wiſhed to know how lime-water [illegible] the earth of alum. I found that it very ſoon loſt its cauſtic taſte, and that the clear earth of alum grew opaque. I ſtrained part of this water, and dropped ſome lixivium tartari into it, but it remained clear; neither was there any precipitate formed by corroſive ſublimate. I afterwards added muriatic acid to the laſt mentioned precipitate, when it diſſolved entirely without leaving any gypſum behind. Thus the earth of alum had united itſelf with lime, and formed a peculiar compound.

I now thought that this compound of the earth of alum and lime might ſeparate gypſum from water; (F) I therefore prepared a large quantity of this compound earth, mixed it with a ſolution of gypſum, and ſet it to reſt for a quarter of an hour, when I ſaw, to my ſurpriſe, that the gypſum remained ſuſpended in the water, and that the precipitate was ſtill ſoluble in muriatic acid, without leaving any gypſum behind. (G) I now mixed a ſolution of gypſum with lime-water, adding alſo pure earth of alum. This mixture perfectly agreed with that mentioned at B. The precipitate was white, and contained gypſum as well as lime. From theſe experiments I conclude, 1. That gypſum is able to combine with more lime than is requiſite for its perfect ſaturation. 2. That calcareous earth is capable of uniting with the earth of alum. 3. That gypſum cannot combine with the earth of alum; but if a ſuperfluous quantity of lime be united with vitriolic acid, it then will ſerve as a means of union, to combine gypſum with the earth of alum, and thus form a combination, conſiſting of three earths. Pure clay has no effect upon lime-water.

ESSAY IX.

Analysis of the Calculus Vesicæ. 1776.

HAVING collected a ſufficient number of calculi, taken from perſons of both ſexes, I undertook an enquiry into their nature, and I now communicate ſome obſervations, which, to my knowledge, have not hitherto been communicated to the public.

All the calculi which I have examined, whether flat and poliſhed, or rough and angular, were of the ſame nature, and conſiſted of the ſame conſtituent parts.

§ 1.

I put a quantity of calculus, reduced to powder, into a ſmall glaſs retort, poured ſome diluted vitriolic acid upon it, and expoſed it to digeſtion, but the powder was not at all attacked. After the humidity was abſtracted by diſtillation, the concentrated acid began to attack the powder, and the ſtone was diſſolved. After the acid was abſtracted to dryneſs by an increaſed heat, a black coal remained; the liquid which paſſed over was vitriolic acid,

 with

with a ſtrong ſmell of the volatile acid of ſulphur.

§ II.

Neither concentrated nor diluted muriatic acid had any effect upon the calculus, not even when boiled with it.

§ III.

(A) The diluted nitrous acid, or aquafortis, had ſome effect upon the calculus, even in the cold. On the application of heat, an effervescence enſued, and red vapours aroſe; the calculus was entirely diſſolved. If the experiment be made in a retort, and lime-water be put into the receiver, it will be precipitated.

(B) This ſolution is acid, though the menſtruum be boiled with a ſuperabundant quantity of powder, ſo that there may remain a portion of it undiſſolved.

(C) This yellow ſolution produces deep-red ſpots upon the ſkin in half an hour after it is applied. If the ſaturated ſolution be a little more evaporated, it aſſumes of itſelf a blood-red colour, which, however, diſappears on dropping in a ſingle drop of nitrous acid.

(D) A ſolution of ponderous earth in muriatic acid precipitates nothing from this ſolution.

(E) Me-

(E) Metallic ſolutions are not ſenſibly changed by this ſolution.

(F) It is not precipitated by alkalis, but only grows a little yellower when the alkali is ſuperabundant, and then this mixture, in a ſtrong digeſting heat, likewiſe aſſumes a roſe-colour, and produces ſpots of the ſame colour very quickly, and without any ſenſe of burning upon the ſkin. This mixture likewiſe precipitates metals of different colours; vitriol of iron, black; vitriol of copper, green; ſilver, grey; corroſive ſublimate, zinc, and lead, white.

(G) Lime-water decompoſes this ſolution, and precipitates a white powder from it, which I have edulcorated and dried. This precipitate is ſoluble in muriatic and nitrous acids without any efferveſcence. Though there be an exceſs of the precipitated powder, the ſolution will be acid. (The ſame thing happens likewiſe with animal earth and fluor ſpar, if they be diſſolved in the ſame acids). If the ſolution be evaporated to dryneſs, it will at laſt take fire. If the precipitate be heated only to a dull-red heat in a cloſe crucible, it grows black, ſmells like burnt alum, and efferveſces with acids. Before the blowpipe it changes into quicklime.

(H) Neither the acid of ſugar nor ſalt of ſorrel precipitate this ſolution. The alkaline

alkaline mixture (F) is alſo not precipitated by theſe acids.

§ IV.

The calculus, when pounded and boiled with a ſolution of alkali of tartar, remains unchanged. But perfectly pure or cauſtic alkali, ſuch as ſhews not the leaſt mark of aerial acid, diſſolves the calculus, even in the cold. The ſolution is yellow, and taſtes ſweetiſh; it is precipitated by all the acids, even by the aerial. Lime-water is not precipitated by this ſolution, but metallic ſolutions are decompoſed. Iron is precipitated brown, copper grey, ſilver black, zinc, corroſive ſublimate, and lead, white. If there be a little ſuperabundance of alkali in the ſolution, it yields a ſmell of volatile alkali. Dry volatile alkali has no effect upon the ſtone, but the cauſtic, prepared with quicklime, diſſolves it; a pretty large quantity, however, is required for this purpoſe.

§ V.

Lime-water likewiſe diſſolves the ſtone by means of digeſtion. Twelve grains of calculus require four ounces of limewater. The lime-water thereby loſes its cauſtic taſte. On adding acids to this ſolution, the calculus is partly precipitated.

§ VI.

§ VI.

Pure water dissolves the calculus entirely, but a large quantity is requisite for this purpose. If eight grains of finely powdered calculus be boiled for a short time with five ounces of water, they will be dissolved. The tincture of lacmus is turned red by this solution. Lime-water is not precipitated. As it grows cold, the greatest part of the calculus separates again in the form of fine crystals.

§ VII.

On distilling, in a small glass retort, one drachm of calculus in the open fire, I obtained a volatile alkaline liquor, like that from hartshorn, but no oil. In the neck of the retort there was a brown sublimate. Upon heating the retort thoroughly red-hot, and then leaving it to cool, I obtained a black coal, weighing twelve grains, which, when put upon red-hot iron in the open air, retained its black colour. The sublimate, which seemed to have been somewhat fused, weighed twenty-eight grains, and on being purified by a new sublimation, it grew white. It had no smell, but a somewhat sourish taste, and was easily soluble in boiling water. It also dissolved in spirit of wine, but a larger quantity than of water was requisite

ſite for this purpoſe. Lime-water was not precipitated. The ſublimate ſeemed to agree, in ſome reſpects, with the ſal ſuccini.

From theſe experiments I conclude, that ſince the terra ponderoſa (§ III. D) is not precipitated, which would, however, be a neceſſary conſequence, if vitriolic acid were a conſtituent part of the calculus; and ſince the acid of ſugar (§ III. H) does not produce any precipitation, which certainly would take place if lime were a conſtituent part of it,—I conclude, I ſay, that calculus is neither calcareous nor gypſeous, but conſiſts of an oily, dry, volatile acid, united with ſome gelatinous matter. The calculus is an oily ſalt, in which the acid prevails a little, ſince it is ſoluble in pure water (§ VI.), and imparts to the tincture of lacmus a red colour. That it contains phlogiſton, appears by its ſolution in cauſtic alkalis and lime-water (§ IV. V.), but eſpecially from the effects produced by means of nitrous acid, from which it acquires quite different properties than from being diſſolved in alkalis, nor can it be precipitated from this ſolution (§ III. F). The animal gelatinous ſubſtance appears on diſtillation, by which a liquor is obtained reſembling ſpirit of hartſhorn, and a fine coal is left behind.

§ VIII.

§ VIII.

I have found calculus diſſolved in all urine, even in that of children. If four kannes of limpid freſh urine be evaporated to two ounces, a fine powder is depoſited as it cools, and a part firmly adheres to the glaſs. This powder diſſolves very readily in a few drops of cauſtic alkali, and has moreover all the properties of a calculus veſicæ. The lateritious ſediment, which is depoſited from the urine of thoſe who labour under an ague, is of the ſame nature. I ſuſpected in the beginning, that there was an unknown menſtruum in this urine, which, being volatile in the open air, was the cauſe of ſuch a large quantity of this powder being kept ſuſpended in the urine; but as ſuch urine likewiſe grows turbid, and depoſits the ſame ſediment when kept in cloſe veſſels, and rediſſolves it again on being expoſed to a ſufficient degree of heat, it appears evident that ſuch a menſtruum is neither preſent nor requiſite.

§ IX.

All urine contains ſome animal earth or lime combined with phoſphoric acid, and, by the ſuperabundance of acid, this earth is kept diſſolved. It is owing to this ſuperabundance that urine imparts a red colour

colour to paper coloured with lacmus. If this ſuperabundant acid be ſaturated with volatile cauſtic alkali, a white powder is precipitated. Three drachms and a half of this powder, when dried, are obtained from four kannes of urine. I diſſolved it in nitrous acid; on adding vitriolic acid ſome gypſum was precipitated. After all the nitrous acid was evaporated, an acid remained, which precipitated lime-water, and, when mixed with lamp-black, yielded phoſphorus on diſtillation; conſequently this powder really contains lime and phoſphoric acid.

§ X.

According to theſe experiments, all urine contains, beſides the ſubſtances already known, (*viz.* ſal ammoniac, common ſalt, digeſtive ſalt, Glauber's ſalt, microcoſmic ſalt, ſal perlatum, and an oily extractive matter) a concrete acid, hitherto unknown or the calculus, and animal earth. It is remarkable that the urine of the ſick is more acid, and contains more animal earth than that of healthy perſons.

Supplement

Supplement to the foregoing Diſſertation.
By T. BERGMAN.

Without knowing any thing of Mr Scheele's analyſis of the calculus veſicæ, I was employed at the ſame time upon the ſame ſubject. My experiments lead nearly to the ſame concluſion, *viz.* that theſe animal ſtones conſiſt of a concrete acid. There are, however, ſome circumſtances in which they differ from thoſe of Mr Scheele. Perhaps the calculi on which we made our experiments were really different in their nature; but as the differences I remarked were conſtant with all the calculi on which I made experiments, I thought it worth while to communicate them to the public, eſpecially as they relate to a matter ſo intereſting to mankind.

I could not ſucceed in entirely diſſolving ſtones of the bladder or kidney, either in diſtilled water, or in nitrous acid; though it is true that the undiſſolved part is the leſs, the more finely the calculus has been previouſly pounded; but even in this caſe a part remains undiſſolved, as appears clearly when the experiment is made in a ſmall cucurbit; ſo that, after the maſs is cooled, the undiſſolved part may ſettle at the bottom in one place. This appears in the cleareſt

cleareſt manner, if ſmall pieces, or ſmall calculi, of a few grains weight only, be put into a ſuperabundant quantity of menſtruum, and be kept in a degree of heat, very near to that which makes water boil. Here it will be obſerved, that the greateſt part of the piece is diſſolved, but that at the ſame time ſome ſmall white ſpongy particles remain, upon which water, ſpirit of wine, acids, or cauſtic volatile alkali, have no ſenſible effect. If the heat be increaſed to full boiling, theſe particles divide into white rare flocculi, and become almoſt imperceptible, but without being diſſolved, at leaſt not entirely. I have not been as yet able to collect a ſufficient quantity of them, in order to determine exactly their nature. This, however, I know, that, when expoſed to fire, they are reduced to a coal, which burns ſlowly to aſhes, and is not ſoluble in diluted nitrous acid.

When calculus veſicæ is diſſolved in nitrous acid, no precipitation enſues on adding the acid of ſugar; whence one is readily induced to conclude, that there is no calcareous earth preſent, becauſe this experiment is the ſureſt way to diſcover it. But I have found, in a variety of experiments concerning elective attractions, that the addition of a third ſubſtance, inſtead of diſuniting two already united, often

often unites with both very closely. That the same thing happens here, I had the more reason to believe, because the acid of sugar contains some phlogistic matter, though of so subtile a nature, that, on being burned, it does not produce any sensible coal; and the event of my experiment has shewn, that I was not mistaken in my conjecture. In order to ascertain this point, I burned coals of the calculus to ashes, which were quite white, and shewed in every respect the same phænomena as lime, caused some effervescence during their solution in acids, united with vitriolic acid into gypsum, were precipitated by the acid of sugar, and were partly soluble in pure water, *&c.* Notwithstanding this, there remains about one hundredth part of the ashes insoluble in aquafortis; the remainder of the above mentioned substance, which, together with the concrete acid, constitutes the calculus. If the calculus be dissolved in nitrous acid, the solution filtered, and evaporated to dryness, and the dry mass calcined to whiteness; a calcareous powder is thus likewise obtained.

As pure vitriolic acid contains no phlogistic matter, I expected that it would, in the present case, immediately shew the presence of lime, a circumstance which really happened. I dropped some pure concentrated vitriolic acid into a ſolution of calculus in nitrous acid, and found, that when the ſolution was ſaturated, ſome ſmall cryſtals immediately ſeparated from it: They proved, on examination, to be gypſum; and, after being diſſolved in diſtilled water, they were precipitated by the acid of ſugar. When the ſolution of the calculus was very much diluted, there appeared no change in the beginning; but, after a little evaporation, the above mentioned cryſtals began to appear. Some calculi of the bladder or kidneys at leaſt certainly contain lime, but ſeldom more than one-half in a hundred parts, or one in two hundred parts.

Concentrated vitriolic acid diſſolves the calculus, when aſſiſted by heat, with effervefcence; the ſolution is dark-brown. If a little water be afterwards added, there ſeems to take place a kind of coagulation; but, on adding more water, all grows clear again, and aſſumes a yellowiſh brown colour.

The muriatic acid ſeems to have no effect upon it. I am however in doubt, whether it will not extract at leaſt a portion of the calcareous earth, and ſhall for this reaſon make ſome farther experiments to determine this point.

The red colour which the ſolution of the calculus in aquafortis may be made to aſſume, is remarkable. A ſaturated ſolution

lution difcovers no fmell of nitrous acid, and if evaporated by itfelf in a large open veffel, the liquor affumes at laft a deep-red colour, and it hardly contains any nitrous acid; for, on the one hand, paper tinged with lacmus fcarce fhews any figns of its prefence; and, on the other hand, the colour is deftroyed by the addition of any acid, without being ever afterwards recoverable, either by alkalis, or any other means known to me. If the folution be quickly evaporated upon a heated furnace, it at laft fwells into innumerable bubbles. This foam grows redder and redder, and, after it is quite dry, it appears dark-red. This dry mafs communicates its colour to a much larger quantity of water than before, and diffolves very readily in all acids, even in fuch as have no action on the calculus; but they entirely deftroy the colour, and that the more quickly, the ftronger they are. Even alum, with its fmall excefs of acid, has this effect. Cauftic alkalis diffolve the colouring matter, and deftroy it, but more flowly.

The nitrous acid has a peculiar effect upon all phlogiftic fubftances; and, as the colour of bodies is efpecially dependent on phlogifton, it appears why no other acid has the power of educing fuch a colour from the calculus. But, in order to obtain it, a proportional quantity of acid is requiſite. The diluted acid of nitre ought therefore to be made uſe of, in order not ſo eaſily to tranſgreſs the proper limits; for if too much be uſed, it will not produce the proper effect; but, in proportion to its ſuperabundance, goes further, and deſtroys more or leſs, or the whole of it. If it be poured undiluted upon powdered calculus, it is converted in a few moments, and without any aſſiſtance of heat, into a mere foam.

The acid of calculus is the more eaſily ſeparated from the aquafortis by evaporation, as the latter is rendered more volatile by the inflammable particles of the former. Alkali added to them both united, does not produce any precipitation, a circumſtance which is generally obſerved when two acids are combined; but both the acids unite with the alkali, according to the law of their attraction. The red maſs obtained after deſiccation, is however very different from the concentrated acid, ſuch as is contained in the calculus; for it is of a darker colour, and very deliqueſcent; the leaſt particle gives to a conſiderable quantity of water a roſe-colour; it is attacked by the muriatic and other ſtrong acids with violence, which ſooner or later produce a quite colourleſs ſolution. Such a remarkable change depends, as much as

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I have hitherto been able to aſcertain, more on the action of the nitrous acid upon the inflammable part than upon any thing remaining behind. Such red ſpots, as are produced upon the ſkin by the ſolution, are likewiſe produced upon bones, glaſs, paper, and other ſubſtances; but then more time is required before they become viſible, which however may be a little accelerated by heat.

I paſs over [illegible] experiments, made partly in a different from thoſe of Mr Scheele, which, however, prove no more than may be learned from his excellent paper. I was alſo prevented from finiſhing ſome of them by other engagements. I have been theſe ſeveral years collecting the different ſtony concretions of animal bodies, in order to inveſtigate their component parts; I have been promiſed ſtill more of them, and hope to be aſſiſted in this matter, ſo intereſting to medical ſcience, by ſuch as have collections of this kind. The only thing from which we may reaſonably expect the diſcovery of proper remedies, for the relief of people labouring under this complaint, is the juſt knowledge of the nature of the calculus. Did we not already know from experience, that lime-water and the cauſtic lixivium are among the beſt remedies againſt the ſtone of the bladder or kid-

 neys,

neys, we might conclude this from its properties, as they are now diſcovered. From a further enquiry, we may perhaps be led to find out a ſtill more convenient remedy. Whether all urinary calculi are of the ſame nature, I hope to aſcertain ſoon.

ESSAY

ESSAY X.

Method of preparing Mercurius Dulcis Via Humida. 1778.

§ 1.

TAKE half a pound of quickſilver, and as much pure common aqua-fortis, pour it into a ſmall cucurbit, with a pretty long neck, ſtop the mouth with a little paper, and put it into warm ſand. Some hours afterwards, when the acid appears no longer to act upon the quickſilver, the fire is to be ſo much augmented as nearly to make the ſolution boil. This heat is to be continued for three or four hours, and the veſſel now and then to be ſhaken *. Towards

* One would imagine, that when the acid no longer effervefces with the quickſilver, it ſhould be ſaturated; but this is far from being the caſe. If the heat is increaſed, this ſolution is ſtill able to diſſolve a great quantity; with this difference, however, that whereas the quickſilver in the beginning is calcined, a great deal of quickſilver, in a metallic form, is afterwards diſſolved, as appears clearly from this, that not only no more elaſtic vapours aſcend, but alſo, that with fixed and volatile cauſtic alkalis a black precipitate is obtained, otherwiſe, when the ſolution contains only calcined quickſilver, the precipitate is yellow. If the black precipitate be gently diſtilled, quickſilver ariſes, and there remains a yellow powder, which is

Towards the end, regulate the heat ſo that the ſolution ſhall gently boil for a quarter of an hour *. In the mean time, diſſolve $4\frac{1}{2}$ ounces of pure common ſalt in ſix or eight pounds of water; pour this ſolution, ſtill boiling, into a glaſs-veſſel, and immediately afterwards mix with it the above mentioned ſolution of quickſilver, which muſt alſo be boiling, in ſmall quantities at a time, with conſtant agitation. When the precipitate has ſettled, decant off the clear liquor and pour hot water again on the precipitate, with which it is to be edulcorated, till the water ſtanding upon it ſhall be entirely taſteleſs. Put the whole obtained by theſe means together; filter and dry it in a mild heat †.

§ 11.

is preciſely that part of quickſilver, which, in the beginning of the operation, was calcined by the acid of nitre.

* The fire muſt neceſſarily be augmented, in order to keep the nitrated mercury diſſolved, which is very much inclined to cryſtalliſe, even in the heat. There commonly remains ſome undiſſolved quickſilver; but it is always better to take too much than too little, for the more metallic ſubſtance the mercurial ſolution contains, the more mercurius dulcis is obtained.

† The mercurial ſolution muſt be cautiouſly poured into that of the common ſalt, that no mercury may follow. Two ounces of ſalt would be ſufficient for the precipitation of all the quickſilver; but when ſo ſmall a quantity is uſed, it may eaſily happen, that ſome

§ II.

If we conſider how mercurius dulcis is obtained in the dry way, or by ſublimation, it will not be difficult to account for the method I have propoſed. Mercurius corroſivus albus is a middle ſalt, and conſiſts, as is well known, of marine acid, combined with calx of mercury. This ſalt can diſſolve a good deal of quickſilver in its metallic form: In order to this, they muſt meet one another when ſeparated into their ſmalleſt particles, which happens when, by means of heat, they are converted into vapour. The ſame thing takes place with the ſolution of mercury that is obtained in the method above deſcribed. This contains the calx of mercury and quickſilver, divided into its fineſt particles. If there be now added marine acid, or, to ſave expence, common ſalt, the marine acid will unite with the calx of mercury,

ſome ſuperabundant corroſive ſublimate may adhere to the precipitate, which water alone is incapable of entirely ſeparating; this is doubtleſs the reaſon why it is generally ſuppoſed that white precipitate is corroſive. I have found, that common ſalt, as well as ſal ammoniac, is capable of diſſolving a conſiderable quantity of corroſive ſublimate. It is on this account that I take 4½ ounces of ſalt, in order completely to ſeparate all the corroſive ſublimate. From the above mentioned quantity of quickſilver, about 8½ ounces of mercurius dulcis are commonly obtained.

cury, by which genuine mercurius corrosivus albus is produced; and as the solution contains quicksilver in its metallic form, it immediately attracts as much of the corrosive salt as is necessary to its saturation; and thus is produced a real mercurius dulcis, which, on account of its insolubility in water, must be precipitated.

§ III.

Experiments prove, that this precipitate is nothing else than a good mercurius dulcis; as, 1*st*, It is entirely tasteless. 2*dly*, I have sublimed the precipitate, and examined what ascended in the beginning of this process, which ought to be corrosive, if the precipitate contained this salt in abundance, because it is well known, that corrosive sublimate rises sooner than mercurius dulcis; but this, as well as that which was afterwards sublimed, was pure mercurius dulcis, and entirely like to that obtained in the common manner. 3*dly*, I also mixed the precipitate with one-fourth part of quicksilver (thinking that, if it had contained too much mercurius corrosivus, it ought now to be able to unite with more quicksilver), and sublimed it, when I found my quicksilver again with its former weight undiminished. 4*thly*, It is known, that caustic alka-

lis

lis and lime-water give mercurius dulcis a black colour. The ſame thing appeared with mine. The black colour is nothing elſe than quickſilver divided into very minute particles.

§ IV.

That the method above deſcribed is really more advantageous than that uſually employed, I cannot doubt; becauſe, *1ſt*, The mercurius dulcis can be prepared with leſs difficulty, with leſs expence, and without employing mercurius corroſivus. *2dly*, It can never become either more or leſs corroſive, if it be only well edulcorated, and conſequently it is always ſafe. *3dly*, One is never expoſed to the vapour which riſes in the old method during the ſaturation of corroſive ſublimate with quickſilver, and which is ſo dangerous to the health. *4thly*, This mercurius dulcis is much finer than the common, which never can be reduced to ſo fine a powder, however long it is triturated.

ESSAY XI.

A CHEAPER AND MORE CONVENIENT METHOD OF PREPARING THE PULVIS ALGAROTHI. 1778.

THE preparation of this powder, as has hitherto been practiſed, is an operation very difficult, and dangerous to the health. As this powder is requiſite, in order properly to prepare antimonial or emetic tartar, I reſolved to try whether the preparation would not ſucceed without corroſive ſublimate, by which means two conſiderable advantages would be gained; the chemiſt would be out of danger, and the great quantity of the firſt mentioned mercurial preparation, which is now employed for making this powder, would be ſaved. Both theſe purpoſes we obtain by preparing mercurius dulcis via humida. For the objection, that no cinnabar of antimony is obtained, is groundleſs; becauſe this cinnabar, purified by ſublimation, is in no reſpect different from the common pure cinnabar.

Before I proceed to deſcribe the new proceſs for preparing the pulvis algarothi, it will be neceſſary to enquire into the theory which has been hitherto received, concerning

concerning the production of butter of antimony, when regulus of antimony is distilled with corrosive sublimate. It is said, that the decomposition of the corrosive sublimate, which in this case happens, takes place, because the elective attraction of the regulus of antimony for the muriatic acid is greater than that of the quicksilver for the same acid; that it therefore leaves the acid, and that this latter uniting with the regulus goes over into the receiver in the form of butter; that at last, on increasing the heat, the mercury goes over by itself, or that it is sublimed in union with the sulphur of antimony, under the name of cinnabar of antimony, provided crude antimony (antimonium sulphuratum) be taken for this purpose instead of the regulus.

This explication does not agree with the late observations in chemistry; for the butter of antimony, or, as it is sometimes called, the antimonial caustic, contains not the least regulus of antimony; but the portion of antimony which it contains is half calcined, and this calcination cannot be owing to the muriatic acid. But as it is well known, that the mercury in the corrosive sublimate is not in a reguline form, but in the state of a calx, and that the mercurial calx in this metallic salt may be reduced, by being put upon live coals;

that

that fuming muriatic acid goes over, if the corrofive fublimate is diftilled with phlogiftic fubftances; and further, that the corrofive fublimate is by no means decompofed when diftilled with pulvis algarothi, or with a half calcined regulus of antimony; it follows that, in the prefent procefs, the mercurial calx, as one conftituent part of the corrofive fublimate, attracts the phlogifton neceffary for its reduction from the regulus of antimony, whereby the muriatic acid is fet free, and then attacks the regulus of antimony, which is dephlogifticated in the fame proportion, and goes over united with it in the form of a thick fubftance, refembling butter.

The butter of antimony confifts, therefore, of concentrated muriatic acid, and of a half calcined regulus of antimony; and it is from this partly dephlogifticated regulus that the antimonial tartar is obtained when it is united with cream of tartar. The regulus of antimony muft be only partially calcined, in order to be foluble either in the muriatic acid, or by cream of tartar; for, in its metallic form, it is entirely infoluble; and the bezoar mineral proves, that this is alfo the cafe if the metal be entirely dephlogifticated; confequently, if regulus of antimony, partially dephlogifticated, be digefted in muriatic

riatic acid, this acid is not able to diſſolve more of it than what has already undergone that degree of calcination, or what has loſt ſo much phlogiſton, as the regulus of antimony generally loſes when it is diſtilled with corroſive ſublimate.

It is a known fact, that emetic tartar may be prepared from liver of antimony and cream of tartar; and that, when this emetic tartar is diſſolved in muriatic acid, and the ſolution diſtilled, the cauſticum antimoniale is generated; there muſt therefore be contained in the liver of antimony a regulus, ſo far calcined as to be fit for this purpoſe; and we ſhould gain our end completely, if the half calcined regulus contained in the hepar could be entirely freed from the hepar. This is the more requiſite, as the ſolution by the cream of tartar in the other caſe is not only very ſlow, but likewiſe contains (if the emetic tartar, which is thus prepared, be not contaminated with ſuperfluous cream of tartar) vitriolated tartar, which, though it be lixiviated with boiling water, cannot be extracted from the vitrified regulus with which it has been united by fuſion. The moſt proper menſtruum for extracting the half dephlogiſticated regulus is muriatic acid, which afterwards quits the antimony if the butter be diluted with boiling water. If this ſolution be diſtilled,

diſtilled, butter of antimony is likewiſe obtained: As, however, the hepar, prepared with equal parts of antimony and nitre, contains not only antimony ſtill undecompoſed, but likewiſe hepar ſulphuris, as eaſily appears, when this hepar is digeſted with muriatic acid, not only from the hepatic ſmell, but alſo from the remaining inſoluble black powder, it is neceſſary to add more nitre; and, inſtead of muriatic acid, which is dearer, a mixture of diluted vitriolic acid and common ſalt ſhould be poured upon it, with which it is afterwards to be digeſted. Thus a real butter of antimony is obtained, from which, when diluted with water, the pulvis Algarothi is precipitated. The ſalts contained in this antimonial ſolution, *viz.* Glauber's ſalt and vitriolated tartar, remain behind in the water, and do not in the leaſt change the precipitate.

The proceſs is therefore the following: Take of powdered crude antimony one pound, powdered nitre one pound and a half, which, after being well dried and mixed, are to be detonated in an iron mortar. The hepar, obtained in this manner, is to be powdered, and a pound of it to be put into a glaſs veſſel, on which, firſt a mixture of three pounds of water and fifteen ounces of vitriolic acid is to be poured, and afterwards fifteen ounces of powdered common ſalt are to be added; the glaſs veſſel is then to be put in a ſand-bath, and kept in digeſtion for twelve hours; during which period the maſs is to be conſtantly ſtirred. The ſolution, when cool, is to be ſtrained through linen. Upon the reſiduum one-third of the above mentioned menſtruum is to be poured, the mixture digeſted and ſtrained. From this ſolution, when it is diluted with boiling water, the pulvis algarothi precipitates, which is to be well edulcorated and dried.

ESSAY XII.

EXPERIMENTS UPON MOLYBDÆNA. 1778.

I Do not intend to treat here of the common molybdæna which is to be met with in the ſhops, for that is very different from the ſort concerning which I am now communicating my experiments to the Royal Society. Mine is that kind which Cronſtedt in his mineralogy calls *molybdæna, membranacea, nitens*, and with which Mr Quiſt and ſeveral others made their experiments. The ſpecimens, which I had an opportunity to examine, were taken from different places, but were all found to be of the ſame nature, and to conſiſt of the ſame conſtituent parts.

§ 1.

I firſt wiſhed to know what effects molybdæna would produce in the moiſt way: It was neceſſary for this purpoſe to have it very finely powdered. This being impoſſible to effect without ſome addition, on account of its flexible lamellæ, I triturated it in a glaſs mortar, with ſome pieces of vitriolated vegetable alkali, and thus I at laſt reduced it to a fine powder; upon which, after it was ſifted, I poured hot water, ſtirring the maſs well together. After the molybdæna had ſunk to the bottom, I poured off the ſolution, and repeated the ſame proceſs ſeveral times, till all the vitriolated tartar was entirely waſhed off; I then dried the powder that remained.

§ II.

I both digeſted and boiled this mineral in all the known acids; but among them all I found but two which have any effect upon it, *viz.* the acid of arſenic and the acid of nitre. The molybdæna not attacked by the acid of arſenic till the water is evaporated. If then the heat be increaſed a little, arſenic riſes into the neck of the retort, and towards the end yellow arſenic or orpiment is ſublimed. Volatile ſulphureous acid goes over into the receiver.

I poured two parts of concentrated nitrous acid upon one part of powdered molybdæna. The mixture was hardly lukewarm in the retort, when it paſſed all together into the recipient with great heat, in the form of dark-red vapours. I doubt not but this mixture would have taken fire if its quantity had been larger; and therefore thought it more adviſable to repeat the experiment with diluted nitrous acid.

§ III.

§ III.

I poured ſix ounces of diluted acid of nitre on one ounce and a half of powdered molybdæna, and put it into a glaſs retort, provided with a luted recipient, and placed it in a ſand-bath. During the digeſtion the acid had no effect upon the powder; but, as ſoon as the mixture began to boil, red elaſtic vapours roſe, with a great intumeſcence; the retort therefore ought to be taken large enough. The diſtillation was continued to dryneſs. Upon the reſiduum in the retort, which was now of a grey colour, I poured the ſame quantity of diluted acid of nitre, when the maſs began to effervefce conſiderably as before. After the mixture was again diſtilled to dryneſs, the reſiduum appeared to be of a whiter colour than before. I poured upon it the ſame quantity of the ſame acid, diſtilled and abſtracted it as before, and repeated the ſame operation the 4th and 5th time, till at laſt a powder as white as chalk remained in the retort. This reſiduum, after being edulcorated with hot water, till it was poured off perfectly taſteleſs, was dried. At this time it weighed ſix drachms and a half; I ſhall call it *terra molybdænæ*. The limpid liquor obtained from the edulcoration was evaporated to half an ounce; it then aſſumed a fine blue colour, and grew thick; it contained a little iron, but was, beſides, chiefly acid of vitriol. On diluting the acid with water, the colour diſappeared; fixed and volatile cauſtic alkalis have no effect upon molybdæna in the moiſt way.

§ IV.

From the fine experiments of Mr Quiſt on molybdæna, we know that this mineral contains ſulphur, and is almoſt entirely volatile in the open fire. A ſmall piece of it expoſed upon a ſilver-plate to the blowpipe makes a beautiful appearance, when the white vapours attach themſelves to the plate in the form of ſmall ſhining ſcales, in the direction of the flame. This white ſublimate becomes blue whenever it is in contact with the blue flame, but diſappears and changes again to white whenever the extreme point of the flame is directed againſt it. This white ſublimate is the ſame earth that is obtained with the acid of nitre (§ III.), and ſhews the ſame phænomena in the flame of the blowpipe.

§ V.

One ounce of pulveriſed molybdæna was mixed with four ounces of purified nitre, and detonated in a crucible heated thoroughly

roughly hot. The maſs thus obtained was of a reddiſh colour; I diſſolved it in water; the ſolution was clear and colourleſs; to the bottom of the veſſel a ſmall quantity of red powder ſubſided, which, after being dried, weighed eleven grains, and proved to be an iron ochre. From the ſolution I obtained, upon evaporation, both vitriolated tartar and nitre in cryſtals; but a good deal of lixivium remained, which refuſed to cryſtalliſe, though there was no mark of ſuperfluous alkali. I mixed it with a little water, to which I afterwards added diluted acid of vitriol, till there appeared no more precipitation. This precipitate, when edulcorated with lime-water, and dried, weighed three drachms. If too much acid of vitriol is added in the foregoing proceſs, the precipitate will be rediſſolved, and the water itſelf retains a part of it in ſolution. Nay, while the ſolution is hot, no precipitation enſues. A precipitate is likewiſe obtained by means of nitrous or muriatic acid.

§ VI.

In order to become better acquainted with this kind of earth, I firſt examined that obtained by means of nitrous acid, *via humida* (§ III.).

(A) I reduced a ſcruple of it in a glaſs-mortar to a very fine powder, and boiled it with two ounces of diſtilled water for a quarter of an hour. The liquid was then poured into another veſſel, and the remainder again boiled with two ounces more of water, which, when poured off, had a peculiar acid, and ſomewhat metallic taſte. I therefore repeated the ſame proceſs ten times over, always with two ounces of freſh water, and found at laſt that nearly the whole was diſſolved. (B) Thinking that perhaps ſome vitriolic acid might have adhered to the earth, and thus be the cauſe of its ſolubility in water, I expoſed part of the terra molybdænæ in a glaſs retort to the open fire, till the retort was very near beginning to melt, and really found in the recipient ſome ſmell of ſulphureous acid. Afterwards I expoſed the earth in a crucible, upon which another inverted one was luted to the fire for a quarter of an hour, when, on opening the crucible, the earth was found to be melted, and immediately a ſmoke aſcended, which fixed itſelf to a cold iron plate, that was held over it, in the form of ſmall ſhining white and yellowiſh ſcales. As ſoon as the covercle was put on, the fumes ceaſed; but as ſoon as the air had acceſs to it, the earth melted, and began again to fume, on which account

count I could not collect any flowers in the upper crucible. The melted earth was poured upon a plate, when it assumed a light-grey colour, with rays emanating from the centre to the circumference.

Under the blowpipe this earth is soon absorbed by charcoal; but when placed upon a silver-plate, it melts, and yields vapours with the same phænomena as molybdæna (§ IV.). I was now desirous to know, whether this melted earth was still soluble in boiling water. (C) It was therefore pulverised, and a little of it boiled in water, as before (A); but it exhibited the same phænomena, and the solution acquired the same taste. This fused earth of molybdæna I made use of for all the following experiments. The flowers which attached themselves to the iron-plate shewed the same phænomena as this earth.

§ VII.

The earth of molybdæna is of an acid nature. The solution (§ VI. C) reddens lacmus, coagulates the solution of soap, and precipitates hepar sulphuris. (B) It has likewise some effect upon metals. If it be boiled with filings of all the ignoble metals, the solution is of a bluish cast. (C) If there be added to it a little alkali of tartar, the earth becomes soluble in greater quantity in water, and after evaporation

poration ſhoots into ſmall confuſed cryſtals. This ſmall quantity of alkali prevents the earth from being volatiliſed in the open fire (§ VI. B). (D) This ſolution, while hot, more clearly ſhews its acid property, and tinges lacmus of a deeper red. It efferveſces with chalk, with magneſia, and with earth of alum, with which earths it forms neutral ſalts, which are very difficult of ſolution in water. (E) It precipitates ſilver, quickſilver, and lead diſſolved in nitrous acid, as alſo lead diſſolved in marine acid. Theſe precipitates are reduced upon charcoal, and the melted earth runs into the pores of the charcoal. The other metals are not precipitated, nor is corroſive ſublimate. (F) It alſo precipitates the earth of the ponderous ſpar from nitrous or marine acid. This precipitate is not a regenerated ſpar, becauſe it is ſoluble in cold water, a property which regenerated ponderous ſpar does not poſſeſs; the ſolutions of other kinds of earth are not precipitated. (G) This ſolution alſo expels the aerial acid from the fixed and volatile alkalis, and forms with them neutral ſalts, which precipitate all metallic ſolutions. Gold, corroſive ſublimate, zinc, and manganeſe, are precipitated in the form of a white powder; iron and tin, from their ſolution in marine acid, of a brown; cobalt, of

a

a roſe colour; copper, blue; the ſolutions of alum and quicklime, white. If the ammoniacal ſalt formed by the earth of molybdæna and volatile alkali be diſtilled, the earth parts with its alkali in a gentle heat, and remains itſelf in the retort, in the form of a grey powder.

§ VIII.

(A) Concentrated vitriolic acid diſſolves, with the aſſiſtance of heat, a great quantity of this kind of earth. The ſolution acquires a very fine blue colour, and becomes thick on cooling; the colour diſappears on the application of heat, but returns again when it grows a little cool; as alſo in water (§ III.): In a ſtronger heat, the earth parts with the vitriolic acid, and remains behind unaltered. (B) The nitrous acid has no effect upon it; (C) But when boiled with muriatic acid it diſſolves in conſiderable quantity; and when this mixture is diſtilled to dryneſs, there remains a dark-blue reſiduum. If the heat be increaſed, there ariſe white flowers, with a little blue ſublimate, and in the receiver is found ſmoking muriatic acid. The reſiduum is grey. The ſublimate and the flowers moiſten in the open air, ſtain metals wetted with the ſolution blue, and are only earth of molybdæna volatiliſed by muriatic acid. (D) If one part of this

this earth be diſtilled with two parts of vitriolated tartar, there goes over at laſt, when the heat is very ſtrong, a little vitriolic acid. The remaining earth is more ſoluble in water than before. (E) Diſtilled with two parts of nitre, it expels ſmoking nitrous acid. The reſiduum diſſolved in water is a neutral ſalt which precipitates all metallic ſolutions, and reſembles the ſalt of § VII. G. (F) When it is diſtilled with two parts of pure common ſalt, the acid is expelled in a fuming ſtate, and there ariſe into the neck of the retort white, yellow, and violet-coloured flowers, which become moiſt in the air; and, when ſprinkled on metals, give them a blue colour (C).

§ IX.

That this metal is not incapable of attracting phlogiſton, appears from the blue colour which the ſublimate receives from the flame of a candle; that it attracts it alſo via humida, the blue colour likewiſe evinces (§ VII. B). (A) In order to acquire more certainty on this point, the earth of molybdæna was diſſolved in boiling water, with the addition of a little alkali. Into this ſolution were poured ſome drops of muriatic acid, and it was divided into ſeveral parts; into each part there were put filings of different metals; the ſolu-

tions

tions ſoon acquired a bluiſh colour, which grew deeper and deeper, and, in an hour's time, during which the bottle was now and then ſhaken, the colour became a very fine and dark blue: That this colour depends upon phlogiſton, may be concluded from the following conſiderations: 1*ſt*, If, inſtead of the metals, you take the different calces, no change of colour takes place. 2*dly*, If there be dropped into the blue ſolution a few drops of acid of nitre, and the ſolution be then put into a warm place, the colour diſappears. It is therefore not a matter of ſurpriſe, that both ſilver and quickſilver ſhould be attacked, ſince a double attraction takes place, the muriatic acid uniting with the metallic calx and the earth of molybdæna with the phlogiſton of the metals, gold, however, is not attacked. (B) If too much muriatic acid be added to the ſolution, it acquires not a blue but a yellowiſh colour, which at laſt turns brown if the metallic mixture be digeſted. Here the earth ſeems to attract more phlogiſton; for if this ſolution be added to a ſolution of earth of molybdæna, the phlogiſton is more divided, and the mixture grows blue. (C) Lixivium ſanguinis, in which the acid prevails, precipitates this earth diſſolved in water brown, and the infuſion of galls, dark-brown.

§ X.

§ X.

I have tried the earth of molybdæna with black flux and charcoal, in order to ſee if I could reduce it; as alſo, with glaſs of borax and charcoal, but in vain. I could not diſcover the leaſt metallic principle. I conjectured that inflammable bodies might have the ſame effect upon earth of molybdæna as the air, *viz.* to volatiliſe it (§ VI. B). I therefore moiſtened ſome of this earth with olive oil, put the mixture into a glaſs retort, and continued the fire till the retort began to melt. But here aroſe no ſublimate; the reſiduum in the retort was like a black powder: Some of this powder was put into a crucible, and expoſed to a ſtrong fire, when it became red-hot, and ſublimed in the form of white flowers. I then put the other part into a crucible, and luted on it another inverted crucible, which was likewiſe expoſed to a ſtrong fire. An hour afterwards, when the whole maſs was grown cool, I opened the crucibles; but the earth was found with its black colour unchanged, without any ſign of fuſion. This black powder ſhewed the following phænomena: 1. It did not diſſolve in boiling water; 2. Nor when alkali was added, and the boiling heat continued, did it diſſolve, notwithſtanding alkali on other

occaſions

occaſions ſo readily diſſolves it (§ VII. G). 3. But, when mixed with a triple quantity of alkali of tartar, and expoſed to fuſion into a crucible, there aroſe a ſtrong effervеſcence. If the maſs be then diſſolved in water, and the ſuperfluous alkali ſaturated with nitrous acid, the product will be a neutral ſalt, conſiſting of the earth of molybdæna and alkali, which decompoſes all other neutral ſalts (§ VII. G). 4. Nitrous acid attacks the phlogiſticated earth very violently in digeſtion, and deprives it of its phlogiſton, upon which it grows white, and regains its former property. Vitriolic and muriatic acids have no effect upon it.

§ XI.

The earth of molybdæna, which is procured by nitre (§ V.), is in ſeveral circumſtances different from that juſt mentioned. 1*ſt*, It requires much more water for its ſolution; two ounces of water, diſſolved by continued boiling, 11½ ſcruples. 2*dly*, It expels not the vitriolic acid from vitriolated tartar. 3*dly*, It is more eaſy of fuſion. 4*thly*, It does not ſublime in an open crucible. 5*thly*, When fuſed with charcoal-powder, it affords a ſolution with water, containing a neutral ſalt, which precipitates all other neutral ſalts.

§ XII.

§ XII.

The cauſe of this great difference lies in the alkali, of which this precipitate obſtinately retains a part: That it contains alkali, though it be purified by repeated ſolutions and cryſtalliſations, is eaſy to infer from the following experiments: 1. When to a hot ſolution ſome concentrated nitrous acid is added, and the boiling continued, the greateſt part of the diſſolved earth falls to the bottom, in the form of ſmall cryſtals. If afterwards the clear liquor is evaporated, ſome nitre is obtained. Theſe ſmall cryſtals have the ſame properties with that earth of molybdæna that is procured by nitrous acid (§ III.) 2. The ſalt which is obtained by fuſion (§ XI. 5.) proves the ſame. This neutral ſalt is produced in the following manner: The earth which contains only a ſmall quantity of alkali, and yet operates like an acid, becauſe it changes the colour of lacmus to red, attracts phlogiſton from the charcoal-powder that is added; but alkali prevents as much earth from entering into this union, as is neceſſary to its ſaturation. It appears from § X. 3, that alkali more ſtrongly attracts the earth than the earth does phlogiſton. This is a neutral ſalt, which is ſoluble in water, and is entirely like the ſalt of § VII. G; the charcoal which remains after the lixiviation

lixiviation yields vapours in an open crucible, and gives a ſublimate, containing phlogiſticated earth of manganeſe. 3. This alkali fixes the earth in the open fire (§ XI. 4.). 4. Hence appears likewiſe the reaſon why this earth does not expel the vitriolic acid from vitriolated tartar; for its attractive power for the alkali muſt diminiſh in proportion as it comes nearer to the point of ſaturation; and as the pure earth contains no alkali, it attracts a little from the vitriolated tartar, conſequently there can appear but a ſlight veſtige of vitriolic acid (§ VIII. D). This ſmall quantity of alkali occaſions its more eaſy ſolubility in water. The ſame earth is found in § VII. C.

§ XIII.

Having now analyſed molybdæna, by means of the experiments which I have communicated, it ſtill remained to be able to recompoſe this mineral of its proximate conſtituent parts. That molybdæna contains ſulphur, is already known, and my experiments ſhew the ſame thing. Some very fine pulveriſed earth of molybdæna (§ VI. C) was mixed with three parts of ſulphur. The mixture was diſtilled in the open fire in a glaſs retort, furniſhed with a luted recipient. The retort was placed in the beginning, in ſuch a manner, that the ſulphur which roſe to the neck ſhould run back again; but at laſt this ſubſtance was entirely driven off. The recipient, beſides the ſulphur, was filled with a ſtinking ſmell of volatile ſpirit of ſulphur. The reſiduum in the retort reſembled a black powder, which, when rubbed between the fingers, ſtained them of a ſhining black colour, and ſhewed the very ſame phænomena in every other reſpect, as native molybdæna itſelf. We have then a kind of earth in molybdæna, which has probably to this time been unknown, and which one may properly call acid of molybdæna, as it has all the properties of an acid. But I think I already hear it objected that it may be ſome metallic earth, combined with an acid hitherto unknown, or elſe *vice verſa*. I am content to let this opinion reſt upon its own merit, as long as it remains unconfirmed by convincing proofs, deduced from unequivocal experiments; and although in certain circumſtances it reſembles a metallic earth, I believe with confidence, that molybdæna conſiſts of an acid mineraliſed by ſulphur.

ESSAY XIII.

Experiments on Plumbago. 1779.

I HAD the satisfaction of seeing my experiments on molybdæna inserted in the third quarter of the Transactions of last year; and as, in the beginning of that paper, I advanced that the black lead or plumbago which is generally known in commerce, is very different from molybdæna, I shall now shew by experiments, that this is really the case. The mineral of which I am to speak at present is called by Cronstedt, "*Molybdæna texturâ micaceâ et granulatâ.*"

§ 1.

Finely levigated and sifted plumbago, after being digested and boiled in all the known acids, both concentrated and diluted, shewed no sign of decomposition, excepting that the menstrua were impregnated with a small portion of iron. The acid of arsenic is the only acid which has any effect upon this mineral, but it produces it only in the dry way. I mixed two parts of dry acid of arsenic with one part of pulverised plumbago; and after having distilled this compound in a retort, found the neck of the veſſel filled with arſenic. That this reduction of the acid of arſenic was not owing to the heat, I ſhall ſhew in the ſequel of this paper.

§ II.

(A) Corroſive ſublimate had likewiſe no effect upon plumbago when they were ſubjected to ſublimation together. (B) With ſal ammoniac, by the ſame operation, I obtained flores martiales and a little cauſtic volatile alkali. The remainder was unchanged. (C) When I mixed plumbago with a double quantity of ſulphur, and again ſeparated it by ſublimation, I found the weight of the plumbago to be the ſame as before. (D) Upon fuſing it with four parts of vitriolated vegetable alkali in a covered crucible, I obtained hepar ſulphuris. (E) When one part was expoſed to the action of heat with eight parts of litharge in a cloſe crucible, the calx of lead was reduced; but no reduction followed when it was treated with glaſs of antimony. That the calx of lead acts more powerfully upon phlogiſton than the calx of antimony, appears upon mixing and fuſing litharge with regulus of antimony; for by this means regulus of lead and black glaſs of antimony are obtained. (F) By diſtillation with common ſalt none of the acid was expelled. (G) On

On diſtillation with nitre, no detonation took place in the retort.

§ III.

(A) I put two drachms of levigated plumbago, together with an ounce of purified nitre, into a red-hot crucible. At firſt a ſtrong effervefcence, and afterwards a violent detonation, took place. There remained in the crucible a black ſhining liquid matter, which ſtill contained a great deal of plumbago. (B) I then mixed one part of levigated plumbago with ſix parts of nitre, and the ſame detonation followed. The maſs remaining in the crucible was exactly the ſame as the former. (C) The ſame proceſs was repeated with eight parts of nitre, and here a little plumbago remained, which was not calcined by the nitre. All the maſſes remaining in the crucibles were diſſolved in water, when a good deal of undecompoſed plumbago fell to the bottom. The limpid ſolution neither contains hepar nor vitriolic acid; conſequently there is no ſulphur in pure plumbago. (D) At laſt I mixed one part of levigated plumbago with ten parts of nitre, and put it into a red-hot crucible; a detonation followed, and after it was kept for a few minutes in a ſtate of fuſion, a white alkaline maſs appeared, which I poured out upon a copper plate, and afterwards diſſolved it in water, upon which a little brown powder was precipitated. From an ounce of plumbago thus calcined with nitre, I obtained fifteen grains of this brown powder, which I found to be ochre of iron. Upon pouring ſome vitriolic acid into the alkaline ſolution, an efferveſcence enſued, and the air expelled was aerial acid mixed with nitrous air (*acidum nitri phlogiſticatum*), and the whole mixture became gelatinous. I filtered the whole together, and found that what remained in the filtre was ſiliceous earth, mixed with a little earth of alum. The ſaturated ſolution yielded, after evaporation, nothing but vitriolated vegetable alkali. (E) But not being convinced by this experiment of the exiſtence of clay in plumbago—for I have elſewhere more particularly ſhewn (*Diſſertation on ſilex, clay, and alum*) how unſafe all experiments of this kind are in common crucibles—I made the ſame detonation with plumbago and nitre in an iron crucible, and found that I was right in my ſuſpicion, for not the leaſt mark of clay was now to be diſcovered.

§ IV.

Mr J. G. Gahn, in roaſting plumbago upon a teſt, experienced a loſs of ninety parts

parts in an hundred of plumbago, without any viſible ſmoke; and Mr P. J. Hjelm, upon repeating the ſame experiment, obtained the ſame reſult. The remainder is nothing but ochre of iron. One ſhould be eaſily tempted to believe, that whatever has been volatiliſed during the uſtulation was nothing but phlogiſton! For there is not any ſulphureous ſmell perceived from pure plumbago, and the calcination requires the free acceſs of air; and, 2*dly*, from its detonation with nitre, &*c*. But then, the phlogiſton would, according to this ſuppoſition, conſtitute the greateſt part of the weight of the plumbago; but it is not probable that ſuch a ſmall quantity of iron ſhould fix ſuch a large quantity of phlogiſton; which would then be preſent in a much larger quantity in plumbago than even in charcoal; for five parts of nitre are ſufficient to decompoſe one part of charcoal; whereas ten parts of nitre are required to produce the ſame effect upon one part of plumbago. This induced me therefore to examine the vapours which ariſe from it in ſuch large quantity during detonation.

§ V.

One part of levigated and ſifted plumbago was mixed with ten parts of powdered nitre, and a little of this mixture was put at intervals into a red-hot tubulated retort, to which a large glaſs receiver was adapted. At laſt the receiver was found full of nitrous air, and covered with a white cruſt, which was eaſily ſoluble in water, and proved, on an exact examination, to be nothing elſe than nitre. Thence it is evident, that, during the uſtulation and diſtillation of plumbago, no ſublimate, or any thing like a ſublimate, is driven off.

§ VI.

There was one circumſtance obſervable, which deſerves the greateſt attention, *viz.* the aerial acid which was expelled during the ſaturation of the fixed alkali (§ III. D). I was led by this to mix fifteen grains of levigated plumbago with eight ſcruples of nitre, and to put it into a ſmall retort of thick glaſs. A large empty bladder was adapted to the retort, and it was placed upon live coals. As ſoon as the nitre entered into fuſion, the maſs in the retort took fire, and the bladder became diſtended. After the whole was cooled, I detached the bladder from the neck of the retort, and found that the air contained in it occupied as much room as thirty-ſix ounces of water. Lime-water abſorbed one-third of this air, and by the remainder flame was ſupported. Plumbago therefore

fore contains likewiſe aerial acid; a great part of which is attracted by the alkali of nitre.

§ VII.

One might perhaps ſuppoſe, that this aerial acid aroſe from the nitre itſelf. To this I anſwer, If ſuch was really the caſe, we ſhould obtain aerial acid in all other detonations with nitre. I therefore mixed (A) half a drachm of tin filings with two drachms of nitre, and detonated the mixture in the manner above mentioned. I thus obtained as much air as occupied the ſpace of four ounces and a half of water; but this air contained not the leaſt mark of aerial acid; it did not extinguiſh a candle. (B) From one drachm of regulus of antimony, detonated with two drachms of nitre, a quantity of air was obtained, which occupied the ſpace of eight ounces of water: It contained no aerial acid, but extinguiſhed flame; neither in the detonation of brimſtone is there any aerial acid obtained. But, in order to remove all doubts and objections, I contrived to decompoſe plumbago without nitre. (C) For this purpoſe I repeated the experiment already mentioned with the acid of arſenic § I. I applied an empty bladder to the retort inſtead of a receiver. When the arſenic roſe into the neck of the

the retort, the bladder was diftended, and I obtained pure aerial acid. (D) I mixed four parts of calcined quickfilver with one part of pulverifed plumbago, and diftilled this mixture in the fame manner as before. The quickfilver was reduced, and the bladder diftended with air. This air was aerial acid, and mixed with one-third of pure air. (E) One part of litharge reduced to glafs *, and then ground to powder, mixed with two parts of plumbago, was reduced in the retort, and the bladder contained pure aerial acid. (F) One part of powdered plumbago, mixed with cauftic fixed alkali, and expofed to diftillation by a ftrong fire, yielded inflammable air. The mafs remaining in the retort had loft its caufticity, and made a ftrong effervefcence with acids.

§ VIII.

Hence I am convinced, that plumbago is a kind of mineral fulphur or charcoal; the conftituent parts of which are aerial acid and a confiderable quantity of phlogifton. The fmall quantity of iron can hardly be taken into the account; for 1*ft*, It feems to be mixed with it only mechanically; and, 2*dly*, I have treated plumbago,

* Litharge generally containing a little aerial acid, it was requifite to fufe it firft, in order to feparate the air.

plumbago, from which I obtained, after calcination, a little more ochre of iron than ufual; and when one part of this kind of plumbago was detonated with fix parts of nitre, I have found fome hepar at laft. When therefore plumbago, during calcination, yields a fulphureous fmell, it muft be mixed with a little pyrites. That pure plumbago does not enter into any union with fulphur, appears from § II. c; and that it contains no fulphur, appears from § I.; for if this were the cafe, I fhould have certainly obtained in the neck of the retort either a red or a yellow fublimate. See likewife § III. c.

If caft-iron be diffolved in diluted vitriolic acid, a black mafs remains, which is infoluble in acids, and which has been fuppofed to be plumbago. I fhall therefore take this opportunity to relate the experiments I made with this refiduum. I extracted an ounce of it by means of aqua regia, which thereby acquired a dark-yellow colour. After having decanted the folution, I poured fome new menftruum upon the refiduum, and continued in the fame manner, till there appeared no more iron in the menftruum. I dried the refiduum, and found that it had a fhining black colour, and between the fingers it felt like plumbago. It now weighed no more than three drachms and a half. Mr

P.

P. J. Hjelm having roaſted this reſiduum under the muffle, found that it calcined ſomewhat more quickly than plumbago. The remainder of this calcination was a very ſmall quantity of white aſhes.

One part of the above mentioned reſiduum of caſt-iron was mixed with five parts of nitre, and put into a red-hot crucible; a detonation followed, as with plumbago; the alkaline maſs remaining in the crucible, which was of a white colour, I diſſolved in water, whence after ſome time a little white ſediment precipitated, which however was not ſufficient for making any deciſive experiment. The ſolution or lixivium efferveſced with acids, and ſhewed the ſame effects as the lixivium of § III. D. The air, ſeparated during this detonation, was alſo collected. It appeared to conſiſt of three parts of aerial acid, and one part of foul or corrupted air. Hence I conclude, that this reſiduum of caſt-iron is plumbago; but as leſs nitre is requiſite for its decompoſition than for the decompoſition of plumbago, it muſt contain leſs phlogiſton than that ſubſtance.

ESSAY XIV.

METHOD OF PREPARING A NEW GREEN COLOUR. 1778.

CHEMISTRY is well known to be indifpenfably neceffary in the preparation of colours for painting, and it often difcovers new ones. It was the defire of the Royal Academy, that the green colour which I obferved during my experiments on arfenic might be made more generally known, together with the mode of preparation. In compliance with this defire I give the prefent account of it, and that with the greater pleafure, as I have found the colour ufeful both in oil and water painting, and as it has not undergone the flighteft alteration in the courfe of three years.

Diffolve two pounds of vitriol over the fire in a copper veffel, in fix kannes of pure water, and, as foon as it is diffolved, take the kettle from the fire.

Then diffolve in another copper kettle two pounds of dry white potafhes, and eleven ounces of pounded white arfenic *, in two kannes of pure water over the

* It is always better to pound the arfenic one's felf than to buy it ready pounded; for this is often adulterated with gypfum, of which any one may readily convince himfelf, by laying a little with the point of a knife upon a red-hot coal. If the whole evaporate without leaving any refiduum, the arfenic is pure.

the fire. When all is diſſolved together, ſtrain it through linen into another veſſel.

Of this arſenical ley a little is to be poured at a time into the above mentioned ſolution of vitriol of copper, while it is kept conſtantly ſtirred with a wooden ſpoon *. When the whole has been added, the mixture ſhould be left to ſtand ſtill for a few hours, during which the green colour will be depoſited at the bottom. The clear ley is then to be poured off, and a few kannes of hot water added under continual agitation. When the colour has fallen again to the bottom, the clear water is to be poured off. This lixiviation with hot water ſhould be repeated a ſecond time.

When the matter has been thus well waſhed †, the whole together is to be ſhaken out on a ſtretched linen cloth; and when the water has all dropped away, the colour is to be placed in ſmall lumps on grey paper, and dried by a gentle heat. From the quantities above preſcribed, one pound, together with ſix ounces and a half of a fine green colour, are obtained.

* As an effervеſcence takes place in this operation, the veſſel in which the mixture is made ſhould not be too ſmall. It ſhould contain about ſixteen kannes.

† The water with which the colour is lixiviated contains a little arſenic, and muſt therefore be thrown out in a place to which cattle have no acceſs.

ESSAY XV.

Of the Decomposition of neutral Salts by unslaked Lime and Iron. 1779.

IT is looked upon as a demonſtrated truth in chemiſtry, that fixed alkalis have a ſtronger attraction for acids than abſorbent or metallic earths, and that the latter are precipitated by the former. There ſeems to be only two exceptions to this rule, namely, in favour of ponderous earth, which has a ſtronger affinity for all acids, and lime which unites more readily with moſt acids than alkalis do. That the foregoing tenet ſhould be ſtill farther limited, I have diſcovered by the following experiments.

I once found in a cellar a wooden veſſel hooped with iron hoops, and containing ſalted turnips. The iron hoops were covered over with a ſalt which appeared perfectly to reſemble mineral alkali. This accident appeared very ſingular, as I well know that the acid of ſalt has a weaker attraction for iron than for mineral alkali; I could not therefore believe that the common ſalt, oozing out through the wood, could be decompoſed by the iron hoops. To

To resolve this doubt, a clean plate of iron was dipped into a saturated solution of common salt, and hung up in a moist cellar. In fourteen days mineral alkali was found on the plate. There appeared also some yellow drops containing iron, which was precipitated when a little of the alkali that was beside them was brought close to them. I afterwards covered over another iron plate, with a saturated solution of Glauber's salt, and hung it up for some weeks in the cellar. The result was, that the fossil alkali effloresced on its surface like wool. The same thing happened upon repeating the experiment with a solution of cubic nitre; but, when I used plates of lead, tin, copper, or silver, no decomposition took place. I afterwards prepared a mass, consisting of unslaked quicklime moistened with a solution of common salt, and placed it in a moist cellar; in a fortnight afterwards the surface was covered over with mineral alkali, which I scraped off, and left the remainder in the cellar. In another fortnight more alkali was visible on the surface, which was scraped off. Water was poured on the remaining mass, and it was well stirred and filtered. The solution had a strong taste of lime-water, on which account I let it stand a few days in the open air, by which means the lime was precipitated. And to determine

determine with more certainty, whether the lime was all precipitated, I poured on it a ſolution of corroſive ſublimate, which remained colourleſs. The whole was then filtered, and a ſolution of the effloreſcent mineral alkali added to it, by which a conſiderable quantity of aerated lime was precipitated.

In the ſame manner I made a maſs of quicklime and ſolution of Glauber's ſalt and cubic nitre, when the ſame effect was produced, and an effloreſcence of foſſil alkali was obſerved: But this did not happen, when, inſtead of quicklime, aerated or calcined magneſia, or aerated lime, were uſed inſtead of unſlaked lime.

It is certain that foſſil alkali always precipitates ſolutions of iron and lime; and it is a conſequence of this, that fixed alkalis more readily combine with acids than theſe ſubſtances. The experiments, however, which I have related, point out a limitation in certain caſes. It is therefore probable, that alkalis have a ſtronger attraction for acids when they contain a certain quantity of water; but, when this is diminiſhed, it is not impoſſible that an earth or a metal ſhould obtain the ſuperiority, eſpecially if the alkali which is ſeparated, ſhould, at the inſtant of its ſeparation, meet with a weaker acid with which it can unite. Such is the aerial acid in this cafe, which is always prefent in confiderable quantities in cellars.

It appears ftrange, that the foffil alkali, efflorefcing upon the iron plate, fhould not be able to precipitate the drops of the martial folution refting upon it: But the caufe is this, that the folution of iron in muriatic acid, when it has become dry, ftrongly attracts moifture, and the alkali which is then feparated and efflorefces, cannot afterwards produce any effect upon it.

If vegetable alkali, like the foffil, had the property of efflorefcing, the neutral falts into which it enters would probably be decompofed in the fame manner; but as they have not this property, this does not happen.

ESSAY XVI.

ON THE QUANTITY OF PURE AIR WHICH IS DAILY PRESENT IN OUR ATMOSPHERE. 1779.

IT is a known fact, that our atmofphere ought not to be confidered as a fimple fluid fubftance, for, when freed from all heterogeneous admixture, it is found, according to the late difcoveries, to confift of two very different kinds of air; the one is called *corrupted air*, becaufe it is very dangerous and fatal, as well to living animals as vegetables; it conftitutes the greateft part of our atmofphere. The other is called *pure air*, *fire air*. This kind of air is falutary, fupports refpiration, and confequently the circulation; without it we could form no diftinct idea, either of fire, or how it is kindled. It conftitutes but the fmalleft part of the whole atmofphere. Now as we know that this air is of the moft immediate neceffity for the fupport of our health, but as it is uncertain whether there is always the fame quantity of it prefent in the atmofphere, I propofed to make obfervations upon it through the courfe of a whole year.

When this pure air meets with phlogiſton uncombined, it unites with it, leaves the corrupted air, and diſappears, if I may ſay ſo, before our eyes *. If, therefore, a given quantity of common atmoſpheric air be included in a veſſel, and meet there with ſome looſely adhering phlogiſton, it will at once appear, from the quantity of corrupted air remaining, how much pure air was contained in it before. Though there is a variety of inflammable ſubſtances and mixtures fit for this purpoſe, I however found a mixture of iron-filings and ſulphur the moſt ſerviceable.

I reduced a pound of ſulphur to very fine powder, and mixed it with two pounds of iron-filings, which were not ruſty, moiſtening the whole with a little water. This mixture I immediately afterwards put into ſeveral ſmall flaſks, which I corked very exactly †, taking care, at the ſame time, not to preſs the powder too hard into the flaſk; for, in twelve hours, in which time the union of iron and ſulphur takes place, as the black colour which it aſſumes

* That light ariſes from this union, I have already proved in my Treatiſe on air and fire.

† The phials muſt be frequently opened, and if one contained the whole mixture, it would be ſoon ſpoiled by the freſh air that is admitted.

aſſumes ſhews, the ſpace occupied by this compound is greatly increaſed; the flaſk, therefore, would burſt if it were preſſed too hard. I ſhall now take the liberty to deſcribe my apparatus.

In a pedeſtal of lead (B) placed in the middle of a veſſel (A), I fixed a glaſs tube; upon the top of the tube was faſtened a flat piece of wood, ſuch as would ſupport a ſmall veſſel filled with the above mentioned mixture of iron and ſulphur. This apparatus was covered with an inverted glaſs cylinder (D), and the veſſel (A) was filled with water *. When the cold was ſo intenſe as to freeze the water, I made uſe of brandy. The glaſs cylinder (D) was capable of containing thirty-four ounces of water. The little veſſel (C), with its mixture of iron and ſulphur, and its ſtand, occupied the ſpace of an ounce of water. There remained, therefore, room for thirty-three ounces.

Having already learned, from the experiments of others as well as my own, that pure air never conſtitutes more than one-third of the whole atmoſphere, I paſted on the outſide of the glaſs cylinder a piece of paper, which was equal in length to

* The original Eſſay is accompanied with a figure of this apparatus; but ſuch aſſiſtance is perfectly unneceſſary, as no one can be at a moment's loſs to comprehend ſo very ſimple a contrivance. T.

one-third of the contents of the glaſs, or 11 ounce-meaſures of water. I divided this paper into equal parts, which I marked with black lines and ſmall cyphers, ſo that each line ſhewed $\frac{1}{33}$ part of the ſpace in the glaſs. The whole piece of paper I varniſhed over with oil-varniſh, in order to prevent the effect of water upon it.

On the firſt of January 1778 I began my obſervations. After having filled the veſſel (c) with the mixture of iron and ſulphur, I inverted the cylinder over it, obſerving the degree of the barometer and thermometer. The water began ſlowly to aſcend into the cylindrical glaſs. After eight hours it ſtopped at No. 9. Though I left the glaſs for ſix hours longer in the ſame ſituation, the water did not riſe any higher. In the mean time the barometer and thermometer had undergone no change. The next day I repeated the experiment, by admitting freſh air into * the cylinder; but the water remained at the ſame mark. The 3d of January

* In order to be ſure that there may not be any corrupt air remaining from the firſt experiment, I always fill the veſſel with water, whereby the air is entirely expelled. This water I afterwards pour out in the air. When I make experiments upon air incloſed in a chamber, I proceed in the ſame manner, and pour the water out of the glaſs into a veſſel in the ſame room.

January the air was the ſame. The 4th, upon making a new experiment, the water roſe more ſlowly, and arrived only at its former height in fourteen hours time; whence I concluded, that the mixture in the veſſel (c) had loſt moſt of its looſely adhering phlogiſton; I therefore afterwards filled, on occaſion of every fourth experiment, the veſſel with a new mixture. With theſe experiments I continued daily the whole of January, filling the glaſs often, even in the night-time, with new air, but conſtantly found the ſame proportion of pure air contained in our atmoſphere. Sometimes the water roſe a little higher, ſometimes it was lower; but this ſeemed to depend on the riſe or fall of the barometer and thermometer. I was led to think it ſufficient to make my experiments for the following months only four times a-week. In the month of February the air appeared to be the ſame as in January, but on the 23d of March the water roſe only to No. 8. which was the more remarkable, as the cold had increaſed, and the barometer had riſen. The 19th of April the water roſe to No. 10. though neither the thermometer nor barometer ſuffered any change during that time. Thus the air continued till the 21ſt, after which the water remained every day at No. 9. In May and June

 between

between No. 8. and No. 9. The 30th of June it rofe to No. 10. The whole month of Auguft it was between 8. and 9. But from the 3d to the 15th of September at No. 9. The 6th of October it again rofe to No. 10. It afterwards kept, during a continuation of very tempeftuous weather, between 8. and 9. till the 4th of November, when it rofe no higher than to No. 8. The fame was the cafe on the 5th of November, though the barometer rofe very high. After this it kept between No. 8. and 9. On the 10th it rofe to No. 10. when the barometer was as high as the 4th and 5th. The 21ft it rofe only to No. 8. Afterwards it kept between 8. and 9. till the 8th of December, when it rofe to No. 9. the barometer being low; but afterwards, till the 31ft, it rofe no higher than between 8. and 9.

Our atmofphere, therefore, contains always, though with fome little difference, nearly the fame quantity of pure or fire air, *viz.* $\frac{9}{33}$, which is a very remarkable fact; and to affign the caufe of it feems difficult, as a quantity of pure air, in fupporting fire, daily enters into a new union; and a confiderable quantity of it is likewife corrupted, or changed into aerial acid, as well by plants as by refpiration; another frefh proof of the great care of our Creator for all that lives.

ESSAY

ESSAY XVII.

On Milk and its Acid. 1780.

§ I.

IT is well known, that milk contains butter, cheeſe, ſugar of milk, ſome extractive matter and a little ſalt,—the reſt is water. But we are yet far from having a juſt chemical knowledge of this ſubſtance. I ſhall firſt conſider a little the ſeparation of the cheeſe from the ſerum, *&c.* and afterwards enquire into the acid, and the properties which whey or milk acquires in a warm place.

§ II.

(A) If any vegetable or mineral acid be mixed with milk, it is well known, that the ſeparation of a cheeſy matter enſues. This cheeſe becomes perfect, if the mixture be aſſiſted by the application of heat, ſince in this caſe the cheeſy particles all coagulate into one maſs. Mineral acids yield leſs cheeſe than the vegetable.

(B) If you put into boiling milk as much of any neutral ſalt as will diſſolve in it, the cheeſy parts will alſo ſeparate from the ſerum or whey. The ſame thing happens with all

all earthy and metallic ſalts, and likewiſe with ſugar and gum Arabic.

§ III.

Cauſtic alkalis will diſſolve the curds by the aid of a boiling heat; and it may be again precipitated by acids. Hence one may eaſily be induced to conjecture, that the cheeſy part is diſſolved in the milk by means of an alkali. In order to find out whether this was really the caſe, I coagulated ſome milk with a little nitrous acid, filtered and evaporated the whey, but not the leaſt mark of nitre was diſcovered in it, but only the common ſugar of milk. The coagulation of the milk by acids muſt conſequently be owing to ſome other cauſe.

§ IV.

(A) The curds obtained by means of mineral acids always manifeſts ſigns of acidity. It is likewiſe partially ſoluble in boiling water.

(B) If with eight parts of water mixed with one part of precipitated, but not dry curds, ſo much mineral acid be mixed that the water acquires a ſouriſh taſte, and it be afterwards boiled, the cheeſe will be diſſolved. Vegetable acids and the acid of milk diſſolve little or nothing of the curds. Hence it appears why

more

more curds are obtained by vegetable than by mineral acids (§ II. A). Hence it is likewiſe evident, why milk coagulates with acids. The curds attract a certain quantity of acid, and this compound requires much more water in order to be kept in ſolution than the milk contains.

(C) If milk be mixed with ten parts of water, no curds are obtained by mineral acids.

(D) If to theſe acidulous ſolutions of curds a ſmall quantity of ſome concrete mineral acid be added, the greateſt part of the curds will be again precipitated. They alſo precipitate on the addition of alkalis and lime-water, but if too much of theſe latter be added, the curds will be rediſſolved.

(E) If curds diſſolved in quicklime or cauſtic alkali be precipitated by vinegar, a diſagreeable hepatic ſmell is produced.

The reaſon why neutral ſalts, whether ſaline or terreſtrial, gums, and ſugar, produce a coagulation of milk (§ II. B), lies probably in the ſtronger attraction of water for thoſe ſalts than for the curds. Infuſions of vegetable aſtringents always ſhew marks of an uncombined acid. It is eaſily underſtood why milk is coagulated by them, and many, if not all vegetables, contain ſome caſeous ſubſtance. It thence likewiſe appears why emulſions

are

are coagulated by decoctions of the bark of the *cinchona officinalis*.

§ V.

As to the conſtituent parts of curds, they are probably, like all animal gelatinous ſubſtances, ſtill involved in obſcurity. This much is certain, that the earth of cheeſe is the univerſal animal earth, and conſiſts of phoſphoric acid ſuperſaturated with lime. For after ſeveral times abſtracting nitrous acid from curds, I at laſt obtained a white reſiduum, which was nitrated lime and animal earth. The ſame earth I obtained from the reſiduum remaining after the diſtillation of curds and its further calcination in a crucible by means of nitre,—for without nitre this reſiduum proves very difficult to be reduced to aſhes. Thirty parts of dried curds contained about three parts of animal earth.

§ VI.

No ſubſtance is more like curds than the white of eggs boiled. It is indeed nothing elſe but pure cheeſe. The white of eggs coagulated by heat diſſolves by means of boiling in very diluted mineral acids, which ſolution is again precipitated on adding ſome concentrated acid. During this precipitation, there is likewiſe a ſmell,

exactly

exactly like that of hepar sulphuris, produced, which is a very singular phænomenon. Silver is coloured by it, and acetated lead rendered black; properties, all of which, are likewise common to the curds of milk (§ IV.). It is also a singular fact, though it be generally known, that heat alone coagulates the white of eggs, and this without any loss of its weight. The true cause of this is, as far as my information reaches, hitherto unknown, but seems to me to be the following: As curds and the white of eggs combine with acids, and are thereby coagulated, and as all the substances which enter into an union with acids may be likewise combined with the matter of heat, a circumstance in which this principle often resembles acids, it is very probable that it enters into a chemical union with the white of eggs, and is thus the cause of coagulation. What confirms me more in this opinion is, that I have observed such a coagulation of the white of eggs produced in the following manner: I mixed one part of white of eggs with four parts of water, and added a small quantity of a solution of caustic alkali, mixing at the same time as much muriatic acid as was necessary for its saturation; the white of the egg then coagulated like curds. I mixed the water with the white of eggs, with

with the view of preventing the heat, which is expelled by acids from cauſtic alkalis from becoming ſenſible, to which the whole phænomenon otherwiſe might eaſily be aſcribed. Here therefore a double decompoſition takes place, the alkali uniting with the muriatic acid, and the principle of heat with the white of the eggs. If aerated alkali be employed inſtead of the cauſtic in the ſame proceſs, no coagulation takes place.

§ VII.

It is a known fact, that milk in a ſhort time grows ſour and thick during the ſummer. This ſourneſs daily increaſes, and is the ſtrongeſt after a fortnight has elapſed. If the whey be then filtered and evaporated to one-half of its quantity, a few curds ſettle to the bottom. If it be filtered again, and a little acid of tartar be added, ſome time afterwards a great number of ſmall cryſtals are generated, which fall to the bottom, and appear on examination to be tartar. The origin of this tartar I cannot aſcribe to the ſmall quantity of muriated vegetable alkali, which the milk always contains; for this ſalt exiſts in milk in too ſmall a quantity to produce any effect here; it is rather to be aſcribed to an eſſential ſalt contained in the milk. This is further evident from this,

this, that when whey evaporated by itſelf to dryneſs, and afterwards reduced to charcoal in a crucible, by which proceſs this eſſential ſalt is deſtroyed, it is found that this coal contains vegetable alkali, mixed with a little muriated vegetable alkali, which may be obtained by lixiviation with water. The whey alſo contains in ſolution a portion of animal earth, as may be ſeen, when it is ſaturated with cauſtic volatile alkali, as alſo with lime-water. Thus the acid of milk contains an eſſential ſalt, animal earth, ſugar of milk, a little muriated vegetable alkali, and ſome mucilaginous matter. We have only then to ſeparate all theſe heterogeneous bodies from the acid, in order to obtain it as pure as poſſible. Diſtillation would indeed be the ſhorteſt way, but this will not anſwer; for though ſome veſtiges of an acid appear in the receiver, which acid is a kind of very weak vinegar, and the cauſe of the ſouriſh ſmell of the whey, almoſt all the acid remains in the retort; and if the heat be increaſed, this acid will be decompoſed; I therefore make uſe of the following proceſs.

§ VIII.

I evaporated ſour whey till one-eighth only remained. The cheeſy part being then perfectly ſeparated, I ſtrained the acid.

acid. In order now to obtain the animal earth, as I knew that this kind of earth is precipitated by lime-water (§ VII.), I ſaw no other way than to ſaturate the acid with lime. I then filtered the ſolution, and diluted it with a triple quantity of water. To ſeparate the lime again from its ſolvent, the acid of ſugar was a moſt excellent medium. I therefore diſſolved a quantity in water, and afterwards added this ſolution to the ſolution of lime, till no more ſaccharated lime precipitated, obſerving carefully not to add more acid of ſugar than was requiſite, which I could eaſily diſcover by means of lime-water. There now remained the other ſubſtances to be ſeparated from the acid of milk. For this purpoſe I evaporated it to the conſiſtence of honey, then diſſolved it in highly rectified ſpirit of wine, and thus ſeparated from it both the ſugar of milk and the remaining heterogeneous ſubſtances. The acid alone being thus diſſolved in ſpirit of wine, I filtered it, and then mixed ſome pure water with this acid ſolution; and after ſeparating the ſpirit of wine by diſtillation, the acid of milk remained in the retort as pure as in my opinion it ever can be got by a chemical proceſs.

§ IX.

§ IX.

The nature of this acid, and its effects upon earths, alkalis and metals, I found to be as follows: 1. Evaporated to the confiftence of a fyrup, it yields no cryftals; and, when evaporated to drynefs, it deliquefces again. 2. When diftilled, water firft comes over, then a weak acid, like fpirit of tartar; afterwards, fome empyreumatic oil, with more of the fame acid, aerial acid, and inflammable air; in the retort there remained a coal. 3. Saturated with fixed vegetable alkali, it yields a deliquefcent falt, foluble in fpirit of wine. 4. A falt of the fame kind is obtained with fixed mineral alkali, which does not cryftallife, but diffolves in fpirit of wine. 5. Combined with volatile alkali, it produces a kind of fal ammoniac, which however deliquefces, and, when diftilled, yields a great deal of its volatile alkali before the acid is deftroyed by the heat. 6. Combined with terra ponderofa, lime and clay, it forms deliquefcent neutral falts; but with magnefia it yields fmall cryftals, which however at laft are again deliquefcent. 7. This acid of milk has no effect either in a digefting or a boiling heat on bifmuth, cobalt, regulus of antimony, tin, quickfilver, filver and gold. This acid, however, having been digefted with tin, precipitated the gold from its ſolution in aqua regia, in the form of a black powder. 8. It diſſolves iron and zinc, and produces inflammable air. The ſolution of iron was brown, and yielded no cryſtals; but the ſolution of zinc cryſtalliſed. 9. Copper communicated to this acid firſt a blue, then a green, and at laſt a dark blue colour, without cryſtalliſing. 10. Lead was diſſolved after ſome days digeſtion; the ſolution had a ſweet aſtringent taſte, and would not cryſtalliſe. I obſerved afterwards a ſmall quantity of a white ſediment in this ſolution, and found it to be vitriol of lead. Thus there is likewiſe ſome veſtige of vitriolic acid in milk.

§ x.

From theſe experiments it appears, that the acid of milk is an acid of a peculiar kind; and though it expels the vinegar from the acetated vegetable alkali, yet it ſeems deſtined, if I may ſo ſpeak, to be vinegar; but, from the want of ſuch ſubſtances, as, during fermentation, produce ſome ſpirituous matter, it ſeems not to be volatiliſed, though a portion of it indeed arrives at this point, and really becomes vinegar; for without a previous ſpirituous fermentation, or, without brandy, there never ariſes any vinegar: But that the milk

milk enters into a complete fermentation, though there is no ſign of brandy preſent, appears from the following experiment: If a bottle full of freſh milk be inverted into a veſſel containing ſo much milk, that the mouth of the bottle reaches below the ſurface; and if you expoſe this bottle to a degree of heat, a little greater than our ſummer heat, you will find in the ſpace of twenty-four hours, that the milk is not only coagulated, but likewiſe diminiſhed in the bottle, and that in a couple of days afterwards, the aerial acid, extricated from the milk, will have expelled the greater part of it out of the bottle. I ſaid above, that the acid of milk cannot be converted into vinegar, from the want of ſuch ſubſtances, as, during fermentation, produce brandy. This appears to be evident from this: If to a kanne of milk you add five ſpoonfuls of good brandy, and expoſe the veſſel, well corked, to heat, in ſuch a manner, however, that you give now and then to the air, developed during fermentation, a little exit, you will find in a month, ſooner or later, the whey changed into good vinegar, which, when ſtrained through a cloth, may be kept in bottles.

ESSAY XVII.

On the Acid of Saccharum Lactis. 1780.

§ I.

THE ſugar of milk is an eſſential ſalt, which is contained in ſolution in milk, and which, on account of its ſweetiſh taſte, has been called ſugar. The taſte of milk is the ſweeter and the more agreeable the more ſugar it contains. Pharmaceutical chemiſtry teaches the manner of preparing it.

§ II.

Sugar of milk yields by diſtillation the very ſame products as other ſugars do. There is, however, one remarkable circumſtance, that the empyreumatic oil ſmells ſomewhat like the ſalt of benzoin. We know that common ſugar contains an acid, which, on account of its ſtrong attraction for all kinds of earths, eſpecially for lime, is indiſpenſably neceſſary in chemical experiments. The origin of this acid is the dephlogiſtication of the ſugar, by means of nitrous acid. What effects are produced on the ſugar of

 milk

milk by the latter acid, the following experiments will ſhew:

§ III.

I poured twelve ounces of diluted nitrous acid upon four ounces of finely powdered ſugar of milk, contained in a glaſs retort, to which a receiver was annexed. The retort was placed in a ſand-bath. As ſoon as this mixture acquired a certain degree of heat, it began to effervesce violently; I therefore took the retort out of the ſand, with the receiver, and put it upon the table. The mixture however grew hotter and hotter, and the effervesſcence ſtronger and ſtronger, with dark-red vapours, and continued to do ſo for about half an hour upon the table, without any fire. A conſiderable quantity of nitrous air and aerial acid were extricated during that time. Whoever therefore wiſhes to repeat this experiment, muſt not take too ſmall a retort, nor lute the retort too tight to the receiver. After the effervesſcence had ſubſided in ſome meaſure, the retort was again placed in the ſand-bath, and the nitrous acid was thus diſtilled off, till the maſs acquired a yellowiſh colour; whereupon the retort was immediately taken out of the fire. In two days time the ſolution ſeemed to have undergone no remarkable change; there was no appearance

pearance of cryſtals; I therefore added eight ounces more of the ſame nitrous acid, and expoſed it to the ſame degree of ſand heat. As ſoon as the maſs grew warm, the yellow colour diſappeared, an effervefcence enſued as before, though it was not ſo ſtrong. After it was over, I again abſtracted the nitrous acid, till the ſolution, which meanwhile had been rendered opaque by a white powder, aſſumed a yellowiſh colour, whereupon the retort was removed from the ſand. After it was grown cool, I found the maſs in the retort inſpiſſated; I therefore rediſſolved it in eight ounces of water, and paſſed the whole through a filter. There remained on the filter a white powder, which, after being edulcorated and dried, weighed $7\frac{1}{2}$ drachms. The ſolution which paſſed through the filter was very ſour; I now evaporated it to the conſiſtence of a ſyrup, poured four ounces more of nitrous acid on it, and evaporated it again in a ſand heat. After the whole was cool, ſome ſmall long acid cryſtals were found together with a ſmall quantity of white powder, which I ſeparated from it, and then poured ſome more nitrous acid upon the remaining maſs, and, on ev ration, more ſuch cryſtals appeared. ſame proceſs was repeated ſeveral by which means the whole maſs laſt changed into ſuch cryſtals, which weighed about five drachms. This ſalt ſhewed in every reſpect phænomena like thoſe produced by the acid of ſugar.

§ IV.

The above mentioned white powder, which weighed $7\frac{1}{2}$ drachms, I took at firſt to be ſaccharated lime, becauſe I thought that as milk always contains a little lime, it might enter into the ſugar, as one of its conſtituent parts, and then, by combining with the acid of ſugar, would conſequently form the ſaccharated lime. But two experiments, which I made with it, ſhew that I was miſtaken in my conjecture. I poured a ſolution of acid of ſugar into a ſolution of ſugar of milk, but no precipitation enſued. I further found that this powder burned in a red-hot crucible like oil, without leaving any mark of aſhes behind.

§ V.

Lime-water ſeemed to have no ſenſible effect upon this powder; but boiling water diſſolved ſome of it, though but a very little; for one part of this powder required ſixty parts of boiling water for its ſolution. After the ſolution was cooled, one-fourth part of the powder ſeparated again from the water in the form of very

ſmall

ſmall cryſtals. The remaining maſs being then collected by evaporating the water from it, a ſmall quantity of acid of ſugar, conſtituting about one-tenth of the powder, remained, which at firſt was not ſo exactly ſeparable by edulcoration. I now found that this powder was a ſalt, becauſe it was ſoluble in water;—it was now purified by means of the ſolution and cryſtalliſation. The properties of this ſalt are the following:

§ VI.

Half an ounce of it was diſſolved in a glaſs veſſel in thirty ounces of boiling water; and after the ſolution was cool, it was filtered. It had a ſouriſh taſte. The tincture of lacmus was reddened by it. It made an effervеſcence with chalk. Two drachms of this ſalt were expoſed to an open fire in a glaſs retort, when it immediately melted, grew black, and frothed very much. Into the neck of the retort a brown ſalt was found ſublimed, which ſmelled like a mixture of the ſalt of benzoin and ſalt of amber. Eleven grains of coal remained in the retort. The receiver contained a brown liquid, without any mark of oil; its ſmell was like the ſublimed ſalt; it alſo contained ſome of this ſalt diſſolved, which was ſeparated from it by a gentle evaporation. The ſalt that

that was ſublimed weighed thirty-five grains, had a ſour taſte, was eaſily ſoluble in ſpirit of wine, more difficultly in water, and burned in the fire with a flame. Concentrated vitriolic acid expoſed to diſtillation with this ſalt became black, frothed very much, and decompoſed the ſalt entirely. All theſe circumſtances ſhew that this ſalt is to be claſſed among the vegetable acids, under the title of *acid of ſugar of milk.*

§ VII. *Its Effects upon Alkalis.*

I poured depurated acid of ſugar of milk, in ſmall quantities at a time, into a hot ſolution of alkali of tartar, till there appeared no more effervescence. A coagulation immediately took place, in conſequence of the formation of ſmall cryſtals, which required eight times the quantity of boiling water for their ſolution. After it was cold the greateſt part of the cryſtals ſeparated again from it. With mineral alkali this acid ſhewed the ſame phænomena, with this difference, that the neutral ſalt thus ariſing requires only five parts of boiling water for its ſolution. If to a ſolution of it, a ſolution of alkali of tartar be added, a number of ſmall cryſtals will be ſoon formed at the bottom of the veſſel, on account of the greater affinity of this acid with the latter alkali.

Both

Both theſe ſalts are perfectly neutral.—Saturated with volatile alkali it forms a kind of ſal ammoniac, which, after being gently dried, has a ſouriſh taſte. When diſtilled, the volatile alkali is firſt ſeparated, the lime-water precipitates, the acid remaining in the retort afterwards yields, with a ſtronger heat, the ſame products as in § VI.

§ VIII. *With Earths.*

The acid of the ſugar of milk forms, with all the earths, ſalts inſoluble in water. I ſhall, therefore, only relate the experiments which I made with it in the way of precipitation. If a ſolution of the ponderous earth in muriatic or nitrous acid be dropped into a cold ſolution of our acid (§ VI.), the earth is immediately precipitated, in combination with this acid. With the ſame ſolutions of lime this acid exhibits the ſame phænomena; but the ſolution of gypſum remains undecompoſed. The ſame thing happens with the ſolutions of magneſia in vegetable or mineral acids, and with earth of alum; all of which, however, are decompoſed by the neutral ſalts above mentioned.

§ IX.

§ IX. *With Metals.*

It produces the ſame effects with the metals as with the earths. With regard to the weakneſs of the menſtruum, ſince the water diſſolves ſo little of our acid, it has no ſenſible effects upon metals; but with the metallic earths, ſalts are formed very little or not at all ſoluble in water. Argentum nitrated ſilver is precipitated by our acid in the form of a white powder: and in the ſame manner is the nitrated mercury and lead. Vitriolated iron, copper, zinc, and mangaueſe, are not hereby precipitated. Muriated tin and mercury are not hereby decompoſed, but muriated lead is precipitated. By the neutral ſalts (§ VII.) all metallic ſolutions are decompoſed.

ESSAY XVIII.

ON THE CONSTITUENT PARTS OF LAPIS PONDEROSUS, OR TUNGSTEN. 1781.

IT is probable that the conſtituent parts of this ſpecies of foſſil have been hitherto unknown to the chemiſts. Cronſtedt enumerates it among the ferruginous ſtones, under the name of, *Ferrum calciforme terrâ quâdam incognitâ intimè mixtum.* That which I employed in my experiments was of a pearl colour; it was taken from the iron mines of Bitſberg; and as I made many experiments upon it, and have diſcovered its conſtituent parts, I take the liberty of communicating the following account to the Royal Academy.

§ I.

(A) In the fire tungſten does not undergo any perceptible change, nor does glaſs of borax produce any ſenſible effect upon it; (B) but with microcoſmic ſalt it forms, by means of the blowpipe, a glaſs of a ſea-green colour. If the globule be kept in fuſion at the extreme point of the flame, the colour gradually diſappears; a very little nitre alſo very ſoon deſtroys the

the colour; but it returns whenever the blue part of the flame is driven on the globule; consequently, it is the phlogiston of the flame which is the cause of the colour. (c) One part of tungsten, reduced to a fine powder in a glass mortar, was mixed with four parts of alkali of tartar, and placed in the fire in an iron crucible. The mixture, when melted, was poured out on an iron plate, and dissolved in twelve parts of boiling water. After standing some hours, the lixivium was poured off from a portion of white powder which had subsided to the bottom. (D) This powder was edulcorated, and nitrous acid added to it, till no more effervescence could be perceived, by which operation great part of it was dissolved. (E) The undissolved part of the powder was dried, and being again mixed with four parts of alkali of tartar, was fused as before: This mass being also dissolved in water, and nitrous acid poured upon the remaining powder, only a very small portion of grey powder was left behind undissolved. (F) The ley (c) was saturated with nitrous acid; it grew thick by the precipitation of a white powder, which was afterwards washed with cold water and dried. (G) The solution in nitrous acid (D) afforded, on the addition of alkali of tartar,

tartar, a white precipitate, which was dried.

§ II.

(A) Boiling water has no action upon tungſten reduced to powder. (B) On one part of finely powdered tungſten were poured two parts of concentrated acid of vitriol, and the mixture was diſtilled. The acid paſſed over unchanged; and the reſiduum, which was of a bluiſh colour, was boiled a ſhort time in diſtilled water, which was then filtered off, and upon cooling depoſited ſome vitriolated lime. (C) On four ſcruples of tungſten, reduced to a very fine powder, were poured twelve ſcruples of common nitrous acid, or pure aquafortis: No effervefcence enſued; the mixture was then expoſed to a ſtrong digeſting heat, whereupon the powder ſoon aſſumed a citron-yellow colour. The acid was then decanted off into a ſeparate phial; and the yellow powder, having been edulcorated with water, was put into another phial. (D) On this yellow powder I poured eight ſcruples of cauſtic volatile alkali, and expoſed the phial to heat; the yellow colour preſently vaniſhed, and the powder became white. This ſolution was then in like manner poured into a ſeparate flaſk, and the powder edulcorated. As the matter was ſenſibly diminiſhed by theſe

theſe operations, I repeated them many times on the ſame powder, digeſting it firſt in the nitrous acid, and then in the volatile alkali, till at length the greateſt part of it was diſſolved. What remained undiſſolved weighed three grains, and ſeemed to be ſiliceous earth. Muriatic acid produces the ſame effect upon tungſten as the nitrous, but the ſolution was of a deeper yellow.

§ III.

(A) The ſolutions made in the foregoing manner with the nitrous acid being all mixed together, ſome drops of phlogiſticated alkali were added, upon which about three grains of Pruſſian blue were precipitated. (B) The mixture was then ſaturated with cauſtic volatile alkali; but as no precipitate appeared, ſome ſolution of alkali of tartar was added; a white powder now fell to the bottom, which, when waſhed and dried, weighed two ſcruples and five grains, and was found to be aerated lime unadulterated; ſo alſo is the earth obtained § I. (G). (C) The extracts procured by volatile alkali were precipitated with nitrous acid; the precipitate was waſhed with cold water and dried; it is exactly the ſame as that mentioned § I. (F). (D) It is of an acid nature, not eaſily ſoluble in water, for near twenty

twenty parts of boiling water are required to one of the precipitate; it colours the tincture of litmus red, and has an acid tafte.

§ IV.

Now, as the earth feparated from tungften by the nitrous acid is calcareous (§ III. B), it became neceffary to try whether the above mentioned acid, combined with calcareous earth, would conftitute a regenerated tungften. Having this in view, and knowing that tungften is not foluble in boiling water (§ II. A), I mixed one part of the acid folution (§ III. D) with fix parts of clear lime-water, upon which the mixture became a little turbid; but as, after an interval of fome hours, there was no depofition, the mixture was made to boil, when immediately a white heavy powder feparated, which, after being dried, gave a fea-green colour to glafs of microcofmic falt, became bluifh on being boiled in the vitriolic acid, and of a lemon colour with the nitrous and marine acids, and confequently was pure tungften.

§ V.

To afcertain more completely the nature of this acid, the following experiments were made. (A) Under the blowpipe the dry acid became firft of a reddish-yellow colour, then brown, and at last black: It neither smoked, nor gave any signs of fusion. (B) With borax it produced a blue, and with microcosmic salt a sea-green glass. This colour is subject to the same changes as are related of the glass § I. B. (C) When pulverised acid of tungsten is boiled with a small quantity of the nitrous or marine acids, the powder becomes yellow; and, with the acid of vitriol, bluish. (D) If the solution of the acid of tungsten in water (§ III. D) be saturated with alkali of tartar, a neutral salt is obtained in very small crystals. (E) With volatile alkali this acid forms an ammoniacal salt, in shape like the points of small pins. This salt, on distillation, yields its alkali in a caustic state; the acid remaining behind in the retort, in the form of a dry powder of a yellow colour. This ammoniacal salt decompounds nitrated lime, in consequence of which regenerated tungsten is produced. (F) With magnesia the acid of tungsten forms a neutral salt of difficult solubility in water. (G) It produces no change on solutions of alum or lime, but it decompounds acetated ponderous earth, and the precipitate is altogether insoluble in water. (H) The following metallic solutions are precipitated, of a white colour, by the acid of tungsten, *viz.* vitriolated iron, zinc,

and

and copper; nitrated ſilver, quickſilver, and lead, as alſo muriated lead; but tin, combined with the ſame acid, is precipitated blue; and corroſive ſublimate, and the ſolution of gold, undergo no change.

§ VI.

When the acid of tungſten is calcined in a crucible, it loſes the property of being ſoluble in water. That the acid is much diſpoſed to attract phlogiſton, appears from the blue colour it acquires with fluxes (§ V. A, B). This circumſtance induced me to mix the dry acid with a little linſeed oil, and to expoſe the maſs to a ſtrong fire in a luted crucible. When it was grown cold, I found the acid black, but in other reſpects quite unchanged. I alſo mixed one part of the dry acid with two parts of ſulphur, and diſtilled off the latter; I then mixed with the reſiduum two parts more of ſulphur, and again diſtilled it off: The acid had acquired a grey colour, but was in other reſpects unaltered. Solution of liver of ſulphur was precipitated of a green colour, by acid of tungſten, but the phlogiſticated alkali white; the latter precipitate is ſoluble in water. If a few drops of marine acid be added to a ſolution of the acid of tungſten in water, and the liquor be ſpread on poliſhed iron, zinc, or even tin, the acid ac-

 quires

quires a beautiful blue colour; and the ſame thing happens if theſe metals be put into the acid.

§ VII.

As the acid of molybdæna likewiſe acquires a blue colour from theſe metals, it might be natural to ſuppoſe that the acid of tungſten is the ſame as that of molybdæna; but as, in other reſpects, it ſhews very different properties, it muſt be of a totally different nature. For, *1ſt*, The acid of molybdæna is volatile, and melts in the fire*, which is not the caſe with the acid of tungſten (§ V. A). *2dly*, The former of theſe acids has a ſtronger attraction for phlogiſton, as appears from its combining with ſulphur, and the change it undergoes on calcination with oil. *3dly*, Lime combined with the acid of molybdæna is not turned yellow by the acid of nitre, and is readily ſoluble in it: With tungſten it is quite the contrary. *4thly*, Ponderous earth, combined with the acid of molybdæna, is ſoluble in water; but the combination of the ponderous earth with the acid of tungſten is inſoluble. And, *5thly*, The acid of molybdæna has a weaker attraction for calcareous earth than the acid of tungſten has; for if the combination

* See the diſſertation on molybdæna.

combination of lime and acid of molybdæna be digefted in a folution of the above mentioned ammoniacal falt (§ v. A), a regenerated tungften will be obtained.

The iron procured from fome forts of tungften is to be confidered as accidentally prefent.

Supplement to the foregoing Eſſay. By T. Bergman.

Several years ago I began an inveſtigation of the conſtituent parts of tungſten. Its great ſpecific gravity induced me to ſeek for ponderous earth in it; but the proceſs by which this earth is uſually extracted, gave, inſtead of it, common calcareous earth; and when the firſt alkaline ſolution, made in the moiſt way, was poured off, and an acid added to the ſolution, it gave on ſaturation a white precipitate of an acid nature. I need not relate the experiments, as I obtained the ſame reſults as Mr Scheele: Some ſmall differences, however, in my experiments with the blowpipe, deſerve to be mentioned.

Tungſten, by itſelf, decrepitates with the blowpipe, but does not melt.

In a ſmall gold or ſilver ſpoon it unites with mineral alkali with ſome efferveſcence, and the bit of tungſten falls into powder.

With microcoſmic ſalt it efferveſces a little at firſt, and then leaves a reſiduum of difficult ſolubility; but the glaſs globule aſſumes a bright ſky-blue colour, without the leaſt ſign of that redneſs, when it is held between the eye and the light, which is produced when cobalt is uſed.

ufed. If more tungften be added, the globule becomes brownifh, but remains ftill tranfparent: With a further addition, it becomes black and opaque.

Borax diffolves it without motion, and almoft without colour; but when the globule is overloaded with tungften, it at length becomes brown or white, and opaque, in cooling.

The acid earth by itfelf produces fome effervefcence with mineral alkali. With microcofmic falt it gives a globule which is at firft light-blue, more of the acid makes it dark-blue, but it ftill remains free from rednefs by refraction: With a further addition it becomes brown. Borax acquires a flight tinge of blue, and with more of the acid becomes of a yellowifh brown colour; but remains tranfparent, provided no further addition be made.

This ultimate brown colour I have not been able to drive off, either with nitre, or the point of the flame.

A very eafy method of diftinguifhing tungften from all other foffils hitherto known, is, to pour upon it, when it is reduced to powder, aquafortis or marine acid, and to fet the mixture in a digefting heat. It will foon be perceived, efpecially when the latter acid has been employed, that the powder gradually acquires a fine light-yellow colour. This happens not only with the fpecies from Bitfberg, but likewiſe with all the foreign ſorts I have hitherto had an opportunity of trying. What is uſually called *white tin ore, in cluſters like grapes*, often belongs to this ſpecies.

With reſpect to the nature of the acid earth, it is nearly allied to that obtained from molybdæna; and both are in a ſtate much reſembling that of white arſenic. It is well known, that arſenic, in its ſemimetallic ſtate, is nothing but a peculiar acid, ſaturated with phlogiſton; and that the white calx is in an intermediate ſtate between acid and metal, containing juſt phlogiſton enough to coagulate the acid; but remaining ſtill ſoluble in water, and ſhewing ſigns of acidity. If a concluſion from analogy be admiſſible, all the other metals ſhould conſiſt in a combination of the ſame nature, of the different radical acids, which, with a certain quantity of phlogiſton, are coagulated to a dry earthy ſubſtance, and, on complete ſaturation, are brought to the ſtate of complete metals.

The reaſons which induced me to ſuppoſe that the above mentioned acid earths are metallic acids, reduced by phlogiſton to that form of metallic calces in which the acid is ſtill perceptible, are the following:

1. They

1. They both ſhew a ſtriking reſemblance to white arſenic in form, in producing effects like acids, and in their little ſolubility in water.

2. Their ſpecific gravity; that of white arſenic is 3,750, that of the earth of molybdæna 3,460, and that of the acid earth of tungſten about 3,000.

3. Their precipitation with phlogiſticated alkali. None but metallic ſubſtances are hitherto known to be precipitated by this alkali: Moreover, arſenic, properly diſſolved in the marine acid, gives with the phlogiſticated alkali a precipitate ſoluble in water, juſt as the acid earth of tungſten.

4. Their property of tinging vitreous fluxes. Metallic calces, but, as far as I know, no other ſubſtances, have the property of communicating a colour, each according to its peculiar kind, to clear glaſs. The effect of white arſenic, in this reſpect, is well known; that of the earth of tungſten has been deſcribed above; and the earth extracted from molybdæna is not leſs powerful; for it gives to microcoſmic ſalt a beautiful green colour; and borax well ſaturated with it appears grey when viewed by the reflected rays, but, by the refracted, of a dark-violet colour.

Theſe

These reaſons have induced me to conſider the acid earths obtained from molybdæna and tungſten as metallic calces. Other occupations have hitherto prevented me from confirming my opinion by reduction; but I thought proper, nevertheleſs, to mention it on this occaſion, as perhaps ſome other perſon before me may be inclined, for the promotion of ſcience, to undertake the neceſſary proofs.

ESSAY

ESSAY XIX.

Experiments and Observations on Æther. 1782.

UNDER the term *æther* chemiſts underſtand a very volatile, penetrating, colourleſs oil, which has an aromatic ſmell, and is ſoluble in water. The firſt method of preparing this oil from vitriolic acid and ſpirit of wine has been long known. In later times, ſeveral methods of preparing a liquor of the ſame kind from nitrous and marine acids, with alcohol, have been propoſed; but it has been obſerved, that this latter acid was not of itſelf ſtrong enough for this purpoſe, but that, in order to produce the deſired effect, it muſt be united with tin, or with regulus of antimony. The theory of the generation of æther is ſtill very imperfect, from the want of ſufficiently deciſive experiments; —the following may perhaps contribute to elucidate this intricate ſubject.

§ I.

(A) If, in the preparation of vitriolic æther, a large retort be made uſe of, and the fire be much increaſed towards the end of the proceſs, it is found, that the volatile

volatile ſulphureous acid in the receiver is mixed with vinegar, without any mark of aerial acid, either in the cavity of the retort or of the receiver. (B) If one ounce of pulveriſed manganeſe be put into a retort, with half an ounce of vitriolic acid, and an ounce of rectified ſpirit of wine, and this mixture be expoſed to a ſand-heat, in a few minutes it will begin to grow hot, and will ſoon boil by itſelf. During this time ſome æther, of a moſt agreeable ſmell, goes over into the receiver. If the fire be increaſed, towards the end a ſmall quantity of vinegar will paſs over, without any mark of volatile ſulphureous acid. The air in the receiver is now found to be mixed with aerial acid, and in the retort there will remain a reſiduum of vitriolated manganeſe, without any exceſs of acid. (C) If two parts of pounded manganeſe and one-half part of vitriolic æther be mixed with one part of vitriolic acid, and the proceſs carried on as in (B), the mixture will likewiſe grow hot of itſelf in about an hour's time. The æther which, a ſmall portion excepted, is again obtained after the proceſs, has a finer ſmell than before. There is likewiſe obtained ſome vinegar, and ſome aerial acid.

§ II.

§ II.

In order to aſcertain whether the vitriolic acid is to be looked upon as a real conſtituent part of the vitriolic æther, the ſuperfluous vitriolic acid ought to be ſeparated from it. In order to effect this, I found the rectification of the æther with dry alkaline ſalt inſufficient, becauſe the alkali does not touch the æther in all its points. I therefore diſſolved cauſtic alkali in ſpirit of wine, and in this alkaliſed ſpirit I diſſolved as much æther as it would take up. I then diſtilled the maſs again by means of a gentle heat. Upon the æther thus obtained, after it was rectified, I cautiouſly poured two parts of pure concentrated nitrous acid. The mixture had perfectly the ſmell of nitrous æther. I evaporated the whole to within a few drops, and then added a little of the ſolution of terra ponderoſa, which inſtantly grew white; conſequently a regenerated ſpathum ponderoſum was here produced. This I think will be quite ſufficient to prove that vitriolic acid is a conſtituent part of vitriolic æther.

§ III.

That calx of zinc, diſſolved in muriatic acid, and that butter of antimony and ſmoking ſpirit of libavius, on diſtillation

tion with ſpirit of wine, produce æther, is a known fact, and my experiments confirm it. I ſhall only add here, that in all theſe diſtillations no aerial acid is produced. Why no æther can be produced from muriatic acid and ſpirit of wine alone, the following experiment may teach: (A) I mixed an ounce of pulveriſed manganeſe with four ounces of common muriatic acid, and two ounces of rectified ſpirit of wine, and put this mixture, after I had covered it well, aſide for ſeven whole months; during which period it was now and then agitated. This mixture at laſt yielded an odour of nitrous æther, and I ſaw ſome drops of oil floating upon it. From this obſervation I was led to put into a tubulated retort two ounces of common ſalt, and as much vitriolic acid; and after luting on a receiver, which contained three ounces of ſpirit of wine, I placed it in a ſand-bath. After ſome time I poured this ſpirit, which was now fuming, into a retort which contained three ounces of powdered manganeſe. The mixture inſtantly aſſumed a fine green colour, but a few minutes afterwards it grew hot, upon which I immediately applied a receiver. The heat increaſed ſo much, that the maſs began to boil of itſelf, and at the ſame time the green colour diſappeared. After the ebullition had ceaſed, I put the contents of the receiver into a flaſk, into which I had previouſly poured a little water, the æther inſtantly ſeparated; it reſembled in its ſmell nitrous æther, when it is mixed with dephlogiſticated muriatic acid. I luted the receiver again to the neck of the retort, and continued the diſtillation to dryneſs, by which operation I obtained more æther; ſome of which floated upon the ſurface, and the reſt kept at the bottom. (B) I then diſtilled a mixture of three ounces of powdered mangaueſe, one ounce of vitriolic acid, and three ounces both of common ſalt and of ſpirit of wine, and obſerved the ſame phænomena, and obtained the ſame products as in (A). (C) I mixed three ounces of powdered manganeſe, with the ſame quantity of common muriatic acid, in a retort, placed the maſs in warm ſand, and applied a receiver, which contained three ounces of ſpirit of wine. The muriatic acid now went over in a dephlogiſticated ſtate into the ſpirit of wine, which ſoon grew very warm, though the neck of the retort was cold. Some time after all the efferveſcence had ſubſided in the retort, I poured the ſpirit out of the receiver into another retort, and diſtilled it by a gentle heat. At firſt ſome æther went over, having the ſmell of nitrous æther. At the end of the proceſs, another kind of æther, or rather oil, came over, which

which ſunk to the bottom, and at laſt muriatic acid paſſed over. (D) I diſſolved ſome biſmuth in aqua regia, conſiſting of three parts of muriatic, and one part of nitrous acid. This ſolution I evaporated to the conſiſtence of a ſyrup, then mixed it with an equal quantity of ſpirit of wine, and diſtilled the maſs by a gentle fire. At firſt pure ſpirit of wine paſſed over, which was followed by ſome æther, that had exactly the ſmell of vitriolic æther. (E) Iron was the laſt among the metals, by means of which I could produce æther with muriatic acid. I ſaturated muriatic acid, by boiling it with crocus martis (for with iron filings no æther can be produced). The ſolution I evaporated to the conſiſtence of honey, and then proceeded as in (D). The æther, thus obtained, was perfectly like the preceding. I ſeveral times poured ſpirit of wine as well upon this reſiduum as upon the reſiduum of biſmuth, and conſtantly obtained ſome æther upon a new diſtillation. In this diſtillation no aerial acid is generated.

§ IV.

In order to determine with certainty, whether the muriatic acid is to be looked upon as a conſtituent part of this æther, it was firſt neceſſary to free it from the ſuperfluous

ſuperfluous muriatic acid as well as poſſible; and with this view I proceeded with this æther as I had done before with the vitriolic § II. The æther, thus purified from muriatic acid, was mixed with a ſolution of ſilver; but obſerving no precipitation to take place, I poured the whole maſs into a glaſs veſſel, and ſet it on fire after the æther was conſumed; I found the ſolution of ſilver turbid, and as it were coagulated by the muriated ſilver; conſequently my conjecture that the muriatic acid was a conſtituent part of this æther was well founded.

§ V.

The action of nitrous acid upon ſpirit of wine is well known; on which account I ſhall take no further notice of it; but the action of the fluor acid upon ſpirit of wine I was curious to learn. (A) For this purpoſe I mixed powdered fluor with an equal quantity of vitriolic acid in a retort, to which I luted a receiver, containing three ounces of ſpirit of wine, and placed the retort in warm ſand. The day following I poured the ſpirit, which now ſmoked, into another retort, and diſtilled it in the common manner. The fluor acid penetrated every where through the lute, but no mark of æther was perceptible. (B) I then mixed the ſpirit which

 was

was contained in the receiver with fluor acid air as before; and having poured the mixture into a retort upon three ounces of pounded manganese, I subjected it to distillation. I here obtained a quite different result; no acid penetrated through the lute; I only perceived the smell of æther through it; and, after I had driven over all the spirit, I poured it into another retort, rectified it by a gentle heat, and by this means obtained a small quantity of æther of a very agreeable smell, resembling nearly that of nitrous æther.

§ VI.

In order to procure a sufficient quantity of concentrated vinegar, I distilled the acid vinegar from acetated copper, and rectified it by another distillation. My view was to prepare and to examine the acetous æther of Count Lauragais. But, notwithstanding all the trouble I bestowed for this purpose, I was not able to produce the least vestige of such an æther; the same disappointment I met with, when I used vinegar obtained by distillation from acetated vegetable alkali. It is singular enough that so many of our modern chemists should have acquiesced in the assertion of the Count as an indisputable certainty. Upon communicating my unsuccessful experiment to Professor Bergman,

man, he had the kindneſs to inform me in anſwer, that Dr Pórner was the only chemiſt who had not blindly admitted the Count's aſſertion, and had aſſerted, that he had not been able to obtain any æther, according to the Count's proceſs. But though this be certainly true, I however found the means of obtaining ſuch an æther; it requires only the addition of a little mineral acid before the diſtillation. Add, for inſtance, (A) to an ounce of concentrated vinegar (which may be obtained from verdegreaſe, cryſtals of verdegreaſe, ſaccharum ſaturni, or acetated vegetable alkali, by means of vitriolic acid), two ounces of ſpirit of wine, and two drachms of common muriatic acid. Diſtil this mixture, till all the ſpirit has been driven over, and then, upon diſtilling it off a ſecond time to one-half into a receiver, which ſhould contain a little water, acetous æther will be obtained. If, inſtead of the muriatic acid, vitriolic, nitrous, or fluor acid be employed, the ſame æther will be produced. This æther is obtained in a larger quantity than any other, and may be prepared in ſeveral different ways. (B) If an ounce of alkali ſaturated with vinegar be diſſolved in three ounces of ſpirit of wine, and then as much of any of the above mentioned four mineral acids be added as is requiſite not only to decompoſe the acetated alkali, but that there ſhall likewiſe be ſome ſuperfluous mineral acid, and the maſs be then diſtilled, the ſame æther will be obtained. (c) If acetated lead be triturated with a ſufficient quantity of muriatic acid, then mixed with ſpirit of wine and diſtilled; (d) if cryſtals of verdegreaſe be diſſolved in a ſufficient quantity of muriatic acid, and diſtilled with ſpirit of wine; (e) if one part of concentrated vitriolic acid be mixed with three parts of ſpirit of wine, one part of common ſalt, and one-half part of powdered verdegreaſe, and diſtilled, an æther of the ſame kind is likewiſe obtained. In the ſame manner, if (f) one part of vitriolic acid be mixed with four parts of concentrated vinegar, and four parts of ſpirit of wine, then put aſide in a well corked phial for a few days, if to this maſs ſome water be added, the ſame ſort of æther will be ſeparated. All the æther obtained floats upon the water, but is not near ſo volatile as nitrous or vitriolic æther; it burns with a blue flame like ſpirit of wine. The union of the component parts of the acetous æther is much eaſier deſtroyed than that of the other kinds, as the following experiments will prove: (g) I diſſolved one part of acetous æther in as much water as was neceſſary for the ſolution, and afterwards

afterwards added two parts of cauftic fixed alkali. On diftilling it by a gentle fire, I hardly obtained the eighth part of the æther diffolved. The acetous æther, thus depurated, did not indeed any longer affect tincture of lacmus as it did before; but, on pouring fome drops of it upon blue paper, it immediately turned it red. I diffolved this æther anew in a weak alkaline ley, and diftilled the folution again. Here it difappeared entirely; the firft liquor that went over retained only a faint fmell of æther. I faturated the remainder in the retort with vitriolic acid, and obtained by diftillation acetous acid.

§ VII.

Some phofphoric acid which was prepared by burning phofphorus was mixed with two parts of fpirit of wine. I diftilled the mixture in the common way, till there was nothing remaining in the retort but the acid. The fpirit which came over into the receiver had a difagreeable fmell. I rectified it, in order to get the æther, by a more gentle degree of heat, but I obtained not a veftige of it. On mixing water with this fpirit it grew white like milk, and fome days afterwards I found a white powder precipitated, which was pure phofphorus. Should the phofphoric acid perhaps contain always a

 fmall

ſmall quantity of phoſphorus undecompoſed, the ſpirit of wine would be a good medium to ſeparate it. The diſagreeable ſmell, as it would ſeem, aroſe from the phoſphorus diſſolved in the ſpirit; but that the ſpirit of wine ſhould carry over along with it into the receiver acid of phoſphorus, as Mr Morveau * maintains, is not in the leaſt probable, as I found not the ſlighteſt mark of it in the ſpirit thus diſtilled.

§ VIII.

The cryſtalliſed acid of benzoin mixed with ſpirit of wine yielded no æther; but on diſtilling one part of the acid of benzoin with three parts of ſpirit of wine and one-half part of common muriatic acid, pure ſpirit firſt came over, whereupon I obſerved two different liquids in the retort, one white, the other brown. I therefore changed the receiver; and, on continuing the diſtillation, afterwards obtained an æther, one portion of which floated upon water, while the other, which was the larger portion, ſubſided to the bottom. This æther had the ſmell of ſalt of benzoin, was not more volatile than acetous æther, burned with a clear flame, and with ſmoke. When diſſolved in alkaliſed

* Elemens de Chemie Théorique et Pratique, tom. iii. p. 338.

kalifed fpirit of wine, and then diftilled, it was as eafily decompounded as acetous æther; and, on diffolving the remainder in the retort in water, and adding fome acid, the whole mixture was coagulated by the precipitation of falt of benzoin.

§ IX.

I muft not conceal the reft of my unfuccefsful experiments made upon this fubject, as they may perhaps afford fome illuftration with regard to the theory of the generation of æther. The acid of tartar had no effect upon fpirit of wine, not even when a mineral acid was added; neither did the addition of manganefe afford any æther. Concentrated acid of lemon gave, in every refpect, the fame refult. Neither does the acid of borax afford any æther, either with or without manganefe. The acid of amber acts in the fame manner, as likewife does the phofphoric acid with manganefe, with concentrated vinegar and acid of tartar, with concentrated vinegar and manganefe. Thefe fubftances diftilled with fpirit of wine yield no æther. The fame thing takes place with the following falts: Acetated zinc, acetated mercury, muriated mercury and iron, muriated manganefe, nitrated filver, muriated magnefia, falt of benzoin and manganefe, fixed cauftic alkali and manganeſe, acid of arſenic, acid of arſenic and manganeſe.

§ x.

From the foregoing experiments I ſhould be unwilling to attempt an explanation of the generation of æther; for though it might be concluded, with ſome degree of certainty, that there is always required a ſubſtance to attract the inflammable principle of the ſpirit of wine, becauſe all the experiments coincide in ſhewing this; yet ſtill I do not ſee how this opinion can be held with regard to æther of vinegar and benzoin, as theſe two vegetable acids have as little affinity with phlogiſton as fluor and muriatic acids have. But if you were even to allow that they attract phlogiſton, though but weakly, a queſtion ſtill remains, In what manner does this *oil of ſpirit of wine or æther* ſeparate from the water with which it was ſo intimately united? Perhaps, however, this phænomenon might be explained upon the ſame principle as the ſeparation of ſulphur from hepatic air. It is known that this air is, like ſpirit of wine, ſoluble in water, and that it conſiſts of phlogiſton, the matter of heat and ſulphur. If any ſubſtance be added which diſunites the phlogiſton from this air, the matter of heat flies off, and the ſulphur precipitates.

This

This I apply to the explication of the generation of æther; and we know beforehand, that mangane∫e, when united with an acid, has a ∫trong attraction for phlogi∫ton. Now, if this metallic calx, ∫pirit of wine, ∫alt and vitriolic acid be mixed, the mangane∫e will unite with a part of the phlogi∫ton of the ∫pirit of wine, and the matter of heat, which becomes ∫o evident in this proce∫s that the mixture boils of it∫elf (§ I. A; § III. A), is ∫et free, by its ∫eparation from the phlogi∫ton; and thus the oil of ∫pirit of wine, or æther, is ∫eparated from the water. The æther, in this ca∫e, commonly carries along with it a ∫mall admixture of the acid, which ∫erved to its ∫eparation from the water (§ II. IV.); but this ∫mall quantity of acid is ∫o in∫ignificant in rectified æther, that it cannot be maintained with certainty that there exi∫ts no æther at all without ∫ome mineral acid. The ∫mall portion of vinegar and aerial acid which I ob∫erved in ∫ome di∫tillations (§ I. C), ari∫es from the total decompo∫ition of a ∫mall portion of æther; for it is very probable that the oil of ∫pirit of wine con∫i∫ts of acetous acid and phlogi∫ton; whereas calx of iron, di∫∫olved in muriatic acid (§ II. C), and di∫tilled with ∫pirit of wine, yields æther; whence it appears why the tinctura ferri of the Pharmacopœia Suecica in time acquires a ∫mell like nitrous æther.

ESSAY

ESSAY XX.

Observations on a Method of preserving Vinegar. 1782.

IT is a fact generally known, that vinegar, of whatever kind, will not keep long; but, in the courſe of a few weeks, eſpecially in the warm temperature of ſummer, grows turbid, and that its ſurface is covered with a thick mucilaginous ſubſtance; during which period the acid diſappears by degrees, and at laſt is entirely loſt; whence the vinegar muſt very often be thrown away. Now, in order to avoid this corruption of the vinegar, four methods have been diſcovered. The firſt is, to prepare the vinegar very ſtrong and ſour at firſt. It is well known, that ſuch vinegar keeps for ſeveral years; but as there are few people who prepare their own vinegar, and as moſt content themſelves with buying it as it is to be had in the ſhops, there are of courſe but few who can make uſe of this method. The ſecond method is to concentrate the vinegar by congelation; after which a hole is made in the cruſt of ice which covers it, through which the part that is not congealed is let out, and afterwards put into

into bottles. This manipulation anſwers well enough; but as nearly one-half is loſt, becauſe that which forms the cruſt of ice is, for the moſt part, nothing but water, good œconomiſts diſlike it. The third method is to prevent the acceſs of air, *viz.* To fill the bottles full, and keep them perfectly well corked. Though vinegar by this method keeps very long, it is not much employed; probably, becauſe it is troubleſome to fill the bottle immediately again, every time you have made uſe of part of its contents, with clear vinegar from another bottle; after which, the vinegar in the bottle that is not full, and to which conſequently the air has acceſs, ſoon grows turbid and vapid. The fourth method is to diſtil the vinegar: Such vinegar ſuffers not the leaſt change, though expoſed to a warm air for years; but, being more expenſive than that which is not diſtilled, this method is ſeldom made uſe of, eſpecially as the following method to preſerve vinegar is the eaſieſt of all.

It is only neceſſary to put your vinegar into a well tinned kettle, and make it boil for a quarter of a minute over a ſtrong fire. It is then to be immediately bottled carefully; or, if any one ſhould be afraid of tin being pernicious to health, he may fill his bottles firſt, and then put them into a kettle full of water upon the fire.

After

After the water has boiled for about an hour's time, the bottles are taken out of the pot and corked. The vinegar thus boiled keeps for ſeveral years, as well in open air as in half-filled bottles, without growing turbid or mucilaginous. It likewiſe may be uſed with advantage for pharmaceutical purpoſes, inſtead of common vinegar; for the preparation of the compound vinegars, which, if not prepared with diſtilled vinegar, ſoon grow turbid, and loſe their acidity.

ESSAY

ESSAY XXI.

Experiments on the colouring Matter in Berlin or Prussian Blue. 1782.

TOWARDS the beginning of the present century, Mr Dieſbach, a manufacturer of colours at Berlin, with the aſſiſtance of Dr Dippel, accidentally diſcovered the blue colour, ſince called Berlin or Pruſſian blue. They kept this preparation with great ſecrecy, till Woodward publiſhed the whole proceſs in 1724. After this period, ſeveral chemiſts have endeavoured as well to improve the colour as to give an explanation of its origin. Brown, both the Geoffroys, and the Abbé Maynan, are known on account of their papers written upon this ſubject; but it was reſerved for Macquer, who publiſhed a diſſertation upon it in 1752, to repreſent the whole in a connected view. After him ſeveral have attempted to determine the nature of the matter, which in general unites with the metallic calces, when they are precipitated from their ſolutions by the lixivium ſanguinis, and which in the preparation of the Pruſſian blue gives to the iron a blue colour: But they have advanced

advanced no further. Some are of opinion that it is phlogiſton which comes into action here, and thence the name *phlogiſticated alkali*. Others think that it is an animal acid. The cauſe of this uncertainty is, that there has been hitherto no method diſcovered to obtain this colouring matter in a perfectly pure ſtate, it being hitherto always united with ſome heterogeneous ſubſtance. Having at laſt, after many repeated trials, found means to obtain it in this pure ſtate, and unmixed, ſo that I was able to make ſeveral experiments with it, I now take the liberty of preſenting an account of them to the Royal Society.

§ I.

(A) If the lixivium ſanguinis, the preparation of which is univerſally known, be expoſed for ſome time to the open air, it loſes its property of precipitating the iron of a blue colour; and the precipitate, thus obtained, is entirely diſſolved in the acid. Now, in order to aſcertain whether the air had hereby undergone any change, I put ſome recently prepared lixivium into a glaſs veſſel, which was well ſealed with roſin; but ſome time afterwards I found the incloſed air as before, and the lixivium ſanguinis unchanged; whence I conclude, that the colouring matter

matter is not abſolutely ſimple phlogiſton *. It occurred to me, that the aerial acid, which was not preſent in ſufficient quantity in air confined, as in the preceding experiments, but exiſts in a much larger quantity in the open air, might be the principal cauſe of the ſeparation of this colouring matter from the lixivium. (B) I therefore filled a glaſs veſſel with aerial acid, and poured a little lixivium ſanguinis into it, carefully preventing the acceſs of the external air. On examining this lixivium the day after, I found that my conjecture was well founded; for calx of iron, precipitated with this lixivium, was entirely ſoluble in acids. (C) I further tried, whether other acids had the ſame effect upon the lixivium ſanguinis. For this purpoſe I ſuperſaturated that preparation with all the known acids, adding afterwards a ſolution of vitriolated iron to them; but neither did I now obtain any precipitate.

§ II.

(A) I now inverted my experiments; I mixed a little vitriolated iron with lixivium ſanguinis, which immediately grew yellow; I then poured ſome of this mix-

† Le bleu de Pruſſe eſt un précipité de fer, avec ſurabondance de phlogiſtique. Macquer Dict. de Chemique, 2de edition.

ture into a glaſs veſſel filled with aerial acid. The day after, I poured this lixivium into a ſolution of vitriolated iron, then ſuperſaturated the lixivium with acid, and obtained a conſiderable quantity of Pruſſian blue. (B) To the ſame lixivium ſanguinis, in which I had diſſolved a little vitriolated iron, I added of the other acids ſomewhat more than was neceſſary for ſaturation; and, on mixing afterwards a ſolution of vitriol with them, I inſtantly obtained Berlin blue. (C) I precipitated a ſolution of vitriolated iron with alkali, and boiled the greeniſh precipitate for ſome minutes in lixivium ſanguinis, which diſſolved part of it; I then filtered the lixivium. This lixivium underwent no change, when expoſed to the open air, or to the aerial acid; it precipitated the ſolution of iron of a blue colour, as well before as afterwards; and although the lixivium was ſuperſaturated with acid, and ſome vitriolated iron was added, a very beautiful Pruſſian blue was obtained. Hence it appears, that the calx of iron in ſome manner fixes the colouring matter in the lixivium; ſo that neither aerial acid, nor any other acid, is capable of ſeparating this matter from the alkali. This is likewiſe the reaſon why the colouring neutral ſalt, which is formed on boiling alkali with Pruſſian blue, does not ſo eaſily ly loſe its power of precipitating iron of a blue colour, either by the action of the aerial or any other acid. (D) But if lixivium ſanguinis be boiled with a perfectly calcined calx of iron, (which I prepared for this purpoſe from vitriolated iron, by boiling it in nitrous acid, and precipitating with cauſtic alkali) no part of it is diſſolved; for if the lixivium be afterwards ſuperſaturated with acid, and vitriolated iron added to it, no Pruſſian blue is obtained. The ſame thing happens, if ſuch a ſolution of perfectly calcined iron be precipitated with lixivium ſanguinis, and ſome acid be afterwards added to it. Hence it likewiſe appears how much the ſmall quantity of phlogiſton, which the calx of iron retains in the vitriol, contributes to the fixing of the colouring matter.

§ III.

(A) In order now to learn whither the colouring matter had gone in the experiments § I. A, B, C, I poured ſome lixivium ſanguinis into a glaſs veſſel, filled with aerial acid; it was kept well corked during the night, and the next day I fixed to the cork a piece of paper, that had been dipped in a ſolution of vitriolated iron, and then pencilled it over with a couple of drops of a ſolution of alkali in water.

The piece of paper was ſoon covered with precipitated iron. A couple of hours afterwards I took the paper again out of the veſſel, and beſmeared it with ſome muriatic acid, when, to my great ſurpriſe, I ſaw it immediately covered with the moſt beautiful Pruſſian blue. (B) The ſame experiment was repeated with lixivium ſanguinis, ſuperſaturated with vitriolic acid. This mixture was put into a glaſs veſſel, and the piece of paper treated as in the laſt mentioned experiment. (A) I here likewiſe obſerved, that the air was filled with the colouring matter; for the piece of paper became blue on applying muriatic acid to it. (C) Though acids expel this matter from alkali, a conſiderable quantity of it nevertheleſs remains in the lixivium ſanguinis ſuperſaturated with acids; for the ſame mixture, removed into another veſſel, imparts to the air the colouring quality, and that repeatedly, according to the quantity of air. (D) When I applied upon the pieces of paper a ſolution of perfectly dephlogiſticated calx of iron, inſtead of a ſolution of vitriol, no Pruſſian blue was formed; but the muriatic acid diſſolved the calx entirely. This agrees with what is ſaid in (§ II. D).

§ IV.

§ IV.

Being now aware that acids really attract the alkali more ſtrongly than the colouring matter does, I wiſhed to know what effect would be produced by diſtillation. (A) I therefore poured lixivium ſanguinis, ſuperſaturated with vitriolic acid, into a glaſs retort, luted on a receiver cloſely, and diſtilled by a gentle fire. When about one-third of the maſs had paſſed over, I changed (B) the receiver, and diſtilled, till half of the remainder went over. (C) The watery liquor, which came over firſt, had a peculiar ſmell and taſte. The air in the receiver was filled with the ſame colouring matter as the glaſs veſſels (§ III.) had been; paper tinged with lacmus was turned red by this liquor; but, upon diſcovering afterwards, by means of the ſolution of terra ponderoſa, ſome vitriolic acid in it, I perceived that I could not depend upon this phænomenon for any concluſion. I mixed with one part of this water a little phlogiſticated calx of iron, or what comes to the ſame thing, a little precipitate from vitriolated iron; and a ſhort time afterwards I added ſome drops of vitriolic acid to it, by which I obtained a fine Pruſſian blue. (D) Part of this water being expoſed for ſome hours to the open air, entirely loſt its colouring quality. (E) The water obtained by the fecond diftillation (B) produced the fame effects as pure water mixed with a little vitriolic acid.

§ V.

When I had thus difcovered the poffibility of obtaining the colouring matter in its greateft purity, I proceeded to make fome experiments, in order to obtain it feparate from the blue itfelf; and this with a view partly to procure a larger quantity of it than the lixivium yields; partly alfo to avoid the troublefome calcination of the blood, and preparation of the lixivium. This matter, though it may be feparated from the Pruffian blue by diftillation, yet it is thus mixed with fo many heterogeneous particles, that it would not ferve my purpofe. On examining feveral forts of Berlin blue, I found in them marks of fulphur, volatile alkali, vitriolic acid, and volatile fulphureous acid, which fubftances are found as well in the lixivium fanguinis as in the lixivium of foot, and adhere to the precipitate in the preparation of Pruffian blue. On diftilling one fort of this preparation, I obtained in the receiver a liquid, which had a fmell of fpiritus cornu cervi, precipitated vitriolated iron, and, on the addition of an acid, was changed into Pruffian blue. In the neck

neck of the retort there was a ſublimate, which proved to be a kind of neutral ſalt, conſiſting of volatile alkali and volatile ſulphureous acid; the air in the receiver was full of aerial acid, volatile alkali, and the colouring matter. The remainder in the retort was black, obedient to the load-ſtone and yielded hepatic air with acids. Being unable by theſe means to attain my purpoſe, I reſolved to examine a little more cloſely a neutral ſalt known in chemiſtry, which is formed when lixivium tartari is boiled with a ſufficient quantity of Pruſſian blue. This ſalt conſiſts of the colouring matter of the lixivium, of calx of iron, and of alkali, and is eſpecially made uſe of for diſcovering iron in mineral waters; but is not entirely to be depended upon for this purpoſe, as long as chemiſtry is unable to free it perfectly from iron; and this cannot be effected without decompoſing this ſalt, of which the iron is conſtantly a conſtituent part, and is the medium by which the colouring matter is attached to the alkali (§ 11. c). The lixivium ſanguinis is more to be depended upon for this purpoſe, though it likewiſe, as well as the lixivium of ſoot, ſhews marks of the preſence of iron. Though I have mentioned (§ 1.), that on ſuperſaturating lixivium ſanguinis with an acid, and then adding vitriolic acid, no ſign of Pruſſian blue is perceived; but as blood and ſoot contain a little iron, there is no reaſon to be ſurpriſed that lixivium ſanguinis ſhould contain iron; whence it happens, that, in ſuch caſes, there may really appear ſome mark of Pruſſian blue, and this the more readily, if the calcined maſs be boiled in an iron veſſel. But if the vitriol be firſt put into the lixivium, and then an acid be added to it, a great difference is found with regard to the quantity of Pruſſian blue obtained. If a perfectly pure lixivium ſanguinis be taken, ſuperſaturated with an acid, and vitriolated iron be added to it, not the leaſt mark of blue appears. Such a pure lixivium is not obtained in the common way, but on mixing the colouring matter in its pureſt ſtate (§ x.) with alkali of tartar.

§ VI.

To return to the above mentioned neutral ſalt, I diſſolved an ounce of it in a glaſs retort in four ounces of water, adding three drachms of concentrated vitriolic acid (other acids produce the ſame effect, but I prefer the vitriolic acid in this proceſs), and diſtilled this mixture into a luted receiver by a gentle fire. As ſoon as the maſs began to boil, it grew thick, from the production of a great quantity of of Pruſſian blue, which was ſeparated. I perceived at the ſame time a ſmell, which penetrated through the lute, and perfectly reſembled the ſmell of water impregnated with the colouring matter (§ IV. C). I continued the diſtillation, till an ounce had paſſed over into the receiver, and then poured the water containing the colouring matter into a phial. The air in the receiver had likewiſe abſorbed this colouring matter, which I detected as in § III. A. The blue maſs remaining in the retort I put upon a ſtrainer, and into the liquid, which paſſed through, I put a piece of vitriolated iron, in order to ſee whether there was ſtill remaining any of the neutral ſalt undecompoſed. But no Pruſſian blue was produced, and thus the ſalt was decompoſed during the boiling. The blue which now remained on the filter, and was free from the neutral ſalt, I again boiled with lixivium tartari; the ſolution was freed by filtration from its ochre of iron, and the maſs was then diſtilled a ſecond time, with the addition of vitriolic acid in exceſs. It now ſhewed the ſame phænomena as at firſt; for as ſoon as it began to boil, Pruſſian blue was again ſeparated, though in leſs quantity, and the colouring matter came over into the receiver. After one-third of the maſs had paſſed over, I added it to that obtained ed by the firſt diſtillation, and then ſeparated the regenerated Pruſſian blue from its acid, which I again extracted by lixivium tartari, and then diſtilled it the third time. Here I again obtained ſome blue, and it thus evidently appears, that, by repeated extractions and diſtillations, all Pruſſian blue might at laſt be entirely decompoſed.

It is not difficult to account for the ſeries of phænomena that occurred in this whole proceſs. The neutral ſalt conſiſts of alkali, a little iron, and the colouring matter; it is therefore a triple ſalt. Now, when an acid is added to this ſalt, the colouring matter, in conſequence of the ſtronger attraction of acids for alkalis, muſt be expelled, which immediately, on account of its volatility, goes over into the receiver during the diſtillation. But as the acids are not capable of expelling this colouring matter from the iron, the calx of iron will contain as much as is requiſite for its ſaturation, or, what comes to the ſame, as much as is requiſite for the production of Pruſſian blue; and this is the part which ſeparates from the ſalt during the diſtillation. If Berlin blue be extracted by lime or terra ponderoſa, theſe extracts ſhew the ſame phænomena during diſtillation with vitriolic acid.

§ VII.

§ VII.

If Pruſſian blue be extracted by volatile alkali, a compound ariſes, which likewiſe conſtitutes a kind of triple neutral ſalt, conſiſting of volatile alkali, iron, and the colouring matter. With vitriolic acid it ſhews the ſame phænomena as the ſalt of § VI. If this neutral ſalt be diſtilled by itſelf, after having been diſſolved in water, the ſolution grows thick, in conſequence of the ſeparation of Berlin blue, and a volatile alkaline liquor goes over into the receiver. If the diſtillation be continued till but little liquid remains with the Berlin blue in the retort, no more ſalt will be found in the retort, but all will have gone over into the receiver. The liquor in the receiver conſiſts of volatile alkali and the colouring matter. It is not precipitated by lime-water; but vitriolated iron is decompoſed by it, and, on adding an acid, Pruſſian blue is generated. If a piece of paper dipped into a ſolution of vitriolated iron be ſuſpended in the receiver, this ſolution is ſoon decompoſed, the air of the receiver being impregnated with volatile alkali. If afterwards the ſame paper be pencilled over with muriatic acid, it grows blue. If the whole liquor of the recei-

ver

ver be expoſed to the open air, it all evaporates, leaving behind pure water.

§ VIII.

Among ſeveral other fruitleſs attempts to ſeparate this colouring matter from the Pruſſian blue in a more commodious way, I found that calcined quickſilver afforded an excellent medium for accompliſhing this purpoſe. I obſerved, that mercurius dulcis grew black in air impregnated with this colouring matter. The ſame thing likewiſe happened if it was put into the tinging water (§ IV. c); and this water thence acquired an acid quickſilver taſte. Hence it was probable that this matter had united with the ſublimate in the mercurius dulcis, or at leaſt with the calx, which is its baſis, and expelled the muriatic acid, which would give riſe to the acid taſte; and as quickſilver, in its metallic ſtate, is not ſoluble in muriatic acid, it muſt therefore ſeparate from it; and this is the cauſe of its black colour. I therefore boiled the liquor with corroſive ſublimate, and the mixture hardly began to boil, when the blue colour had already diſappeared. I then boiled calcined mercury or red precipitate with Pruſſian blue and water. The colour diſappeared entirely, and the filtered ſolution had a ſtrong taſte of quickſilver; it contained

no

no iron, and, what is remarkable, it could not be precipitated either by acids, lime, or alkalis; but, by a long digeſtion with metals, the mercury was reduced to its metallic ſtate, by means of a double elective attraction. If the union of the colouring matter with metals be prevented, it becomes free and uncombined, and may be eaſily ſeparated by diſtillation. This may be effected by means of an acid. After different trials, I found the following method the beſt.

§ IX.

To two ounces of powdered Pruſſian blue, and one ounce of calx of quickſilver, prepared by means of nitrous acid, I added ſix ounces of water in a cucurbit; I boiled this maſs for ſome minutes with conſtant agitation, when it aſſumed a yellowiſh grey colour. I then poured it out on a filter, and upon what remained in the filter I poured a couple of ounces of hot water, in order to elixiviate the whole thoroughly. The ſtrained mercurial ſolution was then poured upon an ounce and a half of iron-filings, free from ruſt, and contained in a glaſs veſſel, there being added three drachms of concentrated vitriolic acid. The whole maſs was well agitated, during which, in a few minutes, it was turned quite black by the reduced quickſilver,

quickſilver, and thereby completely loſt its quickſilver taſte. It, at the ſame time, acquired the peculiar ſmell of the colouring matter. I left the mixture a few minutes at reſt; then poured off the clear liquor into a retort; and diſtilled the fourth part of it off into a well luted receiver. Here I obtained the ſame colouring matter as from the neutral ſalt (§ VI.). It is ſufficient to diſtil off one-fourth; for this matter is much more volatile than water, and goes over firſt.

§ X.

A ſlight veſtige of vitriol eaſily appears in this (§ IX.), as well as in the preceding diſtillation of the neutral ſalt (§ VI.). This little vitriolic taint muſt conſequently be likewiſe ſeparated from the colouring matter. I have remarked (§ I.), that aerial acid is capable of diſlodging this matter from alkali and lixivium ſanguinis. The ſame thing happens if this matter be combined with lime. It is therefore not difficult to ſeparate the vitriolic acid from it. I mixed a little pounded chalk with the diſtilled water impregnated with this matter, and diſtilled the maſs a ſecond time by a gentle fire. The vitriolic acid united during this proceſs with the chalk, and the colouring matter went over in its greateſt purity. In order to hinder, as much

much as poſſible, the eſcape of this volatile matter through the lute, and in order to prevent the air in the receiver from abſorbing too much of it, I make uſe of a ſmall receiver, pouring a little diſtilled water into it, and place it ſo that the greateſt part of the receiver, during the operation, ſhall be immerſed in cold water. This matter has a peculiar, but not diſagreeable ſmell, a taſte ſomewhat approaching to ſweet, and warm in the mouth, at the ſame time exciting cough. Of its nature and conſtituent parts, as likewiſe of its action upon other ſubſtances, I ſhall ſpeak in the ſecond part of this diſſertation.

ESSAY XXI.

ON THE INFLAMMABLE PRINCIPLE IN CRUDE CALCAREOUS EARTH *.

YOU entreat me, my worthy friend, to communicate to you my thoughts on Dr Weber's publication, entitled, *The Nature and Properties of Lime and Cauſtic Subſtances newly diſcovered.* I cannot but wonder, that the controverſy concerning fixed air and the *acidum pingue* ſhould not yet have ceaſed with you: That this acid is a mere chimæra, is acknowledged both by Dr Weber, and, I believe, by all chemiſts: But it would appear that the Doctor wiſhes, by his phlogiſton, to ſupplant fixed air, as this has ſupplanted the *acidum pingue*. Whoever is deſirous of attempting ſatisfactorily to prove any opinion in chemiſtry, ought to be thoroughly acquainted with the bodies with which he makes his experiments, and on which he reſts his proofs: But, when this knowledge is wanting, how eaſily may wrong concluſions be drawn! I do not indeed by

* This is a letter from Mr Scheele to Mr Meyer of Stettin. The original was publiſhed in CRELL's *Neueſten Entdeckungen*, Th. 1. p. 30. &c.

by any means flatter myſelf that we are acquainted ſo completely as could be wiſhed with the conſtituent parts of all bodies, but ſo much is certain, that all oily compounds, derived from the animal and vegetable kingdoms, yield, when they are entirely deſtroyed, an inflammable principle, a mild acid in an elaſtic form, or the true aerial acid (to which the author aſſigns the old appellation, fixed air), more or leſs, or no humidity; as alſo, more or leſs, or no earth. Could Dr Weber decompound pure fixed air, and ſhew demonſtrably, that phlogiſton actually is one of its conſtituent parts, his opinion would acquire much weight. Were this effected (which it can never be by conjectures), it will next be aſked, What is the other principle contained in fixed air? The author's ſuppoſition, that it is the electrical fluid, is a mere hypotheſis, juſt as much as if I were to ſuppoſe that it is ſome acid of a ſtronger nature. The author can by no means eſtabliſh his opinion concerning the preſence of phlogiſton in fixed air, by ſaying that the vapours of fixed air, extricated from chalk by muriatic acid, have a ſmell; fixed air ſeparated from magneſia alba by vitriolic acid is inodorous, and the ſame fluid expelled from *lapis ſuillus* by muriatic acid has a ſtinking ſmell; and yet both theſe

ſpecies

ſpecies of air coincide entirely with reſpect to their principal qualities. Dr Black's experiments are ſo ſolid and convincing, that it ſeems to me impoſſible to form any objection againſt them. He has, indeed, puſhed his concluſion rather too far in ſaying, that the exploſion of fulminating gold, and the increaſe of weight in metallic calces, prepared by heat, are owing to fixed air; but the chief diſcovery does not ſuffer from theſe miſtakes *. Dr Weber cannot maintain, upon the authority of his firſt and ſecond experiments, that crude calcareous earth contains phlogiſton as a conſtituent part; for, in the *firſt* place, that which appears, is to be deduced from a ſmall reſiduum of decaying mineral ſubſtances; and, in the *ſecond*, ſaltpetre can be alkaliſed, by being kept long in a red-heat, provided ſome body be mixed with it to prevent its fuſion. Neither will his opinion, that, in the diſtillation of crude calcareous earth (experiment 3.), the phlogiſton it contains paſſes over along with the moiſture, and precipitates the lime-water in the receiver, eaſily find admittance. Will any

* It is but juſtice to this great philoſopher, whoſe lectures not only teach the principles of a ſcience, and the operations of an art, but contain likewiſe a ſyſtem of practical logic, that he never contended ſtrenuouſly for theſe conjectures, and that he has long abandoned them. T.

reflecting chemist readily suffer himself to be persuaded that pure phlogiston parts from a body, without at the same time being in immediate contact with another body, for which it has a stronger attraction. We cannot shew that water has the smallest disposition to attract phlogiston, considered in a state of purity; and we find in general, that acids must be employed as the means of effecting such an union. The theory of Dr Black explains this precipitation so clearly, that nothing can be objected to it. When the author allows the lime-water to remain in the receiver to the end of the process, while there is at the same time an excess of chalk in the retort, he finds that the lime-water redissolves the regenerated calcareous earth. Now, if we assume with him that phlogiston in excess can dissolve even crude calcareous earth in water, his phlogiston must either be an acid or not an acid; in either case a few drops of nitrous acid must precipitate the solution, (he must grant this, as, according to his first experiment, nitrous acid is capable of attracting it from lime in the fire); but no such thing happens. I have scarce any inclination to advert to the 4th experiment, as it contradicts all experience. The fixed air, expelled by nitrous acid from a quarter of a pound of calcareous earth, does not

precipitate

precipitate more than a quart of lime-water. In the fifth experiment, the author precipitates lime-water with an alkaline ſpirit obtained from horns; but finds that the earth, after it has been dried, is lighter than the lime employed. It cannot be unknown to the author, that the fixed air, ſeparated from the alkaline ſpirit during the precipitation (for expreſs mention is made of an effervescence), has the properties of an acid, and can therefore diſſolve part of the lime. The lime diſſolved in this manner will not fall down, until a good quantity of alkaline ſpirit is added; and why is ſo much required? becauſe it is the cauſtic part only of this ſpirit which effects a precipitation, as it has a ſtronger attraction for the ſuperfluous fixed air, which holds the earth in ſolution. His ſuppoſed reciprocal attraction has no place here. Alkaline ſpirit, obtained from horns and hoofs, ſhould never be uſed in exact chemical experiments. That from common ſal ammoniac is the beſt for theſe purpoſes; and this is the reaſon why the author, after he had ſaturated the ſpirit from hoofs with muriatic acid, and diſtilled the ammoniacal ſalt with ſpirit of vitriol, obtained at the laſt a volatile ſpirit in the receiver, which effervesced with acids. Had the author diſtilled pure but common ſal ammoniac with oil of vitriol, his volatile ſpirit would certainly not have effervefced with acids: But why did the ſpirit obtained by the author effervefce? becauſe it contained ſome oily matter, which was deſtroyed by the vitriolic acid on the application of the heat; as, during the decompoſition of oil, fixed air is always ſeparated (let any one diſtil oil of vitriol with a little fat, he will eaſily diſcover fixed air in the receiver); and as it combines with the ſpirit driven over into the receiver, the ſpirit muſt of courſe effervefce with acids. That the vitriolic acid ſhould remain in the retort, is owing to its fixity, a property which it has in common with other known acids, which are more or leſs fixed as the phoſphoric and arſenical acids, and ſedative ſalt. The author certainly does not know, that a quantity of fixed air is ſeparated from coal during its combuſtion, as being one of its conſtituent parts, otherwiſe he never would have related his 6th experiment. As the atmoſphere always contains ſome uncombined fixed air, what wonder that quicklime ſhould return in time to crude calcareous earth? Putrid vapours contain a far greater quantity of this fixed air, conſequently we know that phlogiſton muſt be combined in the air with ſome ſubſtance; for were it uncombined, ſo that it could

could unite with lime (I very much queſtion, however, whether phlogiſton can unite with pure lime), it would much ſooner combine with pure air, for which it has a very ſtrong attraction: But we know, that in this caſe the air becomes unfit for reſpiration, and therefore the earth muſt have long ſince loſt its inhabitants. He thinks that the 10th experiment is ſo clear and convincing, that no doubt can remain reſpecting his new doctrine. But had he been better acquainted with oils, he would not have looked on his experiment as incontrovertible; for as the vitriolic acid in ſulphur fixes the phlogiſton, even ſo does the fixed air in oils fix the ſame principle. As, when we mix lime with ſulphur, phoſphorus, or regulus of arſenic, and afterwards ſeparate thoſe inflammable bodies from the lime by burning, and obtain in the firſt gypſum, in the ſecond animal earth, and in the third lime combined with arſenic: So alſo muſt lime, when linſeed oil is burned with it, exhibit a combination of lime and fixed air. With reſpect to the 13th experiment, I can aſſure the author, that iron, diſſolved in vitriolic acid, yields but very little fixed air; the air is moſtly inflammable. The author muſt not then compare this with that air which is extricated from chalk by acids;

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for the inflammable air is formed during the solution of the metal in vitriolic or marine acid; but fixed air is present beforehand in chalk. That the air which is expired from the lungs carries along with it fixed air, is absolutely certain, on which account lime-water is precipitated by this air. Fixed air is actually a constituent part of the atmosphere; and the more exactly the phlogiston combined with it is separated from it, the more pure air must make its appearance. Fixed air is also present in putrefying water. That the earth in lime-water is restored to its crude state by phlogiston, the author can neither persuade me nor any intelligent chemist. Had the author examined a little less carelessly the precipitate which appears on pouring lime-water into human urine, he never would have pronounced it to be calcareous earth, as in experiment 19. I can assure him that this precipitate does not effervesce with any acid, but is animal earth, precipitated by the phosphoric acid in urine. The same may be said of the 20th experiment, which the author made very unnecessarily. No exact chemical experiments should be made with the volatile alkali from putrid bodies. Other chemists, as well as myself, have obtained by sublimation good sal ammoniac, from volatile alkali separated from

from ſal ammoniac by lime, and afterwards ſaturated with muriatic acid. Neither is the fixed nor volatile alkali in neutral ſalts cauſtic; neither is the lime contained in *fixed ammoniac*, as it is called. Theſe ſubſtances are cauſtic only, in conſequence of being combined with a conſiderable portion of the matter of heat, which ſeparates as ſoon as an acid is poured on them, the acid having a ſtronger attraction for the bodies than heat. I need not touch upon the 25th experiment. When the lime does not ſlake, it can only make the ley a little cauſtic; for, in the laſt caſe, or when the ley is to be thoroughly cauſtic, it muſt touch the corroſive ſublimate in all poſſible points. As the matter of heat conſiſts of phlogiſton and pure air, while metallic calces, prepared by heat, contain much heat, which muſt be heavier than phlogiſton alone, what wonder that a metallic calx ſhould be heavier than the perfect metal? Such a calx does not, as Dr Black ſuppoſes, contain fixed air. When it is reduced by means of charcoal, the fixed air is to be deduced from the charcoal, and not from the metallic calx. As long as the author conſiders fixed air as phlogiſton and æther, he will eaſily be able to explain, why dry volatile alkali, abſtracted from a metallic calx, becomes cauſtic. But a prudent chemiſt

chemiſt will not ſo lightly yield his aſſent, much leſs will he reaſon ſo much at random; for, in this caſe, we have a double attraction, the fixed air, which is united with the volatile ſalt, and conſtitutes with it a kind of ſal ammoniac, ſince it is a ſpecies of acid—the fixed air, I ſay, uniting with the metallic calx, as at other times it does with lime, and the matter of heat in the calx joining the alkali. In experiment 31. the author diſtilled ſal ammoniac, prepared with volatile ſpirit of urine and oil of vitriol, and he obtained an alkaline ſpirit, which efferveſced with acids. I have repeated the experiment, with this difference, that I uſed ſpirit of ſal ammoniac, and not oily ſpirit of urine for ſaturating the vitriolic acid. My Glauber's ammoniac melted during the diſtillation, and I obtained cauſtic volatile alkali, which neither rendered lime-water turbid, nor efferveſced with acids. The reſiduum in the retort was vitriolic acid; ſome of the ammoniac was alſo ſublimed. The 40th experiment, too, proves nothing. He burns terra foliata tartari, or acetated vegetable alkali, and obtains a ſalt which efferveſces with acids. The injudicious and uninſtructed may indeed be eaſily led into miſtakes by ſuch experiments as this. He ſhould know that there are oily particles in vinegar, and that, if they were

away,

away, it would be no vinegar at all. Theſe oily particles, an eſſential part in all vegetable acids, are deſtroyed by the heat; upon which the fixed air, the other conſtituent part of this oil, and indeſtructible in the fire, combines with the alkali; and what wonder that this elaſtic acid ſhould be expelled by a ſtronger? Experiment 34. is very eaſy to be explained; (for if the author's aſſertions were admitted, calx of iron would have a ſtronger attraction for phlogiſton than nitrous acid). Alkalis, as well as nitre, when they are mixed with metals, or metallic calces, in order to prevent their fuſion, loſe their acids on a long continued calcination, and immediately afterwards the matter of heat unites with the alkalis, which is the only cauſe of their cauſticity.

Lead is a metal which contains very little phlogiſton; for I have obſerved ſcarce any ſenſible mark of liver of ſulphur upon ſtratifying it with vitriolated tartar in a cloſe crucible. Should vegetable alkali have reduced any calx of lead, this might have ariſen from the glue that the ley carried along with it, on being filtered through bibulous paper, or perhaps from ſome impurity adhering to the alkali or minium. Why is not a ſolution of lead reduced by alkali in the humid way? Experiments 42. and 43. have turned out very

very differently, when made by all other chemiſts, even by the late Mr Meyer himſelf, as well as by me; for cauſtic fixed alkali always precipitates a ſolution of calcareous earth in a cauſtic ſtate. The author here did not pay attention enough. Experiments 44. 45. and 46. are alſo inſignificant. According to the 47th, aſhes adhering to red-hot coals ſhould have loſt their phlogiſton. But, if ſo, Why do they effervefce with acids? For, according to the hypotheſis, the earths effervefce, becauſe they contain phlogiſton. P. 137. and 145. the author mentions ſome phænomena, which, in his opinion, cannot be explained at all; as, for inſtance, that alkali does not totally precipitate vitriol; that vitriolated tartar does not entirely precipitate the ſolution of quickſilver; as alſo, that the mother ley of common ſalt cannot be completely precipitated by alkaline ſpirit. But an intelligent chemiſt, accuſtomed to experiment, finds no difficulty in aſſigning the cauſes of phænomena, to the author ſo incomprehenſible; but as they do not belong to the preſent ſubject, I paſs them over.

Theſe obſervations will, I hope, my very worthy friend, convince you, that the doctrine of Black is not only applicable to all the experiments, but that it will maintain its ground in the principal points, and

and is confequently true. Refer to the author's analyfis of fea falt, and you will find (p. 160.) that Glauber's falt, together with the lime diffolved by marine acid, are to be feparated by cryftallifation. In like manner, he fuppofes, (p. 167.), that Epfom falt and Glauber's falt are contained in the mother ley, together with calcareous earth, diffolved by marine acid. He fpeaks, too, of thefe falts at p. 175. Now, it has been known fince the time of Neumann, that vitriolic acid, and the neutral falts into which it enters, feparate calcareous earth from the muriatic as well as other acids.

ESSAY XXII.

Some incidental Remarks on the Affinity of Bodies *.

THE few following obfervations on Mr Wenzel's doctrine of the affinity of bodies, are not made with a view to detract from his merit, but to fhow both my attention to his valuable book, and how neceffary it is to repeat the experiments of others, when they do not coincide with the principles of chemiftry.

Page 9. That metals diffolved in acids are unchanged, and remain juft in their former ftate, is contrary to all experience in chemiftry; which fhews, that they lofe their inflammable principle during folution.

P. 14. The pofition, that falts do not act, unlefs in folution, fails in many cafes. When

* The name of the excellent Mr Scheele, a German, and at prefent fettled as an apothecary at Koping, in Sweden, will ferve as a fufficient recommendation to all his productions. The prefent remarks, though they have a reference only to Mr Wenzel's *Doctrine of the Affinity of Bodies*, bear, like all his other works, the ftamp of acutenefs and truth; and as they are delivered with proper candour, they rather do honour to Mr Wenzel, to whofe merits I here fubfcribe my teftimony. Crell. *Chem. Journ.* th. 4.

When powdered chalk, for inſtance, is boiled with Pruſſian blue, reduced likewiſe to powder, the former attracts the colouring matter of the latter, and yet chalk is inſoluble in water.

P. 40. Mr Wenzel does not explain the decompoſition of vitriolated tartar right. For, if the fixed alkalis had not the property of combining with vitriolic acid in exceſs, the nitrous and marine acids would neither change vitriolated tartar nor Glauber's ſalt into acid neutral ſalts, and therefore one ſhould never be able to pour off the vitriolic acid from the cryſtals of nitre ; but it is always combined with fixed alkali, and cannot be ſeparated by any nitrous acid.

P. 41. I have great difficulty in believing, that cauſtic volatile alkali precipitates the ſolutions of lime and lead. Spirit of ſal ammoniac is always obtained when that ſalt is diſtilled with chalk and water. Simple experiments give ſufficient teſtimony in this caſe.

P. 54. Both alkaline ſalts have not an equal affinity for vitriolic acid. Pour oil of tartar, *per deliquium*, into a ſolution of Glauber's ſalt, and vitriolated tartar, will fall to the bottom in the courſe of a few minutes.

P. 72. and 73. The inflammable air of the zinc and iron ſhould have been taken into the account in the weighing.

P. 81. This earth of alum can ſcarce be without vitriolic acid; for we know, that a part of this acid is very difficult to be ſeparated from it; and, on this account, it could not attract any fixed air. Were the author to diſſolve his earth in diſtilled vinegar, and then to add a few drops of a ſolution of terra ponderoſa, the vitriolic acid would immediately ſhew itſelf.

P. 95. If coals conſiſt of phlogiſton and a little earth, where does the quantity of fixed air, which makes its appearance during their decompoſition, reſide? This muſt contribute very much to their weight.

P. 133. The ſolution of magneſia becomes a little turbid on the addition of cauſtic volatile alkali. How, indeed, ſhould it be otherwiſe? Since there is formed a triple ſalt, conſiſting of the earth, the vitriolic acid, and the volatile alkali; and ſince as much of the earth muſt be diſengaged as the acid attracts of the alkali. If ſome Glauber's ammoniac be firſt added to the ſolution of magneſia, no precipitate will be occaſioned by the cauſtic alkali.

P. 135. In my experiments, iron has never been precipitated, in its metallic form, from its ſolution in muriatic acid by zinc.

P. 149. The calx precipitated from the butter of antimony by oyſter-ſhells, is not a pure precipitate; but, according to my experiments, ſtill contains ſome muriatic acid. I could not accompliſh the dulcification of muriatic acid in the way mentioned by the author.

P. 155. If much nitrous acid be taken for the ſolution of quickſilver, and the whole be boiled together, the quickſilver is completely calcined, and then it affords a white precipitate, on addition of ſpirit of ſal ammoniac. The quickſilver in corroſive ſublimate is in a calcined ſtate; the black matter is nothing but exceedingly fine revivified mercury.

P. 177. It is ſaid, that platina is not precipitated by mineral alkali; but although many agree in this opinion with the author, a precipitation does actually take place.

P. 248. As the neutral ſalt, conſiſting of lemon juice and fixed alkali, is capable of diſſolving iron, it is no wonder that alkali does not cauſe a precipitation. The ſame thing has been obſerved by the author (p. 303.) concerning the ſolution of iron in tartar, and the reaſon is the ſame.

P. 273.

P. 273. The want of fixed air is ſaid to be the cauſe why acetated lead, prepared from minium, does not cryſtalliſe; but it is totally different. The author has not mentioned, that his ſolution, after he had introduced fixed air to it by means of his apparatus, became white, though this was really the caſe. This white matter in the ſolution of lead is nothing but calx of lead ſaturated with fixed air; that is to ſay, real white lead. If this ſuperfluous calx is ſeparated from the ſolution, the compound of lead and vinegar will immediately cryſtalliſe; and this may be effected by the addition of gum Arabic, or by adding more vinegar, in order to diſſolve the abundant calx of lead. Fixed air is ſeldom neceſſary to bring the difficultly cryſtalliſable ſalt to ſhoot. Too much is attributed to this mild acid; and I cannot agree with the author in thinking that the exploſion of gold is owing to it.

P. 286. It would be difficult to ſhew, that all the fixed air obtained by Mr Lavoiſier came from the minium. Part, indeed, does; but as we know that charcoal conſiſts of phlogiſton and aerial acid or fixed air, to abide by the author's appellation, I aſk, What becomes of that fixed air, which thoſe particles of the

 charcoal

charcoal that part with their phlogiſton to the lead, yield? Recent minium gives out much fixed air when it is diſtilled with charcoal.

P. 193. When ſpeaking of tartar, Mr W. mentions an inflammable earth, which is ſeparated on ſaturating tartar with alkali. But the tartar contains ſome calcareous earth, which, with the acid of tartar, conſtitutes a ſalt very difficult of ſolution; on which account, it falls to the bottom. Acid of tartar contains much oily matter, wherefore a compound of that acid and lime muſt burn.

P. 297. We obtain cauſtic alkali, and not a neutral ſalt, as the author affirms; for the latter is obtained only when chalk is boiled with tartar; in which caſe, it is not ſurpriſing that the cauſtic alkali ſhould chryſtalliſe on the addition of an acid.

P. 366. It is ſaid that fixed air is the cauſe of the cryſtalliſation of the neutral ſalt prepared from nitre and arſenic; and as Mr W. could not have been acquainted with arſenic and its conſtituent parts, he is not to be blamed for entertaining ſuch an opinion.

P. 379. The fixing of arſenic by cauſtic ſpirit of ſal ammoniac is truly remarkable. But it is certain, that cauſtic volatile alkali always contains ſome lime. It appears,

appears, when it is kept long in glaſſes that are frequently opened, in the form of a hard pellicle depoſited on the glaſs. Is it not this lime which adheres to the arſenic, and fixes it? If not, and the experiment be exact, the problem is one of the moſt difficult in chemiſtry.

P. 404. It is ſaid that volatile alkali eaſily diſſolves precipitated magneſia; but the ſolution is entirely owing to the water in which alkali is diſſolved. The ſeparation of the earth, when the ſolution is expoſed to the open air, ariſes not from the evaporation of the volatile alkali, but from the eſcape of the aerial acid, which held the earth in ſolution in the water; for, from a pound of Epſom ſalt, diſſolved in 64 pounds of water, no precipitate can be obtained by pure potaſhes without boiling; but, when the air is driven off by boiling, the magneſia is obtained.

P. 423. "Fixed alkalis precipitate a ſo-"lution of ſilver prepared with volatile "alkali." How is that poſſible? It is indeed true that a precipitation takes place; but what a great quantity of fixed alkali muſt be added before all the ſilver is precipitated. With what does the alkali combine? It has no attraction for the volatile alkali; and, without a new combination, it is impoſſible to conceive a precipitation. Saturate pure ſalt of tartar with abſtracted vinegar, or even precipitated nitrous acid, and you will find that the ſolution of ſilver yields ſome precipitate. I have never met with alkali which did not ſhew ſome veſtiges of muriatic acid. When the author comes to examine the precipitate again, he will not fail to recogniſe it for luna cornea.

P. 472. Mr W. has no doubt of the preſence of a great quantity of fixed air in nitre. For my part, I entertain many doubts whether fixed air can be obtained from nitre, and ſtill more, from nitrous acid. I have already obſerved, that a great deal of fixed air is procured from charcoal diſtilled with recently prepared minium; and the ſame thing holds when the phlogiſton of the charcoal unites with the acid of the nitre. Why is no fixed air obtained when metals are deflagrated with nitre? In this caſe, *corrupted air* is obtained, which does not precipitate lime-water. Moreover, only one-ſixth part of the air obtained from gunpowder is fixed air; the reſt is corrupted air.

P. 480. Mr W. maintains, after Beaumé, that calcareous earth may be converted by a very violent fire into a vitriform earth; but in this point I can neither give credit to Mr Beaumé nor the author.

Letter

Letter from Mr SCHEELE *to Dr* CRELL.

I have often prepared the colouring neutral ſalt, contained in lixivium ſanguinis, in the following manner: I extract Pruſſian blue with thoroughly cauſtic fixed alkali. To the liquor containing the extract, after it has been filtered, I add highly rectified ſpirit of wine, upon which the ſalt falls in the form of flocculi to the bottom *. With reſpect to every other method for the purification of the lixivium (thoſe of Scopoli and Weſtrumb † not excepted), I am convinced that they are imperfect; for it is only neceſſary to boil a ſufficient length of time their yellow ſolution with vitriolic or muriatic acid, and Pruſſian blue will be ſeparated. My ſalt continues unaltered, even when expoſed to the open air; for the iron

 ſtrengthens

* Truth obliges me to mention, that three months before I received this letter, Mr Weſtrumb deſcribed the ſame experiment for purifying the lixivium ſanguinis. I can ſay nothing further to decide the priority of the diſcovery. CRELL.

For an account of Mr Weſtrumb's method, ſee the notes on Bergman's Diſſertation on Elective Attractions, p. 337. T.

† Mr Scheele means here the method propoſed by Mr Weſtrumb, in his *Eſſay on the Conſtituent Parts of the Blood, and the lixivium ſanguinis, (Crell's Neueſte Entdeck.)*, and not that alluded to in the laſt note. T.

ſtrengthens the connection between the colouring acid and the alkali, and fixes it ſo, that the aerial acid cannot expel it; which otherwiſe will happen in a few days, provided it be not combined with iron of ſome other metal in the colouring ley. I have not yet obſerved whether the *tinging acid*, for ſuch is the name which Profeſſor Bergman has beſtowed upon it, ſaturated with alkali or lime, will yield cryſtals? If you deſire to know this, the combinations and evaporations muſt be performed in cloſe veſſels.

On

*On the Cryſtalliſation of the Acid of Lemons**.

It has hitherto been a matter of doubt, whether the juice of lemons could be reduced to the form of cryſtals; for it appeared, from a great variety of experiments, that this juice, though evaporated to the conſiſtence of a ſyrup, would not ſhoot into cryſtals. I was led to make ſome trials upon this ſubject, which I have communicated to our Academy of Sciences, and which point out the method by which I at length accompliſhed my purpoſe. I conjectured at firſt, that the mucilaginous matter in the juice prevented its cryſtalliſation; on which account I mixed the inſpiſſated juice with ſtrong ſpirit of wine, and thus produced a coagulation of the whole. I then poured it out upon a filter, and evaporated the acid liquor which paſſed through; but it could not be made to ſhoot by theſe means.

I therefore concluded the great quantity of ſaponaceous matter, which the ſpirit holds in ſolution, is the impediment to cryſtalliſation. In order to ſeparate it, I employed the ſame method that is followed when the eſſential acid of tartar is to be obtained from cream of tartar. I ſaturated

* Crell's Chemiſche Annalen. Th. 7. ſ. 3.

turated the lemon-juice, as it was boiling in the cucurbit with pulverifed chalk, the weight of which was obferved ; the compound fell immediately to the bottom in the form of a middle falt, nearly refembling tartarifed lime. The water, at the bottom of which the precipitate lies, contains the faponaceous and mucilaginous matter, and the pure acid remains in combination with the calcareous earth. The precipitate is to be edulcorated with lukewarm water, till it appears colourlefs on being poured off. The compound agrees with gypfum, in being very fparingly foluble in water. There is next to be added to it a quantity of Englifh oil of vitriol, diluted with ten times its bulk of water, equal in weight to the chalk ufed for faturating the juice. This mixture is to be boiled in the cucurbit for a few minutes : When the whole has grown cold, the acid is to be feparated from the gypfum by means of the filter, and to be treated in the fame way as the acid of tartar. It is however neceffary to try, by evaporating the acid to the confiftence of a thin fyrup, whether it ftill contains any calcareous earth. This appears upon mixing a fmall quantity with oil of vitriol, as, in that cafe, there will be a precipitation of gypfum ; and it will be neceffary to add more oil of vitriol to the whole quantity of acid, as the

the preſence of a ſmall quantity of lime in ſolution totally prevents the cryſtalliſation. The cryſtals will ſhoot juſt as well in a hot temperature as in the cold; and ſhould there be any ſuperfluous vitriolic acid, it will be found in the reſiduum. This cryſtalliſed acid of lemons cannot be changed by the action of nitrous acid into acid of ſugar; but the ſaponaceous extract may be totally converted into that acid.

Diſcovery of a peculiar ſweet and volatile Matter, which is a conſtituent part of expreſſed Oils, and the Fat of Animals *.

Several years ago, upon diſſolving litharge in olive oil, I obſerved a peculiar ſweet matter, diſtinct from the oil floating on the ſurface, which, when inſpiſſated and treated with nitrous acid, appeared to be a modification of the acid of ſugar. I have ſince more particularly examined this peculiar phænomenon, and have diſcovered the ſweet matter, as well in linſeed oil, oil of almonds, and of rape-ſeed, as in oil of olives; and, ſtill more lately, both in hog's greaſe and butter. In my experiments, I made uſe of the following proceſs: One part of pulveriſed litharge was diſſolved in two parts of ſome one or other of the unctuous ſubſtances above mentioned, and ſome water, the mixture being made to boil all the time. As ſoon as it was inſpiſſated to the thickneſs of ſalve, the whole was left to cool, and then the water was poured off. The water is found to contain the ſweet matter in queſtion; and it is to be evaporated to the conſiſtence of ſyrup. If the oil or

* This is taken from the ſecond part of Crell's *Chemiſche Annalen*, p. 99.

or fat be freſh, there does not appear any ſign of diſſolved calx of lead, on addition of the vitriolic acid; but ſhould either the one or the other be old and rancid, ſome calx will then be diſſolved, and ſhould be precipitated by a proper quantity of vitriolic acid. If this inſpiſſated matter be ſtrongly heated, the vapours that ariſe will take fire on the application of a candle. In order to make it paſs over from the retort into the receiver, a degree of heat is requiſite, equal to that which muſt be employed for the diſtillation of vitriolic acid. Half of the ſweet matter goes over unaltered, in the form of a thick ſyrup, and ſtill retains its ſweet taſte; what riſes afterwards has an empyreumatic ſmell, and this is followed by an oil of a brown colour, which ſmells like ſpirit of tartar. There remains in the retort a light ſpongy coal, which does not contain the ſmalleſt particle of lead. This ſweet matter cannot be made to cryſtalliſe; nor, when mixed with water, and ſet in a warm place, does it run into fermentation; for, after the mixture had ſtood for four months, tincture of turnſol did not undergo the leaſt change when mixed with it. It will mix with tincture of cauſtic vegetable alkali; though neither ſimple ſyrup nor honey will do this; but they attract the alkaline ſalt from

from the ſpirit of wine, and then fall to the bottom, in the form of a thick mucilage. If nitrous acid be abſtracted from off this unctuous ſweet ſubſtance, it is at laſt, after many repetitions of the operation, converted into acid of ſugar, and the nitrous acid is very much phlogiſticated. It would ſeem to follow, from theſe experiments, that the ſweet matter in queſtion is combined with more of the principle of inflammability than ſugar and honey.

I have alſo boiled litharge with olive oil, ſeparated from ſoap by vitriolic acid, with the ſame reſult; for I here likewiſe obtained the ſweet matter. I likewiſe ſeparated the oil from the common ſalve (*Empl. Simp.* *); which muſt be done in conſequence of the laws of double attractions. Let the ſalve be ſliced and rubbed in a glaſs mortar, with a mixture conſiſting of eight parts of ſtrong ſpirit of wine, and one part of oil of vitriol. This white mixture is to be poured on a filter, and water is to be added to the liquor that

* The author means, undoubtedly, the *emplaſtrum commune* of the *Pharm. Suecica*, in which there is no ſalve with the denomination *ſimplex*. The *empl. comm.* is prepared from two parts of oil of olives, and one of litharge, which are boiled over a ſlow fire, with continual agitation, and the addition of a little boiling water now and then, till they combine. Pharm. Suec. 1779. p. 74. T.

that runs through, upon which the oil that was contained in the ſalve will be ſeparated. I wiſhed to recompoſe ſalve, by boiling this oil again with litharge; but it grew thick before it could be made to boil. From the water, which I took care to decant, I obtained ſome of the ſweet matter ſo often mentioned, though indeed but in very ſmall quantity.

Letter

Letter from Mr SCHEELE *to Dr* CRELL*.

It ſeems as if the opinion maintained by many chemiſts and philoſophers, that fixed air is a combination of pure or dephlogiſticated air, with a certain portion of phlogiſton, is not yet ſo completely proved. Many rather ſuppoſe, that the pure air muſt be further dephlogiſticated, in order to become aerial acid; and that, when it is totally free from phlogiſton, it conſtitutes nitrous acid. Pure air, fit for ſupporting of combuſtion, is a kind of ſulphur, conſiſting of phlogiſton and the matter of heat.——

In my Eſſay upon æther, I have related a great number of experiments made with manganeſe, ſpirit of wine, and acids. I have, at the ſame time, ſhewn, that acetous æther is never generated without the aſſiſtance of muriatic or nitrous acid.——

In your *New Diſcoveries*, (Part 8. p. 111.), there is an obſervation on my method of preparing the flowers of benzoin †. Lime-water

* Chemiſche Annalen. Th. 8 ſ. 123.

† This obſervation comes from Mr Gren of Bernburg, and is to the following purport:

Mr Scheele's method of preparing flowers of benzoin, by boiling the reſin in lime-water, and then precipitating them with vitriolic acid, is not without its difficulties, water is directed in the Swedish Pharmacopœia; but, in the original paper, (*Transactions of the Royal Academy*), I have mentioned milk of lime; for the particles of the lime not only dissolve the acid of benzoin, but prevent, in consequence of the boiling, the gum from adhering to it, which happens when alkaline salts are employed.

difficulties, since the precipitated acid of benzoin is mixed with the selenite that is produced, and it becomes necessary to separate it by boiling water; but the hot water that is requisite for this purpose, dissolves a considerable quantity of the selenite, by which the salt of benzoin is rendered impure. Mr Gottling has therefore proposed (*Almanack for Chemists*, 1782. *p.* 157.) to use vegetable alkali instead of lime-water; no great advantage will result from this change, as long as vitriolic acid is used for separating the salt of benzoin from the alkali, as the vitriolated tartar is difficult of solution in cold water; and therefore hot water must be used for the edulcoration of the salt of benzoin, which, at the same time, dissolves a considerable portion of it. If then the vegetable alkali is to be used for the extraction, it will be necessary to use some other acid for the separation, in order to form a salt, which cold water will carry off by solution, from the acid of benzoin. In order to extract this acid, I use mineral alkali. I boil sixteen parts of benzoin, with two or three of the alkali, adding a sufficient quantity of water: I then allow it to settle; repeat the boiling with fresh alkali and water; filter the solution while it is hot, and evaporate it till it becomes a little thick. After it has grown cool, I add vitriolic acid as long as any salt of benzoin is seen to precipitate. I separate this salt by means of the filter from the ley, which contains Glauber's salt, and edulcorate it with cold water. T.

I have by no means made ufe of the vitriolic acid for feparating the falt of benzoin, but have directed the muriatic acid for this purpofe; and in this manner are flowers of benzoin prepared here.

There does indeed (as Mr Gren afterwards obferves) take place, a feparation of mineral alkali, when Glauber's falt is boiled with unflaked lime. We obtain, however, but a very fmall quantity of cauftic alkali; for the greater part of the Glauber's falt fhoots again into cryftals. If they be again boiled, fome alkali will indeed be obtained, and fo on continually; but, With what immenfe trouble is this mode of proceeding attended?

Concerning what Mr Hermbftaedt has faid (*Part* 9. *p.* 66.) on the fubject of lapis infernalis, it may be remarked, that the dark colour of this cauftic arifes from copper; for even the fineft filver-leaf contains copper, which is diffolved at the fame time; but, in the melting heat, the copper lofes its folvent fooner than the filver, and being then in the ftate of a calx, it acquires its natural dark colour; and for this reafon it is that lapis infernalis is commonly black. If it be diffolved in water, a black powder will remain behind, which is nothing but calx of copper.

Letter

*Letter from the Same to the Same**.

I believe that the volatile ſweet matter contained in various oily and fat ſubſtances (p. 364.), may be totally deſtroyed by repeated diſtillations. I have at leaſt obtained, after every rectification, a product reſembling ſpirit of tartar, and the ſweet ſubſtance became every time more acrid and bitter. The ſtrong heat, which is neceſſary in order to drive over, is the cauſe of this deſtruction.——

Mr Kirwan's experiments, which are adduced to prove that the aerial acid conſiſts of phlogiſton and pure air, ſeem liable to ſome objections, as long as iron-filings are uſed for the revivification of red precipitate, and a burning-glaſs for the calcination of iron in pure air; for iron commonly contains ſome aerial acid, as it is more or leſs mixed with plumbago, and as this mineral conſiſts of phlogiſton and aerial acid †. If theſe experiments

 were

* Chemiſche Annalen. St. 10. p. 328.

† Mr Cavendiſh has likewiſe made the ſame obſervation on this experiment; and Mr Kirwan, when he came to repeat the experiment himſelf, for it was not originally his, as Mr Scheele ſeems to ſuppoſe, but Dr Prieſtley's, found, upon diſtilling recent and clean iron-filings with red precipitate, or precipitate *per ſe*, in the proportion

were repeated with copper, they would be more convincing ; but the filings of copper muſt be free from duſt, and all other impurities.

ESSAY

proportion of two to one, that no aerial acid, nor any other air is produced, but the whole unites with the iron which is calcined, while the mercury paſſes over. (Journal de Phyſ. Août 1785, p. 146.)

Upon this Dr Metherie obſerves, that the appearance of air depends on the quantity of precipitate and iron-filings employed. I have diſtilled, ſays he, equal quantities of theſe ſubſtances in a mercurial apparatus ; and a little air has appeared, which might probably have been that contained in the veſſels ; it was however more impure than atmoſpheric air. The mercury was revivified, and aroſe into the neck of the retort. There was neither any extrication nor abſorption of air, and the neck of the retort was covered with a conſiderable quantity of moiſture ; the filings were calcined, and lime-water introduced into the retort, was precipitated. On repeating the experiment, with two ounces of precipitate, and 72 grains of filings, a quantity of air was extricated, which contained a little aerial acid, but conſiſted chiefly of pure air. T.

ESSAY XXIII.

Upon the Resemblance which Vegetable Acids bear to one another, particularly those of Must and Sugar*. By Dr Crell.

THE acids that exiſt in the vegetable kingdom differ, in many reſpects, from one another. They may be divided into the Essential, the Fermented, and the Empyreumatic.

The eſſential are almoſt entirely pure, as thoſe of lemons, ſorrel, and ſorrel-dock; or but little altered by the admixture of other matters, as the acids of cherries, barberries, apples, unripe grapes, gooſeberries, currants, tamarinds, &c. They are ſo much covered, as to be hardly diſtinguiſhable in many ſweet fruits, when they are ripe, in grapes, in various roots,

 as

* Chemiſche Annalen, St. 7 p. 89.

The obſcurity and importance of this ſubject would alone juſtify me in the eyes of the intelligent chemiſt, for adding this and the two following papers; but Mr Scheele has had ſo great a ſhare in the diſcovery of the new acids, that they form a peculiarly proper addition to his Eſſays. It was another ſtrong inducement with me to ſubjoin them, as they form an excellent ſupplement to what is ſaid, both by *Bergmann* himſelf in his Eſſay on Attractions, and in the *Notes*, *p.* 334. T.

as carrots, parſnips, in ſugar, &c. Theſe latent acids become more evident, partly in conſequence of fermentation, by which almoſt all plants (a few, particularly thoſe which bear cruciform flowers, excepted) are made to yield vinegar, and partly by dry diſtillation. In the two laſt operations, all vegetables, however different from one another in taſte and other ſenſible qualities, ſeem to yield products very nearly reſembling one another. But however alike, on the one hand, the reſults may be, when different plants are treated in the ſame manner, the products, on the other, which are obtained from the ſame plant by different operations, are as widely different. How different are the qualities of ſugar, when it is diſſolved in water, and left to ferment under proper management, till it is converted into vinegar, when it is diſtilled dry by itſelf *, and when the acid of ſugar is obtained by means of nitrous acid †? In order to be thoroughly convinced of this, it is only neceſſary to compare, in the two laſt caſes, the experiments made by Mr Schrickel and Profeſſor Bergmann on earths, alkalis, and

* SCHRICKEL Diſſ. de ſalibus ſaccharin. vegetab. ex ſacch. albi analyſi acidoque hujus ſpiritu ſpeciatim. Gieſſæ, 1776.

† Bergmann. Opuſc. vol. 1. p. 251.

and metals, with one another. I intend to treat, on ſome other occaſion, of the cauſes of the different products that are obtained from the ſame plant, treated in different ways. I ſhall at preſent confine myſelf to the extrication of the ſame conſtituent parts from different vegetables, when the ſame method is applied to each.

The acid which paſſes over in dry diſtillation, along with an empyreumatic oil, is ſcarce perceptible beforehand, though it is procured from very various plants. All vegetables that run into the acetous fermentation yield a vinegar, which has, in all caſes, the ſame eſſential qualities. This gave riſe, in the minds of many chemiſts, to this very natutural conjecture, that the acid diffuſed through the whole vegetable kingdom, may be of the ſame kind, and the ſpecies may proceed only from the different proportion of oily and mucilaginous particles intermixed with it. Thus it is ſaid by Mr Morveau *, among others, that the acid baſis is probably the ſame in all plants, and only modified by the various conſtituent parts by which it is neutraliſed. Moſt chemiſts maintain, that vinegar is the baſis of the eſſential vegetable acids: Others, as Mr Weſtrumb †, ſuppoſe,

* Elemens de Chemie Theor. et Prat. T. 2. p. 9.
† Neu. Entdeck. Th. 11. ſ. 109.

pofe, that the acid of fugar, or rather *, as Mr Hermbftaedt, that the acid of tartar conftitutes the effence of the other vegetable acids. We have not, I believe, facts enough to afcertain this matter; neither do I think that, as yet, the cafe of two fpecifically different acids, coexifting in one plant, has been confidered; but their properties have been conftantly deduced from one fingle acid. This, however, feems frequently to take place: Thus, Mr Scheele was not able to convert the cryftallifed acid of lemons into acid of fugar, by means of nitrous acid; though he perfectly fucceeded in effecting this with the faponaceous extract, which accompanied the acid before it was cryftallifed. Mr Hermbftaedt, in analyfing the juice of four cherries, obtained acid of fugar with a middle falt containing an excefs of acid, which was probably tartar. In order to anfwer this queftion, it would be proper to enquire, whether the conftituent parts and the products of fugar, and the conftituent parts of wine, the pureft fource of vinegar, are in reality fo very much alike (as is taken for granted, and commonly fuppofed to be proved

* Others hold the acid of fugar to be an artificial product, and not a natural falt. See Mr Wiegleb. Chem Ann. Th. 7. f. 12. and Mr Hermftaedt N. Entdeck. Th. 9. f. 17.

proved by too few circumſtances)? or, Wherein they differ?

The firſt queſtion then would be, Whether ſugar can be extracted from the expreſſed muſt, in the ſame way as Margraaf obtained it from various roots? This admits of but little doubt, ſince the ſame chemiſt aſſerts, that he has obtained ſugar from very fine raiſins. It is, moreover, neceſſary to ſubmit this ſugar of wine, or at leaſt the muſt, after it has been properly purified and evaporated, to a dry diſtillation, in order to ſee whether theſe ſubſtances would afford the ſame products as ſugar; and whether the acid that is obtained acts upon alkalis, earths and metals, in the manner which Mr Schrickel has particularly deſcribed with reſpect to his acid. The ſugar of wine, or the muſt, ſhould be treated with nitrous acid, in order to determine whether acid of ſugar can be obtained from it in equal quantity: I ſay, in equal quantity; for ſome of this acid may well be expected, as wine contains tartar, which, according to Mr Hermbſtaedt, may be converted into acid of ſugar. On the other hand, a kind of wine, according to the proper way of proceeding, muſt be obtained from ſugar. Preſerve it carefully in veſſels, and take notice whether any tartar is depoſited from it. Another part of the fermented ſugar

ſugar muſt be allowed to paſs into vinegar, and afterwards combine the vinegar with all the common ſalts, earths and metals, in order to compare the effect of vinegar obtained from wine upon the ſame ſubſtances, and to determine how far both kinds of vinegar coincide. The firſt kind of experiments with muſt, may be very eaſily made in countries that produce wine; the laſt, with ſugar, any one may make who has opportunity, patience and time. Theſe points, however, if they were clearly decided, would not furniſh an anſwer quite ſatisfactory to the queſtion. Concerning the circumſtances which it would be further neceſſary to aſcertain, I ſhall take the liberty of giving my opinion on ſome future occaſion.

On

On the Conversion of Vinegar into Acid of Tartar, or of Sugar, by the Same.*

I have already thrown out ſome reflections, both on the reſemblance between the acids contained in muſt and in ſugar, and on the difference between them. Now, when muſt has undergone the fermentative proceſs, its acid appears under the two forms of vinegar and of tartar. Are both theſe acids newly generated by the proceſs? or but one? or are they only ſeparated? To the production of tartar, fermentation is not neceſſary; for, according to Rouelle (Bucquet Introd. à l'étude des corps natur. T. 2. p. 177.), it may be procured from the juice of unripe grapes. Pure acid of tartar conſiſts, after diſtillation *per ſe*, of an empyreumatic acid, and the coal that is left behind of oily particles and calcareous earth. (*Bergmann de tubo ferrum*, § 12.), may not then the acetous acid be mere acid of tartar, which did not meet with alkaline ſalt and earth enough with which it might combine, and become more fixed; but, on the contrary, attracted more ſubtile oily particles, and thus became more volatile. The fixed vitriolic acid is converted by phlogiſton into the ſulphureous acid which is ſo volatile, that the acetous acid may acquire its characteriſtic properties,

Chemiſche Annalen. St. 8. 85.

perties, from the want of fixed conſtituent parts, with which it might unite, may be deduced from the changes which it undergoes, when combined with ſome fixed matter, and then diſtilled. Acetated vegetable alkali (*terra foliata tartari*) yields, according to Mr Beaumé (Chym. exp. et raiſon. T. 2. p. 21.), on diſtillation by itſelf, but $\frac{1}{480}$ of pure acid. All the reſt of the acid, employed for ſaturation, is totally deſtroyed, and the reſiduum, both in the retort and receiver, quite alkaline, juſt as the acid of tartar is almoſt wholly deſtroyed by dry diſtillation, the empyreumatic acid, which is obtained, being very weak. According to Beaumé (T. 1. p. 315), if calcareous earth, egg-ſhells, for example, be diſſolved in vinegar, and the cryſtalliſed ſalt be diſtilled, $\frac{3}{64}$ of a red and very ſpirituous and inflammable fluid, that ſmells like empyreumatic acetous æther, and reddens tincture of turnſol, is got. This alſo ſhews the change that has been wrought, and the reduction of the ſtrength of the former acid. The acid in ſugar of lead is in like manner entirely deſtroyed by diſtillation (*Macquer's Dict. vol.* 1. *p.* 328. *of the German tranſlation*). It is ſtill further in confirmation of this, that muſt, diſtilled even before fermentation, yields nothing but an empyreumatic acid, a kind of ſpirit of tartar. Whoever ſhall doubt of of the great difference, which the close combination or absence of earthy particles occasions in an acid, would do well to compare lime combined with somewhat of an excessive portion of vitriolic acid, with the same acid uncombined (Beaumé, l. c. p. 273): Let him at the same time imagine the earth to be so intimately combined as to be inseparable. In this manner, may, I think, tartar be conceived, since, according to Bergmann's experiment, it contains calcareous earth; but it is united with acid in excess, tastes sour, and is soluble. The contrary appears, when acid of tartar is completely saturated with lime; for the selenite is exceedingly difficult of solution, and has scarce any taste.

Is it then a conjecture altogether improbable, that vinegar and tartar have for their basis the same species of acid; and that this acid is only combined with a greater quantity of subtile oil in one case, and with more earth in the other? Will it not be possible to bring vinegar again in some measure nearer towards the state of tartar? In order to accomplish this, we must endeavour to take away the fine volatilising phlogiston of the former, to combine it with more fixed matter, and to restore its grosser oil. The latter seems to be extremely difficult, nor will the former be easily effected. Mr Westrumb (*Chem.*

(*Chem. Ann. St.* 3. *f.* 340.), in examining whether vinegar did not contain acid of ſugar, added nitrous acid to it in various proportions; but he only produced a phlogiſtication of the nitrous acid, and rendered the vinegar more free from phlogiſton. The properties of vinegar, ſo much dephlogiſticated, elude, he adds, further examination, as it would be impoſſible entirely to ſeparate the one acid from the other. I think, however, that this might have been done by vegetable alkali, lime and heavy earth. The nitrous acid, combined with vegetable alkali, would have ſhot into the ordinary hexangular cryſtals; the acetous acid, had it remained unchanged, would have formed the difficultly cryſtalliſable compound; and had it approached to acid of ſugar, it would ſtill have conſtituted a neutral ſalt, that does not readily cryſtalliſe. Nitrous acid only forms difficultly cryſtalliſable compounds, while the cryſtals vinegar forms with it are ſo little liable to deliqueſce, that they effloreſce in the open air*. The effects produced by theſe acids on heavy earth would have been directly oppoſite, the nitrous acid forming ſalts difficult of ſolution, the acetous ſuch as deliqueſce (Bergm. Op. vol. 3. p. 391.). But ſhould the latter have approached to the

* Perhaps alſo ſpirit of wine would ſeparate nitrated from acetated lime.

the nature of acid of ſugar, tranſparent cryſtals would immediately have fallen down (l. c. p. 392.). I think therefore that one might ſeveral times diſtil off nitrous acid from vinegar; and when the former, upon being newly added, yields no more red vapours, ſaturate with calcareous or heavy earth, and ſeparate the ley, that will not ſhoot, from the cryſtals. The nature of the ſalt, which does not contain nitrous acid, may be more certainly determined by its figure, or the effects of other ſalts, in conſequence of a double elective attraction. One might add freſh nitrous acid to the ſeparated ſalt, or to the whole mixture, without any ſeparation of the nitrous ſalt, till the earthy ſalt, which does not contain nitrous acid, be ſaturated. Were the vinegar unaltered, it would diſtil off; if it were converted into acid of ſugar, it would not be diſlodged from the lime by nitrous acid.

In like manner, diſtilled or Weſtendorf's vinegar, ſhould be ſaturated with chalk; the compound ſhould be reduced to cryſtals, and then expoſed to as ſtrong a fire as it can bear without the expulſion of the acid, in order to ſeparate ſome of the phlogiſtic particles. Next, let it be diſſolved, filtered, and ſet to cryſtalliſe again; then let it be treated with nitrous acid. The vinegar may, perhaps, by ſuch a combination,

bination, acquire more fixity; ſo that the nitrous acid ſhall be able to produce a greater change. Should it paſs over again in the form of vinegar, let it be combined once more with calcareous earth, and let the foregoing experiment be repeated, in order to try whether ſome ſenſible change will not enſue. Should this method fail, let the oppoſite be tried; endeavour to add more groſs phlogiſtic matter to the vinegar; try to combine ſtrong vinegar, and that of Weſtendorf, with unctuous oils (*See Macquer's Dict. Th.* 2. *ſ.* 126. *G. T.*) as, for inſtance, with oil from tartar, by means of digeſtion or diſtillation; and afterwards it may be joined with calcareous earth. Thus we might attempt to bring it nearer to tartar, and again, by means of nitrous acid, to convert it into acid of ſugar.

Extract

Extract of a Letter from Dr CRELL *to Mr* D'ARCET *.

The chemifts have always been much occupied in the inveftigation of the nature of the vegetable acids; and the difcovery of their conftituent parts would certainly be an highly interefting event. I think I can fhew that they may all be converted into one; and that this primitive acid is contained in the pureft fpirit of wine. The following are my proofs:

1. If the refiduum of dulcified fpirit of nitre be boiled with a large quantity of nitrous acid, care being at the fame time taken to condenfe the vapours by a proper apparatus; and if the liquid which has paffed over be faturated with vegetable alkali, nitre and *terra foliata tartari* will be obtained. If the latter be feparated by means of fpirit of wine, the vinegar may be got by the ordinary procefs.

2. Upon boiling the refiduum over again with nitrous acid, the fame products are obtained. The oftener this procefs is repeated, the lefs is procured of acid of fugar, and at length no veftige of it is to be found.

3. If pure acid of fugar, completely formed, be boiled with twelve or fourteen

* Journal de Phyfique. Octob. 1785. p. 297.

times its quantity of nitrous acid, the former diſappears, and the receiver is found to contain phlogiſticated nitrous acid, vinegar, aerial acid, phlogiſticated air; and in the retort there remains a little calcareous earth.

4. If acid of ſugar be boiled with ſix times its quantity of vitriolic acid, there are found in the receiver, vinegar, phlogiſticated vitriolic acid, aerial acid, and in the receiver pure vitriolic acid.

5. By ſaturating the reſiduum of dulcified ſpirit of nitre with chalk, there is formed an inſoluble ſalt, which, on being treated with vitriolic acid, yields a real acid of tartar; for, with vegetable alkali, it conſtitutes cream of tartar.

6. If the liquor, from which the tartariſed lime (tartareous ſelenite) was procured, be evaporated, there will remain a dark-coloured matter, which yields, on diſtillation, empyreumatic acid of tartar, and a ſpongy coal. Hence it appears, that ſpirit of wine conſiſts of acid of tartar, of water, and phlogiſton; ſo that it is a native dulcified acid; and nitrous acid, on being mixed with it in moderate quantity, diſlodges the acid of tartar. If more nitrous acid be added, the acid of tartar is converted into acid of ſugar and phlogiſton; and, by adding a new portion

tion of nitrous acid, the acid of fugar is changed into vinegar.

7. If one part of acid of fugar, together with one and one half part of manganefe, be boiled with a fufficient quantity of nitrous acid, the manganefe will be almoft entirely diffolved, and vinegar, with phlogifticated nitrous acid, pafs over into the receiver.

8. If acid of tartar and manganefe be boiled with vitriolic acid, the manganefe will be diffolved, and vinegar, with vitriolic acid, be obtained.

9. When acid of tartar, manganefe and nitrous acid, are boiled together, the manganefe is diffolved, and vinegar, together with phlogifticated nitrous acid, is obtained.

10. If acid of tartar and fpirit of wine be digefted together for feveral months, the whole is converted into vinegar, and the air in the veffel becomes partly fixed, and partly phlogifticated air.

11. If fpirit of wine be boiled with vitriolic acid and manganefe, it will be converted into vinegar, and phlogifticated air.

12. Spirit of wine, by being diftilled upwards of twenty times from off cauftic alkali was changed into vinegar, and a confiderable quantity of water was obtained.

Hence it follows, that the acids of tartar, and ſugar, and vinegar, are modifications of the ſame acid, as it contains more or leſs phlogiſton. The acid of tartar has the greateſt quantity; the acid of ſugar, a little leſs; and vinegar has the ſmalleſt quantity. In theſe experiments, it is neceſſary to employ nitrous acid and fixed alkali, without any admixture of marine acid; otherwiſe the obſerver will be led into miſtakes.

14. By diſtilling vitriolic acid from off mangaueſe, an acid is obtained, which is alone capable of diſſolving gold, ſilver, and mercury, very readily.

The analyſis of camphor has been entered upon. By ſeveral diſtillations with red bole, a ſubſtance like an æthereal oil is obtained. It has all the properties of ſuch an oil, being ſoluble in ſpirit of wine, and ſeparable again on the affuſion of water.

On diſtilling dephlogiſticated nitrous acid eight times with camphor, a ſalt is obtained in the form of a parallelopiped, having an acid and bitter taſte, and changing the juice of violets and turnſol to red. This ſalt, when combined with vegetable alkali, aſſumes an hexagonal form, yields regular cryſtals, with foſſil alkali; and, with volatile alkali, conſtitutes partly cryſtalline maſſes, and partly acicular

acicular and prifmatic cryftals; with magnefia, it forms a white powder, which diffolves in water. It diffolves copper and iron. The latter folution yields, upon evaporation, a yellowifh white powder, which is infoluble. It likewife diffolves zinc, bifmuth, arfenic and cobalt. With manganefe, it forms cryftals, of which the planes are parallel, and which, in fome meafure, refemble bafaltes. It does not precipitate lime from the marine acid, a circumftance, which, together with its effects on iron and magnefia, diftinguifhes it from acid of fugar.

According to Mr Weftrumb's analyfis, a refin may be obtained from the refiduum of vitriolic æther, which contains vitriolic acid, vinegar, Glauber's falt, felenite, calcareous earth, filex, iron, and phofphoric acid.

Three varieties of zeolite have been difcovered in the mountains of the Hartz, and the Tourmalin, or Mount Gothard in Switzerland.

In Cornwall, two mines have been found, extremely rich in the new mineral or acid, tungftein, which the experiment of Bergmann and Scheele have rendered fo famous.

Pruffian blue is half compofed of iron, although Bergmann has maintained the contrary.

Mr Scheele has just discovered, that the salt obtained from urine, and known under the name of *acidum perlatum*, is not a peculiar acid; but that it is only phosphoric acid, disguised by a small quantity of fossil alkali, that is united with it. The analysis is confirmed by synthesis; for, by combining fossil alkali, with phosphoric acid, the author has obtained a true perlate acid. *Journal de Physique*, *p.* 316. *Octobre* 1785.

DISSER-

Dissertation on Prussian Blue. Part II. 1783.

§ XI.

(A) THE colouring liquor rectified, as directed in the preceding paragraph (p. 335.), appears to be neither acid nor alkaline; for it neither reddens paper dyed with lacmus, nor does it reſtore the colour of ſuch paper after it has been made red; but it renders turbid the ſolutions of ſoap and hepar ſulphuris. (B) The ſame liquor, mixed with fixed alkali, produces a compound, which, though it contains a ſuperabundance of the colouring matter, reſtores the blue colour of paper reddened by an acid. If this compound be diſtilled to dryneſs, there goes as much of the colouring matter over as can diſengage itſelf from the alkali. The reſiduum is ſoluble in water, and the ſolution has all the properties of the beſt lixivium ſanguinis. This ſolution is decompoſed by all acids, even by the aerial acid (§ III.). (C) Combined with cauſtic volatile alkali, it forms a kind of ammoniacal ſalt, which has the ſmell of volatile alkali, though the colouring matter be ſuperabundant in the compound. This ſalt inſtantly riſes by diſtillation, and there metallic ſolutions, except upon nitrated ſilver, which is precipitated in the form of a white powder; nitrated mercury, which is precipitated in the form of a black powder; and the ſolution of iron in aerial acid, which is precipitated firſt of a ſea-green colour, but at laſt changes to a blue colour. The other metallic ſolutions undergo no change. (B) This matter has a more ſenſible action upon the calces and metallic precipitates: All the calces, however, are not attacked; for it produces no effect upon the calces of platinum, tin, lead, biſmuth, iron, manganeſe, and antimony; as little does it act upon the acids of molybdæna and of arſenic. The following are the phænomena which it preſents with the other metallic calces: Gold, precipitated by aerated alkali, becomes white. From ſilver, precipitated by the ſame alkalis, it diſengages the aerial acid with a ſlight effervescence, but the calx preſerves its white colour. It diſſolves the calx of quickſilver, and yields cryſtals by means of a gentle evaporation. The calx of copper, precipitated by aerated alkali, effervesces, and aſſumes a faint citron colour. Calx of iron, precipitated from its ſolution in the vitriolic acid by the ſame alkali, effervesces, and aſſumes a dark blue colour. Precipitated cobalt ſhews ſome ſigns of an an effervefcence, and changes into a yellowifh brown colour. Calx of manganefe, precipitated from its folution by aerated alkali, is not attacked.

§ XIII.

The precipitating liquor (§ XI. G) acting upon the metallic folutions by means of a double elective attraction, muft prefent phænomena with thefe folutions different from thofe which the pure colouring matter produces. (A) If a quantity of this liquor be poured into a well faturated folution of gold, the gold precipitates in the form of a white powder; but if it be added in excefs, the precipitate will be rediffolved. This folution is colourlefs, like water. The precipitate is not foluble in acids. (B) The folution of platinum is not changed. (C) Silver is precipitated of a white colour, and of a confiftence like that of cheefe. If more of the liquor be added, the precipitate is rediffolved. This folution is not decompofed either by fal ammoniac or by muriatic acid. The white precipitate is infoluble in acids. (D) Corrofive fublimate feems to undergo no change on pouring this liquor into a folution of it, though it is really decompofed, being, of all the metallic calces, the only one which can be diffolved by the colouring matter (§ XII. B). (E) Mercury

cury diſſolved in nitrous acid, without the application of heat, is precipitated in the form of a black powder, which is reduced mercury. (F) Tin diſſolved in aqua regia is precipitated of a white colour; but as the mixture gave out a ſmell very much reſembling the ſmell of the colouring matter, I examined the precipitate, and found that it was nothing but the pure calx of tin ſoluble in acids. (G) The ſolution of biſmuth ſhewed the ſame phænomena. (H) The liquor alſo produced the ſame effects upon the ſolution of butter of antimony; (I) as likewiſe upon the ſolution of well dephlogiſticated calx of iron. (K) Vitriolated copper, diſſolved in water, was precipitated of a yellow citron colour. If more of the precipitating liquor be added, the precipitate will be rediſſolved, and this ſolution will be colourleſs. This precipitate likewiſe diſſolves in volatile alkali without any colour. If more of the ſolution of vitriolated copper be added, the precipitate likewiſe diſappears, and the ſolution aſſumes a green colour. Acids diſſolve a portion of this precipitate, and what remains of it is white. The muriatic acid diſſolves the yellow precipitate completely; but it is again precipitated by water. (L) The ſolution of vitriol of zinc in water yields a white precipitate, which is not rediſ-

ſolved

ſolved on adding more of the precipitating liquor; but it is ſoluble in acids. Theſe ſolutions have the ſmell of the colouring matter, which latter may really be ſeparated from them by diſtillation. (M) Vitriol of iron is firſt precipitated of a yellowiſh brown colour, which ſoon changes to green, and then becomes blue on the ſurface. Some hours afterwards the precipitate ſubſides to the bottom of the veſſels, and then the whole mixture turns blue; but, on adding any acid, the precipitate becomes inſtantly blue. If a very ſmall quantity of vitriolated iron be put into the precipitating liquor, the precipitate entirely diſſolves, and imparts to the mixture a yellow colour (§ II. A, C). (N) From the ſolution of cobalt, a brown yellow precipitate is thrown down, which does not diſſolve on adding more of the precipitating liquor; neither will it diſſolve in acids. (O) Lead diſſolved in vinegar is precipitated in the form of a white powder, which more liquor does not diſſolve; but, when well edulcorated, it is ſoluble in acids. If the ſolution be diſtilled, the colouring matter goes over into the receiver.

(P) Vitriolated mangancſe ſuffers no decompoſition.

§ XIV.

§ XIV. *On the conſtituent Parts of the colouring Matter.*

I met by accident with a very remarkable phænomenon : As I was one evening about to pour the liquor of the firſt diſtillation of the colouring matter out of the receiver into a bottle (§ VI.), and a burning candle happened to be ſtanding near the orifice, the air contained in the receiver inſtantly took fire, without, however, any exploſion. As long as the maſs continued warm in the receiver, (for the diſtillation was forced rather a little too much), I was able to inflame this air ſeveral times, till at laſt it would no more take fire. As all the phlogiſtic ſubſtances, from the vegetable as well as animal kingdom, contain aerial acid as one of their conſtituent parts, I wiſhed to know whether there was any of this acid contained in the colouring matter. I therefore filled a ſmall retort half full with this latter, and, after applying a receiver, gave it immediately a pretty ſtrong heat. The receiver ſoon grew hot, and as it was at the ſame time filled with thick vapours of the colouring matter, I ſeparated it from the retort, and preſented to its orifice a little burning ſulphur *, which I introduced even

* When we make uſe of a candle for this purpoſe, we can never be ſure that the aerial acid does not come

even into its cavity. The air in the receiver took fire inſtantly. I afterwards poured ſome very clear lime-water into it, which was immediately precipitated. Hence it may be concluded, that the aerial acid and phlogiſton exiſt in this colouring matter. But ſeveral chemiſts having aſſerted that the Pruſſian blue conſtantly yields volatile alkali upon diſtillation, in order to verify this obſervation, I prepared on purpoſe ſome perfectly pure Pruſſian blue from vitriol of iron, and from the precipitating liquor.

§ XV.

I diſtilled this Pruſſian blue in a glaſs retort, to which I adapted a receiver, in which I had put a little diſtilled water. I puſhed the fire till the bottom of the retort was red hot. After the diſtillation was over, I found that the water in the receiver contained colouring matter and volatile alkali, but no oil. The air in the receiver was impregnated with the ſame matter, and with aerial acid. What remained in the retort was black, and obeyed the loadſtone. It therefore appears, that

come either from the tallow or from the wick. I was thus deceived ſeveral times, on ſetting fire to inflammable air. It is, therefore, better to uſe a little brimſtone fixed upon the end of an iron wire.

that the volatile alkali enters into the compofition of the colouring matter. I thought it, however, of importance to examine what phænomena the other metallic precipitations, prepared with the fame precipitating liquor, would fhew when diftilled in the fame manner: (B) The yellow brown precipitate of cobalt (§ XIII. N) yielded juft the fame products as the precipitate of iron. The refiduum in the retort was black. (C) The yellow precipitate of copper took fire, and emitted, from time to time, flight fparks during the diftillation. It yielded but a very fmall quantity of colouring matter; but much more aerial acid and volatile alkali than the precipitates before mentioned. There was likewife a fublimate in the neck of the retort; but in too fmall a quantity for making experiments. The refiduum in the retort was reduced copper. (D) The precipitate of zinc fhewed the fame phænomena as Pruffian blue. (E) The precipitate of filver yielded likewife volatile alkali and aerial acid, but chiefly colouring matter. There was likewife a little fublimate in the neck of the retort, which contained fome filver in combination. The refiduum was reduced filver. (F) The compound formed by the calx of mercury diffolved in the colouring matter, and cryftallifed

lifed (§ XII. B), yielded, by means of diftillation, a little of the colouring matter; but hardly any mark of volatile alkali. In the neck of the retort there was likewife fome mercury fublimed, with a portion of the original compound.

(G) Hence I was difpofed to believe, that the conftituent parts of the colouring matter were volatile alkali, and an oily fubftance. In this opinion I was the more confirmed, when I faw, that, on diffolving martial vitriol in fpirit of hartfhorn, recently diftilled, and adding to it muriatic acid, I obtained Pruffian blue. I however diftilled oxes blood, till nothing more would pafs over into the receiver, and the retort was red hot. I filtered the liquor of the receiver, in order to feparate from it the empyreumatic oil, and then diffolved a little martial vitriol in it, and added a fuperabundant quantity of acid; and thus likewife obtained Pruffian blue. (H) I then refolved to make feveral experiments, the principal purpofe of which fhould be, to unite the volatile alkali with fome oily fubftance. For this purpofe, I diftilled a mixture of concrete volatile alkali and unctuous oil; a mixture of the fame alkali with animal fat; and, on another occafion, with oil of turpentine; a mixture of quicklime, fal ammoniac and axunge; the fame mixture with oil of hartſhorn; likewiſe a mixture of potaſhes, ſal ammoniac, and empyreumatic oil; the ſame mixture with axunge; but all in vain. The liquors obtained in the receiver, which conſiſted of phlegm, mixed with volatile alkali and oil, never yielded even the ſlighteſt mark of Pruſſian blue. Hence I concluded, that, though aerial acid and phlogiſton are obtained every time any oil is decompoſed, it at the ſame time contains water intimately combined with the other conſtituent parts, and that it is abſolutely neceſſary that this water ſhould be ſeparated from them, before a perfect union of the volatile alkali can take place. We know that charcoal-powder, brought into fuſion with fixed alkali, yields likewiſe a kind of lixivium ſanguinis, though weak. I digeſted the colouring matter with concentrated vitriolic acid, and the mixture remained colourleſs. If this matter had contained any oily principle, the mixture would have become black or brown. Having reduced ſome pulveriſed blood, by calcination, to a coal, *viz.* the reſiduum in the retort (§ XV. G), I mixed with it an equal quantity of alkali of tartar, and expoſed this maſs in the ordinary manner to a red heat, and thus I obtained a very good lixivium ſanguinis. It is hence evident, that no oily matter is required for

for the production of the colouring matter.

§ XVI.

Laſtly, I made the following experiments, which convinced me of the truth of my concluſion. I mixed three table-ſpoonfuls of charcoal-powder, with an equal quantity of pulveriſed alkali of tartar, and put the mixture into a crucible. I filled another crucible with a like mixture, and placed both of them at the ſame time upon burning charcoal. I kept them red hot for a quarter of an hour, and then threw one of the portions, which was perfectly red hot, into eight ounces of water. At the ſame time, I put into the other half an ounce of ſal ammoniac, in ſmall pieces, agitated the whole briſkly together, taking care at the ſame time to puſh the ſal ammoniac down towards the bottom of the crucible, which I then again placed in the fire. Obſerving, a couple of minutes afterwards, that there aroſe even then no more ammoniacal vapours, I threw the whole maſs, red hot as it was, into eight ounces of water. I now filtered the firſt lixivium, and trying it in the ordinary way, with vitriol of iron and acids, it yielded little or no Pruſſian blue, (or at leaſt not any ſenſible quantity); but it would perhaps have yielded

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a little, if the fire had been puſhed till the maſs ran into fuſion. I now filtered the ſecond lixivium, and tried it in the ſame manner, with vitriol of iron, which immediately grew yellow, as if lixivium ſanguinis had been added; and, on adding a ſufficient quantity of acid, the ſame phænomena were obſerved, as the beſt lixivium ſanguinis would have produced, and a great quantity of Pruſſian blue was procured. I mixed plumbago with the ſame alkali, and proceeding in the ſame manner with ſal ammoniac, obtained a middling lixivium. From theſe experiments, it appears, that the volatile alkali is capable of uniting with the carbonaceous matter, after it has been ſubtiliſed by a ſtrong heat; that it thus acquires the remarkable property of combining ſo firmly with alkali of tartar, as to be able to ſupport the moſt violent degree of heat, (§ XI. B); and when this alkali is diſſolved in water, there is obtained lixivium ſanguinis, as it is called. It is now eaſy to explain what happens in the diſtillation of Pruſſian blue, as well as of the other above mentioned metallic precipitates, (§ XV. A—F). In the diſtillation of Pruſſian blue, for inſtance, the calx of iron attracts a portion of phlogiſton from the colouring matter. The aerial acid being thus diſengaged, muſt go over into the

receiver

receiver with the volatile alkali, which is ſet free at the ſame inſtant; but as the calx of iron in the heat of this diſtillation cannot unite with more phlogiſton, a portion of the colouring matter, not decompoſed, muſt likewiſe ariſe. If the calx of iron could combine with the whole of the phlogiſton, there would come nothing over into the receiver, but aerial acid and volatile alkali. In order to prove this, I diſtilled a mixture of ſix parts of manganeſe, finely powdered, and one part of pulveriſed Pruſſian blue, and I obtained in the receiver nothing but aerated volatile alkali, without the leaſt mark of colouring matter.

It may be obſerved, 1. That it is probable that this matter may be made to aſſume aerial form, though I have hitherto not been able to effect this.

2. It is remarkable, that our colouring matter, after it has united with the alkali, or with the lime, forms a menſtruum, capable not only of diſſolving metallic calces, but alſo of conſtituting a triple ſalt, which is not decompoſed by the aerial acid, as happens with the lixivium ſanguinis and the precipitating liquor, when expoſed to the free acceſs of air. Iron is not the only metal which has the property of fixing the colouring matter (§ 11. c), the ſame quality belongs likewiſe

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