A DISSERTATION

ON ELECTIVE ATTRACTIONS.

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KNIGHT OF THE ROYAL ORDER OF VASA.

Tranſlated from the Latin by the TRANSLATOR
Of SPALLANZANI'S DISSERTATIONS.
(Thomas Beddoes)

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PREFACE.

THE ufefulnefs of publications, which, like the prefent Differtation, exhibit, from time to time, comprehenfive views of fcientifical knowledge, has been fufficiently pointed out by Lord BACON, whofe dictates upon this fubject, as upon others, have been amply confirmed by experience. The Tranflator, therefore, at firft thought, that every purpofe of the Englifh reader would be abundantly ferved by a faithful tranflation of this admirable manual of theoretical Chemiftry. His duty plainly forbad him to alter or fupprefs any thing; and his reverence for the great author deterred him from the thought of making any addition. But fome time has elapfed fince the tafk of mere tranſlation was completed; in the mean time, chemical inveſtigation being continued with univerſal ardour, new facts were brought to light, and new theories propoſed, ſome of them in books not likely to fall into the hands of every reader. Hence it ſeemed almoſt a matter of neceſſity to add ſome annotations. The Tranſlator now wiſhes, for the convenience of the reader, that they had been ſubjoined to the pages to which they refer, though, for his own ſake, he is not ſorry that they are thrown back as far as poſſible. This accidental circumſtance of their ſituation has led him to be more diffuſe than he would otherwiſe have been. The notes could not, by their intruſion on the reader's eye, divert his attention from the author; and why ſhould any thing which was uſeful, and

perhaps

perhaps inacceffible to many, be withheld, when it had any connection with the fubject?

Two fets of Tables are fubjoined. It was thought that many readers would be diffatisfied with the chemical Characters alone, efpecially as the former edition of the Tables has been already publifhed in words. To fupprefs the figns entirely, feemed improper; for they are fo convenient, that every ftudent of chemiftry ought to make himfelf familiar with them. Befides, as moft Chemifts will wifh for a fet to ftand always open for infpection, the two fets will fcarce be thought fuperfluous by any.

Every man who delights in paying the refpect that is due to genius, learning,

ing, and induſtry, will hear with pleaſure, that the life of our conſummate philoſopher has been promiſed us by his excellent friend, Mr Scheele. The following teſtimony of regret, on account of his premature death, appeared ſoon after that event; an event which thoſe who, by comparing what he did for chemiſtry with the ſhort time during which he applied to it, ſhall become ſenſible of what he would have accompliſhed in a long life, can alone adequately lament.

Pertriſtem

Pertriſtem adferre nuncium oportet,
Poſt exactos mortali vita annos XLIX,
Ereptum eſſe Patriæ,
Cultiori orbi, bonorumque omnium amplexibus,
VIRUM longè CELEBRATISSIMUM,
TORBERNUM BERGMANN.
CHEM. METALLURG. ET PHARMACEUT. IN
ACADEM. UPSALIENSI PROFESSOREM;
EQUITEM AURATUM REG. ORD. DE WASA;
ACAD. IMP. N. C.; REGIARUM ACADEMIARUM
ET SOCIETATUM PARIS. MEDICÆ PARIS.
MONTISPESS. DIVIONENS. UPSAL.
STOCKH. UTRIUSQUE LONDIN. GOETTING.
BEROLIN. TAURIN. GOTHOBURG. LUND.
SODALEM.

Id quod accidit d. viii. Julii anni 1784,
Dum ad acidulas Medvicenſes, in Oſtrogothia,
Adflictæ dudum valetudini quærebatur ſolatium,
Lugent per univerſam Suecogothiam
Optimarum ſcientiarum Patroni et Cultores;
Necdum inveniunt
Quem tanti viri deſiderio modum ponant.
Superſtitibus, autem, cognatis et amicis,
Hoc denique lacrimabile officium relictum eſt,
Ut, mœſtiſſimæ nomine viduæ,
Fautores in exteris gentibus et Conſortes ſtudiorum,
Quæ naturalis omnis ſcientiæ vir peritiſſimus
Excoluit,
De communi clade certiores faciant,
Proque ſuâ adeo agant parte,
Ut juſtiſſimi luctus æquè latè ſentiatur pietas,
Ac BERGMANNIORUM exiſtimatio meritorum
Jam diu inclaruit.

UPSALIÆ d. xvi. Julii 1784.

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XL.

DIS-

DISSERTATION, &c.

> Jamne vides igitur magni primordia rerum
> Referre, in quali ſint ordine quæque locata,
> Et commiſta quibus dent motus accipiantque.
>
> Lucretius.

This Diſſertation was firſt printed in 1775, in the third volume of the New Upſal Tranſactions. It was afterwards tranſlated both into German and French. The two annexed Tables, which exhibit the ſingle and double attractions, were again engraved in London, by the care of Dr Saunders, for the uſe of thoſe who attended the lectures which he read in conjunction with Dr Keir. The ſame year, Mr More, ſecretary to the Society for the Encouragement of Arts and Manufactures, publiſhed the table of elective attractions, on a large ſheet, ſubſtituting Engliſh words in the place of the ſigns.

ON

ON

ELECTIVE ATTRACTIONS.

I.

There ſeems to be a Difference between Remote and Contiguous Attraction.

IT is found by experience, that all ſubſtances in nature, when left to themſelves, and placed at proper diſtances, have a mutual tendency to come into contact with one another. This tendency has been long diſtinguiſhed by the name of *attraction*. I do not purpoſe in this place t inquire into the cauſe of theſe phænomena; but, in order that we may conſider it as a determinate power, it will be uſeful to know the laws to which it is ſubject in its operations,

 though

though the mode of agency be as yet unknown.

It has been ſhewn by Newton, that the great bodies of the univerſe exert this power directly as their maſſes, and inverſely as the ſquares of their diſtances. But the tendency to union which is obſerved in all neighbouring bodies on the ſurface of the earth, and which may be called *contiguous attraction*, ſince it only affects ſmall particles, and ſcarce reaches beyond contact, whereas remote attraction extends to the great maſſes of matter in the immenſity of ſpace, ſeems to be regulated by very different laws; it ſeems, I ſay, for the whole difference may perhaps depend on circumſtances. Conſidering the vaſt diſtance, we may neglect the diameters, and look upon the heavenly bodies, in moſt caſes, as gravitating points. But contiguous bodies are to be regarded in a very different light; for the figure and ſituation,

ſituation, not of the whole only, but of the parts, produce a great variation in the effects of attraction. Hence quantities, which in diſtant attractions might be neglected, modify the law of contiguous attraction in a conſiderable degree; and, moreover, the great power of our globe on all occaſions influences and diſturbs it. This force may therefore produce wonderful variations in the effects, according to circumſtances. But as we are by no means able to aſcertain the figure and poſition of the particles, it remains that we determine the mutual relations of bodies with reſpect to attraction in each particular caſe, by experiments properly conducted, and in ſufficient number.

As contiguous attraction ſcarce extends beyond contact, it is obvious, that the former will be more intenſe in the ſame body, the more the latter is increaſed. Hence, in the following obſervations, many inſtances occur, which prove that a body has greater power in a liquid than in a ſolid ſtate, and ſtill greater when it is reſolved into vapour. See, in particular, what is ſaid of marine acid, with reſpect to phlogiſton, in the forty-ſeventh paragraph; and of the matter of heat, in the forty-eighth.

In this diſſertation, I ſhall endeavour to determine the order of attractions according to their reſpective force; but a more accurate meaſure of each, which might be expreſſed in numbers, and which would throw great light on the whole of this doctrine, is as yet a deſideratum *.

SEVERAL

* Mr Morveau, I believe, firſt determined and expreſſed in numbers the coheſion of quickſilver to ſome of the metals. Mr Achard afterwards publiſhed a large table, in which the coheſive force of many bodies is inveſtigated both by calculation and experiment. Mr Kirwan very lately

SEVERAL ſpecies of contiguous attraction may be diſtinguiſhed. I ſhall here briefly mention the principal. When homogeneous bodies tend to union, an increaſe of maſs only takes place, the nature of the body remaining ſtill the ſame; and this effect is denominated *the attraction of aggregation.* But heterogeneous ſubſtances, when mixed together, and left to themſelves to form combinations, are influenced by difference of quality rather than of quantity. This we call *attraction of compoſition*; and when it is exerted in forming a mere union of two or more ſubſtances, it receives the name of *attraction of ſolution* or *fuſion*, according as it is effected either in the moiſt or the dry way. When it takes place between three reſpectively, to the excluſion of one, it is ſaid to be a *ſingle*

lately began to meaſure the attractions ,by the diminution of bulk that is produced by union; for he is of opinion, that the cauſe and quantity of contraction is to be ſought in the force of attraction.

elective attraction; when between two compounds, each consisting of only two proximate principles, which are exchanged in consequence of mixture, it is intitled *double attraction*. I am particularly to consider the two last species.

II.

Single Elective Attractions.

SUPPOSE *A* to be a substance for which other heterogeneous substances *a*, *b*, *c*, &c. have an attraction; suppose, further, *A*, combined with *c* to saturation, (this union I shall call *Ac*), should, upon the addition of *b*, tend to unite with it to the exclusion of *c*, *A* is then said to attract *b* more strongly than *c*, or to have a stronger elective attraction for it; lastly, let the union of *Ab*, on the addition of *a*, be broken, let *b* be rejected, and *a* chosen in its place, it will follow, that *a* exceeds *b* in attractive power, and

and we ſhall have a ſeries, *a*, *b*, *c*, in reſpect of efficacy. What I here call attraction, others denominate affinity ; I ſhall employ both terms promiſcuouſly in the ſequel, though the latter, being more metaphorical, would ſeem leſs proper in philoſophy.

Geoffroy, in 1718, firſt exhibited at one view the ſeries of elective attractions, by arranging in a table the chemical ſigns, according to a certain order ; but this admirable contrivance, while it is commended by ſome, is blamed by others ; one party contending, that affinities are governed by fixed laws, and the other affirming, that they are vague, and to be aſcribed to circumſtances alone.

Now, ſince all chemical operations conſiſt either in analyſis or ſyntheſis, compoſition or decompoſition, and both the one and the other depend on attraction, it will certainly be of great importance to determine this difpute. Let us not then lightly, and on account of one or two irregularities, perhaps ill underftood, reject the whole doctrine, but let us rather proceed in our examination with caution and care. Should we even at laft find that attractions depend on circumftances, fhall we therefore conclude, that it will be ufelefs to know the feveral conditions that forward or impede or difturb them? By no means, but rather that it will be of extenfive utility. There does not exift in all nature a fingle phænomenon but what is fo connected with certain conditions, that when they are abfent, the phænomenon fhall either not appear, or be varied occafionally. It is of confequence to fcience, that the changes and the combination of caufes in every operation fhould be accurately known, as far as a knowledge of them

is

is attainable ; and the utility of a ſtrict inquiry into attractions will, I hope, clearly appear from many inſtances in the following pages.

But if, on the contrary, a fixed order does really take place, will it not, when once aſcertained by experience, ſerve as a key to unlock the innermoſt ſanctuaries of nature, and to ſolve the moſt difficult problems, whether analytical or ſynthetical ? I maintain, therefore, not only that the doctrine deſerves to be cultivated, but that the whole of chemiſtry reſts upon it, as upon a ſolid foundation, at leaſt if we wiſh to have the ſcience in a rational form, and that each circumſtance of its operations ſhould be clearly and juſtly explained. Let him who doubts of this conſider the following obſervations without prejudice, and bring them to the teſt of experiment.

III.

III.

Whether the Order of Attractions be conſtant.

THIS queſtion can only be properly anſwered from what follows. But let us now ſlightly conſider whether a conſtant ſeries, ſuch as is mentioned in the laſt paragraph, is to be expected. Does *a* expel *b*, and *b a* reciprocally, according to circumſtances? Does *c* perchance expel *a*, while it always gives way to *b*? Let us conſult Experiment, the oracle of nature, with due care and patience, and we ſhall doubtleſs find the proper clue to guide us out of this labyrinth.

I AM far from approving of thoſe general rules which affirm, that earths and metals are in all caſes precipitated by alkalis, and metals by earths, for they are often fallacious. We have, however, many particular obſervations, which,

which, when every thing is properly difpofed, never miflead. We know, for inftance, that volatile alkali is diflodged by fixed alkali and pure calcareous earth; that quickfilver and filver are precipitated from nitrous and vitriolic acids on the addition of copper, which is again feparated by iron. Silver, quickfilver, and lead, which were called the white metals by the ancients, are feparated from the nitrous acid both by the vitriolic and marine. Do not thefe, and other facts long fince known, fhew, that there prevails a conftant order among thefe feveral fubftances? Many other clear proofs occur in the explanation of the new table of attractions, which I fhall referve for their proper places, (XII.—LXX.). The difficulties, when clofely examined, difappear; and none has yet, as far as I know, been pointed out which is really inconfiftent with a continued feries. But fhould there occur in this, as in other branches

of

of natural philoſophy, a few phænomena, which appear to deviate from the ordinary track, they ſhould be conſidered as comets, of which the orbits cannot yet be determined, becauſe they have not been ſufficiently obſerved. Repeated obſervations, and proper experiments, will in time diſpel the darkneſs.

That the effect of three ſubſtances mixed together may appear at one view, I have contrived a way of repreſenting it by ſymbols. It will be proper to illuſtrate it by an example.

Scheme 20. Pl. 1. exhibits the decompoſition of calcareous hepar by the vitriolic acid. On the left ſide appears the hepar, indicated by the ſigns of its proximate principles united; but within the vertical bracket theſe principles are ſeen ſeparate, one above the other. On the right, oppoſite the calcareous earth,

earth, is placed the ſign of vitriolic acid; in the middle ſtands the ſign of water, intimating that the three ſurrounding bodies freely exerciſe their attractive powers in it. Now, as vitriolic acid attracts calcareous earth more forcibly than ſulphur does, it deſtroys the compoſition of the hepar; the extruded ſulphur being by itſelf inſoluble falls to the bottom, which is ſignified by the point of the lower horizontal half-bracket being turned downwards; and as the new compound, vitriolated calcareous earth (gypſum), alſo ſubſides, unleſs the quantity of water be very large, the point of the upper bracket is likewiſe turned downwards. The complete horizontal bracket indicates a new combination, but the half-bracket ſerves merely to ſhew by its point whether the ſubſtance from which it is drawn remains in the liquor, or falls to the bottom. The abſence of horizontal brackets indicates that the original compound

compound remains entire. Such a combination only as continues unaltered can have a place on the right ſide, for if it be likewiſe decompoſed, a new caſe ariſes, which will be noticed hereafter, (V.). Thoſe operations which are performed in the dry way, are diſtinguiſhed by the character of fire, which is placed in the middle.

IV.

A Difference in the Degree of Heat ſometimes produces a Difference in Elective Attractions.

THE only external condition, which either weakens or totally inverts the affinities of bodies ſubjected to experiments, is the different intenſity of heat. But this cauſe can only operate in caſes where the ſame temperature renders ſome

ſome bodies remarkably volatile in compariſon of others.

Suppose A to be attracted by two other ſubſtances; and let the more powerful act at the ordinary temperature with the force a, the weaker with the force b: ſuppoſe, at the ſame time, the former to be the more volatile; let its effort to ariſe be expreſſed by V, and that of the other by v. When theſe three ſubſtances are mixed together, the ſtronger will attract A with a force $=a-b$; but ſhould the heat be gradually raiſed, this ſuperior force will be more and more diminiſhed; and as V will increaſe faſter than v, we ſhall at laſt have $a-b=V-v$. This ſtate of equilibrium will be immediately deſtroyed by the ſmalleſt addition of heat; and thus b, which was before the weaker, and incapable of producing any effect, will now prevail. If the other ſubſtance be entirely of a fixed nature, $v=0$, and the

the caſe will be ſimpler. Many inſtances of this nature will hereafter occur.

HENCE, I think it in general obvious, that thoſe are the genuine attractions, which take place when bodies are left to themſelves: too high a degree of heat is an external cauſe, which forcibly weakens the real affinities more or leſs, nay, in ſome caſes, even totally alters them. Since, however, many operations cannot be carried on without the aid of heat, and the power therefore of this moſt ſubtile fluid is highly worthy of being obſerved, I think the table of elective attractions ought to be divided into two areas; of which the upper may exhibit the free attractions, that take place in the moiſt way, as the expreſſion is; and the lower, thoſe which are effected by the force of heat. This may eaſily be done, ſince we are as yet unacquainted with any other external

ternal condition which deſerves here to be taken into the account; if the internal conditions ever cauſe any deviation, it is either only apparent, or elſe a real change in the nature of the ſubſtances is produced. It cannot indeed be denied, that volatile bodies are actually changed by a combination with the matter of heat; but the change is of ſhort duration, as it totally diſappears on refrigeration, though not till after the deſired decompoſition has been effected.

It is hence evident, what opinion we are to form concerning the various arguments brought againſt the conſtancy of affinities, from the diſtillation, ſublimation, or fuſion of mixtures: ſuch ſometimes is the efficacy of heat, that ſtrong digeſtion, or even that degree of warmth which is produced by the combination of certain ſubſtances, is ſufficient to diſturb the uſual order.

V.

Apparent Irregularities from a double Attraction.

Notwithstanding the trite proverb, That no rule is without exception, I do not therefore think that rules are to be rejected; but the exceptions ſhould be properly inveſtigated, and the rules thus be reduced to their juſt amount. Thoſe, however, which are now to be conſidered, do not come under the denomination of exceptions; for four ſubſtances exert their action, a very different caſe, and more complicated, than where three only are concerned. Many inſtances uſually adduced in refutation of a regular ſeries of affinities belong to this head; and though it is ſaid that reciprocal decompoſition is evidently ſhewn by them, a cloſer

closer examination will dissipate the illusion.

Geoffroy's table intimates, that fixed alkalis adhere to acids more strongly than calcareous earth, and with great propriety, though some would represent this truth as an absurdity. They drop a solution of chalk in nitrous acid into a solution of vitriolated tartar, upon which a precipitation of gypsum immediately takes place; a clear proof, as they think, of the superior attraction of the calcareous earth. But it should be observed, that not even quicklime, when added to a solution of vitriolated tartar, (Scheme 2.), produces any decomposition; but, on the contrary, if vitriolic acid be dropped into the solution of calcareous earth, a precipitation of gypsum will follow, (Scheme 16.): Hence it is obvious to which the stronger elective attraction is to be attributed. When the chalk has been previously dissolved in ſome mineral acid, four ſubſtances come into action; and now the earth, aided by the acid which is combined with it, effects what before it was not able to accompliſh. To render this more evident, let us conſider the 21ſt Scheme, in which, on the left hand, the neutral ſalt, known by the name of vitriolated tartar, is indicated by the ſign of vegetable fixed alkali placed near that of vitriol. I read it in this manner: Vitriolated vegetable alkali, (that is, ſaturated with the acid obtained from vitriol), a denomination by which the proximate principles are known; and theſe alſo appear under their proper ſigns within the adjacent vertical bracket. On the right, muriated lime (ſaturated with the marine acid) is likewiſe repreſented by ſymbols, as alſo its proximate principles within their proper bracket. Whilſt therefore vitriolated tartar and lime ſaturated with the acid of ſalt are mixed together in water, (which

(which is expreſſed by the ſign of water in the middle of the Scheme), the ſame thing happens as if we were to mix certain portions of vegetable fixed alkali, vitriolic acid, marine acid, and pure lime in water: theſe four ſubſtances ſurround water in the figure, and are ſo to be placed, that the two acids ſhould never be in the ſame horizontal line.

We have the ſubſtances that were combined before mixture diſpoſed in a vertical poſition; and, in order to break the combination, there is neceſſarily required a greater ſum of attraction between thoſe which are horizontally, than thoſe which are vertically oppoſite to each other: and ſuch is the preſent caſe; for although the vitriolic acid attracts the fixed alkali more ſtrongly than it does the lime, yet, upon the addition of muriatic acid, which at once ſolicits the alkali, and diminiſhes its coheſion with the vitriolic acid, the attraction between the fixed alkali and the marine acid, together with the attraction between the vitriolic acid and the lime, make together a greater ſum than the attraction between the fixed alkali and the vitriolic acid, together with that between the muriatic acid and the lime.

The horizontal brackets include the new combinations: by the apex of the lower turned downwards, ſubſidence is denoted; but the apex of the upper pointing upwards, ſhews that the combination contiguous to it remains in the liquor, until a certain portion be carried off by evaporation. Thus then is the decompoſition in queſtion effected. That I may more quickly diſpatch the other inſtances, I ſhall once for all obſerve, that I always expreſs double ſalts (ſuch as conſiſt of two proximate principles) by the ſign of the baſe placed on the left, near the ſign of that ſalt from which the acid is ordinarily expelled, which

which acid is at present combined with the base: in the same way I design the others, consisting of two principles intimately united.

Magnesia, and several of the metals, resemble lime in this respect. See Scheme 22. Table 1. contains sixty-four schemes, which exhibit the events of 122 experiments; for No. 24. not only shews, that nitrated mercury is decomposed by seret sal ammoniac, but also that flaming nitre and vitriol of mercury will bear to be mixed without suffering any change; and, in general, if the substances represented on the right and left side make a mutual exchange of their principles, we may judge that those which stand above and below undergo no separation on mixture. In Schemes 21. and 23. it appears that vitriolated tartar and muriated lime change their principles, but not digestive salt and gypsum. Nos. 1.—20. exhibit the single, 21.—40. the double free attractions. The following are brought about by the accession of fire: 41.—47. and 55.—58. by distillation; 48.—50. and 59.—62. by sublimation; and, lastly, 51.—54. 63. and 64. by fusion in a crucible. An explanation of the new characters is found in XI.

Chemists, in determining the single elective attractions, are often deceived by double attractions. The phosphoric acid, as I shall hereafter shew, (XXXIII.), attracts lime more powerfully than fixed alkali; yet the contrary is asserted, since aerated alkali, by means of a double affinity, precipitates phosphorated lime. Even caustic fixed alkali, which seems a stronger proof, causes a precipitation: nevertheless, if the superior attraction is deduced from this alone, the conclusion will be erroneous; for the alkali only takes away the excess of acid which is requisite for solution,

tion, and hence the phoſphorated lime falls to the bottom, (IX.). The difference between the action of alkalis and abſorbent earths, when ſaturated with aerial acid, and when deſtitute of it, has been explained in my eſſay on that acid, and may therefore be omitted here *. What is there ſaid of the volatile alkali, is expreſſed in Scheme 36. and clearly ſhews the reaſon why cauſtic volatile alkali ſeems to act more weakly than the mild, which otherwiſe would be abſurd. It may now, in general, be obſerved, that alkaline and earthy ſubſtances are to be conſidered as double, and by no means as ſimple ſalts, except in their cauſtic ſtate, and then I call them pure. See Schemes 1.—8. 32.—37. 51. 62 and 63.

The precipitation of metals, diſſolved in acids, by other metals, is never the effect of ſingle attraction; for during the

* Op. vol. i. p. 49.

the ſolution, a quantity of phlogiſton is extricated, as I have clearly, I hope, ſhewn elſewhere *. Since therefore metallic ſolutions are of ſuch a nature, that they cannot reſtore what they hold diſſolved to its metallic ſplendour without the acceſſion of a new portion of phlogiſton, it is ſelf-evident, as well as conformable to experiment, that this cannot be effected by the addition of calces. If therefore ochre be put into a ſolution of vitriol of copper, no copper will be precipitated; but iron added to the ſolution is ſoon obſerved to be covered with a cupreous pellicle; for it yields part of its phlogiſton, which is neceſſary to the reduction of the copper, and by this means becomes itſelf ſoluble without the emiſſion of any inflammable air, (Scheme 39.). Silver diſſolved in the nitrous acid is in like manner calcined; as appears from the red vapour, phlogiſtic ſmell, and various

* Op. vol. ii. p. 354. vol. iii. p. 134.

rious other evident ſigns, and therefore cannot be precipitated by the calx, though it may by regulus of copper, (Scheme 38.). The ſame obſervation is applicable to gold and the other metals; for in whatever way they be ſeparated, provided they can acquire no phlogiſton, they appear calcined, and really are ſo: the only difference conſiſts in this, that they are unequally dephlogiſticated, and that the noble metals can recover their loſs by fuſion alone in ignited veſſels, whereas the ignoble ones require an addition of phlogiſton. But more of this hereafter.

In many other caſes, where a ſingle elective attraction is commonly thought to take place, it is really double, on account of the preſence of phlogiſton. Let us conſider an inſtance of this in the diſtillation of butter of antimony from a mixture of corroſive ſublimate and regulus of antimony. We may obſerve, in the

the firſt place, that neither mercury nor regulus of antimony are ſoluble in the marine acid, unleſs they are firſt deprived of a certain portion of their inflammable principle. From this conſideration, the proceſs is eaſily explicable from a double attraction: the calx of mercury in corroſive ſublimate is revivified by that phlogiſton which the regulus muſt loſe in order to become ſoluble in marine acid, (Scheme 58.). The baſis of corroſive ſublimate, indeed, as well as the calces of the noble metals, recovers its reguline ſtate in heat alone, by attracting what is wanting to this ſtate, through the ignited veſſels; but this operation requires a far ſtronger fire than the diſtillation of butter of antimony, in which the reduced mercury riſes without any very ſtrong heat. With white arſenic and corroſive ſublimate no decompoſition is effected, ſince the phlogiſton neceſſary for the reduction of the mercury is wanting; but this

this operation ſucceeds with orpiment, which abounds with phlogiſton.

VI.

Apparent Exceptions from a ſucceſſive Change of Subſtances.

If either of the ſubſtances employed ſhould change its properties, its attractions will, doubtleſs, be liable to alteration. This may be illuſtrated by many examples. It had been long known, that nitrous acid is capable of diſlodging the marine from an alkaline baſis; but Margraaf was the firſt who obſerved that the latter expels the former. This phænomenon, unleſs we are acquainted with the nature of marine acid, eludes all explanation; but now this is known, the problem is eaſily ſolved. The nitrous acid expels the marine, by means of a ſingle elective attraction,

traction, (Scheme 42.), but phlogiston enters into the composition of the marine acid, and is attracted from it by other acids, especially by the nitrous, (XVII.), which, even though saturated with vegetable alkali, strongly attracts the inflammable principle; for nitre kept in a state of ignition for an hour or two, remains perfectly neutral, whence it is plain, that all the acid remains, but it is become so much weakened, by being phlogisticated, that it may be expelled by concentrated vinegar, (XXXVII.). Hence it follows, that part of the marine acid that is poured upon the nitre, yields its phlogiston, in consequence of the heat applied, to the nitrous acid, which in this state is expelled by that part of the marine which is not yet decomposed, (Scheme 55.). That this is the true explanation, appears from the nature of the thing, the necessary proportions, and the matter collected in the receiver, which is found

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to confift of phlogifticated nitrous acid and marine acid, both dephlogifticated and in its ordinary ftate.

On the fame principle, white arfenic is capable, by diftillation, of decompofing thofe neutral falts which contain the nitrous, but not thofe which contain the marine acid. White arfenic is nothing but a fort of fulphur, confifting of the arfenical acid, and a certain portion of phlogifton, (XX.). In this cafe, therefore, four fubftances come into action, (Scheme 56.); and as the nitrous acid ftrongly attracts phlogifton, and its connection with its bafis is much weakened by the acceffion of that principle, the acid of arfenic is capable of expelling it: but the marine acid, already containing the inflammable principle, refufes to combine with a larger portion of it, it therefore remains unchanged, and the arfenical acid has

has no power againſt the ſtronger, (Scheme 57.).

I HAVE long ſince obſerved, that the noble metals, though they reſiſt the force of fire ſo obſtinately, may be more or leſs calcined by ſolution in acids; and it will now be proper to add ſomething concerning iron, which, above all, ſeems liable to this change, eſpecially concerning its ſolution in the vitriolic acid. In the firſt place, we remark that a portion of phlogiſton flies off during ſolution in the inflammable air; next, if the ſaturated ſolution, which is of a green colour, be filtered, and kept in a full and cloſe phial, it will remain clear; whereas, if it be expoſed to the air in an open veſſel, it will gradually, but conſtantly, depoſit ochre, a phænomenon which ariſes from two cauſes. For vital and reſpirable air attracts phlogiſton ſo forcibly as inſenſibly to diminiſh that which is contained in the ſolution

ſolution of iron. Such alſo is the nature of the vitriolic acid, that it will diſſolve ſo much the leſs iron, the more deſtitute the metal is of phlogiſton; whence it follows, that a quantity of acid ſufficient for the ſolution of iron but little dephlogiſticated, gradually becomes inſufficient in proportion as the phlogiſton is ſeparated, and therefore earth of iron muſt fall to the bottom, which, however, again diſappears on the addition of freſh acid. This decompoſition is much accelerated by heat, and eſpecially by boiling, and at laſt the green colour is changed to a dark red, and the whole ſolution aſſumes the nature of an ultimate ley, which is incapable of cryſtallization, as has been admirably ſhewn by Mr Monnet. Succeſſive boiling, however, and cooling, bring about the dephlogiſtication ſooner than continued boiling alone.

This ultimate lixivium, however, may be reduced by the addition of a little vegetable alkali, to white aſtringent cryſtals, like thoſe of alum, whence ſome have been led to believe, that the tranſmutation of vitriol into alum is fully proved; but this ſalt, when diſſolved, may be totally changed into Pruſſian blue, by means of phlogiſticated alkali, and, if common alkali be employed, affords nothing but ochre, and not a particle of alum, provided the vitriol be made by diſſolving iron; that indeed, which is extracted from pyrites, often contains alum, ſince clay frequently enters into the compoſition of pyrites.

With theſe truths in view, it is eaſy to anſwer, if any one ſhould think of proving the reality of reciprocal decompoſition by the caſe of alum, in which the acid ſeems to part with the earthy baſis upon the addition of iron filings, and take

up

up the metallic, while, on the contrary, clay is diſſolved in the laſt lixivium of vitriol, and precipitates the ochre. In the firſt caſe, we have iron combined with its proper portion of phlogiſton, which, when it is put into a ſolution of alum, is taken up only by the exceſs of acid, which adheres more looſely than the ſaturating portion. And the abundant acid being taken away, the clay, being exactly ſaturated, falls down inſoluble. Theſe phænomena have therefore been hitherto ill underſtood, for at the preciſe point of ſaturation, clay is not precipitated by iron.

In like manner, copper yields the acids to iron, while it attracts them from crocus martis. Hence the decompoſition of vitriol of iron by copper, detected by Mr Margraaf, is eaſily explicable; it is by no means reciprocal, for copper precipitates iron only when it is dephlogiſticated beyond a certain limit.

In an open veſſel, the inflammable principle is eaſily ſeparated, eſpecially by means of heat; hence a ſolution of vitriol of iron muſt neceſſarily change in its nature almoſt every moment to a certain point, below which it is impoſſible to proceed in this way. It is the more ſurpriſing, that copper ſhould be ſo eaſily diſſolved in this experiment, ſince it is certain, that this metal is with great difficulty diſſolved in vitriolic acid, unleſs it be in ſome meaſure calcined beforehand. But in the preſent inſtance, the earth of the iron attracts the phlogiſton of the copper, which it ſoon loſes again on the application of heat. The ſolubility of the calx, as well as the regulus, of copper, in a boiling ſolution of martial vitriol, is a clear proof of this conjecture. Concentrated vitriolic acid indeed attracts copper, when aſſiſted by a ſufficient heat; but let it be remarked, that the vapours which then ariſe, are the phlogiſticated gifticated vitriolic acid, which fhews, that a portion of the inflammable principle is carried off. Moreover, how the precipitations of metals from acids, by means of other metals, are to be properly underftood, will be explained more at large hereafter.

VII.

Apparent Exceptions from Solubility.

It fometimes happens that no decompofition appears at firft, though it really takes place. Fixed mineral alkali united with the acids to faturation, and diffolved in water, remains in the limpid folution on addition of pure vegetable alkali, nor is any congrumation or precipitation to be obferved. Hence chemifts of great name have concluded, that the vegetable does not exceed the mineral alkali in attractive power; but let us ſuppoſe for a moment, that the mineral alkali is diſlodged, ſhould the ſolution become turbid? By no means, for the foſſil alkali is ſoluble of itſelf, and cannot therefore impair tranſparency. From this phænomenon alone, therefore, nothing certain is deducible; but let the ſolution be evaporated, and there will be found at laſt uncombined mineral alkali, ſeparately cryſtallized, and beſides, vitriolated tartar, if Glauber's ſalt, cubic nitre, if quadrangular nitre, and digeſtive ſalt, if ſea ſalt was ſubjected to the experiment, (Scheme 3.).

Some metals precipitated from acids, by too much alkali, ſoon diſappear again in conſequence of ſolution. Platina and gold can ſcarce be precipitated in ſuch a manner that the ſolutions will not remain tinged. Zinc, copper, nickle, and cobalt, afford no precipitate when an exceſs of volatile alkali is uſed,

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unlefs they are contaminated by fome heterogeneous fubftance.

There is yet another veil which often hides decompofitions, as when the fubftance expelled from its combination is capable of diffolving the new compound, or at leaft does not hinder the water of folution from doing fo. This happens not unfrequently when the acids of nitre and falt are expelled by thofe of greater power. Thus the vitriolic takes magnefia from the marine, but in fuch a way as totally to efcape the notice of the fenfes; for the extricated acid, fharpening the water of the folution, immediately takes up the vitriolated magnefia, which is indeed otherwife of very eafy folubility, and therefore no figns of it appear, until, by a fpontaneous evaporation, the menftruum is fo much diminifhed as to be incapable of diffolving the whole. Several inftances of this kind occur in the following paragraphs, and it is at the ſame time ſhewn how this impediment may be removed.

To this head we may alſo refer precipitations happening from a ſubtraction of the water of ſolution, upon the addition of a ſubſtance which, though it does not change the former combination, yet deprives it of its water, when there is not enough to diſſolve both; whence the compound ſuddenly concretes into ſmall cryſtals, nearly in the form of a precipitate. This happens when a proper quantity of concentrated vitriolic acid is poured into ſaturated ſolutions of vitriolated tartar, alum, corroſive ſublimate, and other ſalts, not eaſily ſoluble in water, though their proximate principles cannot be parted by vitriolic acid. Vitriol of mercury is really decompoſed by marine acid, which attracts the calx of the metal, and carries it down along with it to the bottom

bottom for want of water: but concentrated vitriolic acid alſo, when poured into a ſolution of corroſive ſublimate, throws down in its turn a white powder; whence ſome have immediately inferred that kind of decompoſition which is generally called reciprocal; but the latter precipitate is found, on examination, to be nothing elſe than true corroſive ſublimate deprived of the water of ſolution. Fixed vegetable alkali, particularly when dry and cauſtic, produces like effects in the ſame circumſtances; I mean, when the baſis attracts the acid with equal or greater force than the alkali employed.

These precipitations are ſeldom complete; for ſomething generally remains diſſolved in the liquor.

Finally, let me notice thoſe anomalous phænomena which depend on apparent ſolubility. Liquor of flints, as

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is well known, contains ſiliceous earth, diſſolved in water by means of fixed alkali. Upon dropping in an acid, the ſiliceous earth ought to be precipitated, as really happens, unleſs the liquor be diluted in twenty-four times its weight of water, or more; in this caſe, no cloudineſs is perceptible, though even more acid be affuſed than is neceſſary for ſaturating the alkali. We have here an appearance of ſolution; but the truth is, that the ſiliceous particles are ſo diſperſed in the abundance of water, that they cannot ſubſide on account of the great proportion of their ſurface to their weight. As I have elſewhere explained this at greater length *, I need only give a ſhort view of the matter here. I ſhall only add, that the earth cannot be diſſolved by the neutral ſalt that is formed; for the ſiliceous particles fall down on ebullition, (which increaſes ſolubility upon other occaſions),

* Op. vol. ii. p. 36.

ſions), in conſequence of the diminiſhed denſity of the liquor by heat. Should any one object, that, for the ſame reaſon, other earths ought alſo to be ſuſpended, he will readily find, on more mature conſideration, that, 1. no other of the primitive earths is ſoluble in alkali, except the argillaceous, which is alſo ſoluble in acids, ſo that there can be no exceſs either of the one or the other without ſolution. 2. Calcareous earth is not precipitated from acid menſtruums in a viſible form by cauſtic fixed alkali well diluted, and gradually dropped in, till paper dyed with brazil wood is changed to a blue, provided the ſolution be firſt diluted with fifty times its bulk of diſtilled water. The liquor remains clear for a time, but by degrees acquires a film on the ſurface. The ſolution employed ought to contain more calcareous earth than an equal quantity of the ſtrongeſt lime-water, otherwiſe it might be ſaid, that the cal-

careous

careous earth is really diſſolved in the clear alkaliſed ſolution, and not ſuſpended. If a ſingle drop of aerated alkali be dropped into the clear ſolution without agitation, white clouds immediately come into view; but if an equal drop be added, while the whole maſs is ſhaken, no cloudineſs enſues, for the motion prevents the coaleſcence of the ſeparated molecules. Here then we have calcareous earth certainly ſuſpended, and all ground of contradiction, I hope, removed.

VIII.

Exceptions from the Combination of three Subſtances.

THERE are ſome ſubſtances of ſuch a nature, that three are capable of uniting without the excluſion of any one. The combination of two attracts a determinate

terminate quantity of a third, and sometimes of more, with so much force, that they become very closely connected, and are scarce to be separated by any art. This inconvenience more especially attends the dry way; for the earths mixed either with one another, or with salts, melt together without exclusion, which is also true of most of the metals. *A* is not indeed attracted by *a* and *b* with equal force, but rather *A a* unites with *b*, or *A b* with *a*, which yet is no reason why *a* should not exceed *b* in attraction, though the particular nature of the combinations prevents exclusion. Volatile alkali, marine acid, and the calx of quicksilver, volatile alkali, vitriolic acid, and magnesia; iron, vitriolic acid, and magnesia, not to mention other instances, adhere so closely in determinate proportions, that they cannot be separated by crystallization, and not easily in any other way.

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This alſo holds with reſpect to four ingredients, as borax with tartar, vitriolated magneſia with common ſalt, gypſum with common ſalt, and many others. To this head alſo belongs liver of ſulphur formed in the dry way by vitriolated tartar and powder of charcoal, as in this caſe the phlogiſton is firſt conceived to ſeparate the acid, and generate ſulphur, which then is diſſolved in the alkali, and yields hepar; it may ſeem that the newly formed particles of ſulphur can ſcarce perſiſt in ſo great an heat, without either being ſublimed or conſumed, but the new compound is formed almoſt in the ſame moment.

From this property of certain ſubſtances, peculiar phænomena often ariſe. Should any one attempt to precipitate vitriolated magneſia, or muriated magneſia, by volatile alkali, he will indeed obtain ſome precipitate, but a new triple combination, a ſalt of a peculiar

nature

nature, will be formed. If ſaturated ſolutions of nitrated lime and nitrated magneſia be mixed, an unexpected precipitate appears, conſiſting of a triple ſalt, compounded of both earths and the common acid, more difficult of ſolution than either of the ingredients, and on this account falling to the bottom. The new ſalt is taken up by a larger quantity of water. I muſt overpaſs many phænomena of this nature.

IX.

Exceptions from a determinate Exceſs of one or other of the Ingredients.

SOME chemiſts, I know, contend, that it is idle to ſuppoſe that a determinate exceſs of acid can be received by neutral or middle ſalts. Many inſtances, however, which I ſhall now mention, clearly prove the preſence of ſuch exceſs, cefs, which, agreeably to the nature of the thing, adheres more loofely than the faturating portion. Let perfectly neutral tartarized tartar be diffolved to faturation in diftilled water; then let fome genuine acid of tartar (XXIII.) be dropped in, and a white fpongy fubftance will feparate and fall to the bottom, which, when collected and examined, proves to be real tartar. What is the caufe of this fingular alteration? We fhall eafily afcertain it by confidering the nature of the fubftances. Tartar is nothing but vegetable alkali with a greater portion of its own acid than is neceffary to faturation. He who is acquainted with the tafte of tartar, its effervefcence with alkalis, the red colour it gives to blue vegetable juices, *&c.* can entertain no doubt concerning the excefs of acid; nay, even till our own times, tartar was confidered as an acid. Take away the abundant acid by the addition of vegetable alkali, and you will

will have tartarized tartar, which the French call vegetable ſalt, *ſel vegetal.* Purified tartar is therefore nothing but tartarized tartar with a determinate exceſs of acid; and when this is added to tartarized tartar, it is immediately generated, and, for want of a ſufficient quantity of water to diſſolve it, falls in great meaſure to the bottom. Tartar, therefore, and tartarized tartar, differ not in the nature, but the proportion of their ingredients; nevertheleſs this cauſe produces a wonderful difference in taſte and other properties, and eſpecially in ſolubility. For tartarized tartar attracts water ſo forcibly, that it commonly deliqueſces in moiſt air: on the other hand, one part of tartar requires 150 parts for its ſolution in a middle temperature; which is ſo much the more ſurpriſing, as we are certain, that the ſuperfluous acid, by itſelf, as well as tartarized vegetable alkali, readily unites with water. The exceſs, which occaſions the difference, can neither be removed by cryſtallization, a moiſtened filter, or, in ſhort, by any other way but ſaturation.

We have therefore a manifeſt example, from which we may conclude, that vegetable alkali, though ſaturated, does not reject, but, on the contrary, eaſily admits an exceſs of the acid of tartar. There is here too a clear inſtance of attraction between a neutral ſalt and an acid of the ſame ſpecies as that which enters into the compound. If any other acid be poured into tartarized tartar, tartar is alſo ſeparated; a phænomenon uſually explained by ſaying, that the acid employed expels the tartar by ſuperior attractive force. But tartar is not a pure acid, as was long ſuppoſed. Why then is the alkali united to it expelled at the ſame time? If the precipitation ariſe from ſuperior attraction, why ſhould acid of tartar effect

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it? Why ſhould vinegar, an acid really weaker, (XXXVII.)? That we may diſtinctly perceive what happens in this operation, let the tartarized tartar be imagined to be divided into two parts, ſo that one part *b* ſhall contain as much acid as is neceſſary for the other *a* to become tartar. Now let the foreign acid be added, ſo as to ſaturate the alkaline baſis of the part *b*, the acid of tartar before combined with it will flow back to the portion *a*, which already tends to it with ſo much force, that it immediately ſeizes it, and is converted into tartar, provided any thing capable of weakening the coheſion of the principles in *b* but in a ſmall degree be added.

Salt of Seignette ſhews the ſame phænomena. If a ſolution of volatile alkali be gradually ſaturated with acid of tartar, another ſpecies of ſoluble tartar will be formed, which is immediately clouded by excefs of acid, and a new tartar is exhibited, very difficultly foluble, but, on account of the loofer connection of the principles, more acid than the common fort.

But it is not only tartar which effentially requires an excefs of acid. We have long been acquainted with feveral falts of this kind. Salt of forrel confifts of vegetable alkali and a peculiar acid in excefs, (XXIV.). So alfo acid of arfenic, precifely faturated with vegetable alkali, cannot be cryftallized; but if there be a proper excefs of acid, we eafily obtain beautiful cryftals, (XX.). Hence it appears why it has hitherto been impoffible to prepare Mr Macquer's arfenical falt in a crucible; for the neceffary excefs has always been expelled by the force of fire.

Duhamel and Grosse have obferved, that foluble tartar may be prepa-

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red from the abſorbent earths, without however underſtanding the real nature of the operation. Now, as upon the addition of alkali, the exceſs of acid is ſaturated, and the whole maſs becomes ſoluble, ſo chalk, by abſorbing this exceſs, immediately generates a ſalt of difficult ſolubility, which of courſe is precipitated, (XXIII.); but when the exceſs of acid is ſeparated from the tartar, nothing but tartarized tartar, which is very ſoluble, remains.

In 1760, Mr Baumé publiſhed an experiment highly deſerving of attention, from which he thinks it evident, that vitriolated tartar may be totally decompoſed by nitrous acid in the humid way. By this inſtance, in the opinion of ſome modern writers, reciprocal affinities are proved beyond all doubt; but a cloſer examination will diſſipate the whole ambiguity. It is therefore to be obſerved, *1ſt*, That vitriolated tartar, diſſolved in water, may be cryſtallized by evaporation, after the addition of a quantity of concentrated vitriolic acid, equal to one third of the ſalt. The cryſtals, with the acceſſion of one third of their weight, remain dry, notwithſtanding they are acid. More acid affords a deliqueſcent ſalt. The exceſs of acid cannot eaſily be driven off by diſtillation in a retort; this end may be more readily obtained by fuſion in a crucible. Repeated cryſtallizations are of no avail. Waſhing with highly rectified ſpirit of wine is the beſt method of edulcoration. *2dly*, We know, that vitriolic acid in proper quantity completely decompoſes nitre even in the moiſt way, whence its ſuperior power of attraction is evident. There is here, therefore, no occaſion for a diſtinction between the dry and the moiſt way. *3dly*, A third part only, or a very little more, of vitriolated tartar, diſſolved in ſtrong and hot nitrous acid, is decompoſed, whatever

quantity

quantity of the acid be employed. *4thly*, There is no occaſion to apply heat, or uſe concentrated nitrous acid; for to a portion ſo much diluted that it emitted no fumes, I added a large quantity of powdered vitriolated tartar, ſet it in a cool place for thirty-ſix hours, and then poured off the liquor; from which highly rectified ſpirit of wine precipitated a white powder, which being collected and dried, proved to be real nitre; and it deſerves to be remarked, that the vitriolated tartar which was not decompoſed, was ſo ſoluble by the aid of the ſuperfluous acid, as to be ſcarce ſeparable by ſpirit of wine. *5thly*, Vitriolated tartar, with a proper exceſs of acid, as that in obſerv. 1. is not at all changed by the moſt concentrated nitrous acid. It is ſcarce ſufficient to moiſten the vitriolated tartar in powder with vitriolic acid; they muſt be diſſolved together in hot water. *6thly*, Not only the nitrous, but the marine, the tartareous, and perhaps many

 other

other acids, in like manner decompoſe vitriolated tartar. Glauber's ſalt, or vitriolated mineral alkali, is alſo totally ſoluble in marine acid; but about a third part only is decompoſed, as Mr Kirwan has obſerved. *7thly*, Two thirds of the vitriolated tartar, which remain unchanged, form cryſtals with the exceſs of vitriolic acid, of the ſame nature with thoſe which are procured in the way mentioned in the firſt of theſe conſiderations.

If we weigh theſe obſervations, it will plainly appear that the ſame thing happens in the preſent caſe, as in that of tartarized tartar. Suppoſe *b* to be ſuch a portion of the vitriolated tartar, as to contain exactly that exceſs, which the other portion *a* can receive. Nitrous acid of itſelf cannot deprive the vitriolic of its baſis; but *a* attracting it at the ſame time, ſo far diminiſhes the reſiſtance, that the nitrous is able

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to ſeize the alkaline baſis of *b*, but its power is confined to certain limits. Suppoſe the vitriolated tartar to be divided into two parts, one of which affords its baſis to the nitrous acid, and the other is not decompoſed. We have here three powers: let that by which the part of the vitriolated tartar remaining entire attracts a determinate exceſs of acid, be called A; B, that by which the part to be decompoſed endeavours to retain its baſis; and, laſtly, C the force of attraction of the nitrous acid to the ſame baſis, it is obvious that no decompoſition can be effected, if $A + C < B$, or if $A + C = B$; but if $A + C > B$, it immediately takes place.

WHAT has been ſaid concerning the ſolution of vitriolated tartar in nitrous acid, is in like manner applicable to Glauber's ſalt, ſecret ſal ammoniac, and perhaps many others, ſo that thoſe decompoſitions cannot be deduced from the

the preſence of phlogiſton, in the alkaline ſalt. Concentrated ſolutions of nitre and digeſtive ſalt yield, upon the addition of acid of tartar, a real tartar, for the reaſons above aſſigned; but quadrangular nitre and ſea ſalt, of which the baſis, mineral alkali, has a far different attraction for acid of tartar, afford no precipitation in experiments of this kind.

Several apparent exceptions originate from the removal or diminution of exceſs of acid; for various ſubſtances produce, with certain menſtruums, ſalts ſo difficult of ſolution, that they cannot be held ſuſpended without ſome exceſs. Thus lime is ſoluble in abundant acid of arſenic; but cauſtic volatile alkali, magneſia, lime itſelf, and, in ſhort, whatever is capable of abſorbing the abundant acid, immediately produces precipitation. If any one ſhould hence conclude that lime is

expelled

expelled by cauftic volatile alkali and magnefia, he is certainly deceived, and ought likewife to maintain, that this is done by the lime itfelf. The precipitate, when examined, does not exhibit lime alone, but lime faturated with arfenical acid, which fufficiently explains the nature of the operation. The fame phænomena occur with lime diffolved in phofphoric acid, and with many other fubftances of difficult folubility.

Almoft all the metallic falts redden tincture of turnfole; and the excefs can fcarce be removed without deftroying the falt.

But it is not the acids alone which fometimes exceed the limits of faturation; this is likewife true of the faline, earthy and metallic bafis. Borax, however well purified, exhibits clear marks of abundant alkali, and ftill requires about

about an equal weight of ſedative ſalt, to be completely ſaturated. Why the arſenical acid, though perfectly ſaturated with vegetable alkali, ſhould yet expel the acid of nitre in diſtillation, I have already ſhewn, (VI.) ; but I may here add that the acid of arſenic likewiſe attracts an exceſs of alkali, when circumſtances allow, and this force undoubtedly promotes the ſeparation. On the ſame principles, the acid of arſenic, exactly ſaturated with vegetable alkali, decompoſes liver of ſulphur and ſoap, as Mr Scheele has diſcovered. In alum there is an exceſs of acid, ſo that it reddens turnſole, and is capable of receiving a ſtill greater exceſs, and reciprocally of being combined with its own baſis beyond the bounds of ſaturation. The calx of lead may alſo be combined in exceſs with plumbum corneum, and ſaccharum ſaturni. Turbith mineral and powder of algaroth have an exceſs of their baſis, and, after

the

the moſt careful waſhing, yield, on diſtillation, a portion of acid. I omit other inſtances; and from thoſe which have been adduced, I think it evident that the doctrine concerning a determinate exceſs of one or other of the ingredients, is not only not abſurd, but that it actually takes place on many occaſions. The exceſs commonly adheres leſs firmly than the portion requiſite for ſaturation, and therefore in many inſtances may be eaſily removed, but it is not on this account the leſs real. There is in theſe caſes, as I have before remarked, an attraction between the ſaturated ſalt, and a determinate exceſs of the acid or the baſis. Perhaps ſuch an attraction takes place in all compound ſalts, and ſometimes the power which attracts the acid, and at others, that which attracts the baſis, may prevail, though we are as yet acquainted with only a few inſtances. It is alſo probable that the ſaline particles,

when

when diffolved, can admit of a greater excefs than when in a concrete ftate; at leaft, fuch is their relation to the matter of heat, a fubftance far more fubtile, for when they coalefce after they have been feparated, they part with a certain portion which they attract when diffolved. A new field opens here before us, as yet uncultivated, and indeed fufficiently difficult, fince the attraction of compounds is weaker and fometimes fcarce perceptible; fometimes, however, remarkable phænomena are to be derived from them alone. Let mercury, for inftance, be digefted in an equal weight of nitrous acid, with fuch a degree of heat as will prevent cryftallization. At firft the metal is taken up with effervefcence in the common manner, but at length the generation of bubbles ceafes, nor does any nitrous air arife, though in the mean time moft of the mercury infenfibly difappears. In

this

this experiment, ordinary nitrated mercury, with a calcined basis, is formed, and this is afterwards saturated with mercury, that retains its phlogiston. If a solution of sea salt be added to a solution of this salt, a white powder is precipitated, which is real mercurius dulcis, and which in the last Swedish Pharmacopœia is directed to be prepared in this way *. When the mixture is made, the marine acid attracts the calcined mercury, and forms corrosive sublimate, which immediately seizing the complete mercury, becomes perfectly mild; nor does any thing else happen when calomel is prepared in the dry way.

X.

* Scheele in the Stockh. Transactions, 1778.

X.

How we are to determine the single Elective Attractions.

After this view of the difficulties which may occur, let us hasten to our subject. Suppose *a*, *b*, *c*, *d*, &c. to be different substances, of which the attractive forces for *A* are to be ascertained.

A.] Let *Ad*, (i. e. *A* saturated with *d*,) be dissolved in distilled water, and then add a small quantity of *c*, which may either be soluble in water by itself or not. First let it be soluble; then a concentrated solution ought to be employed, which, when dropped into a solution of *Ad*, sometimes immediately affords a precipitate, which, being collected and washed, either proves to be a new combination, *Ac*, with peculiar properties,

properties, or *d* is extruded, or sometimes both. It now remains to be examined, whether the whole of *d* can be dislodged by a sufficient quantity of *c* from its former union. It should be carefully noted in general, that there is occasion for twice, thrice, nay sometimes six times the quantity of the decomponent *c*, than is necessary for saturating *A* when uncombined. If *c* effect no separation, not even in several hours, let the liquor stand to crystallize, or at least become dry by a spontaneous evaporation; high degrees of heat must be avoided, lest they disturb the affinities, (IV.). Here the knowledge of the form, taste, solubility, tendency to effloresce, and other properties, even those which, in other respects, appear of no consequence, of the substances, is of great use in enabling us to judge safely and readily, whether any, and what decomposition has taken place. Sometimes the disengaged substance, whether that which was added or expelled, gives the operator much trouble, by concealing the genuine properties of the other, and therefore, if poſſible, ſhould be removed, according to circumſtances, either by water or ſpirit of wine.

Next, ſuppoſe *c* to be inſoluble, as, for inſtance, a metal, let a bright and clean plate of it be put into the ſolution of *A d*, and let it be obſerved, whether any thing is precipitated. By putting ſeveral laminæ in ſucceſſion, we find at laſt whether a part only of *d*, or the whole, is ſeparated. Sometimes no decompoſition is effected, though the ſurface of the metal ſhould have been lately filed, unleſs there be a ſmall exceſs of acid; and as far as I have hitherto been able to collect, it is not always of conſequence that the ſuperfluous acid ſhould be of the ſame nature as that which *A d* contains or not.

If

If only one of the compounds *Ad* and *Ac* be ſoluble in highly rectified ſpirit of wine, there is ſcarce any need of evaporation; for if the mixture be made, and left a few hours at reſt, and then ſpirit of wine be added, that which cannot be diſſolved in it is ſeparated.

The ſmell alſo often indicates what is taking place. Thus, vinegar, acid of ants, of ſalt, nitre, volatile alkali, are eaſily diſtinguiſhed when ſet free. The taſte likewiſe often informs an experienced tongue.

b.] Let *Ad* then be treated with *b* and *a*, &c. ſeparately in the ſame manner.

c.] In like manner, let *Ac*, *Ab*, *Aa*, be examined in their order.

By ſuch an examination properly conducted, the order of attractions is diſcovered. This taſk, however, exerciſes all the patience, and diligence, and accuracy, and knowledge, and experience of the chemiſt. Let us ſuppoſe only a ſeries of five terms, *a*, *b*, *c*, *d*, and *e*, to be examined with reſpect to *A*, twenty different experiments are requiſite, of which each involves ſeveral others: a ſeries of ten terms requires ninety experiments, and, in general, if *a* be the number of the ſeries, $n.\overline{n-1}$ will be the number of experiments.

d.] In like manner, each compound with *a*, *c*, *b*, ſhould be examined in the dry way; but it muſt be in a crucible, or, if poſſible, in a retort heated to incandeſcence, that the volatile part may be collected at the ſame time.

Such, in general, is the method which I have followed; the continuance of this

this labour will perhaps diſcover various ſhorter paths, which will at leaſt be convenient in certain caſes. But we ſhould be cautious in guarding againſt fallacies ariſing from the apparent exceptions above deſcribed.

XI.

The neceſſity for a new Table of Attractions.

The tables which we have at preſent contain only a few ſubſtances, and each of theſe compared only with a few others. This is no reproach to the authors of them, for the taſk is laborious and long. Although, therefore, I have been employed upon it with all the diligence I could exert, and as much as my many other engagements would permit, yet I am very far from venturing to aſſert, that that which I offer is perfect, ſince I know with certainty, that the ſlight ſketch now propoſed will require above 30,000 exact experiments, before it can be brought to any degree of perfection. But when I reflected on the ſhortneſs of life, and the inſtability of health, I reſolved to publiſh my obſervations, however defective, leſt they ſhould periſh with my papers, and I ſhall relate them as briefly as poſſible. In itſelf it is of ſmall conſequence by whom ſcience is enriched; whether the truths belonging to it are diſcovered by me or by another. Meanwhile, if God ſhall grant me life, health, and the neceſſary leiſure, I will perſevere in the taſk which I have begun. I ſhall now explain the end I had in view, and my plan; ſhould they be approved by the maſters of the ſcience, I hope that many will lend me their aſſiſtance, for it is eaſier to accompliſh one or two columns, than to bring all to perfection: I exhibit a great number of the more ſimple ſubſtances which

occur

occur in chemiſtry. Many of theſe are not only compounded, but are eaſily reſolved into their proximate principles, ſuch as hepar, ſulphur, the imperfect metals, *&c.*; but they do not come into view here, but inaſmuch as they effect compoſition and decompoſition in their entire ſtate; but when their proximate conſtituent parts are ſeparated, double attractions take place, which are not conſidered in this table.

Moreover, I have inſerted many lately diſcovered, of uncertain origin and compoſition, ſuch as the acids of fluor, arſenic, tartar, ſugar, and ſorrel; of earths, magneſia and terra ponderoſa; of metals, platina, nickle, manganeſe, and ſiderite, of which more in the place belonging to each. In the obſcurity of their origin, theſe ſubſtances agree with others that have been the longeſt known. Should they be derived from others, they ought not, on this account, to be excluded, for they are now different, have conftant properties, exercife their attractive powers without decompofition, and can at pleafure be obtained perfectly alike. It is therefore proper to inquire into their powers. Every fubftance that we employ is probably compounded, and although we are at prefent ignorant of its principles, they may hereafter be detected.

The upper ftratum of the table, if I may fo call it, contains fifty-nine rectangles horizontally placed, which exhibit fifty-nine different fubftances, denoted by figns formerly in ufe, or by new ones, which I fhall now therefore enumerate in the order of the adjacent numbers, for there is fcarce any one in the following which does not appear in the firft: 1. Is vitriolic acid; 2. Phlogifticated vitriolic acid; 3. Nitrous acid; 4. Phlogifticated nitrous acid; 5. Muriatic acid; 6. Dephlogifticated muriatic

muriatic acid; 7. Aqua regia; 8. Fluor acid; 9. Arſenical acid; 10. Acid of borax; 11. Acid of ſugar; 12. Acid of tartar; 13. Acid of ſorrel; 14. Acid of lemon; 15. Acid of benzoin; 16. Acid of amber; 17. Acid of ſugar of milk; 18. Diſtilled vinegar; 19. Acid of milk; 20. Acid of ants; 21. Acid of fat; 22. Acid of phoſphorus; 23. Acidum perlatum; 24. Acid of Pruſſian blue; 25. Aerial acid; 26. Pure fixed vegetable alkali; 27. Pure fixed mineral alkali; 28. Pure volatile alkali; 29. Pure ponderous earth; 30. Pure lime; 31. Pure magneſia; 32. Pure clay; 33. Pure ſiliceous earth; 34. Water; 35. Vital air; 36. Phlogiſton; 37. Matter of heat; 38. Sulphur; 39. Saline liver of ſulphur; 40. Alcohol; 41. Æther; 42. Eſſential oil; 43. Unctuous oil; 44. Gold; 45. Platina; 46. Silver; 47. Mercury; 48. Lead; 49. Copper; 50. Iron; 51. Tin; 52. Biſmuth; 53. Nickle; 54. Arſenic; 55. Cobalt;

56.

56. Zinc; 57. Antimony; 58. Manganese; and, 59. Siderite.

THESE ſubſtances are, as it were, the heads of each column, at the top of which they reſpectively ſtand: to theſe thoſe that are placed below bear this relation, that the nearer they ſtand, the ſtronger attraction they muſt be underſtood to have. Every column, therefore, not only muſt exhibit every one of the fifty-nine ſubſtances which is capable of being combined with the principal ſubſtance at the top, but alſo the order which ſuch combinations follow. The double line diſtinguiſhes from the others the thirtieth ſtratum, which is the firſt that belongs to the dry way. The ſubſtances which occur in theſe rows refer alſo to the heads of the columns.

LASTLY, I have diſtinguiſhed the horizontal rows, as well as the columns, by numbers on each ſide, that each rectangle

rectangle might be more readily found and quoted. On account of the new ſubſtances, I am obliged to divide the table of ſingle elective attractions into two parts; and when, from multiplied experiments, more than two can contain ſhall require admiſſion, it may be conveniently divided into four parts; the firſt for the acids, the ſecond for the alkalis and earths, the third for the inflammables, and the fourth for the metals.

XII.

Column Firſt, the Vitriolic Acid.

CONCERNING the head of this column, as it is ſo well known, there is no occaſion to premiſe much. So firm is its compoſition, that its proximate principles have not yet been diſcovered. Some late excellent experiments * have been

* Lavoiſier's, in the Mem. of the Acad. of Paris, 1777.

been thought to difclofe the ftructure of this acid; but they are, if I miftake not, to be underftood in a different manner. Sulphur, when burned in a veffel filled with atmofpheric air, and clofed by means of mercury, abforbs a portion of vital air, and yields an acid of twice or thrice the weight of the burned fulphur. The acid, therefore, is fuppofed to have exifted in fulphur, far lighter, and without air. The fame thing is confirmed by the efflorefcence of fulphureous pyrites, which is converted into vitriolated iron, not however without the abforption of a certain portion of vital air. To recover the air inherent in this acid, vitriolated mercury is reduced in a pneumatic apparatus by the aid of fire to its metallic form. During this operation, a large quantity of vital air, which is fuppofed to enter into the compofition of the acid, is collected. Of thefe facts the following feems the true explanation. It has been fully proved

proved by experiments, that every ſubſtance has a certain ſpecific quantity of fire, which yet varies more or leſs in one and the ſame, according to the different ſtates of ſolidity, liquidity, and fluidity, (XLVIII.). Now the vitriolic acid exiſts in a ſolid ſtate in ſulphur, but, on deflagration, deliqueſces, and therefore recovers the heat proper to its liquid ſtate. The ſpecific heat of ſulphur is to that of vitriolic acid as 0, 183 to 0, 758, that is, nearly as 1 : 4. But the acid extricated in this experiment contains very little water, only the quantity indiſpenſably neceſſary to fluidity, which it attracts from the air and the mercury, that almoſt always contain it. But the leſs water the acid contains, the leſs is its ſpecific heat, and it undoubtedly, in this caſe, is below 0, 758 : let us ſuppoſe it to be 0, 549, and thus the proportion will be changed to 1 : 3. It follows, then, that the vital air enters into the compoſition of the

ſpecific

ſpecific fire. It is evident, that it loſes its aerial form during the combination, which it cannot regain without a decompoſition, ſince, in other experiments, it may be expelled from acids by alkalis and other ſaturating ſubſtances, in the ſame manner as the aerial acid out of chalk; but the heat only is ſet at liberty, and no part of the vital air. That which appears in the reduction of vitriolated mercury perhaps ariſes from decompoſed heat, as we ſhall more clearly ſee in XLVIII. The principles of vitriolic acid have not yet therefore been ſatisfactorily ſet looſe; for as to the matter of heat, it exiſts in every body yet known.

Among the ſubſtances hitherto tried, vitriolic acid adheres moſt tenaciouſly to

2.] *Cauſtic terra ponderoſa,* which, when added to a ſolution of vitriolated tartar, generates

generates the ponderous ſpar, which remains inſoluble at the bottom. The liquor contains cauſtic vegetable alkali, (Scheme I.). Cauſtic or pure vegetable alkali is incapable of decompoſing ponderous ſpar.

3.] Next ſtands *cauſtic vegetable alkali*, which, when added in ſufficient quantity to a ſolution of Glauber's ſalt, yields vitriolated tartar and uncombined mineral alkali, which is unable to detach the vitriolic acid from vegetable alkali.

4.] Cauſtic *mineral alkali* precipitates the calcareous baſis of gypſum, but the inverſe experiment does not ſucceed.

5.] *Cauſtic calcareous earth* is ſuperior to magneſia; for vitriolated magneſia (Epſom ſalt) is immediately decompoſed in lime-water, and yields its acid to the lime. Moreover, lime ſeparates volatile alkali

alkali and all the metals from vitriolic acid.

6.] *Caustic magnesia* added to a solution of secret sal ammoniac, seems to produce no change which is sensible to the smell; but if the mixture be kept for a few days in a close phial, a distinct smell of volatile alkali will be perceived on opening it. The difference however of force is very small; so that the smallest diminution of that of the former, or increase of that of the latter, inverts the attractions. Hence a precipitation of vitriolated magnesia is often effected by caustic volatile alkali: for the alkali cannot easily be obtained quite pure, being either, on the one hand, contaminated by a small quantity of aerial acid, or, on the other, by quicklime, either of which effects a separation, the former by means of a double (V.), the latter by a single attraction. But the chief and perpetual

cause

caufe of precipitation, is the formation of a triple falt, more difficult of folution, as we have before explained, (VIII.).

7.] *Cauftic volatile alkali* precipitates clay from vitriolic acid, and zinc likewife, unlefs it be added in fufficient quantity to rediffolve the precipitate, (VII.). The fame caution is applicable to the other metals; but there will be no ambiguity in the refult, if the metal be infoluble in the precipitate. See alfo what is faid of volatile alkali in XVI. and XXXIX.

8.] *Pure clay*, i. e. earth of alum, long digefted in alkaline water, and then well edulcorated. I have already treated at fufficient length concerning the precipitation of alum by zinc, iron, and fome other metals, (VI.). But the metallic calces feem to have the fame degree of attraction for acids as clay, at leaft I have in vain tried to decompofe vitriol of copper by clay; and reciprocally calx of copper tinges a ſolution of alum, and a white ſediment is depoſited; but this effect, as I have before explained, is owing to exceſs of acid.

9.—23.] This ſpace perhaps belongs to the *metallic calces*. In all the tables of attractions which have been publiſhed, and even in that which I offered to the world in 1775, the metals were placed in the columns of the acids; but upon farther reflection, I am forced to exclude them. That theſe ſubſtances are attracted and diſſolved by acids, is known even to beginners; but let it be remembered that they are not, as was ſuppoſed, taken up entire, and in their complete form by menſtrua: for ſome particles of the acid carry off the ſuperfluous phlogiſton, while others diſſolve the calcined metal. Since therefore they exiſt in the menſtruum mutilated, and in a great meaſure deprived

prived of one of their principles, the condition under which the procefs may be referred to fingle attractions, does not exift. Hitherto the precipitations of metals by metals have been ill underftood. When I obferved many years ago, for the firft time, that the feries of the metals was the fame with refpect to all the acids, I was ftruck with great furprife at the coincidence, confidering in how many particulars earths and alkalis differ with regard to them. I therefore began to entertain a fufpicion, that the precipitation of metals depended, not on the election of the acids, but on fome other principle, which I now certainly know to be the attractive power of the diffolved calces for the phlogifton of the precipitating metal. I have elfewhere treated of this fubject *, and fhall fay more upon it in the fequel, (XLVII.). Complete metals therefore are properly excluded, but

F 2 are

* Diff. de phlogifti quantitate in div. metallis, § 2.

are the calces alſo to be ſet aſide? They are really diſſolved; and it ſeems agreeable to the nature of things to ſuppoſe, that the ſame acid would find ſome difference in ſixteen different calces, in conſequence of which it would prefer ſome to others. But as reaſoning is fallacious, without the teſtimony of experience, I performed experiments with the calces, eſpecially with thoſe of ſilver and copper. I firſt procured as ſaturated a ſolution of ſilver in the nitrous acid as poſſible, which I could not indeed bring to ſuch exactneſs that it would not redden turnſole; but the exceſs can ſcarce be taken away without the precipitation of the metallic ſalt. To this ſolution I added copper calcined by fire, and expoſed it to a heat of digeſtion for ſeveral days; but though it was only very ſlowly diſſolved, and the colour of the liquor changed to a blue, no ſigns of precipitation appeared. Another ſolution of ſilver,

ſilver, equally ſaturated, diſſolved that calx of mercury which is uſually called precipitate *per ſe*, without any diminution of its tranſparency. I afterwards ſaturated nitrous acid with copper, and added the calx of ſilver precipitated by cauſtic fixed alkali; here there was only an inconſiderable ſolution, and no precipitation at all. It ſeems, therefore, that an acid takes up calcined metals without diſtinction, provided they have loſt a certain quantity of phlogiſton; for more or leſs of this principle makes a remarkable difference in ſome caſes. Beſides, when the nitrous acid is uſed, it ſometimes happens that a calx, in a proper ſtate, is gradually deprived of its phlogiſton beyond the determinate limit, and then it is immediately rejected. Such events, proceeding from the peculiar nature of certain ſubſtances, muſt be carefully obſerved, leſt erroneous concluſions ſhould be drawn. I have before obferved, that the calces attract each o-ther, particularly thofe of zinc and copper *. Thefe combinations, when dif-folved in the fame acid, produce, without doubt, triple falts, which deferve farther examination.

I have inferted the metallic calx in the order in which they are ufually precipitated, fince it may not be without ufe to be acquainted with it; but I have obliterated the horizontal lines, in order to fhew that the acids have not yet been found to poffefs any power of felection.

24.] I here place *water*, fince it dif-folves moft of the vitriols, and reftores them unchanged. I am aware, indeed, that mercury, tin, bifmuth, and antimony, are feparated from the vitriolic acid, upon the addition of water; but it fhould be obferved, at the fame time, that

* *Ibid.* § 5. d.

that a large quantity is requiſite, which firſt carries off the exceſs of acid eſpecially neceſſary to theſe ſalts, and more ſlightly adhering to them, and then by the concurrence of heat ſeizes the remainder; but a proper quantity does not render the ſolutions turbid. We know that the vitriolic acid cannot be perfectly deprived of its ſuperfluous water by boiling, but that it retains more than one-fifth of its weight; which therefore is the leaſt poſſible quantity in metallic ſolutions. But by a ſufficient quantity of water, and in a certain length of time, all the vitriols perhaps may be decompoſed; in which caſe another place ſhould be aſſigned to it, unleſs ſome other cauſe exerts its influence at the ſame time.

25.] *Phlogiſton* comes laſt, to which, however, ſome of the moderns give the firſt place; but I am as yet unacquainted with any experiment from which it can be ſafely concluded that phlogiſton, in the humid way, and by attracting the acid, is capable of decompoſing either neutral or middle ſalts, whether earthy or metallic. It is indeed ſtrongly attracted by the vitriolic acid, as appears from the dark colour which it contracts from the ſmalleſt portion of oily matter, whether this be uncombined or intimately united with ſome other ſubſtance ; however, a ſufficient quantity of water both prevents the offuſcation, and removes it when it has been long preſent. Moreover, this acid, though in the moſt concentrated ſtate, does not affect the phlogiſton of charcoal, except by means of a proper degree of heat. Metals put into the vitriolic acid, loſe a certain portion of phlogiſton, but this is the effect of heat ; at leaſt, of that degree which is excited by the ſolution ; and I have before obſerved that this privation is neceſſary to ſolution, (V.) and ſhall bring farther proof in XIII.

31.] In the dry way, *phlogiſton* occupies the firſt place, for vitriolated tartar, Glauber's ſalt, ponderous ſpar, and gypſum, loſe their acid by the intervention of the inflammable principle of charcoal, and a ſufficient heat.

32.] It is probable, that *terra ponderoſa* decompoſes vitriolated tartar in this way; it remains, however, to be confirmed by experiment.

33.] *Vegetable alkali* expels the volatile.

34.] So does *mineral alkali*; but whether the latter yields to the vegetable has not yet been examined.

35.] *Lime*, as well as

36.] *Caustic magnesia* deprives secret sal ammoniac of its acid.

37.] All the *metals* probably, or rather their calces, expel the caustic volatile alkali. Experiments have been made with lead, tin, copper, iron, *&c.*

38.] *Volatile alkali.*

39.] *Pure clay* cannot detach the acids from ammoniacal salts.

XIII.

Column Second, the Phlogisticated Vitriolic Acid.

It was an emphatical and just observation of the ancients, that phlogiston lent wings to vitriolic acid, which, though it requires an intense heat to be sublimed before its union with phlogiston,

giſton, afterwards evaporates ſpontaneouſly. The effects, however, vary wonderfully, according to the different proportions. For the acid, when fully ſaturated, conſtitutes common ſulphur; if it be combined with a ſmaller quantity, it generates aeriform vitriolic acid, known likewiſe by the name of vitriolic acid air, which, when collected in mercury, cannot be condenſed into a liquid by cold; is very light, not exceeding 000,246 in ſpecific gravity. It immediately diſſolves camphor, and extinguiſhes flame. An hundred grains of diſtilled water, ſcarce take up five of this aeriform acid; and I call this liquor, for the ſake of diſtinction, *phlogiſticated vitriolic acid.* This acid freezes in the ſame temperature as pure water; and what is remarkable, the acid elaſtic fluid remains in the ice, though in open veſſels it forſakes the water. What is highly worthy of notice, is, that if it be expoſed to heat in a tube hermetically

hermetically ſealed for twenty days, a ſmall quantity of ſulphur is ſeparated. Has the decompoſition of heat any ſhare in this phænomenon?

The vitriolic acid, by the aid of fire, and properly treated, may be phlogiſticated by moſt ſubſtances containing the inflammable principle; but it cannot be reduced to this ſtate by means of aerial acid. The phlogiſton, in theſe operations, works wonderful changes, for a very fixed, heavy, inodorous, acrid liquor, becomes elaſtic, light, and ſo volatile, that its very penetrating ſmell threatens ſuffocation, and moreover ſo weak, that vegetable acid attracts alkali from it. I have not yet learned from experiment, whether there hence ariſes any variation in the elective attractions. I know that it diſſolves alkalis; that cauſtic fixed alkali, and pure lime expel volatile alkali; and alſo, that lime-water precipitates magneſia;

magnefia ; and till the order of the o-ther fubftances fhall have been afcer-tained, I follow the fame as in the pre-ceding column. The neutral and middle earthy falts, formed by this a-cid, differ a little in figure, tafte, and other properties, from thofe which con-tain pure vitriolic acid ; the difference, however, difappears in time, for the phlogifton gradually flies off.

But as all metals, in order to be fo-luble, muft be deprived of a determi-nate portion of phlogifton, which, for each, is various, (for none can be taken up in its reguline ftate by vitriolic acid, without the feparation either of inflam-mable air, or aeriform acid ; while, on the contrary, each, when deprived of a certain portion of phlogifton, is not only more eafily diffolved without any farther lofs of phlogifton, but likewife afford the fame vitriols as in the preceding cafe ;) hence it neceffarily follows, that the phlogiſticated vitriolic acid ſhould reject them; and there are ſome experiments from which it would appear that it really is ſo. Zinc, which is quickly diſſolved in diluted vitriolic acid, is changed, by the ſame acid properly phlogiſticated, into a white powder, which ſeems neither to be taken up by vitriolic nor marine acid. Each particle of the menſtruum muſt be loaded with phlogiſton, otherwiſe thoſe which are free from it act at firſt in the uſual way; but when they are ſaturated, ſolution ceaſes. It is ſaid, that, by the aid of heat, the zinc is attacked, and that a quantity of inflammable air is extricated; but I have not yet ſeen this. Flowers of zinc are taken up by the phlogiſticated acid. Iron agrees with zinc, except that when it is too much calcined, it is ſcarce ſoluble. Copper is not viſibly changed in this menſtruum. Metallic precipitates procured by alkalis are by no means to be

conſidered

confidered as reguli minutely divided; for they are more or lefs deprived of phlogifton, as appears partly from what has been faid above, and partly from the fediments thrown down by any metal ufed as a precipitant; which differ from the former both in fplendour and nature; I have therefore no doubt but phlogifticated vitriolic acid will diffolve metals properly calcined; but I confefs, that the particular phænomena have not been examined with proper attention. This volatile menftruum cannot be fubjected to experiments in the dry way.

XIV.

Column Third, Nitrous Acid.

1.] This acid, likewife, feems to have fuch firmnefs of ftructure, that its principles have not hitherto been afcertained.

ed*. Expofed to the fire with various fubftances, it yields a great quantity of vital air; but it remains as yet doubtful whether the air exifted uncombined in the acid, or is formed by its being fufficiently phlogifticated. This queftion will be difcuffed hereafter, (XLVI.). It exerts its elective attractions nearly in the fame order as the vitriolic acid.

2.] *Cauftic ponderous earth* cannot be feparated from nitrous acid by the cauftic vegetable alkali. When the aerial acid is prefent, it is precipitated in confequence of a double attraction; but if there be too much, it will be rediffolved.

3.]

* The Count de Saluces politely fent me his letter on the generation of nitre, but he has not yet publifhed his proportions, and I have not therefore had the fatisfaction of obferving this fpectacle. Mr Thouvenel, too, has very lately obtained the prize from the Parifian Academy, for procuring nitrous acid from atmofpheric air and putrid vapour.

3.] *Cauſtic vegetable alkali* decompoſes quadrangular nitre, and forms priſmatic.

4.] *Cauſtic mineral alkali* precipitates nitrated lime.

5.] *Lime* precipitates nitrated magneſia.

6.] *Cauſtic magneſia* expels the volatile alkali from nitrum flammans.

7.] *Cauſtic volatile alkali* precipitates clay, zinc, and the reſt of the metals.

8.] The place of *pure clay*, as alſo of the ſubſtances which follow has not been ſufficiently determined.

9.—24.] The *metals* properly calcined.

25.] Water feems to prevent the acceffion of phlogifton. The acid juft expelled from nitre, by vitriolic acid, contains about two-thirds of its weight of water.

26.] The nitrous acid foon detaches from the metals that portion of phlogifton which impedes folution; and when heat is employed, it fometimes goes beyond proper bounds, infomuch, that being too much calcined, they cannot be held in folution. Thus, tin and antimony are taken up with vehemence, but are foon let fall again to the bottom.

In the dry way, the fame order as in column firft, as far as I have yet been able to learn, is obferved. Phlogifton occupies the firft rectangle, for in detonation the acid forfakes both ponderous earth and vegetable alkali to unite with phlogifton. Whether it be converted into vital air, I do not here enquire,

enquire, but the intenſity of the deflagration, even in vacuo, clearly ſhews the preſence of this air, which ſeems to be totally converted into heat; for nitre, in detonating with charcoal in cloſe veſſels, yields fixed and foul air, but ſcarce any thing fit for ſupporting ignition and reſpiration.

XV.

Column Fourth, the Phlogiſticated Nitrous Acid.

Nitrous acid, eſpecially when concentrated, eagerly attracts the inflammable principle, and, when contaminated with it, emits red vapours, and the liquor acquires a reddiſh colour, which, however, may be ſo far driven off by a ſlow diſtillation, that the liquor ſhall appear as limpid as the cleareſt water; ſuch an acid is juſtly called *pure*. But the colour which has been made to disappear, returns upon the ſmalleſt addition of phlogiſton; even the ſolar rays induce a yellow colour, and cauſe the acid to emit yellow fumes, as Mr Scheele has obſerved. Smoking nitrous acid, moreover, furniſhes a fine proof, that different colours depend upon the different denſity of phlogiſton; for if nitrous acid, when red and concentrated, be diluted with about a fourth part of its bulk of water, it aſſumes a beautiful green colour, and yet emits red fumes; but an equal, or a greater portion of water makes it blue, while twice or thrice its bulk deſtroys all colour. The red ſmoke which riſes ſpontaneouſly, or may be driven off by heat, preſerves its elaſticity in a cloſe veſſel, and cannot be reduced to a liquid by cold; it is therefore properly called *aeriform nitrous acid.* It is abſorbed by water, which, with a certain portion, becomes blue; with a larger, of a beau-

tiful

tiful green; when ſaturated, is yellow, and is then found to have received an increaſe of one-third of its bulk. Such are the variations of *phlogiſticated nitrous acid.* The blue ſpontaneouſly emits *nitrous* air, the green ſcarce any, and the yellow none at all. It well deſerves to be noticed, that nitrous air ſometimes exceeds the phlogiſticated acid from which it has been expelled, tenfold in bulk, though water cannot receive above one-tenth *. Yellow nitrous acid, expoſed to heat in a tube hermetically ſealed, becomes of a more intenſe colour, the green or blue is turned yellow; but by refrigeration the former hue is brought back. When the heat is continued for a long time, a colour permanent in the cold is acquired; the tinging matter may be expelled in the form of a red vapour, and the acid will remain without colour; but after refrigeration, the vapour again enters into the acid, un-

* Prieſtley.

lefs it be changed by a long continued heat *.

The phlogifticated acid diffolves alkalis and metals, but it adheres to them very loofely, (XXXVII.). A fufficient quantity of acid, (unlefs it be quite faturated), in an open veffel, is not much prevented by the phlogifton from diffolving metals, for the particles which are contaminated, or which attract this volatile fubftance, fly off; and moreover, this menftruum attacks them on account of their inflammable part, and does not take up thofe which are calcined beyond certain limits. The calx of manganefe, known alfo by the name of magnefia nigra, furnifhes an admirable proof of the effects of a certain portion of phlogifton; for this calx contains a very fmall quantity of the inflammable principle, on which account a fcarce fenfible quantity is diffolved

* Prieftley.

ſolved by pure nitrous acid, unleſs upon the addition of ſugar, honey, or ſome other inflammable ſubſtance, capable of affording the neceſſary complement; but the phlogiſticated acid perfectly diſſolves it. Theſe ſolutions precipitated by alkalis afford a white powder, readily ſoluble in acids, but which, by heat, is turned black, and recovers the properties of magneſia nigra; the white ſediment, therefore, is nothing but the calx united with as much phlogiſton as is neceſſary to its ſolution in pure acids; but the regulus contains a ſuperfluous quantity, ſince red vapours are formed during its ſolution in nitrous acid. Mercury diſſolved in nitrous acid, in the cold, depoſits cryſtals ſpontaneouſly; by cauſtic volatile alkali, it is precipitated of a black colour, and differs in many other reſpects from that which, in conſequence of the application of heat, has loſt more of its phlogiſton. The ſame remark is applicable to iron, and ſome other metals. Every metal indeed muſt be deprived of a portion of phlogiſton; but if this proceſs is carried beyond certain limits, either no ſolution takes place, or one widely different from a real ſolution. The order of attractions, not having been ſufficiently explored by experiment, is adjuſted according to the preceding orders.

XVI.

Column Fifth, the Muriatic Acid.

1.] The acid of ſea ſalt is nothing but water more or leſs combined with marine or muriatic air. This air is properly denominated *aeriform marine acid*, of which diſtilled water is capable of abſorbing one half of its weight, and then yields *phlogiſticated marine acid*. The acid recently expelled by vitriolic acid from ſea ſalt, commonly contains three-fourths

fourths of water. This acid ſeems to exert its attraction in the ſame way as the preceding, though indeed in ſome caſes more obſcurely.

2.] *Ponderous earth*, diſſolved in marine acid, cannot be expelled by pure vegetable alkali.

3.] *Pure vegetable alkali* expels the mineral. (See Scheme 3. and 32.).

4.] *Pure mineral alkali* expels lime, (Scheme 4.).

5.] *Pure lime* ſeparates magneſia, volatile alkali, and the metals.

6.] *Pure magneſia* is to be placed before volatile alkali, for the reaſon before mentioned. The acid, magneſia, and volatile alkali, in a proper quantity, unite and form a triple ſalt: hence, in order to attain the proper proportion, a little magneſia

magnesia is always separated on the addition even of the purest volatile alkali; but it is only the quantity necessary for attaining this end.

7.] *Pure volatile alkali* has no power against lime, (Scheme 5.); but the aerated precipitates it in consequence of a double elective attraction, (Scheme 36.). It precipitates metals.

8.] *Clay.*

9.—24. *Metallic calces.*

25.] *Water.* (See XII.).

26.] We shall see in the next paragraph, the relation of *phlogiston* to marine acid. Some of the substances adduced in the preceding columns are wanting in those which follow, for all cannot be dissolved in each menstruum; but I leave the rectangles which otherwise

wiſe would belong to them empty, that the difference may be the more ſtriking.

In the dry way, it may be preſumed, that the ſame order is obſerved as in 1. and 3. till experiments ſhall have ſhewn the contrary. I confidently preſume that the volatile metals, both with reſpect to one another, and thoſe which are fixed, have by no means the ſame action as in the humid way. Corroſive ſublimate is decompoſed by all the acids, in conſequence of a double elective attraction, as was above explained with reſpect to antimony; and this alſo is without doubt the caſe with lead, ſilver, and other metals ſaturated with acid of ſalt, which, when diſtilled with antimony, yield butter of antimony. If we are unacquainted with this cauſe, thoſe experiments of Mr Pott, which ſhew that corroſive ſublimate yields a butter with regulus of arſenic, and that,

on

on the other hand, not a grain is obtained with white arſenic, are abſolutely unintelligible ; but, when we are acquainted with it, there remains no obſcurity in theſe phænomena.

XVII.

Column Sixth, the Dephlogiſticated Marine Acid.

The illuſtrious Stahl reckons phlogiſton among the proximate principles of the nitrous acid. All the experiments which have been ſince made, ſhew, that this acid attracts the inflammable principle with great avidity ; but we cannot hence draw any concluſion with reſpect to its compoſition, unleſs we are to believe an axiom in moſt inſtances falſe and contrary to phænomena, according to which, thoſe ſubſtances which contain ſome common principles

of

of the ſame nature have a greater attraction than thoſe which are formed of principles altogether different. Martial vitriol is not ſoluble in ſpirit of wine, though a dephlogiſticated ley of it is very readily ſoluble, not to mention a great number of other inſtances. No one, at leaſt on this ground, ſuſpected the preſence of phlogiſton in marine acid, which ſo obſtinately rejected that volatile principle ; but this is now certain, from the diſcovery of the ingenious Mr Scheele *: for magneſia nigra, which we have before conſidered as almoſt deſtitute of phlogiſton, attracts it with ſo much force as to decompoſe the marine acid in a heat of digeſtion ; it is perfectly ſoluble in this acid, and is precipitated of a white colour from it, which ſhews the acceſſion of phlogiſton, (XV.). But the acid thus dephlogiſticated, conſtitutes an elaſtic fluid, of a light red colour, of the ſame ſmell,

* Stockh. Tranſactions, 1774.

ſmell, if the greater maſs be conſidered as hot aqua regia; it is not eaſily ſoluble in water, and ſcarce leaves an acid taſte, when made to paſs through it; but if it be confined over water for twelve hours, four-fifths are abſorbed, and the reſiduum conſiſts of common air: that which has paſſed through water is capable of making ſolutions, but the unwaſhed is the moſt efficacious. It ſhould therefore be collected in cylindrical phials, ſucceſſively adapted to the neck of the retort, which, when full, ſhould be cloſed with glaſs ſtopples. A little water is beforehand put into the phials to abſorb the muriatic air. Subſtances which are to be expoſed to it ſhould be put in with the ſtopples. It attacks phlogiſtic bodies with great vehemence; whitens all the colours of vegetables; reddens martial vitriol; diſſolves all the metals directly, and affords the ſame ſalts which are formed by the acid entire, which may alſo

alſo be affirmed with reſpect to earths and alkalis; it changes white arſenic to a liquid acid, (XX.); always regaining its original form when its loſs is reſtored; ſo that this truth is ſufficiently proved both analytically and ſynthetically. It ſhould be carefully noticed, that the red elaſtic fluid is properly entitled to the name of dephlogiſticated marine acid, and not the liquor in the receiver, which, although it has received a portion of the elaſtic fluid, yet conſiſts chiefly of common marine acid, (XVIII.).

THAT the dephlogiſticated acid ſhould form with alkalis, ſalts exactly like thoſe which contain the entire acid, is a proof that they contain ſome of the inflammable principle by which the deficiency is ſupplied. What I have ſeveral times before obſerved, concerning the neceſſity of depriving metals of a certain portion of phlogiſton, before

fore they can be diſſolved in acids, is admirably confirmed by the power poſſeſſed by the dephlogiſticated marine acid, of diſſolving them all. This ſeems to take place according as the phlogiſton adheres more looſely to them; but whether the order is the ſame as that of the preceding acids, muſt be decided by future experiments. Its volatility prevents its action in the dry way.

As marine acid is already ſufficiently provided with phlogiſton, it refuſes a larger portion in its liquid ſtate; but in its aerial form, having a larger ſurface, and being freed from its aqueous cover, it ſeems to admit more; nay, even to attract it with avidity, and when ſufficiently ſupplied with it, to become inflammable. It may perhaps be ſuſpected that dephlogiſticated marine acid is nothing but the acid in an aerial form; on compariſon, however, I found a great difference, for the former is taken up by water ſlowly, not immediately; it does not become inflammable by decompoſing phoſphorus gradually, but attacks it inſtantly, reſolves it into white vapours, and regenerates aeriform marine acid; it melts neither ice nor camphor, effects no change either on nitre or alum, *&c.* That which is at firſt collected, while a diſtinct odour of aqua regia is perceived, from a mixture of muriatic acid, with half the quantity of magneſia nigra, by a gentle ebullition, contains about nine-tenths of common air; but that which is obtained towards the end, contains ſcarce one-eighth. The foul air which was mixed with the dephlogiſticated vapour, ſuffers a ſcarce ſenſible diminution from nitrous air.

XVIII.

Column Seventh, Aqua Regia.

We have now no difficulty in explaining why a mixture of nitrous and marine acids ſhould be capable of diſſolving gold, though neither of them of itſelf attacks this metal. Gold muſt firſt be deprived of a portion of phlogiſton, after which it is taken up by various menſtrua. Now the nitrous acid, ſeizing phlogiſton with great avidity, eaſily decompoſes the marine, whether it be diſengaged or united with any baſis, as appears both from the ſmell of hot aqua regia, which is exactly like that of the dephlogiſticated marine acid, and likewiſe from the effect, for this menſtruum, thus deprived of phlogiſton, can repair its loſs from any metal; in conſequence of which, gold becomes ſoluble, particularly in the marine acid,

acid, (XVII.). Hence cryſtals of gold, procured by ſea ſalt diſſolved in nitrous acid, (for the two acids uncombined ſcarce afford any), and freed by edulcoration from the heterogeneous matters adhering to them, are found to contain the marine acid only. In this proceſs, therefore, the nitrous acid has no other effect than to dephlogiſticate the real ſolvent, as much as is neceſſary: that acid, however, alone, when concentrated by long continued boiling, directly attacks the inflammable principle of gold, very ſubtilely divided, ſuch as occurs in the proceſs of parting; it then diſſolves the calx, and retains it ſo feebly, that it often falls down ſpontaneouſly, or in conſequence of ſhaking. And this is the true explanation of Mr Brandt's experiment, who found that gold was ſoluble in nitrous acid *. There is no need to conſider the other ſolutions by aqua

 regia

* Acta Stockh. 1748.

regia one by one; we may only obſerve, that this compound menſtruum does not always yield triple ſalts, for in thoſe caſes in which the nitrous or the muriatic acids can of themſelves effect a ſolution, the compounds commonly cryſtallize ſeparately, at leaſt in part.

The elective attractions here alſo follow the order ſet down in the preceding columns.

XIX.

Column Eighth, Fluor Acid.

How this acid may be expelled from fluor by the vitriolic, has now been known for a conſiderable time *. When diſengaged, it always aſſumes and retains an aeriform ſtate, till it comes in con-

tact

* Stockh. Tranſ. 1771.

tact with water, which abſorbs it as well as other aeriform acids; and we thus procure *phlogiſticated acid of fluor*, which gradually corrodes glaſs, extracting particularly the ſiliceous part. This acid, however, in its aerial ſtate, acts upon glaſs much more efficaciouſly, eſpecially if the vapours be hot, which, though they be loaded with ſiliceous earth, conſtitute a tranſparent elaſtic fluid. When it is diſſolved in water, it depoſits part of the ſiliceous earth under the form of a white powder, but the reſt remains diſſolved in the liquor. Let me enter into a ſhort diſcuſſion, and enquire whether this be an acid different from every other, or mere muriatic acid, modified by an earthy baſis. Peculiar properties diſtinguiſh it from every other acid, from the vitriolic and marine in particular, with reſpect to which doubts have ariſen; for when digeſted with a little calx of ſilver, and then depurated by gentle diſtillation, it does not form argentum corneum; nor with fixed alkali does it yield vitriolated tartar, or Glauber's ſalt, or digeſtive or ſea ſalt; with lime it regenerates fluor; with magneſia it forms a cryſtallizable ſalt; with terra ponderoſa, an efflореſcing compound, and with clay, a ſweet and viſcid ſalt, like jelly: it alſo diſſolves ſiliceous earth itſelf, which totally rejects all other acids, (XLIV.)

It is indeed true, that this acid is generally adulterated with a little of the marine, whence, without doubt, the reſemblance of ſmell; but is the origin of the nitrous acid therefore to be deduced from the marine, becauſe both are preſent in aqua regia? How ſmall the portion of the acid of ſalt is, appears from the very ſparing precipitation of ſilver and mercury from the nitrous acid. The fluor acid, as far as I have yet found from experiment, neither

neither derives its origin from the marine nor the vitriolic; at leaſt I cannot comprehend how the intimate union of an earthy baſis ſhould produce ſo wide a difference. We know that acids, in ſuch a combination, become in ſome degree milder, and loſe their acrimony. Why then ſhould the fluor acid, when reſolved into vapours, corrode, and ſometimes perforate even glaſs, a property belonging to no other yet diſcovered, with whatever baſis it may be united? If any one ſhould attempt to prove, from nitrated ſilver, *(lapis infernalis)*, corroſive ſublimate, and other metallic ſalts, that the natural acrimony of acids is heightened by combination with certain baſes, the opinion, if we examine into the matter cloſely, will appear to be groundleſs. It is clear, from an hundred inſtances, that the acrimony of acids is diminiſhed in proportion to their ſaturation; to ſuppoſe it increaſed is repugnant to the nature of the thing: besides, an extraordinary degree of vehemence is ascribed to these corrosive salts, because they attack animal bodies when they come in contact with them. But the true cause of the corrosion is the dephlogistication of the metallic bases, (XV. XVII.), which are for this reason capable of tearing away the inflammable principle contained in animal substances, for to this they always tend with great force; and thus they in some measure moderate their strong attraction, for the acids are insufficient to saturate them. The various hypotheses concerning the origin of the nitrous and marine acids from the vitriolic, are well known, but they remain to this day unsupported by any valid argument, as will also hereafter appear, if I mistake not, with respect to the fluor acid.

THE

The preceding acids attract alkalis in preference to earths; but here a different order begins. Fluor acid, saturated with vegetable alkali, is decomposed by lime-water, and yields fluor and uncombined alkali. The acids which abound in phlogiston seem, for the most part, to prefer lime to alkalis. Ponderous earth, saturated with fluor acid, is soluble in a large quantity of hot water, and, upon the addition of lime-water, yields its solvent to the lime, an effect easily ascertained, for the liquor is rendered turbid, and fluorated lime is deposited. Fluor acid seems to take magnesia from vitriolic acid, but this does not hold with respect to lime; hence, therefore, the first place might be assigned to magnesia; but when I afterwards repeated the experiment, with all possible care, there was no appearance of precipitation. The sediment, therefore, in the first experiment, was perhaps siliceous earth, which

which quitted the acid when it came to be diluted in the ſolution.

In the dry way, the order of this acid is made the ſame with the preceding, though it remains to be determined by experiment. It is certain, however, that fluor mineral is not decompoſed by cauſtic fixed alkali, (Scheme 51.), though aerated alkali effects a decompoſition; but it is in conſequence of a double elective attraction, (Scheme 63.).

XX.

Column Ninth, the Arſenical Acid.

That admirable diſcovery, which diſcloſed the compoſition of marine acid, at the ſame time points out a method of acquiring pure acid of arſenic. Macquer's arſenical ſalts indeed ſhew evidently the acid nature of white arſenic;

ſenic: the pure acid, however, could not be ſeparated before the method of dephlogiſticating the muriatic acid was brought to light. We are now acquainted with two ways. In the firſt, one part of pulverized black magneſia, and three parts of acid of ſalt, of which the ſpecific gravity to that of water, ſhould be as 5 : 4, are mixed in a tubulated glaſs retort, having a bulb capable of containing four times the quantity of the ingredients: to the retort a receiver is adapted, containing one-fourth of pulverized white arſenic, together with one-eighth of diſtilled water: the retort is to be heated in a ſand bath, and the manganeſe will quickly dephlogiſticate the marine acid, which again regains its complement from the white arſenic. The acid of ſalt being thus regenerated, unites with a portion of the water, and diſſolves part of the arſenic: the reſt of the water is ſeized by the arſenical acid, as it

is

is gradually dephlogiſticated; ſo that the liquor of the receiver is divided into two ſtrata, and in a few hours all the arſenic diſappears: at this period the liquors ſhould be diſtilled to dryneſs in a retort. That which is collected in the receiver, conſiſts of butter of arſenic, and marine acid unmixed; but the white reſiduum in the retort, which ſhould be heated red hot to free it completely from acid of ſalt, exhibits real acid of arſenic in a ſolid form, (Scheme 17.), which is eaſily ſoluble in water.

The other method, is as follows: let two parts of pulverized white arſenic be diſſolved in a tubulated glaſs retort, in ſeven parts of marine acid, by ſlow boiling. Let the liquor collected in a receiver luted to the retort, be poured back, and at the ſame time three and one-half parts of nitrous acid, of the ſame ſpecific gravity as the above-mentioned marine, be added; then let a

receiver

receiver be adapted again, but without a lute. By the aſſiſtance of the heat, the nitrous acid ſeizes the phlogiſton of the arſenic, and emits red fumes; but the diſtillation muſt be carried on till no more of theſe fumes are ſeen. Then, one part of white arſenic is to be added, which ſhould be in like manner diſſolved by gentle boiling, and afterwards one and one-half part of nitrous acid, which dephlogiſticates the diſſolved arſenic with effervеſcence, and red fumes ariſe. Laſtly, diſtil to dryneſs, and the reſiduum, after ſlight ignition, will be found to conſiſt of pure arſenical acid, which is fixed in the fire, attracts moiſture in the open air, and is ſoluble, if it be ſufficiently dephlogiſticated, in twice its weight of water. It ſhould be freed by thorough waſhing in a filter from the ſiliceous powder, which comes from the corroſion of the glaſs during ignition.

ARSENICATED

Arsenicated vegetable alkali is immediately decompofed by lime-water, and the alkali is difengaged. I have fcarce any doubt but ponderous earth and magnefia prevail over alkaline falts; though I muft confefs that this conjecture has not been yet confirmed by experiment.

If acid of arfenic does not diffolve metals in their complete ftate, it at leaft diffolves them when calcined to a due degree. It is, moreover, to be obferved, that no inflammable air is generated during the folution of iron; for the phlogifton, being abforbed by the acid itfelf, regenerates white arfenic.

XXI.

XXI.

Column Tenth, Acid of Borax.

The ſubſtance commonly called ſedative ſalt, is more nearly allied to acids than any other claſs of bodies. It reddens turnſole; ſaturates alkalis and ſoluble earths. It alſo diſſolves various metals, and has other properties which ſhew its acid nature; and it ſeems better entitled to the name of acid of borax, than that of ſedative ſalt.

Depurated borax may be decompoſed by boiling with lime; the acid forſakes the cauſtic foſſil alkali to ſeize the lime, and produces a ſalt ſcarce ſoluble. That the ſame thing takes place with vegetable alkali, ſaturated with acid of borax, is hitherto only a probable conjecture; as alſo on the addition

tion of ponderous earth and magnesia.

Acid of borax attacks metals with difficulty. The easiest way to combine these substances is by a double affinity; but, to avoid mistakes, the borax should be saturated with sedative salt, of which there is required somewhat above an equal weight, before the reaction of the alkali entirely ceases. I have dropped a solution of such borax into metallic solutions, freed as much as possible from superfluous acid. Gold, platina, bismuth, and manganese, dissolved in their proper menstrua, remained undisturbed; but solutions of mercury, lead, copper, iron, tin, nickle, cobalt, and zinc, were immediately rendered turbid, and yielded metallic salts of very difficult solubility, (Scheme 28.).

XXII.

XXII.

Column Eleventh, Acid of Sugar.

Most vegetables ſhew manifeſt ſigns of acidity in their fruit or juices; and as the very few vegetable acids, which are known with tolerable accuracy, have different properties, the diligence of poſterity will certainly bring to light a great number. The chief obſtacle which prevents us from becoming acquainted with them, is the great difficulty of purifying them; for they are ſo involved in other ſubſtances, as ſcarce to admit of being extricated. I produce but a few here, of which the greater part labour under the imperfection of being deſtructible by fire. Do all of them agree in their primary principles? Can they be tranſmuted? Theſe queſtions muſt be determined by accurate experiments, made with this view. Of the acids of tartar, lemon, and milk, it is certain, that they all, upon the addition of ſpirit of wine and water, and after a digeſtion of ſeveral weeks, are changed into vinegar. At preſent they muſt be conſidered as different, ſince they can always be obtained perfectly the ſame, and poſſeſs properties perfectly diſtinct, conſtant, and of the utmoſt importance in chemiſtry.

THE acid which exiſts in ſugar, is found to be ſo cloſely united with an oily matter, that it has never yet been poſſible to ſeparate it, but by the nitrous acid which deſtroys that matter. For this purpoſe, let ſix—eight parts of ſtrong nitrous acid be poured upon one of white ſugar, reduced to powder, in a glaſs retort, and be gently boiled. The nitrous acid in a ſhort time ſeizes the phlogiſton, and emits red fumes; after the ceſſation of which, the liquor remaining

remaining in the retort ſhould be pour-ed into a large veſſel, and it will afford cryſtals of a priſmatic form, and very acid taſte. If the lixivium be dephlo-giſticated by two—four parts of nitrous acid, it will again depoſit cryſtals of inferior purity indeed, but they may be purified by ſolution and repeated cryſtallization. This acid may be al-ſo obtained from honey, gum arabic, and ſpirit of wine, by means of the ni-trous acid, but in ſmaller quantity. It poſſeſſes all the properties of acids in general; and beſides theſe, ſeveral peculiar to itſelf, by which it is di-ſtinguiſhed from all others. It totally differs from nitrous acid, and in many reſpects is of an oppoſite nature; ſo that its origin cannot with any degree of probability be aſcribed to that acid. But this queſtion is conſidered at great-er length elſewhere *; the attractions

I 2 are

* Opuſc. vol. i. p. 251.

are the chief object of the present dissertation.

It attracts lime most strongly, and forms with it a saline combination, insoluble in water, whence we may easily perceive the necessity of lime-water in the refining of sugar. The juice of the sugar-cane has an excess of acid, which prevents the concretion of the sugar. For if this acid be added to a solution of perfect sugar, it will not yield crystalline grains, but a glutinous mass. Nothing can therefore be of greater service than lime-water, which not only absorbs the uncombined acid, but likewise forms an insoluble salt, that either falls to the bottom or floats in the froth. Alkalis indeed saturate this acid, but they form salts which can scarce be separated on account of their solubility.

PONDEROUS

Ponderous earth, magnesia, and alkalis, yield this acid to lime. It attacks almost all the metals. Its comparative power, with respect to other acids, will soon be seen in the columns of alkalis, earths, and metals. This acid is an excellent test for detecting lime any way dissolved or suspended in water, for the smallest drop of a solution of it immediately seizes the lime, forming with it a white insoluble powder, which falls to the bottom. If we know the quantity of lime in a given weight of this saline powder, we easily learn, at the same time, the quantity of lime, in any case, from the sediment, completely precipitated from a determinate quantity by means of this acid, carefully collected, washed, and weighed.

It cannot sustain experiments in the dry way. The crystals alone, being exposed to fire in a glass retort, partly indeed ſublime, almoſt unaltered, but the greater part is reſolved into an acid liquor, which will not cryſtallize, as alſo happens to the ſublimate, if it be again ſubjected to the operation. During this deſtruction of the acid, a great quantity of inflammable air and aerial acid is extricated. The acid of ſugar undoubtedly abounds with unctuous matter, yet it is of a very ſubtile nature, for in the fire it leaves no traces of charcoal or ſoot.

XXIII.

Column Twelfth, Acid of Tartar.

I HAVE above explained the nature of tartar, (IX.), and ſhall now briefly mention the proceſs for obtaining the acid pure. To an hundred parts of cream of tartar, diſſolved in boiling water in a tin boiler, let ſmall quantities

of

of chalk, waſhed, dried, and pounded, be added at intervals. This muſt be continued as long as any efferveſcence is excited by the addition; about twenty-eight parts will be required. When the point of ſaturation has thus been attained, let the liquor be decanted and evaporated to dryneſs; it will yield fifty parts of tartarized vegetable alkali. The powder remaining in the bottom is lime ſaturated with the abundant acid of tartar, which, when waſhed and dried, amounts to above triple the chalk uſed, *viz.* an hundred and three. Let this compound be put into a phial, and let there be gradually added three hundred parts of vitriolic acid, containing two hundred and ſeventy of water, and thirty of the ſtrongeſt acid. Let the mixture be digeſted for twelve hours, and often ſtirred with a wooden ſpatula. Laſtly, let the clear liquor be poured off, and the reſiduum waſhed till it has loſt its acid taſte; let the water be filtered and added to the decanted liquor. We have here a ſolution of acid of tartar, which, if evaporated to dryneſs, affords near thirty-four parts of a cryſtalline maſs. To try whether it contains any vitriolic acid, let one or two drops of a ſolution of ſugar of lead be dropped into the diluted ſolution, a white ſediment will immediately fall down, upon which concentrated vinegar ſhould be poured, and it will ſoon diſappear, if it conſiſt of lead, ſaturated with acid of tartar; but vitriol of lead will not be diſſolved. Should ſome of this be detected, it ſhews that the acid of tartar is adulterated; but it may be eaſily purified by digeſtion with a ſmall quantity of tartarized lime. On the other hand, if too little vitriolic acid has been added, ſome acid of tartar will remain in the reſiduum, which is eaſily tried by throwing it on red hot coals; for pure gypſum neither grows black in the fire, nor emits an odour of ſpirit

of

of tartar, which, however, happens, if it be contaminated with tartarized lime. A filtered ſolution of acid of tartar evaporated to dryneſs will gradually depoſit cryſtals in a cool place, which generally conſiſt of divaricating lamellæ.

If newly burned lime be uſed in the place of chalk, twice the weight of tartar will be totally decompoſed, and therefore there will be uncombined vegetable alkali in the liquor; but aerated lime can only abſorb the exceſs of acid, and the tartarized tartar will remain unaltered. An hundred pounds of purified tartar contains about twenty-three pounds of pure vegetable alkali, forty-three of ſaturating, and thirty-four of abundant acid. The difference of wines, and of proceſſes for purification, will doubtleſs occaſion ſome difference,

rence, but I have not yet been able to aſcertain the limits.

From what has been ſaid, it appears that lime, with reſpect to acid of tartar, has the ſuperiority over vegetable alkali, which is alſo true of ponderous earth and magneſia; for theſe earths, when deprived of aerial acid, and added to an exactly neutral ſolution of tartarized vegetable alkali, in a few minutes attract the acid of tartar in a heat of digeſtion; and evident ſigns of uncombined alkali appear on adding the proper teſts. Mineral and volatile alkali exhibit the ſame phænomena. To aſcertain whether lime or ponderous earth prevails, I dropped lime-water into a ſolution of tartarized ponderous earth, by which it was quickly rendered turbid, ſo that every doubt with reſpect to the ſuperior attraction of lime is removed.

Crystallized

CRYSTALLIZED acid of tartar, when expoſed to fire, immediately grows black, and yields a ſpongy charcoal, which, however, ſoon turns white, if heated to incandeſcence, and is much contracted in bulk. When diſtilled from a glaſs retort, it affords, in the receiver, a phlegm ſcarce acid, together with oil; the carbonaceous reſiduum conſiſts of a portion of earth, which ſhews no ſigns either of alkali or acid. Hence, therefore, it appears, that there exiſts oil in this acid, which is deſtroyed in the fire, and is by no means convertible into fixed alkali. Treated with nitrous acid in the method above deſcribed, (XXII.), it afforded no acid of ſugar, and could not indeed be ſo much deprived of oily matter, as not to grow black in the fire. Some perſon is ſaid, however, to have ſucceeded in converting acid of tartar into acid of ſugar, which I have not yet been able to confirm by a repetition of the experiment.

riment. Acid of tamarinds, and perhaps of berberries, ſeem to agree in all reſpects with that under conſideration.

XXIV.

Column Thirteenth, Acid of Sorrel.

SALT of ſorrel is vegetable alkali ſaturated in exceſs with a peculiar acid, and therefore of the ſame nature as tartar. To obtain this acid pure, is a work of difficulty. The vitriolic, nitrous, and muriatic acids, attract indeed the baſis, but it is very hard to free the acid, thus ſet looſe, from all impurities. An hundred and thirty-ſeven parts of chalk perfectly decompoſe an hundred of this ſalt, attracting both the ſaturating and exceſſive acid. The clear liquor yields thirty-two parts of aerated vegetable alkali; nearly the ſame quantity

tity as is obtained by fire. The ſediment contains *ſorrelled* or *oxalited* lime, which, after edulcoration and exſiccation, weighs an hundred and ſeventy-three. The component parts of this ſalt cannot be ſeparated like thoſe of tartar, for the acid of ſorrel takes lime from the vitriolic. Mr Scheele diſcovered another proceſs. He added the abundant acid of ſalt of ſorrel, ſaturated with volatile alkali, to a nitrous ſolution of terra ponderoſa ; an exchange of principles immediately took place, in conſequence of a double elective attraction ; and the ponderous earth, with the acid of ſorrel, a compound difficult of ſolution, fell to the bottom, (Scheme 25.). This ſediment is decompoſed by acid of vitriol, which prefers ponderous earth to every ſubſtance yet known ; and the acid deſired may be poured off ; but as it has been but lately diſengaged, its properties have been little examined. Meanwhile, it ſeems

ſeems more nearly allied to acid of ſugar than of tartar; it differs, however, from both, for the abundant acid of ſorrel forms, with vegetable alkali, ſalt of ſorrel, analogous to tartar, but decrepitating in the fire, fuſible, ſcarce turning black, and capable of being totally decompoſed by aerated lime,—properties not belonging to tartar. Now, ſaccharated vegetable alkali agrees neither with tartar nor ſalt of ſorrel.

I KNOW with certainty that acid of ſorrel prefers lime and ponderous earth to alkaline ſalts; but it is as yet doubtful whether this be true of magneſia.

THIS acid is alſo deſtructible by fire, but it neither ſwells ſo much, nor turns ſo black as acid of tartar; by diſtillation, a phlegm, far more acid than that which is ſeparated from tartar by this proceſs, but no oily matter, is obtained. Genuine ſalt of ſorrel, as it is found in the ſhops, varies not a little in the pro-

portion

portion of its proximate principles. An hundred parts of ſome ſpecimens yield, on combuſtion and elixation, but thirty-one of vegetable alkali, while, to ſaturate the exceſs of acid, there is required an hundred and twelve and one-half. Others afford above thirty-ſeven, and require not above eighty-ſeven for ſaturation. It is obvious, that in the former caſe the ſaturated acid is to the abundant as 1 : $3\frac{1}{2}$, but in the latter as 1 : $2\frac{1}{2}$. The abundant portion is always larger than the ſaturated, which explains the ſtronger acidity of this ſalt compared with tartar. But the difference perhaps depends ſolely on the place where the ſorrel grows, or on the method by which the ſalt is extracted. The acid of ſorrel, (or more properly, perhaps, the *oxaline* acid), when procured by diſtillation, precipitates ſilver, quickſilver, and lead, from the nitrous acid; with alkalis, forms cryſtallizable compounds, and, by evaporation with-

out

out addition, may be reduced to acid cryſtals.

XXV.

Column Fourteenth, Acid of Lemon.

Although the acid of lemon has been long known, it has been but ſuperficially examined. The expreſſed juice is to be freed from mucilage and fœculent matter, by a long ſubſidence, and ſhould then be expoſed to cold, that the watery part may be frozen. It ſeems to contain a little vegetable alkali, for upon dropping in acid of tartar, in a few days a ſmall quantity of tartar is found at the bottom. Stahl affirms that acid of lemon, ſaturated with crabs-eyes, and with the addition of a little ſpirit of wine, inſenſibly aſſumes, if it be kept in a phial ſlightly ſtopped, the nature of vinegar. An equal

equal quantity of the ſame juice of lemon requires, for its ſaturation, of pure vegetable alkali ſixty-nine parts, of pure mineral fifty-one, and of volatile twenty-five. Theſe compounds do not eaſily cryſtallize.

It remains to be determined, by a greater number of experiments, whether acid of lemon certainly prefers lime, ponderous earth, and magneſia, to alkalis.

The acids of fluor, arſenic, borax, ſugar, tartar, ſorrel, and phoſphorus, agree in this reſpect, that if they be ſaturated with earths they are ſcarce ſoluble in water; and, therefore, if ſmall quantities of earth be added, the ſolutions remain clear, on account of the exceſs of acid, but near the term of ſaturation they become a little turbid; and when this is attained, all that was diſſolved is inſtantly precipitated, and can ſcarce be again diſſolved but by exceſs of acid. The ſame thing is perhaps true of ſome other acids, but not of all.

XXVI.

Column Fifteenth, Acid of Benzoin.

The reſin, which, in the ſhops, paſſes by the name of *benzoin*, or *aſſa dulcis*, contains an acid ſalt, which may be ſeparated by ſublimation, and concretes into cryſtalline filaments or ſpiculæ. It may be acquired in the humid way more free from oily matter, by extracting the acid with lime, and then ſeparating the compound with muriatic acid *. The acid of benzoin being diſlodged, falls to the bottom, uncombined, and more difficult of ſolution than when united with the lime.

Boiling

* Scheele in the Stockholm Tranſactions, 1775.

Boiling water takes up one twenty-fourth of its weight; but at the ordinary temperature ſcarce more than one five-hundredth. The taſte, approaching to that of ſugar, gives a ſlight ſenſation of acrimony, but none of acidity. It, however, reddens tincture of turnſole.

Spirit of wine readily diſſolves it, even without heat.

It is totally reſolved by fire into white vapours: it is, however, fuſible with ſmoke, on the ſudden application of a ſufficient heat; but can ſcarce be inflamed without the actual contact of ſome burning ſubſtance.

It readily combines with alkaline ſalts; but none of the compounds, except that with mineral alkali, afford cryſtals, that are not liable to deliqueſcence.

Lime-water, dropped into the ſolutions, precipitates the alkaline baſes, as alſo magneſia and clay. Lime, therefore, exceeds them in attractive power, but it is unable to ſeparate ponderous earth; nor does the latter, when burned and diſſolved in water, precipitate lime united with acid of benzoin; ſo that here a combination of three ingredients ſeems to take place.

The earthy ſalts, containing acid of benzoin, are with difficulty diſſolved in water, eſpecially thoſe that contain the ponderous and calcareous earths.

XXVII.

Column Sixteenth, Acid of Amber.

A crystallized volatile acid may be obtained from amber, by diſtillation, together with an acetous liqour and an oil.

oil. The acid may be in ſome meaſure purified by ſolution, and a ſecond cryſtallization. That which I uſed in the following experiment was thus prepared; it ſhews evident ſigns of acidity.

Combinations of this acid with alkalis may indeed be made to cryſtallize, but they are all deliqueſcent, except that into which the mineral alkali enters. Lime and ponderous earth afford ſalts of difficult ſolubility; clay yields cryſtals, and magneſia a compound like gum.

The metals, when duly dephlogiſticated, are ſoluble in this acid, and for the moſt part they afford permanent cryſtals.

Ponderous and calcareous earths, and magneſia, take this acid from alkalis. Ponderous earth alſo precipitates ſuccinated lime and magneſia; lime-water makes no change in the ſolution of ſuccinated ponderous earth, but it diſtinctly prevails over magneſia.

XXVIII.

Column Seventeenth, Acid of Sugar of Milk.

BARTHOLET firſt mentioned ſugar of milk in the year 1619 *, but no one till Mr Scheele gave a complete analyſis of it †. An hundred parts of this ſalt yield fifteen and one half parts of acid of ſugar, and of another acid hitherto found only in ſugar of milk, and which is here to be conſidered about twenty three and one half.

THIS

* Encyclop. Hermetico-dogmatica.

† Stockh. Tranſ. 1780.

This acid is obtained in the form of a white powder, and is not eaſily ſoluble in water, for ſixty parts of boiling water take up but one of the acid. The ſolution turns turnſole red.

In combination with alkaline ſalts it forms compounds far more ſoluble indeed, but ſtill requiring a weight of boiling water many times exceeding the ſolvend. The compounds formed by this acid and earths, are ſcarce ſoluble at all. As to attractions, alkalis obſerve the uſual order. Ponderous and calcareous earths, and magneſia, are ſuperior to alkalis, but it is difficult to determine the ſuperiority among them, as they are ſcarce ſoluble.

XXIX.

Column Eighteenth, Distilled Vinegar.

This acid, produced, during fermentation, from the preceding, which may in some measure be denominated crude, differs from them in the great inferiority of its attractive power for earths and metals; but, on the other hand, exceeds them in subtilty, not being altered by distillation. Vinegar also contains phlogiston, but more intimately combined, or at least more concealed. It has been mentioned above that acid of tartar, digested with water and spirit of wine, affords vinegar. B. de Vigenere long ago observed, that crystals of tartar sometimes form in vinegar *. An acid also, very nearly resembling vinegar, may be procured by distillation from guaiacum and

* Du feu & du sel, cap. 35. 1608.

and birch, from wax, ſugar and amber, which is not to be confounded with acid of ſugar, and ſalt of amber.

Pure lime cannot detach vinegar from fixed alkali, and it therefore ſeems to reſemble the vitriolic, nitrous and muriatic acids in its attractions; and I have diſpoſed them in the ſame order, though the priority of ponderous earth has not yet been confirmed by experiments.

I conjecture, that, in the dry way, the ſame ſeries, as in the fifth column, prevails, till I have leiſure to confirm or correct this opinion by experiment.

XXX.

XXX.

Column Nineteenth, Acid of Milk.

To obtain the acid of milk, curdled by ſpontaneous aceſcency, let the whey be collected and evaporated to one-eighth. This reſiduum is to be ſaturated with lime, that the phoſphorated lime may be ſeparated; then let the calcareous earth that has been diſſolved be precipitated by acid of ſugar; and at laſt by highly rectified ſpirit of wine, the acid of milk is obtained free from the phoſphorated lime, ſugar of milk, vegetable alkali, and mucilage which milk contains *.

This acid ſeems to be intermediate between vinegar and acid of ants; it, however, exceeds vinegar in attractive power. By the addition of ſpirit of wine,

* Scheele, Act. Stockh. 1782.

wine, it is really changed into vinegar, after a month's digeſtion.

WITH the alkalis, it forms deliqueſcent ſalts, and alſo with the earths, among which magneſia, contrary to what would be expected, forms the moſt permanent combination. Scarce any metal, beſides zinc, forms cryſtals with this acid; not even lead, which yields a ſweet ſolution, and depoſits ſome vitriolated lead.

WITH reſpect to alkalis and earths, the order of attractions is the ſame as that of vinegar.

XXXI.

Column Twentieth, Acid of Ants.

THIS acid approaches very near vinegar; they differ, however, in many reſpects.

respects. The former forms with magnesia, zinc, and iron, cryſtallizable ſalts; the latter only deliqueſcent. Its combination with magneſia is peculiarly remarkable *.

Its attractions have hitherto been very imperfectly examined; in the mean time, as far as has hitherto appeared, this acid obſerves the ſame order as vinegar; which, however, is weaker, as the following columns ſhew.

All the acids of vegetables, as well as that of ants, may be totally reſolved into an elaſtic fluid, conſiſting partly of aerial acid, and partly of inflammable air.

XXXII.

* Opuſc. vol. ii. p. 389.

XXXII.

Column Twenty-first, Acid of Fat.

The celebrated Crell, by repeated diſtillations of fat, obtained from 2 lib, $14\frac{1}{8}$ ounces of oil, of charcoal $10\frac{19}{24}$, and of acid $7\frac{1}{4}$ *.

The ſalts formed by this acid, ſaturated with alkalis and earths, are very like thoſe that vinegar generates with the ſame baſes. Alkalis yield it to earths. A compariſon of this with other acids will be found in the ſequel.

XXXIII.

* Chemiſche Journal.

XXXIII.

Column Twenty-ſecond, Phoſphoric Acid.

ANOTHER acid which pervades all the kingdoms of nature, is eſpecially obtained from human urine, by collecting the ſubſtance, uſually called microcoſmic ſalt, and fuſing it in the fire: but it is to be obſerved, that this is a triple ſalt, and always contains two acids, the phoſphoric and *perlatum*, which ſhall be immediately more fully deſcribed, together with volatile alkali. When the acid is obtained in water by ſlowly burning phoſphorus in the air, it abounds with phlogiſton; which however, in an open veſſel, is gradually diſſipated: it thus becomes much fitter for aſcertaining attractions than the former; for the preſence of perlate acid in that, may give riſe to a diverſity in the decompoſitions.

THE

The acid of phoſphorus prefers lime to alkalis; and therefore alkalis united with it, are immediately rendered turbid by lime-water, and a ſaline powder, very difficultly ſoluble in water, is gradually depoſited, conſiſting of lime ſaturated with phoſphoric acid. As phoſphorated vegetable alkali can receive an exceſs of acid, I ſuſpected that this exceſs only might produce the precipitation with lime-water, and that the neutral compound might remain entire; but I decompoſed the whole with a ſufficient quantity of lime-water, and nothing but an alkaline liquor was left. Phoſphorated lime is indeed precipitated by alkali, but not in conſequence of a ſuperior elective attraction. This ſalt is not ſoluble in water without an exceſs of acid; and whatever takes away the medium of ſolution, as in the preſent caſe the alkali does by ſaturating it, cauſes a precipitation of phoſphorated lime: aerated alkali, however,

ever, decompoſes it by means of a double attraction; and aerated lime falls down, (IX.). In ambiguous caſes of this kind, we muſt form our concluſion from the decompoſition of that ſalt which is more eaſily ſoluble. Thus, the preſent queſtion is anſwered by the precipitation of phoſphorated alkali by lime-water, and not by that of phoſphorated lime by alkali. The ſuperior power of magneſia and terra ponderoſa is not yet aſcertained with ſo much certainty.

In the dry way, I place lime before magneſia and ponderous earth, ſince the former undoubtedly diſpoſſeſſes fixed alkalis, which is not yet certain concerning the latter.

XXXIV.

XXXIV.

Column Twenty-third, Acidum Perlatum.

In 1740, Haupt found a ſalt in human urine, and deſcribed it under the title of *ſal mirabile perlatum*; it is the ſame which Margraaf mentions as altogether unfit for generating phoſphorus with powdered charcoal. Nevertheleſs, many have ſuppoſed, that this ſalt, which occurs in urine with the microcoſmic ſalt, contains the phoſphoric acid, and have explained its rejection of phlogiſton from the ſuperior attraction of foſſil alkali. But Mr Prouſt has lately diſengaged the ſubſtance, which alone performs the office of an acid in *ſal perlatum*; in microcoſmic ſalt, indeed, it is united with the phoſphoric acid. He digeſted ſal perlatum in diſtilled vinegar, brought it to afford cryſtals, and precipitated from the mother ley, by ſpirit of wine, a thick liquor, which, after being well waſhed in ſpirit of wine, and then diſſolved in diſtilled water, yielded an acid * which I call the *perlate*, till a more accurate examination ſhall ſuggeſt a better name. Mineral alkali, if I miſtake not, covers the acid. The cryſtallization, taſte, reaction, and efflореſcence, point out an exceſs of alkali. Perhaps this exceſs prevents ſpirit of wine, which rejects no acid, from extracting the acid part. It fuſes with ebullition, and appears pellucid, but when cooled it becomes opaque: it is taken up by acids, and may be ſeparated by ſpirit of wine: it exiſts with the phoſphoric acid, as well in bones as in microcoſmic ſalt.

It certainly prefers lime, ponderous earth, and magneſia, to alkalis. With mineral alkali, it regenerates ſal perlatum.

It

* Rozier's Journal.

It would be a peculiar and highly remarkable phænomenon, if a neutral compound, by means of an intimate union with phlogiſton, could act as an acid without decompoſition. This, however, ſeems to be the caſe with ſedative ſalt, and ſtill more certainly with the acid of Pruſſian blue, which will be deſcribed below. That obtainable from ſal perlatum, is, if I miſtake not, of the ſame nature. By means of a ſtrong impregnation of phlogiſton, it is ſo cloſely combined with a certain portion of foſſil alkali, that we have not as yet been able to effect a ſeparation of the principles; and what well deſerves notice, the compound, as a ſimple acid, takes up alkalis, earths, and metals, though ſeveral properties plainly indicate an exceſs of alkali. Meanwhile till their nature is better aſcertained, I conſider them as acids, ſince they ſeem to approach neareſt to theſe ſubſtances.

XXXV.

Column Twenty-fourth, Acid of Pruſſian Blue.

I HAVE long conjectured, not without reaſon, that the tinging matter in Pruſſian blue is of an acid nature, as it forms compounds of an intermediate kind with alkaline ſalts, as well as with earths and metals. Mr Scheele has lately taught us how to ſeparate the acid in a pure ſtate *. Phlogiſticated alkali, as it is commonly called, is a triple ſalt; containing the tinging acid, ſaturated partly with iron, and partly with alkali. This ſalt, boiled in a retort with weak vitriolic acid, emits the tinging acid in an inflammable aerial form, which may be abſorbed by water placed in the receiver. And as at the ſame time, ſome vitriolic acid paſſes

* Act. Stockh. 1782.

paſſes into the receiver, the liquor ſhould be again diſtilled with a little chalk, till one-fourth ſhall have paſſed over; which is a ſolution of the preſent acid in water. The following proceſs anſwers the ſame end with leſs trouble: let ſixteen parts of Pruſſian blue be boiled in a cucurbit, with eight of mercury, calcined by means of nitrous acid, and forty-eight of water, for a few minutes, with conſtant agitation. The mixture becomes of a cineritious yellow; it ſhould be put on the filter, and the reſiduum elixated with boiling water. To the filtered liquor, let twelve parts of pure iron filings be added, and three of concentrated vitriolic acid. After a ſhaking of ſome minutes, the whole maſs is turned black by the reduced mercury. After the ſubſidence of the powder, the clear liquor is to be decanted into a retort, and one-fourth abſtracted.

This acid, in ſome reſpects analogous to the perlate, is diſtinguiſhed by a peculiarly diſagreeable taſte and ſmell, and conſiſts of aerial acid, volatile alkali, and phlogiſton. It ſpeedily flies off in an open veſſel: it ſeems to prefer alkalis to earths. Its forcible attraction for metals will be more particularly conſidered in the ſequel.

XXXVI.

Column Twenty-fifth, the Aerial Acid.

Of this acid, which is common to all the kingdoms of nature, I have treated at length in another eſſay, and have particularly examined its attractions in § 20. *. I ſhall now add only a ſhort compariſon of it with phlogiſticated vitriolic acid, ſince they are wretchedly confounded by ſome, who find it more eaſy

* Opuſc. vol. i. p. 43.

eaſy to burden natural philoſophy with feigned hypotheſes, than to enrich it with accurate experiments. I have ſaid above, that phlogiſton, united with vitriolic acid, in different proportions, produces either vitriolic acid air, which, when abſorbed by water, is called phlogiſticated vitriolic acid, or ſulphur, (XIII.).

PHLOGISTICATED VITRIOLIC ACID has a moſt penetrating ſmell;—ſaturated with vegetable alkali, generates the ſulphureous ſalt of Stahl; the cryſtals ſpiculæ indiſtinctly hexangular; — they detonate with nitre;—may be totally ſublimed by a proper application of heat;—do not effervefce with other acids; — gradually loſe their phlogiſton, and are at laſt ſpontaneouſly changed into vitriolated tartar.	THE AERIAL ACID has no ſmell;—with vegetable alkali, forms aerated alkali; the cryſtals quadrangular priſms;—they do not yield a ſpark with nitre;—are fixed;—emit conſtant numberleſs air-bubbles, till the ſaturation is complete, even with phlogiſticated vitriolic acid, to which the aerial acid is inferior in attractive power; — remain unchanged, unleſs fire or ſome ſtronger acid expel the weak aerial acid.

HENCE let thoſe who are ſkilled in chemiſtry, and regard truth, form a judgment. If any one ſuppoſes other combinations of vitriolic acid with phlogiſton, beſides thoſe mentioned above, he muſt prove the mode of their formation, not by opinions, but by experiments.

A SIMPLE experiment proves that the aerial acid is attracted by atmoſpheric air; for if a phial filled with the former be ſet in an open place, where the ambient fluid undergoes no agitation, it will be found to contain atmoſpheric air only. Nay, aerated water yields its volatile acid to the atmoſphere.

XXXVII.

XXXVII.

Column Twenty-ſixth, Cauſtic Vegetable Alkali.

HAVING examined the attractions of the acids, we now come to the alkalis, which are commonly combined with aerial acid, but when freed from this, are called cauſtic, or even pure; and it is in this ſtate only that they can be employed for the preſent purpoſe, for, when aerated, they give riſe to double affinities; ſee Schemes 1—8. 32—36. 46. 51. 62. and 63. Thoſe which are properly called ſaline, are of three kinds. The firſt is denominated vegetable alkali, being all obtained from this kingdom; and of this only I ſhall ſpeak in the explanation of column twenty-ſixth.

THE

The vegetable alkali adheres moſt ſtrongly to vitriolic acid, for it not only is not diſlodged by either of the others, but takes this acid from them. In what manner nitre and ſea ſalt effect a partial decompoſition of vitriolated tartar, and the acid of tartar, likewiſe of nitre and digeſtive ſalt, I have explained above, (IX.), and in Scheme 9. 10. and 11. have ſymbolically repreſented the partition of the acid by darts.

The ſecond place belongs to the nitrous, (VI.), and the third to the marine acid. Whether the aeriform muriatic acid is capable of decompoſing nitre, has not been ſufficiently tried. In order to account for the order of the other acids, it will be proper to mention the chief experiments.

The celebrated Crell has admirably ſhewn, that the acid of fat is neither expelled

expelled by the acids of fluor nor of phoſphorus. That of fluor dropped into a ſolution of phoſphorated vegetable alkali, immediately precipitates a triple ſalt, conſiſting of fluor acid, vegetable alkali, and flint *. I dropped arſenical acid into a ſolution of phoſphorated vegetable alkali; after the mixture had ſtood twenty-four hours, ſpirit of wine precipitated the phoſphoric ſalt in no reſpect altered, and the acid of arſenic remained in the ſpirit. Therefore the phoſphoric is the ſtronger. The acid of tartar decompoſes all the ſalts which contain vegetable alkali, as far as I have tried, as the combinations of this baſis with the vitriolic, nitrous, marine, ſaccharine, phoſphoric, and arſenical acids, ſome completely, but others only in part, (IX.). To diſcover, therefore, its real power, acid of tartar ſhould be dropped into ſolutions of mineral alkali, combined with the ſeveral acids,

* Opuſc. vol. ii. p. 34. 37.

acids. For this alkali attracts the acids in the ſame order as the vegetable, without acquiring any exceſs, by which the obſerver might eaſily be miſled. The acid of ſugar ſeems more powerful than that of tartar; thoſe of ſorrel, lemon, and amber, weaker; but their order with reſpect to each other has not yet been ſufficiently aſcertained. Next follow the acids of ants, milk, and benzoin, which are ſtronger than vinegar. Acid of borax is expelled by vinegar, as alſo the perlate acid, the nitrous and vitriolic fully phlogiſticated. The aerial yields almoſt to all; it however precipitates ſolutions of flint, ſulphur, and oil; it even expels the acid of Pruſſian blue. Vegetable alkali takes up copper and tin, but their places are uncertain.

In the dry way, the acids of phoſphorus, borax, arſenic, and perlatum, are ſuperior on account of their fixity,

(IV.):

(IV.): the reſt, except thoſe that are deſtroyed by ſtrong heat, obſerve the ſame order as in the moiſt way. Pure earths coaleſce with alkalis in heat, but in what order is uncertain; nor can it be eaſily aſcertained, ſince when any one is united by fuſion with alkali, it is not precipitated by the addition of another, but both combine with the menſtruum, and form an homogeneous maſs. The ſame thing holds with reſpect to ſulphur.

XXXVIII.

Column Twenty-ſeventh, Cauſtic Mineral Alkali.

THIS fixed alkali has received the name of mineral, from the great quantity of it which occurs in the mineral kingdom; it is alſo found in plenty in ſome vegetables growing in the ſea,

or

or in a ſalt ſoil. It differs from the preceding, being both weaker, (XII. XIV. XVI.), and generating different ſalts with the ſame baſes. The acid of tartar does not in any reſpect change ſea ſalt, (Scheme 12.), which affords an eaſy method of diſtinguiſhing it from digeſtive ſalt. For the acid of tartar is the beſt teſt yet known for detecting the preſence of vegetable alkali in any mixture, as it decompoſes all the ſalts which have this baſis, ſome totally, others only in part, (IX.). This decompoſition is denoted by the depoſition of tartar, which, if the doſe of alkaline ſalt be conſiderable, and the ſolution concentrated, becomes perceptible in an inſtant: a ſmaller quantity, eſpecially in a weaker ſolution, requires the ſpace of a day or two.

As to the order of attractions repreſented in this column, I have not found it to differ from that in the thirty-

ſeventh.

ſeventh. This acid more certainly ſhews the true order with reſpect to acid of tartar, and in certain caſes more diſtinctly, as the compounds are more difficult of ſolution than thoſe containing the vegetable alkali. This is often advantageous in determining the attractions. Scheme 13. ſhews the decompoſition of borax by nitrous acid; Scheme 42. of ſea ſalt by the ſame, and 43. by acid of arſenic.

XXXIX.

Column Twenty-eighth, Cauſtic Volatile Alkali.

The order of attractions for acids ſeems to be the ſame in this inſtance as that of the fixed alkalis; but the volatile alkali takes up ſeveral metals, which are left untouched by the others.

That

That zinc precipitates the other metals, when diſſolved in volatile alkali, is certain, (Scheme 18.), and for the ſame reaſon as thoſe which are diſſolved in acids; a reaſon that has been formerly mentioned, and will be farther illuſtrated hereafter, (XLVII.); on this account I have placed them in the ſame order as in the columns of the acids, till experiment makes us acquainted with a better.

The influence of phlogiſton on the ſolution of metals in acids, has been ſhewn above in various inſtances, (V. XIII. XV. XVII.); let me now conſider ſome combinations of volatile alkali. To cauſtic volatile alkali let ſome filings of copper be added; if the phial be quite full and be immediately ſtopped, no ſolution will take place, but if a little ſpace above the liquor be left to the air, or the phial remain open for a quarter of an hour, in a few days a ſolution

ſolution will be obtained as colourleſs as water; but if the ſtopple be taken away, it ſoon grows blue at the ſurface, and the ſame tinge gradually pervades the whole maſs. A ſolution thus coloured may be ſoon procured in an open phial. The ſolution loſes its colour, if new filings be added, and the phial be kept cloſed for twenty-four hours. Theſe remarkable variations depend on phlogiſton: copper is inſoluble in its metallic form, but it is very ſoluble when a little of the inflammable principle is extricated. Such a privation is effected in a veſſel, either open, or only filled in part, by means of the air which ſtrongly attracts this principle, as will be ſhewn hereafter, (XLVII.), and the effects will vary in proportion to the quantity. If juſt as much is carried off, as is neceſſary to render the copper at all ſoluble, the ſolution will be colourleſs; but if it be farther deprived of phlogiſton, the calcined copper yields a blue ſolution, which is obvious even to the eye, for the colourleſs ſolution is ſoon deprived of phlogiſton, by being expoſed to the air, and therefore immediately begins to turn blue, upon coming into contact with the air. On the other hand, the blue ſolution loſes its colour, in the way above mentioned, ſince the alkali more willingly attacks copper but a little dephlogiſticated, than that which is much calcined. The force with which volatile alkali attracts dephlogiſticated copper, promotes the effect of the air.

Volatile alkali detonates with nitre, whence it manifeſtly appears to contain phlogiſton, and that as a proximate principle, which is ſeparated by the calx of mangaueſe, quickſilver, gold, and various other ſubſtances, in conſequence of a ſtronger attraction; and then an elaſtic fluid, of a peculiar nature, is obtained, which probably is the

the other principle: I ſay *probably*, for it has not yet been reduced to volatile alkali by the addition of phlogiſton. Moreover, in this decompoſition it deſerves to be remarked, that no ſigns of vegetable alkali occur, ſince many contend that the volatile originates from the vegetable, intimately combined with phlogiſton.

In the dry way, the attractions of volatile alkali ſeem to differ from thoſe immediately preceding in this, that it may be expelled by fire alone, when united with certain fixed matters; and on this account I have thought proper to exclude them entirely.

XL.

Column Twenty-ninth, Caustic Ponderous Earth.

THE celebrated Margraaf asserts that the base of ponderous spar is calcareous earth, and indeed experiments shew that they agree in various properties; but Dr Gahn and Mr Scheele, by a more particular investigation, detected a great difference between them, and from my experiments it appeared to be still greater. Both agree in effervescing in acids; in losing the aerial acid, when exposed to fire, and thus acquiring solubility in water, and affording a cream in the open air; in rendering alkalis caustic, and in dissolving sulphur, &c. But they differ widely at the same time; for gypsum is lighter, and totally soluble in water, but ponderous earth forms with the vitriolic acid ponder-

ous

ous ſpar, of which the ſpecific gravity is 4,500, and which can ſcarce be at all diſſolved in water; with nitrous and marine acids lime forms only deliqueſcent ſalts, but ponderous earth difficultly ſoluble cryſtals; lime ſaturated with acetous acid affords cryſtals, but ponderous earth an almoſt deliqueſcent ſalt: finally, they differ widely in their attractions, as is evident from the preceding obſervations, and will now be made to appear more clearly.

This earth is but ſparingly ſcattered over the ſurface of the earth, and has hitherto been found only in combination with the vitriolic acid; a combination ſo cloſe that it can ſolely be deſtroyed by the phlogiſton of oils and charcoal, with the aſſiſtance of fire, and then with difficulty. To obtain it pure, it ſhould be afterwards diſſolved in nitrous acid, and precipitated by aerated fixed alkali, which is effected by virtue of a double elective attraction, for it cannot be dislodged by caustic fixed alkali, (XIV.).

Ponderous earth forms, with most acids, salts of difficult solubility. From all, the smallest drop of vitriolic acid immediately throws down ponderous spar in the form of powder; wherefore I know nothing better than a solution of this earth, in acetous or marine acid, for detecting the faintest traces of vitriolic acid, for it takes it from every other basis.

The acid of sugar occupies the next place. If it be dropped into a saturated solution of ponderous earth, in the nitrous or marine acids, it separates, in a few minutes, pellucid crystals, consisting of the earth combined with the acid that was added. The same acid decomposes the compounds formed of

terra

terra ponderoſa, and the acids of amber, of fluor, phoſphorus, of the perlate, and that of ſugar of milk, which are all ſtronger than the marine acid.

The acid of amber comes into the third ſtation; that of fluor into the fourth, for it precipitates ſolutions made by acids of amber, fluor, ſorrel, phoſphorus, of perlate ſalt, nitre or ſea-ſalt; and leſt any one ſhould aſcribe this to the preſence of vitriolic acid, let it be obſerved that this ſediment, when collected and added to vitriolic acid, gives out fluor acid.

The acid of ſorrel expels the phoſphoric and perlate acids, that of ſugar of milk, nitre and ſea-ſalt, and forms a compound ſcarce ſoluble, which come next. The ſtrength of the ſebaceous acid has not yet been determined; in the mean time I have placed it after the marine. The remaining form this ſeries: acid of lemon, tartar, arſenic, ants, milk, benzoin, vinegar, of borax, of vitriol and nitre phlogiſticated, the aerial, and that of Pruſſian blue. The relative ſituation of the firſt mentioned individuals wants confirmation. Acid of arſenic does not viſibly render acetated ponderous earth turbid, but ſeems to form a triple compound; it, however, palpably expels the acid of benzoin.

I CONJECTURE, that, in the dry way, our earth comes next to the fixed alkalis; but I exclude the other earths, ſince the ponderous ſcarce fuſes with them. Beſides, I have ſubjoined fixed alkali, and calx of lead, ſince it enters into fuſion with theſe.

XLI.

XLI.

Column Thirtieth, Lime.

Pure calcareous earth, or lime, in the ſtrict ſenſe of the word, is that which is free from every heterogeneous ſubſtance; but by this appellation I indicate the abſence of acids, eſpecially the aerial. Its attractions are very different from thoſe of ponderous earth. The firſt place belongs to acid of ſugar, which takes lime from every other, (Scheme 14.). To this ſucceeds acid of ſorrel, which decompoſes even gypſum, by attracting its baſis. Vitriolic acid exceeds the nitrous, and the others, (Scheme 16.). Acid of tartar takes lime from that of amber, the phoſphoric, perlate, and the following; and in like manner phoſphoric acid, the perlate, and that of ſugar of milk, from the nitrous, marine, fluor, arſenical, of ants,

ants, milk, lemon, and vinegar. Fluor acid attracts lime more powerfully than that of ants and vinegar ; but is ſcarce ſuperior to the nitrous and marine, unleſs by the aid of water, and a double attraction. Acids of lemon and benzoin exceed vinegar. The arſenical acid does not diſturb formicated and acetated lime, unleſs the ſolution be concentrated. The place of the ſebaceous is ſtill uncertain. The laſt individuals follow the order of the preceding column.

WHAT is ſaid in the preceding paragraph may be applied to the attractions of lime, magneſia, and clay, in the dry way, except that the laſt ſcarce attacks ſulphur.

XLII.

XLII.

Column Thirty-first, Caustic Magnesia.

This salt, which is called in the shops *magnesia alba*, differs in various respects from lime, as I have shewn in a particular essay. I once thought, that this earth attracted acid of fluor most forcibly, and that all others were expelled by it, (Scheme 15.); but the repetition of the experiments gives room to suppose that I was misled by the siliceous sediment: I therefore assign the first place to acid of sugar, and so on as in the column; of which the order is for the most part established by experiments, in the dissertation above mentioned. Some places are, however, uncertain, especially those occupied by the acids of sorrel and lemon. Calcined magnesia is insoluble in water, which

which is a great obſtacle when we are endeavouring to aſcertain attractions.

XLIII.

Column Thirty-ſecond, Pure Clay.

Under this denomination I underſtand earth of alum well purified, for common clay is always more or leſs mixed with the ſiliceous in powder: it contains, however, the real baſis of alum, and thence derives its peculiar properties.

The vitriolic acid attracts clay more powerfully than any other, next the nitrous, and then the marine acid. The order of the reſt is not ſufficiently aſcertained; it is, however, certain, that the acids of fluor, arſenic, ſugar, tartar, and phoſphorus, take clay from the acetous. The determination of the attractions is in this caſe prevented, not only

only by the infolubility of pure clay, as in the cafe of magnefia, but likewife by the obfcure cryftallization or deliquefcence of the compounds, which commonly conceal the decompofition.

XLIV.

Column Thirty-third, Siliceous Earth.

Whilst the vitriolic expels from fluor its proper acid, the furface of the water in the receiver, even in the gentleft heat, is gradually covered with a white powder, which foon forms a cruft. When this is broken, and finks, another is generated, and fo on, as long as any acid of fluor paffes over. This matter, when collected and wafhed, has all the properties of filiceous earth. I collected a parcel, and fent it to Mr Macquer, who affured me that it had all the properties which fi-

liceous

liceous earth ſhews in the focus of a burning glaſs. Now, whence comes this powder? Does it exiſt in the fluor, and is it volatilized by the heat? Or is it extracted from the glaſs? Or is it formed from its principles?

I BY no means deny, that fluor ſometimes contains ſiliceous particles, but they are accidentally preſent; for that of Garpenberg, which I generally uſed in this operation, ſometimes contains not a particle. This, when reduced to the fineſt powder, is totally ſoluble, by a long digeſtion, in aqua regia, which would never happen if it contained flint. Hence, therefore, it is evident, that ſiliceous earth enters the compoſition accidentally, and that the powder collected in the receiver is by no means to be aſcribed to it, ſince no ſuch ſubſtance exiſts in the compound. But perhaps other ſpecimens from Garpenberg are more or leſs mixed ed with it. Glaſs indeed abounds in ſiliceous earth, and is corroded during the proceſs; but as Mr Scheele ſaw the powder appear when metallic veſſels were uſed, I have long thought that in this experiment there was a generation of ſilex. Into a phial of iron or copper, upon which concentrated vitriolic does not act, there was put fluor mineral in powder, with an equal weight of ſtrong vitriolic acid; the cover was then applied, to which were faſtened below ſeveral different bodies, ſome dry, and others wet. The phial was expoſed for ſeveral hours to a gentle heat of digeſtion, and upon opening it all the moiſt ſubſtances were found to be covered with powder, and the dry ones quite free from it. But the fluor uſed in this caſe, without doubt, contained ſiliceous earth; for Mr Meyer has ſince found, by accurate and well conducted experiments, that no ſiliceous powder appears in metallic veſſels

when

when no glaſs is uſed. The fluor with vitriolic acid yielded nothing; but the ſame mixture, in equal quantity, ſet in a metallic veſſel, when glaſs was added to it, ſwelled very much, and a ſiliceous powder was volatilized. The fluor acid, therefore, when reſolved into vapour, ſeizes ſiliceous earth with violence, extracts and retains it till it is abſorbed by water; for upon entering into this new combination, it is forced to depoſit part of the ſilex: the reſt remains diſſolved in the acid liquor, and may be thrown down by alkaline ſalts *. But no other acid is capable of diſſolving ſiliceous earth, not even in the very tender ſtate of a precipitate, from liquor ſilicum †.

Fixed alkalis, eſpecially when cauſtic, diſſolve very fine ſiliceous powder in the

* Opuſc. vol. ii. p. 34.

† *Ibid.* p. 36. and vol. iii. p. 314.

the moiſt way, but far more plentifully in the dry. All the acids, not even the aerial excepted, effect a ſeparation.

Liquor ſilicum is precipitated even by fluor acid; but the powder which falls does not conſiſt of pure ſiliceous earth, for it contains likewiſe fluorated alkali, and thus exhibits a triple ſalt.

Water entirely rejects ſilex in a moderate temperature. I always procure by evaporation a ſmall portion of ſiliceous earth from the water of the Upſal ſprings, notwithſtanding it has paſſed through the filter ſeveral times; but it without doubt is ſo fine, as when once mixed with the water, to be retained by friction; for diviſion increaſes the ſurface, and with it the friction, which at laſt becomes equivalent to the difference of ſpecific gravity.

In the dry way, ſiliceous earth is fuſible with borax, minium, and other proper ſubſtances, but moſt eaſily by fixed alkali.

Some of the moderns reckon *earth of ivory* among the ſimple earths, but improperly, for it is doubtleſs a compound, and, like earth of hartſhorn, contains both aerated and phoſphorated lime.

XLV.

Column Thirty-fourth, Water.

Since ſand in a very attenuated and volatile ſtate preſerves a level, ſo that animals may be drowned in it; ſince pounded gypſum ſet in a kettle over the fire ſeems liquid, not to mention other inſtances, why may not liquids in general be conſidered as ſolid molecules too ſubtile to be perceived by the ſight, however aſſiſted, and on account of their levity, bulk, figure, or by the interpoſition of another fluid, moveable with

with the greateſt eaſe, and affecting an horizontal ſurface? Hence water would ſeem to be nothing but earth kept liquid by heat. It certainly concretes into a ſolid body when the heat is diminiſhed to a determinate degree; but when the heat is increaſed to a certain term, it is reſolved into elaſtic vapours.

Every particle having a certain force of attraction for the principle of heat, forms a little atmoſphere for itſelf. As long as theſe atmoſpheres prevent the particles from coming into contact, the whole remains liquid; when they are enlarged, the diſtances increaſe, and an expanſion takes place, till at laſt the ſuperficial particles are reſolved, by the neceſſary quantity of heat, into elaſtic vapour. At 212° the whole maſs undergoes this change. The vapours then ariſe in great abundance, and produce the agitation of boiling. They exceed the bulk of the water 14,000 times,

 and

and then the vaſt ſurface is able to abſorb a far greater quantity of heat than before; and is it not thus that all evaporation produces cold? On the other hand, the exceſs of heat being gradually diminiſhed by the coolneſs of the air, or in any other way, the bulk of the vapours is contracted, and they are condenſed at laſt into drops of water. If the matter of heat goes on to decreaſe, the particles drawing near to contact loſe their reſpective mobility, and concrete into ice. What is hereafter to be ſaid on the ſubject of ſpecific heat, will farther illuſtrate theſe remarks, (XLVIII.).

SALINE, gummous, and ſpirituous ſubſtances are eſpecially ſoluble in water. In what order the ſalts are taken up, has been hitherto little examined, nor is this an eaſy taſk. Concentrated vitriolic acid takes water from a ſolution of vitriolated vegetable alkali, of alum,

vitriol,

vitriol, corrosive sublimate, and other substances, which it does not decompose, so that they crystallize almost instantaneously. The other acids scarce exert this power perceptibly.

Caustic alkalis likewise attract water strongly, and precipitate various salts which they do not decompose.

Water attracts spirit of wine more forcibly than those salts which are insoluble in spirit of wine, and which therefore may be precipitated by it. This is the case with volatile alkali, which, when thus precipitated, is called *Van Helmont's soap, Sapo Helmontii.*

The elective power of water with respect to neutral and middle salts is hitherto unknown, and has been totally neglected. It is, however, probable, that each is attracted with unequal force, and that one gives way to another.

Æther may in ſome meaſure be ſeparated from ſpirit of wine by water.

XLVI.

Column Thirty-fifth, Vital Air.

A.] The atmoſphere which every where ſurrounds our globe, conſiſts of a pellucid, elaſtic, and apparently homogeneous fluid, which we denote by the name of *common* or *atmoſpheric* air: when more cloſely examined, it is found to contain, beſides vapours which vary wonderfully, according to the diverſity of ſituations and winds, three fluids mixed together, and widely differing in their nature. The greateſt part, which certainly exceeds the others three times or more in bulk, is neither fit for ſupporting fire, nor for reſpiration, probably derives its origin from the vital part,

part, in confequence of fome change not yet certainly known, perhaps proceeding from the addition or fubtraction of phlogifton, and may therefore be called *corrupted* air. That which in England is called *dephlogifticated*, and which I have formerly termed uncombined, good or pure, but now think with the hiftorian of the Parifian Academy, that it fhould be diftinguifhed by the appellation of *vital;* this, I fay, differs widely from the preceding, being not only fit, but indifpenfably neceffary for fire and refpiration, every other air being mephitic. The aerial acid forms the fmalleft part of the atmofphere, fcarce ever amounting to one-fixteenth.

B.] Vital air is found but fparingly mixed with the atmofphere, amounting fcarce to one-fourth of its bulk, feldom or never exceeding one-third, as I have juft intimated. It may, however, be obtained by various means. An ounce of nitre, expoſed to heat in a pneumatic apparatus, affords 500—600 cubic inches of air, far better, eſpecially at firſt, than common air. Nitrous acid poured upon many metals and earths, and then abſtracted to dryneſs, yields firſt nitrous air, if any phlogiſton be preſent, and then more or leſs of vital air. Vitriol of iron, copper, and zinc, and various vitriolated earths, nay, lapis calaminaris, mangancſe, and the calces of the noble metals acquired by precipitation, afford, when expoſed to a due degree of heat, a portion of vital air during their reduction. Hence it may be juſtly concluded, that this air can indeed be obtained without nitrous acid, but that by means of it a much larger quantity is procured, ſo that it is ſcarce to be doubted but that it enters as a principle into the acid, or the acid into it. In the former ſuppoſition, ſomething muſt be removed, which when

when again added to the vital air in proper quantity, muſt impart to it, beſides other properties, a ſtrong acidity. The nature of this is unknown. Nitrous air alone is at leaſt inſufficient, unleſs the exiſtence of phlogiſton be denied, which, however, would be contrary to evident experiments; nor does it ſeem to be the inflammable principle, by which, on other occaſions, all the acids are debilitated, and, when fully ſaturated, are as it were fettered. It ſhould, however, be remembered, that compounds ſometimes have properties not belonging to either of the ingredients. But in the caſe in queſtion, this bare poſſibility is unſupported by any experiment, which ſhews that diſtinct acidity proceeds from phlogiſton. The latter propoſition is countenanced by the following conſiderations. It appears from experiment, that nitrous acid very forcibly attracts phlogiſton, is rendered much

weaker

weaker by it, and at length, by the aid of a certain portion of the matter of heat, acquires an aerial form, being changed into the aeriform nitrous acid: with a greater portion of phlogiſton, nitrous air is formed, containing the acid ſaturated; may not, therefore, a farther addition of phlogiſton or ſpecific fire, as the increaſe of weight ſeems to indicate, or both theſe cauſes, produce a new variation, and may not this be vital air? This opinion is, however, liable to difficulties, which ſhall be mentioned in the ſequel. Meanwhile, granting theſe poſitions, and aſſuming Mr Scheele's hypotheſis, the phænomena accompanying its generation admit of a conſiſtent explanation. We know that the acid as preſent in nitre may be phlogiſticated by fuſion. The coheſion is diminiſhed in proportion to the increaſe of phlogiſton, and by a certain quantity is totally deſtroyed, ſo that it is changed into vital air, and may be expelled

expelled by heat. The acceſſion of phlogiſton is derived from the decompoſition of heat; now, by the ſeparation of one principle, the other which is left uncombined, according to the hypotheſis, is vital air, and which therefore comes from two ſources, compoſition and decompoſition. If theſe things be true, we can eaſily comprehend how it is obtained from nitrous acid, poured upon almoſt any ſubſtance; and alſo how we come to procure a new portion, by adding freſh nitrous acid, when the former portion has been exhauſted. So great is the volatility of this acid, that it eſcapes before it is ſufficiently concentrated to receive phlogiſton; the baſis fixes the acid, and when it contains phlogiſton, contributes, at the beginning of the proceſs, while the heat is moderate, to the production of nitrous air.

THE

The subſtances which furniſh vital air without nitrous acid, contain, for the moſt part, ſome metallic principle, which, when acted upon by a ſtrong fire, decompoſes either their inherent ſpecific heat, or that which flows in through the veſſels. The noble calces ſeem by theſe means to be reduced to a metallic form, without the addition of phlogiſton, even ſuch as neither receive any aerial acid, nor contain any nitrous air, as gold diſſolved in dephlogiſticated muriatic acid, and afterwards precipitated. The ignoble calces of lead, iron, zinc, manganeſe, and perhaps others, are alſo capable of decompoſing heat, but cannot retain a quantity ſufficient for their reduction. Manganeſe does not indeed grow black from the action of heat alone; but by the aſſiſtance of vitriolic acid, it fixes a quantity ſufficient to render it ſoluble. Such phænomena ſometimes, though rarely, occur in the

humid

humid way. Upon minium dephlogisticated, by a long continued calcination, and put into a ſmall retort, let a little more than its bulk of concentrated vitriolic acid be poured; the mixture ſoon grows warm, and acquires a black colour, a phænomenon which is produced by heat alone; then ſome degree of efferveſcence takes place, during which, ſome aerial acid is extricated; but in a minute or two the heat becomes inſupportable to the touch, and at the ſame time there iſſues out with vehemence a white ſmoke, which yields pure vital air: the volatilization of the powder gives it at firſt the appearance of ſmoke. The addition of pulverized glaſs renders minium more penetrable to the vitriolic acid; without this addition, the upper ſtratum of the maſs grows white, while the lower ſtrata ſtill remain black, or are not yet acted upon by the acid; in which caſe, aerial acid is extricated during the whole time of the

the production of any elaſtic fluid. I have treated minium in like manner with the muriatic acid; but in this operation the menſtruum muſt be made to boil. Then aerial acid is extricated, as alſo dephlogiſticated marine acid, and the vital air ſcarcely amounts to one-fourth. I have no doubt of the exiſtence of aerial acid in the minium; but it remains to be tried, whether it be preſent in minium recently prepared. I cannot determine this, ſince it is not made in Sweden. It probably does not unite with the lead during calcination, but is afterwards attracted from the atmoſphere, as happens with regard to lime. But the origin of the vital air is an important enquiry. Some deduce it from the dephlogiſtication of the aerial acid; Mr Scheele from the decompoſition of heat. All minium, hitherto examined, contains a ſmall portion of magneſia nigra, which is capable of decompoſing the matter of of heat, and lead may perhaps have the ſame power. Muriatic acid is more eaſily decompoſed ; and therefore, by employing this menſtruum, we gain but little vital air. Aerated lead, treated in the ſame manner, yields only aerial acid ; but nitrated mercury, calcined to redneſs, and the ſpontaneous ſediment of vitriolated iron, when treated with vitriolic acid, produce nearly the ſame effects as minium. Iron is ſcarce ever without manganeſe, and ſeems itſelf capable of decompoſing heat ; for that which is not magnetic, acquires this property in the crucible without any addition of phlogiſton.

The great ſpecific heat of vital air, which can be ſhewn by proper experiments, renders its origin from nitrous acid, by the addition of phlogiſton, not a little ſuſpicious ; and perhaps future

experiments

experiments will ſhew that it is not the real one.

C.] The relation of vital air to other bodies is now to be conſidered. There is no ſubſtance hitherto known, on which vital air acts more readily and efficaciouſly, than on nitrous air. At the inſtant of contact, the whole maſs almoſt hiſſes, turns red, grows warm, and contracts in bulk. The enquirers into nature are not yet agreed about the cauſe of theſe phænomena. There are two prevailing opinions, of which one will probably prove true. Mr Kirwan has thus explained it *. Phlogiſton is more ſtrongly attracted by vital air than by nitrous acid; wherefore the nitrous air is dephlogiſticated, loſes its nature, and the red vapour of nitrous acid is produced, which water readily abſorbs. But vital air, ſaturated with phlogiſton, forms aerial acid, and

* Phil. Tranſ. 1782.

and with a ſtill larger portion is converted into corrupted air. The bulk is ſometimes diminiſhed to $\frac{3}{100}$, in conſequence of the deſtruction of the nitrous air, and the generation of aerial acid, which being heavier than the vital air, and having leſs ſpecific heat, ought neceſſarily be contracted, and, moreover, may be totally abſorbed by water. The incaleſcence is produced by the deſtruction of the nitrous air, which, as well as the phlogiſticated vital air, parts with a portion of ſpecific heat. This is a very ingenious explanation; but before it can be received as quite ſatisfactory, ſo much aerial acid, as it ſuppoſes, muſt be more preciſely demonſtrated. If I miſtake not, the production of aerial acid is deduced from the precipitation of lime-water, and its quantity from the diminution of bulk. With reſpect to the former concluſion, it is well known that lime-water is manifeſtly rendered turbid by a very ſmall quantity of aerial acid, accidentally mixed with vital air; but the diminution, if it be repeatedly paſſed through recent lime-water, may ariſe from another cauſe, for water abſorbs one-fourteenth of its own bulk of vital air; if, therefore, a ſufficient quantity of water be preſent, the whole diminution may happen in this manner. In Mr Scheele's hypotheſis, the relation of vital to nitrous air is alſo made to conſiſt in the dephlogiſtication of the former; but it is ſaid, that the matter of heat is generated by this combination, which, in the preſent caſe, is not abſorbed by any of the ſurrounding bodies; for the nitrous air changing from fluidity to a liquid ſtate, muſt give out a portion of ſpecific heat, to be diſtributed among the contiguous ſubſtances, and evidently paſſing through glaſs. On what foundation this origin of heat reſts, I ſhall hereafter examine, (XLVIII.).

THE

The inflammable air of metals contains phlogiston almost pure, in an aerial form; yet it neither changes vital air, nor is changed by it, not even when the surface of contact is increased by the accession of external heat; a circumstance which seems ill to agree with what has been just said of nitrous air. But it is to be observed, that the decomposition of nitrous air is the effect of a double attraction; the phlogiston is attracted by vital air, and the acid part by water. Therefore, when the mixture is made in a phial immersed in mercury, the experiment fails. But the contact of flame, or a glowing body, produces a wonderful effect in the mixture of inflammable with vital air; for it takes fire with so much violence, as far to exceed common fire in heat and efficacy, and to dazzle the eyes with the brightness of the light. If the conflagration be performed in a space closed by mercury, as may be done by prudent management, the whole bulk of air is found to have in great meaſure diſappeared after the extinction of the flame, and the cooling of the apparatus. The reſiduum affords corrupted air, ſcarce ever mixed with aerial acid. This diminution is explained, as before, in two ways. It is impoſſible to deny, that a contraction of bulk muſt take place, if vital air be changed, by combination with phlogiſton, into aerial acid, which is heavier, and has leſs ſpecific heat; but the farther change of aerial acid by phlogiſton into corrupted air, a lighter ſubſtance, and therefore neceſſarily occupying a larger ſpace, ſeems ill to agree with the ſmall portion which remains after deflagration, though even the whole of the inflammable air ſhould become fixed.

If we ſuppoſe both airs perfectly pure, this inflammation would ſeem the moſt ſimple of all; for there is no ſuperfluous principle preſent, either to

give

give out any extraneous fluid during the operation, or to yield any reſiduum which greedily abſorbs a portion of the mixture.

Electric ſparks ſeem to come neareſt to this operation; they may be conſidered as ſmall flames changing the vital air which they meet with on the ſurrounding medium, by means of their phlogiſton, either into aerial acid or heat, as muſt be determined by future experiments. Alkaline air is changed by the electrical ſpark into inflammable air of thrice its bulk, which ſufficiently ſhews that theſe ſparks give out phlogiſton in a free and elaſtic ſtate.

In vital air, without the aid of external heat, phoſphorus is conſumed very ſlowly, and ſcarce at all, unleſs water be preſent to forward the decompoſition, by a double attraction. It may be burned by proper management in a glaſs veſſel cloſed with mercury.

The method that beſt ſucceeded with me, was to introduce a ſmall piece into the glaſs veſſel, and ſet fire to it, by applying the flame of a candle externally. This was repeated as long as the bits ſucceſſively introduced could be made to deflagrate. After the apparatus had grown cool, there never remained above one-fourth, often not above one-tenth of air, and ſometimes ſtill leſs; the reſiduum conſiſted of corrupted air, very ſeldom mixed with aerial acid. Here the hypotheſis, concerning the origin of the aerial acid and corrupted air, from the phlogiſtication of the vital, ſeems ſcarce admiſſible. We have in this experiment no uncombined phlogiſton, by conſolidation of which the bulk might be diminiſhed. The difficulty is, however, leſſened, by the abſorbing power of the uncombined phoſphoric acid, of which more will be ſaid hereafter. Sulphur may be burned

in

in the ſame way, and exhibits almoſt the ſame phænomena.

THAT kind of inflammation is moſt complex, which conſumes a body that gives out aerial acid from its own ſubſtance, and at the ſame time yields an abſorbent reſiduum. To this head belongs the combuſtion of pyrophorus, candles, and other animal and vegetable ſubſtances. There can be no inflammation without vital air, whence it may be conſidered as the pabulum of fire; yet the phænomena vary according to the nature of the bodies to be conſumed. It is aſſerted, that in a ſpace limited by mercury, a candle which is left to burn as long as it can, diminiſhes the air little or none; and it is certain that the bulk is found the ſame after cooling, for the conſumed fat yields a quantity of fluid nearly equal to the vital air conſumed by the flame. It is known that oils, when decompofed in clofe veffels by fire, gives out aerial acid.

Hepatic air, dephlogifticated by vital, depofits fulphur but flowly; whereas nitrous air is decompofed at the moment of contact.

Metals, being loaded with phlogifton, cannot but be expofed to the power of vital air. The ignoble ones are decompofed more or lefs quickly, according to circumftances; the noble refift obftinately: however, the pureft gold, when fufed, and fufficiently rarefied by the focus of a lens, is forced to part with fome of its phlogifton *. Mercury, which feems intermediate between the noble and the ignoble, when fufficiently heated, is well and quickly calcined in vital air, but remains unchanged in corrupted air, as Dr Prieftley has found. I have experienced the fame

* Macquer Dict. de Chimie.

ſame thing with that mixture of lead, tin, and biſmuth, which is fuſible in the heat of boiling water. The effects are here alſo explicable from the generation of aerial acid, or the matter of heat. On the former ſuppoſition, a difficulty ariſes from the rejection of aerial acid by many metallic calces, and from the reduction of gold without addition, when it has been diſſolved in dephlogiſticated marine acid, and precipitated by alkali, when the calx is neither contaminated with aerial acid nor nitrous air. By Mr Scheele's ſyſtem, theſe difficulties are avoided, but others occur not eaſily to be obviated by the decompoſition of heat. The calcination of lead by mercury in common air *, which is diminiſhed one-fourth, and yields an aerated calx, is among them; for I have never found in common air a quantity of aerial acid amounting to one-fourth of common air, nor, I believe,

* Mr Kirwan.

lieve, has any one elſe: it remains, however, to be tried, whether the bulk of the aerial acid, when expelled, correſponds to the above-mentioned diminution. The increaſe of weight is aſcribed, with great probability, to aerial acid, when it is preſent; but I can ſcarce doubt that ſomething is contributed by the increaſe of ſpecific heat. Nor is the abſorption of moiſture by a ſpongy maſs, like that in queſtion, always to be neglected.

Besides theſe ſubſtances, many more are undoubtedly changed by the action of vital air, eſpecially thoſe containing phlogiſton; but the mode is unknown.

XLVII.

XLVII.

Column Thirty-ſixth, Phlogiſton.

This very ſubtile matter admits, like the aerial acid, of two ſtates, a ſtate of combination, and freedom. In the former, it enters into the ſtructure of bodies, eludes all our ſenſes, and can only be recogniſed by its effects, for which reaſon ſome have ſuppoſed it to be a fictitious ſubſtance, and totally impalpable, but without juſt reaſon. The two celebrated philoſophers, Prieſtley and Kirwan, have clearly proved its exiſtence, both analytically and ſynthetically, ſo that I think all reaſons for doubting are now removed. This principle, when in combination, and then it is properly called phlogiſton, may be ſet looſe by various methods; having recovered its elaſticity, and gained

gained an aerial form, by a proper increafe of fpecific heat, it receives the name of inflammable air. In the next paragraph, we fhall find data from the analyfis of charcoal for eftimating the weight of phlogifton in inflammable air; a cubic decimal inch of inflammable air is equal in weight to $\frac{63}{1000}$ of an affay pound, and it contains as much phlogifton as two pounds of forged iron, *i. e.* $\frac{5}{100}$ *; therefore $\frac{63-50}{1000}=\frac{13}{1000}$ give the weight of fpecific fire neceffary to the aerial form, of which more will be faid in the next paragraph, (XLVIII. C. E.). I fpeak here only of the inflammable air of metals: that which organic bodies yield, appears to be lefs pure, and efpecially combined intimately with a portion of aerial acid.

Phlogiston is perhaps to be found in all bodies, though in many it is concealed by its exility. The attractions of

* Analyfis Ferri, p. 24.

of the more remarkable combinations into which it enters can alone be examined here; a taſk which is incumbered by no trivial obſtacles. Magneſia nigra, for inſtance, attracts it with ſuch violence as to decompoſe acid of ſalt. It takes this principle from all the metals, but not without the aid of ſome acid; a circumſtance to be carefully noted. Nor does it act with ſo great force, till it has obtained the quantity neceſſary to perfect ſaturation, but only till it has acquired that which is neceſſary to its ſolubility in acids. When this point has been once attained, the complement which effects complete reduction is attracted more feebly than by any other metallic calx. An attraction of this kind, ſtopping at a certain point, takes place in many other metals, though it has hitherto been little examined. Thus, calx of iron, and perhaps of the other ignoble metals, by expoſure to heat, acquires phlogiſton enough to become

come magnetic, but cannot acquire enough for reduction. In general, the reducing portion of phlogifton adheres much more weakly than the coagulating. Thefe attractions are in fome meafure analogous to thofe which acid of tartar exerts upon falts containing vegetable alkali, (XXXVII.). When the doctrine of affinities is brought to perfection, I forefee that it will often be neceffary to adduce the fame fubftance in two or more different ftates. Here the black and white calx of manganefe may be introduced feparately; but the former does not act by its fingle power, for it requires to be affifted by an acid. That, therefore, which is placed in this column is the white.

A PLACE can fcarce be allotted to vital air, as it has fcarce any effect, unlefs it be affifted by a double affinity, or a great degree of heat. We have before fpoken ſpoken of its action on nitrous acid. Either external heat, or ſurrounding moiſture, is neceſſary to the complete decompoſition of phoſphorus.

Calcined mercury is reduced by digeſtion in acid of ſalt; but the cauſe has not yet been ſufficiently explored. As this acid, when dephlogiſticated, attacks the metal itſelf, the calx can ſcarce dephlogiſticate the acid. It remains, therefore, to be examined, whether dephlogiſticated air is produced during digeſtion. According to Mr Scheele's hypotheſis, the decompoſition of heat is ſufficient.

Volatile alkali is dephlogiſticated by magneſia nigra; but the cauſe is complex, depending upon nitrous acid.

Therefore theſe phænomena are at preſent of no uſe in determining the elective attractions; but the following are

are more ſimple, and ſeem adapted to this end.

Nitrous acid decompoſes ſulphur, very ſlowly indeed without boiling; but it ſeparates the principles of muriatic acid in a middle temperature.

Dephlogisticated marine acid does not act upon ſulphur; but it gradually decompoſes white arſenic, and immediately reſolves phoſphorus into a white ſmoke.

Though the precipitation of metallic ſolutions by complete metals is really the conſequence of a double attraction, yet a ſingle attraction would be ſufficient, could phlogiſton be ſupplied in a proper ſtate. The inflammable principle has a different attraction for different calces, and combines with them to ſaturation; after which, the metals fall down in a complete ſtate, and

and cannot be rediſſolved, unleſs the exceſs of phlogiſton be removed. When any other metal whatever is put into a ſolution of gold, the gold is immediately precipitated, not on account of the inferior attraction of the acid, as it has hitherto been univerſally explained, but becauſe phlogiſton more readily unites with the calx of gold, than with the calx of the added metal. That this is the true cauſe, may be ſhewn both by the dry and humid way. With reſpect to the latter, a fine diſcovery, made by Mr Sage, throws great light on the queſtion. He puts into a diluted ſolution of a metal a piece of phoſphorus, which yields its phlogiſton to the metallic calx, and in ſome caſes completely reduces it. The calces of the noble metals, and of copper, thus recover their metallic ſtate*. Though there is here no reciprocal exchange of principles, yet two powers

* Rozier, Journal de Phyſique, 1781.

effect the decompofition. Water alone gradually extracts the acid part of phofphorus, but very flowly, and thus renders the combination of the metallic calx with phlogifton more eafy. We have experiments yet more direct. A folution of acid of arfenic in water is made to acquire a reguline form, by paffing a ftream of inflammable air through it, as Mr Pelletier attefts *. The fame thing happens to fome other metallic folutions. Metallic calces may be reduced by the flame of pure inflammable air; which alfo happens if they are immerfed in this air in clofe veffels, and expofed to the focus of a burning glafs, as Dr Prieftley has found. The air is diminifhed in this operation; but the refiduum retains its former nature, and is juft as fit for contributing to reduction as before. Befides, it is well known, that fome metallic calces may be reduced by

* Journal de Phyfique, 1782.

by fuſion, with the addition of iron or any other proper metal.

The phænomena, therefore, which come under this head, when deduced from their real cauſe, totally invert the ſeries of metallic calces laid down in former tables. Thus, gold riſes from the laſt place to the firſt or ſecond, and zinc is reduced to the loweſt. This holds with reſpect to the reſt, as appears in the table of attractions.

It is certain that the arſenical acid attracts the inflammable principle with greater force than the phoſphoric; for if phoſphorus be put into arſenical acid, the ſurface ſoon grows black in conſequence of reduction.

In the dry way, I have placed the metallic calces according to the order juſt eſtabliſhed. I have placed the acid of arſenic before the calx of ſilver; for this acid expoſed to the action of fire with ſilver, diſſolves a portion of it, which cannot be done without dephlogiſtication. The dephlogiſticating portion is ſublimed in the form of white arſenic; the other immediately diſſolves the calx.

Supposing the matter of heat to conſiſt of phlogiſton and vital air, the place of vital air is between the calx of mercury, which is reduced as well as the noble calces, and the ignoble calces. It cannot, however, be denied, but that theſe alſo are capable of decompoſing part of the heat, though not ſo as to effect a complete reduction.

XLVIII.

XLVIII.

Column Thirty-seventh, the Matter of Heat.

A.] The nature of fire exercifed the genius of philofophers in the earlieft times, nor has the diverfity of opinion yet been reconciled. Nay, it has been made a queftion, *Whether the phænomena which are afcribed to fire are to be deduced from a peculiar matter?* Or, *Whether they depend only on the motion of the particles of bodies?* Now fince all motion, which is excited on our globe, meets with refiftance, and, therefore, when left to itfelf, is progreffively diminifhed, as every day's experience teftifies, it is not eafy to conceive how the motion excited by the production of a fpark, which muft meet with continual retardation, fhould neverthelefs fometimes acquire fuch augmentation as to be able to confume a houfe, nay, a whole city. Here the effect far exceeds the cause. But in this age, almost all philosophers agree, that there is a peculiar matter of fire, which has gravity; exerts an attractive power; possesses other peculiar properties very palpable in various cases, and capable of being accurately determined. I therefore think it superfluous to dwell any longer upon the proof of this position. The nature of this matter is a point much more difficult to be determined, and affords a fine field for the exertion of the greatest abilities. I think there can be no doubt that it ought to be called the matter of heat rather than of fire. Fire is the action of heat when increased to a certain degree, and, therefore, soon passes away after the consumption of the fuel; but the heat continues though it becomes rarefied, and is distributed among other bodies. There is always heat in fire; but all heat is not sufficient for exciting

citing fire: a determinate accumulation is required in every caſe.

Unless, therefore, we ſhould chuſe to invert the uſual mode of ſpeaking, the denomination which I have placed at the head of the paragraph ſeems more ſuitable to the nature of the thing.

B.] The chief opinions now prevailing concerning the matter of heat may be referred to three ſyſtems.

Firſt, Some conſider light itſelf as elementary fire, which every where ſurrounds our planet, in an uncombined ſtate, becoming lucid when in ſufficient motion, and occaſioning different temperatures by its unequal denſity, highly elaſtic, light, ſubtile, and penetrating. Notwithſtanding its wonderful tenuity and mobility, it may be fixed in bodies, and enter into their compoſition as a proximate principle; in which ſtate it is denominated phlogiſton. The great ſimplicity of this hypotheſis recommends it; but it can ſcarce maintain its ground, ſince it has been ſhewn that uncombined phlogiſton is nothing but inflammable air, (XLVII.). Light ſeems moreover to be inferior in tenuity to heat.

Secondly, Others argue, that elementary fire, which in a ſtate of liberty occaſions warmth, is not only different from phlogiſton, but ſo oppoſite that one every where expels the other, at leaſt in part. Air during phlogiſtication gives out much ſpecific fire, which, when free, heats, calcines, cauſes ignition, &c. It is proved, that the very attenuated matter of heat is not equally diſtributed, and in proportion to the bulk of bodies, as Boerhaave affirmed, but that each body, by a peculiar attraction depending upon its nature, acquires

acquires a greater or leſs quantity. If the heat marked by the thermometer is increaſed or diminiſhed in a place where there are ſeveral bodies of the ſame weight, it is diſtributed among them in proportion to their powers; and in like manner, in reſtoring the equilibrium which is diſturbed by a diminution, they exonerate themſelves in proportion to their powers. A body abſorbs more heat in becoming liquid than it contains when ſolid; and there is need of a ſtill greater portion to induce the ſtate of vapour. Animals grow warm by reſpiration, *&c.* not to mention other phænomena which will be related below.

PART of the ſyſtem concerning the increaſe of latent or combined heat, when a ſolid becomes liquid, or a liquid is converted into a fluid, owes its riſe to the illuſtrious Black. It has ſince been cultivated with ſo much ſuc-

ceſs,

cefs, both in England and Sweden, that it now feems to reft on a fure foundation *. The function of refpiration has been particularly illuftrated by Prieftley and Crawford.

The *third* fyftem is that of my fagacious friend Mr Scheele, who thinks that the matter of heat is not fimple, but compounded of phlogifton and vital air, clofely combined, and that light confifts of the matter of heat, with an excefs of phlogifton. His Treatife on Air and Fire will beft fhew how he arrived at thefe conclufions. This hypothefis is not without its difficulties, which I every where mention; it however feems to agree better with experiment than any other, and therefore I have often adapted my explanations to it.

* See Crawford on Animal Heat, Magellan du Feu Elementaire, and Wilcke, in the Stockholm Tranfactions of 1773,—1781.

it. It is by no means neceſſary in this hypotheſis, that the contraction of the bulk of the air ſhould always be aſcribed to the heat paſſing through the glaſs. There is no reaſon why it may not be abſorbed on particular occaſions.

C.] I acknowledge that the new doctrine concerning the diſtribution of heat is well eſtabliſhed in many reſpects; but as it is connected with attractions, it will be proper to explain with greater accuracy in what light I view it.

Let the heat which we can meaſure by the thermometer be called *ſenſible*, and that which is ſo fixed by the attraction of bodies, that it cannot be indicated by the thermometer, *ſpecific*. For the ſake of compariſon, the ſpecific heat of water is expreſſed by unity,

to

to which the ſpecific heat of other bodies of equal weight, and the ſame ſenſible temperature, is referred and expreſſed in numbers *, which indicate the proportion, but not the quantities. Let us ſuppoſe two bodies, *A* and *B*, of the ſame weight, whoſe ſpecific heats are as *a* to *b*; let the ſenſible heat in the vicinity of the bodies be increaſed by the quantity *m*, which is to be divided between *A* and *B*, the former will receive an increaſe $= \frac{a}{a+b}m$, and the latter $= \frac{b}{a+b}m$, ſo that $\frac{a}{a+b}m : \frac{b}{a+b}m :: a : b :: a + \frac{a}{a+b}m \quad b + \frac{b}{a+b}m$. This is alſo the caſe if *m* be ſuppoſed to be negative, or to denote a diminution, for in either caſe ſuch a diſtribution will take

* See Mr Magellan, who has given this theory an elegant mathematical form. The method of determining the ſpecific heats differs from that of Wilcke, but the events agree; a circumſtance which not a little confirms the truth of the doctrine.

take place, that the proportions of fixed heat ſhall remain the ſame.

But the ſpecific heats do not follow the proportions of ſpecific gravity, nor of bulk, but, if I miſtake not, the compound ratio of the peculiar attraction, and the ſurfaces. I do not mean the mere external ſurface, but the internal likewiſe: it is well known that there is no body perfectly ſolid, nay, gold itſelf, the heavieſt of all ſubſtances hitherto known, is perforated with inviſible pores to the amount of one-half of its bulk, as has been rationally conjectured by Newton. Hence we may form ſome judgment of the vacuities of other bodies, ſince they may be at leaſt relatively determined by their ſpecific gravity; but this aſſiſtance is of no uſe in the preſent caſe. Though every other figure affords a larger ſurface, yet let us aſſume ſpherical pores for the ſake of ſimplicity, and the vacuity

cuity of any body reduced to a ſphere of the diameter 10, the internal ſurface will be as the ſquare, that is, as $10 \times 10 = 100$. Suppoſe now this vacant ſpace to be divided into ten equal ſpherules, of which let the diameter, to avoid fractions, be expreſſed by *m*, and the internal will be as $10\,m^2$. If it be divided into an hundred ſpherules, it will be as $100\,n^2$, and ſo we may go on as long as we pleaſe. Thus the internal ſurfaces increaſe as the ſize of the pores decreaſe, and, in the ſame proportion, the ſpecific heats, if I am not miſtaken. As the pores amount always to more than half the bulk, and in moſt inorganic bodies altogether elude the ſight, however aſſiſted, by their minuteneſs, the external ſurface may be neglected as infinitely ſmall, and this perhaps holds concerning the peculiar force of attraction. The internal ſtructure of bodies may indeed be truly compared to a ſponge, though the

the apertures cannot in general be perceived. Now heat penetrates into all the pores of bodies, and when fixed, ſurrounds the ſmalleſt atoms like an atmoſphere, and adheres to them, deprived of its power of exciting warmth. The thickneſs of this ſtratum is increaſed or diminiſhed according to circumſtances. The following are a few inſtances which ſeem to confirm my conjecture, for the nature of the thing forbids us to expect a rigorous demonſtration. The particles of water, in the ſtate of congelation, touching each other at a greater number of points, cohere in conſequence of their attraction. But if a ſufficient quantity of heat penetrates into ice, the particles are gradually ſeparated, regain their little atmoſphere, and recover their mobility. In a ſtronger heat the maſs is dilated by larger atmoſpheres ſurrounding the particles, and their tenuity cannot but be increaſed by them.

Laſtly,

Laftly, in the boiling temperature, every particle is fo much dilated, as to occupy a fpace 14,000 times greater, and fuppofing the form to be fpherical, as is in fome meafure vifible, acquires a furface about 600 times more extenfive. By this expanfion, the contact and the attraction depending on it increafes exceedingly, fo that a remarkable degree of cold is produced in the contiguous bodies, by the quantity of heat neceffary to faturation being collected and fixed.

My opinion is alfo illuftrated by the following facts. Let a thermometer, with a void fpace above the liquor, and with the top clofe, be fupended in the receiver of an air-pump; as foon as the air begins to be rarefied by the ftrokes of the pifton, the liquor of the thermometer will fink, as was firft obferved by Dr Cullen. The defcent is owing to the dilatation of the glafs, in con-

fequence

ſequence of the removal of the external preſſure, for if the point be broken before ſuſpenſion, the level of the liquor will not be changed by the rarefaction of the air. A vacuum does not therefore of itſelf produce cold. But if the globe of the open thermometer be moiſtened, the liquor will deſcend on the rarefaction of the air. The cauſe is to be ſought in the ambient air, for its particles being expanded afford a ſpace wider, and better fitted for abſorbing heat eſpecially from the water on the ball, which repairs its loſs from the glaſs, and is converted into vapour; the glaſs attracts heat from the mercury, which therefore contracts, till the equilibrium be gradually reſtored from the neighbouring bodies. We have then three places filled of the column, at the top of which ſtands the matter of heat; the firſt is occupied by air, the ſecond by glaſs, and the third by the liquid metal. That vapours transfer heat to rarefied air, I conclude from their ſudden condenſation into drops. It is obvious, that evaporation is much forwarded, in this caſe, by the rarefaction of the air. The moiſture is diſſolved by the heat which flows out, and is, therefore, expanded into vapours that are viſible, and productive of cold, as is well known. The air, however, can ſcarce deprive the glaſs of its heat, without the expanſion of the water into vapour, for when rarefied, it acts very ſlowly on the dry globe of the thermometer; abundant moiſture acts more efficaciouſly than when it is in ſmall quantity; nay, in general, the more volatile is the liquor uſed, the lower does the mercury deſcend. Therefore vitriolic æther, highly rectified ſpirit of wine, cauſtic volatile alkali, water and eſſential oils, ſhould, it would ſeem, be placed in the ſeries after air.

I

I HAVE formerly ſhewn that heat is abſorbed during the ſolution of ſalts which acquire a far more extenſive ſurface, and that it is let looſe again by ſudden cryſtallization *. For the ſame reaſon, muriatic air eagerly attracts phlogiſton, (XVI.), not to mention other proofs of efficacy heightened by an increaſe of ſurface. Beyond the ſphere of contact there is ſcarce any attraction, and therefore the area is of more importance than the denſity. For if as much be fixed to a denſe, but ſmall, as to a rare but extenſive ſurface, the elaſticity of the matter to be fixed will be more or leſs reſtrained below the equilibrium prevailing in the contiguous bodies, but the attractive power can ſcarce ſuſtain ſuch compreſſion.

EVERY body has a determinate ſpecific heat, which, however, appears, from

* Opuſc. vol. i.

from experiment, to vary with the ſtate of the body. In the ſolid ſtate it contains leaſt, in the liquid more, and the fluid, in which there is the weakeſt coheſion, has the moſt ſpecific fire. Within the limits of the ſtate of ſolidity, no variation has as yet been obſerved, though without doubt the ſpecific heat ought gradually to increaſe, in proportion to the approximation to liquidity, and *vice verſa.* It can ſcarce be doubted that ſuch variations are perceptible in the ſtate of fluidity.

Does this ſtratum of ſpecific heat, which involves the ſmalleſt particles of a body, in any way affect the weight of the whole? Without doubt this ſubtile matter has gravity, and when it is ſo fixed to the body by attraction, as not to act upon the thermometer, it ought to cauſe an increaſe of weight. In ſolids, indeed, it conſtitutes but an infinitely ſmall augmentation, ſo that the weight

weight cannot be obſerved without great difficulty; but in fluids, in which it abounds more, and bears a greater proportion to the weight of the whole, it ought not to elude the accuracy of our inſtruments. Some experiments of Mr Lavoiſier afford hopes that it may be actually determined *. That very accurate chemiſt burned ſulphur and phoſphorus incloſed in common air by means of mercury; and when the apparatus was grown cold, he found that the acids, when freed from their combination, twice or thrice exceeded the burned materials in weight. Now whence comes this increaſe? Let the table at the end of this paragraph be conſulted, and it will be found that the ſpecific heat of ſulphur, and concentrated vitriolic acid, is as 0, 183 : 0, 758, that is nearly as 1 : 4. But if we conſider, that the ſpecific heat of vitriolic acid increaſes along with the inherent water,

* Mem. de l'Acad. de Paris, 1777.

and that our ufual concentrations leave a confiderable quantity of fuperfluous water, we fhall be obliged to own that the fpecific heat of the vitriolic acid, deprived of all extraneous water, ought to be reduced to 3, and probably ftill lower. Now Mr Lavoifier affirms, that the increments of the acid refidua exactly anfwer to the weight of the vital air loft during the operation; whence, he juftly concludes, that this air has been abforbed by the acid. As the fpecific heat of phofphorus has not yet been determined, a like deduction cannot be made with refpect to it. Meanwhile, thefe experiments, inftituted with a very different view, feem not a little favourable to Mr Scheele's hypothefis. When the vitriolic acid is fet at liberty by the combuftion of fulphur, its fpecific heat ought to be increafed in the proportion of 3 : 1. This increafe is found upon experiment to have taken place. At the fame time,

an

an equal weight of vital air is loſt, and is quickly abſorbed, together with that portion of phlogiſton, which, when combuſtion is otherwiſe performed, generates vitriolic air; for the acid in Mr Lavoiſier's experiments, was without ſmell. The like phænomena occur in the combuſtion of pyrophorus, as the ſame chemiſt has found. Does not then the matter of heat coincide with the combination of vital air and phlogiſton in the preſent caſe? It has not yet been proved, nor is it indeed probable, that the aerial acid is among the principles of the vitriolic; it does not emit pure air, when combined with pure alkalis, unleſs perhaps in conſequence of the decompoſition of heat, but a large quantity of uncombined heat is extricated. Moreover, I think this experiment ſhould be repeated, not only in mercury but in dry air, in order to try whether the vitriolic acid can be obtained dry. It is as yet doubtful, whether the liquid which we find, does not originate in part from extraneous moiſture. A very accurate weighing of the reſiduum likewiſe, without any foreign additaments, may perhaps ſerve to determine the abſolute weight of heat, which promiſes the illuſtration of many obſcurities. Laſtly, we ſee the prepoſterous manner in which the gravity of heat has been hitherto ſought; metals, the heavieſt of all bodies, have been uſed for this purpoſe, though they were of all others the moſt unfit.

The laſt ten years are remarkable, among other things, for the change of many ſubſtances into an aerial form. And it is certain, that the generation of elaſtic fluids is highly worthy of examination. The experiments which have been hitherto made, ſeem to indicate,

1. That

1. That the *ſubſtances liable to this change are the more ſimple,* eſpecially ſalts, both alkaline and acid. We have long known, that the vitriolic, nitrous, muriatic, fluor, and acetous acids, as well as all thoſe of vegetable and animal origin, as alſo the vegetable and volatile alkali, may be brought to the ſtate of air. Theſe, retaining their acid or alkaline nature, are readily abſorbed by water, and ought, therefore, to be collected in veſſels full of mercury. The aerial acid is as yet of obſcure origin. Moreover, ſulphur * may be reſolved into hepatic air; nay, ſiliceous earth, with all its fixity, may be made to aſſume the form of air †. Many more bodies will, doubtleſs, hereafter, be brought to the ſame ſtate. Gold itſelf may be converted into the form of vapour by means of fire; but whether

* Opuſc. vol. ii. pp. 340. 345.

† *Ibid.* vol. iii. p. 397.

whether it can put on that of air, cannot be determined *a priori.*

2. THAT *the principal cause of this transformation is to be sought in the matter of heat,* which subtilizes substances, and gives them elasticity, by loosening their particles. No elastic fluid is found without a large portion of specific heat; nay, phlogiston itself is resolvable by these means into an elastic form. The matter of heat comes in some processes, either from the fire itself, when, for instance, the aerial acid is expelled from chalk, inflammable air from iron by heat alone; or when it is extricated by the vitriolic acid, for in the new combination the acid cannot retain all its specific heat; what is superfluous is extricated, and either totally or in part absorbed by the air that is generated. This will be well illustrated, if we take equal portions of water, and add to the first, caustic vegetable alkali, to the second,

cond, aerated vegetable alkali, and to the third an equal weight of aerated volatile alkali; upon pouring in nitrous acid, a great degree of warmth will arise in the first, a moderate degree in the second, and in the third one still less considerable; nay cold, when the quantities are varied, is produced upon some occasions. The reason is, because, in the first case, the acid in uniting with the caustic alkali gives out its superfluous heat without diminution; in the second, the aerial acid absorbs great part of it; and as, in the third case, more of this acid is extricated, more heat is absorbed, insomuch that the quantity set free being insufficient, the deficiency is supplied from the water of the solution, and sensible cold is generated. On the other hand, in the combination of the aerial acid with caustic alkali, the heat necessary to maintain the aerial form is set loose, and produces a degree of warmth corresponding refponding to its quantity. The other elaftic fluids fhew the fame thing; the contiguous bodies are cooled during their production, and heated when they are fixed.

3. PHLOGISTON appears *likewife to be neceffary*. Thus the acids, as the vitriolic and the nitrous, which in a ftate of purity contain no phlogifton, are refolved by warmth into elaftic vapours, but are condenfed into drops on mere cooling; but, by the addition of phlogifton, afford permanently elaftic fluids: this fubftance is therefore to be confidered as a bond, affixing the neceffary quantity of heat. The fame thing holds with refpect to hepatic air, which cannot be obtained from fulphur, without the addition of phlogifton. But the acids which always contain phlogifton, as the muriatic, that of fluor, thofe procured from the vegetable and animal kingdom,

kingdom, need nothing but heat to put on an aerial form.

4. Moreover, *the different quantity of phlogiſton occaſions a great change.* In nitrous air extricated from different metals, there is ſome variation; that which ſurrounds iron filings in a cloſe veſſel, is by degrees ſo much corrected that it not only does not extinguiſh flame, but even dilates it.

In this ſtate, it is called by ſome *dephlogiſticated*, with what propriety I can ſcarce perceive, ſince the filings are at the ſame time calcined, which clearly ſhews a loſs of phlogiſton. Beſides, this experiment ſeems to coincide with that hypotheſis which derives vital air from nitrous acid ſufficiently phlogiſticated. The electric ſpark taken in alkaline air, produces inflammable air, either by tranſmuting part of it, or, as it ſeems, by ſetting free the combined phlogiſton,

phlogiston, and furnishing the necessary specific heat; for the bulk is much augmented. Other instances of variation arise from the diminution of phlogiston: such is that elastic fluid which is called *dephlogisticated sea salt*. To this head we may also refer that air which is procured from nitrated volatile alkali, digested with magnesia nigra, and which resembles corrupted air. The power of magnesia nigra in dephlogisticating other substances is well known. That which is generated by the explosion of fulminating gold, in which some degree of dephlogistication certainly takes place, is of the same nature *.

Although the quantity of phlogiston in various bodies should decrease, as the specific fire increases, I would be far from deducing from this circumstance any mutual repulsion. The augmentations and diminutions compared together do not warrant such a conclusion;

* Opusc. vol. ii. pp. 161, 162.

ſion; and ſpirit of wine, a ſubſtance abounding in phlogiſton, has a greater quantity of ſpecific heat than water, not to mention other arguments.

Before I leave the genealogy of aeriform fluids, I muſt explain what I mean by the phraſe *aerial form.* I underſtand by this term ſuch a ſubtilization of a body as renders it elaſtic, pellucid, inviſible, light and permanent in cold, though not capable of paſſing through the pores of glaſs. *Vapours* which conſtitute imperfect kinds of air, are condenſed by refrigeration. On the other hand, we have elaſtic fluids, which may be not improperly ſtyled *æthereal;* to ſuch, neither the pores of glaſs, nor of any other known body, are impenetrable. To theſe belong the matter of heat, and the magnetic fluid. The electrical fluid eaſily penetrates all bodies, except electrics *per ſe.* Moreover, light ſeems to be ſomething intermediate

mediate between aerial and æthereal ſubſtances; for it paſſes through the pores of glaſs, but not thoſe of metals and other opaque ſubſtances.

Hence the neceſſity of determining the weight of the ſpecific heat, in the analyſis of aeriform fluids, plainly appears. With reſpect to inflammable air, I have before offered a ſketch; and I truſt that Mr Kirwan, who has ſo ſucceſsfully engaged in this taſk, will not neglect this important part, ſince the analyſis will be otherwiſe imperfect; and when it is once known, their nature and origin will be wonderfully illuſtrated.

Here follows a table of ſpecific, as far as they have been hitherto inveſtigated. I thought it proper to diſpoſe them according to the three ſtates of ſolidity, liquidity, and fluidity. The ſpecific heat of water is denoted by

unity.

unity. Water heated to 130 degrees melts an equal weight of ſnow; but the water thus brought to a liquid ſtate is at the point of congelation. It would certainly be worth while to weigh, with the utmoſt exactneſs, a piece of ice in a perfectly cloſe veſſel, and to repeat the operation after it was melted. The ſtopple muſt fit, in the moſt accurate manner, leſt any thing ſhould be loſt in conſequence of evaporation. This experiment has not yet, as far as I know, been performed with proper care and accuracy; it may, however, aſcertain, in ſome meaſure, the abſolute weight of a quantity of the principle of heat correſponding to 130 degrees.

SOLIDS.

	Spec. grav.	Spec. heat.
Aerated volatile alkali,		1,851
Swedish glass, -	2,386	0,187
Flint glass, - -		0,174
Agate, - -	2,648	0,195
Ice, - -		0,900
Sulphur, - -		0,183
Gold, - -	19,040	0,050
Silver, - -	10,001	0,082
Mercury, - -	13,300	0,033
Lead, - -	11,456	0,042
Copper, - -	8,784	0,114
Iron, - -	7,876	0,126
Tin, - -	7,380	0,060
Bismuth, - -	9,861	0,043
Antimony, - -	6,107	0,063
Brass, - -	8,356	0,116
Calcined lead, -		0,068
Calcined iron, -		0,320
Calcined tin, -		0,096
A mixture of lead and tin calcined, -		0,102

Diaphoretic

	Spec. grav.	*Spec. heat.*
Diaphoretic antimony washed, -		0,220

L I Q U I D S.

	Spec. grav.	*Spec. heat.*
Pure water, - -	1,000	1,000
Clear vitriolic acid,	1,885	0,758
Dark coloured vitriolic acid, - -	1,872	0,429
Pale nitrous acid, -		0,844
Red and smoking,	1,355	0,576
Smoking muriatic acid,	1,122	0,680
Red wine vinegar, -		0,387
Concentrated distilled vinegar, - -		0,103
Alkali of tartar by deliquescence, -	1,346	0,759
Caustic volatile alkali,	0,997	0,708
Of vitriolated fossil alkali 1 part, in of water p. 2. 9. -		0,728

	Spec. grav.	*Spec. heat.*
Of nitrated vegetable alkali, p. 8. - -		0,646
Of muriated foſſil alkali, p. 8. - -		0,832
Of muriated volatile alkali, p. 1. 5. -		0,798
Of depurated tartar, p. 237. 3. - -		0,765
Of vitriolated magneſia, p. 2. - -		0,844
Of vitriolated clay, p. 4. 45. - -		0,649
Of vitriolated iron, p. 2. 5.		0,734
Brown ſugar diſſolved,		1,086
Oil of olives, - -		0,710
—— linſeed, -		0,528
—— whale, (ſpermaceti)		0,399
—— turpentine, -		0,472
Rectified ſpirit of wine,	0,783	1,086
Volatile liver of ſulphur,	0,818	0,994

FLUIDS.

F L U I D S.

	Spec. grav.	Spec. heat.
Vital air, -	000,132	87,000
Atmoſpheric, -	000,125	18,000
Aerial acid, -	000,181	0,270

I HAVE been informed by Mr Kirwan, in a letter, that Dr Crawford found the ſpecific heat in equal bulks of inflammable and atmoſpheric air equal. Admitting this, if the ſpecies of air in Mr Kirwan's table, publiſhed by Mr Magellan, are eſtimated by weight, the ſpecific heat of inflammable air will be 281, which is more than triple of that of vital air.

D.] The theory of the diſtribution being now in ſome meaſure explained, it is proper to conſider the origin of fire in *inorganic* bodies, its propagation, and the confequences.

Fire is fuch an accumulation of heat that the bodies expofed to it become ignited or inflamed. The chief means of exciting it are:

1. The ftriking of flint or pyrites againft fteel, by which the abraded globules are ignited, fufed and calcined.

2. The forging of iron, which is brought to ignition by repeated ftrokes of the hammer.

3. The mixing of fulphur and fteel filings, which, with a proper degree of moifture, grow warm, and burft afterwards into flame.

4. Adding the fmoking nitrous acid in a proper manner to oils.

5. Pyrophorus grows red hot in atmoſpheric air, and produces flame in vital air *.

In all theſe caſes, there is no heat produced without vital air, which alſo, according to circumſtances, is more or leſs diminiſhed. Phlogiſton is likewiſe preſent in them all. The late Engliſh philoſophers contend, that the diſengaged phlogiſton unites with vital air, and forms aerial acid, or when in a larger proportion corrupted air, by which change, a great quantity of ſpecific heat is neceſſarily ſet looſe, and being accumulated, produces ignition, and even flame when inflammable air is preſent. Scheele contends, that vital air may be totally changed by phlogiſton into the matter of heat. Both

* Mr Kirwan has lately informed me by letter that there is a certain kind of earth found in Derbyſhire which takes fire in a ſhort time, on the addition of linſeed oil. I have not as yet ſeen this earth.

opinions are ſupported by ſtrong arguments. It is, therefore, of great importance, that the nature of the combination of phlogiſton and vital air ſhould be demonſtrated. Mr Kirwan thinks the aerial acid is the product; and by his ſagacity, has been able to render this opinion very probable: there is, however, ſtill room for ſome doubts; when theſe have been removed, the ſyſtem of Scheele will ſcarce be tenable. It is probable, that, in the two firſt caſes, a part of the ſpecific heat is expreſſed by the compreſſion of the pores, and accumulated when the dephlogiſticating temperature commences, and is afterwards increaſed by the ſurrounding air. The ignition or inflammation of inorganic bodies is propagated to others that are capable of it, by contact or vicinity. All bodies may be ignited; a few only can be inflamed; ſuch are ſulphur, phoſphorus, inflammable

inflammable air, arſenic, zinc, and ſome others.

The conſequences of ignition or deflagration vary according to the diverſity of bodies, and the degrees of fire. The accumulation of heat cauſes expanſion, dries, liquefies, makes bodies red hot, expels ſuch as are volatile, indurates, inflames, volatilizes, calcines, vitrifies, reduces. The reſidua abſorb a quantity of heat ſuitable to their nature, as is very evident from pyrophorus, which deſtroys, during its ignition, nearly $\frac{3}{4}$ of atmoſpheric air, whereas other mediums ſcarce diminiſh it by $\frac{1}{5}$: in vital air it takes flame, and nearly $\frac{143}{144}$ diſappear *. The cauſe is to be ſought in the hepar which is contained in pyrophorus, and in the decompoſition of the ſulphur, in conſequence of which the vitriolic acid is laid bare, and muſt neceſſarily be furniſhed with its portion

* Lavoiſier, l. c.

portion of ſpecific heat *. Some reſidua are of an acid nature and deliqueſcent. Others are found in the form of calces, aſhes, ſaline or reſinous compounds.

E.] *Vegetables*, though they yield the greateſt quantity of combuſtible matter in our globe, and eaſily propagate fire once lighted, generate it themſelves but very ſlowly. To produce it by friction, there is required wood, hard, dry, and penetrated with much inflammable matter, and even, in theſe circumſtances, the operation is a trial of patience. It is ſaid, that fire has often ariſen from the accumulation of graſs not ſufficiently dried, but no one yet, as far as I know, has examined theſe phænomena with due care.

When dry wood is expoſed to fire, it grows warm and expands; the humidity, which is generally acid, is reſolved into

* See the ſubdiviſion marked C.

into vapour; the phlogiston is disposed to be driven off, and then is attracted, partly by the surrounding vital air, and is partly disengaged with the requisite specific heat in the form of inflammable air, and, in the same instant, is set on fire and produces flame. Thus, the whole fabric of the wood is gradually destroyed, and, in the mean time, more or less smoke is emitted, by which the soot is deposited. Fire cannot subsist without vital air. Hence, when it is lighted, an afflux of air in a continual stream takes place, which rises loaded with phlogiston, and rarefied by warmth, carrying along with it carbonaceous particles not sufficiently burned; which particles are loaded with fixed vegetable as well as volatile alkali, and with earth and sal ammoniac. I have asserted, that the particles not sufficiently burned, generate soot; for the furnace, which has the name of

ακάπνος,

ἀκάπνος, totally deſtroys the ſmoke which is brought through the fire-place.

When the inflammable air, and, of courſe, the flame fail, the conflagration is diminiſhed, and nothing but charcoal and aſhes remain. In a cloſe veſſel the charcoal amounts to one-fourth, ſeldom to one-fifth of the weight of the wood; but in the open air, great part of the charcoal is reſolved into aſhes. This is effected by a double attraction; the vital air ſolicits the phlogiſton, while the alkali and alkaline earth attract the aerial acid. In a cloſe veſſel charcoal reſiſts the moſt intenſe fire. This ſubſtance is nothing but a combination of phlogiſton and aerial acid, a ſpecies of ſulphur which is found intimately combined with cauſtic alkali and alkaline earth, and hence it approaches, in ſome meaſure, to the nature of hepar. By combuſtion in the open air, 100 parts of charcoal contain

contain about 6 of aſhes ; of theſe $\frac{1}{900}$ conſiſts of alkali, the reſt of earth, in great meaſure alkaline. I have particularly examined well burned charcoal made of the pinus ſylveſtris of Linnæus. Of this 1 part, during detonation, alkalizes 3 of nitre, hence the phlogiſton it contains, is, in compariſon of that contained in forged iron, as 3 to $\frac{1}{2}$ *. Upon 100 parts reduced to powder, I poured concentrated vitriolic acid, then diſtilled to dryneſs, and, in a pneumatic apparatus, collected about 82 cubic inches of aerial acid, of which each is equal in weight to a docimaſtic pound. If then we add 3, which nearly correſpond to 6, the parts of the aerated aſhes, there remain 15, which give the weight of phlogiſton. No veſtiges of vital air appear. The proportion of the principles varies according to the diverſity of the wood, age, exſiccation, and

* Analyſis ferri, pp. 51, 52.

and combuſtion. Meanwhile, it appears from preceding obſervations, that 1 part of phlogiſton can fix nearly $5\frac{1}{2}$ of aerial acid. The ſpecific heat of wood is a little greater than the ſpecific heat of charcoal, of equal weight.

MOREOVER charcoal has a peculiar attraction for elaſtic fluids. Ignited charcoal abſorbs, during refrigeration, about 6 times its own bulk of any kind of air. If the hot coal be cooled in quickſilver, or in a void ſpace, it nevertheleſs retains this power of abſorption, and, when immerſed in air, exerts it inſtantaneouſly, as the celebrated Fontana has obſerved. This air is expelled by water or any other liquid.

THE parts of animals are, in like manner, conſumed and converted into charcoal, which, however, ſeems to abound more in phlogiſton, and to retain it more obſtinately. I have not yet

yet attempted to analyſe it. Soot from animal ſubſtances generally abounds more in volatile alkali and ſal ammoniac, than that obtained from vegetables. The ſmell of the ſmoke is exceedingly offenſive.

F.] In animals with hot blood, we find a ſenſible temperature ſuperior to that of the atmoſphere, which is alſo conſtant and permanent, though the ſurrounding medium, from its greater coolneſs, ought to abſorb the difference, as happens in the caſe of other bodies. This phænomenon indicates a cauſe perpetually in action, which, in this age, has been ſought by many, but ſeems to have been moſt ſucceſſively inveſtigated by Dr Crawford. Many conſiderations tend to ſhew, that animal heat is generated in the lungs. The larger theſe are, the hotter are the animals. Hence birds exceed animals in this reſpect. Reſpiration is accelerated by a more violent motion than ufual, and the heat is at the fame time increafed, an effect to be afcribed to the quantity of air refpired, and by no means to friction in a body full of liquids. Animals without lungs have their temperature depending on that of the medium in which they live; to us they feel cold, not to adduce any more proofs of the efficacy of the air. But the manner in which the effect is produced, is connected with the prefent enquiry. Dr Prieftley contends that common air ferves to carry off the fuperfluous phlogifton of the body. Dr Crawford afterwards embraced this opinion, and has admirably illuftrated the whole procefs. Having not yet feen his pamphlet, I have borrowed my idea of his fyftem from Mr Magellan's effay. The fpecific heat of common air is to that of aerial acid, as 69 : 1, fo that if thefe two fluids were to receive an addition of heat of one de-

gree

gree, the former would fix 69 times more than the latter. Now we know, from the obſervations made at Peterſburgh, that the mercury may deſcend at leaſt 111 degrees of the Swediſh thermometer, below the mean temperature. Therefore, if the common air was to be changed into aerial acid, $69 \times 111 = 7659$ degrees of heat muſt be ſet free, *i. e.* 13 times more than is neceſſary to turn iron red hot. Now, as common air is phlogiſticated in the lungs, and converted into aerial acid, we may hence form ſome judgment of the quantity of heat, which is ſet free by reſpiration, and may ſerve to warm the body. Beſides, as the ſpecific heat of the arterial blood is to that of the venous, as 100 : 89, the author thinks it evident, that phlogiſton is gradually accumulated in the veins, and exonerated in the lungs,

 that

that the blood may be rendered capable of receiving the due ſpecific heat.

All this is pretty conſiſtent, and highly ingenious: but that all the fundamental parts of this theory, which are certainly not improbable, may be further illuſtrated by new experiments, I ſhall add a few remarks.

1. It remains to be aſcertained, whether animals or vegetables contain moſt phlogiſton. I know no experiment which decides this queſtion, and it ſeems indeed very difficult of ſolution, for the problem is, not concerning this or that particular part, but to compare the whole body of an animal with a vegetable of the ſame weight. If we conſider our food, conſiſting entirely of organiſed bodies, we ſhall find that they have been for ſome time dead, before they appear on our tables, often long before; and there can be no

doubt,

doubt, but more or leſs of phlogiſton is extricated during the interval. Next the operations of cookery diſſipate a conſiderable quantity, nor can we be certain that this is compenſated by the ſauces. The flatulency that is expelled from the belly, is inflammable, and the ſolid excretions are well known to abound with phlogiſton. Beſides, a great quantity of phlogiſton ſeems to be requiſite for the purpoſes of the animal œconomy at all times, and in every part of the ſyſtem, and I confeſs that I know not whether that which is taken in with the ingeſta is ſufficient. Still leſs can I be certain that there is any ſuperfluity to be carried off.

2. Experiment ſhews a greater ſpecific heat in the arterial than the venous blood. Let us grant that the acceſſion of phlogiſton often leſſens the ſpecific fire, it by no means follows that

 phlogiſton

phlogiſton is the agent in the preſent caſe. We have other means of bringing about the ſame diminution. Thus the pureſt vitriolic acid, added to water, excites a great heat. The water combined with the acid cannot retain all its former ſpecific heat, wherefore the ſuperfluous part is ſet free, and that without the aid of phlogiſton. While the blood is circulating, various changes may diminiſh the ſpecific heat, which indeed ſeems neceſſary, that the parts at a diſtance from the heart, may continually receive ſome heat.

3. I KNOW no experiment which directly ſhews that the blood imparts phlogiſton to the air. The air is indeed corrupted, but that this can only be effected by phlogiſton, is a mere ſuppoſition. On the contrary, by the contact of blood, nitrous air is dephlogiſticated,

dephlogiſticated, and atmoſpheric air is meliorated *.

4. THAT the expired air contains a portion of aerial acid cannot be doubted, but I think that the quantity requires to be determined more accurately. If all that is good is converted into this acid, 1000 cubic inches of atmoſpheric air, of which one $\frac{1}{3}$ is vital, ought, according to the analyſis of Mr Kirwan, to be condenſed to the bulk of about 926, *i. e.* $\frac{1}{14}$ ſhould diſappear, and of vital air, 1000 ſhould be reduced by reſpiration to 863, *i. e.* they ſhould be diminiſhed by $\frac{1}{3}$, if they can be inhaled by the lungs till they are totally corrupted. Suppoſing that aerial acid is further changed into corrupted air, a ſmaller contraction may be expected.

BUT the doctrine concerning the origin of animal heat, is reducible to the

* Dr Prieſtley.

fundamental queftion, concerning the change of vital air into aerial acid, and of this into corrupted air; an opinion which every day feems to receive confirmation. Mr Kirwan has lately communicated to me a new experiment of great importance, made by Dr Prieftley: That calx of mercury, which is commonly called precipitate *per fe*, and which, when expofed to fire, yields pure vital air, afforded but $\frac{1}{6}$ of vital air on the addition of iron filings, and $\frac{5}{6}$ of aerial acid. If the filings had fuffered no degree of calcination, this refult feems to decide the queftion. Meanwhile, I rejoice, that it is reduced to fuch a ftate, that we cannot long remain uncertain.

XLIX.

XLIX.

Column Thirty-eighth, Sulphur.

SULPHUR prefers fixed alkalis to earths; on which account, hepar made with lime, and diſſolved in water, is decompoſed by alkali, and a ſaline hepar is formed. Between vegetable and mineral alkali no difference in this reſpect has yet been obſerved. The power likewiſe of ponderous earth has not been aſcertained; it probably yields to fixed alkali, for volatile alkali, both cauſtic and aerated, precipitates hepar made with lime, when diſſolved in a ſmall quantity of water, and ſeparates the calcareous earth. Let magneſia alba be put into a phial with flowers of ſulphur, and diſtilled water; let the phial be cloſely ſtopped, and then digeſted a few hours in a water bath; when it is afterwards cooled, it will yield a weak ſolution, emitting an hepatic ſmell, and turning black on the addition of nitrated ſilver, or acetated lead.

Volatile hepar, obtained from ſulphur diſtilled with ſal ammoniac and lime, is very ſoon decompoſed in the open air, ſince pure volatile alkali attracts the aerial acid in preference to ſulphur. That this alkali is ſuperior to earths, appears from what has been ſaid above. It is well known, that mercury and arſenic take ſulphur from it, for theſe metals, and even their calces, when added to the volatile hepar, are mineralized in the moiſt way; the former yielding cinnabar, and the latter red arſenic. It is probable, that this is true of other calcined metals. Hence it appears, that the calces of metals may be combined with ſulphur, a truth which ochre of iron ſhews clearly and directly; for by being mixed with ſulphur, it yields effloreſcent vitriol: the operation

operation may be forwarded by moiſt-ening the mixture. It has been elſe-where ſhewn *, that calx of antimony can take up ſulphur. Nay, the calces of lead, tin, and ſilver, when added to ſaline hepar, ſeem to take ſulphur from vegetable alkali.

It now ſeems no longer doubtful, where the oils ſhould ſtand in columns 26 and 27; for I have obſerved, that a drop of oil, added to either ſaline or earthy hepar, produces white coagula, reſembling ſoap. This matter is alſo ſoluble in ſpirit of wine, and the oil may be precipitated from ſuch a ſoluti-on by water. But it is as yet undeter-mined in what order ſulphur attracts the oils.

In the dry way, alkali occupies the firſt place; then follow the metals, of which the reſpective ſtation is to be aſcertained

* De antim. ſulphur. p. 177.

afcertained by their mutual precipitations; but as diftinct reguli are feldom obtained by thefe means, the operation ought to be frequently repeated, that the truth may be fully determined: the places of nickle and of cobalt are as yet uncertain. Gold, platina, zinc, and perhaps manganefe, refufe to unite with fulphur, unlefs they be conjoined with fome proper additament.

L.

Column Thirty-ninth, Saline Hepar.

SALINE liver of fulphur has no place here, except in thofe cafes in which it fuffers no decompofition. It diffolves and retains almoft all the metals, zinc alone excepted; but no one has afcertained with what force it attracts them, and whether they can be mutually precipitated in the dry way. They

can

can ſeldom be combined without fuſion; but when the combination is once formed, it is ſoluble in water. Mercury, however, and antimony, are diſſolved in the moiſt way, with the aſſiſtance of heat, which has not yet been aſcertained with reſpect to any other.

Hepar diſſolves charcoal both in the dry and moiſt way; the ſolution is of a green colour.

In the dry way, the metals precipitate one another more diſtinctly than when combined with ſulphur; the operations ſhould be repeated oftener than once, that we may be quite certain of the concluſions; and though I have ſeveral times made ſuch experiments, I have not yet attained ſo much certainty as I could have wiſhed. Meanwhile, I follow the order which my experiments have ſuggeſted; I leave it to be be confirmed or corrected by future trials.

Manganese ſeems to have the ſame attractive force as iron; at leaſt I have not yet been able to ſeparate them by means of hepar. Next follow, iron, copper, tin, lead, ſilver, gold, antimony, cobalt, nickle, biſmuth, mercury, and arſenic. The places of the two laſt particularly are doubtful; nor are thoſe of gold and antimony ſatisfactorily ſettled.

LI.

Column Fortieth, Spirit of Wine.

I here ſuppoſe the ſpirit deprived, as much as poſſible, of ſuperfluous water; that I mean which does not enter into its compoſition. It attracts water very forcibly,

forcibly, insomuch that æther dissolved in it is separated, at least in great measure. Essential oils seem to adhere to it with less force than æther. It takes up pure alkalis, and hepar, but the order is as yet unsettled. The Count de Lauraguais has shewn how the vapours of sulphur may be dissolved in spirit of wine.

LII.

Column Forty-first, Æther.

THIS, as it were, intermediate substance between spirit of wine and essential oils, forcibly attracts spirit of wine, essential and unctuous oils. I cannot yet establish with certainty the superior force of either of the first mentioned substances. Such is its subtilty, that it dissolves the elastic resin, which, as well

well as ſulphur, may be precipitated by water.

LIII.

Column Forty-ſecond, Eſſential Oil.

These oils take up æther, ſpirit of wine, and ſulphur, but the ſeries has not been ſufficiently examined; nor can this eaſily be done, ſince they do not precipitate each other, but form triple compounds.

LIV.

Column Forty-third, Unctuous Oil.

Five ſubſtances occur here, but their places, if we except the laſt, are not clearly fixed. Some acids take up empyreumatic vegetable oils. Spirit of tartar,

tartar, as it is called, abſorbs no ſmall portion of oil of tartar ; and therefore, at the concluſion of the diſtillation, they ſhould be ſeparated, otherwiſe the oil will be ſenſibly diminiſhed by the acid. Vinegar has likewiſe this power.

LV.

Column Forty-fourth, Gold.

I HAVE already ſeveral times noticed the difference between the noble and ignoble metals. The king of metals, to ſpeak with the ancients, is directly attacked by dephlogiſticated muriatic acid, (XVII.) by aqua regia, (XVIII.) and nitrous acid, (XIV.) ; but the other acids, being deficient in power to carry off the neceſſary quantity of phlogiſton, do not take it up, unleſs it has been precipitated from ſome one of the three juſt mentioned. That a precipitate procured

procured by alkali is a true calx of gold, is evident from the want of brilliancy, its ſolubility in aqua regia without producing red fumes, its power of tinging glaſs, &c. The calx is diſſolved by the acids of vitriol, arſenic, fluor, tartar, phoſphorus, fat, and above all, by the acid of ſea-ſalt in its entire ſtate; but the ſeries remains to be aſcertained. The acid of ants has not this power, at leaſt it does not turn yellow; the calx, however, ſoon grows black, but is not reduced, ſince it is taken up by muriatic acid. The ſame thing is true of vinegar; but inſtead of a black colour, an obſcure purple is produced. The acid of Pruſſian blue, ſaturated with calcareous earth, precipitates gold from aqua regia, in the form of white powder; but when too much is added, it diſſolves the ſediment. The powder of gold precipitated by alkali, in like manner grows white,

when

when put into the acid of Pruſſian blue.

Æther takes gold from all the acids. It alſo directly diſſolves the calx, leaving gold itſelf, however minutely divided, quite untouched.

Calcined gold ſeems moreover to be ſoluble in alkali; for when it is added to a ſolution of gold, ſo as to exceed the point of ſaturation, there ſtill remains in the ſolution enough of the metal to produce a diſtinct yellow colour.

In the dry way, gold combines with all the metals; but in what order they are to be placed, can ſcarce be diſcovered, ſince three and more eaſily unite without the excluſion of any one, (VIII.). I have, however, placed thoſe uppermoſt to which it ſeems moſt willingly, and thoſe below to which it ſeems more re-

 luctantly

luctantly to unite. The ſame thing holds with reſpect to moſt other metals, concerning which let this admonition ſuffice.

Gold is ſoluble in ſaline hepar, though it rejects ſulphur.

LVI.

Column Forty-fifth, Platina.

What has been juſt ſaid of gold, is applicable in great meaſure to platina, which, however, in the ſtate of a precipitate, is ſoluble in more acids, as in that of ſugar, ſorrel, lemon, ants, and in vinegar. The acid of Pruſſian blue ſeems to have no power either as a precipitant or a ſolvent.

That platina is always contaminated with iron, in my opinion, indicates nothing

nothing but the preſence of both metals in the places where platina is found. He alſo who ſhall conſider the great difficulty with which platina is fuſed, will not wonder that the alloy is defended by it ſo as ſcarce to be ſeparable. This is ſtrongly confirmed by the precipitate of platina from aqua regia by ſal ammoniac, which ſhews no veſtiges of iron, when it is well fuſed in microcoſmic ſalt *. It ſeems moſt probable that the magnetic power of the inherent iron is acquired by the triture in the iron mould, while the gold is amalgamated; it is at leaſt by this means contaminated with quickſilver. Scarce any platina is brought to Europe, which has not firſt undergone this operation. Gold mixed with iron in ſuch a proportion as to equal platina in ſpecific gravity, totally differs from it.

* Opuſc. vol. ii. p. 179.—181.

The experiments of the celebrated Dr Lewis ſeem to indicate that platina is in ſome degree attacked by liver of ſulphur.

LVII.

Column Forty-ſixth, Silver.

Muriatic acid attracts ſilver more ſtrongly than any other, and takes it from all the reſt. The acid of fat, however, ſeems to equal it. It is probable that the acid of Pruſſian blue is ſuperior to none but the aerial. By the former ſaturated with lime, ſilver is precipitated from vitriolic and nitrous acid, in the form of a white powder, but is rediſſolved when too much is added. The acid of ſugar ſeems to come next that of fat, for it decompoſes lunar vitriol by attracting its metallic baſis: nitrated ſilver is precipitated by the vitriolic

vitriolic acid, by that of ſugar of milk, and likewiſe by the arſenical acid, but ſo imperfectly that it ſhould, in appearance, be placed after that of nitre. The places of the following acids are leſs certainly determined. Silver precipitated by cryſtallized alkali is ſoluble in aerial acid, which may again be expelled by fire; aerated ſilver, however, is not taken up by water. Vitriolated ſilver is not precipitated by aerial acid, unleſs it contain a mixture of muriatic acid.

PURE volatile alkali diſſolves calcined ſilver, and the ſolution will afford cryſtals. There is a new claſs of ſalts, conſiſting of metals diſſolved in alkalis, highly worthy of attention, though they have as yet been but little, or not at all, examined.

LVIII.

Column Forty-feventh, Mercury.

Mercury, in point of fufibility, conftitutes one extreme among the metals, and platina the other. The former requires only fuch a degree of heat as is rarely wanting in our atmofphere, but when the cold is increafed by art to the temperature denoted by 40° of the Swedifh thermometer, this metal likewife begins to concrete, and, in due time, becomes quite hard. Dr Pallas fays that it was feveral times congealed in Siberia by the natural cold. In its common ftate, therefore, it is to be confidered as a metal in fufion; and fince, in its folid ftate, it is nearly as malleable as lead, it by no means ought to be placed among the femimetals, otherwife the whole clafs muft be confidered ſidered as brittle, for none is malleable when in fuſion.

Acid of fat is placed firſt, for it diſengages all the reſt, even the muriatic, to which the ſecond place belongs. The acids of ſugar, ſorrel, amber, arſenic, and phoſphorus, ſoon expel the vitriolic and nitrous, and fall with the calx of quickſilver to the bottom ; but their reſpective forces have not been ſufficiently compared : acid of ſugar of milk precipitates mercury, but yields to the muriatic, but whether to the vitriolic and thoſe yet ſtronger, is uncertain. Acid of lemon produces a copious precipitation of mercury, diſſolved in the cold in nitrous acid, though but a ſparing one when the ſolution is forwarded by heat. The ſame holds with reſpect to the acid of tartar, of which it is moreover certain that it yields to the vitriolic. The fluor acid ſeems to be weaker than the nitrous : the acid of ants does not, as we learn from Margraaf, diſſolve, but reduce the calx. The ſtations of acetous acid, phlogiſticated vitriolic acid, and the acid of borax, remain to be aſcertained with greater accuracy. The calx of mercury, precipitated by mild alkali, combines with the aerial acid; but this metallic ſalt is not ſoluble in water. The acid of Pruſſian blue decompoſes aerated mercury, and forms cryſtals. This acid precipitates ſilver from its ſolution in nitrous acid, when made in the cold, in the form of a black powder. Whether it prevails over the vitriolic, and thoſe ſtill ſtronger, by its ſingle power, has not yet been determined by experiment.

LIX.

LIX.

Column Forty-eighth, Lead.

The vitriolic acid attracts lead with greater force than any other, and immediately takes it from them. The acid of Pruſſian blue, alone, has no power; but by a double attraction a white powder is ſeparated, which cannot be rediſſolved by adding an exceſs of the precipitant. The acids of fat, of ſugar of milk, ſugar, arſenic, tartar, phoſphorus, and ſorrel, certainly expel the muriatic and nitrous acids, at the ſame time forming new compounds ſcarce ſoluble; but their reſpective order requires to be aſcertained by farther examination. The fluor acid prevails over vinegar, as alſo do probably the acids of lemon and ants. To the reſt, the obſervations in LVIII. are applicable. The calx of lead, when it contains

tains no aerial acid, ſeems to attract it with the ſame force as fixed alkali, for the calx in this ſtate renders the alkali cauſtic in part, as reciprocally happens to the aerated calx when put into the cauſtic ley.

Pure fixed alkali, and alſo unctuous oil, diſſolve the calx of lead.

LX.

Column Forty-ninth, Copper.

Acid of ſugar occupies the higheſt rectangle, ſince when it is dropped into vitriolated or muriated copper, it ſeizes the metal, and exhibits at the bottom of the veſſel a greeniſh ſky-blue powder. Acid of tartar likewiſe precipitates theſe ſalts, but not ſo quickly; it forms blue cryſtals. The muriatic acid is ſuperior to the vitriolic, for blue vitriol

vitriol is readily diſſolved in it; the menſtruum ſoon grows green, and yields a yellow ſympathetic ink, which cannot be obtained without muriated copper; not however to truſt to the colour alone, I add highly rectified ſpirit of wine to muriatic acid, ſaturated with vitriol; no ſeparation, however, took place, as neceſſarily happens whenever copper is united with vitriolic acid. At the ſame time, let it be obſerved, that a very ſmall degree of heat, even the rays of the ſun, reſtore the ſuperiority to vitriolic acid, inſomuch, that cryſtals of vitriol are at laſt obtained, or may indeed be ſeparated by ſpirit of wine without evaporation. This is a remarkable inſtance of the power of heat, (IV.). The muriatic acid dropped into a ſolution of nitrated copper, precipitates a white ſaline powder, conſiſting of marine acid and the calx of copper in exceſs: this powder is not ſoluble in water. The acid of fat, of ſugar of milk, and

of

of nitre, are expelled by the vitriolic, and the acetous by the arſenical; but the ſtrength of the reſt has not been ſufficiently examined. The Pruſſian acid, without aſſiſtance, decompoſes aerated copper; but ſcarce any other compound of this metal. When combined with alkali, it decompoſes them all, by means of a double attraction, and the precipitates are rediſſolved when too much is added. The other acids take up only part of theſe ſediments; what remains is of a white colour. Volatile alkali totally diſſolves them; the colour of the ſolution is a bluiſh green, but they are again precipitated by water.

ALKALIS and oils attack copper, but in what order is not known.

LXI.

LXI.

Column Fiftieth, Iron.

Acid of ſugar immediately turns a ſolution of martial vitriol yellow, and gradually ſeparates a yellow powder, conſiſting of the calx of iron, and the added acid. The acid of tartar, in like manner, decompoſes it; but the new ſalt does not ſo ſoon become viſible, and it is more cryſtalline. Green vitriol, diſſolved in muriatic acid, is ſeparated by ſpirit of wine, and therefore the vitriolic is to be placed firſt. Acid of ſugar of milk is incapable of ſeparating the vitriolic acid; and the acid of fat yields to the nitrous. Pruſſian blue is diſſolved by its own acid; the ſolution is of a yellow colour: other acids have no action upon it, which would ſeem to ſhew that this acid has the

the ſtrongeſt attraction for iron; and it does indeed precipitate it from the aerial acid, but from no other, as far as I know, unleſs it is ſaturated with alkali, that is, by means of a double elective attraction. The following places remain to be confirmed by farther experiment; it is, however, certain that the acetous acid is inferior to the arſenical.

LXII.

Column Fifty-firſt, Tin.

In almoſt the whole of this column the ſeries is doubtful, and very difficult to be aſcertained, ſince tin requires an exceſs of acid to be ſuſpended. It is certain that the acids of arſenic, and ſugar of milk, yield to the vitriolic and marine, while they are ſuperior to the acetous. The acid of fat

fat exceeds the marine in ſtrength of attraction.

Both fixed and volatile alkali attack calx of tin.

LXIII.

Column Fifty-ſecond, Biſmuth.

Bismuth readily diſſolves in nitrous acid; but the acids of ſugar, fat, ſorrel, tartar, phoſphorus, and arſenic, when added to this compound, attract the baſis; but their relative powers are undetermined: the new compounds fall to the bottom ſcarce ſoluble, in the form of very fine powder, except only tartarized biſmuth, which, however, affords pellucid cryſtalline grains, in 10—15 minutes. As water alone cauſes a precipitation, I either employed a ſolution with ſuch an exceſs of acid, that

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a number of drops of water, equal to that of the precipitants, caufed no permanent cloudinefs, or elfe added acids, which may be procured in a concrete form, as moft of thofe juft mentioned. Thefe acids, in like manner, decompofe a folution of bifmuth in the vitriolic acid: which menftruum, when diluted, attacks the calx; but to diffolve the regulus, it muft be in a concentrated ftate; and, in order to feparate the phlogifton, it muft be evaporated to drynefs.

Distilled vinegar boiled with the calx of bifmuth for half an hour, does, in reality, diffolve part, as appears from the tafte, the addition of phlogifticated alkali, and the above mentioned acids; what is diffolved cannot be precipitated by water, unlefs perhaps in great quantity, and by long ftanding. The regulus is diffolved in the fame manner, but fo fparingly that it can fcarce be afcertained. What has been faid concerning

concerning vinegar, is likewiſe applicable to acid of ants. The remaining places are uncertain, nor are even the reſpective powers of vitriolic, nitrous, and marine acid determined.

LXIV.

Column Fifty-third, Nickle.

Nickle is not yet univerſally acknowledged as a diſtinct metal; but as it may be diſtinguiſhed from others by conſtant criterions, ſuch as its deep green colour, when diſſolved in thoſe acids which attack it; its blue colour in volatile alkali; the greeniſh white precipitate it yields on the addition, either of common or phlogiſticated alkali; the hyacinthine tinge it communicates to glaſs, characteriſtics which, taken together, belong to no other; moreover, ſince when it is properly purified, it cannot be resolved into others, though it be ever so long tortured, both in the dry and moist way; lastly, since no one has produced by synthesis, a mixture agreeing with nickle in the properties above mentioned, from copper, arsenic, purified cobalt, iron, or other metals fused together; for these several reasons, I cannot but consider nickle as a distinct metal, till I am better informed by new experiments. Most chemists have been seduced by the extreme difficulty which attends the purification of it. It is indeed always contaminated with arsenic, cobalt and iron, sometimes also with copper and other metals. Copper is easily separated, arsenic with great difficulty, the last vestiges of cobalt with still greater, but iron by no method hitherto discovered, as is related more at length in my dissertation on this metal. I do not, therefore, wonder

wonder that nickle, if it be ſo ſparingly contaminated with cobalt, that the particles of the former metal ſurround thoſe of the latter on every ſide, ſhould not afford, according to the common method, glaſs of a green colour, and yet that this colour ſhould appear on the addition of white arſenic; for this addition not only weakens the coheſion of the cobalt and nickle, but renders the maſs more fluid, and deprives the cobalt of the phlogiſton which before prevented the effect. Cobalt does not tinge glaſs, except when in the ſtate of calx; this calx contains a wonderful ſtore of colours; but when exceſſively dephlogiſticated, it cannot either be fuſed or reduced, without great difficulty. Nickle contaminated with iron alone, which I have not been able to remove by any means, is malleable, and very tenacious, ſo that I doubt whether it ought to be reckoned among the brittle metals. It is ſometimes magnetic, is

U 2 difficult

difficult of fufion, and does not yield a blue glafs on the addition of white arfenic ; it, however, gives a very deep green to acid menftrua, and fhews the above mentioned criterions.

NICKLE prefers no acid to that of fugar ; by this it is taken from every other, and appears in the form of a whitifh green infoluble powder : It is likewife precipitated by acid of forrel. The acid of fat yields to the nitrous. The other places remain to be determined by farther examination ; the trials, however, that have been made, feem to indicate that the arfenical acid is to be placed after the acetous.

LXV.

LXV.

Column Fifty-fourth, Arſenic.

The ſolutions of arſenic are, in ſome meaſure, imperfect, at which we need not be ſurpriſed, the calx being only a real acid, coagulated by phlogiſton, (XX.). It has, however, as yet been little examined, with a view to its elective attractions. That the vitriolic acid yields to the muriatic, appears from this, that arſenic, diſſolved in the former, yields, upon addition of the latter, and expoſure to a very gentle heat, butter of arſenic. The vitriolic is likewiſe extruded by the ſaccharine, and the ſebaceous by the nitrous. The reſt is doubtful.

LXVI.

Column Fifty-fifth, Cobalt.

Cobalt differs from nickle, in imparting a red colour to all the acids, and volatile alkali, when it is diffolved in them; in the reddifh afh-coloured precipitate thrown down either by common or phlogifticated alkali; in attracting faline hepar from nickle in the dry way; in refufing to combine with filver, bifmuth and lead by fufion, which metals do not reject nickle unlefs it contain too much cobalt; in the fuperior richnefs of its colour; for which reafon, though it be prefent in the fame mafs, in far lefs quantity than nickle, yet it prevails; for a regulus containing a much larger portion of nickle, yields neverthelefs a red folution in acids, without any fhade of green, and with a ftill more inconfiderable

derable alloy, it tinges glafs of a blue colour.

Cobalt is moft ftrongly attracted by acid of fugar, which precipitates it from other acids, in the form of a pale rofe-coloured powder; and as it is very difficult of folution in water, unlefs a great excefs of acid be prefent, its power of attraction has not yet been compared with that of the acid of forrel, which likewife precipitates cobalt from the muriatic, and other acids. The vitriolic is expelled by the muriatic acid, as may be fhewn in various ways. Highly rectified fpirit of wine refufes vitriol of cobalt, but not muriated cobalt. Since, therefore, a folution of this vitriol in marine acid, affords no precipitate on the addition of fpirit of wine, it is evident that the vitriol muft have been decompofed. Befides, muriated cobalt (but not vitriolated) yields fympathetic ink;

now a ſolution of vitriol, upon the addition of muriatic acid, (or of ſea-ſalt, which contains it, and then the decompoſition is effected by a double attraction), immediately acquires this property, and in a dry ſtate of the air, writing is turned green, and becomes legible. I ſay, when the air is dry, for when the letters are inviſible, if the paper be put over newly burned lime, or concentrated vitriolic acid, in a cloſe phial, they ſoon become manifeſt. Fire, therefore, or heat, acts only by drying, which is agreeable to Hellot's explanation. Cobalt precipitated with phlogiſticated alkali, is neither ſoluble in phlogiſticated alkali, nor acids.

Acid of arſenic is incapable of taking cobalt from vinegar, at leaſt it cauſes no precipitation. The other places remain to be further examined.

LXVII.

LXVII.

Column Fifty-sixth, Zinc.

Acid of ſugar takes zinc from every other acid, and when united with it, immediately falls to the bottom in the form of a white powder; but the acid of ſugar of milk yields to the vitriolic, and that of fat to the nitrous. Zinc precipitated by phlogiſticated alkali is not acted upon by an exceſs of it; but it is taken up by acids. Vitriolic, nitrous, and muriatic acids, prevail over that of arſenic; but the acetous yields to it. Vitriolic acid comes before the muriatic; for vitriol of zinc, diſſolved in acid of ſalt, is precipitated by ſpirit of wine. Acid of ſorrel has not been tried; but if I miſtake not, it will be found to expel the vitriolic.

LXVIII.

LXVIII.

Column Fifty-ſeventh, Antimony.

The attractions of antimony have as yet been but little examined; the examination is indeed attended with difficulty, ſince the ſolutions require an exceſs of acid. The firſt place belongs to the acid of fat, and the next to the muriatic; the vitriolic is expelled by the ſaccharine. The vitriolic, nitrous, and muriatic, are ſuperior to the arſenical; to which, however, the acetous yields. I have not yet been able to aſcertain a greater number with accuracy.

LXIX.

Column Fifty-eighth, Manganefe.

The fpecific gravity of magnefia nigra, the property it poffeffes of tinging glafs, and, above all, the white precipitate produced by phlogifticated alkali, in folutions made in every acid, led me, many years ago, to perceive diftinctly that this fubftance contained a peculiar metal. Dr Gahn, who was formerly my pupil, firft eliquated the regulus, which has moft diftinguifhing properties; and fince neither analytic experiments have refolved it into others, nor fynthetic compofed one with the fame properties, it is proper to diftinguifh it. Manganefe in its metallic ftate is hard, brittle, has a granular, white and fhining fracture; and fuch is its refractorinefs, that it is more difficult of fufion than iron, whence

whence I at firft conjectured, that it was the fame as platina; it feems to refufe fulphur; it yields a perfectly pellucid and colourlefs vitriol, of which the cryftals are parallelopipeds. The calx, when deprived of almoft all its phlogifton, is black; but when it has a fufficient quantity to be capable of folution in acids, it is white; when in combination with a ftill larger portion, it acquires a reguline nature. The black calx, in the fire, gives an hyacinthine tinge to borax, and a purple one to microcofmic falt; but on the addition of a fufficient quantity of phlogifton, both colours difappear. This metal parts with great difficulty from all its iron; but who knows not the difficulty of feparating the laft veftiges of foreign matter, when it is furrounded by other particles, which attract them ftrongly, efpecially if the mixture be refractory?

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The black calx is taken up indeed by the vitriolic and marine acids, but the ſolutions are coloured, and never without a tinge, unleſs an addition of ſugar, or ſome other matter, be added to ſupply the neceſſary phlogiſton; but it is perfectly diſſolved in acids, either artificially phlogiſticated, as thoſe of vitriol and nitre, or thoſe naturally containing inflammable matter, as thoſe of lemon and tartar; and it decompoſes them at the ſame time.

The acids of ſugar, tartar, ſorrel, lemon, phoſphorus, and fluor, expel the nitrous, vitriolic, and marine; for when vitriol of manganeſe is diſſolved in them, there appear ſmaller cryſtals, eaſily ſoluble in ſpirit of wine, which totally rejects vitriol; and, moreover, the ſolution in which the cryſtalline grains are immerſed, when poured off, afforded no precipitation on the addition of ſpirit of wine. The acids of

nitre,

nitre, fat, and arſenic, expel the acetous. The reſt is doubtful.

In the dry way, copper, iron, gold, ſilver, tin, and ſiderite, combine with manganeſe. The other metals remain to be tried. Liver of ſulphur ſcarce ſeparates the alloy of iron, but diſſolves both metals together.

LXX.

Column Fifty-ninth, Siderite.

This metal, which renders iron cold-ſhort, ſeems to me to be different from all others. The few circumſtances which I have hitherto been able to obſerve concerning it, may be ſeen in my eſſay on that ſubject. Much remains for inveſtigation ; and I have been obliged to put off my reſearches for want of materials to work upon. The three common

common mineral acids diſſolve it, but with difficulty. In the ſeries of precipitations by metals, ſiderite ſeems to ſtand higher than lead. It cannot, any more than tin, be precipitated in a metallic form, but always falls down in the ſtate of a calx.

Such is this extenſive ſubject, and ſuch a multitude of experiments and obſervations does it ſtill demand. I have diſtinguiſhed what is certain from that which remains doubtful, that it may appear what remains to be done by him who wiſhes to try his powers and patience in the cultivation of this ſcience. The ſtations which are ambiguous or doubtful, have not been aſſigned totally without reaſon, though indeed inſufficient to produce full conviction. Moreover, if I have any where erred, the condition of humanity muſt plead my excuſe. I do not, however, doubt but

that

that many aſſertions, which ſhall ſeem obſcure, or perhaps falſe, to ſome, will be quite plain and evident to him who ſhall ſeriouſly apply to this taſk.

E N D.

NOTES

ON THE

PRECEDING DISSERTATION.

P. 4.] CONCERNING these admirable experiments of M. de Morveau, we have a very acute and pertinent obſervation by an author, frequently ſuperficial. He remarks, that there is a ſource of error in them of which M. de Morveau was not aware, for the inferior ſurface of the highly poliſhed plates, which are brought into contact with the mercury, being more or leſs readily diſſolved by it, according to the nature of the metal, will acquire an unequal addition of matter; and hence the difference in the weights, neceſſary to ſeparate the laminæ from the ſurface of the mercury, may ariſe, not from any difference of attractive power, but from inequality of maſs. (Fourcroy, Leçons Elem. Diſſ. ſur les Affinit.).

P. 32.] THE ſentence beginning in l. 11. would be clearer, if placed in the following manner:

" In the firſt place, we remark that a portion of " phlogiſton flies off in the inflammable air," *&c.*

 P. 47.

P. 47. l. 1. &c.] M. Quatremere D'Isjonval affirms, (*Collection de Memoires*, *Paris* 1784, p. 219. &c.) that when folutions of muriated magnefia and muriated lime, and likewife of vitriolated volatile alkali and vitriolated magnefia, are mixed together, the precipitation which takes place, is without decompofition, and the effect of the ftrong attraction of one of the compounds for water. But the exceffive ignorance this author betrays of the moft common obfervations in chemiftry, (for he affirms, that when nitrated lime and vitriolated tartar are mixed together, the latter falt is precipitated) fhews that his opinion is not worthy of the flighteft attention.

It is more furprifing that Mr Morveau, the tranflator and correfpondent of Bergman, and, unqueftionably, one of the moft philofophic chemifts in France, fhould put the following queftion, five years after it had been folved by our author, (N. Act. Upfal, V. III. 1775.) " How does it happen that two falts, which " when feparate have a fufficient quantity of water " for their folution, fhould, upon mixture, immediate-" ly yield cryftals, as if the water had been attracted " by fpirit of wine? This a *totally new* queftion," &c. (l. c. p. 221.).

P. 65. l. 20.] The words *of the fubftances* may be ftruck out without injuring the fenfe; and the omiffion would make the fentence run fmoother.

P. 77.] Neither do the phænomena which attend the combuſtion of ſulphur, nor others of the ſame nature, admit of rational explanation upon any principles hitherto known, unleſs we adopt Mr Cavendiſh's diſcovery concerning the conſtituent parts of water. The experiments of that excellent chemiſt, in my opinion, lead to more ſpeculations, and promiſe the ſolution of more phænomena, than any which have been publiſhed ſince the fundamental diſcovery of Dr Black. But I ſhall have occaſion to conſider them more particularly below.

P. 89. 32.] This conjecture of the author's would ſeem to be erroneous, for Mr Wiegleb (Crell's Neueſt Entdeck. Th. 11. p. 14. 1783.) relates ſome experiments, from which it evidently appears, that fixed vegetable alkali has a ſtronger attraction for vitriolic acid, *viâ ſiccâ*, than the heavy earth ℥ſs of the heavy ſpar being expoſed to a ſtrong heat in a crucible, with ʒvi of ſalt of tartar, was decompoſed all but 28 grains. Mr Wiegleb adds, that this is a much eaſier proceſs than that of Scheele and Bergman Dr Withering has ſome experiments (Phil. Tr. v. lxxiv. p. 304. 1784.) that exactly coincide with theſe, but Mr Wiegleb's ſeem to be of an earlier date. No mention is made by either of foſſil alkali; but it may be ſuppoſed to agree with the vegetable. I have arranged theſe ſubſtances accordingly, but have drawn no line between them, ſince it is not abſolutely certain (though I have little doubt of it) that pure fixed alkali will effect this change. That the aerial acid comes into action in the above mentioned experiment, there can be no doubt, for Mr Wiegleb makes exprefs mention of an effervefcence.

P. 96. l. 2.] WHENEVER the author difpofes fubftances by conjecture or analogy, he takes care to inform his reader. As he therefore fpeaks pofitively in the prefent paragraph, it is to be concluded that he fpeaks from experiment. Dr Withering, however, (l. c.) affirms the contrary with great confidence. I have fo often, fays he, repeated thefe experiments, to fatisfy myfelf and others, that I am perfuaded the terra ponderofa cauftica ought to be placed below the alkalis, exceptin the column appropriated to the vitriolic acid. Mr Kirwan, confiding in the accuracy of Bergman, afks, Whether a deception may not have arifen from the abforption of an excefs of acid, by the alkalis that were added? It is likewife to be remembered, that when Dr Withering employed pure vegetable alkali, he obtained a precipitate, foluble neither in water nor acids, *viz.* a combination of the alkali and earth. The fame precipitate likewife appeared when an aqueous folution of pure terra ponderofa was added to pure vegetable or foffil alkali, but none when it was added to pure volatile alkali. Thefe precipitates are undoubtedly well worthy of farther examination. It muft furely, *a priori,*

priori, ſeem juſt as extraordinary, that volatile alkali ſhould throw down the heavy earth, as that the fixed alkalis ſhould be precipitated by it. Meanwhile, till this matter is thoroughly cleared up, I have placed a note of interrogation after the heavy earth, in the table of words.

Ibid. note.] MR CAVENDISH found that the water proceeding from the deflagration of inflammable and dephlogiſticated air, is always impregnated with nitrous acid, whenever thoſe airs are exploded in ſuch a proportion, that the burnt air is not much phlogiſticated, from whatever ſubſtance the dephlogiſticated air may have been procured. But if the proportion be ſuch, that the burnt air is almoſt entirely phlogiſticated, the condenſed liquor is not at all acid, but ſeems pure water, without any addition whatever; and when they are mixed in this proportion, very little air remains, almoſt all being condenſed. Theſe phænomena may be explained, by ſuppoſing, either that nitrous acid, in ſmall proportion, is a conſtituent part of dephlogiſticated air, or that phlogiſticated air is nitrous acid, with a larger proportion of phlogiſton than nitrous air. To the latter ſuppoſition Mr Cavendiſh evidently inclines, and obſerves, that, in conformity to it, part of the phlogiſticated air, with which the vital is debaſed, is, in his experiment, converted into nitrous acid, by the ſtrong affinity of the latter to phlogiſton. As a confirmation of his ſuppoſition, pofition, he remarks, that when nitre is deflagrated with charcoal, the acid is almoft entirely converted into this kind of air.

THIS acute conjecture points to the origin of nitrous acid, a difcovery which, fince chemifts have been fo converfant with elaftic fluids, has always feemed to be near at hand, though it has conftantly eluded their grafp. For if it be true, it is reafonable to imagine that Nature has fome procefs by which fhe difengages the acid, and perhaps, in the variety of her operations, another by which fhe again combines it. At all events, the fubject is worth profecuting. And it would feem advifable to expofe nitrous air to various fubftances, by which we may expect to communicate phlogifton to it; for although this has been already done, as by expofing it to liver of fulphur, and the refult has been fuch as feems rather to favour Mr Cavendifh's hypothefis, yet we are not enough acquainted with it to draw a certain conclufion.

ANOTHER method might be, to obferve the effect of vital upon phlogifticated air, under as many different circumftances as can be imagined. Some experiments on inflammable air, to be mentioned hereafter, would feem to afford encouragement for fuch an inveftigation. Thefe elaftic fluids are indeed conftantly prefent together in the atmofphere, but that is a fituation not calculated for fuch obfervations. Might not the electric fluid be of great fervice here alfo?

WE

We are befides indebted to Mr Becker of Magdeburg, for fome recent obfervations on the origin of the nitrous acid. In a pamphlet, (Entdecktes Saltpeter-fauer in den Animalifchen Aufleerungen, Deffau. 1783), he rejects both the ancient and modern opinions concerning the generation of this acid, either as palpably falfe, or as unfupported by any adequate proof. He afferts, that the putrid fermentation is not at all neceffary to its production. He found (Experiment I.) nitrous acid in cows urine, which had been expofed for eight days to the fun. He mixed fome of the foakings of a dunghill with a ley of burnt fheeps dung, and chalk in powder. The mixture began to ferment on the following day, and on the fourth, the internal commotion having ceafed, he found at the bottom of the phial, regular cryftals of prifmatic nitre.

In a fupplement to this publication, he tells us that he has found the full folution of the problem concerning the generation of nitre, and that the acid is not to be fought in the air, but in the vegetable kingdom, *by means of the excretions of animals.* " I found further, fays he, that this kingdom affords not only the common fixed alkaline falt, but alfo a fixed-alkaline-animal neutral falt, which appeared on lixiviation, notwithftanding the dung was dried and burnt. It is truly furprifing, that during the burning of the ftraw or dung, its alkali, together with the acid contained in the dung, fhould not be deftroyed by the

 procefs,

procefs, but fhould combine with each other. The farther I proceeded, the more I difcovered. On examining the earth of ftables and cow-houfes, I found that its lixivium yielded prifmatic nitre, while that of the dung would only afford fmall cryftals, which required an addition of nitre, in order to be reduced to a prifmatic form. Moreover, I can extract nitre at pleafure, in the courfe of three days, from the earth of ftables and cow-houfes, by ufing for faturation well purified potafhes."

THESE experiments do not, indeed, fhew the conftituent parts of nitrous acid, but they may ferve to warn us againft falfe theories. I am forry that I can give no account of the experiments and opinions of Mr Thouvenel, the fuccefsful candidate for the prize offered by the French Academy, having never yet been able to obtain a perufal of his differtation.

P. 111. l. 15.] IT may be worth while to examine into this matter a little more narrowly. The difference between neutral falts containing phlogifticated and dephlogifticated acids, is very ftriking, in many inftances. Should we even admit, that the alkali contains a portion of the inflammable principle, and communicates it to the acid, there muft ftill be a deficiency, *i. e.* lefs phlogifton than in common falt, unlefs it be fupplied from fome other quarter ; and we might expect a fenfible difference. It is not to be expected, from what is faid of the attraction of vital air for phlogifton, phlogiston, that the aerial acid (supposing it to consist of these two substances) of the alkali will be decomposed by the dephlogisticated muriatic acid. I wish, however, that the experiment were made, with a view to the examination of the elastic fluid.

SINCE this part of the note was written, I have seen a paper on the dephlogisticated marine acid, by Mr Bertholet, (Journ. de Physique, Mai 1785.) who directed his attention, in some measure, to this very object. He boiled in an air-apparatus a mixture of fossil alkali and dephlogisticated marine acid, and found that the disengaged elastic fluid was at first aerial acid with common air; next, air of a purer kind; and, last of all, aerial acid again. From calcareous earth, *no aerial acid is disengaged, but only atmospheric air, which gradually becomes more and more pure, and is at last very pure dephlogisticated air.* This last experiment looks very like a confirmation of my conjecture, that the dephlogisticated acid gets phlogiston from the elastic fluid. But Mr Bertholet has, by no means, sufficiently investigated the problem, though what he observed may serve still further to shew that it is worthy of investigation.

THE atmospheric air, in the first experiment, was beforehand contained in the vessels. Whence the vital air that appears afterwards proceeds, it is not easy to tell. Can it come from the decomposition of water, which perhaps the strong attraction of the dephlogisticated acid may assist in accomplishing in a gentle heat?

Mr

Mr Bertholet himſelf, conformably with the new French hypotheſis, deduces it from the dephlogiſticated muriatic acid.

THE neutral ſalt, formed in this experiment, was exactly like common ſalt.

WHAT he ſays of volatile alkali, is very obſcure. He perceived an efferveſcence, even when the alkali was cauſtic; and the elaſtic fluid was of a peculiar kind, and, as he thinks, is formed by the combination of volatile alkali, and the dephlogiſticated air yielded, according to his hypotheſis, by the acid.

POSSIBLY the acid, by attracting the phlogiſton of the volatile alkali, may decompoſe part of it; and if ſo, the elaſtic fluid that is extricated will be the ſame as that which is obtained by the exploſion of fulminating gold, (Scheele on air and fire, Bergman Opuſc. vol. ii.); and the acid being thus reduced to common marine acid, will unite with the reſt of the volatile alkali, and form ſal ammoniac, which was the product obtained by Mr Bertholet.

P. 115. l. 11. 12 &c.] MR TILLET, who has lately (Mem. Paris. *année* 1780.) examined the action of nitrous acid upon gold, in the circumſtances deſcribed by Mr Brandt, has been led to form an oppoſite opinion. He allows, that nitrous acid, under theſe circumſtances, does actually *attack* gold *in leaves, and in a ſtate of ductility*, but contends, that it does not really diſſolve it either wholly or in part, keeping it only

mechanically

mechanically ſuſpended. Whether he has brought any new experiments or arguments that prove his aſſertion ſatisfactorily, let the reader judge. He obſerves, and it was known before, 1. *That, if a little ſilver be added to nitrous acid containing gold, the latter metal will be precipitated.* The connection between mechanical ſuſpenſion and this effect, is not very obvious; but, if we ſuppoſe the gold to be diſſolved, then it may be ſaid, that the phlogiſton afforded by the ſilver is the cauſe of the precipitation ; ſo that this phænomenon would appear to be rather unfavourable to the author's opinion, and ſo far unfavourable as to counterbalance all his other arguments.

2. GOLD *thus precipitated,*(1.) *notwithſtanding its tender and ſpongy ſtate, is not taken up by nitrous acid, however concentrated and aſſiſted by heat.* It certainly ſeems extraordinary, that metallic particles, diffuſed through the ſubſtance of another metal, ſhould be, in ſome meaſure, ſoluble ; and yet, that theſe very particles, in a ſtate of equal tenuity, ſhould become inſoluble, when the other metal has been removed. But the fact, however remarkable, can ſcarce be thought concluſive. It is the oppoſite of that caſe, in which the particles of a body, eaſily ſoluble by themſelves, are yet prevented from being diſſolved, by being mixed with a large proportion of an inſoluble body.

3. MR TILLET *found, that all the gold was depoſited while the nitrous acid was paſſing through a filter of four folds of paper.* Mr Brandt obſerved, that the gold

was

was depoſited after the acid had ſtood ſome time, and alſo on agitation.

4. On *examining a drop of the acid with the microſcope, Mr Tillet ſaw the particles of gold in their metallic ſtate, floating in it.* Can we ſuppoſe, that ſome particles are ſuſpended, while others are diſſolved? Or, may it be conjectured, that, as the noble calces eaſily recover their phlogiſton, a ſource of error might ariſe from the expoſure of the ſolution to the ſun's rays? That ſuch an accident might happen, appears from Mr Tillet's total ſilence with reſpect to this circumſtance.

The Commiſſioners, moreover, (l. c. p. 615.) obſerve, that it appears from ſeveral of their experiments, that the pureſt nitrous acid takes up (*ſe charge avec*) a few particles of gold.

P. 120. l. 7. 8.] This opinion concerning the cauſe of the corroſive nature of certain metallic ſalts, has been adopted and confirmed by many experiments by Mr Bertholet, [Journal de Medecine, 1780, p. 50. The ſame eſſay was likewiſe ſince reprinted, with additions, in the Mem. Par. for 1780.] Among his experiments, the following ſeem the moſt concluſive: Corroſive ſublimate, expoſed to heat, (not a violent degree), with oil, is, for the moſt part, reduced. A piece of fleſh being put into a ſolution of this mercurial ſalt, a copious precipitation took place; the liquor now reddened

reddened ſyrup of violets, whereas it had before turned it green. The precipitate was calomel.

PRECIPITATES of corroſive ſublimate, whether with lime, or alkalis diſſolved in nitrous acid, without effer-veſcence or red vapours.

MERCURY diſſolved in aqua regia yields corroſive ſublimate ; whence, as well as from other conſidera-tions, the author concludes, that the muriatic acid ex-iſts in corroſive ſublimate, in a dephlogiſticated ſtate. He has ſince given (Journ. de Phyſ. Mai 1785.) a very beautiful and ſimple proof of the ſame poſition. By only adding the dephlogiſticated acid to a nitrous ſolution of mercury, he obtains corroſive ſublimate. Nitrous ſolutions of mercury become more corroſive, as they are more deprived of phlogiſton.

FROM theſe, and ſome other experiments, the au-thor thinks himſelf fully entitled to conclude, that the corroſive quality of metallic ſalts depends on their at-traction for phlogiſton.

P. 129.] NOTWITHSTANDING the ſtrong attrac-tion of the acid of ſugar for lime, there are caſes in which it will not ſhow its preſence. We have an in-ſtance of this important practical obſervation in Mr Scheele's and our author's analyſis of the calculus. The former perceiving no precipitation to take place on the addition of acid of ſugar, immediately conclu-ded, that there was no lime preſent ; but the latter ha-ving often obſerved, that a third ſubſtance ſuperadded

to

to two already united, inftead of effecting a feparation, enters into clofe combination with them, fufpected, that this might be the cafe here, efpecially as he knew, that the faccharine acid contains an unctuous matter, though of great fubtilty. And upon burning fome calculus to afhes, obtained a fubftance which exhibited the moft unequivocal marks of calcareous earth. (Stockh. Tranfact. vol. xxxvii. p. 333.) Hence we learn, how defirable it is in chemiftry to be poffeffed of more than a fingle teft, as it is called, of different fubftances.

P. 139. l. 21.] THIS perfon probably is Mr Hermbftadt of Berlin; for we have a paper by him on this fubject in Crell's Neueft. Entdeck. part 9. p. 6. It is obvious to fufpect, that the vegetable acids of fugar and tartar, at leaft, and perhaps of vinegar, are, at bottom, one and the fame, only modified by fome addition, rather accidental than effential. This fufpicion is favoured, not only by a refemblance in fenfible qualities; but alfo, by the production of one or other of thefe acids, according to the different circumftances of a body, as in the feveral ftages of fermentation. But fuch confiderations are, by no means, fitted to decide any chemical queftion; they can only ferve to fuggeft proper experiments. Accordingly, Mr Hermbftadt attempted fuch as were likely to decide the queftion: one part of acid of tartar, treated with four parts of nitrous acid, (of which the fpecific gravity was

to

to water as 41 : 28,) as in the preparation of faccharine acid, yielded fome cryftals like thofe of this latter acid, but only in the proportion of $\frac{1}{16}$ in one experiment, and about $\frac{1}{9}$ in another.

BUT upon adding four ounces of fmoking nitrous acid to fix drachms of acid of tartar, and abftracting it with a brifk fire, he obtained four drachms and two fcruples of columnar cryftals, which produced, in a great number of experiments, the fame effects as the acid from fugar, and, in many refpects, different from that of tartar. Though fuch numerous proofs of coincidence fcarce leave any doubt, yet it is ftrange, that Mr Hermbftadt fhould neglect what may be confidered as the *experimentum crucis*, the precipitation of a folution of gypfum. He promifed, indeed, more experiments; but I have not been able to find them, either in the continuation of Crell's Journal, or any other work. It is however to be remembered, that Bergman treated the acid of tartar with nitrous acid, without obtaining any acid of fugar, [Opufc. vol. i.] Nor is it to be forgotten, that two vegetable or animal acids are very frequently prefent in the fame compound, as in the cafe of fugar of milk and microcofmic falt. But we can furely fcarce fuppofe, that fo large a proportion of acid of fugar fhould be accidentally prefent.

MR WESTRUMB, another very intelligent German chemift, obtained four drachms, two fcruples of acid of fugar, from an ounce of tartar, treated with nitrous acid. His method of proceeding is worth mentioning.

To

To an ounce of tartar, he added two ounces of weak nitrous acid, and diſſolved it by means of a gentle heat. The liquor was then expoſed to evaporation in the ſun's rays, and, in ſome days, he obſerved cryſtals of nitre formed, amounting to two drachms, five grains; when it would yield no more of theſe, two ounces of ſtrong nitrous acid were added to the acid and viſcid reſiduum; when the phial had ſtood a ſhort time, red vapours began to ariſe; the addition of ſtrong nitrous acid was repeated, as long as the liquor retained any viſcidity, or any red vapours aroſe, in which four ounces of nitrous acid were conſumed in all, and the quantity of ſaccharine acid obtained was four drachms, two ſcruples.

P. 158.] INSTEAD of obtaining phoſphoric acid by the tedious and waſteful method of combuſtion in the air, I ſhould think chemiſts would procure it by decompoſing phoſphorus with nitrous acid, as Mr Lavoiſier directs, Mem. Paris, *ann.* 1780, p. 349. & ſeq. Nothing is required to procure the acid in a ſtate of as great purity, as by combuſtion, and with the greateſt eaſe and expedition, but a prudent management of the fire.

P. 165.] THE proceſſes mentioned in this page, ſuggeſt what has been ſought by ſo many chemiſts, an unexceptionable method of preparing Pruſſian or phlogiſticated alkali; all that remains to be done after the

ie acid has been once obtained, is to ſaturate it with
n alkali or with an abſorbent earth, which, if we
ay judge from ſeveral inſtances mentioned in the
ext, ſeems to anſwer equally well. But a ſhorter
rocefs occurred, in conſequence of the diſcovery of
ie nature of phlogiſticated alkali, to Mr Scheele,
nd much about the ſame time to Mr Weſtrumb.

THE method of the latter is as follows: he ſaturates
ure vegetable alkali by frequently boiling it with
ell-waſhed Pruſſian blue. He then boils the filtered
quor with white lead, in order to ſeparate any ſul-
hureous or phlogiſtic particles that may happen to
dhere to it. He then adds vinegar, which when it
as been diſtilled in tin-veſſels, occaſions the precipi-
tion of a white matter in great abundance; but not
particle of blue is ſeen to fall. He then, in con-
rmity with Scopoli's advice, expoſes the liquor to
ie ſun's rays, and keeps it in that ſituation as long
any red precipitate is obſerved to ſeparate. Upon
is the lixivium is filtered, and then mixed with a
ouble quantity of highly rectified ſpirit of wine,
hich throws down the proper ſalt of the *lixivium
nguinis* in the form of ſhining flocculi; they are to
ſeparated by means of the filter, and all the ſaline
atter ſoluble in ſpirit of wine is to be extracted by
at menſtruum. The ſolution of the ſalt in water,
of a bright yellow colour; does not ſhew the leaſt
ſtige of iron upon the addition of an acid; precipi-

Y tates

tates that metal of a beautiful blue colour, copper red, *&c.*

Mr Scheele's method is far leſs complicated. He extracts, as before, Pruſſian blue, with perfectly cauſtic fixed alkali, and then mixing highly rectified ſpirit of wine with the filtered liquor, he obtains the ſalt in the form of flocculi. Mr Scheele adds, that he is thoroughly convinced of the inefficacy of every other method of purifying the *lixivium ſanguinis*; for if the yellow ſolution be properly boiled with muriatic or vitriolic acid, Pruſſian blue will always be ſeparated. The ſalt obtained by the proceſs juſt deſcribed, is not liable to alteration in the open air; for the iron holds the tinging acid in cloſer union with the alkali, and fixes it ſo that it cannot be diſlodged by the aerial acid, which otherwiſe would happen, was it not combined with iron or ſome other metal in the tinging lixivium.

P. 187. § 42. Magneſia.] Mr Butini of Geneva (*Nouv. Obſerv. et Recherch. ſur la Magneſie. A Geneve.*) having lately publiſhed ſeveral curious obſervations on magneſia, which have not, as far as I know, been laid before the Engliſh reader, I am tempted to give a ſhort account of them, although they are not ſo immediately connected with the doctrine of attractions. He was not acquainted with the diſſertation of Bergman on this earth[a]; but he nearly agrees with him, in ſaying that an ounce of diſtilled

water

water is capable of diſſolving a grain, or at moſt $1\frac{1}{2}$ grain of magneſia, whereas the ſame quantity of aerated water takes up thirteen grains. He found that magneſia does not at firſt diſſolve in aerated water, but decompoſes it by attracting the fixed air; when once ſaturated, it diſſolves without decompoſition; in its ordinary ſtate, therefore, this earth is not ſaturated with aerial acid, the alkali uſed for its precipitation not ſupplying it with a ſufficient quantity. Mr Butini determines by exact experiments, that ſaturated magneſia contains $\frac{1}{10}$ of the aerial acid, more than in its ordinary ſtate. The ſolution in aerated water in the proportion of 1 : 64, becomes turbid in a temperature of 158° of Fahrenheit. But one of the moſt remarkable among his obſervations, is, that water may be over-ſaturated with magneſia, and yet paſs through the filter, and ſeem clear. Such a ſolution is obtained by immediately filtering the water in which Epſom ſalt has been decompoſed; if it be heated to 68° Fahrenheit, (which may be done in the palm of the hand), it lets fall its earth, which is rediſſolved when the liquor cools to about 59°. This is a very amuſing experiment.

THE ſpontaneous cryſtallization is alſo a new and curious phænomenon. It will abandon the water, even when that is not ſaturated, in order to arrange its integrant parts into regular forms. The cryſtals are hemiſpherical *matrices*, conſiſting of needles, from the length of half a line, to that of five or ſix lines,

 which

which are tranſparent hexaedral priſms, terminated by an hexagonal plane.

When it is made to cryſtallize in a temperature of 59°—62°, two kinds of cryſtals are formed, *viz.* groups of needles and ſolitary *blocks*, of which the ſhape is not exactly defined, though it is to be referred to that of an hexaedral priſm, terminated by an hexagonal pyramid. In a heat of 39° to 41°, nothing but blocks appear; and again from the 73° to the 77°, the needles only are formed.

By repeated or violent calcination, magneſia loſes its property of eaſy ſolubility in acids. Its particles, without acquiring a greater degree of mutual coheſion, gain a remarkable hardneſs, whence they become capable of ſcratching ſteel, &c. Water does not diſſolve above $\frac{1}{7992}$ of calcined magneſia, nor does the ſolution yield any cryſtals. During calcination, this earth emits a phoſphoric light, and adheres with great tenacity to cold bodies, it alſo preſents that appearance of fluidity, which is remarked in gypſum. Calcined magneſia, expoſed to an atmoſphere of aerial acid, or left in a veſſel covered only with a piece of looſe paper, does not recover its fixed air.

Neutral ſalts heighten the ſolvent power of water, while alkalis diminiſh it.

To theſe experiments of Mr Butini, let me be allowed to ſubjoin ſome of another author, not leſs remarkable, though they relate to another part of the chemical hiſtory of magneſia, *viz.* its combination with acids.

Mr Quatremere D'Isjonval (Coll. des Memoires, p. 207.) gives an account of his having obtained permanent compounds, with magnefia and nitrous acid; and what is more extraordinary ftill, with muriatic acid likewife. To obtain this effect with the firft, he precipitated purified Epfom falt, diffolved in cold water, with fixed vegetable alkali; he then faturated the magnefia with pure nitrous acid, and evaporated the folution, which at firft yielded nitre, on account of fome alkali carried down by the precipitate. After this was feparated, he rediffolved the faline magma, and evaporated it again: Thefe operations he repeated two or three times, till fome rudiments of cryftals appeared, which being rediffolved, afforded, on evaporation, cryftals that had a ftronger tendency to effloresce than deliquiate, even in a moift place. They have the form of four-fided prifms, truncated acutely. With muriatic acid he proceeds much in the fame manner, taking care to faturate the acid completely.

He fubjoins two cautions of importance for the more certain and fpeedy production of thefe cryftals: 1. That not above half the magnefia fhould be precipitated, for he is afraid of the prefence of calcareous earth; and 2. That the magnefia fhould be diffolved in the acid, while it is yet in the tender form of a precipitate.

I was unwilling to with-hold thefe curious obfervations of a chemift who had carried away the prize, when Bergman was his competitor; but, whatever authority this may add to his name, I think that he who ſhall peruſe his writings, will be careful how he gives entire credit to his aſſertions, before he has repeated his experiments, though it muſt be confeſſed, that they receive ſome authenticity from a letter of Mr de Morveau (p. 222.) to whom Mr D'Isjonval ſent ſpecimens of his cryſtals.

P. 198. *paragraph* B.]. I MUST confeſs myſelf ignorant of any good reaſon for believing *phlogiſticated*, *foul*, or *corrupted* air, to be a modification of vital air. Mr Kirwan's reaſons for ſuppoſing it to be aerial acid, combined with more phlogiſton, convey to me no ſort of conviction. Mr Cavendiſh has thrown a ray of light upon this obſcure ſubſtance, as I have already mentioned, and unleſs his rational conjecture ſhould be ripened into a diſcovery, it is better to own our entire ignorance of the nature of this elaſtic fluid, than to content ourſelves with any of the explanations that have yet been offered.

P. 199. & ſeq. *paragraph B.*]. THE connection between nitrous acid and vital air now begins to appear in a very different light. To ſuppoſe that theſe two ſubſtances were but modifications of one and the ſame, was both natural and allowable, when vital air was firſt procured from nitre; but when it appeared, in the progreſs of enquiry, that ſo many other bodies, free from all ſuſpicion of any mixture of nitrous acid, were

were found to yield the fame fluid, the opinion could be no longer tenable, nor is it, by any means, conformable to the ufual feverity of the author's logic. The experiments of Mr Cavendifh and Mr Watt fhew, that the common office of nitrous acid and other fubftances, is merely to dephlogifticate water. The latter, who made an attempt to recover the nitrous acid, found, upon procuring vital air from this acid and earths, that, however thoroughly the acid and earth might be dephlogifticated, the acid always became highly phlogifticated after the procefs. (Ph. Tr. vol. lxxiv. p. 338.). He found, moreover, in one experiment, that thirty-fix ounces meafure of vital air were produced, and only five grains of weak nitrous acid miffing; and in another, thirty-four grains weight of the fame air were produced, with the lofs of only two grains of *real* acid, p. 343.

FURTHER, when vital air is obtained from vitriolic falts, vitriolic acid air appears, at the fame time, even when the falts are not known to contain any phlogiftic matter, p. 344.

P. 208. & feq. *paragraph C.*] IT is now no longer probable, either that Mr Kirwan's or Mr Scheele's opinion will be confirmed. Both muft give way to the difcovery of Mr Cavendifh, concerning the conftituent parts of water. By fome experiments made in the fummer of 1781, and read before the Royal Society in 1784, he found, that, upon firing together inflammable and vital air in close vessels, they were condensed into water. Other chemists, both at home and abroad, have now amply confirmed this unexpected observation, as Dr Priestley, S. Laudriani at Milan, and Mr Lavoisier at Paris, who has used very large quantities in his experiments, but has shamefully attempted to appropriate the discovery to himself; and he is accordingly mentioned in many foreign journals as the first discoverer. Dr Priestley found, that after inflammable and vital air had been deflagrated together, and the vessel had cooled to the temperature of the atmosphere, as much mercury or water, in whichever of these liquids the mouth was immersed, entered, as was sufficient to fill it within $\frac{1}{200}$ part of its contents: moreover, when the moisture adhering to the glass was wiped off with a piece of sponge paper, first carefully weighed, it was found exactly, or very nearly, equal to the airs employed. (Mr Watt, Ph. Trans. vol. lxxiv. p. 332.). This discovery is so much the more to be admired, as no hints had been thrown out by any other author which could lead to it, nor could it have been surmised by any analogical reasoning. It promises, however, to furnish explanations of many of the obscurest operations, both in art and nature. Thus the generation of vital air, the disappearance of vital and nitrous air, when mixed together, the production of vital air by vegetables, the diminution of the air in the combustion of sulphur, phosphorus, *&c.* are now no longer

ger phænomena that require, for their explanation, hypothefes uncountenanced or contradicted by experiments. But Mr Cavendifh's difcovery leads to much wider views. It fuggefts new experiments on the increafe of weight of calcined metals, a problem ftill remaining to be folved, notwithftanding fo many late attempts. The firft object of thofe who fhall now labour on this fubject, fhould be to afcertain, whether a quantity of water, equal to the difference of weight, is generated during calcination. The general principle is equally applicable to volcanos and to ftatical phyfiology; for it is now obvious to fufpect that the exhalation from the lungs is not thrown off in that form by animals, but rather generated by the mixture of the dephlogifticated part of the common air with phlogifton. But this is not the proper place to indulge in fuch fpeculations.

To offer any arguments againft Mr Scheele's doctrine of the compofition of heat, would be now fuperfluous, fince Mr Kirwan (Notes to the Treatife on Air and Fire) and Fontana (Opufc. Litt. à S. Adolph. Murray) have abundantly confuted it. Bergman, himfelf, notwithftanding he has adapted feveral explanations to it, feems to acknowledge at laft, that it is liable to infurmountable objections. One alone is fufficient: that lofs of weight, which muft enfue if the vital air and phlogifton pafs off through the veffels in the form of heat, is not obferved. But it is a proof of Mr Scheele's acutenefs, that he firft perceived

ved the neceſſity of ſome ſubſtance containing vital air and phlogiſton in ſo many chemical experiments.

Mr Kirwan's explanation, is equally inadmiſſible; for Mr Cavendiſh has ſhewn, in the moſt ſatisfactory manner, that no fixed air is generated by the mixture of nitrous and vital air, any more than in the exploſion of inflammable air; or at leaſt, if any be generated, it is ſo ſmall a quantity, "as to elude the "niceſt teſt we have." (Ph. Tr. vol. lxxiv. p. 121. 122.; and 172. 173.)

P. 211. l. 3. and 4.] Mr Senebier (Recherches ſur l'air inflammable) has found that inflammable air actually does change vital air in a length of time. By keeping theſe ſubſtances over water, he obſerved that a diminution took place, and that the reſiduum did not undergo any alteration on the addition of nitrous air. From what Mr Kirwan ſays, (Ph. Tr. vol. lxxiv. p. 168.) it ſeems that Dr Prieſtley has made obſervations to the ſame purport; for he tells us, that the Doctor has diſcovered, ſince his laſt publication, that inflammable and dephlogiſticated air will unite.

P. 223. l. 5. & ſeq.] Precipitate *per ſe*, and red precipitate, are ſoluble in marine acid, and during the ſolution, nothing is diſengaged, but a great heat is produced, as in the ſlaking of quicklime; the

ſalt

ſalt which is obtained by reducing the ſolution to cryſtals, is corroſive ſublimate.

This obſervation does not coincide with the experiment of Bergman, who affirms, that calcined mercury is reduced by digeſtion in muriatic acid. I cannot gueſs how he could have made his experiment; for whenever I have added precipitate *per ſe* to muriatic acid, I have always obſerved ſolution to take place with the production of much heat, and have obtained cryſtals of corroſive ſublimate on refrigeration. It is true indeed, that when red precipitate is employed, a black powder, conſiſting of mercury, ſeparates; but this mercury is not any of the calx revivified; it ſeparates during the time of ſolution, becauſe the muriatic diſſolves no mercury *that is not combined with vital air*; and this mercury happened to be mixed with the calx; ſo, if we take notice of what paſſes in the preparation of red precipitate, it will be ſeen that firſt nitrous air, and afterwards red precipitate paſs over, long before the mercury riſes. May not Bergman have uſed this precipitate, and thus been led into a miſtake? He knew not how to explain the reduction. Mr Kirwan (Phil. Tranſ. vol. lxxiv. p. 159.) ſays that the reduction is owing to the expulſion of the fixed air from the mercurial calx; which fixed air, at the moment of its expulſion, is decompoſed, leaving its phlogiſton to the mercury, which is thereby revived. But this explanation is inadmiſſible,

ſince

fince no reduction takes place, as I have already ob-ferved. (*Pelletier J. de Phyf. Mai*, 1785.)

P. 253. l. 11. & feq.] DR PRIESTLEY fays, that the iron is *fuperphlogifticated*, and has lately affured us, [Phil. Tranf. vol. lxxiii.] that he has frequently re-peated the experiment with the fame refult. I fear, that neither Prieftley nor Bergman have examined the ftate of the iron, otherwife than fuperficially. Perhaps, on a more accurate examination, fomething might appear that would lead to an explanation of the phænomenon.

P. 257. l. 4. & feq.] CRELL advifes (Chem. An-nal. St. i. p. 94.) to ufe in this experiment another equal and fimilar veffel, containing a quantity of water A, of equal weight, and at the fame temperature (32° Fahr.) with the ice B; let the two veffels, he adds, be placed near one another, and obferve how long a time A requires to attain the temperature of the room. Moreover, obferve how long a time B re-quires, *1ft*, to melt, and, *2d*, to attain the tempera-ture of the room. Next, multiply the degree of heat acquired by A, by the time B *1ft*, took to melt, and, 2*d*, to attain the temperature of the atmofphere. Then, fuppofing the degrees of the thermometer to corre-fpond to equal acceffions of the matter of heat, we may fay, as much heat, (*i. e.* fo many particles of fire),

as

as is ſufficient to raiſe the thermometer to a certain heat, has ſuch a weight.

I HAVE heard, that one of thoſe Philoſophers who believe heat to be merely a quality, has made the experiment propoſed by Bergman, with this ſtrange reſult, that, during the melting of ice, a diminution of *abſolute* gravity takes place. If my information be right, I ſhould think ſuch a concluſion could prove nothing, but either the difficulty of making the experiment, without ſuffering ſome of the vapours to eſcape, or elſe the careleſsneſs of the obſerver.

P. 258. 259. 260.] MR LAVOISIER and De la Place have lately given the following table of ſpecific heats:

Common water, - -	1,
Sheet iron, - -	0,109985
Glaſs without lead, or cryſtal, -	0,1929
Mercury, - -	0,029
Quicklime, - -	0,21689
Mixture of water and quicklime, in the proportion of 9 to 16, -	0,334597
Oil of vitriol, (ſpec. grav. 1,87058,)	0,60362
Mixture of this oil with water, in the proportion of 4 to 5, -	0,663102
Nitrous acid, (not ſmoking, ſpecific gravity, 1,29895,) -	0,661391

Mixture

Mixture of this acid with quicklime, in the proportion of $9\frac{1}{3}$ to 1, -	0,61895
Mixture of 1 part of nitre with 8 of water, - -	0,8167

The ingenious machine, contrived for the purpofe of meafuring the fpecific heat of bodies, by thefe gentlemen, confifts principally of three cavities inclofed in one another. The outermoft is filled with pounded ice, which is defigned to intercept the influence of the atmofphere upon the ice contained in the middle cavity. This latter is the real fubject of the experiment, and the quantity of it melted by the bodies which are placed in the innermoft cavity, gives the proportion of their fpecific heats, which are evidently as the quantity of water obtained. But there is reafon to fear left this ingenious and promifing contrivance fhould fail of anfwering the end propofed; for Mr Wedgewood, who repeated fome of the experiments, obtained the moft oppofite refults, when the fame body was heated to the fame degree. His difappointment arofe chiefly from two caufes; the firft of which was the abforption of the water by the pores of the ice; for, though the French Philofophers pretend, that no error can arife from this caufe, fince the ice has already imbibed as much water as it can, yet it is obvious, that, as the precife degree of force with which the pounded ice is preffed together cannot be adjufted, more or lefs water will be fucked up, up, as it forms a leſs or more compact body. The other difficulty ſeems ſtill more inſuperable. Mr Wedgewood found, that the two proceſſes of freezing and thawing were going on at the ſame time :—whether it be, that water in the ſtate of vapour is liable to freeze in a higher temperature than when liquid, as Mr Wedgewood conjectures, or the ordinary abſorption of heat by evaporation alone produces the effect, without any ſuch diſpoſition in the vapour. At all events, the preſent table, as well as thoſe which Mr Lavoiſier and De la Place promiſe, muſt be received with diffidence, till theſe impediments to accuracy be removed.

P. 263. *note.*] THE ſubſtance mentioned in this note, is called black wadd ; by Da Coſta, *ochra friabilis nigra.* Its remarkable property of taking fire when mixed with oil, was firſt diſcovered accidentally at a painter's in Derby in 1752. Mr Wedgewood has lately (Phil. Tranſ. vol. lxxiii. p. 284.) publiſhed an analyſis of it. He finds it to conſiſt of inſoluble earth, chiefly micaceous, of lead, iron, and manganeſe.

22 parts contain

of earth about -	2
of lead - -	1
of iron - -	9½
of manganeſe - -	9½
	22

P. 268.

P. 268. 269.] This analyfis of charcoal differs exceedingly from that of Dr Prieftley. He obtained not the leaft particle of aerial acid from charcoal, when it had been perfectly well burned; but the whole quantity was converted, by means of burning lens, into inflammable air, except a very inconfiderable portion of afhes. (Phil. Tranf. vol. lxxiii. p. 411.)

P. 273.] It is now completely afcertained by the experiments of Mr Hutchins at Hudfon's bay, that the freezing point of mercury correfponds to the 40th degree below 0 of Fahrenheit's thermometer; therefore the numbers in the text muft be much reduced. The other data of Dr Crawford, *viz.* the converfion of vital into fixed or phlogifticated air, have, by no means, the certainty of eftablifhed principles. We muft now look for the origin of the heat, in the condenfation of vital air into water by phlogifton. And thus we have Mr Cavendifh's difcovery extended to another of the moft obfcure and familiar phænomena in nature.

P. 278.] Before the publication of Mr Cavendifh's paper on air, (Phil. Tranf. vol. lxxiv. p. 119. & feq.) Mr Kirwan feems to have almoft fucceeded in perfuading chemifts, that fixed air is generated in phlogiftic proceffes, by the union of vital air with phlogifton. Others had thrown it out long before as a probable fuppofition; but Mr Kirwan was, I think, the

the firſt, who, by collecting and arranging the numerous facts publiſhed by different authors, gave the opinion a great degree of plauſibility. Still, however, the complete proof, from unequivocal, analytical, and ſynthetical experiments, was wanting, and many of the moſt important caſes of phlogiſtication gave no ſort of countenance to the ſuppoſition.

Mr Cavendish, by a rigorous examination of the arguments, has fairly reduced them within a very narrow compaſs. In the firſt place, he juſtly obſerves, that all experiments, in which any organiſed bodies are employed, muſt be ſet aſide. He is inclined, likewiſe, to conſider the experiments with the electric ſpark as equivocal; being of opinion, that when turnſol is uſed, the aerial acid may ariſe from the burning of this vegetable matter; and, in the caſe of lime-water, from ſome impurity in the tube, or elſe from ſome inflammable matter in the lime.

There remain then but four caſes; the calcination of metals, the combuſtion of ſulphur or phoſphorus, the mixture of nitrous air, and the exploſion of inflammable with vital air.

Neither in the combuſtion of ſulphur and phoſphorus, nor in the exploſion of inflammable air, has any veſtige of aerial acid been perceived. That this is alſo the caſe in the mixture of nitrous air, Mr Cavendiſh has clearly ſhown, contrary to the general ſuppoſition, as I have already obſerved.

We have, therefore, left, for the ſupport of ſo important and extenſive a doctrine, only the calcination of metals: And in examining theſe experiments, made with care and cloſe veſſels, we do not find any evidence of the generation of fixed air. Mr Lavoiſier and Dr Prieſtley found none in the air in which they had formed their experiments; and, if it be ſaid, that the metallic calces abſorbed it, it is anſwered, that none has been extracted from calces ſo prepared. It is indeed true, that metallic calces prepared in open veſſels, or ſuch as have lain long expoſed to the atmoſphere, contain aerial acid; but here the atmoſphere is an evident ſource from which it might ariſe.

Mr Kirwan endeavours to remove theſe objections, by adducing ſeveral experiments, which ſhow, that aerial acid exiſts in very ſparing quantities in the atmoſphere, and by repreſenting it as improbable, that metals, during their calcination, ſhould attract it; becauſe lime, expoſed to a red heat ever ſo long, does not regain any. He inſiſts upon what he had formerly advanced, that the revivification of certain mercurial calces, and the production of vital air, is owing to the decompoſition of the aerial acid contained in the calces.

He thinks his opinion ſtrongly corroborated by an experiment of Mr Laſſone, in which filings of zinc having been digeſted with cauſtic alkali, an efferveſcence was obſerved on the addition of an acid; but Mr Cavendiſh ſuppoſes, that the efferveſcence aroſe, not

from

from the expulſion of aerial acid from the alkali, but of inflammable air from the incompletely diſſolved zinc.

WITH reſpect to the experiment of Dr Prieſtley, mentioned in the text, Mr Cavendiſh relates an experiment, which ſeems to render it probable that the aerial acid proceeds from plumbago and other impurities contained in the iron: 500 grains of red precipitate, mixed with 1000 of iron filings, yielded 7800 grain meaſures of aerial acid; and 2400, partly of vital, and partly inflammable air. But 500 grains of the ſame red precipitate yielded 9200 of aerial acid, and 4200 of indifferent vital air; when they were mixed the plumbago and other impurities, which were the reſiduum of 1000 grains of iron filings, diſſolved in diluted vitriolic acid. Hence, as more aerial acid was produced when the red precipitate was mixed only with the impurities, than with the iron filings themſelves, it ſhould ſeem to follow, that its production was owing, not to the iron, but to the plumbago, which is known to contain a great deal of it. As, however, it was found, that the iron filings were mixed with $\frac{1}{13}$ of their weight of braſs, and, as more fixed air was produced, than the plumbago uſually contained in 1000 grains of iron can ſupply, (which is Mr Kirwan's objection), Mr Cavendiſh candidly acknowledges, that the experiment ought to be repeated in a more accurate matter.

Mr Kirwan, befides, infifts upon the diminution of common acid by the electric fpark, as the moft convincing argument in favour of his opinion. An experiment, too, in which Dr Prieftley having amalgamated lead with mercury, obtained aerial acid from the black powder into which the lead was converted, feems really favourable to him.

Such is the ftate of a doctrine which fo widely influences the theory of chemiftry. Every one muft acknowledge, that much ftronger proofs muft be adduced before it can be received as a fundamental propofition. Now, when we know that vital air and phlogifton conftitute water, and that this will fufficiently account for the diminution of the air, it is no longer a neceffary hypothefis: And this very difcovery feems to give the opinion a general appearance of improbability, which the few facts that yet remain to countenance it, do not, by any means, outweigh; nay, it is probable, that thefe facts, as they are more narrowly fcrutinifed, will put on a different afpect, as has already happened in the mixture of nitrous and vital or common air. May not fome fuch experiments as I have propofed above, for exploring the nature of phlogifticated air, ferve to fhow whether aerial acid is really a compound of phlogifton and fome other fubftance?

P. 285. Æther.] The reader will furely excufe me if I digrefs a little from the fubject of attractions, and the text of the author, in order to give him a fhort ſhort account of ſome late experiments of Mr Scheele on this ſubſtance. They are to be found in the Stockholm Tranſactions, part iii. for the year 1782. Mr Scheele has not indeed yet been able fully to clear up the obſcure theory of the generation of æther; but his experiments have led him to ſome new views.

When vitriolic æther is prepared in a large retort, and a briſk heat is applied towards the laſt, volatile ſulphureous acid is obtained together with vinegar, but no veſtige of aerial acid:—when to an ounce of pounded manganeſe, half that quantity of vitriolic acid, and an ounce of ſtrong ſpirit of wine was added, he got both vinegar and aerial acid, and found in the retort vitriolated manganeſe, without any exceſs of acid. He found that vitriolic and muriatic acids are conſtituent parts of their reſpective æthers, but in exceedingly ſmall proportions. Beſides zinc, antimony, and tin, by the intervention of which, it is well known that muriatic æther may be made, he obtained æther by a ſolution of biſmuth in aqua regia, evaporated to the thickneſs of a ſyrup, and of crocus martis (iron filings will not anſwer the purpoſe) in muriatic acid. He alſo obtained æther by ſaturating ſpirit of wine with fluor acid air, and adding manganeſe. No acetous æther is to be obtained by the proceſs of the Count de Lauraguais, notwithſtanding almoſt all chemical writers, except Poerner, have admitted that proceſs as an effectual one: Mr Scheele, however,

 found

found a way of preparing acetous æther, and that, in greater quantity than any other kind of æther (this obſervation is ſurely important in practice) by adding to ſtrong vinegar a little vitriolic, nitrous, muriatic, or fluor acid. Acetous æther is more eaſy of decompoſition than any other. No æther could be procured with phoſphoric acid, nor any with ſalt of benzoin alone, though the latter yields ſome with the help of muriatic acid. Neither did his trials ſucceed with acid of tartar, of lemons, of borax, of amber, and ſeveral compound ſalts.

CONCERNING the theory, he obſerves, that though it may ſeem, that ſome ſubſtance, which has an attraction for the phlogiſton of ſpirit of wine muſt be brought into action; yet this ſuppoſition can ſcarce be applied to the acetous æther, or that of benzoin, or to the acids of fluor and ſea-ſalt. But granting that theſe ſubſtances actually do attract phlogiſton, how is the *oil of ſpirit of wine* itſelf, or the æther, ſeparated from the water with which it was before united? Perhaps this phænomenon may be explained in the ſame way as the ſeparation of ſulphur from hepatic air: this latter is ſoluble like ſpirit of wine in water, and conſiſts of phlogiſton, ſulphur, and the principle of heat. On the acceſſion of a body that ſeparates the phlogiſton of this air, the principle of heat eſcapes, and the ſulphur is precipitated. In applying this ſuppoſition, Mr Scheele obſerves, that manganeſe has a ſtrong attraction for the inflammable

principle

principle when an acid acts upon it. This metallic calx, ſpirit of wine, and vitriolic or muriatic acid being added together, the former attracts part of its inflammable principle from the ſpirit, whence the heat (which is ſo conſiderable, that this mixture boiled of itſelf) eſcapes, and the ſubtile oil or the æther is ſeparated from the water. The portion of acid in highly-rectified æther, is very inſignificant, though it can be made obvious. The ſmall quantity of acetous and aerial acid, which he has obſerved in ſome diſtillations, proceeds from the decompoſition of a ſmall portion of æther; for it is very probable, that the oil of ſpirit of wine conſiſts of acetous acid and the principle of inflammability.

P. 318. Siderite.] THIS ſuppoſed new metal, ſiderite, [*Hydroſyrum*, *Waſſereiſein*] has been reduced by the firſt diſcoverer, Mr Meyer of Stettin, to a mere compoſition of iron and phoſphoric acid. The reader will be beſt pleaſed with his own reflections on the ſubject. "It is, ſays he, (Crell's Chemiſche Annalen, B. i. St. 3.) but too eaſy to fall into miſtakes "in chemiſtry; a truth daily confirmed by the number of diſputed and contradictory experiments, and, "of which, I myſelf probably furniſh a freſh example. For my new metal, obtained from caſt iron, that was run from a marſhy ore, of which I "have treated in the obſervations of the Berlin Society

" ciety * is, in all probability, neither more nor lefs
" than iron combined with phofphoric acid. My rea-
" fons for this opinion are the following. I diffolved
" fome of my fuppofed new metal in vitriolic acid,
" taking care to ufe more acid than was neceffary for
" the folution. I obtained in the retort a gray
" powder, and fome fulphur appeared on its neck.
" Upon diffolving the gray powder, and evaporating
" the folution, I obtained a thick brown lixivium,
" in which, when it had ftood ftill for a confiderable
" time, fome cryftals of true martial vitriol fhot:
" The remainder of the ley fhewed the fame phæ-
" nomena, as thofe I have noticed in the above men-
" tioned papers. Hence it was too apparent, that
" this metallic fubftance contained a large quantity of
" iron. But with what could it be combined? I
" could think of nothing but phofphoric acid.

" Having poured a little water upon 20 grains of
" iron that had been fluxed with inflammable matter,
" and afterwards forged, I dropped into it a little phof-
" phoric acid, procured by the burning of phofphorus,
" and applied heat. The acid attacked the iron, and
" what was diffolved formed a gray powder. I ad-
" ded, by degrees, acid enough to diffolve all the i-
" ron, and then left it to dry by fpontaneous evapo-
" ration. The gray powder, when dry, weighed
" 55½ grains. Upon trying to fufe half a drachm of
" this with 20 grains of glafs of borax, I found that
" it

* B. ii. p. 334. ; and B. iii. p. 380.

“ it did not flow well: nor when 20 grains more
“ were added, did it run into complete fuſion. I
“ found in the glaſs particles of metal that were melt-
“ ed into grains not perfectly round, which were al-
“ ſo found to be very brittle, fuſed with difficulty
“ under the blow-pipe, and were converted into
“ ſcoriæ. The magnet had but little effect on them,
“ attracting only ſome ſmall particles. Upon the re-
“ maining earth I poured oil of vitriol, diluted with
“ an equal quantity of water; it was left to dry, and
“ then diſſolved in a very ſmall quantity of water,
“ and filtered it. Upon mixing this ſolution with wa-
“ ter, it became milk-white, and there fell down a
“ conſiderable quantity of white earth, in appear-
“ ance like the earth of ſiderite. I have not yet
“ been able to repeat and continue theſe experi-
“ ments; but have no doubt of their being confirm-
“ ed; and, in that caſe, I muſt alter the title of my
“ eſſays; but I hope the eſſays are not without their
“ uſe. What a plentiful ſource of phoſphoric acid
“ would be opened to us, if it were but eaſy to ſe-
“ parate? The cloſe combination of this acid with
“ iron, would alſo be remarkable.

“ Bergman has adopted my water-iron (Waſſer-
“ eiſen) as a new metal, under the title of ſiderum.”

What Mr Meyer gathers from theſe two experiments, is confirmed by Aſſeſſor Klaproth of Berlin, who, by a remarka le coi idence, came to the very ſame concluſion, without any communication with Mr Meyer.

Meyer. He did not attempt to eſtabliſh his opinion by analytical experiments, as he conceived that it would be difficult to ſeparate the iron and acid, either by phlogiſton or any other way. He found, however, the artificial compound of phoſphoric acid and iron, to agree in its properties with the *calx ſideri alba* obtained by Bergman; and Meyer from cold-ſhort iron. Native Pruſſian blue contains this combination in much larger proportion.

* * * * *

SINCE the firſt publication of this diſſertation in 1775, beſides many alterations which totally change the diſpoſition of it, not leſs than nine new columns have been added, which, if all the rectangles were filled up, make $9\times50=450$ new rectangles. I have no doubt but that an equal or a greater number of additions will hereafter be made in an equal number of years. Even ſince the publication of the third volumn of the *Opuſcula* in 1783, two, or perhaps three ſubſtances have been diſcovered which will claim a place on the table of elective attractions; theſe are what Mr Scheele conſiders as the acid inherent in tungſtein, or *lapis ponderoſus*, the metal which Meſſrs Luyart obtained from tungſtein; for Wolfram only differs from it in being combined with iron and manganeſe, and the acid of the ſilk-worm, and ſome other inſects, deſcribed by Mr Chauſſier in the Dijon Memoires for 1783. Little, I preſume, is as yet known

concerning

concerning the elective attractions of these substances. Mr Scheele tells us, that the tungstein acid, as he supposes it to be, when combined with volatile alkali, decomposes nitrated lime, by a double elective attraction, and regenerates tungstein. He adds, that it produces no change on solutions of alum or vitriolated lime, but it decomposes acetated ponderous earth, the precipitate being quite insoluble in water; that vitriolated iron, zinc, and copper, nitrated lead, silver, and mercury, with acetated lead, are precipitated white, and muriated tin-blue; and that corrosive sublimate is not changed. All this was well known to Bergman; yet he has made no use of it, perhaps wisely judging that the experiments of Mr Scheele, as well as his own, could not be much relied upon, on account of the small quantity of matter they had to work upon: And, in fact, Messrs Luyart found, that what the Swedish chemists had taken for the acid of tungstein, was a triple salt, containing, besides the substance furnished by the stone, some of the acid and alkali employed in extracting and saturating it.

* * * * *

SINCE the notes on p. 96. *note*, and some other passages, were printed, I have had the satisfaction of seeing a paper lately read by Mr Cavendish before the Royal Society, and containing experiments which deeply affect some of the general theories mentioned as well in the dissertation as the notes. This paper, joined

joined to that which I have ſo frequently quoted, tends to clear up more obſcurities in this branch of chemiſtry, than all the other facts and theories with which I am acquainted put together; and with whatever modeſty and ſimplicity his experiments may be related by the author, they ought to be accepted by thoſe who have been perplexed by the endleſs doubts and difficulties that occur in all that has been written on aeriform ſubſtances, as great and important diſcoveries.

I HAVE already mentioned (p. 326.) the idea, that Mr Cavendiſh had thrown out on the nature of phlogiſticated air, and obſerved, what was very obvious from the conſideration of that philoſopher's experiments, that the matter might be fully aſcertained, by treating this elaſtic fluid with vital air. Mr Cavendiſh did not fail to purſue the path which thus lay open before him. He mixed phlogiſticated and vital air together, and paſſed the electric ſpark through the mixture. In theſe trials, a diminution of bulk always was obſerved, inſomuch that when five parts of vital air were added to three of common air, almoſt the whole diſappeared. Moreover, by continuing his experiments, he diſcovered, that an acid liquor was produced, and that this acid was the nitrous. Thus, was his conjecture concerning the conſtitution of phlogiſticated air fully confirmed; and as, in the experiments already publiſhed, he had ſhown, that vital air is the ſame thing as water deprived of phlogiſton; ſo, in the preſent caſe, the addition of vital air is equivalent to the addition of water.

BUT

But his paper contains other experiments on the ſubject of aerial acid, that are equally intereſting. Mr Kirwan, ſo far from admitting the validity of Mr Cavendiſh's objections to theſe experiments in which the elaſtic ſpark is made to paſs through common or vital air, confined by a ſolution of litmus or of lime, retains them as the beſt arguments in favour of that opinion which he has eſpouſed. It was therefore deſirable to ſee how far experiment would countenance them.

When the electric ſpark was taken in ſmall portions of common air, confined by a ſolution of litmus, the liquor was turned red. This had been obſerved before; but it was not before known, that, by continuing the ſparks, the ſolution becomes quite clear and tranſparent; ſo, however, it is: beſides, half the air diſappears, and, by the addition of lime-water, it is reduced $\frac{1}{5}$ more. It is, therefore, unqueſtionably true, that the litmus ſuffers a decompoſition, loſes its purple colour, and yields fixed air; but there is nothing in any of theſe, or of the following experiments, which favours the opinion of air being diminiſhed by means of phlogiſton communicated by means of the electric ſpark.

When lime-water was uſed inſtead of litmus, not the leaſt cloud was obſerved; the air was reduced to $\frac{2}{3}$ of its original bulk; whereas, by phlogiſtication *, it

* To ſhew the impropriety of the former erroneous phraſeology, is always among the firſt conſequences of new diſcoveries; for, as the expreſſion depends on the opinion that is formed of phænomena,

it loſes but $\frac{1}{5}$. When the ſpark was taken in common or vital air not quite pure, no cloud was perceived, nor even when ſome aerial acid was introduced; but when, beſides aerial acid, pure volatile alkali was added, a brown ſediment immediately appeared. Hence, it is evident, as Mr Cavendiſh obſerves, that the calcareous earth muſt have been ſaturated by ſome acid, (*viz.* the nitrous), which was generated during the experiment; but, on the addition of pure volatile alkali, four powers came into action, the nitrous acid uniting with the volatile alkali, and the aerial acid with the lime. The brown colour of the ſediment might be owing to ſome quickſilver being diſſolved. It is, moreover, undeniable, that, if any aerial acid had been generated, it would have precipitated ſome of the earth, till a ſufficient quantity of the other acid was produced to diſſolve the whole.

Thus then it appears, that what in the opinion of its warmeſt maintainer are the moſt convincing proofs of the doctrine in queſtion, are no proofs at all in its favour.

na, the former way of ſpeaking will ſcarce ever be adapted to the new notions. By altering the meaning of the preſent phraſe, it may perhaps be retained, ſince the vital part of the air does actually receive phlogiſton; but it ſeems to me to expreſs better, that the remaining elaſtic fluid has received an addition of phlogiſton, by which its nature has been changed: whence, there will ariſe this inconvenience, that paſt writers will have uſed the ſame expreſſion with one meaning, and future writers will uſe it with another. I think, therefore, that confuſion will be beſt avoided, by ſubſtituting a new one.

favour. I never experienced greater furprife than on reading thefe experiments of Mr Cavendifh. The precipitation of lime, in thefe circumftances, was fo generally believed, that no one had fcrupled to affume it as a certain ground of reafoning. Speculative men cannot learn, from a more ftriking inftance, how neceffary it is to begin with a ftrict examination of facts.

But whence arifes the aerial acid that appears in thofe phlogiftic proceffes in which animals are concerned? We find it not only in the air that has been refpired by animals provided with lungs, but Mr Scheele detected it in air in which he had kept infects, and Mr Achard in common and vital air that had been injected into the cellular tiffue of animals. If it does not proceed from any change of vital air, what remains but that it muft be thrown off in fubftance? I would, therefore, propofe this as a proper fubject of experiment, not becaufe I think it calculated to decide the chemical queftion concerning the conftitution of the aerial acid, but becaufe it is a curious phyfiological problem. I know but one fact that has any immediate connection with the folution of this problem, and that is contained in Mr Achard's paper on artificial emphyfemas. He always found a large portion of aerial acid in inflammable air that had been forced into the cellular tiffue of animals. If it was not contained beforehand in the inflammable air, and little or no common air was introduced along with it, which I think altogether unlikely, the refult feems very much to favour the opinion

nion that ſuppoſes aerial acid to be an animal emanation.

I KNOW not whether I ſhall eſcape cenſure for dwelling ſo long, both here and before, on the queſtion concerning the aerial acid; but I preſume, with ſome confidence, that no one who is capable of perceiving its extenſive influence on the theory of ſo many chemical operations, will blame me with much ſeverity. That the author of the diſſertation conſidered it as a queſtion of the utmoſt importance, appears from his accurate ſtatement of the ſeveral theories, and of the objections that may be made to them. *Gaudemus interea*, ſays he, *quæſtionem eo redactam fuiſſe, ut certitudo diu deſiderari nequit;* and accordingly, I think, we can now determine, with tolerable certainty, the merit of thoſe theories, as well as explain the nature of phlogiſtic proceſſes.

ON this ſubject, I have only to add, that in column 36. *vital air* ought to be placed above *nitrous acid.*

P. 188.] I FORGOT to obſerve, that ponderous earth had now been found, in more places than one, combined with aerial acid. The author himſelf received, a little while before his death, a ſpecimen of this combination, which was tranſmitted to him from this country.

EXPLANATION

SINGLE ELECTIVE ATTRACTIONS.

No. III

In the MOIST WAY.

	41 ÆTHER	42 ESSENTIAL OILS	43 EXPRESSED OILS	44 CALX OF GOLD	45 CALX OF PLATINA	46 CALX OF SILVER	47 CALX OF MERCURY	48 CALX OF LEAD	49 CALX OF COPPER	50 CALX OF IRON	51 CALX OF TIN	52 CALX OF BISMUTH	53 CALX OF NICKLE	54 CALX OF ARSENIC	55 CALX OF COBALT	56 CALX OF ZINC	57 CALX OF ANTIMONY	58 CALX OF MANGANESE	59 CALX OF SIDERITE
2	Alcohol	Æther	Æther	Æther	Æther	Marine acid	Acid of fat	Vitriolic acid	Acid of sugar	Acid of sugar	Acid of fat	Acid of sugar	Acid of sugar	Marine acid	Acid of sugar	Acid of sugar	Acid of fat	Acid of sugar	Vitriolic acid
3	Essential oils	Alcohol	Essential oils	Marine acid	Marine acid	Acid of fat	Marine acid	Acid of fat	Acid of tartar	Acid of tartar	Acid of tartar	Acid of arsenic	Acid of sorrel	Acid of sugar	Acid of sorrel	Vitriolic acid	Marine acid	Acid of sorrel	Nitrous acid
4	Expressed oils	Expressed oils	Pure fixed alkali	Aqua regia	Aqua regia	Acid of sugar	Acid of sugar	Acid of sugar of milk	Marine acid	Vitriolic acid	Marine acid	Acid of sorrel	Marine acid	Vitriolic acid	Marine acid	Marine acid	Acid of sugar	Acid of lemon	Marine acid
5	Water	Pure fixed alkali	Pure volatile alkali	Nitrous acid	Nitrous acid	Vitriolic acid	Acid of amber	Acid of sugar	Vitriolic acid	Acid of sugar of milk	Vitriolic acid	Acid of tartar	Vitriolic acid	Nitrous acid	Vitriolic acid	Acid of sugar of milk	Vitriolic acid	Phosphoric acid	
6	Sulphur	Sulphur	Sulphur	Vitriolic acid	Vitriolic acid	Acid of sugar of milk	Arsenical acid	Arsenical acid	Acid of sugar of milk	Marine acid	Acid of sugar	Phosphoric acid	Acid of tartar	Acid of fat	Acid of tartar	Nitrous acid	Nitrous acid	Acid of tartar	
7				Arsenical acid	Arsenical acid	Phosphoric acid	Phosphoric acid	Acid of tartar	Nitrous acid	Nitrous acid	Arsenical acid	Vitriolic acid	Nitrous acid	Acid of tartar	Nitrous acid	Acid of fat	Acid of tartar	Fluor acid	
8				Fluor acid	Fluor acid	Nitrous acid	Vitriolic acid	Phosphoric acid	Acid of fat	Acid of fat	Phosphoric acid	Acid of fat	Acid of fat	Phosphoric acid	Acid of fat	Acid of sorrel	Acid of sorrel	Marine acid	
9				Acid of tartar	Acid of tartar	Arsenical acid	Acid of sugar of milk	Acid of sorrel	Arsenical acid	Phosphoric acid	Nitrous acid	Marine acid	Phosphoric acid	Acid of sorrel	Phosphoric acid	Acid of tartar	Acid of sugar of milk	Vitriolic acid	
10				Phosphoric acid	Phosphoric acid	Fluor acid	Acid of tartar	Marine acid	Phosphoric acid	Arsenical acid	Acid of amber	Nitrous acid	Fluor acid	Fluor acid	Fluor acid	Phosphoric acid	Phosphoric acid	Nitrous acid	
11				Acid of fat	Acid of fat	Acid of tartar	Acid of lemon	Nitrous acid	Acid of sorrel	Acid of sorrel	Acid of sorrel	Fluor acid	Acid of sugar of milk	Acid of sugar of milk	Acid of sugar of milk	Acid of lemon	Acid of lemon	Acid of sugar of milk	
12				Acid of Prussian blue	Acid of sugar	Acid of sorrel	Nitrous acid	Fluor acid	Acid of amber	Fluor acid	Fluor acid	Acid of sugar of milk	Acid of amber	Acid of amber	Acid of amber	Acid of amber	Acid of amber	Acid of amber	
13					Acid of sorrel	Acid of lemon	Fluor acid	Acid of lemon	Fluor acid	Acid of amber	Acid of sugar of milk	Acid of amber	Acid of lemon	Acid of lemon	Acid of lemon	Fluor acid	Fluor acid	Acid of fat	
14					Acid of lemon	Acid of ants	Acetous acid	Acid of ants	Acid of lemon	Acid of lemon	Acid of lemon	Acid of lemon	Acid of ants	Acid of ants	Acid of ants	Arsenical acid	Arsenical acid	Arsenical acid	
15					Acid of ants	Acid of milk	Acid of borax	Acid of milk	Acid of ants	Acid of ants	Acid of ants	Acid of ants	Acid of milk	Acid of milk	Acid of milk	Acid of ants	Acid of ants	Acid of ants	
16					Acid of milk	Acetous acid	Acid of Prussian blue	Acetous acid	Acid of milk	Acid of milk	Acid of milk	Acid of milk	Acetous acid	Arsenical acid	Acetous acid	Acid of milk	Acid of milk	Acid of milk	
17					Acetous acid	Acid of amber	Aerial acid	Acid of borax	Acetous acid	Acetous acid	Acetous acid	Acetous acid	Arsenical acid	Acetous acid	Arsenical acid	Acetous acid	Acetous acid	Acetous acid	
18					Acid of amber	Acid of Prussian blue		Acid of Prussian blue	Acid of borax	Acid of borax	Acid of borax		Acid of borax		Acid of borax	Acid of borax	Acid of borax		
19						Aerial acid		Aerial acid	Acid of Prussian blue	Acid of Prussian blue	Acid of Prussian blue	Acid of Prussian blue	Acid of Prussian blue	Acid of Prussian blue	Acid of Prussian blue	Acid of Prussian blue	Acid of Prussian blue	Acid of Prussian blue	Acid of Prussian blue
20									Aerial acid	Aerial acid		Aerial acid	Aerial acid		Aerial acid	Aerial acid	Aerial acid	Aerial acid	
21				Fixed alkali				Pure fixed alkali	Pure fixed alkali		Fixed alkali								Fixed alkali
22				Volatile alkali		Pure volatile alkali			Pure volatile alkali		Volatile alkali	Volatile alkali	Volatile alkali	Volatile alkali	Volatile alkali	Volatile alkali			Volatile alkali
23									Expressed oils					Unctuous oils					
30														Water					Water

In the DRY WAY.

	GOLD	PLATINA	SILVER	MERCURY	LEAD	COPPER	IRON	TIN	BISMUTH	NICKLE	ARSENIC	COBALT	ZINC	ANTIMONY	MANGANESE	SIDERITE
32	Mercury	Arsenic	Lead	Gold	Gold	Gold	Nickle	Zinc	Lead	Iron	Nickle	Iron	Copper	Iron	Copper	Cobalt
33	Copper	Gold	Copper	Silver	Silver	Silver	Cobalt	Mercury	Silver	Cobalt	Cobalt	Nickle	Antimony	Copper	Iron	Nickle
34	Silver	Copper	Mercury	Platina	Copper	Arsenic	Manganese	Copper	Gold	Arsenic	Copper	Arsenic	Tin	Tin	Gold	Iron
35	Lead	Tin	Bismuth	Lead	Mercury	Iron	Arsenic	Antimony	Mercury	Copper	Iron	Copper	Mercury	Lead	Silver	Manganese
36	Bismuth	Bismuth	Tin	Tin	Bismuth	Manganese	Copper	Gold	Antimony	Gold	Silver	Gold	Silver	Nickle	Tin	
37	Tin	Zinc	Gold	Zinc	Tin	Zinc	Gold	Silver	Tin	Tin	Tin	Platina	Gold	Silver		
38	Antimony	Antimony	Antimony	Bismuth	Antimony	Antimony	Silver	Lead	Copper	Antimony	Lead	Tin	Cobalt	Bismuth		
39	Iron	Nickle	Iron	Copper	Platina	Platina	Tin	Iron	Platina	Platina	Gold	Antimony	Arsenic	Zinc		
40	Platina	Cobalt	Manganese	Antimony	Arsenic	Tin	Antimony	Manganese	Nickle	Bismuth	Platina	Zinc	Platina	Gold		
41	Zinc	Manganese	Zinc	Arsenic	Zinc	Lead	Platina	Nickle	Iron	Lead	Zinc		Bismuth	Platina		
42	Nickle	Iron	Arsenic	Iron	Nickle	Nickle	Bismuth	Arsenic	Zinc	Silver	Antimony		Lead	Mercury		
43	Arsenic	Lead	Nickle		Iron	Bismuth	Lead	Platina		Zinc			Nickle	Arsenic		
44	Cobalt	Silver	Platina			Cobalt	Mercury	Bismuth					Iron	Cobalt		
45	Manganese	Mercury				Mercury		Cobalt								
47	Saline liver of sulphur	Saline liver of sulphur	Saline liver of sulphur	Saline liver of sulphur	Saline liver of sulphur	Saline liver of sulphur	Saline liver of sulphur	Saline liver of sulphur	Saline liver of sulphur	Saline liver of sulphur	Saline liver of sulphur	Saline liver of sulphur		Saline liver of sulphur	Saline liver of sulphur	
48			Sulphur	Sulphur	Sulphur	Sulphur	Sulphur	Sulphur	Sulphur	Sulphur	Sulphur	Sulphur		Sulphur		

S I

No.

In the Moist Way.

	21 Acid of Fat	22 Acid of Phosphorus	23 Acidum Perlatum	24 Acid of Prussian Blue	25 Aerial Acid	26 Pure Vegetable Alkali	27 Pure Fossil Alkali
2	Lime	Lime	Lime *	Pure vegetable alkali	Pure ponderous earth	Vitriolic acid	Vitriolic acid
3	Pure ponderous earth	Pure ponderous earth	Pure ponderous earth	Pure fossil alkali	Lime	Nitrous acid	Nitrous acid
4	Pure magnesia	Pure magnesia	Pure magnesia	Pure volatile alkali	Pure vegetable alkali	Marine acid	Marine acid
5	Pure vegetable alkali	Pure vegetable alkali	Pure vegetable alkali	Lime	Pure fossil alkali	Acid of fat	Acid of fat
6	Pure fossil alkali	Pure fossil alkali	Pure fossil alkali	Pure ponderous earth	Pure magnesia	Fluor acid	Fluor acid
7	Pure volatile alkali	Pure volatile alkali	Pure volatile alkali	Pure magnesia	Pure volatile alkali	Phosphoric acid	Phosphoric acid
8	Pure clay	Pure clay	Pure clay	Pure clay	Pure clay	Acid of sugar	Acid of sugar
9	Calx of zinc	Calx of zinc	Calx of zinc	Calx of zinc	Calx of zinc	Acid of tartar	Acid of tartar
10	Calx of iron	Calx of iron	Calx of iron	Calx of iron	Calx of iron	Acid of arsenic	Acid of arsenic
11	Calx of manganese	Calx of manganese	Calx of manganese	Calx of manganese	Calx of manganese	Acid of sorrel	Acid of sorrel
12	Calx of cobalt	Calx of cobalt	Calx of cobalt	Calx of cobalt	Calx of cobalt	Acid of amber	Acid of amber
13	Calx of nickle	Calx of nickle	Calx of nickle	Calx of nickle	Calx of nickle	Acid of lemon	Acid of lemon
14	Calx of lead	Calx of lead	Calx of lead	Calx of lead	Calx of lead	Acid of ants	Acid of ants
15	Calx of tin	Calx of tin	Calx of tin	Calx of tin	Calx of tin	Acid of milk	Acid of milk
16	Calx of copper	Calx of copper	Calx of copper	Calx of copper	Calx of copper	Acid of benzoin	Acid of benzoin
17	Calx of bismuth	Calx of bismuth	Calx of bismuth	Calx of bismuth	Calx of bismuth	Acetous acid	Acetous acid
18	Calx of antimony	Calx of antimony	Calx of antimony	Calx of antimony	Calx of antimony	Acidum perlatum	Acidum perlatum
19	Calx of arsenic	Calx of arsenic	Calx of arsenic	Calx of arsenic	Calx of arsenic	Acid of sugar of milk	Acid of sugar of milk
20	Calx of mercury	Calx of mercury	Calx of mercury	Calx of mercury	Calx of mercury	Acid of borax	Acid of borax
21	Calx of silver	Calx of silver	Calx of silver	Calx of silver	Calx of silver	Phlogisticated vitriolic acid	Phlogisticated vitriolic acid
22	Calx of gold	Calx of gold	Calx of gold	Calx of gold	Calx of gold	Phlogisticated nitrous acid	Phlogisticated nitrous acid
23	Calx of platina	Calx of platina	Calx of platina	Calx of platina	Calx of platina	Aerial acid	Aerial acid
24	Water	Water	Water	Water	Water	Acid of Prussian blue	Acid of Prussian blue
25	Spirit of wine	Spirit of wine			Spirit of wine	Water	Water
26	Phlogiston	Phlogiston	Phlogiston			Unctuous oils	Unctuous oils
27						Sulphur	Sulphur
28						Metallic calces	Metallic calces
29							
30							

	28 Pure Volatile Alkali	29 Pure Ponderous Earth	30 Lime	31 Pure Magnesia	32 Pure Clay	33 Pure Siliceous Earth
2	Vitriolic acid	Vitriolic acid	Acid of sugar	Acid of sugar	Vitriolic acid	Acid of fluor
3	Nitrous acid	Acid of sugar	Acid of sorrel	Acid of phosphorus	Nitrous acid	Pure vegetable alkali
4	Marine acid	Acid of amber	Vitriolic acid	Acidum perlatum	Marine acid	
5	Acid of fat	Fluor acid	Acid of tartar	Vitriolic acid	Acid of sugar	
6	Fluor acid	Acid of sorrel	Acid of amber	Fluor acid	Acid of arsenic	
7	Phosphoric acid	Phosphoric acid	Phosphoric acid	Acid of fat	Fluor acid	
8	Acid of sugar	Acidum perlatum	Acidum perlatum	Acid of arsenic	Acid of fat	
9	Acid of tartar	Acid of sugar of milk	Acid of sugar of milk	Acid of sugar of milk	Acid of sorrel	
10	Acid of arsenic	Nitrous acid	Nitrous acid	Acid of amber	Acid of tartar	
11	Acid of sorrel	Marine acid	Marine acid	Nitrous acid	Acid of amber	
12	Acid of amber	Acid of fat	Acid of fat	Marine acid	Acid of sugar of milk	
13	Acid of lemon	Acid of lemon	Fluor acid	Acid of sorrel	Acid of lemon	
14	Acid of ants	Acid of tartar	Acid of arsenic	Acid of tartar	Acid of phosphorus	
15	Acid of milk	Acid of arsenic	Acid of ants	Acid of lemon	Acidum perlatum	
16	Acid of benzoin	Acid of ants	Acid of milk	Acid of ants	Acid of ants	
17	Acetous acid	Acid of milk	Acid of lemon	Acid of milk	Acid of milk	
18	Acidum perlatum	Acid of benzoin	Acid of benzoin	Acid of benzoin	Acid of benzoin	
19	Acid of sugar of milk	Acetous acid	Acetous acid	Acetous acid	Acetous acid	
20	Acid of borax	Acid of borax	Acid of borax	Acid of borax	Acid of borax	
21	Phlogisticated vitriolic acid	Phlogisticated vitriolic acid	Phlogisticated vitriolic acid	Phlogisticated vitriolic acid	Phlogisticated vitriolic acid	
22	Phlogisticated nitrous acid	Phlogisticated nitrous acid	Phlogisticated nitrous acid	Phlogisticated nitrous acid	Phlogisticated nitrous acid	
23	Aerial acid	Aerial acid	Aerial acid	Aerial acid	Aerial acid	
24	Acid of Prussian blue	Acid of Prussian blue	Acid of Prussian blue	Acid of Prussian blue	Acid of Prussian blue	
25	Water	Water	Water			
26	Unctuous oils	Unctuous oils	Unctuous oils			
27	Sulphur	Sulphur	Sulphur	Sulphur		
28	Phlogiston					
29						
30						

	34 Water	35 Vital Air	36 Phlogiston	37 Matter of Heat	38 Sulphur	39 Saline Liver of Sulphur	40 Alcohol
2	Pure vegetable alkali	Phlogiston	Nitrous acid	Vital air	Calx of lead	Calx of gold	Water
3	Pure fossil alkali		Vitriolic acid	Æther	Calx of tin	Calx of silver	Æther
4	Pure volatile alkali		Dephlogisticated marine acid	Alcohol	Calx of silver	Calx of mercury	Essential oils
5	Alcohol		Acid of arsenic	Pure volatile alkali	Calx of mercury	Calx of arsenic	Pure volatile alkali
6	Aerated volatile alkali		Phosphoric acid	Water	Calx of arsenic	Calx of antimony	Pure fixed alkali
7	Vitriolated fossil alkali			Essential oils	Calx of antimony	Calx of bismuth	Saline hepar
8	Æther			Glass	Calx of iron	Calx of copper	Sulphur
9			Calx of platina	Mercury	Pure fixed vegetable alkali	Calx of tin	
10			Calx of gold		Pure volatile alkali	Calx of lead	
11			Calx of silver		Pure ponderous earth	Calx of nickle	
12			Calx of mercury		Lime	Calx of cobalt	
13			Calx of arsenic		Pure magnesia	Calx of manganese	
14			Calx of antimony			Calx of iron	
15			Calx of bismuth				
16	Vitriolic acid		Calx of copper				
17	Vitriolated vegetable alkali		Calx of tin				
18	Vitriolated clay		Calx of lead				
19	Vitriolated iron		Calx of nickle				
20	Corrosive sublimate mercury		Calx of cobalt				
21			Calx of manganese				
22			Calx of iron				
23			Calx of zinc				
27					Unctuous oil		
28					Essential oil		
29					Æther	Alcohol	
30			Water		Alcohol	Water	

In the Dry Way.

	21	22	23	24	25	26	27
31	Lime	Lime	Lime			Phosphoric acid	Phosphoric acid
32	Pure ponderous earth	Pure ponderous earth	Pure ponderous earth			Acidum perlatum	Acidum perlatum
33						Acid of borax	Acid of borax
34	Pure magnesia	Pure magnesia	Pure magnesia			Acid of arsenic	Acid of arsenic
35	Pure vegetable alkali	Pure vegetable alkali	Pure vegetable alkali			Vitriolic acid	Vitriolic acid
36	Pure fossil alkali	Pure fossil alkali	Pure fossil alkali			Nitrous acid	Nitrous acid
37	Metallic calces	Metallic calces	Metallic calces			Marine acid	Marine acid
38	Pure volatile alkali	Pure volatile alkali	Pure volatile alkali			Acid of fat	Acid of fat
39	Pure clay	Pure clay	Pure clay			Fluor acid	Fluor acid
40						Acid of amber	Acid of amber
41						Acid of ants	Acid of ants
42						Acid of milk	Acid of milk
43						Acid of benzoin	Acid of benzoin
44						Acetous acid	Acetous acid
45						Pure ponderous earth	Pure ponderous earth
46						Lime	Lime
47						Pure magnesia	Pure magnesia
48						Pure clay	Pure clay
49						Pure siliceous earth	Pure siliceous earth
50						Sulphur	Sulphur

	28	29	30	31	32	33
31		Phosphoric acid	Phosphoric acid	Phosphoric acid	Phosphoric acid	
32		Acidum perlatum	Acidum perlatum	Acidum perlatum	Acidum perlatum	
33		Acid of borax	Acid of borax	Acid of borax	Acid of borax	
34		Acid of arsenic	Acid of arsenic	Acid of arsenic	Acid of arsenic	
35	Vitriolic acid	Vitriolic acid	Vitriolic acid	Vitriolic acid	Vitriolic acid	
36	Nitrous acid	Acid of amber	Acid of amber	Acid of fluor	Nitrous acid	
37	Marine acid	Fluor acid	Nitrous acid	Acid of fat	Marine acid	
38	Acid of fat	Nitrous acid	Marine acid	Acid of amber	Fluor acid	
39	Fluor acid	Marine acid	Acid of fat	Nitrous acid	Acid of fat	
40	Acid of amber	Acid of fat	Fluor acid	Marine acid	Acid of amber	
41	Acid of ants	Acid of ants	Acid of ants	Acid of ants	Acid of ants	
42	Acid of milk	Acid of milk	Acid of milk	Acid of milk	Acid of milk	
43	Acid of benzoin	Acid of benzoin	Acid of benzoin	Acid of benzoin	Acid of benzoin	
44	Acetous acid	Acetous acid	Acetous acid	Acetous acid	Acetous acid	
45	Pure ponderous earth					
46	Lime	Pure fixed alkali	Pure fixed alkali	Pure fixed alkali	Pure fixed alkali	Pure fixed alkali
47	Pure magnesia					
48	Pure clay	Sulphur	Sulphur	Sulphur	Sulphur	Phosphoric acid
49	Pure siliceous earth					
50	Sulphur	Calx of lead	Calx of lead	Calx of lead	Calx of lead	Calx of lead

	34	35	36	37	38	39	40
31			Calx of platina		Pure fixed alkali	Manganese	
32			Calx of gold		Iron	Iron	
33			Acid of arsenic		Copper	Copper	
34			Calx of silver		Tin	Tin	
35			Calx of mercury		Lead	Lead	
36			Calx of arsenic		Silver	Silver	
37			Calx of antimony		Cobalt	Gold	
38			Calx of bismuth		Nickle	Antimony	
39			Calx of copper		Bismuth	Cobalt	
40			Calx of tin		Antimony	Nickle	
41			Calx of lead		Mercury	Bismuth	
42			Calx of nickle		Arsenic	Mercury	
43			Calx of cobalt			Arsenic	
44			Calx of manganese				
45			Calx of iron				
46			Calx of zinc				

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To.

SINGLE ELECTIV ATTRACTIONS.

In the MOIST WAY.

No	1 Vitriolic Acid	2 Phlogisticated Vitriolic Acid	3 Nitrous Acid	4 Phlogisticated Nitrous Acid	5 Marine Acid	6 Dephlogisticated Marine Acid	7 Aqua Regia	8 Acid of Fluor	9 Acid of Arsenic	10 Acid of Borax	11 Acid of Sugar	12 Acid of Tartar	13 Acid of Sorrel	14 Acid of Lemon	15 Acid of Benzoin	16 Acid of Amber	17 Acid of Sugar of Milk	18 Acetous Acid distilled	19 Acid of Milk	20 Acid of Ants
2	Pure ponderous earth	Pure ponderous earth	Pure vegetable alkali?	Pure vegetable alkali?	Pure vegetable alkali?	Pure vegetable alkali?	Pure vegetable alkali?	Lime	Lime	Lime	Lime	Lime	Lime	Lime	Lime	Pure ponderous earth	Lime	Pure ponderous earth	Pure ponderous earth	Pure ponderous earth
3	Pure vegetable alkali	Pure vegetable alkali	Pure fossil alkali?	Pure fossil alkali?	Pure fossil alkali?	Pure fossil alkali?	Pure fossil alkali?	Pure ponderous earth	Pure ponderous earth	Pure ponderous earth	Pure ponderous earth	Pure ponderous earth	Pure ponderous earth	Pure ponderous earth	Pure ponderous earth	Lime	Pure ponderous earth	Pure vegetable alkali	Pure vegetable alkali	Pure vegetable alkali
4	Pure fossil alkali	Pure fossil alkali	Pure ponderous earth?	Pure ponderous earth?	Pure ponderous earth?	Pure ponderous earth?	Pure ponderous earth?	Pure magnesia	Pure magnesia	Pure magnesia	Pure magnesia	Pure magnesia	Pure magnesia	Pure magnesia	Pure magnesia	Pure magnesia	Pure magnesia	Pure fossil alkali	Pure fossil alkali	Pure fossil alkali
5	Lime	Lime	Lime	Lime	Lime	Lime	Lime	Pure vegetable alkali	Pure vegetable alkali	Pure vegetable alkali	Pure vegetable alkali	Pure vegetable alkali	Pure vegetable alkali	Pure vegetable alkali	Pure vegetable alkali	Pure vegetable alkali	Pure vegetable alkali	Pure volatile alkali	Pure volatile alkali	Pure volatile alkali
6	Pure magnesia	Pure magnesia	Pure magnesia	Pure magnesia	Pure magnesia	Pure magnesia	Pure magnesia	Pure fossil alkali	Pure fossil alkali	Pure fossil alkali	Pure fossil alkali	Pure fossil alkali	Pure fossil alkali	Pure fossil alkali	Pure fossil alkali	Pure fossil alkali	Pure fossil alkali	Lime	Lime	Lime
7	Pure volatile alkali	Pure volatile alkali	Pure volatile alkali	Pure volatile alkali	Pure volatile alkali	Pure volatile alkali	Pure volatile alkali	Pure volatile alkali	Pure volatile alkali	Pure volatile alkali	Pure volatile alkali	Pure volatile alkali	Pure volatile alkali	Pure volatile alkali	Pure volatile alkali	Pure volatile alkali	Pure volatile alkali	Pure magnesia	Pure magnesia	Pure magnesia
8	Pure clay	Pure clay	Pure clay	Pure clay	Pure clay	Pure clay	Pure clay	Pure clay	Pure clay	Pure clay	Pure clay	Pure clay	Pure clay	Pure clay	Pure clay	Pure clay	Pure clay	Pure clay	Pure clay	Pure clay
9	Calx of zinc	Calx of zinc	Calx of zinc	Calx of zinc	Calx of zinc	Calx of zinc	Calx of zinc	Calx of zinc	Calx of zinc	Calx of zinc	Calx of zinc	Calx of zinc	Calx of zinc	Calx of zinc	Calx of zinc	Calx of zinc	Calx of zinc	Calx of zinc	Calx of zinc	Calx of zinc
10	Calx of iron	Calx of iron	Calx of iron	Calx of iron	Calx of iron	Calx of iron	Calx of iron	Calx of iron	Calx of iron	Calx of iron	Calx of iron	Calx of iron	Calx of iron	Calx of iron	Calx of iron	Calx of iron	Calx of iron	Calx of iron	Calx of iron	Calx of iron
11	Calx of manganese	Calx of manganese	Calx of manganese	Calx of manganese	Calx of manganese	Calx of manganese	Calx of manganese	Calx of manganese	Calx of manganese	Calx of manganese	Calx of manganese	Calx of manganese	Calx of manganese	Calx of manganese	Calx of manganese	Calx of manganese	Calx of manganese	Calx of manganese	Calx of manganese	Calx of manganese
12	Calx of cobalt	Calx of cobalt	Calx of cobalt	Calx of cobalt	Calx of cobalt	Calx of cobalt	Calx of cobalt	Calx of cobalt	Calx of cobalt	Calx of cobalt	Calx of cobalt	Calx of cobalt	Calx of cobalt	Calx of cobalt	Calx of cobalt	Calx of cobalt	Calx of cobalt	Calx of cobalt	Calx of cobalt	Calx of cobalt
13	Calx of nickle	Calx of nickle	Calx of nickle	Calx of nickle	Calx of nickle	Calx of nickle	Calx of nickle	Calx of nickle	Calx of nickle	Calx of nickle	Calx of nickle	Calx of nickle	Calx of nickle	Calx of nickle	Calx of nickle	Calx of nickle	Calx of nickle	Calx of nickle	Calx of nickle	Calx of nickle
14	Calx of lead	Calx of lead	Calx of lead	Calx of lead	Calx of lead	Calx of lead	Calx of lead	Calx of lead	Calx of lead	Calx of lead	Calx of lead	Calx of lead	Calx of lead	Calx of lead	Calx of lead	Calx of lead	Calx of lead	Calx of lead	Calx of lead	Calx of lead
15	Calx of tin	Calx of tin	Calx of tin	Calx of tin	Calx of tin	Calx of tin	Calx of tin	Calx of tin	Calx of tin	Calx of tin	Calx of tin	Calx of tin	Calx of tin	Calx of tin	Calx of tin	Calx of tin	Calx of tin	Calx of tin	Calx of tin	Calx of tin
16	Calx of copper	Calx of copper	Calx of copper	Calx of copper	Calx of copper	Calx of copper	Calx of copper	Calx of copper	Calx of copper	Calx of copper	Calx of copper	Calx of copper	Calx of copper	Calx of copper	Calx of copper	Calx of copper	Calx of copper	Calx of copper	Calx of copper	Calx of copper
17	Calx of bismuth	Calx of bismuth	Calx of bismuth	Calx of bismuth	Calx of bismuth	Calx of bismuth	Calx of bismuth	Calx of bismuth	Calx of bismuth	Calx of bismuth	Calx of bismuth	Calx of bismuth	Calx of bismuth	Calx of bismuth	Calx of bismuth	Calx of bismuth	Calx of bismuth	Calx of bismuth	Calx of bismuth	Calx of bismuth
18	Calx of antimony	Calx of antimony	Calx of antimony	Calx of antimony	Calx of antimony	Calx of antimony	Calx of antimony	Calx of antimony	Calx of antimony	Calx of antimony	Calx of antimony	Calx of antimony	Calx of antimony	Calx of antimony	Calx of antimony	Calx of antimony	Calx of antimony	Calx of antimony	Calx of antimony	Calx of antimony
19	Calx of arsenic	Calx of arsenic	Calx of arsenic	Calx of arsenic	Calx of arsenic	Calx of arsenic	Calx of arsenic	Calx of arsenic	Calx of arsenic	Calx of arsenic	Calx of arsenic	Calx of arsenic	Calx of arsenic	Calx of arsenic	Calx of arsenic	Calx of arsenic	Calx of arsenic	Calx of arsenic	Calx of arsenic	Calx of arsenic
20	Calx of mercury	Calx of mercury	Calx of mercury	Calx of mercury	Calx of mercury	Calx of mercury	Calx of mercury	Calx of mercury	Calx of mercury	Calx of mercury	Calx of mercury	Calx of mercury	Calx of mercury	Calx of mercury	Calx of mercury	Calx of mercury	Calx of mercury	Calx of mercury	Calx of mercury	Calx of mercury
21	Calx of silver	Calx of silver	Calx of silver	Calx of silver	Calx of silver	Calx of silver	Calx of silver	Calx of silver	Calx of silver	Calx of silver	Calx of silver	Calx of silver	Calx of silver	Calx of silver	Calx of silver	Calx of silver	Calx of silver	Calx of silver	Calx of silver	Calx of silver
22	Calx of gold	Calx of gold	Calx of gold	Calx of gold	Calx of gold	Calx of gold	Calx of gold	Calx of gold	Calx of gold	Calx of gold	Calx of gold	Calx of gold	Calx of gold	Calx of gold	Calx of gold	Calx of gold	Calx of gold	Calx of gold	Calx of gold	Calx of gold
23	Calx of platina	Calx of platina	Calx of platina	Calx of platina	Calx of platina	Calx of platina	Calx of platina	Calx of platina	Calx of platina	Calx of platina	Calx of platina	Calx of platina	Calx of platina	Calx of platina	Calx of platina	Calx of platina	Calx of platina	Calx of platina	Calx of platina	Calx of platina
24	Water	Water	Water	Water	Water	Water	Water	Water	Phlogiston	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
25	Spirit of wine	Spirit of wine	Spirit of wine	Spirit of wine	Spirit of wine	Spirit of wine	Spirit of wine	Spirit of wine	Water	Spirit of wine	Spirit of wine	Spirit of wine	Spirit of wine	Spirit of wine	Spirit of wine	Spirit of wine	Spirit of wine	Spirit of wine	Spirit of wine	Spirit of wine
26	Phlogiston	Phlogiston	Phlogiston	Phlogiston	Phlogiston	Phlogiston	Phlogiston	Pure siliceous earth	Spirit of wine	Phlogiston	Phlogiston	Phlogiston	Phlogiston	Phlogiston	Phlogiston	Phlogiston	Phlogiston	Phlogiston	Phlogiston	Phlogiston
27																				
28																				
29																				
30																				

In the DRY WAY.

No	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
31	Phlogiston		Phlogiston		Phlogiston		Phlogiston		Phlogiston											
32	Pure vegetable alkali		Pure ponderous earth?		Pure ponderous earth?		Pure ponderous earth?	Lime	Lime	Lime					Lime	Pure ponderous earth	Lime	Pure ponderous earth	Pure ponderous earth	Pure ponderous earth
33	Pure fossil alkali		Pure vegetable alkali		Pure vegetable alkali		Pure vegetable alkali	Pure ponderous earth	Pure ponderous earth	Pure ponderous earth					Pure ponderous earth	Lime	Pure ponderous earth	Pure vegetable alkali	Pure vegetable alkali	Pure vegetable alkali
34	Pure pond. earth		Pure fossil alkali		Pure fossil alkali		Pure fossil alkali	Pure magnesia	Pure magnesia	Pure magnesia					Pure magnesia	Pure magnesia	Pure magnesia	Pure fossil alkali	Pure fossil alkali	Pure fossil alkali
35	Lime		Lime		Lime		Lime	Pure vegetable alkali	Pure vegetable alkali	Pure vegetable alkali					Pure vegetable alkali	Pure vegetable alkali	Pure vegetable alkali	Lime	Lime	Lime
36	Pure magnesia		Pure magnesia		Pure magnesia		Pure magnesia	Pure fossil alkali	Pure fossil alkali	Pure fossil alkali					Pure fossil alkali	Pure fossil alkali	Pure fossil alkali	Pure magnesia	Pure magnesia	Pure magnesia
37	Metallic calces		Metallic calces		Metallic calces		Metallic calces	Metallic calces	Metallic calces	Metallic calces					Metallic calces	Metallic calces	Metallic calces	Metallic calces	Metallic calces	Metallic calces
38	Pure volatile alkali		Pure volatile alkali		Pure volatile alkali		Pure volatile alkali	Pure volatile alkali	Pure volatile alkali	Pure volatile alkali					Pure volatile alkali	Pure volatile alkali	Pure volatile alkali	Pure volatile alkali	Pure volatile alkali	Pure volatile alkali
39	Pure clay		Pure clay		Pure clay		Pure clay	Pure clay	Pure clay	Pure clay					Pure clay	Pure clay	Pure clay	Pure clay	Pure clay	Pure clay
40																				
41																				
42																				
43																				
44																				
45																				
46																				
47																				
48																				
49																				
50																				

I N

5 ACID
getable al-

Chemical Signs explained.

Acids.

1. + ⊕ vitriolic
2. + ⊕🜍 — phlogisticated
3. + ⦶ nitrous
4. + ⦶🜍 — phlogisticated
5. + ⊖ marine
6. + ⊖🜄 — dephlogisticated
7. 🜅 Aqua regia
8. +F of fluor
9. ⚯ arsenic
10. + ⌂ borax
11. + ⊗ sugar
12. + 🜿 tartar
13. + ⊕ sorrel
14. + C lemon
15. + ⚯ benzoin
16. + ∞ amber
17. + ⊚ sugar of milk
18. ⁜ acetous distilled
19. + ⊚ milk
20. +f ants
21. + 8 fat
22. + 🜍 of phosphorus
23. + 🜍 perlatum
24. + ♁ of prussian blue

Alkalis.

26. ⊖√vp pure fixed vegetable
27. ⊖√mp pure fixed mineral
28. ⊖^p pure volatile

Earths.

29. ♆p pure ponderous
30. ♆p pure calcareous. Lime
31. ♆p pure magnesia
32. 🜄p pure argillaceous
33. 🜄p pure siliceous
34. ▽ water
35. △ vital air
36. 🜍 phlogiston
37. △ matter of heat
38. 🜍 sulphur
39. ⊖🜍 saline hepar
40. 🜄 spirit of wine
41. ∴ æther
42. ∴ essential oil
43. ◎ unctuous oil

Metallic Calces.

44. ♆☉ gold
45. ♆☽☾ platina
46. ♆☽ silver
47. ♆☿ mercury
48. ♆♄ lead
49. ♆♀ copper
50. ♆♂ iron
51. ♆♃ tin
52. ♆♉ bismuth
53. ♆8 nickle
54. ♆⚯ arsenic
55. ♆♌ cobalt
56. ♆ô zinc
57. ♆♁ antimony
58. ♆♁ manganese
59. ♆♂ siderite

… Moist Way.

	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58
1	🜁	⍋	△	⍋	⊖⍋	🜄	⁘	∴	◎	Ψ☉	Ψ☽☉	Ψ☽	Ψ☿	Ψ♄	Ψ♀	Ψ♂	Ψ♃	Ψ♉	Ψ⚲	Ψ⚯	Ψ☊	ΨÔ	Ψ♁	ΨФ
2	⍋	+⦶	🜁	Ψ♄	Ψ☉	▽	🜄	⁘	⁘	⁘	⁘	+⊖	+8	+Ⓐ	+⊗	+⊗	+8	+⊗	+⊗	+⊖	+⊗	+⊗	+8	+⊗
3		+Ⓐ	⁘	Ψ♃	Ψ☽	⁘	∴	🜄	∴	+⊖	+⊖	+8	+⊖	+8	+⊓	+⊓	+⊓	⚮	+⌖	+⊗	+⌖	+Ⓐ	+⊖	+⌖
4		+⊖🜄	🜄	Ψ☽	Ψ☿	∴	◎	◎	⊖~p	VR	VR	+⊗	+⊗	+◎	+⊖	+Ⓐ	+⊖	+⌖	+⊖	+Ⓐ	+⊖	+⊖	+⊗	+C
5		⚮	⊖^c	Ψ☿	Ψ⚯	⊖~p	▽	⊖~p	⊖~p	+⦶	+⦶	+Ⓐ	+ↂ	+⊗	+Ⓐ	+◎	+Ⓐ	+⊓	+Ⓐ	+⦶	+Ⓐ	+◎	+Ⓐ	+⍋
6		+⍋	▽	Ψ⚯	Ψ♁	⊖~p	⍋	⍋	⍋	+Ⓐ	+Ⓐ	+◎	⚮	⚮	+◎	+⊖	+⊗	+⍋	+⊓	+8	+⊓	+⦶	+⦶	+⊓
7			∴	Ψ♁	Ψ♉	⊖⍋				⚮	⚮	+⍋	+⍋	+⊓	+⦶	+⦶	⚮	+Ⓐ	+⦶	+⊓	+⦶	+8	+⊓	+𝓕
8		Ψ☽☉	XX	Ψ♂	Ψ♀	⍋				+𝓕	+𝓕	+⦶	+Ⓐ	+⍋	+8	8	+⍋	+8	8	+⍋	+8	+⌖	+⌖	+⊖
9		Ψ☉	☿	⊖~p	Ψ♃					+⊓	+⊓	⚮	+◎	+⌖	⚮	+⍋	+⦶	+⊖	⍋	+⌖	+⍋	+⊓	+◎	+Ⓐ
10		Ψ☽		⊖~p	Ψ♄					+⍋	+⍋	+𝓕	+⊓	+⊖	+⍋	⚮	+ↀ	+⦶	+𝓕	+𝓕	+𝓕	+⍋	+⍋	+⦶
11		Ψ☿		Ψp	Ψ⚲					+8	+8	+⊓	+C	+⦶	+⌖	+⌖	+⌖	+𝓕	+◎	+◎	+◎	+C	+C	+◎
12		Ψ⚯		Ψp	Ψ☊					⍝	+⊗	+⌖	+⦶	+𝓕	+ↀ	+𝓕	+𝓕	+◎	+ↂ	+ↂ	+ↂ	+ↂ	+ↂ	+ↂ
13		Ψ♁		Ψp	ΨФ						+⌖	+C	+𝓕	+C	+𝓕	+ↂ	+◎	+ↂ	+C	+C	+C	+𝓕	+𝓕	+8
14		Ψ♉			Ψ♂						+C	+𝒻	⁜	+𝒻	+C	+C	+C	+C	+𝒻	+𝒻	+𝒻	⚮	⚮	⚮
15		Ψ♀									+𝒻	+⊽	+⌂	+⊽	+𝒻	+𝒻	+𝒻	+𝒻	+⊽	+⊽	+⊽	+𝒻	+𝒻	+𝒻
16		Ψ♃									⊽	⁜	+⍝	⁜	+⊽	+⊽	+⊽	+⊽	⁜	⚮	⁜	+⊽	+⊽	⊽
17		Ψ♄									⁜	+ↂ	🜁	⌂	⁜	⁜	⁜	⁜	⚮	⁜	⚮	⁜	⁜	⁜
18		Ψ⚲									+ↂ	⍝		+⍝	+⌂	+⌂	+⌂		+⌂		+⌂	+⌂	+⌂	
19		Ψ☊										🜁		🜁	+⍝	+⍝	+⍝	+⍝	+⍝	+⍝	+⍝	⍝	+⍝	⍝
20		ΨФ													🜁	🜁		🜁	🜁		🜁	🜁	🜁	🜁
21		Ψ♂								⊖v				⊖~p	⊖v		⊖v							
22		ΨÔ								⊖^		⊖~p			⊖^		⊖^	⊖^	⊖^	⊖^	⊖^	⊖^		
23																								
24														◎	◎					◎				
25																								
26				◎																				
27				∴																				
28				⁘																				
29				🜄	🜄																			
30		▽			▽							*In the Dry Way*								▽				
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34		Ψ☽		♃	♃					☽	♀	☿	☽☉	♀	⚯	Ф	♀	☉	⚯	♀	⚯	♃	♃	☉
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36		Ψ⚯		☽	☽					♉	♉	♃	♃	♉	Ф	♀	☉	♁	☉	☽	☉	☽	⚲	♃
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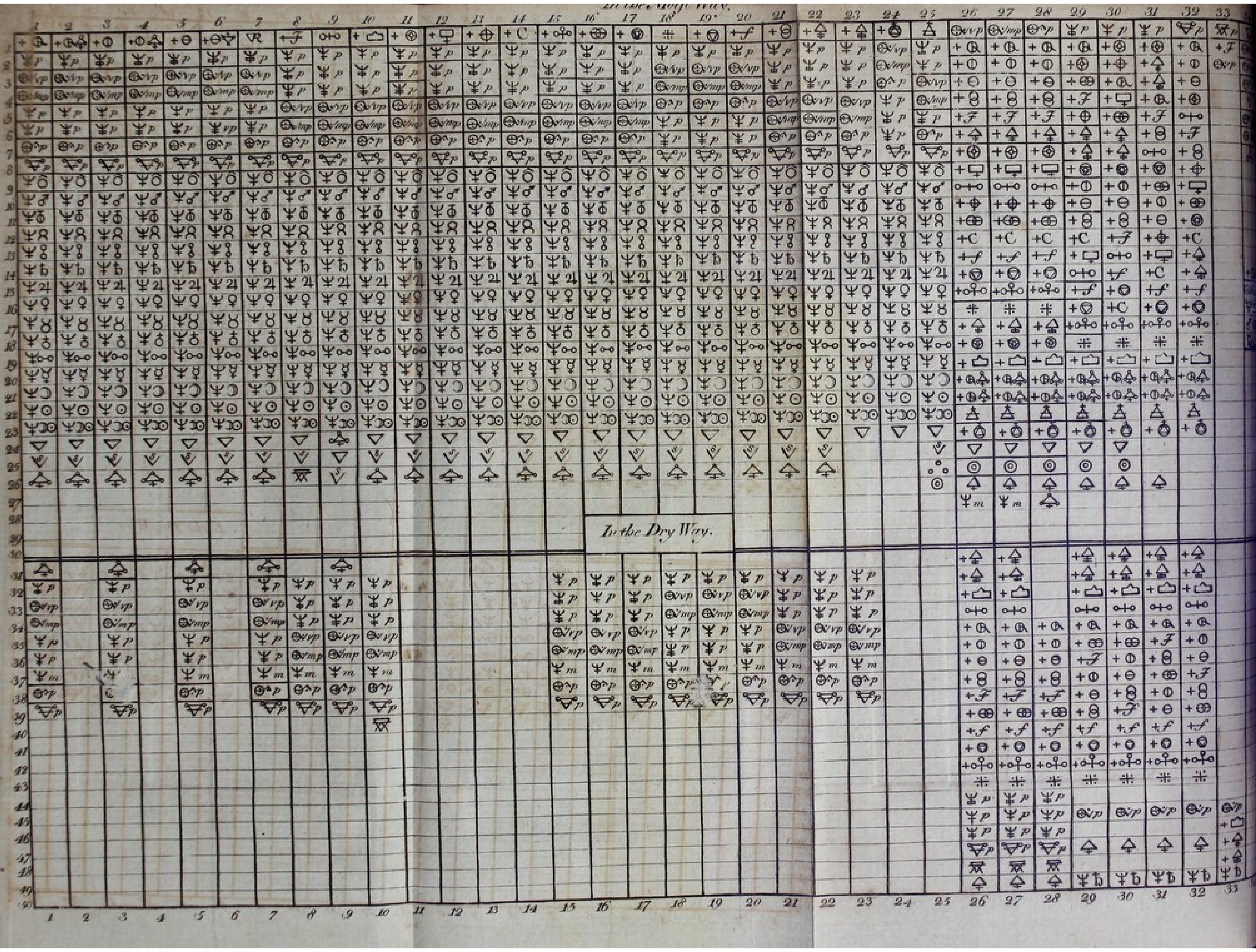

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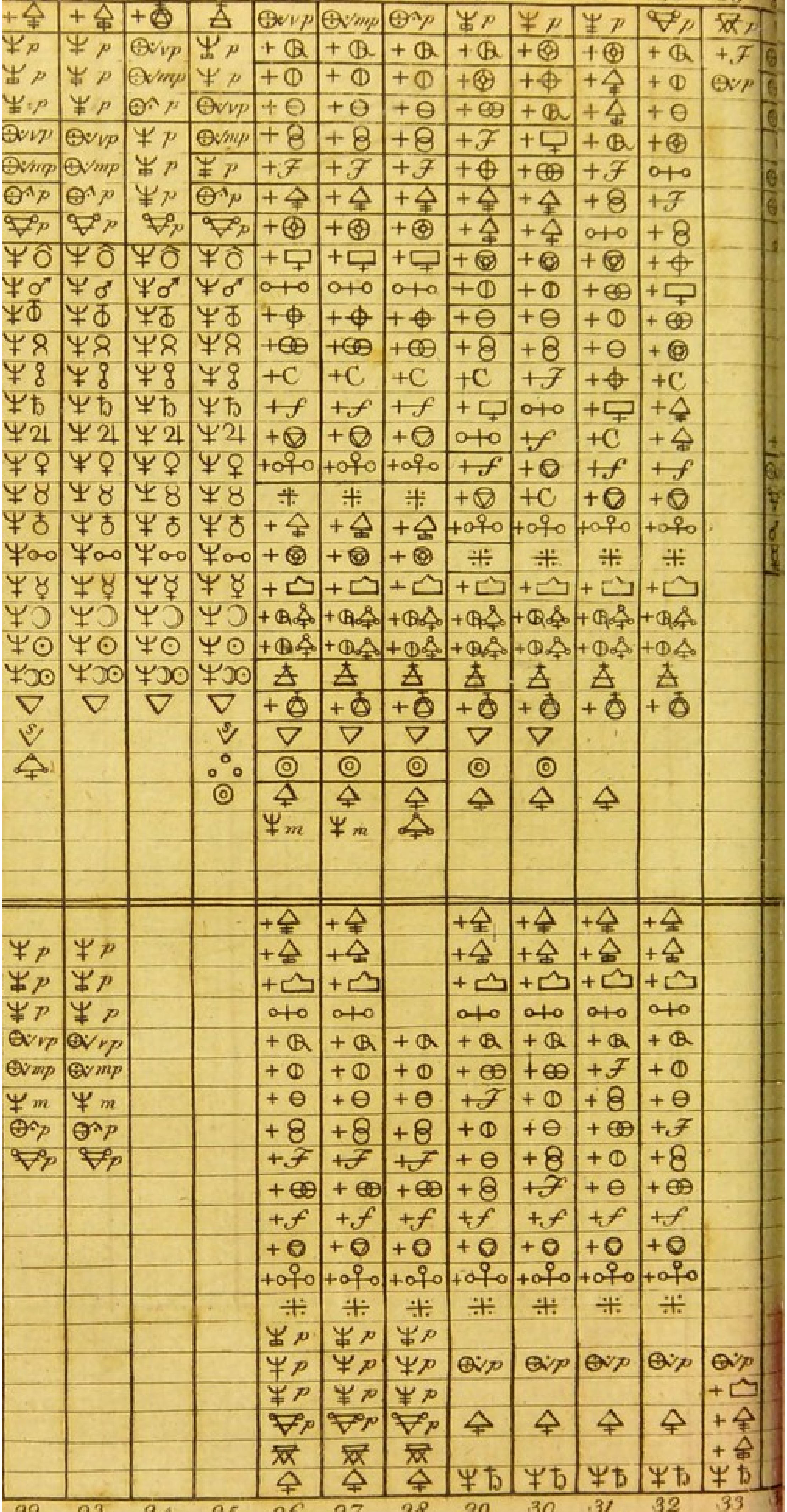

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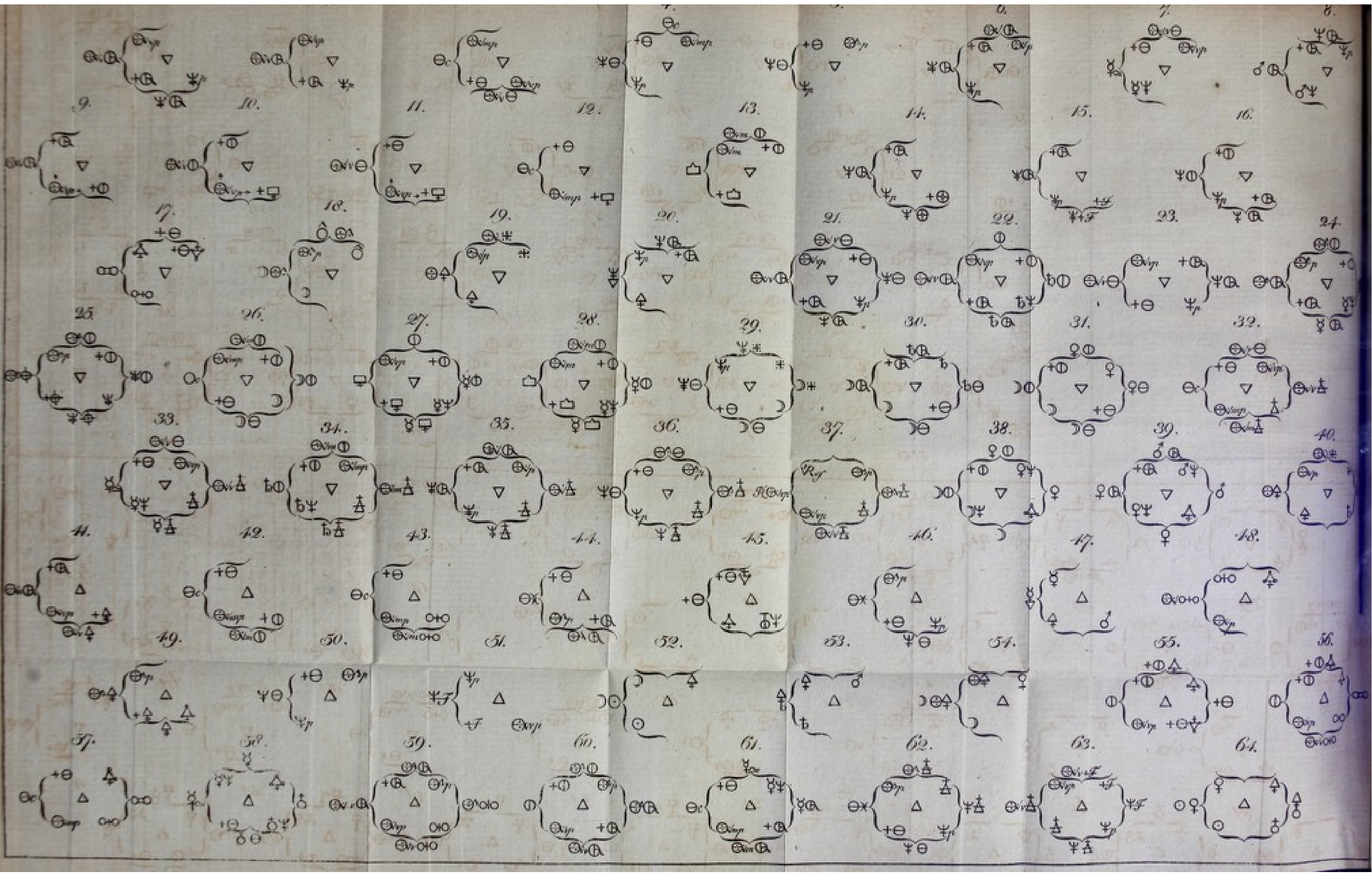
1. 2. 3. 4. 5. 6. 7. 8.
9. 10. 11. 12. 13. 14. 15. 16.
17. 18. 19. 20. 21. 22. 23. 24.
25. 26. 27. 28. 29. 30. 31. 32.
33. 34. 35. 36. 37. 38. 39. 40.
41. 42. 43. 44. 45. 46. 47. 48.
49. 50. 51. 52. 53. 54. 55. 56.
57. 58. 59. 60. 61. 62. 63. 64.

Explanation of the TABLE of Double Elective Attractions.

The first Forty take place in the Humid Way.

Scheme 1. represents the decomposition of vitriolated vegetable alkali by ponderous earth, the vitriolated ponderous earth falling down insoluble, and the pure alkali remaining in the water.

Scheme 2. shews that lime produces no such effect.

Scheme 3. the decomposition of muriated fossil alkali or sea-salt by pure vegetable alkali, the new compound and the disengaged alkali both remaining in the liquor.

Scheme 4. the decomposition of muriated lime (fixed ammoniac) by pure fossil alkali, the lime falling to the bottom.

Scheme 5. Lime produces no change in a solution of muriated fixed alkali.

Scheme 6. the decomposition of vitriolated magnesia (Epsom salt) by pure fixed alkali, the pure magnesia falling to the bottom, and the new compound being dissolved.

Scheme 7. the decomposition of corrosive sublimate by pure vegetable alkali, the mercurial calx falling down, and the new compound (digestive salt) being dissolved.

Scheme 8. the decomposition of vitriolated iron (green vitriol)by lime, both the metallic calx and the new compound (gypsum) being precipitated.

Schemes 9. 10. 11. These schemes are admirably explained in the ninth section; see also p. 170. The ninth represents the partial decomposition of vitriolated vegetable alkali by the nitrous acid: the tenth and eleventh that of nitre and digestive salt by the acid of tartar.

N. B. There is an error in the tenth Scheme of the original plate, which, as well as many others, is corrected in the Tables annexed to this Translation.

Scheme 12. shews, that, on the contrary, the acid of tartar does not, in any respect, change muriated fossil alkali (sea-salt).

Scheme 13. the decomposition of borax by nitrous acid, the new compound being dissolved, and the acid of borax appearing in a solid form.

Scheme

SCHEME 14. the decompoſition of vitriolated lime (gypſum) by acid of ſugar, the ſaccharated lime falling down inſoluble.

SCHEME 15. ſhews the decompoſition of vitriolated magneſia by fluor acid: but ſee p. 187.

SCHEME 16. ſhews the decompoſition of nitrated lime by vitriolic acid, the gypſum falling down.

SCHEME 17. ſhews the decompoſition of white arſenic by dephlogiſticated marine acid, the acid of arſenic appearing in a ſolid form.

SCHEME 18. ſhews that zinc precipitates ſilver from volatile alkali.

SCHEME 19. ſhews, that ſaline liver of ſulphur is decompoſed by the acetous acid, the ſulphur being precipitated.

N. B. This Scheme includes many others, *a fortiori.*

SCHEME 20. ſhews the decompoſition of calcareous liver of ſulphur by vitriolic acid, both gypſum and ſulphur falling down.

SCHEME 21. ſhews, that when ſolutions of vitriolated vegetable alkali and muriated lime are mixed, a double decompoſition takes place, the digeſtive ſalt being diſſolved, and the gypſum precipitated.

Scheme 22. ſhews, that when vitriolated vegetable alkali in ſolution is added to muriated lead (plumbum corneum), a double decompoſition takes place, the ſea-ſalt being diſſolved, and the vitriolated lead precipitated.

Scheme 23. ſhews, that when muriated vegetable alkali and vitriolated lime are mixed together, no double decompoſition takes place.

Scheme 24. ſhews, that when vitriolated volatile alkali and muriated mercury are added together, a double decompoſition takes place, the muriated volatile alkali (ſal ammoniac) being diſſolved, and the vitriolated mercury precipitated.

Scheme 25. ſhews, that when nitrated terra ponderoſa and oxalited volatile alkali are added together, an exchange of principles takes place, the oxalited earth falling down, and the nitrous ammoniac being diſſolved.

Scheme 26. ſhews the double decompoſition of nitrated ſilver and common ſalt, the new neutral ſalt (nitrated foſſil alkali) being diſſolved, and the muriated ſilver (argentum corneum) falling down.

Scheme 27. ſhews, that when tartar and nitrated mercury are mixed, they ſuffer a mutual decompoſition,

tion, the nitre being diſſolved, and the tartarized mercury precipitated.

Scheme 28. ſhews, that when borax and nitrated mercury are mixed, a double decompoſition takes place, the boraxated mercury falling down, and the nitrated foſſil alkali diſſolved.

Scheme 29. ſhews, that when muriated magneſia and acetated ſilver are mixed, an exchange of principles takes place, the acetated magneſia being diſſolved, and the muriated ſilver precipitated.

Scheme 30. ſhews, that when vitriolated ſilver and muriated lead are mixed, a double exchange happens, and both muriated ſilver and vitriolated lead fall down inſoluble.

Scheme 31. ſhews, that when nitrated ſilver and muriated copper are mixed together, a double decompoſition takes place, the nitrated copper being diſſolved, and the muriated ſilver falling down.

Scheme 32. ſhews, that when common ſalt and aerated vegetable alkali are mixed, a double exchange takes place, the digeſtive ſalt (muriated vegetable alkali) and the aerated foſſil alkali being both diſſolved.

SCHEME 33. ſhews, that when corroſive ſublimate and aerated vegetable alkali are mixed, a double decompoſition happens, the muriated vegetable alkali being diſſolved, and the aerated mercury precipitated.

SCHEME 34. ſhews, that when nitrated lead and aerated foſſil alkali are mixed, a double exchange is effected, the aerated lead falling down, and the nitrated foſſil alkali being diſſolved.

SCHEME 35. ſhews, that when vitriolated magneſia and aerated fixed alkali are mixed together, a double exchange takes place, the vitriolated alkali being diſſolved, and the aerated magneſia falling down.

SCHEME 36. ſhews, that when muriated lime and aerated volatile alkali are mixed together, a double exchange takes place, the muriated volatile alkali (ſal ammoniac) being diſſolved, and the aerated lime falling down.

SCHEME 37. ſhews, that when aerated volatile alkali is added to a tincture of pure vegetable alkali, the vegetable alkali combines with the aerial acid, and falls down, while the volatile alkali combines with the alcohol.

SCHEME 38. ſhews, that when to nitrated ſilver copper is added, a double exchange takes place, the phlogiſton

phlogiston of the copper unites with the silver, which falls down, and the nitrous acid with the copper, which is dissolved.

SCHEME 39. shews, that if iron be added to copper dissolved in vitriolic acid, the phlogiston combines with the calx of copper, which is precipitated, and the vitriolic acid with the calx of iron, which is dissolved.

SCHEME 40. shews, that when saline liver of sulphur is mixed with acetated lead, a double exchange takes place, the lead falling down with the sulphur, and the acetated alkali being dissolved.

N. B. I cannot undertake to assign the reason why those cases of double attraction which are effected by the tinging acid, in combination with alkalis, and, as I suppose, with absorbent earths, at least with lime, are omitted in the present Table. The nature of the operation could not be unknown to the author, because he mentions it expresly, p. 302. I see, indeed, that he has omitted others that were known to him; nay, that he mentions in this very dissertation; whether it was that the reader could easily infer them from those cases that are represented in the Schemes, or whether they were doubtful, or of small importance in practice: but none of these considerations apply to the attractions in question; for they seem to be well ascertained as to their theory, and are undoubtedly of daily occurrence in the practice of chemistry.

It remains, that the deficiency be, in ſome meaſure, ſupplied; and I cannot do this better than by the following table, which I have extracted from the author's eſſay on metallic precipitates. The firſt column ſhews the colour of the precipitate; the ſecond its quantity, from 100 grains of the regulus, diſſolved in ſome acid menſtruum.

	Colour.	Weight.
Gold,	yellow,	not perfectly precipitated.
Platina,		no precipitation.
Silver,	dark yellow,	145.
Mercury,	whitiſh at firſt; turns yellow when dry,	apt to be rediſſolved.
Lead,	white.	
Copper,	greeniſh yellow; blackiſh red when dry,	530.
Iron,	deep blue,	590.
Tin,	white,	250.
Biſmuth,	yellowiſh,	180.
Nickle,	yellow; dark brown when dry,	250.
Arſenic,	white,	180.
Cobalt,	bluiſh red; browniſh red when dry,	142.
Zinc,	white; citron yellow when dry,	495.
Antimony,	white,	138.
Manganeſe,	at firſt bluiſh, then yellowiſh blue, laſtly dark green.	

The

The precipitates of tin, bifmuth, nickle, antimony, and manganefe, generally have their colours altered by the admixture of particles of Pruffian blue, from the iron that is prefent. The ponderous earth is likewife precipitated by the combination of the tinging acid and alkali, (Preface to the Sciagraphia, and Withering, *ibid.*). Hence I imagined, that vitriolated ponderous earth might poffibly be decompounded by the fame powers. Having reduced a fmall quantity to a fine powder, I digefted it in the funfhine for feveral hours in a folution of Pruffian alkali, prepared according to Mr Scheele's method. After the fupernatant liquor was poured off, and the refiduum edulcorated, nitrous acid was added to it, which I fuppofed would expel the tinging acid from the earth, if any fuch union had taken place, and diffolve the latter ; but upon dropping fome vitriolic acid into the nitrous, no precipitation was obfervable, which fhews that it held no ponderous earth in folution. Whether this decompofition may be accomplifhed by applying a ftronger heat, or following other methods, I know not.

This experiment led me to doubt, whether the Pruffian alkali was capable of decompounding certain other compounds of acids and metals, befides the folution of platina. If any would refift its action, I thought vitriolated and muriated lead, and perhaps filver, to be the moft likely ; particularly the former, from the conjecture that Bergman has thrown out in the preface to his *Sciagraphia*, concerning the identity of the calx of lead and ponderous earth. I was, moreover, unable to recollect any thing satisfactory on this point in authors. Bergman himself, (Opusc. Diss. xxiii. § 5. letter E), says only, that "lead is "precipitated of a white colour from its solution in "nitrous acid by aerated and caustic fossil alkali, as "well as by Prussian alkali." I attempted, therefore, to satisfy myself, by repeating the foregoing experiment with vitriolated lead, except that I happened to use the acetous acid instead of the nitrous. But I now observed a white precipitate, both on the addition of vitriolic and muriatic acid, which seems to show, that a double decomposition had actually taken place. However, farther enquiry is necessary before any thing certain is determined; and I purpose to examine the several metallic salts above mentioned, when I have some tolerable convenience for making chemical experiments.

SCHEME 41. If vitriolated vegetable alkali be distilled with phosphoric acid, it will be decompounded; the vitriolic acid will be driven over, and the phosphorated alkali will remain at the bottom.

SCHEME 42. If common salt be subjected to distillation with nitrous acid, the marine acid will rise, and the nitrated fossil alkali remain in the retort.

SCHEME

Scheme 43. If common ſalt be ſubjected to diſtillation with acid of arſenic, the marine acid will riſe, and the arſenicated foſſil alkali remain in the retort.

Scheme 44. If muriated volatile alkali (ſal ammoniac) be diſtilled with vitriolic acid, the marine acid will riſe, and the vitriolated volatile alkali will likewiſe be ſublimed.

Scheme 45. If marine acid be diſtilled with the black calx of manganeſe, it will be dephlogiſticated and riſe, the white calx remaining fixed.

Scheme 46. If ſal ammoniac be treated with quicklime in diſtilling veſſels, the pure volatile alkali will ariſe, and the muriated lime remain.

Scheme 47. If ſulphurated mercury (cinnabar) be ſubjected to diſtillation with iron, the mercury will riſe in its metallic form, and the ſulphurated iron remain.

Scheme 48. If arſenicated fixed alkali be ſublimed with inflammable matter, the arſenic will riſe in a reguline form, and the alkali will remain?

Scheme 49. If phoſphorated volatile alkali be ſublimed with inflammable matter, it will be decompoſed, and the volatile alkali and phoſphorus will both ariſe?

Scheme

Scheme 50. ſhews, that muriated lime is not decompounded by being expoſed to diſtillation with volatile alkali.

Scheme 51. ſhews, that fluorated lime is not decompounded by being expoſed to fuſion in a crucible with fixed vegetable alkali.

Scheme 52. ſhews, that when an alloy of gold and ſilver is fuſed with ſulphur, the ſulphur combines with the ſilver, and leaves the gold free.

Scheme 53. ſhews, that when ſulphurated lead and iron are fuſed together, the ſulphur unites with the iron, and leaves the lead free.

Scheme 54. ſhews, that when copper is fuſed with a combination of ſaline liver of ſulphur and ſilver, the copper unites with the liver of ſulphur, and the ſilver is ſeparated.

Scheme 55. ſhews, that when nitre and muriatic acid are diſtilled together, the nitrous acid attracts the phlogiſton of the marine acid, and quits the vegetable alkali.

Scheme 56. ſhews, that when nitre and white arſenic are diſtilled together, the nitrous acid attracts

tracts the phlogiſton, and riſes, while the arſenical acid combines with the vegetable alkali.

Scheme 57. ſhews, that when common ſalt and white arſenic are ſubjected to diſtillation together, no change is effected.

Scheme 58. ſhews, that when corroſive ſublimate is ſubjected to diſtillation with regulus of antimony, the calx of the mercury unites with the phlogiſton of the antimony, and riſes, while the muriatic acid combines with the calx of antimony, and riſes in like manner.

Scheme 59. ſhews, that when vitriolated vegetable alkali is expoſed to ſublimation with arſenicated volatile alkali, the vitriolic acid combines with the volatile alkali, and riſes, while the arſenical acid combines with the vegetable alkali, and remains fixed.

Scheme 60. ſhews, that when nitrated vegetable alkali and vitriolated volatile alkali are expoſed to ſublimation, the nitrous acid riſes, combined with the volatile alkali, while the vitriolated vegetable alkali remains fixed.

Scheme 61. ſhews, that when muriated foſſil alkali and vitriolated mercury are ſublimed together, the muriatic acid combines with the mercury, and riſes, rifes, while the vitriolated foffil alkali remains at the bottom.

SCHEME 62. fhews, that when muriated volatile alkali and aerated lime are expofed to fublimation together, the aerial acid and volatile alkali rife combined, while the muriated lime remains fixed.

SCHEME 63. fhews, that when aerated vegetable alkali and fluorated lime are fufed together, the acid of fluor combines with the vegetable alkali, and the aerial acid with the lime, both remaining fixed.

SCHEME 64. fhews, that when an alloy of gold and copper is fufed with fulphurated antimony, the fulphur unites with the copper, and the gold with the antimony, both remaining fixed.

EMENDANDA.

P. 41. l. 16. add *vitriolated tartar, nitre, and ſome other ſalts, are thus thrown down.*

P. 66. l. the laſt, ſtrike out *or not.*

P. 68. l. 12. for *a* read *n.*

P. 107. l. 13. for *acids*, read *metals.*

P. 170. l. 5. after *manner*, inſert *the acids of.*

P. 182. l. 17. read the words, *which come next,* immediately after *ſea-ſalt.*

P. 236. l. 14. inſert : between the two laſt quantities of the equation.

P. 256. l. 17. after *ſpecific*, add *heats.*

N. B. There are a few *literal errors,* which the context will at once direct the reader how to correct: And if there be a few wrong ſtrokes yet remaining in TABLE III. they may be corrected from the correſponding Table of words.