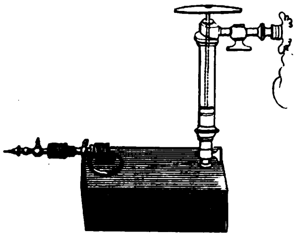
A MANUAL OF CHEMICAL EXPERIMENTS.

Fig 1.



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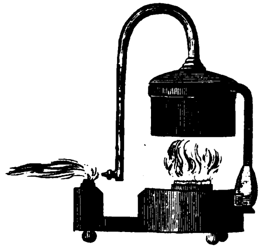

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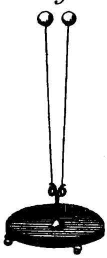

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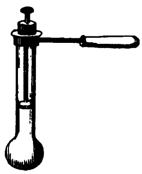

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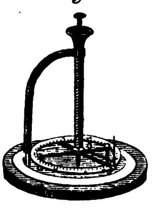

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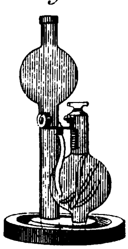

R. Martin. 124 High Holborn

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A

MANUAL OF EXPERIMENTS

ILLUSTRATIVE OF

CHEMICAL SCIENCE,

SYSTEMATICALLY ARRANGED.

REMARKS ON THE NOMENCLATURE,

And Theory of Definite Proportions;

APPLICATION OF TESTS FOR THE DETECTION OF POISONS,

EXAMINATION OF MINERAL WATERS;

VOCABULARY OF TECHNICAL TERMS, &c.

BY JOHN MURRAY, F.S.A. F.L.S. F.H.S. F.G.S.

Member of the Meteorological Society of London, and of the Wernerian Society of Edinburgh; 'Honorary Member' of the Medico-Chirurgical Society of Hull, of the Medical Society of Inverness, of the Philosophical Societies of Sheffield, Whitby, Hull, and Norwich; and of the Mechanics' Institutes of Exeter, Devonport, Portsmouth, Hull, York, Scarborough, Huddersfield, Halifax, and Bristol; 'Corresponding Member' of the Northern Institution, the Horticultural Society of Edinburgh, &c.

THIRD EDITION.

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1833.

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TO

THE REVEREND

DR. BUTLER, F.S.A.

&c. &c. &c.

SHREWSBURY,

THIS LITTLE VOLUME

IS INSCRIBED,

WITH EVERY SENTIMENT

OF

GRATEFUL RESPECT.

CONTENTS.

ADVERTISEMENT.

It is presumed that the following pages may encourage the growth of chemical knowledge in the tyro of its science. Experiment is an inviting field, and chemistry is a science of experiment—the time is now past for speculation and hypothesis either to claim or receive attention.

This little volume is the work of one allowed to be a successful experimentalist; and may possess several advantages over its contemporaries. None of the experiments are admitted on the *ipse dixit* of any one, having undergone frequent repetition and scrutiny. Many are entirely new, and the whole systematically arranged under distinct sections, so that the experimenter, as he progresses, is gradually led through the entire range of chemical phenomena. The circumstances which ensure successful results are pointed out and explained; to each illustration an ample explanation is appended, and those of difficulty or danger have superadded the necessary caution.

This manual is written with a view to invite the dent of nature to a very lovely, interesting, and us branch of knowledge, by softening down the asper and difficulties of chemical research; and it is ho the end in view may be accomplished.

PREFACE

TO THE THIRD EDITION.

THE sale of nearly *two thousand copies* of this little work is a sufficient evidence of the public approbation, and has stimulated me to still greater exertion in bringing forward the THIRD EDITION. While the former arrangement is continued, new experiments are added, and the explanatory plate and wood-cuts will, it is hoped be found a considerable improvement. I have withheld no effort in my power, to evince my grateful sense of popular favour, in the success which has crowned these endeavours to extend the knowledge of chemical principles, so important in the economy of life.

I have distinguished by asterisks such chemical phenomena; or new, or modified methods of their exhibition, as I may fairly claim for my own. This is not done in the spirit of egotism, but is founded on the principles of self-defence. My knowledge of chemical phenomena stands committed for the accuracy of the experiments described, and their explanation. As far as may be consistent with my task, I have discarded theory; an where the question has forced it upon me, have ir dulged in as little speculation as possible. A moı elaborate and extended vindication of my views an opinions, on the subject of flame and the safety-lamp, elsewhere eliminated.

HULL,
1 July, 1833.

EXPLANATION OF THE PLATE.

FIG. 1. The compound Gas Blowpipe, which is supplied, by compression, with several atmospheres of a mixture of two volumes of hydrogene and one volume of oxygene. It is introduced to shew the attachment of the safety box to the jet pipe, containing numerous folds of wire gauze. The adjunct is that of Dr. Hope, and with this arrangement I have made numerous experiments, in perfect safety, without oil or water in the cell.

FIG. 2. The Alcoholic Blowpipe, on the principle of that of Dr. Hook. It is used in France, and is a very powerful instrument. If a quart of water, contained in a tin canister, be exposed to the agency of its flame, it is boiled in about 2½ minutes.

FIG. 3. A little invention of Mr. Towson, of Devonport—it consists of two spiral coils of steel and brass, to which wires are attached, capped with pith balls. The divergence of the pith balls exhibits the influence of heat upon the coils; and when separated, the application of ether causes them to collapse instantly, from the cold, occasioned by its evaporation.

FIG. 4. A Glass Ball, containing ether, with a gas jet attached to it; the application of heat to the ball occasions the conversion of ether into gas, or inflammable vapour, (Olifiant Gas?) The heat, occasioned by a mixture of sulphuric acid and water, is sufficient for this purpose, and illustrates a phenomenon connected with latent caloric.

FIG. 5. The *Thermometre Metallique* of the late M. Breguet. It is composed of a coil, consisting of gold, platinum, and silver laminæ, suspended from a support. The last, or lowest ring, carries a delicate gold index, which, by its march, indicates the temperature, as ascertained by the divided circle on the dial over which it moves. I purchased this instrument from M. Breguet, and in its extreme sensibility for detecting minute changes of temperature, otherwise inappreciable, is a most valuable adjunct to refined manipulation.

FIG. 6. Jackson's Inflammable Lamp Apparatus. It appears to me to be the best and most simple application of the curious fact discovered by Dobreiner of Jena, namely, that finely divided or "spongy" platinum is ignited by a current of hydrogene. The lower ball is supplied with the

materials for generating hydrogene, which are strips or fragments of zinc, water, and sulphuric acid, when the hydrogene is evolved, it occupies the lower ball, &c. and presses the liquid into the other stem. The production of gas ceases when the liquid sinks beneath the laminæ of zinc; and when the stopcock is turned, the gas rises, and is impelled toward a small box or cavity containing the platinum, which being ignited, kindles, in its turn, the jet of hydrogene, and this at the same moment lights a wax taper interposed between them.

Fig. 7. Wollaston's Steam Engine Principle, a simple and beautiful apparatus, whereby the elevation and depression of the piston, by the elasticity of steam, and its condensation, becomes strikingly evident.

REMARKS

ON

THE NEW NOMENCLATURE,

AND

THEORY OF DEFINITE PROPORTIONS,

WITH A

DEFINITION OF THE GASES, AND METHOD OF PREPARING THEM.

INTRODUCTION.

I.—THE NEW NOMENCLATURE.

There is of necessity a Nomenclature in every science; and Chemistry has its peculiar terms as well as other departments of knowledge, though we believe that its principles may be acquired without any extraordinary expenditure of mental exertion.

In the construction of the language of modern chemistry the terms employed happily express the materials of which bodies are composed; and being thus descriptive, become apposite and appropriate. Were the nomenclature of this science the exclusive property of any people or country, it would be a "sealed fountain" to all else beside, but since chemistry is the birthright of all, her legend must be formed of plastic materials obtained from a common source, that all may read the history of her wonders. The terms of the modern nomenclature are therefore obtained from that language which is venerable for antiquity—the vehicle of classic song, which has ever formed an essential part of the scholastic *studies of* Europe—significant epithets are employed, having their root in this spring of universal recognition, and are selected as descriptive of the form and character of chemical research.

A proper estimate of the superior value of the new nomenclature may be best obtained by comparison, contrasting the new and old in juxta position; and we much mistake, if, while it throws the old terms into the back ground and the shade, it does not bespeak a ready acquiescence in favour of the new nomenclature. In this estimate and contrast, amplification would be useless and uncalled for, the selection may therefore be limited and yet supply an ample specimen. Oil of tartar, oil of vitriol, butter of antimony, horn silver, sugar of lead, and cream of tartar, are terms altogether void of meaning, and "signify nothing." The nomenclature, which forms a part of this volume, will supply abundant materials of a similar complexion. Is *sugar* of lead said to be descriptive of its peculiar sweetness?—so are the salts of ittria and glaucina in a still higher degree. Oil of vitriol, &c. mislead by the adjunct *oil*, as the chemical constituents of oil are entirely absent. In the term *copperas* we consider copper to be present; and we naturally enough expect to find *lead* in "Black Lead;" while the former is a sulphate of iron, and the latter a compound of iron and carbon. Nor is this the worst of these antiquated and unmeaning epithets, for the unwary would little suspect a *fatal poison* under the gifted name of "Acid of Sugar."

When we turn to the new nomenclature, a more welcome language presents itself, though it cannot be *reasonably* expected; that we are enabled to apply terms critically descriptive of some invariable feature, to all the principles and elements of chemical research. Could this indeed be effected, the structure erected would be a durable monument of skill, it would be stamped with a permanence which nothing could by possibility destroy, and the novelties of discovery could never affect. Chlorine and iodine are examples of this description, the names are full of meaning, and the features on which they are founded can never change. Chlorine as chlorine, whether simple as now considered, or hereafter proved to be compound, can never cease to be presented in a *green* attire; and iodine in the state of vapour will ever assume a *violet* colour. Chlorine is derived from a Greek word signifying *green;* and iodine from a Greek word importing *violet.* So far these names are expressive and appropriate.

Oxygene is a species of elastic air or gas; we do not say that the name conferred on it is critically correct, because it has no right to an exclusive monopoly of the term, which implies it to be the acidifying principle; but though it be connected with the production of acid forms, we find that there are acids, into the constitution of which oxygene does not enter; such as hydro-sulphuric acid, hydro-chloric acid, and hydro-cyanic, hydro-iodic, and hydro-bromic acids. Indeed, there are examples wherein the base may form acids as well with hydrogene as with oxygene, as sulphur, iodine, &c. If sulphur be burnt in oxygene, sulphurous acid, in the state of vapour, will be the product; but if potassium be heated in this vapour the oxygene will be abstracted from the elastic gas, and transferred to the potassium, giving rise to the alkali called caustic potassa; so that the combination of one base with oxygene forms an acid, and another base with it, an alkali.

Oxygene however, in combination with metals, in minor proportionals, forms compounds, known under the general names of *oxydes*, as oxyde of tin, or oxyde of iron; but as these proportionals are fixed and definite in quantity, the prefix *pro* (or proto), or the prefix *per*, are conjoined to denote the lesser or greater weight or measure of the combined oxygene. These are the extremes, and the intermediate space or links between them are described by the Greek numerals *deuto, trito,* &c., such as the deutoxyde of lead, or lead combined with two determinate proportionals of oxygene and tritoxyde of manganese, or manganese in chemical combination with three measures of oxygene.

When sulphur combines with oxygene to form an acid, having distinct and specific powers of acidity, that acid will have its title or distinction conformable with the amount or degree of acidification, and a simple change in the term will announce its nature. Hence sulphur-*ous* and sulphu-*ric* acids, the former being the weaker degree of acidity, and the latter the greater acidity; and the occasional use of the prefix *hypo* implies a still inferior proportional of oxygene, and of necessity an inferior acidity. Thus hypo-sulphurous acid is a compound of 100 vapour of sulphur + to 25 of oxygene; sulphurous acid is composed of 100 sulphur + to 100 oxygene. Hypo-sulphuric acid consists of 100 sulphur + 125 oxygene; and sulphuric acid 100 sulphur + 150 oxygene. Combinations of the former with alkaline earths or metallic bases would be hyposulph-*ites* or sulph-*ites*, as hyposulphite of potassa, and sulphite of lime, or sulphite of iron; and in the latter, hyposulph-*ates* or sulph-*ates*, as hyposulphate of magnesia, and sulphate of manganese; deuto-sulphate of manganese points out the combination of sulphuric acid with the deutoxyde of that metal. When hydrogene is concerned in the acid change which supervenes, *hydro* is the apposite prefix, as hydro-cyanic acid, as *oxy* is in cases where oxygene is connected. Hence oxyiodic acid. Measures of the combined acid have in like manner distinctive appellations as descriptive of quantity; carbonate or chromate is descriptive of the neutral salt. Bicarbonate of magnesia, and bichromate of potassa yield us the specific information that the former is composed of two proportionals of carbonic acid, united with the earth called magnesia, and the latter, two of chromic acid with potassa. We have also binoxalate, quadroxalate, and tetraoxalate of potassa, or potassa combined with two, four or five proportionals of oxalic acid.

Hydrate is a term which is applied to express the combination of *water* with a metallic oxyde; hence we say hydrate of lime, and hydrate of copper. It is substituted for the word *hydro-oxyde*. An *anhydrous* salt implies the absence of water of crystallization or composition.

Combinations of carbon, sulphur, phosphorus, &c., not being acidified by oxygene, &c., are termed carburets, sulphurets, or phosphurets, in general terms; or specifically proto-sulphurets, per-carburets, &c.

In some instances *triple salts* are formed. In this case the term applied must express the combination; and as one of these *may* act in concert with the acid, and not form a *double base*, we say soda-muriate of gold; soda-muriate of rhodium; ammonia-sulphate of potassa; baryta-sulphate of platinum; ferro-cyanate of potassa; potassa-sulphate of nickel; and so on. In the salts of the earth, called *glaucina*, there is a *sulphate* and a *sesquisulphate*. The latter term denotes an added proportional of base; thus, the sesquisulphate of glaucina consists of 100 proportionals of sulphuric acid and 98·4 of glaucina, whereas the sulphate is composed of 100 of acid and 64·1 of base.

This brief description must speak powerfully in favour of the new nomenclature; since, however imperfectly explained, and limited in examples, there is ample proof, that in reference to expressive simplicity and usefulness, there can be no just comparison between it and the old.

II.—THEORY OF DEFINITE PROPORTIONS.

THE term *atom*, as used by Democritus, signified the unchangeable elements into which matter was ultimately divisible. If a given quantity of acid and alkali be mixed together, there is a point when their respective characters are extinguished. This was called the point of saturation; and modern chemists, perceiving that this had a fixed and determinate limit, and that different acids required different proportionals of any given alkali, for this end, assigned to the law in question the term of definite proportions.

It is readily allowed that Mr. Higgins, of Dublin, first entertained the singular and fortunate idea that bodies might combine as 1 to 1, 1 to 2, or 1 to 3, &c.; and so far the merit is conspicuous, and praise must be allowed; but at this period the data were far too few to become the groundwork of any general conclusion. It might or might not be. It cannot be considered therefore in any other light than as a pretty speculation, for it wanted the requisites of inductive science to recommend it to attention and acceptance. Besides, Mr. Higgins seems to have abandoned his offspring as soon as it was born, for we hear no more of it even from him; and the question was suffered to slumber in forgetfulness, till Dr. Dalton established the happy conclusion through the medium of experimental research. It was then fixed on an immutable basis, and warranted universal reception. We would not withhold the meed of applause from an acute and brilliant idea, though our praise must chiefly alight on him who established the doctrine by the evidence of fact. It can now no longer be controverted, and the chain of evidence is complete at every link. The united testimony of every scientific chemist guarantees its truth.

We are therefore now no longer at liberty to suppose that bodies combine in any, or in indeterminate proportions, or otherwise, than by a fixed and invariable law. The combination is always uniform, and in a continuous ratio; or in other words, in definite quantities or proportions.

Carbonate of lime, whether artificially produced or formed naturally, uniformly discovers, under analysis, 55 proportionals of lime, and 45 of carbonic acid gas, in the 100 parts. The nitrate of potassa, collected from its native bed, or formed in the chemical laboratory, yields in both cases 54 parts of nitric acid, and 46 of potassa. Muriate of soda in like manner, whether obtained by evaporation of the waters of the ocean, or rock salt, evolves, under analysis, 46 proportionals of muriatic acid, and 54 of soda; and it is the same in artificial production.

When two measures of hydrogene, and one measure of oxygene, are exploded by flame or the electric spark, the product is water, and the gases disappear; if we however double the amount of oxygene, while that of the hydrogene remains the same, one measure of the oxygene will be left. It is from hence very evident that there can be no intermediates, that two cannot combine with three, nor three with four; that in fact one must be a simple multiple of the rest, or a unit that never changes, while the other rises in a specific ratio. We further conclude that these ultimate parts or atoms may be represented correctly by numbers.

Let us suppose two bodies, A and B; the latter represented by 10, and the former by 5: we conclude that A combines with one of B, valued at 10, or with two of B, whose value would then be 20, or three of B 30, &c., or the reverse may be considered: B, combines with one of A=5, or two of A=10, or three of A=15. In the former case we conclude that A remains unchanged from first to last; and in the latter that the value of B continues the same.

Manganese combines with 4 proportionals of oxygene. Let the ultimate atom of the former be represented by 100, and the latter by 14; then one atom of manganese, whose numerical value is 100, combines with 1 atom of oxygene 14, and forms the protoxyde of manganese; 1 of manganese added to 2 atoms of oxygene=to 28, makes the deutoxide of manganese; 1 of manganese added to 3 atoms of oxygene = to 42, the tritoxyde of manganese; and 1 of manganese, added to 4 atoms of oxygene = to 56, the peroxyde of manganese; and these are relatively as one to one, one to two, one to three, and one to four: here the oxygene changes its numerical value, while the manganese remains precisely the same.

Seeing that two volumes of hydrogene unite to one of oxygene in the case of water, M. Gay Lussac, considering all bodies as originally in an elastic form, or capable of being so, has espoused the doctrine of volumes, and thus two volumes of hydrogene, added to one of oxygene, form water. On the other hand, if we assume one atom of each, we must suppose that the atom of hydrogene is double the size of that of oxygene, and we know certainly, that ammoniacal gas may, by the electric spark, be expanded into double its former volume.

If equal volumes of hydrogene and oxygene be weighed over against each other, the oxygene will be found to weigh sixteen times more than the hydrogene; but if the atom of the latter be *double* that of the former in size; in that case their relative weights will be 1 to 8.

Sir H. Davy, and subsequently Mr. Brande, assumed hydrogene for his unit, and since it is the lightest of all known substances, the election is so far happy. On the other hand, Dr. Thomson adopts oxygene as his unit. Wollaston values it at 10; and Berzelius at 100. These are easily made to tally. One-tenth of the numbers of Berzelius makes them correspond with those of Wollaston; and one-tenth of the latter bring the numbers to those of Thomson. It is easy to illustrate the application of numbers to the theory of definite proportions. If water be a compound of one atom of oxygene, and one atom of hydrogene, and oxygene be estimated as unit; then, 1 of oxygene added to $\frac{1}{8}$th or $\cdot 125 = 1\cdot 125$, the numerical value of an atom of water;

and if muriatic acid gas be a compound, of an atom of hydrogene = ·125, and an atom of chlorine = 4, then ·125 + 4 = 4.125 an atom of muriatic acid gas.

Dr. Wollaston's scale of equivalents is founded on these principles; and it affords to the analytical chemist a facility and despatch in his operations truly marvellous. This, however, is only one among the many happy inventions of that acute and distinguished philosopher, to whom science and the arts are so deeply indebted. Professor Brande considers hydrogene as 1, or the simple unit, and oxygene as 8. In this case, however, it is taken for granted that the *volume* of the ultimate atom of the former is *double* that of oxygene, since two volumes of hydrogene combine with one volume of oxygene in the formation of water. According to Mr. Brande, *water* would be thus numerically represented, 1 atom of hydrogene = 1 + to 1 atom of oxygene = 8. Hence the number representing water would be 9; but hydrogene being, volume for volume, 16 times lighter than oxygene; in the latter case it would be 1, + 16=17.

The scale of equivalents is now extensive in its range, (though as originally constructed by Dr. Wollaston limited,) and calculated to return definite replies to innumerable questions connected with the results of analysis and recomposition, with the relations of neutral salts to each other. Suppose that any specific number of grains of carbonate of lime are decomposed by muriatic or any other acid, the slider being moved, so that the given number of grains be opposite carbonate of lime, as engraved on the scale, the constituent proportionals of the new neutral salt will be seen at a glance, as well as the amount of disengaged carbonic acid gas. The relative quantities of other acids, and of other bases, equivalents of those composing the new salt, will be also seen by inspection. Such is the nature of this interesting arrangement, commonly called the logometric scale of equivalents. Mr. Cuff's extension of the scale has very much enhanced its value.* Dr. Boswell Reid, and Mr. Brande, have also published scales, &c.; the latter is characterized by much accuracy. It is, however, from its great length, unwieldy, and too expensive for general practice, though indispensable in the laboratory.

In Mr. Cuff's scale, founded on the original basis of that of Wollaston, assuming however oxygene as 8, agreeable to Mr. Brande, the instrument has been extended and arranged so as to meet all the usual desiderata of the experimental chemist, as well as the preparations of the pharmacopoeia. Suppose by this scale we wished to ascertain how much sulphuric acid would be required to dissolve 160 grains of lead, we move the slide upwards, so as to bring the number 160 opposite lead on the left hand; 75 will be the number opposite to liquid sulphuric acid of the Sp. Gr. 1.85; and the quantity of sulphate of lead formed is 235, which will be found opposite sulphate of lead on the left hand. Another illustration of this scale will suffice. Suppose 100 grains of sulphate of lime is to be decomposed by nitrate of baryta. Bring the number 100 on the scale, opposite

* This excellent scale is sold by Messrs. WATKINS and HILL, of Charing-Cross.

sulphate of lime, and it will then be found that it is a compound of 41 lime and 59 sulphuric acid; it will be also indicated by the scale that 195 grains of nitrate of baryta, composed of 115 grains of baryta, and 80 grains of nitric acid, would decompose it, and give rise to 174 grains of sulphate of baryta, which consist of 115 grains of baryta, and 59 of sulphuric acid. Hence 195 grains of nitrate of baryta are *equivalent* to 100 grains of sulphate of lime: these are in both instances neutral salts. No excess or residue would be found in either case; the decomposition is perfect, and these are equivalents to one another.*

It would be waste of praise to eulogise this beautiful doctrine, the splendid achievement of modern science. It throws over our details the interest of beautiful simplicity, and it has affixed to it the sign manual of truth. It is most happily expressed in the sublimity of the sacred Record, which refers to Deity, in the creation of material things,—"He weighed the hills in scales, and the dust in a balance." There is thus proved to be a sublime literality in this extraordinary passage, far surpassing the grandeur of orientalism,—reserved for these latter days to illustrate. It is thus true that created forms are by weight and measure—and matter, in its multifarious combinations, reveals at length the important truth.

* Dr. Wilkinson, of Bath, shewed me a neat circular logometric scale, of his own construction, for the solution of problems in chemical analysis and synthesis, wherein moveable pointals, or indexes, as in astronomical planispheres, indicated the relations of component constituents.

III.—DEFINITION OF GASES, WITH THE METHOD OF PREPARING THEM.

Definition of Gases.

By a gas is to be understood that form of matter which remains *permanently elastic,* or is aërial at a reduced temperature; we thus adopt a distinction between gas and *vapour,* the latter becoming liquid or solid as soon as the temperature is sufficiently decreased. Hence steam is an elastic vapour; but when the temperature is lowered by only a few degrees, it is resolved into water again; *iodine* also at 158° F. becomes a violet-coloured vapour, but when cool it condenses into crystals, which by Wollaston's reflective goniometer, appear to be octohœdra.

The distinction now assumed, however, must not be pressed too closely, since modern discovery has effected the condensation and liquefaction of such gases as are absorbable by water; and it is not improbable that the condensation of others may eventually be accomplished. In the *carbonates,* the carbonic acid gas is locked up in a highly-compressed form. In water, oxygene and hydrogene, its chemical elements, are exceedingly condensed; and in *chloride of azote,* its gaseous constituents, chlorine and azote, are so closely united, that a gallon of the combined gases in this compound might repose within the shell of a hemp-seed;—its explosive and expansive force is terrible.

I have discovered, that the vapour of sulphuric ether, and that of sulphuret of carbon, at the common temperature, may be treated very much like carbonic acid gas in its character of superior specific gravity, and they have become the means of a series of interesting experiments.

For the liquefaction of the gases we are indebted to Mr. Faraday: cold and compression are the agents employed, though Sir H. Davy stated his having accomplished the liquefaction of carbonic acid gas by the elastic force of the vapour of sulphuric ether, heat being applied. * These liquid gases are subjects of considerable interest. A piece of ice dropped into liquid sulphurous gas, makes it boil, from the *heat* communicated by the ice. The pressure of the vapour of sulphuretted hydro-

* I am not without considerable scepticism on this question. Some years ago Sir David Brewster shewed me an experiment in conjunction with the singular expansion of the fluids in crystals, then a recent discovery of his, which by the approach of a heated wire, completely and instantly filled their respective cavities. The experiment referred to consisted in introducing into the fire a tube, *partially* supplied with sulphuric ether, when the liquid expanded, and entirely filled the tube. It was necessary to screen the face, from an accidental explosion, by sheets of talc, which permitted the experiment to be seen, and yet formed a defence against possible injury. The peculiar character of the vapour of ether referred to as my discovery, being extremely elastic, yet capable of condensation into a liquid form, would render the liquefaction of the carbonic acid gas as a phenomenon extremely equivocal in this particular instance.

gene at 50° Fah., appears to be equal to that of 17 atmospheres. That of carbonic acid gas, at the temperature of 32° exerted a force equal to 36 atmospheres, and tubes including this liquid gas, by a slight increase in the heat of the weather, exploded with great violence. The pressure of liquid nitrous oxyde at 45° F. exceeds that of 50 atmospheres, and it boils readily by the difference of temperature between 50° and 0° or zero. No doubt some of these may be found extremely serviceable as mechanical agents, and finally supersede the use of steam. Mr Brunel has secured, we believe, by a patent, this mechanical application of liquid carbonic acid gas. Vessels sufficiently powerful to resist its tremendous power have not, however, yet been found, and are likely to interpose a barrier for some time to its practical employment; besides, the liquid gas is found to exude even through metallic cylinders.*

Preparation of the Gases.

In the following directions for the preparation of the gases, we are limited to those obtained over water, and not immediately absorbed by that liquid. Those which

* The preparation of these liquid gases is so pregnant with danger, that their introduction and exhibition in a lecture room is not *warrantable* under *any circumstance*. Whatever risque the operator may personally choose to run in his laboratory, he incurs a frightful responsibility in daring to bring the lives of his auditors into jeopardy. It is hoped that the recent melancholy death of Mr. Barry will operate as a salutary caution and warning against introducing such dangerous and formidable materials. In braving the dangers of the laboratory I will yield to none; but I should tremble to peril the lives of others.

follow do not include *all* which may be thus collected, but embrace the greater part of them, and such as are of general interest and importance. Arsenicated hydrogene is a gas requiring such a degree of precaution lest it should be accidentally respired, that it has been deemed prudent to overlook its preparation entirely. A continental chemist fell a victim to its casual respiration.

I. HYDROGENE.

This gas may be obtained from iron-turnings or filings, by placing them in a *gas-bottle*, adding a little water, and sulphuric acid; the gas as it is disengaged must be collected over water by means of the pneumatic trough. *Granulated zinc* is much preferable to iron turnings; the gas being purer and less odorous. Hydrogene may be also obtained by passing steam through an ignited iron tube, or a porcelain one containing iron-turnings; and collecting the gas in the usual manner.

II. CARBONIC ACID GAS.

Carbonic acid gas is easily procured by adding diluted muriatic acid to powdered marble in a gas-bottle, and collecting the gas over water. Limestone, chalk, and other substances effervescing on contact of an acid, yield the same gas, and any acid* may be used instead of the muriatic; but nitric acid is too expensive, and sulphuric acid producing an insoluble sulphate of lime, the salt is washed out with difficulty.

* This must be accepted in a *restricted* sense; hydrocyanic acid, for instance, will not displace carbonic acid gas.

III. OXYGENE.

Oxygene may be obtained by exposing peroxyde of manganese to *intense heat* in an iron retort; a long flexible tube conducts the gas to the receiver, resting on the shelf of the pneumatic trough; the first portions that come over being impure, must be rejected. The gas may in this way be obtained from nitre, and is purer and more abundant, it also evolves in great purity by exposing *peroxyde of mercury* to intense heat in an *earthenware* retort. If peroxyde of manganese be mixed with sulphuric acid in a *glass retort,* the heat of an Argand's lamp will be sufficient to occasion its evolution. The neatest as well as the purest and most prompt method of obtaining pure oxygene, is to expose in a *small glass retort* a quantity of oxymuriate or *chlorate of potassa,* say about half an ounce. This requires the heat of a spirit-lamp, and though a little more expensive than the preceding methods, it is every way preferable. The salt will soon melt, and the gas be disengaged.

IV. CHLORINE.

To about half an ounce of peroxyde of manganese, contained in a retort of a few ounces' capacity, add 2 or 3 ounces of muriatic acid; mix the ingredients; apply a gentle heat and receive the gas over water; reject the first portions, and take care not to inhale the chlorine, as it is very powerful and irritating.* This is the best

* A little alcohol on sugar is said to relieve the oppressive effects produced by accidentally breathing chlorine.

process, though it may also be obtained by mixing common salt with peroxyde of manganese, and adding sulphuric acid to these ingredients contained in a retort. The sooner it is used the better.

V. NITROGENE.

This gas is procured by adding nitric acid to animal muscle contained in a retort; apply heat, and receive the nitrogene or azote over water.

Nitrogene may also be separated from atmospheric air, of which it constitutes 79 per cent. by burning phosphorus in a confined quantity of atmospheric air over water, which will combine in the act of combustion, with the oxygene of the atmosphere, and form phosphoric acid, which being agitated in contact with the water, will be entirely absorbed, leaving the nitrogene. Nitrous gas also passed up into atmospheric air, confined over water will combine with its oxygene, form nitrous acid absorbable by water, and thus insulate the nitrogene.

VI. NITROUS GAS, OR NITRIC OXYDE.

Add nitric acid to either copper or tin filings, or mercury, in a retort. If the acid be undiluted, it will require no heat for its production; but if diluted with water, a gentle heat will be found necessary; nitrous gas is received over water in the usual way.

VII. NITROUS OXYDE.

Introduce into a retort a portion of the salt called *nitrate of ammonia,* and apply the heat of a spirit lamp somewhat cautiously; the salt will melt, and the liquid will soon afterwards give off the gas. If the heat be considerable, the nitrous oxyde will be disengaged with great rapidity, evolving under the form of *smoke;* but when the gas comes over more slowly and tranquilly, it is found purer than in the other case. Collect over water.*

VIII. HYDRO-CARBONIC OXYDE.

This gas was discovered by Dr. Thomson; and may be collected over water, being obtained by adding sulphuric acid to powdered prussiate of potassa in a retort. The heat of the spirit-lamp will soon effect its disengagement.

IX. CARBONIC OXYDE.

This gas is evolved from a mixture of dry carbonate of baryta and iron filings, or from oxyde of zinc and calcined charcoal, by applying a strong heat to the tube containing the ingredients. The gas must be washed with lime water to absorb the carbonic acid gas mixed with it.

Carbonic oxyde may be also obtained by mixing oxalic acid with sulphuric acid contained in a retort: the last method is the most certain and simple.

* Before the nitrate of ammonia is put into the retort, it will be advisable to reduce it to powder, and expose it in a shallow dish before the fire. This will deprive it of water of crystallization, and prevent the water rushing up into the retort, from the sudden condensation of disengaged vapour.

X. OLIFIANT GAS.

Mix together *cautiously* in a retort, of the capacity of 8 ounces, one ounce of alcohol, and four ounces of sulphuric acid by measure, adding the acid gradually, holding the retort inclined, with the ball under, and at each addition shaking the retort to mix the liquids: the mixed liquid will thus become *brown*, and a cautiously applied heat will after some time cause it to give off the olifiant gas. These proportionals, which we have always found to be the best, must be accurately observed, and great attention paid to the management of the temperature.

XI. SULPHURETTED HYDROGENE.

Mix a little proto-sulphuret of iron into a small retort, with muriatic acid: the gentlest heat, as that of a wax taper, will be sufficient to disengage the gas; as it is very noxious, and possesses a fœtid smell, none of the sulphuretted hydrogene must be suffered to escape.

XII. PHOSPHURETTED HYDROGENE.

To a solution of caustic potassa contained in a small retort, add a quantity of phosphorus cut into fragments about the size of a small pea; apply a gentle, steady heat, and do not plunge the beak of the retort* into the water-trough till a slight explosion shall have expelled

* I have found it convenient to use a small and very shallow evaporating basin supplied with water; if the beak of the retort be immersed in the water in the basin, the water will on any sudden condensation rush a small way up the stem, but be insufficient to reach the contents of the retort.

the included air. It may be collected in *small phials* over water.

This gas may be also obtained by adding muriatic acid to chips of phosphuret of lime in a similar manner.

Note.—It will always be found prudent, as a general rule, to remove the retort before the lamp is withdrawn; for if the gas be nearly expelled, the sudden reduction of temperature might cause the cold water to rush up into the retort, and effect its destruction. In removing the glass jars from over the shelf of the pneumatic trough, care must be taken not to bring them over the retort, for a drop of cold water falling on the intensely heated ball, especially in the obtainment of oxygene, would certainly occasion its immediate fracture. A bit of wet cloth or paper will be found useful in preventing the retort from slipping from its position: the beak or stem of the retort will securely rest upon it, interposed between the glass and the lip of the trough. Retorts should be set apart for specific gases, and not used indiscriminately: the gas bottle should be entirely confined to the process of obtaining hydrogene and carbonic acid gas. The deflagrating spoon, used with sulphur in a previous experiment, should not be employed for phosphorus, until the former has been entirely consumed, as an explosion might occur by their combination. The retort used for oxygene, from chlorate of potassa, must be *made* not exceeding 1 to 2 ounces capacity. The operator should observe that the ebullition in the gas bottle be regular and continued, and the gas evolved steadily, which is easily done by plunging the beak of the curved tube in water. It is proper to caution against igniting hydrogene from a tube inserted into a cork in a bottle. Such experiments are always hazardous from an almost unavoidable mixture of atmospheric air. Deflagrating jars should always have wide mouths, and be lipped: being open below, a small depth of water, will be found extremely serviceable in extinguishing the product of combustion. When phosphorus in combustion is introduced into oxygene, nitrous gas and nitrous oxyde, no attempt should be made at the close of the experiment, to withdraw the deflagrating spoon with phosphorus still burning, the light being too dazzling to do so without incurring the risque of contact with the lip of the jar as well as a portion of it being ejected on the glass. If the spoon however be plunged into the water below, it is extinguished, and all such danger obviated. Should a fragment of burning phosphorus fall on the surface of the glass, it will certainly occasion its fracture, unless *immediately extinguished.* A drop of *water* only accelerates the accident, but a little *dry sand* or *magnesia* added, would extinguish the combustion, and save the vessel from fracture. All chemical glass apparatus should be well annealed to resist sudden changes of temperature, and the cylinders should be stout, ground flat on edge, and have plates of glass ground so as to be air-tight. When a watch spring is deflagrated in oxygene, it will be prudent to have a stratum of an inch of water in the dish, as the melted scoriæ which fall frequently *penetrate the shallow porcelain tray* used to transfer the gas from the pneumatic trough.

EXPERIMENTS

ILLUSTRATIVE OF

CHEMICAL SCIENCE,

SYSTEMATICALLY ARRANGED.

OBJECTS OF CHEMICAL SCIENCE.

By means of chemistry we discover the *nature* and *properties* of bodies, and the *proportions* of their constituents; we estimate the amount and force of the powers which unite them, and of the several compounds formed under different modifications of these constituents. The agencies which produce these changes, and to which they are subordinated, form also an essential and proper branch of this science.

Indestructibility of Matter.

I. Pour a solution of caustic potassa into a vessel of carbonic acid gas, and cover it immediately with a wet bladder, then shake it, and the bladder will become hollow. Add a little muriatic acid, and the carbonic acid will re-fill the vessel.

Rationale. The bladder becomes hollow from the absorption of the carbonic acid gas by the caustic potassa, and the muriatic acid displaces the gas from its combination, while this displacement is rendered sensible by the effervescence. It is obvious the same changes may be repeated with the carbonic acid gas, *ad infinitum.*

CHEMICAL ATTRACTION AND ITS RESULTS.

CHEMICAL *attraction* takes place between bodies that are *altogether unlike each other,* or have no common character. Thus alkalis are acted on by acids; sulphuric acid combines with iron, nitric acid with mercury, and so on.

The results of such chemical action and attraction, introduce to us an entirely *new substance,* having no feature in common with the constituents, or parts which compose it. Thus the action of dilute sulphuric acid on iron gives rise to a mass of green translucent crystals; that of nitric acid on mercury produces a group of transparent needle-form crystals, *et cætera; corrosive* bodies, by combining chemically, may produce *mild salts,* of which *common salt* affords an example; colourless bodies may thus become coloured, and coloured bodies colourless; mild and inert substances may become corrosive and pungent; solids may become fluids; and even gases, as in the case of muriate of ammonia, become *concrete and solid.*

Changes produced by Chemical Agency.

I. To a solution of sulphate of iron add a little tincture of galls—*ink* will be formed.

Rationale. The blackness arises from the combination of the gallic acid with the iron — the former being found in tincture of galls, and the gallate of iron is *black.*

II. To the black mixture formed in the last experiment add a little muriatic acid, and the *colour will be discharged.*

Ration. The acid added, decomposes the ink, and separates the gallic acid.

III. To a solution of sulphate of iron add solution of hydro-cyanate of potassa, and a *prussian blue* colour results.

Ration. The hydro-cyanic acid combines with the iron, and forms hydro-cyanate of iron, or prussian blue.

IV. To a solution of sulphate of iron add a solution of chromate of potassa, and a *brown colour* will be formed.

Ration. The chromic acid in this case forms the chromate of iron, which is *dark brown.*

V. To a solution of sulphate of copper add ammonia, and a beautiful violet tint will be produced.

Ration. There is here formed an ammonia-sulphate of copper, which is of a violet tint.

VI. To a solution of the violet-coloured liquid add a little nitric acid, and the violet tint disappears.

Ration. The nitric acid separates the ammonia, and combines with it.

VII. To a solution of sulphate of copper add prussiate of potassa, and it becomes *brown*.

Ration. The prussiate of copper is formed in this instance.

VIII. To a solution of sulphate of copper add a solution of arseniate of potassa, and it becomes *green*.

Ration. The arseniate of copper is produced in this experiment, (Scheele's mineral green.)*

IX. To a small portion of protomuriate of mercury (calomel) add a few drops of ammonia — it becomes *black*.

Ration. This black powder is the protoxyde of mercury, the ammonia combining with the muriatic acid.

X. To a solution of permuriate of mercury (corrosive sublimate) add lime-water or caustic potassa, and an orange red precipitate will be formed; the change produced with the lime-water is much darker than with the potassa.

Ration. The lime-water, or the caustic potassa, combining with the muriatic acid, the *red peroxyde* of mercury is evolved.

XI. To the preceding formation add a little nitric acid, and the whole will be re-dissolved and become colourless.

* This product is almost *solid*.

Ration. The nitric acid dissolves the precipitated peroxyde

XII. To a solution of peracetate of lead (sugar of lead) add chromate of potassa, and a ***brilliant yellow*** is produced.

Ration. The chromate of lead thus formed is yellow, and is commonly known under the name of ***chrome yellow***.

XIII. To a solution of nitrate of silver add chromate of potassa, and a ***crimson*** precipitate is formed.

Ration. The chromate of silver is produced, and is of a crimson tint.

XIV. To a solution of nitrate of mercury add solution of chromate of potassa, and a ***vermilion*** tint will be formed.

Ration. The chromate of mercury herein formed is of a scarlet colour.

Note.—With salts of copper, chromate of potassa forms ***green*** chromates; and with those of tin, ***purple*** chromates.

XV. To a solution of peracetate of lead add a solution of hydriodate of potassa — ***yellow*** is formed.

Ration. The hydriodate of lead thus produced is a fine light yellow.

XVI. To a solution of permuriate of mercury add solution of hydriodate of potassa, and a ***brilliant scarlet*** ensues.

Ration. The hydriodate of mercury here produced is a brilliant red.

Note.—This colour is, perhaps, among the most beautiful ever obtained by art. It was at my suggestion, many years ago, employed in a painting, but unfortunately was not permanent.

Intense Chemical Action.

I. Pour a little nitric acid on granulated tin—a fierce action ensues from the affinity existing between them, and nitrate of tin is the result.

II. A little nitric acid on copper filings will exhibit an equally intense action, and forms nitrate of copper.

Note.—The red vapour which escapes is owing to the decomposition of a part of the nitric acid, the one portion of the decomposed quantity, namely, *oxygene*, going to the tin, or copper, to oxydize it, while the other, *nitrous* gas, evolving, combines with the oxygene of atmospheric air, and produces red vapours of *nitrous acid gas.*

III. To iron turnings, or granulated zinc, add a little water and sulphuric acid—a considerable action ensues, with the escape of an inflammable gas.

Ration. By the united action of the iron or zinc, and acid, the water is decomposed, the oxygene of the water unites to the iron or zinc, and the acid then dissolves them, forming sulphate of iron in the one case, and sulphate of zinc in the other.

Note.—It may be observed that acids do not combine with metals, unless the latter are in the state of oxydes. The oxygene may be, as in this case, obtained from the decomposition of the water, or from that of the acid, as exemplified in the action of nitric acid on mercury in the production of nitrous gas.

IV. Into dilute sulphuric acid throw a portion of solid carbonate of ammonia—the carbonate of ammonia will move up and down for some time, giving off a train of numerous minute air bubbles, and will finally be completely dissolved.

Ration. The sulphuric acid attacking the carbonate of ammonia decomposes it, and while the carbonic acid gas is disengaged with effervescence, the sulphate of ammonia is formed.

V. To carbonate of soda, dissolved in water, add muriatic acid, a considerable effervescence is produced.

Ration. By the action of the muriatic acid, the muriate of soda, or *common salt* is formed, while the carbonic acid gas is disengaged.

VI. Drop sulphuric acid on strong ammonia, the action is exceedingly fierce, and the liquid is dispersed in vapour.

Ration. The affinities here are very energetic, producing a degree of temperature above the ebullition of water. Sulphate of ammonia is formed.

Note.—The action here is so fierce, that considerable caution is necessary in making the experiment.

VII. Powder some nitrate of copper, and place it on tin-foil, then sprinkle it with water and fold it up rapidly and tightly—much smoke will be evolved with occasional sparks.

Ration. The superior affinity which the nitric acid has for the tin, compared with that which it has for the copper, its first combination, is so much more intense that this spontaneous combustion is the result.

VIII. Mix a little chlorate of potassa with alcohol or ether in a small evaporating dish; pour a little sulphuric acid over it, and it will burst into flame.

IX. Powder sugar-candy and a little chlorate of potassa *separately*, then mix them intimately on a porcelain tile, add a few drops of sulphuric acid, and the whole will burst into a brilliant combustion.

Ration. In experiments No. VIII. and IX. a peculiar elastic gas, of an *orange tint*, called deutoxyde of chlorine, is formed, which ignites these inflammable substances.

Simple Affinity.

By *simple affinity* is to be understood the decomposition of a compound, by the addition of some substance capable of detaching, by superior power, one of its constituents, thus forming a new combination; the constituent separated, will be, commonly speaking, *simple;* and will sometimes be precipitated or thrown down; at other times held suspended, if soluble, while the new compound will be precipitated.

Analysis implies the separation of a compound into its simple or constituent parts. *Synthesis*, the reproduction of the compound, by conjoining the constituents.

I. To a solution of sulphate of iron add a portion of solution of caustic potassa, a *reddish brown* precipitate will be formed.

Ration. The caustic potassa has a superior affinity for the sulphuric acid than for the iron, in consequence of which the sulphate of potassa is formed, and held in solution, while peroxyde of iron is thrown down.

II. To solution of camphor in alcohol add water, the camphor ascends and floats in a solid form.

Ration. The water having a superior affinity for the alcohol, than the alcohol has for the camphor, combines with it, and frees the camphor from its combination with the alcohol. The solution of camphor in alcohol is not, strictly speaking, *chemical,* but it affords a simple illustration.

III. To solution of sulphate of magnesia add solution of caustic potassa, white flocculi are precipitated.

Ration. Sulphate of potassa remains suspended in solution, and flocks of caustic magnesia fall down being insoluble.

Compound Affinity.

This kind of affinity is called complex or compound, because in order to effect the decomposition or separation of the constituents, the substance added, for this purpose, must be compound, and the resulting new products will be severally compound.

I. To a solution of sulphate of alumina (alum) add peracetate of lead, (sugar of lead) in solution. Here an abundant white precipitate is formed.

Ration. A little acetic acid added to solution of alum produces no change; but in *combination with lead* the decomposition is effected. The sulphuric acid leaves the alumina, and forms, with the lead, sulphate of lead, which is thrown down as an insoluble precipitate; while the acetic acid, disengaged from the lead, combines with the alumina, and is held in solution above, and thus sulphate of lead (insoluble) and acetate of alumina (soluble) are formed.

Repulsion.

I. Place a piece of money in a vessel of water, and scatter lycopodium* over the water. The money may be withdrawn without the hand being wet.

Note.—Repulsion is generally connected with the intervention of some foreign or extraneous body, but is less equivocally displayed in the phenomena of magnetism and electricity.

* The dust or seed of the *lycopodium clavatum*, or club moss. It is exceedingly inflammable, and is used extensively in Chinese fireworks. It is also employed to mimic lightning in theatres; and used in Germany by apothecaries for pills, instead of liquorice powder or magnesia.

II. Olive oil floats on water, or sinks in alcohol, without admixture in either case. There is no chemical affinity, and they consequently separate, agreeably to their respective specific gravities.

CALORIC.

Free or Uncombined.

The *agent* producing heat is termed *caloric,* to distinguish it from the *sensation* produced. In its free or uncombined form, it expands or dilates bodies; hence, by the absorption of heat, solids become liquids, and liquids again become vapours. Caloric tends to diffuse itself equally around, radiating into free space, and extending to all objects. The phenomena of the thermometer depend on the equable and uniform expansion of the included mercury, as affected or acted on by uncombined or free caloric.

I. Invert a ball, with a long stem containing water, coloured with sulphate of indigo, and pour into the stem a little sulphuric ether, then plunge the orifice of the stem, thus inverted, into water: the ether will ascend and occupy the superior part of the ball. Pour over it, boiling water, and the ether, expanding into an elastic form by the heat, will expel the coloured water. If, after this, cold water be poured over it, the column will re-ascend.

Ration. This experiment proves the expansion of bodies by heat.

II. Take a cylinder of brass, previously fitted to a gauge both in diameter and length, *heat* the cylinder, and it will no longer enter the gauge either way.*

Ration. This clearly proves that metals expand equally every way, and the cause of this uniform expansion is thus referrible to heat. Hence a metallic rod, on being heated, will not pass through a ring, which it accurately fitted when cold.

Conduction of Metals.

I. Take the cylinder used in the preceding experiment, and wrap a slip of writing paper round it; introduce it into the flame of a spirit-lamp, and the paper will not be consumed. Substitute this metallic cylinder by one of *wood*, and the paper will then be charred.

Ration. The metallic cylinder conducts away the heat, and prevents the impression of flame, while the wood, being without this property, the paper is necessarily charred. Thus, too, may a *leaden bullet* be melted, being closely wrapped up in paper, and held in flame. Sand, charcoal, and glass are examples of non-conductors of heat.

II. If the ends of bars of different metals be coated with bees' wax, and the other extremities be plunged

* See the Figure.

into heated sand, it will be found that the different portions of wax will be melted in different periods. By this experiment it will be proved, that silver and copper are superior conductors to platinum and iron.

Ration. The caloric being transmitted more easily and promptly by copper and silver than by platinum or iron, will sooner melt the wax, and a greater portion of it will be found dissolved in a specific period.

III. Take iron, copper, and silver rods, pass them through an arch of wood, so that at the superior end they may diverge (fan-like), the other ends being brought together to a point. If the further ends are supplied with a small fragment of *amadou*,* moistened with phosphorus dissolved in sulphuret of carbon, while the lower united points are introduced into the flame of a spirit-lamp, it will be seen that the pieces of amadou will inflame in order, according to the conducting power of the metals to which they are affixed: as silver, copper, iron.

I have found this a more elegant and striking method of illustrating the principle than the former.†

Conduction of Water.

I. Take the temperature of water contained in a glass basin, pour over it a portion of sulphuric ether, and then

* Boletus ignarius, or German tinder.

† See the Figure.

inflame it;—though a considerable flame will be produced, yet, on its extinction, ***no additional temperature*** will be discovered in the water.

Ration. It is quite clear that in this experiment the water did not conduct the heat downwards by its surface, though metals conduct heat in every direction. Boiling water may remain incumbent on cold water, and water be boiled in contact with ice, the latter remaining solid.

Latent Caloric.

Latent caloric is a peculiar state of heat wherein it may be considered as in chemical combination with a substance, but incapable of affecting the thermometer. Thus snow may indicate a temperature of 32° F.; but, after being exposed to the fire until it is ***entirely liquefied,*** the water will still exhibit the same temperature. When there is an ***increase*** of density by mixture or combination, heat is evolved; but when there is an ***increase*** of mass or volume, or a decreased density, the temperature is lowered.

I. Mix equal parts of water and sulphuric acid together, ***cautiously:*** a very considerable heat is produced, and on re-measuring the liquid it will be found that it has ***decreased in volume.***

Ration. When bodies become more dense or more solid, heat is produced: the temperature thus sensibly evolved, must have been *latent* in the liquids, their mixture disengaging the heat.

Note.—There is a long tube, terminating in a double ball at the top with a stopper, employed for this illustration.* Sulphuric acid is poured in so as to fill the tube and lower ball: the upper ball is again filled up with water, and the stopper replaced: on inverting the apparatus the decrease of volume is seen.

II. Condense air smartly on a bit of amadou, by means of a small syringe, and it will inflame it.

Ration. Here the heat is liberated from the air by being compressed into a smaller space, and becomes thereby more dense.

III. Mix common salt, or nitrate of potassa, &c. in water, and the thermometer will sink considerably.

Ration. Here the melting or solution of the salt in water lessens or attenuates its density or solidity—and *cold* is the result. When snow or ice melts, cold is felt in the transition from solidity to a liquid form. Therefore, cold, or the absence of heat, is the result of a change of state from a solid to a liquid form, or that of vapour.

IV. Mix fresh fallen snow and muriatic acid together, and plunge a Florence flask, containing water, into the mixture: the water will soon be converted into ice. Dr. Wollaston's *cryophorus*, which shows the curious phenomenon of freezing at a distance, will exhibit the same result.‡

* See Figure. ‡ See Figure.

Ration. Here is still an attenuated density, and the result is cold. In like manner, the solution of various salts in water, as nitrate of potassa, sulphate of soda, muriate of ammonia, &c. (as in Experiment III.) produce freezing mixtures sufficient even to congeal mercury.

V. Equal parts of water and of nitrate of ammonia will reduce the temperature from 50° to 4° F.

VI. Ice, say at 32°, and water at 172°, will cool the mixture down to 32°; hence 140° of temperature are lost, and have become *latent*.

VII. If water be boiled in a retort, and the beak be immersed in a tumbler of cold water, the disengaged steam will raise the water to the boiling temperature; and the water will thus be seen to boil at a distance from the source of heat. This method of heating by means of steam is extensively employed in manufactories.

VIII. If cold water be thrown on a lump of quicklime from the kiln, the heat produced in *slacking* will be sufficient to set phosphorus on fire, or, at any rate, its solution in sulphuret of carbon.

Note.—These experiments all show the absorption and evolution of heat as connected with *change of volume*.

Evaporation, a Source of Cold.

I. Wrap a little lint, or tow, round the ball of a thermometer, and dip it in ether; the liquid will sink considerably in the stem, an effect which will be accelerated by a cold current of air.

Ration. The sulphuric ether robs the ball of its caloric, and is volatilised in consequence of this abstraction of heat, the current of air accelerating the effect.

II. If the ball of a thermometer similarly supplied with tow, be moistened with sulphuret of carbon, and placed in the receiver of an air-pump, a spirit-of-wine thermometer will be soon reduced to 72° below 0°, or 104° below freezing.

When Mr. Towson's little instrument represented in the plate, diverges by heat, sulphuric ether applied, causes the wires to collapse instantaneously.

Radiation of Caloric.

I. In the focus of a concave reflector of tin or copper, put a red-hot ball, or other heated body, then place another reflector opposite, the distance between them being several feet. If a thermometer be placed in the focus of the reflector opposite to that with the heated body, it will show an elevation of temperature. Leslie's differential thermometer is, from its sensibility, best adapted to this experiment.

Ration. The radii of heat emanating from the ball impinging on the reflector immediately behind, are reflected to the one opposite, and from thence converge on the instrument.

II. If a slip of paper be dipped into solution of phosphorus in sulphuret of carbon,* and placed in the situation of the thermometer in the last experiment, it will inflame in a few seconds.

Light.

Opinion has been much divided on the nature of light. Some have considered it as composed of material parts, or particles, while others view the phenomena of light as the effect of undulatory motion. When light is evolved in the case of phosphorescence excited by heat, as in *chlorophane, Canton's phosphorus,* &c., I decidedly consider it to be the effect of *thermo-electric agency.*

Note.—This view of phosphorescence has since the publication of the second edition in 1830, where it was first propounded, been experimentally verified.

I. Flint and steel, or steel and an alloy of iron and antimony, on being struck together, emit sparks that are luminous.

Ration. Hence collision produces light. Quartz peebles also emit light when struck, and pieces of rattan cane, by similar collision, exhibit sparks.

II. If a bit of sugar be simply broken between the fingers in the dark, light is produced at the moment of fracture.

* This solution I have proved to be very valuable in detecting minute quantities of evolved caloric, having found it to inflame at a temperature not exceeding 80° F.

III. If powdered *fluor spar* be strewed on a heated plate, it will be luminous in the dark; and the same phenomenon will ensue on throwing it on a surface of heated oil.

Ration. Hence temperature has the power of evolving light from certain bodies.

IV. Canton's phosphorus, when thrown on a heated metallic plate, yields light. Even some liquids when heated become luminous.

Note.—I have found that Canton's phosphorus becomes beautifully phosphorescent in contact with a surface of mercury when introduced into the electric circle of the Galvanic Battery.

Flame.

I am inclined to consider flame as the tranquil exhibition of ignited vapour entering into new chemical arrangements; the continuity of flame being supported by successive supplies of inflammable matter flowing from its source.

I. Pour some alcohol into a watch-glass, inflame it, and stretch a thread of platinum wire across, it will appear ignited only at the *exterior surface* of the flame.

Ration. *Flame is hollow,* and consists of a mere superficial film, hence the platinum wire is not ignited in the *central part,* where *no flame exists.*

II. Place a straw across this flame, and it will be only ignited and charred; as in the preceding example, at the outer edge.

III. Introduce gunpowder (in a small platinum spoon) through the flame into the interior, and it will remain there for a few seconds unconsumed.

Ration. It is thus evident that there is no ignited matter in the centre of the flame.

IV. Introduce a chip of camphor under similar circumstances, and it will not burn.

Ration. There can therefore be no *oxygene* in the interior to support flame. In this experiment the camphor vaporizes and imparts to the flame a greater illuminating power.

V. Introduce a chip of phosphorus into this flame, it will not burn, and *if* inflamed previous to introduction it will be immediately extinguished.

Note.—A *platinum* spoon must not be used in this experiment as phosphorus corrodes it.

VI. A glass tube introduced into the centre of this cone of flame, becomes the medium of the escape of inflammable vapour, which may be ignited at the upper orifice.

Ration. The foregoing experiment proves that the interior of flame is charged with inflammable vapour.

Intensity of Flame.

*I. Pour a little sulphuret of carbon into a watch-glass, and kindle it, a brush of steel wire will burn beautifully, on its introduction into this flame.

Ration. This proves the flame to be exceedingly intense. I have burnt even a watch-spring in it.

Coloured Flames.

I. Kindle alcohol holding in solution nitrate of copper, in a watch-glass. It will burn with a *green* flame.

II. Alcohol, holding common salt in solution, when kindled, yields a *yellow* flame.

III. Alcohol, with nitrate of strontia in solution, burns with a *red* flame.

IV. Alcohol, with muriate of baryta in solution, yields a *yellow* flame.

V. Alcohol, with boracic acid gives a *green* flame.

VI. If a portion of alcohol and chlorine, or muriatic or nitric acid with alcohol be ignited in an iron ladle, over the flame of a spirit-lamp, it gives a bluish green flame, striped; forming a beautiful phenomenon.

Ration. The colour imparted to flame seems generally dependant on the nature of the *base* of the substance mixed with the alcohol.

Combustion.

Combustion may be defined as a phenomenon altogether independent of the distinction of supporters of combustion and inflammables; but is connected with change of volume or mass; its amount will be in some ratio of the rapidity or energy of the chemical changes superinduced: the *heat* and *light*, which are the accompaniments of combustion, seem to be mere manifestations of this intense chemical action.

I. If an ignited taper be plunged into a jar of oxygene, it will burn with great intensity and beauty.

Ration. Oxygene is an eminent supporter of combustion, and combines energetically with the constituents of the burning material.

II. Place a chip of phosphorus in an iron deflagrating spoon; kindle, and introduce it into oxygene—the light is most intensely vivid, and scarcely supportable by the eye.

Ration. Phosphorus is a substance exceedingly inflammable, and combines with oxygene, at exalted temperatures, with extraordinary energy.

III. Throw powdered antimony into a long tube filled with chlorine, and it will fall like a shower of burning stars of a yellow light.

Ration. This experiment proves that previous ignition is not a necessary auxiliary to combustion.

IV. Put a small portion of iodine into a Florence flask with a chip of potassium, and heat the flask cautiously—the iodine will rise in vapour, and the potassium will seem to burn with a violet flame, from the medium through which it is seen. The flask in this experiment is generally fractured.

Ration. This experiment proves that combustion can be maintained in other media than those of oxygene and chlorine.

V. Throw a chip of potassium on *ice*, and it will burst into flame.

Ration. Here combustion is the consequence of the abstraction of oxygene by the metal and combination with it.

Note.—In one experiment, I pressed the potassium on a disc of ice with a penknife, when the blade became ignited throughout its extent.

VI. Put a small portion of phosphorus into a deep glass with as much cold water as will cover it, then fill it up with *hot* water, and the phosphorus will be seen to melt. Press, from a bladder, through a small metallic pipe, a stream of oxygene on the phosphorus,* and a brilliant combustion will ensue *under water*.

Ration. In this case the oxygene is brought into contact with phosphorus, at an elevated temperature,

* In every experiment with phosphorus, the greatest caution is necessary. It must be cut *under water*, and carefully preserved in a phial of water, *contained in a tin case;* for fear of accidental fracture.

and the conditions of combustion are provided independent of the surrounding medium.

VII. Throw into water, contained in a cylindrical glass of small diameter, a portion of chlorate of potassa, and add a small quantity of phosphorus, cut into chips about the size of a hemp seed, then, by means of a long funnel passing through the water, pour in a little sulphuric acid, and a beautiful *combustion under water* will ensue.

Ration. In this experiment the sulphuric acid decomposes the chlorate of potassa, and the supporter is brought into contact with the phosphorus; the acid and water mixing, produce increased heat which melts the phosphorus.

Note.—Deutoxyde of chlorine is the efficient supporter in this instance.

VIII. Into a Florence flask put some sublimed sulphur, and with it Dutch foil (copper leaf), then heat the flask—the sulphur and copper will combine with energy, and evolve flame.

Ration. Here the phenomena of combustion are displayed independent of a *supporter*, resulting entirely from the combination.

IX. Into a Florence flask, containing a little sulphur, introduce a chip of potassium, and heat the flask by a spirit-lamp; the combination will be attended with combustion, accompanied by flame.

Ration. Here, as in the preceding experiment, combustion is the result of the combination.

X. Substitute sodium for potassium, as in the last experiment, and a beautiful combustion will ensue—more energetic than in the former case.

Ration. The explanation is similar.

**Note.*—If the flask with the potassium and sulphur, or sodium and sulphur, be *withdrawn* from the spirit-lamp at the moment the sulphur melts, and smoke evolves within the flask, a fine combustion will ensue on the combination taking place. These phenomena occur when the subjects of experiment are excluded from contact with air or any other supporting medium, as when insulated by a film of oil of olives, or vapour of naptha.

XI. Wrap up a portion of antimony in a slip of platinum foil, and hold it in the flame of a spirit lamp; by a pair of forceps. So soon as a dull red heat is communicated, a brilliant combustion suddenly ensues, and the newly-formed alloy of platinum falls down in a melted form, or is dispersed in ignited globules.

Ration. Here combustion is the result of the combination of two metals in the formation of an alloy.

XII. Substitute granulated tin for the antimony, and the beautiful combustion is attended with brilliant minute globules, that are scattered in all directions.

Ration. The combination of the tin with the platinum is the cause of the combustion exhibited. Lead, bismuth, &c., may be substituted for the tin, or antimony, in the previous experiment.

Note.—The spirit-lamp must be *guarded* by a plate of tinned iron passing over the lamp, and resting on its neck, to prevent *fracture.* The experiment of *zinc and platinum,* I know from experience, is *too dangerous* to be hazarded.—There is a caution connected with the foregoing experiments which it may be useful to mention; a *platinum spoon* must on no account be used to melt a fragment of tin, antimony, lead, &c., as *both* would assuredly fuse together.

XIII. If an alloy of potassium and sodium be brought into immediate contact with a small portion of mercury, in a watch-glass, combustion follows.

Ration. The product is an *amalgam*, wherein the two metals are chemically combined with mercury.

XIV. Relative combustibility may be thus exhibited: — allow a taper to burn out in a confined volume of atmospheric air, introduce inflamed sulphur into this medium, and permit this flame also to expire. Phosphorus will still continue to burn in this last atmosphere, being kindled previous to introduction.

Safety Lamp.

I. Introduce Davy's safety-lamp slowly into a large jar containing a little sulphuric ether, the vapour of which will partially fill it, if previously covered for a short time. The wick-flame will be seen to extend itself in the form of a lengthened spire; and, as the lamp is lowered, be encompassed by a dilute foreign flame;—this last becomes insulated, the wick-flame in the mean time being extinguished. Finally, the foreign flame which *entirely possessed* the cylinder, will be extinguished also.

Note.—This experiment forms an additional illustration of the *hollowness* of flame, evincing the non-existence of flame within flame. This volume not being intended as controversial, or theoretic, it may be simply here stated that I differ *toto cœlo* from the explanation given by Sir H. Davy of this invention, believing, as I do, that the phenomena presented by the miners' safety-lamp are alone satisfactorily explicable on the supposition that they are entirely dependant, not on any supposed *cooling* influence, but on the combined agencies of an admixture of the products of combustion with the explosive atmosphere which enters the cage, together with the rarefaction and attenuation of this inflammable mixture, by the *heated* wire-gauze. For a more elaborate discussion of the question, and defence of this new view, I must refer the reader to my "Practical Observations on Flame and Safety-Lamps."*

II. Bring a piece of wire-gauze over a gas flame, or flame of alcohol, it will *spread below*, but not pass through the gauze, though much inflammable vapour will escape, and may be kindled above.

Ration. This is a fine proof of the non-passage of flame through wire-gauze. I have also found that *muslin, haircloth, &c.*, can intercept flame.

III. Over the wire gauze used in the last experiment, place a portion of camphor, and bring it over flame; the camphor will melt and pass through, and flame will attach to the *under* surface. Apply a taper above, and it will take fire there, and burn with flame.

Ration. This also affords another striking proof that flame will not pass through wire-gauze.

* London, 8vo. 1833.

Aphlogistic Phenomena.

May be defined as combustion without *flame.*

I. Pour a little sulphuric ether into a narrow glass, then coil up platinum wire at one end; ignite the coil and introduce it into the vessel, it will continue to glow and exhibit light without flame.

Ration. This curious and singular phenomenon, accompained by a phosphoric flame, dilute and lambent, is owing to a slow or inferior combustion—a volatile acid matter being evolved.

II. Mr. Daniel Ellis, of Bath, has invented an aphlogistic lamp, by attaching a few rings of platinum wire to a spirit-lamp with a minute wick: when the lamp is kindled, the rings are also ignited; if the flame be blown out, or extinguished by a momentary application of the cap, the coil still remains ignited; and on bringing a small jar of oxygene over it, the lamp will be rekindled.

Ration. The phenomenon is dependant on the same principles as the preceding. This lamp has been recommended for the sick-room, but from the *pungent vapour* developed, it ought to be entirely discarded.

Note.—It is erroneous to say that "platinum and palladium, metals of *low* conducting character for heat, alone succeed in producing this phenomenon." Professor Sementini, of Naples, shewed me, in 1818, that both *silver* and *copper*, eminent conductors of caloric, produced aphlogistic phenomena; and in 1819, on my return through Paris, I shewed experiments with the former metal to M. Robiquet and other Sçavans, as well as to several of the professors of the university of Aberdeen, subsequently. Mr. Herapath, of Bristol, told me that he had observed the same thing with brass wire; and if I mistake not, Dr. Thomson, of Glasgow, stated also that he had succeeded with finely divided gold. Mr. Ellis *first* observed the acid product obtained from the aphlogistic lamp, incorrectly assigned to Mr. Daniel. When *Eau de Cologne* is substituted for the alcohol, an odoriferous vapour is disengaged. Spirits of turpentine, under such circumstances, continually evolves smoke, though the rings are not visibly ignited. Mr. Merryweather, of Whitby, has applied a combination of twelve of these lamps to sustain, for an indefinite period, a uniform temperature of 360° F. A *green* taper may, if not properly extinguished, smoulder away gradually, and be productive of serious injury: this effect is aphlogistic, the colour being produced by acetate of *copper*.

SUPPORTERS OF COMBUSTION,

OR

ELECTRO-NEGATIVE BODIES.

Supporters of combustion are *media*, in which inflammable bodies burn, from the continued support derived from them, Sometimes the combustible body is *spontaneously* ignited by being brought into contact with the supporter; at other times, it must be kindled previous to its introduction. Copper leaf, antimony, &c., spontaneously inflame in chlorine; but sulphur, phosphorus, &c., must be set on fire before their immersion into à medium of oxygene. The energy of combustion most likely depends on relative chemical or electrical affinities, which will necessarily be enhanced if the grade of previous ignition be considerable. This class of bodies is called *Electro-negative,* because they are evolved at the positive pole of the galvanic circle,

I.—*Oxygene.*

I. Extinguish a taper, and while the wick remains red-hot, plunge it into a vessel of oxygene; it will be rekindled, and burn with brilliancy.

Ration. The supporter of combustion is thus made to combine with the inflammable base at a red heat—

its energy being thereby increased, it is exalted into flame.

II. If a slip of paper be kindled and the flame extinguished, the red-hot paper will be rekindled. This experiment may be many times repeated with the same supply of gas.

Ration. The explanation of the last experiment applies equally here.

III. If a piece of steel wire, coiled up in a spiral form, having a fibre of cotton dipped in sulphur attached to its extremity, be kindled, and introduced into oxygene, it will burn with intensely vivid and beautiful coruscations, till wholly consumed; and if the oxygene be pure, (as that obtained from chlorate of potassa,) a watch-spring with sulphur, &c. applied to the tip and kindled, when introduced will be consumed in a most striking and brilliant manner; the interior surface of the glass will be lined with a *red powder*, while scoriæ, being a combination of protoxyde and carburet, will fall.

Ration. In these experiments the iron combines with the oxygene, and forms the peroxyde of iron *(red)*, exhibited as a deposit on the inner surface of the glass, and the carbon of the steel forms, with another portion of the oxygene, carbonic acid gas.*

IV. If a portion of charcoal, of the bark of birch-wood, be kindled at the edges, and introduced into

* The globules of melted scoriæ which fall down are complex in their constituents, and rendered still more so in passing through the water at the bottom.

oxygene, the entire vessel will be filled with the most vivid and beautiful sparks.

Ration. The carbon thus unites with the oxygene, and forms carbonic acid gas.

Note.—Alcohol, camphor, ether, &c. being ignited and introduced into this gas, burn with increased energy and expanded flame. Also alcoholic solutions of nitrate of copper, boracic acid, &c., yield brilliant coloured flames.

II.—*Chlorine.*

I. A portion of *metallic* arsenic thrown into a tube of chlorine, will exhibit a fall of *white* stars.

Ration. In this beautiful spontaneous combustion the *chloride of arsenic* is formed.

II. Heat a portion of mercury in a deflagrating spoon to ebullition, it will exhibit flame on being introduced into chlorine, and continue to burn for some time.

Ration. At this temperature inflammation ensues, and a *chloride of mercury* is formed.

III. Zinc, tin, and other metals when heated, become ignited on introduction into chlorine.

IV. If a small portion of potassium be thrown on water, with this gas superincumbent, it will inflame in contact with the water, and the *potassiated hydrogene,* spontaneously inflammable, is supported by the medium of chlorine.

Ration. This experiment also proves the claim of chlorine to rank with supporters of combustion.

V. If a small portion of phosphorus be introduced, it will be spontaneously inflamed.

Ration. A chloride of phosphorus results from this spontaneous combustion in chlorine.

Note.—A solution of phosphorus in sulphuret of carbon will also spontaneously inflame.

VI. An inflamed taper introduced into chlorine burns with contracted dimensions, the flame is a blood-red colour, and evolves much smoke. This flame is extinguished on the taper being withdrawn.

Ration. This shows, with respect to the combustion of a *common taper*, a diminished power of supporting combustion. The products are carbonaceous matter in the form of smoke, and muriatic acid gas from the combination of the chlorine with hydrogene.

VII. Inflamed alcohol, ether, &c. will also burn in chlorine.

VIII. If a piece of coloured cloth, as for instance blue or green calico, be wetted and introduced into chlorine, the *colour will be discharged*—hence the application of this gas to bleaching.

Ration. Here the hydrogene seems abstracted from the water by chlorine, forming muriatic acid gas, and the oxygene, the other constituent of the water, thus destroys the colour, from the formation, it is probable, of deutoxyde of hydrogene.

IX. A red rose, or blue, &c., flowers, will be beautifully blanched in chlorine.

Ration. The preceding explanation applies here.

X. Manuscript on paper will be immediately destroyed by the contact of this gas.

Ration. The same decomposition takes place here, but printed books are not affected, as printers' ink contains oil, its carbon resisting the action of the gas.

Note.—Oxalic acid may be successfully employed to remove ink stains.

XI. Copper leaf introduced into chlorine kindles immediately, burning with a yellow flame.

Ration. The energy of copper, in relation to chlorine, is here exemplified—a chloride of copper is formed.

Note.—Metallic, &c., chlorides are generally converted into *muriates* by contact with *water*. There are, however, *solutions* of of chlorides, as those of lime and soda, extremely valuable as *disinfecting agents*, and introduced with the greatest success by M. Delabarraque. It may be observed that chlorine is nearly passive on colours when *dry*.

XII. If a slip of paper, moistened with spirits of turpentine, be immersed into chlorine, it inflames immediately, with evolution of much smoke.

XIII. If a little chlorine be passed up into a cylinder containing sulphuretted hydrogene over water, a decomposition will ensue, and sulphur be deposited.

Ration. Here the chlorine, combining with the hydrogene, forms muriatic acid gas, which is absorbed, and the sulphur is freed from its combination.

Note,—This well illustrates the application of chlorine as a counter-poison in infectious diseases, or contagion, and is the principle of Guiton de Morveau's preservative phial—the septic aerial poison being destroyed by decomposition. A still more striking experiment is exhibited, under the same circumstances, with arseniated hydrogene, a flash of purplish light ensuing, and a brilliant metallic film of reduced arsenic lining the cylinder.

XIV. If equal volumes of chlorine and hydrogene be kindled, an explosion ensues, and vapour is exhibited.

Ration. In this experiment muriatic acid gas is formed, being composed of equal volumes of these gases, thus forced into intimate chemical combination—the vapour-like appearance is owing to the combination of muriatic acid gas with the aqueous particles of the atmosphere.

III.—*Iodine.*

I. If a small portion of iodine be heated in a globe by a spirit-lamp, it will rise in a violet coloured vapour.

Ration. Iodine sublimes at a temperature of 158° Fahrenheit, and condenses on the cooler surface of the flask in the form of octohedral crystals: its purity may be thus determined.

II. If a chip of phosphorus, quite dry, be brought into contact with iodine in a watch-glass, inflammation immediately ensues.

Ration. This combustion results from the heat extricated in the combination, being sufficient to kindle the phosphorus.

III. If a portion of iodine be thrown into liquid ammonia, and allowed to remain there several hours, it forms a brownish-looking mass, which must be taken out of the liquid, and divided into small portions. This being allowed to dry on blotting-paper, is fraught with detonating properties of an extraordinary kind, and very violent.

Ration. The *iodide of azote* is formed, which is a substance so susceptible of explosion, that the contact of a slip of paper, or drop of water, or even * letting it fall through the atmosphere is sufficient to cause it: it also explodes on the contact of solution of phosphorus in sulphuret of carbon, which *it inflames.*

IV.—*Bromine.*

I. When phosphorus, or solution of phosphorus in sulphuret of carbon, is brought into contact with bromine, immediate combustion ensues.

Ration. This adds another illustration to the phenomena which belong to supporters of combustion.

Bromine is an electro-negative principle of comparatively recent introduction.

II. When antimony, and some other metals, are projected into bromine, they burn spontaneously.

INFLAMMABLE AND ACIDIFIABLE,

OR

ELECTRO-POSITIVE BODIES.

Inflammable bodies are such as are capable of being set on fire, and will continue to burn, provided they be placed in a medium capable of supporting their combustion, but are themselves unable to support combustion. Inflammable and acidifiable bodies are evolved at the *negative pole* of the galvanic battery, and are imbued with *positive* electricity.

I.—*Hydrogene.*

I. Hydrogene may be inflamed on bringing a lighted taper near to the mouth of a vessel containing it.

Ration. This particular species of air is thus proved to be inflammable.

II. Bring a cylinder containing hydrogene in an inverted position over a candle—it will inflame, and if depressed, the flame of the candle will be extinguished.

Ration. This proves its levity to be much greater than atmospheric air, while at the same time, though it burns, being inflammable, yet extinguishes flame, and is therefore not a *supporter* of combustion.

III. This gas, from its inferior specific gravity, may be collected in an inverted cylinder, without the intervention of water—a taper may be passed up into this gas, which it kindles at the lower orifice, but the flame of the taper is extinguished in it as a medium: when withdrawn, it is rekindled on its issue into the atmosphere, by the still flaming gas.

Ration. The foregoing experiment illustrates the superior levity of hydrogene, its inflammability, and its non-supporting character as a medium.

IV. If soap-bubbles be inflated with hydrogene, they will ascend, and may be inflamed in their ascent.

Ration. This, while it demonstrates the levity of hydrogene, exhibits the principle of a balloon.

V. If a narrow tube of glass, &c., be brought over a minute jet of the inflamed gas it will produce very singular intonations.

Ration. This is evidently the effect of a vibratory motion communicated to the flame by the air entering from below. The tube is heated before the intonations commence, and the flame is evidently in a state of vibration.

VI. A miniature balloon, formed of the distended craw of a turkey, or of gold-beater's skin, when inflated with hydrogene, will ascend.

Ration. This, while it explains the principle of aërostation, demonstrates (as in Experiment IV.) the extreme levity of hydrogene.

II.—*Carbon.*

I. Charcoal, when ignited and introduced into oxygene, becomes vividly red-hot, though without flame.

Ration. This combustion is the effect of chemical energy and combination at an exalted temperature

II. A fragment of diamond enveloped in a tissue of fine platinum wire, if previously intensely ignited, and introduced into oxygene, continues to burn, its product being carbonic acid gas, without change of volume.

Ration. This experiment demonstrates that the diamond is pure *carbon,* unassociated with hydrogene.

III.—*Sulphur.*

I. Sulphur, melted and inflamed in the deflagrating spoon, burns, when introduced into oxygene, with a blue atmosphere.

Note.—This combination gives rise to *sulphurous* acid, which may be ascertained by immersing moistened litmus paper into the vessel, the blue test paper becoming *red.* It is this gas, produced in the ordinary combustion of sulphur in a confined space, as in a close chamber, which is used to whiten silk, and blanch straw and flannel.

II. If inflamed sulphur be plunged into a cylinder containing carbonic acid gas, it is extinguished, but rekindled on its removal into the atmosphere.

Ration. This proves that inflamed sulphur cannot decompose carbonic acid gas, or overcome its negative relations, though its temperature is sufficiently high to continue in combustion, in contact with atmospheric air.

III. If inflamed sulphur be introduced into a jar of nitrous oxyde, it burns with a blue flame, and *rose-coloured* fringe.

Ration. Sulphurous acid gas, mingled with nitrous gas, are the products.

IV. If eight or ten parts of sulphur are burnt with one of nitre in a close vessel, and condensed by water, tinged blue with tincture of litmus, it will be changed to *red.*

Ration. Sulphuric acid is formed by this act of combustion, and is dissolved in the water.

IV.—*Boron.*

I. Boracic acid, dissolved in alcohol, burns when kindled with a *green* flame.

Ration. This green flame is characteristic of *Boron,* the base of boracic acid.

V.—*Phosphorus.*

I. If characters be described on a board with phosphorus, they will be *luminous* in the dark.

Ration. This is the effect of a slow combustion, with the production of phosphorus acid, as is evident when we write on *blue sugar-loaf paper,* the characters being *red.*

Note.—Phosphorus, when allowed to remain for some time in carbonic acid gas, imparts a luminous property to it, but a stick of phosphorus emits no light, in pure desiccated oxygene, until azote or carbonic acid gas be introduced.

VI.—*Azote.*

I. A lighted taper being introduced into this gas is extinguished.

Ration. This shows its negation with respect to flame, azote being distinguished by *negative,* rather than by positive properties. It soon escapes from the cylinder, and does not render lime-water turbid. These last properties more immediately distinguish it from carbonic acid gas.

Sulphuret of Carbon.

I. A small portion of sulphuret of carbon may be made to float on water, and be inflamed while thus floating.

Ration. This shows its comparative specific gravity, though a small portion of the sulphuret will fall through the water, and I have found that a chip of phosphorus being brought into contact with it in this condition, will combine and form a *fluid* compound.

II. If sulphuret of carbon be inflamed and plunged into oxygene, it burns with a fierce and expanded flame.

Ration. The products of its combustion in this medium are carbonic acid gas and sulphurous acid gas.

III. The flame of sulphuret of carbon expands, and is fringed with rose-colour, in nitrous oxyde.

Ration. Carbonic acid gas, sulphurous acid gas, &c., are the products in this instance.

*IV. If a drop of sulphuret of carbon be introduced into a cylinder of oxygene, it will diffuse, and produce an explosive atmosphere, which may be kindled either by the contact of flame, or that of a chip of potassium thrown into the cylinder, having a small portion of water at the bottom.

Ration. The products of explosion are sulphurous and carbonic acid gases.

COMPOUND GASES.

I.—*Nitrous Oxyde.*

I. If a taper be plunged into this gas, it will burn nearly as in oxygene.

Ration. This shows it to be a supporter of combustion.

II. A chip of potassium, or sodium, thrown into a volume of this gas, over water, will inflame.

Ration. Here the flame is supported by the medium. The sodium burns with its characteristic yellow flame.

III. The gas, *if pure,* may, under certain conditions, be taken into the lungs to the amount of from three quarts to a gallon: it produces a singular delirium, analogous to the effects of intoxication.

Ration. This proves that it is respirable: though an incautious administration of it, as in cases of a predisposed determination of blood to the head may prove noxious, if not fatal. This experiment is not only *not* recommended, but it is deemed right to caution against its exhibition *altogether,* even when the gas is *perfectly pure,* as apoplexy and madness have followed its administration, and a case of permanent derangement from this source, has been communicated to me.

II.—*Nitrous Gas, or Nitric Oxyde.*

I. If a taper be inflamed and introduced into this gas, it will be extinguished.

Ration. This shows its negation, in reference to common combustion.

II. Inflamed sulphur, when immersed, is extinguished, and is rekindled on its transit into atmospheric air.

Ration. This also proves its non-supporting character with respect to the flame of sulphur.

III. If Homberg's pyrophorus be thrown into nitrous gas, it is ignited.

Ration. There can be little doubt that such ignition depends on the evolution, in this as in other pyrophori, of the metallic basis of an alkali or earth.

IV. If a chip of potassium be thrown into this gas, incumbent over water, it will inflame.

Ration. This medium supports the flame of potassium, which is thus proved capable of decomposing the gas.

V. If a bit of phosphorus, in a state of intense and active inflammation, be introduced, it burns with vivid splendour.

Ration. The phosphorus, in this intense combustion, can *decompose* the nitrous gas, and burn in the separated oxygene; but if the phosphorus be introduced in a state of *feeble* combustion, it is *extinguished.*

Note.—Solution of phosphorus in sulphuret of carbon will inflame in this gas, even when its combustion, prior to introduction, is but *feeble.*

VI. Equal parts of this gas and hydrogene may be ignited in an inverted jar, and will burn with a peculiar, tranquil *green* flame.

VII. If a jar of this gas be opened into the atmosphere, it evolves *red fumes.*

Ration. The oxygene of the atmosphere combining with the nitrous gas, forms gaseous nitrous acid.

III.—*Olifiant Gas.*

I. A jar of this gas may be inflamed inverted, or as it passes through jets of different diameters and forms. It burns with a brilliant white light.

Note.—Coal and oil gas owe their illuminating power and property to the presence of olifiant gas. A portable gas-lamp was invented by the late Mr. Gordon, in which oil-gas in a highly compressed form was employed; the stopcock being turned so as to allow the smallest portion of the gas to escape, the light becomes exceedingly feeble, but the required amount of illumination is instantly obtained by increasing the quantity of gas. I wàs informed that a medical gentleman, who had been in the habit of employing a portable gas-lamp at night, found that it was on two occasions extinguished by moths. Under such circumstances, the gas would form an atmosphere deleterious to respiration, and might compose an explosive medium. The introduction of coal or oil gas into a bed-room, is most injurious to health.

IV.—*Sulphuretted Hydrogene.*

I. This gas may be kindled in an inverted cylinder, when it will burn with a bluish flame, depositing sulphur.

Ration. Sulphurous acid gas and water are the products, the excess of sulphur being deposited.

II. If a slip of paper, having characters written with acetate of lead, nitrate of silver, or pernitrate of bismuth, &c., be passed up into this gas, they become dark brown, and are thus rendered legible.

Ration. In this case, sulphurets of these metals are formed. It illustrates the application of paper dipped in solution of sugar of lead to test the purity of coal-gas, and it also proves that secret correspondence might thus be carried on—the paper being a *carte blanche* till dipped into solution of sulphuretted hydrogene, or hydro-sulphuret of ammonia, or the sulphuretted waters of Gilsland, Moffat, Harrogate, &c. In this gas moistened litmus paper will be *reddened.*

III. If a slip of paper dipped into nitric, or nitrous acid, be passed up into sulphuretted hydrogene, a yellow vapour will be developed.

Ration. This shows the decomposition of the sulphuretted hydrogene by nitric or nitrous acid; the hydrogene being abstracted, the sulphur becomes visible, and proves analogically that nitrous and nitric acids may be successfully used as disinfecting agents.

V.—*Carbonic Acid Gas.*

I. If a taper be inflamed and introduced into the gas it is extinguished.

Ration. This proves its negation in combustion.

II. If we breathe, by means of a tube, through *lime-water*, it will become turbid or cloudy.

Ration. Carbonate of lime is formed. The carbonic acid evolved from the lungs, combines with the lime, and forms an insoluble carbonate of lime.

III. Hence, if a little lime-water be poured into a vessel containing carbonic acid gas, it becomes milky.

Ration. Carbonate of lime is formed, as in the previous example evincing at once a distinction between azote and carbonic acid gas; and exhibiting its *acid* properties by combination.

IV. This gas may be poured over a candle, when it will be extinguished. It may also be *laved* from one vessel to another; transferred or emptied by stopcocks,* and poured through a funnel, or pumped out.

Ration. These interesting facts show its superior specific gravity, and the various modes by which it may be got rid of, as being pumped from a well, mine, &c., or emptied by the spigot from the fermenting guile.

* See the figure for the vessel used in this illustration.

V. If tapers of *unequal* heights be placed in a tumbler, and this gas be poured gradually into the vessel, the lowest will be first extinguished, and the others in rotation.

Ration. This shows that the gas will repose in the lowest stratum of the atmosphere of a mine. It also illustrates the phenomena of the ***Grotto del cane,*** near Naples.

VI. Phosphorus previously kindled, will burn with a lambent flame in this gas, and the mingled vapour will render the gas visible.

VII. A wide mouthed phial or cylinder entirely immersed in this gas, will be filled with it, the previously contained air being displaced by the heavier gas.

VI.—*Muriatic Gas.*

I. If an inflamed taper be introduced into this gas, it is extinguished.

Ration. This proves that it does not support combustion. A visible vapour is also formed on its evolution into the atmosphere; this appearance is occasioned by the gas combining with aqueous vapour, by which it becomes *visible.*

II. A ittle ammonia thrown into this gas produces a very dense white vapour.

Ration. Here *sal ammoniac* is formed.

III. If a bit of ice be introduced into muriatic acid gas it melts.

Ration. This arises from the condensation of the elastic gas, and the *heat* developed in that condensation.

Note.—This gas may be evolved in a narrow cylinder, by adding sulphuric acid to common salt.

Alkalis.

Alkalis are either fixed, as potassa, soda, and lithia; or volatile, as ammonia. This class of bodies renders oils miscible with water, abstracts carbonic acid from the atmosphere, and becomes carbonated. They also combine with other acids, and form alkaline salts.

Alkalis are caustic and corrosive: they change vegetable blue colours to green, yellows to red, and reds to brown. These changes, though generally characteristic, are not without exceptions.

Note.—I discovered that subacetate of lead turns the syrup of violets and tincture of cabbage *green*; and when some blue vegetable colours are reddened by acetic, &c. acids, that sulphate of iron, nitrate and sulphate of copper, &c., will restore the original tint. I found also that the tincture of red beet became brown by the contact of ice, and that litmus paper when heated, was changed to red, its blue colour reappearing on ammonia being applied.

I. If blue litmus paper be dipped into an acid, it is reddened, and if transferred to an alkali, in solution, the original colour is restored.

Ration. It is the property of acids to turn vegetable blues red, and of alkalis to restore the original tint.

II. If a solution of caustic alkali, as potassa or soda, be added to syrup of violets, it is turned green.

Ration. Alkalis turn vegetable blues green.

III. If paper, stained with tincture of brazil, be introduced into an alkali, it becomes brown.

Ration. It is the property of alkalis to turn vegetable reds to brown.

IV. If turmeric paper be dipped into a solution of alkali, it becomes red.

Ration. Vegetable yellows become red by alkalis. A similar change is superinduced on turmeric paper by super-carbonate of lime, and boracic acid.

Note.—On tinctures of litmus, turmeric, and brazil, in test glasses, similar changes of colour may be exhibited.

*V. Put a little caustic potassa into a narrow cylinder containing carbonic acid gas, cover the orifice with the hand, and agitate the mixture ; the hand will adhere, in consequence of the absorption of the gas, and pressure of atmospheric air.

Ration. This experiment shows the ready transit of caustic alkali to the state of a carbonate, by the absorption of carbonic acid gas. Hence, caustic alkalis soon become *mild* by abstracting this gas from the atmosphere.

VI. Add a little olive oil to water, and a portion of solution of caustic alkali. This when agitated will form a homogeneous mass of the consistency of cream.

Ration. Alkalis render oils miscible with water, and thus soap is produced. Potassa forms a soft, and soda a hard soap.

METALLIC BASES OF ALKALIS.

I.—*Potassium.*

I. If a portion of potassium be thrown on water it immediately inflames.

Ration. This metal having a great affinity for oxygene, decomposes the water, and becomes red-hot in combining with its oxygene, thus igniting the evolved hydrogene which dissolves a portion of potassium.

II. If a small chip of potassium be quickly thrown into a *narrow* cylinder containing hydrogene, with a little water, the hydrogene will be kindled with explosion.

Ration. The flame evolved, as in the last experiment, kindles the mass as soon as a little air has, by mixing with it, rendered it explosive.

*III. A bit of potassium thrown into a mixture of equal parts of hydrogene and chlorine, with a little water, instantly kindles the mixture, with explosion, and evolution of white vapour.

Ration. Muriatic acid gas is the product, and the chemical combination is effected by the energetic decomposition of water by the potassium, wherein the metal becomes *ignited.*

*IV. When a chip of potassium is cast on water, with carbonic acid gas superincumbent, the potassium assumes the appearance of a red hot ball, without flame; from the mingled vapour, the gas becomes visible, and when poured out may be seen to fall to the ground.

II.—*Sodium.*

I. If a portion of sodium be thrown on cold water, it hisses violently, and moves on its surface, but does not inflame.

Ration. The affinity of sodium for oxygene is thus lower than that of potassium.

II. Sodium thrown on hot water burns with a fierce yellow flame.

Ration. The temperature of the water exalts it to ignition, by an increase of its affinity.

III. If a chip of sodium be placed on sulphuric acid it may remain uninflamed, but the contact of a drop of water sets it on fire.

Ration. The mixture of water and sulphuric acid produces a high temperature, and occasions the ignition.

*IV. If a bit of sodium be thrown into water with chlorine over it, it burns with scintillations of yellow light.

Ration. The action of the chlorine ignites the metal.

*V. If sodium be thrown into water with nitrous oxyde incumbent, it burns with flashes of yellow flame.

VI. If a chip of sodium be thrown on nitrous acid, it burns with a fierce yellow flame.

Ammoniacal Gas and Ammonia in Solution.

I. An inflamed taper on being introduced into ammoniacal gas, discovers an enlarged and foreign flame, and is then extinguished.

Ration. Ammoniacal gas is, under proper circumstances, inflammable, especially when the volume of the gas is considerable.

II. If equal volumes of ammoniacal gas and chlorine be brought together, a flash of light pervades the cylinders, and a white crust lines the interior.

Ration. Sal ammoniac is formed, and the light probably proceeds from the instantaneous formation of a portion of chloride of azote, the vapour of which, expanding and decomposing in the new-formed void, emits light.

III. If two large cylinders, one containing a little liquid ammonia, and the other a portion of muriatic acid, be brought into contact, a white vapour will be formed.

Ration. Muriate of ammonia is formed by this conjunction of the liquids.

IV. A little strong liquid ammonia being introduced into chlorine, either on a slip of paper moistened with it, or in a deflagrating spoon, spontaneously inflames, and continues to burn.

Note.—This singular fact was discovered by me about ten years ago, but I am not aware that it has yet been noticed in any chemical work.

Ration. The explanation is similar to that in Experiment II.

V. If solutions of chlorine and of ammonia are introduced into a long narrow tube, so as to fill it, and the tube be agitated, its lower orifice being immersed in water, gas will be liberated, and occupy the superior part of the tube.

Ration. This gas is azote, and is one of the constituents of ammonia.

Note.—There is an extraordinary phenomenon produced by introducing an amalgam of potassium and mercury into a cavity, formed in sal-ammoniac, moistened with liquid ammonia. The amalgam gradually increases its volume to many times its former bulk, but without any sensible diminution of its consistency. When this singular amalgam is thrown into water, elastic matter is developed, and the mercury becomes insulated. No satisfactory explanation has yet been offered.

Metals and their Combinations.

Metals possess a peculiar opacity and lustre, and are conductors of heat and electricity.

* *Aqua ammon. fortiss.* of Howard.

Some metals are ductile, or may be drawn into wire, others are malleable, or may be beaten into laminæ: platinum, gold, silver, and copper, afford examples of both. There are metals, however so extremely brittle, as to be easily reduced to powder, such as arsenic and antimony. Some tarnish, corrode, or oxydate, by exposure to air or moisture, as silver, iron, &c.; others preserve their lustre unimpaired, as platinum and gold. Mercury remains fluid at the common temperature. Iron and platinum grow soft before they melt, and may be thus united by welding. In specific gravity metals differ much among themselves; platinum is 21 times heavier than an equal volume of distilled water, while potassium will float on sulphuric ether.

Note.—There are THIRTY metals known exclusive of the metallic bases of the alkalis and earths. Some metals are coloured as gold; others white and brilliant as silver: some metals have not that peculiar lustre which has been deemed characteristic, or at least have been only imperfectly reduced. Some metals rise in vapour at a comparatively gentle heat, as arsenic; others, as platinum, bear unchanged the most intense temperature. Some metals, as osmium, are characterized by a peculiar smell. There are metals that combine with hydrogene and assume a gaseous form, tellurium for instance; while others, as molybdenum, chromium, &c., combine with oxygene, and form acids. It does not appear that selenium is a conductor of electricity, and we should therefore hesitate to place it among the metals.

I. If *coarse* red wafers are burnt in the flame of a candle, globules of pure lead drop down, and may be received on white paper.

Ration. This is a very simple example of reduction, the oxygene of the red lead combining with the charcoal of the paste, passes off as carbonic acid gas, and the pure metal is thus evolved.

II. If red lead be mixed with powdered charcoal, and exposed in a crucible to the action of heat, pure metallic lead may be obtained.

Ration. The explanation of the last experiment applies here.

III. If gold leaf be put into pure nitric acid, and pure muriatic acid, apart, it will remain in each unchanged: but on their mixture the gold is dissolved.

Ration. Gold is only soluble in nitro-muriatic acid, thus formed. This mixture, which becomes of an orange tint, evolves chlorine, and gold is soluble in solution of chlorine.

IV. Fulminating silver will explode by the simple friction of flints, if a minute portion be applied to the edge.

V. Fulminating silver will explode if placed on a slip of paper, and held over the flame of a candle: it perforates the paper, and extinguishes the candle, the force being exerted downwards.

Note.—Fulminating silver must be used with the utmost caution: a grain, or even less, at a time,—its explosive force being great.

VI. If fulminating mercury be ignited, it burns like gunpowder.

*VII. On a polished piece of plate glass, ignite by a taper, a small quantity of fulminating mercury—the metal will be beautifully reduced.

Ration. This striking and interesting experiment forms a mirror from the opposite side, and proves that reduction takes place in every instance wherein fulminating metals are exploded.

*VIII. If fulminating mercury be placed on a slip of paper, and held over the flame of a spirit lamp, it ignites like gunpowder; requiring a less temperature than fulminating silver. It inflames even before the paper be charred.

IX. If fulminating mercury be struck by a hammer on an anvil, it explodes with a loud report.*

Note.—To what principle fulminating compounds owe their singular properties, seems by no means a settled point. The opinion formerly entertained on this subject ascribed it to the combination of azote; more recently however, it has been supposed that most, if not all, the compounds which possess the property of exploding, contain a peculiar acid, somewhat allied to cyanic acid—identical with it in constitution according to Gay Lussac; but essentially different from it according to Edmund Davy. This peculiar acid has received the name, *fulminic*. We cannot comprehend the extraordinary dogma to which we should be lead by Gay Lussac's deduction, namely, that identity of constituents, as well as identity in their relative ratio, do not of necessity imply identity of constitution.

* Fulminating mercury will be found every way superior to what is called percussion gunpowder,—it is safe, certain, and unaffected by damp. There is only one drawback to its exclusive and unqualified adoption,—that is the low temperature at which it inflames, so that when the fowling-piece gets heated by frequent discharges, this substance might thereby be kindled. Percussion caps, formed of pasteboard, or other non-conducting substance, would obviate this accident.

X. If a stream of hydrogene be pressed through a fine capillary tube on spongy platinum, it is ignited, and sets fire to the hydrogene.

Note.—This curious discovery was made by Dobreiner. Inflammable lamps have been constructed on this principle; that of Mr. Jackson is at once the simplest, the most elegant, and the best. It has also been employed *eudiometrically*, by passing up into the gaseous mixture, a small ball of spongy platinum mixed with alumina.

XI. If caustic potassa be poured into a solution of sulphate of copper, it will form a gelatinous mass.

Ration. Here the potassa separates the sulphuric acid, while the oxyde of copper is evolved, and combines with water, forming a hydrate of copper.

XII. There is a fusible metal composed of tin, lead, and bismuth, in definite proportions, which melts below the boiling point of water. Spoons are made of this alloy, for purposes of amusement. The alloy may be melted on paper, over the flame of a candle.

Ration. This circumstance of low fusibility proves a chemical change in the alloy: the average temperature at which these separately fuse is 510°, Fahrenheit.

Note.—This alloy is composed of three parts of tin, (fusing at 442° F.) five parts of bismuth, (fusing at 476°) and two parts of lead, (fusing at 612°).

XIII. Sticks of phosphorus left in solutions of nitro-muriate of platinum, and of gold, become coated with films of reduced platinum, and gold. In sulphate of copper the phosphorus becomes coated with copper; in nitrate of silver, with silver; and in muriate of mercury, it is studded with globules of running mercury.

XIV. Put equal parts of solutions of nitrate of mercury and of silver into a wide-mouthed phial, and suspend in it a portion of mercury, tied up in a linen bag—needle-like crystals of pure silver will bristle this nucleus of mercury.

Ration. The effect is no doubt galvanic, and depends on the relative electric character of the silver and the mercury, the silver being negative, and the mercury relatively positive.

XV. A plate of copper introduced into nitrate of silver reduces the silver that attaches to the copper, in the form of brilliant laminæ.

Ration. It is presumed that this, too, is a galvanic phenomenon. The copper is positive, with respect to the silver.

XVI. A ball of zinc being introduced into acetate of lead in solution, will soon exhibit the lead precipitated in the form of metallic branches or a species of arborisation.

Ration. The lead is negative, with respect to the zinc.

Note.—Experiments XIV. and XVI. are commonly called *metallic trees.*

Vegetable Chemistry.

The proximate or immediate principles of vegetation are, tan, gum, resin, gluten, fecula, camphor, jelly, &c., and these are severally obtained by the action of cold and hot water, cold and boiling alcohol, and concentrated sulphuric ether.

The ultimate or elemental forms of vegetable matter are, carbon, hydrogene, and oxygene, being thus resolved by heat, with the addition of peroxyde of copper, or chlorate of potassa.

I. To an infusion of green or black tea, in a test tube, add a solution of isinglass, and a tawny precipitate will be formed.

Ration. The gelatine combines with the tannin existing in the tea, and forms a compound, which is a species of leather. Hence tannin exists in tea, leather is merely a compound of the gelatine of the *pelt* or hide with the tannin of the oak-bark.

II. To an infusion of tea add a solution of sulphate of iron—*black* results.

Ration. In this experiment *ink* is formed, from the gallic acid of the tea combining with the iron, and forming gallate of iron.

III. If a few drops of tincture of iodine be added to a large quantity of water, a little starch (prepared with hot water), stirred in the liquid, will develope a fine *violet* colour, intense according to the proportion of tincture of iodine added.

Ration. This affords a test for fecula or starch, and shows their reciprocal affinity. Glazed calico becomes blue in the tincture of iodine, from the British gum used in the glaze,—British gum being a modified starch.

IV. A chip of camphor will float on water, and may be ignited.

Ration. This shows the specific gravity of camphor to be less than that of water, and at the same time proves its inflammability.

V. If a portion of camphor be put on a metallic plate under a glass funnel of convenient size, it will be beautifully sublimed by the heat of a spirit-lamp, in the form of an efflorescent crust.

Ration. This concrete essential oil is purified by sublimation, and is sublimed unaltered.

VI. A little of this sublimed camphor, if mixed with finely powdered chlorate of potassa, may be inflamed by the contact of sulphuric acid.

Ration. Here the liberated orange-coloured gas kindles the camphor.

VII. If a portion of powdered loaf-sugar be put into a deflagrating spoon, fused, and kindled, a fine jet of flame will be exhibited.

Ration. This flame is carburetted hydrogene, formed from its constituents in sugar, and a spongy charcoal remains.

VIII. Place some powdered gum benzoin on a metallic plate over a lamp-flame,—it will sublime into a paper cone placed above it, in the form of fine silky crystals, and if the branch of a shrub be included, it will be invested with the semblance of frost-work.

Ration. The sublimed crystals are benzoic acid, and the experiment affords an example of an acid formed by sublimation.

IX. A bit of caoutchouc inflamed, and introduced into oxygene, burns with a brilliant and sparkling flame.

Ration. Much smoke or carbonaceous matter is deposited, and the flame is that of carburetted hydrogene.

X. Small bottles of caoutchouc may be inflated to a considerable size and extreme thinness, by an attached condenser; or by the introduction of a little ether, the caoutchouc bottles being softened by hot water. These globes may be made very thin, so as to become transparent, and being filled with hydrogene, ascend in the air. Figures of flowers and insects are sometimes painted on them.

XI. Gluten, obtained from wheaten flour by kneading and washing it till it ceases to whiten water, may be distended like the membrane of a drum.

Fermentation, Distillation, &c.

I. If a portion of beer or porter be put into a retort, the beak of which is plunged into lime-water, it will soon render it milky, on the application of a gentle heat.

Ration. This proves that carbonic acid gas is the product of fermentation, and remains combined with the beer, porter, &c. The formation of carbonate of lime occasions the turbidness.

Note.—Beer or porter froths up in the rarified medium of the air pump. This fermentation might be accelerated by removing the pressure of the atmosphere, and retarded by a condensed atmosphere of carbonic acid gas.

II. If wine, beer, &c., be put into an alembic, and heat applied, alcohol will soon distil over into the glass vessel attached to receive it.

Ration. The heat here merely separates the alcohol, and thus acts a mechanical part.

III. If a solution of subacetate of lead, or protonitrate of tin, be mixed with port wine, and this put on a filter, a colourless liquid will pass through, and being mixed with a due quantity of dry subcarbonate of potassa, will separate an inflammable liquid, which will float on the surface, and may be inflamed.

Ration. This experiment may be called distillation without heat, and proves that heat acts in common distillation as a mechanical agent; the subacetate of lead disentangles the colouring matter, and the subcarbonate of potassa carries down the water; the alcohol is then disengaged. A shallow dish exposing a considerable surface, renders the separation of the alcohol more certain.

IV. If to nitro-muriate of gold, in solution, one-fourth its volume of rectified sulphuric ether be added, the gold will be separated from its acid combination, and float incumbent;—finely polished steel, as needles, lancets, &c., when dipped into this etherised gold, and transferred to water to take off the adhering acid, will be gilt.

Ration. This seems a galvanic phenomenon, the gold being negative with respect to the steel, and forms a convenient method of preserving surgical instruments, &c., from corrosion.

V. Phosphorus is soluble in ether. If a little of this phosphorised ether be poured on hot water in the dark, the surface of the water becomes luminous.

* VI. I find that at common temperatures sulphuric ether evolves a vapour, which may be poured out from one vessel to another, in an invisible form, like carbonic acid gas; or may be poured through a funnel, pumped from one vessel to another, laved out, transferred through spigots or stopcocks, &c.

* VII. This vapour may be retained in a funnel, with a fine capillary bore and long stem.

VIII. Concentrated sulphuric ether boils at a very low temperature—it has been rated as low as 98°; but circumstances will alter the degree, and in a long narrow *tube its* temperature may be raised 20° to 30° higher;

and it will be found that the introduction of foreign substances, as, for instance, chips of cedar wood, will determine its ebullition under circumstances which would require many degrees of additional temperature. In the receiver of the air pump, ether readily boils.

IX. Alcohol dissolves phosphorus,—if this phosphorised alcohol be poured on the surface of cold water in the dark, it will also become luminous.

APPLICATION

OF

TESTS

FOR

METALLIC POISONS;

EXAMINATION

OF

MINERAL WATERS,

&c.

DETECTION OF METALLIC POISONS.

I.—*Copper.*

Copper is the material employed in the fabrication of many culinary vessels: some, however, are tinned; but for the production of specific colours (considered necessary in the science of the kitchen), the copper vessel is unprotected, in order that the full amount of its poisonous effects may be secured. Strange that any should incur the risk of being poisoned through a foolish ambition to have pickles of a peculiar and determinate tint! It is quite evident, on a moment's reflection, that if no other metallic vessels, except those of copper or brass, can communicate the peculiar green colour which these impart, it must needs proceed from a dissolution of the copper in the acid used in pickling; and let it be remembered, that all the salts of copper, without exception, are poisonous. *Verdigris* is formed by the action of the acetous acid or vinegar on the copper vessel. So far has this singular ambition carried the *cuisinier*, that even halfpence are directed in some early cookery-books to be boiled up with the pickles to make them "beautifully green," and what is called *greening* is duly prepared. In preserves, the same fatal poison is developed by the use of copper or brass pans, unsecured by tin lining; fruits contain peculiar acids, (the citric, mallic, acetic, &c.) which form salts of copper, and become poisons. The same thing takes place where oily or fatty substances are cooked in copper vessels; they contain usually a peculiar acid, called *sebacic acid,* equally formidable in its effects.

It is worthy of remark, that though the vessel contains only a small portion of tinning, as has been shown by the French chemists, it is still preservative; the effect is of an electric or galvanic description; the acid being confined in its action to the tin, and the copper being thus rendered relatively negative, escapes unacted upon. If, for instance, a plate of copper is immersed in dilute nitric acid, it is soon corroded and dissolved; but if a plate of zinc be introduced, the action is completely changed, the zinc is dissolved, and the copper remains unaltered and uninjured. This is the principle on which Sir H. Davy proposed the preservation of copper sheathing on the bottom of ships, which though completely successful in this respect, eventually promoted the attachment of sea weed and marine molluscæ. It is clear, therefore, that if we use a *silver* spoon, compared with which the copper is *positive,* that a poisonous salt of copper must be formed; and even if there should be a partial tinning left on the copper, should a silver spoon be used, it is probable, that a minor quantity of poison would still be elaborated. An *iron* spoon, where there is no tinning, would protect the copper from action, were it never withdrawn.

It is not generally known that fatty or acid matter acts more energetically when *cold* than when hot, and this partial suspension, I presume, is to be ascribed entirely to a *thermo-electric* influence. It is absurd to suppose that if the copper or brass pan be scoured bright and clean, that there is little or no danger; for this makes but a trifling difference; such vessels for culinary purposes ought to be banished for ever from the kitchen.

Copper leaf is the material employed in GILT gingerbread. Sulphate of copper has been fraudulently employed to impart an artificial "Blue mould" to cheese; and is also added to *writing* ink, the reason why the edge of the penknife is so soon lost. Mr. Brande recommended the addition of corrosive sublimate to ink as a preservative!

If copper be suspected to be present, the liquid, after being passed through bibulous or blotting paper, should be tested by the following re-agents:—

I. *Ammonia* will produce a beautiful *violet colour*, and if carefully dropped on the surface of the liquid, a violet-coloured film or stratum will be evolved. A slip of card paper being dipped into ammonia, and subsequently into the liquid, will therefore be tinged violet, if copper be present.

II. Arseniate of potassa will also form a delicate *apple-green* tint.

III. Ferro-cyanate of potassa produces a *brown* precipitate.

IV. A fragment of phosphorus is coated with metallic copper.

These are the best tests for the detection of copper. It may be added, however, that a plate of *polished iron* will become coated with a film of copper when introduced into a liquid containing it,* and pure iron-filings will be soon invested with a metallic reduction of copper.

II.—*Corrosive Sublimate, or Permuriate of Mercury.*

The tests for discovering this virulent poison are as follow :—

I. Caustic potassa in solution, dropped into the filtered liquid, produces a brick-red or orange precipitate, redissolved by nitric acid.

II. Lime-water will produce an effect somewhat similar, though less sensible and delicate.

III. Hydriodate of potassa forms a brilliant scarlet.

IV. A stick of phosphorus suffered to remain in the solution, will, after some time, be coated with small globules of metallic mercury.

V. A plate of polished iron or steel will produce a phenomenon similar to the preceding, and iron-filings will, in due time, reduce the entire muriate.

VI. White of egg will be coagulated.

* If *gerkins* be suspected to contain copper, from their unusually *fine green* colour, cut one of them across with a knife, and suffer the latter to remain a few minutes,—a coppery film will be left should it exist.

VII. A drop of the liquid let fall on gold leaf, will evolve metallic mercury if connected with the gold leaf, by means of an arc of iron wire.*

Note.—A drop of ammonia let fall on *calomel* immediately changes it to a *dark grey*, almost black.

III.—*Arsenic.*

In accidental poisoning or suicidal acts, this is generally the fatal agent employed, and purchased under pretence of destroying rats, &c.;† it is most unwise to vend it under any such pretence,—and nothing can be more irrational than to employ it for such a purpose: children, servants, and other heedless persons, may get hold of it inadvertently. Sometimes it is thrown incautiously into a drawer or cupboard, where it lies neglected and forgotten, till some new domestic arrangement may call it forth, or may be only remembered at last, through the unhappy medium of its fatal effects on one of the

* Almost all *anti-syphilitic quack medicines* contain *corrosive sublimate*. "Gowland's Lotion for the Skin," according to Dr. Paris, contains it, and the case of a lady, supposed to have fallen a sacrifice to its use, has been communicated to me.

† *Carbonate of Baryta* is now employed as a substitute for arsenic, but it must not be disguised that its effects are equally fatal to *man*, with this interesting difference, that for carbonate of baryta there is a *specific antidote*, but for arsenic there is NONE, and even the stomach pump, from its difficult solubility, is of little use.

inmates of the house. In Norfolk, it is used as a bath to steep seed corn in, before sowing, to prevent *blight*, &c., though it requires a wiser head than I affect to possess, to discover its efficiency. The *druggist* is scarcely warranted in selling arsenic to any one; and it is a subject of astonishment to me, why it should be suffered to exist at all on the shelves of the apothecary, as it is of no use in medicine.*

In using arsenic for the purpose of destroying rats, mice, or beetles, persons ought to remember that these creatures may in many ways introduce the poison into their own food. Besides, it has occured, that the house has been rendered uninhabitable from the putrefaction of the accumulated numbers of rats or mice, thus destroyed. Arsenic may also be introduced into porter, wine, &c. by means of the shot lead, which is frequently though improperly employed in cleansing bottles, and left adhering to the bottom. I have met with a case of this description, where porter had nearly proved fatal to an entire family; and part of a bottle of perry, from a similar cause, was attended with serious effects to myself: shot lead always contains *arsenic;* nor is it attempted to be disguised that *wine-coopers* use a composition containing *arsenic*, to impart an oily-like surface to *white wines*.

I. Add a small portion of potassa to the solution which

* Arsenical lotions, for external application, can be substituted with advantage by other preparations, and *Fowler's Solution* has been happily supplanted by *sulphate of quinine*. Arsenic belongs to the *colourman*, not the druggist.

may be supposed to contain arsenic, and then a little sulphate of copper—a delicate green will be thus formed.

Note.—I do not advert to the *aliaceous* smell, &c. evolved by projecting the substance on a hot iron, &c. Dr. Wollaston's method is also very elegant.

II. Add a few drops of acetic acid, and a little hydro-sulphuret of ammonia, when a *golden* precipitate will be formed, appearing first as a yellow cloud.

III. Add a few drops of ammonia, and a little nitrate of silver in solution,—a *yellow* cloud will be formed, and yellow films or strings, commencing at the point of contact, appear on touching the surface of the liquid with a stick of lunar caustic.

IV. Ammoniuret of copper, or ammonia-sulphate of copper* in solution, added, in like manner, will produce a yellowish cloud. Iodine has also been recommended as a test for arsenic. As alkaline phosphates produce effects somewhat similar on solutions of silver and of copper, the enumerated tests must be always considered secondary, and in a court of justice are of subordinate weight and validity. The most conclusive evidence is obtained by mixing the powder, collected by picking out, one by one, the white particles, which may be generally accomplished from its difficult solubility, such particles remaining undissolved among the contents of the stomach, or may be easily

* Easily formed by adding a little dilute ammonia to solution of sulphate of copper, producing a *violet* liquid.

detected in the food that remains: these, mixed up with a small portion of powdered charcoal, and introduced into a narrow glass tube, being held over the flame of a spirit-lamp, will soon produce in the superior part of the glass a beautiful ring of sparkling points of metallic arsenic, resembling particles of polished steel, remaining permanently attached for many days.

I am of opinion that a *deceptive appearance* may be occasioned by a *glistening metallic film* proceeding from the lead, one of the constituents of glass developed at a considerable temperature—*metallic points*, surmounted by a band of whitish oxyde, this last being the *first* which sublimes, will determine the question unequivocally.

IV.– *Lead.*

Lead is a very common source of poisoning. The water which supplies our beverage, or is used in domestic economy, flows into our houses through pipes of lead, and it is preserved in tanks and cisterns of the same poisonous metal,—milk remains in vessels of lead, and animal food in leaden trays—the jars*, too, in which pickles and preserves are put up, are glazed with lead, acted on by the acid of the pickle or preserve. Malt is steeped in tanks lined with lead; cyder and perry are also manufactured in copper vessels partially supplied with a belt of lead,—and beer and porter are drawn by engines through leaden pipes of considerable extent

* Those called *Bristol ware* are safe, the glazing being without lead.

in public houses: brass cocks are used in the casks of the dram shop or the tavern. Balls of lead are also suspended in wine-casks to correct the acetous change by uniting with the acid as it forms; and when wines have already become acid, litharge, an oxyde of lead, is added, to neutralize the acid, and "sweeten" such wines. Vinegar, as it is commonly sold, is not only adulterated with "*oil of vitriol*," but contains lead (sometimes copper); *annotto*, for colouring cheese, is sometimes adulterated with red lead. "Sugar of lead" is not unfrequently used in France in the case of cooking vegetables, as brocoli, &c., whereas a little alkali (as *salt of tartar)* would do equally well. Confectionery is very frequently dyed with poisonous materials—muriate of lead, per-sulphuret of mercury, sulphate of copper, &c.; *children's toys* are painted with metallic poisons. The effects of lead are most injurious, and to an extent which it is difficult to estimate. A great proportion of the diseases incident to humanity spring from this source, and terminate in paralysis and apoplexy: in reference to the delicate and susceptible constitution of the young, the question is a very serious one.

The circumstances under which we have occasionally detected lead have quite surprised us, as in the case of water simply flowing through a leaden pump. The chemical character of the water as to its constituents, will determine its greater or less energy of action on the surface of the lead with which it is in contact.

I. Hydro-sulphuret of ammonia will produce a dark brown precipitate if the solution contain lead, and a similar phenomenon will ensue by passing a stream of sulphuretted hydrogene through the liquid—easily effected by introducing a portion of the sulphuret of iron in powder, into a small retort with muriatic acid—the beak of the retort is then plunged into the liquid, and the flame of a common candle will cause an evolution of the gas, which, in its transit, blackens it.

II. *Chromate of potassa* will produce a beautiful and bright *yellow*.

III. Hydriodate of potassa will form also a precipitate of a lighter shade of yellow.

IV. A cylinder of zinc will produce an arborisation of metallic lead.

It is altogether impracticable to enter on the minutiæ of detail in reference to poisons, in their various forms and phenomena; we shall however just glance at the tests for OXALIC ACID, PRUSSIC ACID, and OPIUM.

I. *Oxalic Acid.* The crystals of this acid, which have been mistaken for those of "Epsom Salts," are of a powerful acid character, so much so that in one case suspicion was excited, and life in all probability saved, from a drop of the solution having made a hole in a fine cambric handkerchief by providentially falling on it. A blot of writing ink will be obliterated by oxalic acid. Litmus paper will be instantly reddened, and even the purple paper, the envelope of the sugar loaf. If a crystal of oxalic acid be brought in contact with the surface of lime-water, or even "hard water," contained in a wine glass, white threads will instantly descend through the liquid, proceeding from the crystal as their point of suspension.

II. *Prussic Acid.* The smell being that of *bitter almonds,* is easily recognized. The substance in which it is suspected may be tested with a small portion of pure potassa in solution, when a drop of sulphate of iron will become *blue,* and that of sulphate of copper *brown.* Crystals of these sulphates may be employed instead of their solutions—a method that I have adopted with advantage.

III. *Opium.* I know of no better test than a little solution of caustic potassa, followed by nitro-muriate of gold, when it assumes a *black* hue, if opium be present. I prefer this decidedly to permuriate of iron, which is somewhat equivocal, as the sulpho-cyanate of the saliva produces a similar indication of *red.*

It will be an elegant employment of each test to use slips of card paper, dipped previously into the respective re-agents, as of chromate of potassa, and dried—when their partial introduction into the liquid under examination, will easily discover the suspected metal, &c. Of course, those of a *volatile* character cannot be so applied. These slips might be preserved in a little case or rouleau, and thus be made extremely portable. In many instances the tests in the form of pure crystals may be applied, and become more sensible indexes than when in solution.

Note.—The subject of poisons is treated of at length in my work on "THE HISTORY AND PHENOMENA OF POISONS, with their Tests and Antidotes," where ample directions are given, and specific details will be found; many of the researches being entirely new.

MINERAL WATERS AND THEIR CONTENTS.

The substances found in mineral waters are various; those usually discovered are,

Carbonic acid gas,
Azote,
Oxygene,
Sulphuretted hydrogene,
Sulphate of soda,
Sulphate of magnesia,
Sulphate of lime,
Muriate of soda,
Muriate of lime,
Muriate of magnesia,
Carbonate of iron,
Carbonate of lime,
Carbonate of magnesia.

To the preceding list may be added iodine, alumina, boracic acid, sub-borate of soda, silica, muriate of ammonia, muriate of potassa, sulphate of iron, &c. But these are more rare.

I.—*Carbonic Acid.*

Carbonic acid may be detected by paper stained by raddish, hyacinth, iris, violet, cabbage, &c. (the first in order is remarkably delicate), when these test papers will be reddened, *before* the water is boiled, but not afterwards. Lime-water will also become turbid or milky. Carbonated waters sparkle, particularly on the addition of a few drops of acid. When a solution of baryta in water is added, it is precipitated—and should this precipitate be occasioned by carbonic acid, it will be dissolved with effervescence by muriatic acid; whereas if a sulphate has occasioned the precipitation, it will be found insoluble in muriatic acid.

II.—*Sulphuretted hydrogene.*

The waters which contain this gas are vulgarly called *sulphurous* waters. The smell is extremely fœtid: a few drops of nitric acid, as well as iodine, deposits sulphur, and a stream of chlorine produces a similar effect. A slip of polished silver is blackened, and a bit of paper dipped into a solution of acetate of lead, nitrate of silver, or pernitrate of bismuth becomes *dark brown.*

III.—*Sulphates.*

It may be remarked of *sulphates* generally, that solution of nitrate of baryta, or of muriate or acetate of baryta, will form a white precipitate, insoluble in nitric acid.

Depositions of sulphate of lime are occasionally found on the inner surface of boilers; they do *not effervesce* on the contact of muriatic acid, which is the case with deposites of carbonate of lime, and are thus easily distinguished.

IV.—*Muriates.*

Solutions of acetate, nitrate, or sulphate of silver, will detect the presence of *muriates,* as those of magnesia and soda. I have detected *muriate of ammonia* in sea salt, by mixing it with quick lime, and submitting the mixture contained in a retort to heat; the beak of the retort being then immersed in dilute solution of sulphate of copper, has discovered, by a *violet* streak, the evolution of ammonia. I have also detected the presence of *muriate of ammonia* in the Cheltenham and Gloucester mineral waters; and Dr. Wollaston has found *muriate of potassa* in rock salt.

V.—*Carbonates.*

The carbonates of lime, &c. being held in suspension by a slight excess of carbonic acid gas, will, on the water being boiled, be precipitated, and this precipitate will dissolve with effervescence on adding a few drops of muriatic acid. A crust forms on tea-kettles and boilers from this cause,* as the carbonate of lime is precipitated, becoming insoluble from the expulsion of a part of its carbonic acid by the agency of heat. This phenomenon is very striking in the "petrifying springs," as they are called, at Matlock, in Derbyshire; a portion of the carbonic acid on emerging into the free atmosphere escapes, and the subcarbonate of lime being insoluble, is precipitated on various substances, exhibiting curious incrustations, as on birds' nests, branches of fir, &c.; a similar phenomenon is exhibited in the baths of *San Fillipo,* near Acquapendente, in Italy, where the calcareous deposite being received into moulds, forms beautiful casts. Should the carbonate of lime thus precipitated have an ochry appearance, it may be occasioned by *iron,* and in that case, a little ferro-cyanate of potassa will occasion a *blue colour.*

VI.—*Iron.*

Iron may be detected in mineral waters by ferro-cyanate of potassa, or ferro-cyanate of ammonia, forming a prussian blue colour, while tincture of galls will produce *black.* According to Mr. Richard Phillips, if the iron be in the state of *protoxyde,* the action of the tincture of galls may be rendered more sensible by a little lime-water or alkali; and, on the other hand, if the iron should be in the form of a *peroxyde,* the lime-water, &c.

* An effect said to be prevented by allowing a *marble* to remain in them: thus too, in steam-boilers, foreign substances are retained s preventives.

would prevent the action of the tincture of galls: by these means, should this be found correct, we shall be able to determine with facility whether the iron dissolved be in the state of peroxyde or protoxyde, A slice of gall-nut, suspended by a thread, will discover a dark cloud enveloping the gall-nut as its nucleus, after an interval of some hours. Benzoate and succinate of ammonia have been also mentioned as tests of iron, but I have never been able to discover on what principle they have been recommended—they are certainly far inferior to the others; and prussiate of potassa, and tincture of galls, are sufficiently sensible.

VII.—*Lime.*

Oxalate of ammonia in solution will detect the presence of lime, and is a delicate and sensible test. It will form a white cloud. This test is much more valuable than either *oxalic acid,* or *fluate of ammonia,* both of which have been named as tests. Fluate of lime is decomposed by sulphuric acid; it is obvious that in reference to the latter as a test, the recommendation is founded on error.

VIII.—*Magnesia.*

Add a little bicarbonate of ammonia in solution, and when the effect has subsided, a few drops of the solution of phosphate of soda; these will detect magnesia. I have found the *phosphate of ammonia* very sensible without the pre-addition of carbonate of ammonia. Mr. Richard Phillips has recommended lime-water as a test for magnesia.

IX.—*Hard Waters.*

These generally owe their character to the presence of *sulphate of lime,* hence soap curdles when used with hard water: the sulphuric acid of the sulphate of lime combining with the soda of the soap. The lime, and oil or tallow, being thus freed from their respective combinations, float through the liquid medium in flakes: the phenomenon, therefore, is entirely that of decomposition. On this principle, solution of soap in alcohol will determine the relative hardness of water, and is generally employed by the well-digger.

Free acid will be detected by litmus paper becoming *red,* and free alkali by turmeric paper changing to red, and Brazil paper to brown. It should be observed, however, that *boracic acid* reddens turmeric paper, thus producing an alkaline effect, and supplying an easy mode of discriminating between boracic acid and the other acids. *Super-carbonate of lime* produces the same effect on turmeric paper.

Silica combined with iron, under the form of a *silicate,* wherein it seems to act the part of an acid, is found in the mineral waters of Lucca and Bath; and with soda, obtains in the Geysers of Iceland.

The tarnishing of silver leaf and violet tint with starch, when decomposed from the hydriodate by sulphuric acid, will be found delicate tests for iodine, an ingredient occasionally met with in mineral waters.

In January, 1828, I discovered iodine in the Gloucester Spa-water, also in the waters of Cheltenham, though in smaller proportion.* The method I adopt is to evaporate the water to one-fourth its original volume, add a few drops of sulphuric acid, and allow a strip of white glazed calico to remain some hours in the solution, when it is finally tinged of a *violet* colour, if iodine obtains in quantity; and *pink* if the quantity be very small.

To ascertain the presence of *ammonia*, I heat the residual water in a long narrow tube with pure potassa, when a stopper, moistened with concentrated acetic acid, discovers its presence.

Potassa is discriminated from soda by nitro-muriate of platinum, which becomes *brown* with the former.

The *proportionals* of these ingredients are ascertained by a refined and laborious process, which our present limits forbid us to describe.

* The *first disc*[illegible]f iodine in the mineral waters of England. (See "Gloucester [illegible]rnal" of that month.) It is therefore remarkable that Dr. Daubeny should have claimed this as his discovery more than two years after its publication. The late Mr. Cuff, of Bath, was subsequently induced to examine the Bath Spa waters, and discovered iodine in them, having evaporated an immense volume of water for this purpose: it remained in solution, for I could not detect a trace of iodine in the dry residual matter. In the brine springs of Ingestrie, which I analyzed for Earl Talbot, the traces of

iodine and bromine were somewhat equivocal, but I find that both these chemical principles exist in the Sutton Spa, near Shrewsbury. I was supplied with a specimen of the *Caldas da Rayhna thermal springs* of Portugal, by the Chevalier Mascarhenas, and found in it iodine and bromine in unusual quantity. The method to be adopted for detecting the presence of bromine is sufficiently simple. The water being evaporated to a minute quantity, a stream of chlorine is passed through the solution, which becomes brownish yellow with bromine, and then being shaken in contact with rectified sulphuric ether, a hyacinth red tint is communicated to the supernatant ether, should bromine be present in the water. Starch is a test for bromine as well as iodine, but in the former case it assumes an orange tint.

NOMENCLATURE.

Old Names.	*New Names.*
Acetous Salts,	Acetites.
Acid of Vitriol, Phlogisticated,	Sulphurous Acid.
Acid of Alum, Acid of Vitriol, Acid, Vitriolic, Acid of Sulphur,	Sulphuric Acid.
Acid of Nitre, Phlogisticated,	Nitrous Acid.
Acid of Nitre, Dephlogisticated, Acid of Saltpetre,	Nitric Acid.
Acid of Sea Salt, Acid, Marine,	Muriatic Acid, or Hydro-chloric Acid.
Acid, Dephlogisticated Marine, Acid, Oxymuriatic,	Chlorine.
Acid, Pyrolignous	Acetic Acid.
Acid, Aerial, Acid of Chalk, Acid, Cretaceous, Acid of Charcoal, Acid, Mephitic,	Carbonic Acid Gas.
Acid of Fluor Spar, Acid, Sparry,	Fluoric Acid.
Acid of Borax,	Boracic Acid.
Acid of Apples,	Mallic Acid.
Acid of Sugar, Acid, Saccharine,	Oxalic Acid.
Acid of Lemons,	Citric Acid.
Acid of Phosphorus, Phlogisticated,	Phosphorus Acid.
Acid of Phosphorus, Dephlogisticated,	Phosphoric Acid.
Acid of Fat, Acidum Pingue,	Sebacic Acid.

Old Names.	*New Names.*
Air, Dephlogisticated, ... Air, Empyreal,............ Air, Vital, ... Air, Pure,................	Oxygene.
Air, Impure or Vitiated,.... Air, Burnt, ... Air, Phlogisticated,.........	Azote, or Nitrogene.
Air, Inflammable,.............	Hydrogene.
Air, Marine Acid,.............	Muriatic Acid Gas.
Air, Dephlogisticated Marine Acid,.................. Air, Oxymuriatic, (Gas)	Chlorine.
Air, Hepatic, ... Air, Fœtid, of Sulphur, ...	Sulphuretted Hydrogene, or Hydro-sulphuric Acid Gas.
Air, Fixed, ... Air, Solid, of *Hales*	Carbonic Acid Gas.
Air, Alkaline, ...	Ammoniacal Gas.
Alkali, concrete volatile.......	Carbonate of Ammonia.
Alkali, effervescent and not caustic, aerated or mild,........	Carbonated Alkalis.
Alkali, Prussian,..........	Prussiate of Potassa, &c. or Ferro-cyanate of Potassa, &c.
Aquafortis, ...	Nitric Acid of Commerce.
Aqua Regia,.................	Nitro-muriatic Acid.
Aqua Reginæ, ...	Nitro-sulphuric Acid.
Argil, or Argillaceous Earth,..	Alumina.
Ash, Pearl, ...	Carbonate of Potassa, (impure.)
Bezoar Mineral, ...	Oxyde of Antimony.
Black Lead, ...	Percarburet of Iron.
Blue, Prussian, ...	Prussiate (or hydro-cyanate) of Iron.
Bittern..................	Residual Solution of Muriate of Magnesia.
Barilla, (Kelp)	Carbonate of Soda, (impure.)
Borax, ...	Sub-borate of Soda.
Butters of the Metals, ...	Muriates, as of Antimony, &c.
Calces, Metallic, ...	Metallic Oxydes.
Calomel, ...	Proto-muriate of Mercury.
Caustic, Lunar, ...	Nitrate of Silver, run into moulds.
Ceruse, (White Lead),........	Carbonate of Lead.
Chalk, ...	Carbonate of Lime.
Charcoal, Pure, ...	Carbon.
Colcothar of Vitriol, ...	Brown-red Oxyde of Iron.
Copper, Acetated,............	Acetite of Copper.
Copperas, Green,............	Sulphate of Iron.
Copperas, Blue, ...	Sulphate of Copper.
Copperas, White, ...	Sulphate of Zinc.

Old Names.	*New Names.*
Cinnabar,	Persulphuret of Mercury.
Earth, Calcareous,	Lime.
Earth, Aluminous, Earth of Alum,	Alumina.
Earth, Magnesian or Muriatic,	Magnesia.
Emetic Tartar	Antimoniated Tartrite of Potassa.
Ethiops, Martial,	Black Oxyde of Iron.
Ethiops, Mineral,	Proto-sulphuret of Mercury.
Flowers, Metallic,	Sublimed Metallic Oxydes, as of Zinc, &c.
Flowers of Sulphur,	Sublimed Sulphur.
Fluors,	Fluates, as of Lime, &c.
Hepars, or Sulphures,	Sulphurets, as of Potassa, &c.
Kermes Mineral,	Hydro-sulphuret of Antimony.
Lapis Infernalis,	Sticks of Caustic Potassa.
Lead, Sugar of,	Peracetate of Lead.
Litharge,	Vitrified Protoxyde of Lead.
Liver of Sulphur, Alkaline,	Sulphuret of Potassa.
Lunar Cornea, (Horn Silver)	Muriate of Silver.
Magistry of Bismuth, (Pearl White,)	Proto-nitrate of Bismuth.
Magnesia Alba, Magnesia, Aerated,	Carbonate of Magnesia.
Massicot,	Protoxyde of Lead.
Minium, (Red Lead,)	Deutoxyde of Lead.
Mother Waters,	Deliquescent saline residue.
Nitre, (or Saltpetre,)	Nitrate of Potassa.
Oil of Tartar, *per deliquium*,	Deliquescent Potassa.
Orpiment,	Persulphuret of Arsenic.
Phlogiston,	An imaginary inflammable principle.
Plumbago, (Black Lead,)	Percarburet of Iron.
Precipitate, Red, Precipitate, *per se*,	Peroxyde of Mercury.
Pyrites of Copper,	Sulphuret of Copper.
Pyrites, Martial,	Sulphuret of Iron.
Realgar,	Proto-sulphuret of arsenic.
Regulus of Metals,	Metallic, or pure form of Metals.
Rust of Copper,	Green Oxyde of Copper.
Rust of Iron,	Oxyde and Carbonate of Iron.
Saffron of Mars,	Oxyde of Iron.
Sal-Ammoniac,	Muriate of Ammonia.
Sal-Mirabile,	Sulphate of Soda.
Sal-Prunelle,	Fused Nitrate of Potassa.
Sal-Polychrest,	Sulphate of Potassa.
Sal-Enixum,	Acid Sulphate of Potassa.

Old Names.	*New Names.*
Salt, Common Table,	Muriate of Soda.
Salt of Tartar,	Subcarbonate of Potassa.
Salt, Sedative,	Boracic acid.
Salt, Prout's Perlated,	Phosphate of Soda.
Salt of Wormwood,	Carbonate of Potassa.
Salt, Vegetable,	Tartrite of Potassa.
Salt of Lemons, (essential).. / Salt of Sorrel,	Quadroxalate of Potassa.
Salt, Febrifuge, of *Sylvius*	Muriate of Potassa.
Salt, Microcosmic,	Phosphate of Soda and ammonia.
Salts, Glauber,	Sulphate of Soda.
Salts, Epsom,	Sulphate of Magnesia.
Salts, Rochelle,	Tartrate of Potassa and Soda.
Scheele's Green,	Arsenite of Copper.
Saltpetre,	Nitrate of Potassa.
Selenite, (Gypsum,)	Sulphate of Lime.
Spar, Calcareous,	Crystallised Carbonate of Lime.
Spar, Fluor,	Fluate of Lime.
Spar, Ponderous,	Sulphate of Baryta.
Spirit, ardent,	Alcohol.
Spirit of Nitre,	Nitric Acid.
Spirit of Nitre, fuming,	Nitrous Acid.
Spirit of Salt,	Muriatic Acid.
Spirit of Sal-ammoniac,	Ammonia.
Spirit of Vitriol,	Sulphuric Acid.
Spirit of Wine,	Alcohol.
Spiritus Rector,	Aroma.
Sublimate Corrosive, (Corrosive Muriate of Mercury,)	Permuriate of Mercury.
Sugar of Lead,	Peracetate of Lead.
Tartar,	Acidulous Tartrite of Potassa.
Tartar, Emetic,	Antimoniated Do.
Tartar, Vitriolated,	Sulphate of Potassa.
Tartar, Cream of,	Super-tartrate of Potassa.
Tartars,	Tartrites.
Turbith, Mineral,	Subsulphate of Mercury.
Verdigris, or Rust of Copper, exposed to air,	Green Oxyde of Copper.
Verdigris,	Acetite of Copper mixed with Oxyde.
Verdigris, Distilled,	Crystallised Acetite of Copper.
Vinegar, Distilled, / Vinegar, Radical,	Acetous Acid.
Vitriol, Blue, or Roman,	Sulphate of Copper.
Vitriol, Green, / Vitriol, Martial,	Sulphate of Iron.

Old Names.	*New Names.*
Vitriol, White, ...	Sulphate of Zinc.
Vitriols, ...	Sulphates.
Vermilion, ...	Persulphuret of Mercury.
Water, Acidulated,........	Water impregnated with Carbonic Acid Gas.
Water, Hepatic, ...	Sulphuretted Hydrogene in Water.
Zaffre	Oxyde of Cobalt, and Earthy Matter.

VOCABULARY

OF

TECHNICAL TERMS.

ADOPTER. An intermediate tube of glass or porcelain, serving to connect the retort with the receiver and lengthen the distance between them.

AFFINITY. That influence by which bodies attract each other and combine.

ALBUMEN. Found in the serum or colourless part of blood. White of egg is albumen.

ALEMBIC. Stell. Of silver, copper, crystal, &c., for the distillation of alcohol, or essential oils.

ALLOY. Combination of one metal with one, two, or more of another.

AMALGAM. Applied exclusively to the combination of a metal with mercury.

ANALYSIS. Separation of a compound substance into the parts of which it is composed.

ATTRACTION, of aggregation or cohesion. The affinity of similar or homogeneous particles, by which they cohere, or are agglutinated together in the entire mass.

ATTRACTION, CHEMICAL. The affinity of heterogeneous or dissimilar particles, in virtue of which they act and re-act on each other.

ATOM. The ultimate particle into which matter is supposed to be divisible.

ANNEALING. That process of gradual and slow cooling, by which the material is enabled to resist sudden extremes of temperature.

ANHYDROUS, without water: an anhydrous salt is possessed of no water of crystallization.

BASE. Alkali, earth, or metal with which the acid may be combined.

CALCAREOUS. Containing lime.

CALCINATION. Reduction to a caustic, &c. form, by exposure to heat; thus, oyster-shells may be calcined.

CALORIC. Material of heat.

CALX. A metallic oxyde.

CAPUT MORTUUM. The residum of charcoal, &c. left at the close of the process, in the retort, or crucible.

CARBONACEOUS. Containing carbon or charcoal.

CARBURETS. Combination with carbon, as carburet of sulphur, and carburet of iron.

CASE HARDENING. Communication of a surface of steel by heating charcoal in contact with the surface.

CAUSTICITY. Property of corroding or inflaming the skin, &c.

CEMENTATION. Formation of steel, by placing bars of iron in contact with strata of charcoal, and exposing them to intense heat.

Chalybeate. Impregnation with iron; thus, a chalybeate mineral water.

Combustibles. Inflammable substances, such as are capable of being set on fire.

Comminuted. Matter finely divided.

Concentration. Density or specific gravity increased by evaporation, &c.

Conduction. Property of conveying or transmitting heat, electricity, or magnetism.

Crucible. A vessel of a peculiar structure in which the substance is placed, to sustain the action of fire. Crucibles are of different materials, as platinum, silver, porcelain, and plumbago.

Crystallization. The act by which are formed the geometric structures of salts, &c.

Cupel. Small cup of bone ash, or phosphate of lime, in which the silver for purification or assay is placed.

Condensation. The process of changing an elastic or volatile product into one more dense.

Cupelation. Process of purifying silver by alloying it with lead or bismuth, and submitting it to intense heat, with a free current of air.

Dissication. The process of drying whether by heat; or absorption of moisture by dry muriate of lime.

Decantation. Leaving the precipitate by pouring off the supernatant liquid.

Decoction. Applied to vegetable matter, &c. submitted for some time to the action of hot water.

Deflagration. Vivid combustion, as that of nitre or chlorate of potassa; or of metallic laminæ, in the galvanic battery.

DELIQUESCENCE. Applied to salts. Salts become deliquescent, or moist, by absorbing water from the atmosphere, as muriate of lime, which melts.

DETONATION. Explosive report; thus, sulphur and chlorate of potassa rubbed together, in a mortar, detonate.

DIAPHANOUS. Transparent, as air, water, or crystal.

DIGESTION. Slow and regular action of a solvent, as of water.

DISSOLUTION. Solution of a metal in an acid, as of mercury in nitric acid, identical with solution.

DUCTILITY. Property or capability of being drawn out into wire.

DECOMPOSITION. Process of resolving a compound into its elements.

EFFERVESCENCE. Frothy disengagement of air, as that liberated by the action of an acid; carbonic acid disengaged from limestone, by muriatic acid, affords an example.

EFFLORESCENCE. Applied to saline bodies wherein the water of crystallization is abstracted by the atmosphere. Alum and sulphate of soda, present examples.

ELASTIC. Springy; vapour is a temporarily elastic fluid, air a permanently elastic one.

ELECTIVE ATTRACTION. Identical with chemical affinity.

EXPANSION. The increase of volume, as by heat.

EBULLITION. The process commonly termed boiling, by which the substance is changed into vapour.

Equivalent. The relative quantity or proportion of any given substance necessary to combine with and neutralize another substance.

Eudiometer. An instrument for determining the purity of airs, particularly that of the atmosphere, by a medium absorbing oxygene, as nitrous gas, or green sulphate of iron, impregnated with it.

Evaporation. Disengagement of the volatile matter or vapour, liquids being thus generally vaporised by heat. In this process, heat being abstracted, evaporation becomes a source of cold.

Filtration. Passing the solution through a strainer, as bibulous or blotting *(unsized)* paper, by which the insoluble matter is retained.

Fixity. Property by which a great heat is resisted unchanged, as in the case of gold or platinum.

Flux.* A substance which aids the fusion of ores, &c. as *borax*, and nitre.

Fulmination. Explosive report or noise, as when fulminating mercury is struck on an anvil.

Fusion. Melting down, by the agency of heat: sugar, potassa, lead, &c. fuse or melt by heat.

Granulation. A process by which metals are reduced into minute forms.

Gas. A permanently elastic air, as oxygene.

* *White* flux is composed of equal parts of nitre and subcarbonate of potassa, deflagrated in a crucible. *Black* flux consists of one part of nitre, and two parts of crude tartar, prepared in the same way.

GRAVITY. Weight. *Specific gravity*, difference of weight, the bulk, or volume, being the same.

HEPARS. Combinations of sulphur, called also *livers*, as sulphuret of potassa.

HEPATIC GAS. Sulphuretted hydrogene, a gaseous combination of sulphur and hydrogene.

HYDRATES. Metallic oxydes combined with a definite quantity of water; thus, hydrate of copper.

HYDRO-GURRETTED SULPHURETS. Sulphurets, which by acting on water, decompose it, and are thus transmuted.

INFUSION. The extract obtained by the action of hot water, simply poured on the substance.

INTEGRANT. The proximate particle which may be separated by mechanical division.

LUTES. Plastic and cohesive materials employed to conjoin chemical apparatus.

LAMINÆ. Fine plates, or leaves, as those of gold, silver, and copper.

LEVIGATION. Reducing to a fine powder, on a marble slab, &c.

LIXIVIATION. The process of separating, by water and the filter, soluble from insoluble substances.

MACERATION. Extraction of the virtues of any solid, by the continued action of cold or warm water.

MALLEABILITY. Property of being rolled up into plates, or beaten into leaves or folia.

MINERAL. A metal in combination with sulphur or arsenic, &c.

Muffle. A case to receive the cupel, made of fire-clay, it protects the cupel from the ashes, yet allows the heated air to act on the alloy.

Molecule. A term applied to the ultimate nucleus, as that of a crystal.

Neutralization. This term is applied to the reciprocal balance of acid and base.

Opacity. Without transparency, as a metal.

Oxyde. Combination of a metal with oxygene (not acid), as protoxyde of iron, deutoxyde of lead, &c.

Parting. Process of separating silver from platinum or gold, by the action of nitric acid. It is also called *quartation.*

Precipitate. The insoluble portion thrown down by the test, or re-agent.

Radical. Identical with element.

Re-agents, or *Tests.* Applied to discover, in virtue of their superior and powerful affinities, the composition of bodies, as of mineral waters.

Receiver, or *Recipient.* That which serves to collect the liquid product distilled over.

Rectification. Increasing the strength of spirit, &c. by a second or third distillation.

Reduction. Revival or recovery of metals from their oxydes, &c., as of oxyde of lead by charcoal heated in contact with it.

Refrigeration. The process of cooling, as by the employment of freezing mixtures.

Reguline. In the metallic form.

RETORT. A vessel of a peculiar form, which holds the subject of experiment, and is to afford the gaseous or other product: it is usually blown with an elliptical ball, extended by a curved tube, and is of crystal or porcelain.

SALINE. Having the properties of a salt.

SATURATION. A fluid is said to be saturated when it can dissolve no more of the material, as of sulphate of soda.

SEMI-METAL. Formerly, though improperly, applied to a brittle, and easily vaporised metal, as antimony, arsenic, &c.

SILICIOUS. A substance of which silica forms, a considerable part.

SOLUTION. Salts, &c. dissolved in a liquid medium, hence called the solvent.

SUBLIMATION. Volatilization of a substance by heat, and subsequent condensation; thus arsenic, sulphur, and iodine.

SYNTHESIS. The re-union or composition of a substance from its constituents, as of sulphate of lead by the combination of sulphuric acid and lead; opposed to analysis.

TINCTURE. Obtained by dissolving the substance in alcohol.

TRITURATION. Applied to the process of reduction to the state of a fine powder, as in the mortar.

VITRIFICATION. When the substance assumes somewhat of a glassy consistency; thus, resin is said to break with a *vitreous* fracture, and litharge is a semi-vitreous form of protoxyde of lead.

VOLATILITY. Tendency to the gaseous state, or form of vapour.

WELDING. Property of being united under the hammer when ignited, from growing soft before fusion; thus, bars of iron, or of platinum, may be united.

ZERO. Marked o, being 32° below the "freezing point" on the scale of Fahrenheit.

LIST OF TESTS OR RE-AGENTS

REQUIRED IN

CHEMICAL ANALYSIS.

Sulphuric Acid. Specific gravity 1·25.
Nitric Acid. Specific gravity 1·45.
Muriatic Acid. Specific gravity, 1·12.
Potassa, in Solution.
Liquid Ammonia.
Acetic Acid.
Lime-water.
Alcohol, *say* specific gravity ·812.
Sulphuric Ether.
Solution of Carbonate of Ammonia.
——— Carbonate of Potassa.
——— Oxalate of Ammonia.
——— Nitrate of Baryta.
——— Phosphate of Soda.
——— Subacetate of Lead.
——— Chromate of Potassa.
——— Sulphate of Copper.
——— Persulphate of Iron.
Tincture of Galls.

Tincture of Litmus.
———— Turmeric.
———— Brazil.
———— Cabbage.
———— Iodine.
———— Soap.
———— Logwood.
Syrup of Violets.
Solution of Starch.
———— Isinglass.
———— Nitrate of Silver.
———— Nitrate of Mercury.
———— Nitrate of Lead.
———— Nitro-muriate of Tin.
———— Ferro-cyanate of Potassa.
———— Muriate of Ammonia.
———— Sulphuret of Ammonia.
———— Hydriodate of Potassa.
———— Pure Baryta.
———— Silicated Potassa.
———— Sulphate of Ammonia.
———— Nitro-muriate of Platinum.
———————— Gold.
Test Papers—Litmus, Turmeric, and Brazil.
Phosphorus.
Black Flux.
White Flux.
Metallic Rods, of Iron, Copper, Zinc, Tin, and Lead.
Distilled Water.

The preceding catalogue comprises the most essential tests required in chemical analysis—of some of these six or eight ounces may be required, and of the rest only one to three ounces. The sulphuric, nitric, and muriatic acids, together with potassa, ammonia, alcohol, and ether, should have glass caps, adapted to the phials by grinding, to secure the stoppers. The phial containing phosphorus in water, should be kept in a tin case. The other phials should be accurately closed with glass stoppers, particularly those containing tincture of iodine, nitrate of silver, hydro-sulphuret of ammonia, acetic acid, nitro-muriate of platinum, and nitromuriate of gold, being volatile and corrosive. Several of the tests recommended by some authors may be dispensed with: ferro-cyanate of potassa, for instance, may do instead of ferro-cyanate of ammonia. Oxalate of ammonia is a much better test than oxalic acid simply, for the presence of lime: fluate of ammonia is of no value. In like manner, nitrate of baryta appears a more accurate test than acetate or muriate of baryta; and the nitrate of silver renders superfluous the acetate and sulphate of silver. The test papers may entirely substitute the *tinctures* of litmus, turmeric, and Brazil. The black and white flux, being *deliquescent*, must be preserved in phials. Tests under the form of *crystals* are not merely *portable* and convenient, but, if I mistake not, are far more *sensible* and *delicate* than re-agents in solution.

List of Chemical Apparatus Requisite.

Much may be done in chemical manipulation with a few watch-glasses, wine-glasses, and tumblers, Florence flasks, &c. For more extensive and refined research, the following may be deemed necessary; though a few of them will usually suffice. It is to be regretted that writers on practical chemistry have, by exhibiting an extensive and complicated apparatus, injured the cause of science, and puzzled and perplexed the pupil in his outset by an adventitious show, that "leads to bewilder, and dazzles to blind." Many interesting and important chemical facts and phenomena may be exhibited by an apparatus that would cost only a comparative trifle. The most beautiful and sublime discoveries in physical science were accomplished with instruments of little intrinsic value. Newton and Franklin may be appealed to,* and the richest discoveries of modern chemistry, prior to those of Sir Humphry Davy, were effected by means of simple apparatus: Scheele and Priestley are practical examples; and Tennant and Wollaston were not more eminent for the depth and originality of their investigations, than the extreme simplicity of their apparatus.

Small Brass Stand, with rings.
Spirit Lamp.
Pneumatic Troughs, two sizes.
Small Cast-iron Mercurial Trough.

* M. Biot, in adverting to the experiment made by Dr. Franklin with the kite, very happily observes, " Depuis les belles expériences de Newton sur les couleurs dévelloppées par les bulles d'eau savonneuse, ce fut la seconde fois que les jeux d'enfans devinrent pour la physique les instrumens des plus belles decouvertes."—*Traite de Physique, Tome I. p.* 518.

Glass and Porcelain Capsules, and evaporating Dishes, of sizes.—Wedgewood's porcelain is best calculated for chemical purposes.

A Copper Basin, to contain sand for a sand-bath.

Platinum Spoon.

Platinum disc (foil).

Steel Forceps, with Platinum tips.

Glass Rods, for Stirring Liquids.

Graduated Tube, (cubic inch.)

Wollaston's Dropping Phial.

A Tube, with Bulb, for transferring small portions of Liquid—one end is drawn out very fine.

Deflagrating Jars with wide mouths, (from one inch to two inches in diameter,) and accurately closed with ground-glass stoppers, of sizes, from two inches to four inches diameter in the cylinder, and from four to eight inches high.

Deflagrating Spoons, from half an inch to an inch diameter.

Cylindrical Vessels, for Precipitations, Gases, &c. of various diameters, ground at the bottom and on the lip above, from one inch diameter to three inches: some of them particularly strong.

Circular pieces of plate glass, of various diameters, for covers.

A support for holding watch-glasses over the spirit-lamp.

A support for holding Test Tubes over the lamp.

Test Tubes.

Test Tubes, or Glasses, with a foot to stand securely.

Gas Bottle, with curved tube, (Sigmoid's.)

Retorts, of various sizes, of glass, some tubulated, from one to eight ounces capacity.

Receivers, two or three sizes, of glass, two of them quilled and tubulated.

Funnels of sizes, glass and porcelain, one or two of these with long stems.

A. Welter's Tube of Safety.

Glass Graduated Measure, say eight ounces.

Anvil and Hammer.

Filtering Paper.

Scale of Chemical Equivalents.*

Thermometers, *mercurial* and *alcoholic.*

Blow-pipe. (That of Wollaston or Black.)

Test Phial, with a ground-glass cap, and elongated stopper reaching to the bottom of the phial.

Bolt Head, small.

Small Glass Alembic.

Bell Glass, with stopcocks, ferrules, &c., for the transfer of Gases.

Dutch Tiles, small.

Glass and Wedgewood Mortars, small.

Long Tubes, some hermetically sealed at one end, others open.

A small Black Lead Furnace.

There are others necessary to make a laboratory complete, and for the higher and more complicated and refined manipulations; such as,

Newman's Mercurial Trough, and its appendages.

Fontana's Detonating Eudiometer.

Woulf's Apparatus, with Welter's Safety Tubes.

* Cuff's extension of Wollaston's scale is recommended as neat and accurate.

Graduated Bell Glass, with stopcocks and Globe.
Flask for exhaustion, to weigh Gases.
Silver Alembic.
Platinum and Silver Crucibles.
Crucibles of Porcelain, Black Lead, &c.
Muffle and Cupel.
Knight's Black's Furnace.
Wollaston's Reflecting Goniometer.
Reflectors for Radiation of Caloric, and stands.
Separatory Funnel.
Italian Recipient.
Sir Humphry Davy's Apparatus for Analysis of Soils.
Davy's Pocket Eudiometer.
Hope's or Pepy's Eudiometer.
A delicate Balance to turn with 1-100th of a grain.

*Note.—Ritchie's Balance is at once simple and accurate.**

Differential Thermometer.
Air Thermometer.
Silver Capsule.
Specific Gravity Bottle, with counterpoise.
Argand's Lamp.
Electro-magnetic Apparatus.
Galvanic Batteries and their attachments.
Thermo-electric Apparatus.
Cubic Inch for Distilled Water, with counterpoise.
Compound Gas Blow-pipe.

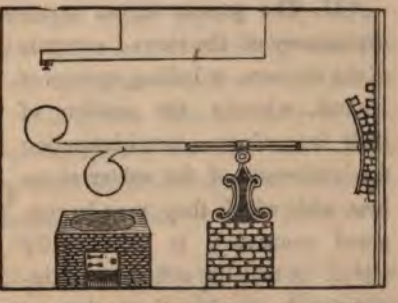
* Captain Kater, some years ago, proposed a delicate and accurate balance. Its price, unadjusted, was £4., and when adjusted, £6.—See *Brande's Journal.*

An Air Pump, with auxiliary Apparatus.
Gas-holder (Pepy's Improved.)
An Electrical Machine, and Leyden Jar.

Note.—For philosophical and chemical instruments and apparatus, I can safely and conscientiously recommend Mr. Banks, Bond-Street; Mr. Carey, Strand; Mr. Newman, Regent-Street; Messrs. Watkins and Hill, Charing Cross; and Mr. Tarbotton, Briggate, Leeds.

DESCRIPTIVE LIST OF SOME PARTICULAR APPARATUS.

As the following apparatus are among the more essential parts of the usual processes of chemical manipulation, it has been deemed advisable to annex figures, representing the form and arrangement I have found most convenient in my own experimental researches.



*I. The annexed figure represents the model of an apparatus, invented by me, for the employment of ether in vapour, as a prime mover: the apparatus consists of a globe, with a ball branching from it. When this globe, containing sulphuric ether, dips into the vessel, supplied with water at a temperature exceeding 100 F., the ether assumes the elastic form, and impels a double headed piston to the further extremity of the horizontal cylinder connected with it, which, as the cylinder is equipoised when the piston is central, (being suspended like the balance on a fulcrum) will then preponderate in that direction. This elevation of the branching ball, also charged with etherial vapour, serves to raise a plug, from whence a small stream of cold water descends, and, condensing the vapour, the piston is impelled in the contrary direction, and depresses the globe into the hot water, which speedily converts the ether again into an elastic form—checks, in the horizontal cylinder, regulate the movements of the piston, which, being thus driven backwards and forwards, serves to elevate and depress the balance. The etherial vapour, and the re-action of the atmosphere on the condensation of the former, being the efficient cause in these movements.

* II. The present figure represents my invention explanatory of the views I entertain of the phenomena of the Geysers, or boiling springs of Iceland, wherein the problem of their *intermission*, notwithstanding the uniformity of the subterranean heat with which they may be supposed connected, is satisfactorily solved. A metallic cylinder, terminating at the top in a basin, is supplied with water through a central pipe, a plug permitting the previously contained air to escape: as soon as the water boils within the

cylinder, steam is disengaged, and filling the space between the surface of the water and dome of the cylinder, finally expels, by its elasticity, the water through the central pipe, which issues in the form of a jet, and falls again into the basin; where, being cooled down by the contact of atmospheric air, it serves to condense the elastic steam within the cylinder, when the basin is speedily emptied of its contents,—the water rushing back again into the pipe, from whence it again issues, after a short interval, from the orifice of the pipe. The flame of the spirit-lamp placed beneath the cylinder continues uniform, notwithstanding these intermissions. The silicious pipe, connected with the basin in the Geysers of Iceland, is clearly ascertained; and if we only suppose the silicious and stallactitic pipe to be contracted towards its lower orifice, the experiment made by Dr. Henderson, of accelerating the period of its flow, by casting stones into the central pipe, is easily understood, because the entire steam, which might otherwise partially escape, will be sooner raised to its maximum pressure, at least what is more than necessary to overcome the resisting atmosphere, and raise that majestic column of water, which often ascends from its crater, and forms so imposing a spectacle to the observer.*

* III. This figure illustrates an arrangement I have constructed, for the purpose of shewing the relative conducting properties of the metals in reference to

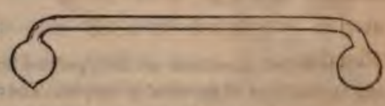
* These two inventions are incorporated here as affording pleasing applications of chemical principles. The one being the practical elucidation of an elastic vapour applied to the movement of machinery; in the other the elasticity of steam is introduced in illustration of a remarkable natural phenomenon.

caloric. The metals employed are silver, copper, and iron; and these rods, passing through the segment of an arc, of wood, are united in a point in one direction, which is introduced, as represented, into the flame of a spirit-lamp.

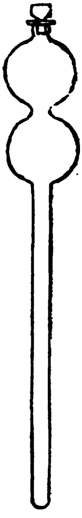
The rods diverge in the contrary direction, and each extremity carries a minute portion of amadou, or German tinder, which, being moistened with a drop of the solution of phosphorus in sulphuret of carbon, will, by their relative priority of ignition, announce their comparative relations as conductors of caloric.

IV. A brass cylinder attached to its handle, with a mould that it exactly fits in its diameter; also longitudinally, when at the common temperature of the atmosphere; but when heated, it is by reason of its expansion no longer susceptible of entering the notch in the mould or the circular opening of the gauge.

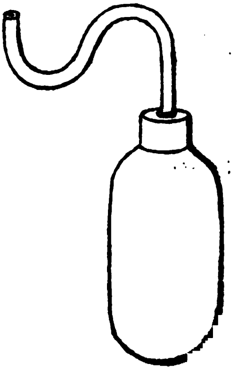
V. Wollaston's Cryophorous, or *frost bearer*, for



shewing the process of freezing at a distance, the wate r being contained in the spherical ball, passes into the state of ice, as soon as the other ball, terminating in a point, is plunged into a vessel containing a freezing mixture.

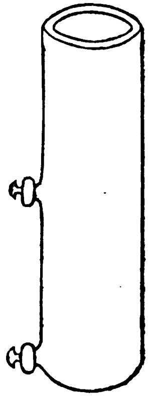


VI. An apparatus for shewing the diminution of volume which takes place in the mixture of sulphuric acid and water; the stem and lower ball being filled with sulphuric acid, the upper ball is supplied with cold water to overflow, and the stopper being replaced, the instrument is reversed, when the acid and water being mixed together, a considerable increase of temperature ensues, and the empty space, in the superior part of the stem, indicates the diminution of volume.



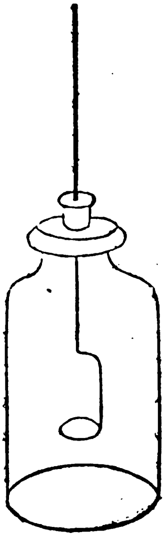
VII. The gas bottle with Sigmoid's tube, for the disengagement of hydrogene and carbonic acid gas, from the materials employed in their production.

VIII. A narrow cylinder, supplied with two lateral stop cocks, which I employ in a great variety of experiments, such as carbonic acid gas, the vapour of sulphuric ether, &c.

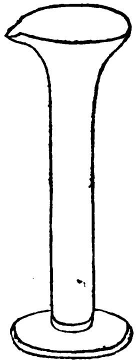


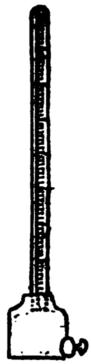
IX. A bell glass, with a globe conjoined, by means of a stop-cock connecting them, a necessary adjunct to the pneumatic cistern, for the transfer of gases.

X. A deflagrating jar with brass cap, the deflagrating spoon passing through a collar of leathers: the mouth of the jar should be wide and *lipped;* and the edge of the jar below without a "welt."



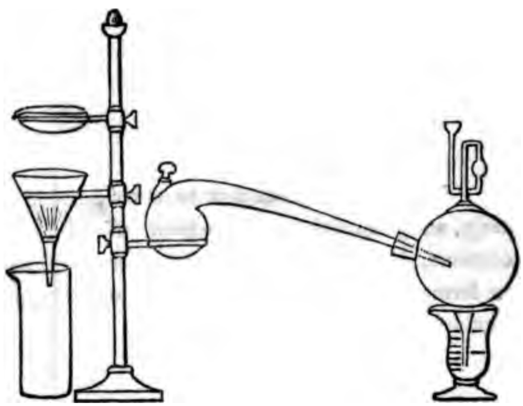
XI. A test glass, with foot to stand securely, and a lip, convenient to pour off its contents, in the case of a precipitate being formed. It is wide at the top to receive a small filter.





XII. Hope's Eudiometer. The lower part is filled with a solution of green sulphate of iron, impregnated with nitrous gas, the graduated tube, of course, filled with atmospheric air, is then inserted into the neck of the apparatus, which being shaken, the oxygene of the imprisoned atmosphere will be absorbed, and when the stopper is opened under water, the fluid will rise in the graduated stem, and indicate an absorption to the amount of 21 per cent. In Mr. Pepy's Eudiometer the lower part of the apparatus is of *caoutchouc*, and the pressure of the external atmosphere will then shew, by the ascent of the liquid, the amount of absorption.

XIII. Exhibits a retort stand and rings. On the one side is an evaporating dish, and in the ring below a



funnel, with a lipped cylinder, convenient for filtration; on the other side is a stoppered retort, the beak of which enters a quilled receiver, the quill passing into a graduated measure; the receiver is surmounted by a tube of safety, containing a small portion of mercury, which will rise and fall on the principle of the barometer, and thus compensate for any sudden extrication of elastic vapour, or its sudden absorption.

XIV. A brass stand with rings. On the one side is attached a reflector for experiments on the radiation of caloric; and on the other an alembic, the beak of which is extended, so that the product of distillation may flow into the deep lipped glass arranged to receive it.

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HYDROPHOBIA:

PROPHYLACTIC AND CURATIVE.

"Mr. Murray (who always recommends himself to our attention by his skill in the valuable art of condensation,) has furnished us with a great deal of what may be called the Literature of Hydrophobia."—*Monthly Review, July* 1.

"The work displays both ability and learning, and is calculated to be popular and useful."—*Leeds Mercury*, June 19.

"We hail with pleasure the excellent little volume of Mr. Murray, an able Chemist, on this subject. We think his opinions of the nature of the disorder are worthy of great attention, and that his chemical plans of cure deserve an extensive trial."——*Monthly Gazette of Health*, July 1.

IV.

A TREATISE

ON ATMOSPHERICAL ELECTRICITY.

SECOND EDITION.

Note.—Mr. Murray's New Lightning Conductor is erected on St. Paul's Church, and the new Infirmary, Huddersfield.

"A very ingenious and very interesting little work."—*Monthly Review,* February 1.

"A useful little work, full of amusing as well as valuable anecdotes and instances."—*Atlas,* July 18.

"This work contains much curious and useful information."—*Leeds Mercury,* December 5.

"Sincere is our declaration of the keenness and value of Mr. Murray's research."—*Gentleman's Magazine,* September 1.

"This, though a brief, is a very interesting History of Electricity. It presents a satisfactory view of its agency in almost all the phenomena of Nature; shews how it may be collected, directed, and managed by art; and describes its wonderful powers, and the instruments which have been invented to detect its presence and character."—*Magazine of Natural History,* No. XVI. for November, 1830.

"A volume of simple and conclusive facts."—*Bristol Mercury.*

"The recommendation of paragreles in the treatise on Atmospherical Electricity is well deserving attention."—*Metropolitan,* May 2.

V.

AN INVENTION,

FOR FORMING AN INSTANTANEOUS COMMUNICATION IN SHIPWRECK.

Note.—The National Institution for Preservation from Shipwreck has already established this Invention on the Sussex Coast. It is also attached to the life-boat at Whitby.

"This Invention is exceedingly simple, but appears capable of much useful application. The design seems entitled to high commendation."—*Friends' Mag.* April 1.

"We trust that this pamphlet will meet with immediate attention from the numerous bodies of humane associations which have been formed in this country on the same benevolent principles as seem to have actuated Mr. Murray. The compliment is challenged with tenfold force in favour of a contrivance which has for its author a gentleman with the information, experience, and abilities of Mr. Murray."—*Monthly Review*, April 1.

"The Life-Preserving Arrow.—Mr. Murray's description is perspicuous, and the simplicity and apparent efficacy of the Invention are such as to recommend it strongly to general attention."—*Spectator*, April 16.

"Mr. Murray's active and philanthropic mind has been turned to the discovery of a simpler and less expensive apparatus for conveying a line from the shore to a vessel in distress, than that of Captain Manby."—*Leeds Mercury*, May 21.

"Mr. Murray's Invention is most important, and will, no doubt, be properly appreciated and encouraged. In its success, every man of common feeling must take a deep interest."—*Liverpool Mercury*, July 30.

"—It is a subject of much importance to a nation like ours, and every attempt to save Shipwrecked Mariners, deserves close examination and due encouragement. The merits of Captain Manby's Invention have been honorably rewarded, and we hope that the efforts of Mr. Murray will not be disregarded."—*Imperial Mag.* Aug. 1.

The experiments appear to have been as yet perfectly satisfactory. Blessed be the man who shall perfect these schemes!"—*United Service Journal*, December 1, 1831.

"A complete set of Mr. Murray's Apparatus for saving Lives from Shipwreck having been procured by a subscription among several of the gentlemen of Whitby, was tried on the pier on Friday, and we understand gave great satisfaction to the subscribers and others who witnessed it. This Invention of Mr. M.'s is meant to answer the same purpose as Capt. Manby's Apparatus, viz. by throwing a line across a vessel on the strand, to effect a communication with the shore."—*Hull Advertiser*.

"The experiments detailed, leave no doubt on our minds, that Mr Murray's apparatus is by far the most efficient that has yet been devised; while at the same time it is so cheap and portable, that inclination alone is all that can be wanting to bring it into universal use."—*Mechanics' Mag.* May 21, 1832.

"Perhaps there are few contemporary writers on practical science to whom the thanks of mankind are more due than to the originator of the above Invention. Such a man is indeed a Benefactor to his species."—*Arcana of Science and Art*, for 1832.

"Mr. Murray has endeavoured to improve it—(Captain Manby's Invention)—besides this, he illuminates his arrow in a very ingenious manner; we look to the principle of Mr. Murray's laudable exertions, and heartily wish him success in his philanthropic experiments."—*Nautical Mag.* May 1, 1832.

"Mr. Murray's excellent Invention for Saving from Shipwreck, abstracted from a pamphlet published by that ingenious and very philanthropic gentleman." "We cannot anticipate less than its speedy adoption along all our shores." "We trust that a great and generous nation will mark in some suitable manner its sense of the valuable present he has made to it. If Capt. Manby was thought well deserving of £3,250 for his imperfect Apparatus, it cannot be that the Inventor of one in every respect superior to it, should be suffered to go wholly unrewarded."—*Mechanics' Mag.* May 26, 1832.

VI.

RESEARCHES IN NATURAL HISTORY.

SECOND EDITION.

"The author of this little work has chosen some of the most remarkable phenomena in nature, for description and illustration, treated with much practical knowledge, gained, it would appear, from extensive and patient investigation."—*Magazine of Natural History.*

"The chapter on the Chameleon is particularly interesting, and contains the fullest account of that singular animal. A learned disquisition on the ascent of the Spider follows in the second and third chapters. On the question of torpidity, and the numerous instances of torpid animals brought before us, with the facts that illustrate their habits, the author is very happy. The whole of the remarks on migration are valuable."—*Atlas,* July 4.

"His work is curious and instructive."—*Gentleman's Mag.* September 1.

"That most clever and ingenious little work, 'Researches in Natural History.'"—*Author of the 'Journal of a Naturalist.'*

"The value of such Publications as those before us greatly consists in their being adapted to excite and form a taste for these most healthful and salutary studies," &c. "This object Mr. Murray has had particulary in view in his present volume, which though bearing the marks of extensive scientific attainments, is of a miscellaneous and popular character." "The style and feeling displayed in such works as 'Salmonia,' 'Journal of a Naturalist,' and 'the British Naturalist,' remind us, it is remarked 'of the good old times of Evelyn and Walton, Derham and Ray, and last not least, the amiable Philosopher of Selborne,' with these works his own Researches deserve to class as an instructive and valuable addition to the materials of physiological science."—*Eclectic Review*, July 2, 1832.

VII.

A MEMOIR ON THE DIAMOND.

"The 'Memoir on the Diamond' is interesting."—*Metropolitan*, April 2.

"Mr. Murray, in addition to the many curious and valuable contributions he has made to knowledge, has written a little treatise on the Diamond, where all that is known of that extraordinary production is collected and illustrated. Mr. Murray tells us of its history, of its site, of its nature, and its various remarkable specimens."—*Spectator*, May 7, 1831.

"This little work abounds in curious and interesting information, both chemical and historical, and will very well repay the reader." —*Leeds Mercury*. May 21.

"—This work will be read with interest. It contains the history of the largest diamonds known, with their weight. &c., and a great deal of information in a small compass."—*Courier*, May 10.

"Much interesting and valuable information in a very condensed form, and in clear and concise language."—*Athenæum*, July 2, 1832.

VIII.

DESCRIPTIVE ACCOUNT OF A NEW SHOWER BATH, &c.

SECOND EDITION.

"We have here another illustration of the Author's aim to render the inventions of science tributary to the real benefit of mankind: the great superiority of this Shower Bath to those ordinarily used, is the facility which it affords of dividing the same supply of water into an unlimited number of showers, &c. &c.

"Mr. Murray has also given us an account (with a plate) of an apparatus for restoring suspended animation, for which we may venture to offer him the thanks of the Profession."—*North of England Medical and Surgical Journal*, June, 1831.

"Though the Shower Bath, as an important auxiliary to health, *may be* an object of no slight general interest, as it has been of the successful attention of our scientific author; yet the Apparatus for restoring Suspended Animation, and which appears well adapted to its design, is the subject of chief moment. It occupies the principal part of these pages, and is described with much clearness and intelligence."—*Friends' Mag.* June 1, 1831.

"This Pamphlet contains an account of two ingenious Inventions. We part from the author with sentiments of respect and esteem for his talents and acquirements. *Bath, &c. Gazette*, May 17.

"A sensible and well written pamphlet. The Apparatus for restoring Suspended Animation is intended to operate with air on the lungs as a syringe. The Shower Bath is simple and excellent."—*Imperial Mag.* Aug. 1.

"We have before noticed this gentleman's efforts to preserve the lives of shipwrecked seamen, and have now a pamphlet describing an ingenious improvement on the Shower Bath, and giving valuable directions to be observed in the treatment requisite to resuscitate persons who are apparently drowned. * * *. This is an elegant way of enlisting natural philosophy into our service, and disarms this excellent and convenient mode of bathing of all its former objections. Besides offering to the public a highly improved apparatus for inflating the lungs of drowned persons, Mr. Murray enhances the benefit by some very sensible remarks, leading to precautions too often neglected."—*United Service Journal*, May 1.