



XLIV.—Observations and experiments concerning Mr. Davy's hypothesis of electro-chemical affinity

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impure acids and alkalies of commerce, are to be had every where. All the instruments and bottles are arranged in such a manner that they may be seen at one view when the chest is open, and they are so packed that they may readily be taken out; and, when replaced, fit in such a way, that the whole, when the chest is locked, may be turned upside down without risk of receiving injury.

Compton-Street, Soho,
March 1, 1811.

FREDRICK ACCUM.

XLIV.—*Observations and Experiments concerning Mr. Davy's Hypothesis of Electro-chemical Affinity.*—By M. DONOVAN, Esq.

[Concluded from p. 233.]

WHEN water is decomposed by means of metallic wires, which have an affinity for oxygen, the wire conveying positive electricity becomes oxidated. When a platina wire is employed, it does not oxidate. But by the hypothesis the union ought to take place; for the platina, naturally positive, has its energy considerably exalted, and consequently should unite with as much force to negative oxygen as any other metal under the same circumstances. The matter is simply thus: The cause of combination is attraction, the cause of attraction is existence in differently electric states: the more energetic these states are, the more violent is the attraction. Mr. Davy's words on this part of the subject are: "As the chemical attraction between two bodies seems to be destroyed by giving one of them an electric state different from that which it naturally possesses, that is, by bringing it artificially into a state similar to the other, so it may be increased by exalting its natural energy. Thus, while zinc, one of the most oxidable of the metals, is incapable of combining with oxygen when negatively electrified in the circuit, even by a feeble power; silver, one of the least oxidable, easily unites to it when positively electrified; and the same thing may be said of other metals." In the instance present, the oxygen is in the negative state, the platina is strongly positive, and precisely in the same circumstances as the silver in Mr. Davy's instance. Why then do they not combine with violence*?

It

* In the Philosophical Magazine, vol. xxxiii. p. 83, we find the following, from a Correspondent:

"Mr. Davy showed, by a refined application of his principles, that, in the decomposition of a neutral salt in solution, the order of the arrangement varies.

It would seem as if this one fact were sufficient to establish a decided difference between chemical affinity and electro-chemical attraction; since the former is absent, where the latter is present in an eminent degree.

Pursuing this reasoning, we find that, at the other wire, hydrogen is evolved. Mr. Davy has shown that the least oxidable metals easily unite to oxygen when their opposite states are exalted. Such is the case with silver. Now since silver in its natural state has little attraction to oxygen, and since in its exalted state it easily unites, is it an unfair conclusion, that, if made strongly negative, it should unite also to hydrogen? for, as the cause of combination is the same in both, we ought to obtain the compound of silver with hydrogen as well as that with oxygen. If there be any difference in the circumstances, it is that silver has naturally some attraction to oxygen, and none to hydrogen; which would cause the combination with the former to be somewhat more quickly formed than that with the latter.

Having now shown instances of bodies in different states, not combining, I proceed to the next position, that "bodies in similar states do combine."

With a view of ascertaining by direct means whether bodies in similar states of electricity do combine, I made the following experiment.

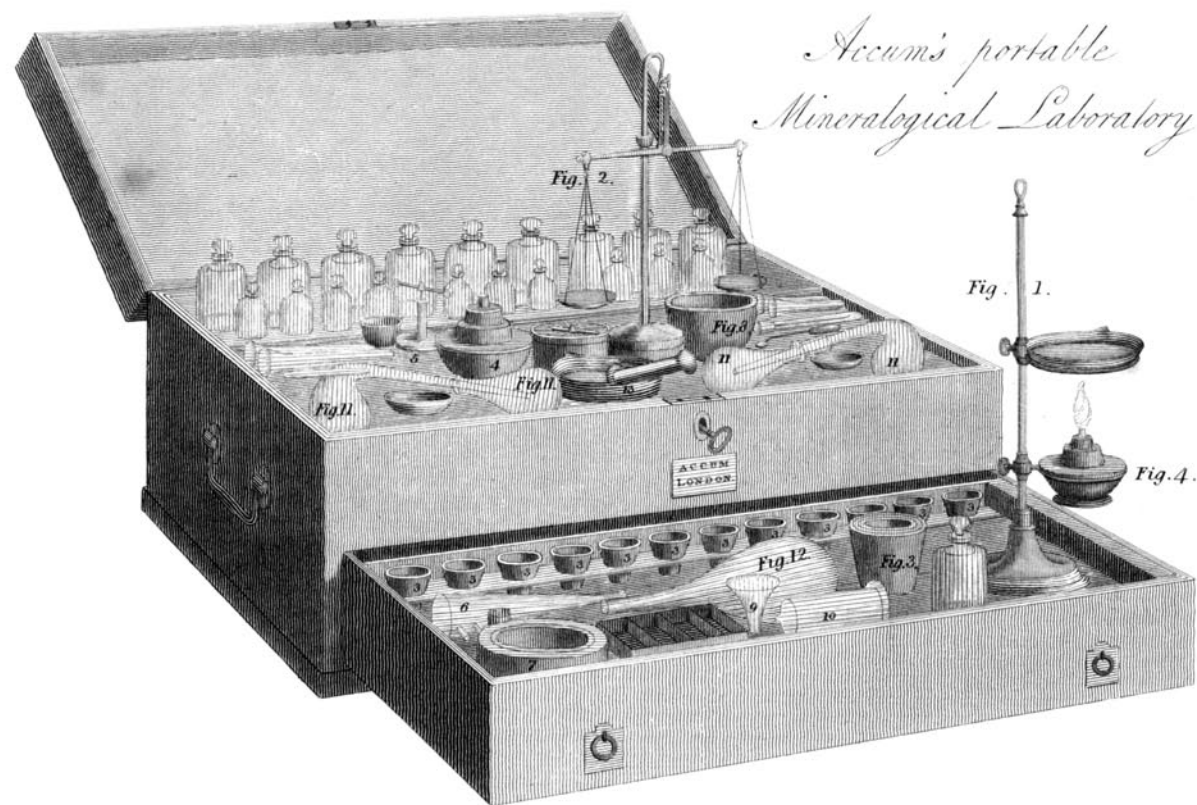
Two cylindrical vessels (Fig. 1, Plate V.) one of glass, the other of metal, are connected by a stop-cock in such a manner that the cock, when open, allows all the fluid of one vessel to flow into the other. The vessels are insulated, and have each a wooden stopper, through which a conductor forms a communication between an electric machine and the fluid within. There are quadrant and pith-ball electrometers, the ends of which also plunge in the fluid. The use of the conductors is to throw in an electricity, which must in both be of the same kind, as it is furnished from the same source; but to prove it beyond doubt is the use of the pith-balls, and can readily be done with sealing-wax in the usual manner. The quadrant electrometers in-

varies. When copper wires, which readily combine with oxygen and are easily soluble in acids, are used to transmit the electricity, the positive wire attracts the oxygen and acid, and repels the hydrogen and alkali. But when platina wires are employed, which have but a very slight affinity for oxygen, [are not electric attraction and affinity the same?] the phenomenon is very different. Oxygen and acid, as before, are attracted by the positive pole; but as they are incapable of uniting to the platina, [why?] they instantly receive by contact its electric state, and exercise a repulsive power towards it: the same effect takes place with the hydrogen and alkali at the negative pole.

This philosopher seems to have overlooked a position manifestly in contradiction to the hypothesis which he intends to support.

dicte

*Accum's portable
Mineralogical Laboratory*



dicate the equal intensities of the powers thrown in. The vessel *a* is made of metal, lest it should be thought that the change resided in the surface if made of glass, and contains a quantity of oxalic acid in solution. The other vessel *b* contains solution of lime, which being naturally positive admits the use of glass for the convenience of seeing the result. The stop-cock is furnished with a long insulating handle, and the whole is set on an insulated stool. Matters being in this state, a full stream of positive electricity was poured in from a very powerful machine, through the two conducting wires. After the pith-balls were proved by wax, and the quadrant electrometers observed to stand the same number of degrees, the stop-cock was turned by its glass handle. On the mixture taking place, the oxalate of lime immediately precipitated.

Having emptied and dried the apparatus, the whole was arranged as before. The metallic vessel contained solution of oxalic acid, the glass-vessel was empty. A stream of electricity was poured into the solution, and the stop-cock meanwhile opened: when the fluid touched the wire of the pith-balls in *b*, the pith-balls immediately diverged with positive electricity; clearly demonstrating that the acid solution had carried with it positive electricity.

In the experiment the agency of negative electricity cannot be suspected. If any had been produced by the contact of the two solutions, it must have been immediately destroyed by the constant streams pouring in from the machine. I made use of oxalic acid and lime, these substances being instanced by Mr. Davy as remaining in different states when separated.

Oxygen and substances in which oxygen predominates, as acids, are attracted to positively electrified surfaces, and are repelled by surfaces negatively electrified. These bodies are therefore themselves in the negative state. Now if for example phosphorous acid be negative and oxygen in the same state, why have these substances so strong an attraction, and why do they combine to form phosphoric acid? It might be said that the phosphorus in the acid being positive, although combined with oxygen in the negative state, but not to saturation, yet has an excess of positive electricity, and that this excess attracts the additional quantity of negative oxygen. Were this the case, phosphorous acid with its positive excess should be repelled by the positive and attracted by the negative pole; which is not only contrary to fact, but contrary to the hypothesis.

I can also produce instances of bodies neutral* with regard to attraction, which combine with the most intense force. Potassium has an amazing attraction for oxygen; their combination is quick, and the heat and light intense. The result of all such powerfully energetic attractions is a compound which is neutral as to other bodies. Such a body is also water. Here then are two neutral bodies; and yet so powerful is their affinity for each other, that in ordinary processes we never obtain potash free from water.

Mr. Davy seems to place great reliance on the fact that a copper wire which is naturally positive, when made negative, will not be acted on by nitrous acid, which is naturally negative. This however proves nothing; for it does not follow that it is electric repulsion which prevents the combination: and if it did follow, it would be far from proving that combination is caused by electric attraction.

Having now given examples, in which combination ought to take place, and does not, as well as instances in which combination does take place, and ought not; I shall proceed to some general remarks.

There are, I think, a variety of facts inexplicable by the agency of electricity, which are easily accounted for if attributed to affinity: for instance, the various attractions coexisting in certain salts. Let the example of superphosphate of potash be selected, the component principles of which have been already mentioned. Positive phosphorus unites to negative oxygen, forming phosphorous acid; and this must be supposed to be still positive, as it unites with another dose of negative oxygen, forming phosphoric acid. Positive potassium combines with negative oxygen, forming potash: this being positive has an attraction to the negative phosphoric acid: they combine, and form superphosphate of potash; which must be still positive, as it has another attraction to an excess of acid: this additional dose enters into union, and at length there is formed superphosphate of potash, which has also an attraction to water, forming

* "Similar effects may be conceived to occur in the case of oxygen and hydrogen, which form water, a body apparently *neutral* in electrical energy to most other substances: and we may reasonably conclude that **there is the same exaltation of power in all cases of combustion.** In general, when the different energies are strong and in perfect equilibrium, the combination ought to be *quick*, the heat and light *intense*, and the new compound in the *neutral* state. This would seem to be the case in the instance just quoted, and in the circumstances of the union of the strong alkalies and acids. But when one energy is feeble and the other strong; all the effects must be less vivid; and the compound, instead of being neutral, ought to exhibit the excess of the stronger energy."—Davy's Bakerian Lecture. Phil. Trans.

the

the crystals of this salt : and lastly, the water itself is a compound of oxygen and hydrogen, united by a very powerful attraction.

Here are no less than fourteen electric attractions forming seven combinations, all operating quietly together. Is it possible, from any thing we know of electricity, to form a definite idea of so many complicated powers ; so nicely balanced too, that in some instances the smallest touch, nay, the friction occasioned by falling through air, is sufficient to make them arrange themselves in a new order, and the change is attended by the most violent effects ?

By admitting that these combinations are caused by an attraction *sui generis* called affinity, which is an essential property of matter, the explanation becomes extremely easy. But the difficulty of the other is not surmounted by supposing with Mr. Davy that electricity is no more than a property of matter. For, beside that the hypothesis is inadmissible, as shall be presently shown, we know that the facts are objects of sense convincing and unalterable, whatever conceptions we may have of that power which occasions their production.

I shall now state my reasons for affirming that electricity is a fluid *sui generis*. If electricity be a property of matter, it ought to be inseparable from matter ; we can have no clearer conception of a property abstracted from matter, than we can of colour independently of the body coloured. If it be shown that it is separable, it necessarily follows that it is an absolute substance ; as the moment it is separated it ceases to be a property. That we do obtain it in an insulated state is, I think, shown by experiments with the Torricellian vacuum. Do we not see streams of electricity pervade the vacuum * ? Can we not detect it in its progress by its effects ? It is clearly shown also by holding a quire of paper in the interrupted circuit of a battery. On making the discharge, the paper is perforated with violence ; and we see a prodigious volume of condensed electricity. What has done this ? Is it done by that which has no more existence *per se* than solidity, extension, or figure, have without substance ; which is no more separable from matter, than splendour, tenacity, ductility, from metals ? If it be not a substance, what causes the smell and taste so apparent from electrified points ? It is not caused by particles

* If air be entirely absent, it is true the light is much less perceptible, if at all ; but that electricity still passes, is proved by the divergence of balls connected by conductors with the vacuum.

driven

driven off from the points, so small in quantity as not to have appreciable gravity, as some have asserted; for the smell and taste are the same, whatever be the substance from which they issue. Lastly, I would know what is it which diffuses itself from one conductor over the surface of another, when separated by a great space; which in fine affects the organs of sensation with every effect of materiality.

It is pretty certainly known that caloric enters into chemical combination with bodies; and that it is a really chemical combination is proved by the mutual change of properties consequent on the union. Thus ice combining with free caloric forms water; the ice has lost its solidity, the caloric is become insensible. Are we to suppose that caloric is in a state differently electrical from that of water? The powerful attraction must be all on the side of the caloric, as water is said to be neutral with regard to other bodies.

The hypothesis gives no satisfaction concerning the separation of oxygen from various bodies by light. Is this substance also possessed of electric energy?

It is scarcely possible to conceive how the firm combinations with which we are acquainted, can be occasioned by so weak an attraction as that of electricity; and the less so when it is considered how very small is the quantity of this power apparent in these very experiments which gave origin to the hypothesis of electro-chemical attraction.

The contact of very large surfaces almost always requires to be made several times before the gold leaves of Bennett's electrometer are sensibly affected. Every one is acquainted with the amazing sensibility of this instrument. What must be the effect of a single contact of one pair of atoms? Yet it is certain that the attraction of one pair of atoms is of as great intensity as the combined powers of all, however great the quantity. The difficulty is considerably increased, if we suppose that the electricities of heterogeneous bodies exist in an absolute state. They must then be so feeble as not to be appreciable by the most delicate instruments in our possession; beside that, in the latter case, the agency of electricity must be entirely supposititious. The following experiment of Mr. Davy's, I think, tends to confirm my objections against the efficiency of electric agency.

Mr. Davy heated together a plate of copper and a plate of sulphur. The electricity which was scarcely sensible at 56°, even to a condenser, became only powerful enough at 100° to cause a divergence of the gold leaves without con-

condensation. They increased in a higher ratio as the sulphur approached its point of fusion; at a little above which these bodies combine with the evolution of light and heat.

The electricity at 100° was barely sufficient to make the gold leaves diverge. How extremely low must have been its intensity! for it is certain that the leaves of Bennett's electrometer diverge with almost any change in the surrounding media. Thus, if powdered chalk be blown from the nose of a bellows upon the brass cap, the leaves diverge; or it is only necessary to let the chalk powder fall on the cap. Can it be supposed, although the electricity increased in a ratio somewhat higher towards the melting point of sulphur, which is 226° , that so low an intensity, as it still must be, could cause a combination attended by such a violent extrication of heat and light?

I also have made some experiments on the contacts of different substances. A plate of insulated copper and a plate of glass were heated to about 130° . When separated, each caused a divergence of the gold leaves. The electricity was always weak. Once, when the sun shone very strongly, the electrometer had acquired exquisite sensibility, and under these circumstances the divergence was somewhat considerable. I never afterwards succeeded so well.

A plate of sulphur and a plate of glass, when heated and afterwards separated, caused a very sensible divergence of the gold leaves. When the glass on one side was coated with tin foil equal to the diameter of the sulphur, and heated as before, the leaves diverged nearly half an inch. These experiments exactly coincide with some made by Mr. Wilcke in a different manner. This philosopher found that, when sulphur was melted, and allowed to solidify in glass vessels, they both acquired a strong electricity; but that the electricity was much stronger if the glass were coated with metal.

I repeated Mr. Wilcke's experiment with some little variation. I poured melted sulphur on a *plane* of glass, and cemented on an insulating handle. When solid, its electricity was so strong that it attracted large pith-balls as vigorously as if excited by strong friction. The intensity of the glass was much lower. These experiments of melted sulphur do not differ from that of the heating of sulphur made by Mr. Davy, otherwise than that the former mode is more decisive; a complete contact is formed, and the heat is general and equal, and accordingly the results are less equivocal.

Æpinus

Æpinus found that when two plates of glass, such as are used for looking-glasses, were pressed together and afterwards separated, they acquired a strong electricity, but different in each plate.

These experiments can be only performed under certain circumstances of the atmosphere, as when the air is dry and the sun shining strongly.

If Mr. *Davy's* experiment be sufficient to ground the supposition that sulphur and copper combine by the attraction of their different electricities, I have the same grounds for supposing that copper and glass, sulphur and glass, or glass and glass, unite chemically; since by contact they produce different states of electricity.

Having made a statement of the principal objections which occurred respecting the electro-chemical doctrines of combination, I shall now proceed to notice whatever remains on decomposition.

The manner of decomposition in general has been already noticed. I am now prepared to enter on this branch of the inquiry more minutely.

Mr. *Davy* has, in different parts of his writings, given two modes in which decomposition is effected, each of which I conceive to be essentially different from the other.

1. That the electricity of each pole attracts that principle of the compound which is an opposite state of itself, and repels the principle which is a similar state; and that this happens at both poles.

2. That the electricity of each pole, where it is in contact with the compound, brings the component principles into similar states, and that they consequently repel each other.

I shall endeavour to show that decomposition cannot be produced according to either of these positions. This I hope to accomplish by proving,

1. That the interchange of electrical powers ought not to cause electro-motion in the principles of the compound; and, allowing electro-motion, that combination and not decomposition ought to take place.

2. That, if the decomposition of combined bodies be caused by the repulsion of similar states artificially acquired, both principles of the compound ought to be found in a separate state collected round the polar wires.

Beginning with electro-motion, it is evident that, in the solution of a salt, we must suppose a number of particles surrounded by water. That water is a conductor of that electricity

electricity which is supposed to cause combination has been already shown. Whether it be a conductor of such intensities as the Voltaic, is perfectly immaterial to the inquiry. When in the saline solution are immersed the polar wires, the latter as usual exert their attractions in concert to the opposite electricities of the saline elements. It becomes a question, Why do not the electricities of the decomposed elements pass through the fluid conducting medium towards the poles, without carrying also the elements with which they were combined? for the original electricity of the elements is immediately annihilated in its passage towards the poles. Consequently all attraction between it and the element with which it was combined, must be destroyed. Besides, in all our experiments, we find that to produce attraction or repulsion it is necessary to have an electric-interposed between the body acting and the body acted on.

It is next to be examined how far decomposition can be effected in the manner stated.

It is an axiom, that a force cannot be overcome by a force which is not greater. Then, if a quantity of artificial electricity thrown into a compound occasion decomposition, that electricity must be possessed of superior intensity. We will suppose it the positive power thrown into solution of sulphate of potash. The first effort of the superadded power will be to attract the negative acid, which will become saturated or neutral. The second effort will be to combine with, and to exist sensibly and absolutely in, the neutral acid. Thus the acid which was, in the combination, negative, is now positive. The alkali suffers this change conversely, and becomes negative. We have now all the conditions as they primarily existed for producing combination; with this difference only, that the attractions of the bodies are by far more intense; for, if otherwise, the original combination would never have been broken. Why then do they not combine with increased force? And why are they attracted to these very poles, which being in similar states should violently repel them? Independently of increased intensity there are two powerful causes operating to favour combination; one only of which tended to sustain the original salt. First, the bodies are forced to approach directly by their reciprocal attractions; and indirectly by the strong repulsion of the similarly electrified poles. Consequently they should pass to, and occupy the situation in, the fluid where there is least resistance; namely, the middle point, where the repulsion of one pole ends and the attraction

attraction of the other begins. This new combination, if not permanent, ought at least to be sustained while the causes continue to exert their influence.

Let us apply these objections to the decomposition of water by Voltaic electricity. When the polar wires are immersed in a vessel of water, the positive wire attracts the negative oxygen, and repels the hydrogen; the negative wire attracts the positive hydrogen, and repels oxygen. During these repulsions, the negative oxygen and the positive hydrogen must meet and unite, again forming water. There are also oxygen and hydrogen attracted to their separate poles. Here each must immediately acquire a state similar to that of the polar wire, in consequence of which each must be repelled; and the course of the gas during its repulsion must be directed by the attraction of the opposite pole. This repulsion taking place at each pole, the gases, oxygen and hydrogen, strongly electrical in different states, should in their attempts to cross, meet and unite; for their power of combination is considerably increased: and thus water should be recomposed.

But if by any ingenuity it can be shown, that they ought not to unite, it ultimately comes to this, that the gases will cross each other, and will pass to poles which, being in different states, will attract and afterwards repel them; and thus a continual series of attractions and repulsions will follow—precisely in the same manner as a suspended pith-ball will continue to play between two jars differently electrified, attracted to one, repelled from that and attracted to the other, so long as there remains contrariety of power in the jars. This example is applicable by a direct analogy. But whether the gas do or do not combine, a bubble ought never to be discharged in a sensible state.

With a view to ascertain whether or not water is recomposed at the central point, as supposed by Mr. Davy*, I made the following experiment. (See fig. 2.)

A glass tube filled with dry powdered muriate of lime, through which passed a platina wire hermetically sealed at

* "The oxygen of a portion of water is attracted by the positive surface, at the same time that the other constituent part, the hydrogen, is repelled by it; and the opposite process takes place at the negative surface: and in the middle or neutral point of the circuit, whether there be a series of decompositions and recompositions, or whether the particles from the extreme points only are active, there must be a new combination of the repelled matter, and the case is analogous to that of two portions of muriate of soda separated by distilled water; muriatic acid is repelled from the negative side, and soda from the positive side, and muriate of soda is composed in the middle vessel."—*Davy's Bakerian Lecture.*

both

both ends, was placed horizontally on a small glass pillar; the ends of the platina wire projected beyond the extremities of the tube, and terminated in two small hooks. From these hooks on each side were suspended small bell-glasses, in each of which was contained a platina wire sealed at the top; the latter wire passed through the bell, and formed the connexion with the hooks. The lower ends of the bells, which were open, were immersed in small glasses, and both bells and glasses were filled with distilled water. The conducting wires which proceeded from the battery were armed with a slender piece of well-burnt charcoal. Each piece of charcoal was plunged in the water of the glasses;—so that the electricity was conveyed from the charcoal to the wire in the bell. Here the decomposition commenced. The electricity was conducted through the wire in the horizontal tube; from thence to the wire in the second bell, where another decomposition took place, and at length to the other piece of charcoal. [See the Plate.]

By this arrangement the middle point, where Mr. Davy says water is recomposed, was muriate of lime, which would absorb any water that might be formed, and here it might reasonably be expected to be found.

Having ascertained the exact weight of the horizontal tube and its contents, I connected to the apparatus a battery of 100 pairs of 4-inch plates. The battery was kept in a state of activity for four hours. At the end of this time oxygen was found in one bell, and hydrogen in the other. But the horizontal tube was precisely the same weight as before, notwithstanding that a considerable quantity of water had been decomposed.

The positive wire attracted the negative oxygen, and repelled the positive hydrogen, through the wire and muriate of lime; where meeting with negative oxygen repelled from the other bell, the two gases, being in different electrical states, must have, as Mr. Davy allows, united to form water. As the horizontal tube gained no weight at the end of the experiment, is it not a sufficiently well warranted conclusion that no water was formed, and that consequently the theory given for the evolution of pure gases must be erroneous? These gases, if conveyed through the wires, must have passed through no less than four air-tight sealings. Why should these gases pass, and air be detained?

We now come to the second position, That decomposition is produced by bringing one of the combined substances into a state different from that which is natural to it.

When a particle of a compound has its elements thus brought

brought into similar states, it is certain that they must repel each other. But it is equally certain that they must both be repelled from the polar wire, for it is also in a similar state. The elements should now be attracted over to the other pole. The same thing taking place at the latter pole, the elements there separated ought in the same manner to be attracted to the opposite pole. During the whole, the repulsion of the one pole is aided by the attraction of the other. Applying this to a particular example, suppose to sulphate of potash; we know that potash is naturally in the positive state: when the sulphuric acid is rendered positive by the electricity thrown in, the two substances will repel each other; but both will be repelled from the positive and attracted to the negative wire. The same change is produced by the negative wire; in consequence of which, acid and alkali will be attracted to the positive wire. Thus we should have both elements in a separate state collected round each of the polar wires. If this be followed up, we shall find that the two bodies cannot rest for any length of time at either pole, constantly acquiring similar states;—on which account an endless series of attractions and repulsions will ensue. These effects happen, if the substances in different states be supposed to pass each other without union. If they do not pass, the two substances should combine, and neither acid nor alkali should be found permanently at either pole.

It has been shown that Mr. Davy's first assumption of bodies combining still retaining their peculiar energies, is unfounded; and that after combination there no longer remains any electricity. There is then no reason why electricity thrown in should exert an electric attraction to the one, more than to the other element; or why a sensible electricity may not be diffused over a particle of a compound, without causing a repulsion of its elements. The repulsion should rather be supposed between the ultimate particles of the compound, than between those of its elements.

It now only remains to notice the insufficiency of Mr. Davy's explanation* of the influence of quantity on decomposition. Selecting the instance of the partial decomposition of sulphate of soda by muriatic acid, let us examine how far this could be produced by electric attraction. Muriatic acid and soda are held together by an affinity which

* "For the combined effect of many particles possessing a feeble energy may be conceived equal, or even superior, to the effect of a few particles possessing a strong electrical energy."—*Davy's Bakerian Lecture.*

is overcome by that of sulphuric acid; sulphate of soda is formed. From this it appears that sulphuric acid, being more negative with regard to soda than muriatic acid is, exerts a more powerful attraction, and with this attraction exists in sulphate of soda. When muriatic acid is added, which has a weaker energy, it is impossible to conceive how the weaker *electrical* energy could displace the stronger. The soda possesses as strong an attraction to the sulphuric acid as the latter does to the soda. Here there are two attractions, either more powerful than that which is supposed to break the combination. Were the soda in a free state, its electricity might be saturated by a great quantity of a weak power. But it were absurd to suppose that the soda would separate in order to unite with a weaker electricity for which it can have no attraction, being already saturated with the opposite stronger power of the sulphuric acid. The attractions of electricity obey intensity, not quantity; and it may be proved by a decisive experiment. This law alone is sufficient to establish a difference between electric attraction and affinity.

The intensity of electricity is in the inverse ratio of the surface charged compared with the quantity. If a battery and a small jar be electrified with the same quantity of fluid, the intensity of the jar will be to that of the battery inversely as the superficial contents of the former are to those of the latter. Thus if the jar be = 1, and the battery = 3, the quantity of fluid = 6 in each; thus the intensity of the jar will be = 6, and that of the battery = 2, or three times greater. This superior intensity, although not the ratio, may be easily shown by attaching electrometers to the jar and battery. When the quantities thrown in are alike, the electrometer of the jar rises to its maximum, while that of the battery is not affected. The application of the experiment now becomes extremely easy, and its force manifest.

Let a jar be charged by a certain number of revolutions of an electric machine; when removed, let a battery receive the quantity produced by an equal number of revolutions. The ball of the battery is to be placed at some distance from that of the jar, and midway between them is to hang a gilt pith-ball suspended by a gilt thread from a negatively charged jar above. The pith-ball may be confined in its position by means of a silk thread extended by a hand underneath. When the silk thread is let loose, the gilt ball will be attracted to the jar. The same thing happens if the battery contain twice, or perhaps twenty times

the charge of the jar. The battery represents muriatic acid, the positive jar represents sulphuric acid, and the negative jar represents soda. The powers are reversed; but it does not affect the conclusion. These experiments may be made also by employing large and small conductors.

Conclusion.

If I have been thus free in stating my objections to the opinions of one of the most distinguished philosophers of the age, I was encouraged to proceed, when I reflected that, as the establishment of truth was the object of research, the discovery of error as a preparation, would be to no one more highly pleasing, than to the illustrious framer of this ingenious hypothesis.

XLV. *An Analysis of Fluor-Spar.* By THOMAS THOMSON, M.D. F.R.S.E.*

THE mineral called Fluor-Spar has been long known, and valued on account of its beauty and the ease with which it can be turned on the lathe into various ornaments and useful utensils. It occurs chiefly in veins, and very frequently accompanies lead-ore. Some of its properties have been described more than a century ago; as, for example, its phosphorescing when heated, and its corroding glass when mixed with sulphuric or nitric acid. But it is not forty years since its composition was discovered by Scheele, who demonstrated that it is composed of lime and a peculiar acid called fluoric. Chemists now distinguish it by the name of fluuate of lime.

Hitherto, no chemical analysis of this salt has been published, except a very incorrect one by Kirwan and Gren, which has been ascribed to Scheele, though I cannot find it in any of his dissertations on fluor-spar. By that analysis, it is made to contain 27 per cent. of water,—a proportion very inconsistent with the properties of native fluuate of lime, which, when strongly heated in a wind furnace, loses at an average only $\frac{1}{10}$ th part of its weight. The obvious inaccuracy of the analysis given by the authors just mentioned induced me to make a set of experiments on it last summer (1807). I selected the purest transparent colourless crystal, which I found by repeated trials to be very nearly pure fluuate of lime. When reduced to a fine powder,

* From the Wernerian Transactions.