Outlines of a course of lectures on chemical philosophy: or, of a theory which considers attraction, repulsion, electricity, caloric, light, &c.; as the diversified phenomena and effects of one power / By Matthew Allen, lecturer, &c.;

OUTLINES

OF A

Course of Lectures

ON

CHEMICAL PHILOSOPHY:

OR,

OF A THEORY WHICH CONSIDERS

ATTRACTION, REPULSION, ELECTRICITY,
CALORIC, LIGHT, &c.

AS THE

DIVERSIFIED PHÆNOMENA AND EFFECTS OF ONE POWER.

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Advertisement.

THE manner of beginning this small work, and the delay which has taken place in its publication, will account for its very peculiar and imperfect form.

FIRST.—It was begun, and one page printed after another, and given to my audience (then attending a Course on Chemical Philosophy, April, 1817), at the commencement of each Lecture, with the sole purpose of laying before them, in an unusually enlarged Syllabus, a slight sketch of some peculiar doctrines on the subject: and I then determined to devote no more than one page to each Lecture; but afterwards found it impossible to exhibit the most condensed and abstract view of my theory within a space so very limited. This difficulty will be easily credited when I state its nature. According to this theory, I conceive that the modern distinctions in Science, of a number of different powers and agencies in nature, are artificial, arbitrary, and fatally injurious to the interests of Philosophy; and I assert, there is only ONE GRAND POWER OR AGENT IN CREATION,—that the different effects and appearances, which have hitherto been classed under different names, are all clearly explained, as arising, not from powers differing in kind, but from differences in the quantity, energy, and rapidity of the movements of this power, operating on different kinds of matter, and in different circumstances.

It is from this mode of beginning these outlines, that while three or four of the first Lectures only contain one page each, the rest are so disproportionately lengthened; and yet, to prevent this, I have anxiously laboured to curtail my forms of expression, to avoid the repetition of a single idea, and almost every thing in the way of illustration; so much so, that all order and arrangement have been sacrificed to this brevity; as, for instance, in the very outset, the application of this theory to Electricity is not only extremely imperfect, but the few more intelligible hints appear not in their proper place, but in the eighth Lecture on Chemical Affinity. In like manner it is, that the most beautiful and luminous proof of its application to Galvanism, instead of being in the sixth, is introduced in the eleventh Lecture, because it was more easily explained in connection with my views of the solution of bodies in one grand and universal solvent. Also, on Light, I have contented myself with barely explaining its principal characters in the most condensed and abstract form; conceiving this defect was in some measure supplied, by asserting that heat and light bear the same relation to each other, as I have briefly shown Electricity and Galvanism bear to one another; trusting the Philosophical reader will draw the parallel himself, conscious as I am, that he who does so, will find this assertion correct. And, lastly, I have omitted altogether the most beautiful and sublime part of the subject, and one where the proofs in support of these views unite and concentrate themselves, in my opinion, with that peerless splendour which truth alone possesses—its application to Astronomy; but it was utterly impossible to introduce this part of the subject in such a confined and cramped publication. There are also many facts and experiments, in some measure original, ready to be brought for-

ward, in support of these principles, which are deferred to some future period; and, in short, all the facts and experiments accumulated in science, are, in my opinion, not only explained on these principles, but on no other can I explain or understand them. I say this, not from the captivating warmth which novelty produces, but from an experience which more than twelve years has steadily supported; for, though a combined view of this theory in my mind has long produced the most delightful conviction of its truth, yet this, in some measure, is counteracted by the melancholy that I feel, on finding it (in the present situation, in which circumstances have placed me), so slow and so difficult a process to transfer these feelings to others; not so much from any credit that I am anxious to obtain, but *from believing*, what I trust I shall be able hereafter to prove*, that it unfolds principles† which throw light on many subjects of science, and which increase our avenues to intellectual pleasure: and it is time the world should know that those which flow from the benevolent and useful exercise of the heart and mind, alone deserve the name.

However inauspicious circumstances may be, and however slow the process of convincing others, I am still of opinion, not only that "there is good in every thing" to him who thinks so, but also that it is, if not more dangerous, at least more galling to our feelings, to receive approbation without intelligence, than that condemnation which the blindness of prejudice inflicts. But so far from experiencing this, I have everywhere found those, who are esteemed capable of judging for themselves, approve and admire this theory in proportion as

* The same principle I had previously applied to Medicine, Metaphysics, &c.

† See Locke on *Fundamental Verities*.

they knew and understood it. And the annals of the human mind certainly afford this consolation, that these men are, as it were, the very basis on which lasting opinion is founded, and who, on philosophical subjects, ultimately guide the rest of mankind. This fact, added to my own unshaken conviction of the truth of this theory, encourages me to hope that, even short and imperfect as this work is, it may still comprehend enough to evince to the candid and scientific, who alone are Philosophers, that these views and this conviction have not been formed and adopted on a hasty, careless, or a superficial process of thought, —and that a great deal may be brought forward in their support, which cannot, on account of the reasons already stated, appear in this place. For the same reasons, I shall not now enter upon the refutation of those objections I might, from experience, very easily anticipate. It will be seen, however, that these views are developing, in the form of essays, in Mr. Tilloch's *Philosophical Magazine*, which are intended as the prècis of a more elaborate work: when such a work is completed, I shall then, I trust, be warranted in assuming a bolder attitude, and of challenging the reader to adduce one fact, either unexplained on these principles, or better explained on any other.

SECONDLY.—I shall now mention "the cause which has produced the delay in question." I feel that the bare mention of the fact I have to state, may be deemed by some out of place, and by others affected; I feel, too, that I am touching on a delicate subject to myself, and I could wish to pass it over. I mention it, however, from very different feelings to those which give rise to an affectation of sensibility, or the impertinent intrusion of self,—"a subject on which we are often fluent, but seldom agreeable."

I have already said, that these outlines were begun in April, 1817, with the intention of finishing them at that time, as a more enlarged Syllabus, for the audience then attending my course. Mrs. A. was suddenly taken ill, and the first proof-sheets were corrected during my watchings as nurse: the event of her death, which took place a few days after this, threw my mind into that state in which the power of confining its attention to any thing of a serious nature, and, still more so, to such objects of association with that event, as this became, if not absolutely impossible, at least difficult and dangerous in the extreme. Death, I know, is a common calamity; but there may be circumstances, connected with such an event, which greatly aggravate our misery,—an event which is, of all other human calamities, the most "overwhelming;" and when such circumstances happen to one, not only possessing warm feelings by nature, but *which a succession of strong and peculiar excitements have, throughout life, encouraged, supported, and augmented*, it may be easily conceived that such an occurrence, itself associated with every circumstance of horror, might produce, on one so constituted, misery and distraction to an unusual degree and duration. It is to some *such* circumstances, in my case, *of a later and more recent date*, to which I shall make *some slight allusion*, not merely because they explain the real cause of this small publication having been so long "in the press," but also because they explain the delay which has taken place in my original views of Lecturing in Edinburgh.

When I came, for the second time, to Edinburgh, 1810, my objects were—first, prosecuting and finishing my medical studies in the first year; and, secondly, after graduation, practising Medicine and Lecturing on Chemistry; in this I was, from some commercial engagements and *a pecuniary disappointment*, cruelly

thwarted; and which gave rise, not merely to immediate miseries, sore and grievous, but to those circumstances, *of a later and more recent date*, to which I have already alluded; for this disappointment, by increasing the solicitude, I had long felt, of settling in active life (from which I had too long been suspended or deterred by many causes I need not mention), led me, from an over anxiety of doing something, into a plan of beginning a new concern in connection with a friend in England, and of which concern he alone was to have the management; this arrangement was adopted that it might not interfere with the views I still entertained. This friend, after every thing was ready for his entrance on the charge, was, by a severe Hæmoptysis, and consequent Phthisis Pulmonalis, prevented from doing so. After waiting, in suspence, for more than six months, his death obliged me, contrary to my wishes, my feelings, my habits, and my former way of life—to undertake it myself: this not only defeated my original plan, but also produced, along with harassed spirits, ill health, confidence in others, great losses by securities, loans of money, connections with others, &c. a long and dreadful succession of most distressing circumstances, to which Mrs. A. (fitted for different scenes) submitted, from principle, and with fortitude. I shall not add either what torture this was at the time, or now is on reflection; it is vain now: a torture which is increased by the *kindness* and by the *proofs* I daily receive that my original plans would *then* have succeeded well. I trust the reader will excuse this, which various reasons have induced me to state; I can assure him, I am as glad to drop my pen on the subject, as he can be wearied with what I have written.

I shall now close this advertisement with an address to

the critic; if this small and imperfect work should be so fortunate or unfortunate as to be honoured with his praise or his censure. I would remind him of that which, I think, he, too often, in the zeal of self-assumed authority, forgets,—that a first performance ought to be touched with sympathy's softest fingers, and not seized with merciless fangs, and torn to pieces with malignant pleasure. A new work has, from many obvious causes, strong claims on his indulgence; how much more so, in the present instance, where not merely a new subject is introduced, but introduced under untoward circumstances, and deprived of all adventitious aids of recommendation.

A just and good critic is a man of profound, powerful, and comprehensive thought; and such a one will know, from experience, the time and labour which is required before new ideas become such welcome and familiar inmates to our minds, as gives us the power to clothe them in suitable and varied forms of expression, and to present them to others, not with that cold and repulsive air which science too generally assumes, but with that warm and attractive grace we use on introducing one friend to another. "It is one thing," says Locke, "to think right; and another to know the right way to lay our thoughts before others with advantage and clearness:" and as this difficulty must be increased by the nature and extent of the subject, it cannot be small on one like the present—a subject which essays to unfold one grand, sublime, and comprehensive view of the operations of that Divine Agent which produces the harmony of the universe; and which further essays to explain all this beauty and harmony on one simple and majestic principle—a principle alike applicable to the doctrines of the intellectual as to those of the physical world. In saying this, I am far from arrogating to myself any merit: what merit can

there be in stating that which circumstances have forced upon me, or to which they have guided and directed me? and of which I have not made that useful application I might and ought to have done! Nature is the seminary in which we are placed; and, "in that kind school where no proud master reigns," we might learn, from the purest and highest source, (had we that spirit *such pupils* ought to possess), those divine and delightful lessons of truth and wisdom, which "guide their opinions, direct their conduct," and constitute their felicity.

Woodend Cottage, November, 1818.

OUTLINES

OF

A COURSE OF LECTURES,

ON THE THEORY AND PRACTICE OF

Philosophical and Experimental Chemistry.

LECTURE I.

ON THE HIGH IMPORTANCE, THE GRAND PRINCIPLES, AND UNIVERSAL APPLICATION OF CHEMICAL SCIENCE.

On the importance of Chemistry to civilization,—its grand agent, Fire,—its various applications and important effects,—a slight glance of the ideas of the ancients on this power,—how far they are founded on a correct and enlarged view of nature and art,—how far its diversified effects on matter principally depend on differences in its quantity, intensity, and direction,—what support this derives from an accurate conception of the phenomena of heat and flame in combustion,—by an examination of the arts, by a scientific observation of nature, and by our practical researches into the elements and constituents of matter.—*The specific facts stated, and illustrative experiments performed, under each head.*—How far these examinations, observations, and investigations, enable us to enlarge our views of the nature of this science;—whether, by ascertaining some of its properties, we may not be able to determine the laws and principles of its action, and thus venture to predict its high destiny in Philosophy, as the power which produces all the motion and union of matter.

LECTURE II.

Introductory and Preparatory Observations to the Course; together with some Views on the Origin and Original State of Science in general, and Chemical Science in particular.

Recapitulation of our last Lecture,—*a repetition of experiments,—Experiments to exhibit the wonderful effects of different explosive or combustible mixtures.*—All intended to give us a more accurate conception of the heat and flame, to which we erroneously restrict the term combustion and fire,—that they depend on the rapidity with which combinations are formed or subverted by this power,—that though we do not apply these terms when changes are more slowly produced, the power and its principles of operation are the same:—The nature and properties of this power briefly stated,—the laws and principles that we may infer from them,—their susceptibility of proof,—*Grand fundamental experiment,*—whether all the properties of this power are ascertained,—the method of pursuing the investigation;—Are Electricity, Galvanism, Magnetism, modifications of this power?—how account for the apparent differences:—our reasons for these preparatory and preliminary remarks;—the want of fixed principles, and of generalization in science in general and in Chemistry in particular,—their necessity and importance,—their infallibility if acquired from nature;—nature our proper school-master,—what conduct becomes her pupils,—how few they are,—the causes of this,—why so difficult to remove,—rules, directions, and remedies,—The history of Chemistry,—the origin and meaning of the word,—its connection with fire,—the relation of fire to the science and mythology of the ancients; the influence all this has had on the world.

LECTURE III.

New arrangement of Science in general, and of Chemical Science in particular, proposed, including an abstract view of the principles which form the basis of this Course, and of the principal ideas to be unfolded as we proceed through the whole.

RECAPITULATION.—Our division of the subject, into the power, the phenomena of its operations, and the objects acted upon; or, into *attraction, attractive agencies,* and *passive substances.*

I. ATTRACTION considered and defined,—its universality, and the inapplicability of the term repulsion,—no such distinct and antagonist power in nature.

II. ATTRACTIVE AGENCIES,—reasons for this generic term, under which we include Electricity, Galvanism, Magnetism, Caloric, and Light,—and the reasons for classing them together.

III. PASSIVE SUBSTANCES,—reasons for this generic term, under which we include solids, fluids, and gasses,—their subdivisions enumerated,—a definition of matter in general,—and a definition of each kind or division of matter in particular:—definitions and explanations of terms.

THE PROPERTIES OF ATTRACTION;—the laws of its action deducible from them,—the particular effects or phenomena of its determinate energies under peculiar and definite circumstances;—distinctions between gravitation and chemical attraction, &c.

Several striking experiments in their proper place, to illustrate the powerful operation and universal existence of the power of attraction;—and of its diversified phenomena, Electricity, Galvanism, Caloric, and Light, &c.—

LECTURE IV.

II. Division.—1st. *Electricity.*

Recapitulation.—Electricity,—its meaning, merely expressive of a fact not descriptive of a science, the earliest and most remarkable passage which notices this fact:—its agreement with Sir Isaac Newton's conjecture:—this conjecture stated, and the views which probably led to its formation, examined:—the very partial and imperfect nature of the science in his time and the rapidity of its modern rise:—That this conjecture supposes it the mere phenomena arising from one power modified in its action by circumstances:—whether this idea is supported by a comparative view of those circumstances which attend the production and operations peculiar to Electricity, Galvanism, Caloric, &c.:—Whether such a view enables us to ascertain its nature, and form a descriptive definition,—that "*Electricity is the science which treats of the Mechanical and Natural means of separating the Electric fire from some of its combinations, and, of ascertaining its actions in this state.*"—Facts stated from which we infer it is the purest and most energetic form of the grand agent;—these facts enumerated and explained, on the principle of negative and positive points, as stated in our last Lecture, and not on that of two Electricities:—That, "negative and positive are mere relative statse of existence, and do not depend on any power peculiar to, or inherent in each:"—that any two bodies will be more or less positive and negative in proportion as they are to each other more or less conductors; hence the body, in general, will be positive which has least conducting power, and the other which has more, negative.

LECTURE V.

Electricity continued.

That attraction and repulsion, negative and positive, are mere relative states of existence; that a body negative in one situation connected with one body, is positive placed in another position with a dissimilar body; that the point or body where it is accumulated, and is of course positive, is carried by this excess, and the other point or body which is deficient, and is of course negative, is drawn towards it, and hence we have two apparent currents, or movements in opposite directions; bodies, or the particles of bodies carried in one way and drawn in another; two different poles, negative and positive, imparting in one direction and receiving in another, and hence two bodies, as they receive and impart with greater or less facility, the circulating current of this power, become to each other positive and negative; the one body which has least conducting power will be positive, and the other which has more, will be negative; that is, will be abstracted from that which is the best conductor, and imparted to that which is the worst, where it will be received, retained, and of course accumlated; that this relation is more obviously striking on very imperfect conductors; unless, as in the Electric Machine, we avail ourselves of this relation, and by combining the properties of conductors and non-conductors at the same time, contrive to arrest, fix, and concentrate the current of this power, which we do by placing the prime conductor, communicating with the Cylinder, on a non-conductor, and thus we have a body which

receives with facility without the power of imparting the current from this revolving Cylinder, which, being itself a non-conductor, intervenes also to intercept the return of this current. On the same principle, depends every amusing experiment in Electricity, on our placing bodies in those circumstances in which they become to each other alternately positive and negative. That this power being the grand agent; the grand cause of all the motion and union of matter; the grand and universal solvent, we conceive, that circumstances must modify its action, and will account for its distinct phenomena in Electricity, Galvanism, Magnetism, Caloric, Light, &c.; for instance, (to state in a brief manner) there are various ways of deranging in a greater or less degree its distribution, and hence it will be imparted and received from substances, in greater or less quantity, with more or less intensity, and in a certain and determinate direction, and this arises from bodies being to each other more or less conductors; its subsequent actions will also be greatly varied after it has been imparted from and received by substances, not only by this difference in quantity, intensity, and direction, but also as it holds other substances more or less in solution, hence it will be more or less pure, more or less attenuated or condensed, and will of course have power to pass through substances with more or less facility, and will be more or less rapid in its movements and more or less active, energetic, and effectual in its actions: these and a variety of other circumstances, have never yet, as far as we know, been noticed, and yet they agree with facts and most beautifully explain their principles. Illustrations, from every source, particularly from Atmospherical Phenomena: A great number of experiments, Thunder, &c. &c.

LECTURE VI.

2nd. GALVANISM.

INTRODUCTION. History; the fact, that two dissimilar metals, placed one above, and the other below the tongue, produces, by bringing the moistened and projecting surfaces in contact, a very perceptible sensation, was first noticed in 1767 by Seltzen a German; similar facts have been observed, but without any elicitation or connection of a fixed idea or principle, and were of course overlooked, until Lady Galvani, wife of Professor Galvani of Bologna, in 1790, perceived the limb, of a frog, excited into action, by the touch of a scalpel, during the action of the Electric Machine, placed on the same table; which fact, the Professor eagerly embraced as confirming in his opinion, a favourite theory he had previously adopted, that the human system was excited and supported in its action by the electric fluid. Volta, also an Italian, in 1800 discovered that the effect was increased, by augmenting the arrangement of dissimilar metals in alternate rotation, and hence arose his theory in opposition to Galvani's, that the convulsion of the frog was merely a test of that Electricity in, and produced by, the metallic arrangement of the Pile; the truth here, as in almost all controversies, is, we conceive, divided between them. Volta's discovery led to the formation of the present Galvanic Trough, by which was ascertained the grand Chemical Agencies of Galvanism, the principles of which were first pointed out by Hissinger and Berzelius, and afterwards so successfully carried into effect by Sir Humphry Davy, in 1807, with an expensive and enormous apparatus, at

the Royal Institution. Sir H. D. also made several experiments on the construction of the Pile, proving, *in our opinion*, that positive and negative, depend solely on the arrangement of conductors bearing alternately, (on the principles stated in our last) different electrical states of existance to each other, and having imperfect conducting fluids interposed between them; that Galvanic excitation, depends on the same principles, though varied by circumstances as that of Electricity. Galvanism we therefore define as, " *The science which treats of the Chemical and Natural means of partially separating the Electric fire from some of its combinations, and, of ascertaining its actions in this state.*" Electricity we have considered as the most pure and separate form of fire, consequently more attenuated than any other, more rapid in its movements, and less resistible in its passage through substances, but that Galvanism being the same power, only *partially* separated from its combinations, differs widely in all these respects, hence we perceive the solution of " that most interesting question;—How do Galvanism and Electricity differ from each other?" If we attend to the solvent, attractive and energetic properties of this power, as already pointed out, and to the different methods and circumstances peculiar to its production in Electricity and Galvanism, it is evident they must differ from each other. In Electricity we contrive by mechanical means to collect the loose and uncombined quantity of this power from the Earth or Atmosphere, and this we do in circumstances in which it has nothing to act upon, as free from moisture of any kind, in fact from every thing readily dissolved in heat, as possible, we therefore have defined Electricity as, " *The science which treats of the Mechanical and Nasural means of separating the Electric fire from some of its combinations, and, of ascertaining its actions in this state;*" whereas in Galvanism this solvent power, this Electric fire, is produced in circumstances

in which it has snbstances to act upon, substances which are most readily dissolved in it; substances, in fact, which seem to form the grand medium of communication between this POWER and PASSIVE SUBSTANCES; and which are partially dissolved in it; and hence we have defined Galvanism as Electric fire, or the GRAND AGENT, " only partially separated from its combinations," we refer principally to Oxygen and Hydrogen. With this in view, we may answer such questions as these—" Why does Galvanism exist in a lower state of intensity than Electricity, in producing shocks?" because its active energies are less, being in part occupied by holding other bodies in solution; from the same cause, it is less attenuated, consequently, less rapid in its movements, or passes through substances with greater difficulty. But " why again is its power, in producing Chemical effects, so much greater than Electricity?" First, because its quantity, produced in a given time, is so much greater; but chiefly, because it is combined with substances which have a powerful tendency to direct and fix its actions, and which are, as it were, the grand uniting medium of this POWER with PASSIVE SUBSTANCES; and hence has arisen the proverbial fact, that when such fluids are employed in the Galvanic apparatus as least produce this decomposition and solution of Oxygen and Hydrogen, the Electrical effects are then greatest, and the Chemical effects are then slightest, and not perceptible at all, when there is no fluid or moisture present. In this way, we would explain why De Luc's Column, which is excluded from the air and moisture, produces no Chemical effect; why the Electric Machine produces so much less than that produced by the Galvanic means. Hence Galvanism burns Charcoal

with such intense brilliancy, and yet the Charcoal is scarcely consumed, because the Oxygen and Hydrogen, held in solution, produce, in part, this effect; hence a wire, heated by Galvanism, continues so longer than when heated by Electricity; hence Platina Wire may be kept ignited in vacuo for any length of time; hence also the fusion of Metallic Wire by Galvanism is less violent, and the particles are not scattered to the same distance as when produced by Electricity; and hence we perceive the explanation of a very singular fact, that the Chemical effects of Galvanism are increased by increasing the surface or the size of the plates to a certain extent, but if it passes *certain limits*, it then ceases to have these effects. The explanation, I conceive, is this; by increasing the surface of the plates, we increase the Chemical action in each distinct division of the Pile, by which the movement or current is proportionally retarded and broken; by this retardation it is of course accumulated, and hence its power to decompose and dissolve so much more Oxygen and Hydrogen—this quantity of Oxygen and Hydrogen again, to a certain extent, increases its Chemical action; and, at the same time, from the motion being slower, the Chemical power of that quantity, thus I conceive the *partial* solution of Oxygen and Hydrogen, assists and modifies the Chemical agencies of Galvanism. If, however, this retardation is too much extended, and a considerable volume of fluid intervening between the plates, then, the Galvanic fluid or fire becomes saturated, or its solvent and attractive powers occupied and suspended, with this Oxygen and Hydrogen held in solution; and to prove this is the correct view, the series may be very much extended, if the volume of interposed fluid

is, in any way, diminished. Hence also it is, that the Galvanic shock is greatest on the person with a dry and tense, and least on a moist and lax fibre, and consequently is perceptibly milder, where fear does not render appearances deceitful, in its action on ladies than on gentlemen. Thus we perceive, that when this GRAND AGENT of NATURE, is *more perfectly* separated from its combinations; it is ELECTRICITY. When *partially* separated, GALVANISM. When no means are used to retain it in either of these states, but when, in its actions, it passes from one substance into another; CALORIC, or fire, in its common acceptation; and to confirm this view, every fact and experiment, under their respective heads, are seen to be mutually convertible into each other. If Caloric abounds in an uncombined state, artificially or naturally, we easily collect it, by the Electric Machine, in its purest form; if Chemical or Natural actions of this power call forth a current faster than it can dissolve the substances on which it acts, we obtain it *partially separated*, as in Galvanism, &c. If the current either acts with greater intensity on decomposable and soluble substances, as in common combustion, or is accumulated in quantity, but more impeded in its progress, as in a Galvanic Apparatus of immense size, we have it with substances dissolved in it, and that substances are dissolved in it is seen by the varied colours that is imparted to flame, and by its oxygenating and hydrogenating effects in all these, as well as in every other instance. If then Electricity and Galvanism depend on the same power, which pervades the Universe, and circulates through matter, we perceive, that this explanation or theory accords with the facts and phenomena of nature. There it is evident this POWER is more or less impeded in its passage, as

bodies differ in their conducting power and capacity, and according to their greater or less degree of solubility in it; therefore, every thing dissimilar in contact becomes relatively to each other in excess or defective, negative or positive, and, of course, exhibits proofs of these disturbed and deranged states; and from the energetic reactions of this power, arising from them, they either destroy each other,—assimilate into one,—or give rise to new forms and existences: iron nails in copper, and every dissimilar metal, in contact, rapidly corrode,—rocks of dissimilar composition, moulder into soil, &c.—It is on these principles of derangement, and on the exertion of nature to effect a proper distribution, that we attempt, in this Course, to explain all the movements and changes of the Universe.

This I conceive the true explanation of the different phenomena produced by Electric and Galvanic contrivances. The Electric contrivances I have called MECHANICAL, and the Galvanic CHEMICAL. In both instances, the same grand, attractive, and solvent power is called into action. In Electricity, this grand agent of nature is, from its attraction for substances, disturbed in its due and relative diffusion, by motion and friction; and that, when these mechanical actions are made in a given direction, a current of this power is attracted, and carried in the same course; that the point from which it is abstracted becoming negative, in its turn demands a new supply. It is thus the action of the Electric machine, and all the facts and experiments connected with Electrical science, on these principles, receive a ready explanation. In the production of this power, by the Electric machine, as fast as that part of the machine from

which the revolutions of the cylinder recede, is robbed of its natural quantity, it demands it from the earth and the surrounding media, (hence the necessity of a conducting and communicating chain); while, on the other hand, that side to which the motion proceeds receives this current by means of metallic points, fixed to the prime conductor, these metallic points receive with readiness; and, being connected with a large conducting mass, the current is more powerfully attracted by that mass than these points; and consequently they continue to receive and impart it to this prime conductor, where, by its insulation, it is retained and accumulated. This power is called into action in Galvanism in a different way, but still depending on the same principles; with this exception, that here its SOLVENT as well as attractive properties are exerted. In Galvanism, the excitation of this power depends on the alternate arrangement of dissimilar metals, having a fluid interposed between them, for which the one metal has a greater affinity than the other; that Chemical changes are the consequence. The fluid is decomposed; the products assuming the gaseous form, a demand is made on this grand agent, in order to dissolve and support these new forms of existence which are thus produced. (It has been before explained how this power, in different quantities, produces and sustains bodies, in all their various forms, states, and stages of existence.) In this way, the metal in contact becomes robbed of its natural quantity, and demands a fresh supply; which is no sooner received, than it is imparted to the metal having the stronger affinity for the fluid, and where these changes and gaseous results require and demand it. Thus a current is produced, alternately positive and ne-

gative, but which differs from electricity not only in the retardation these actions occasion, but in having to traverse a different medium,—an imperfect conducting fluid, by which the current has its velocity not only farther retarded and broken, but its qualities modified. We shall recur to these differences and modifications in these Outlines, at the conclusion of Chemical affinity.

LECTURE VII.

Chemical Affinity.

Chemical Attraction has been defined, "that Attraction which takes place between bodies of a different nature;" and it is even said "that the Attraction which takes place between particles of a similar nature, is independent of any Chemical power;" but why should the power which unites one metal be different from that which unites two into one, except this, that the dissimilarity of the particles increases their positive and negative state of existence, and, of course, according to this theory, must exhibit differences in effect, in proportion as their qualities are varied and dissonant? It is evident, that Chemical actions depend on these principles; for, in consequence of motion, friction, pulverization, mixture, &c. the balance of that power "which produces all the motion and union of mat-

ter; and the primary law of which is to diffuse itself over nature," is disturbed and deranged, and every derangement in this balance, is, in other words, to accumulate it on one point, and render it defective on another; and hence by the law "which commands, that every particle should have its own appropriate and relative share," the point or particle where it is most accumulated, or most in excess, is carried, by the radiating power it possesses, in proportion to its excess, towards the one which is deficient, and that one point or particle which is deficient is equally drawn towards that which is in excess, and they instantly unite and combine, and the excess of this again moves on to the nearest particle, which is conveyed to and attracts another, and they also unite and combine; and in the same way it is propagated through the whole mass. It is thus we have attraction and repulsion at the same instant,—or particles attracting and attracted,—negative and positive points,—drawing in one direction, and carrying in another. It is thus then "we have not only the motion and union," produced by the same power, but at the same time. Now it is evident, that it cannot merely be any particle which is in excess, which will be carried towards and attract another which is deficient, that constitutes Chemical affinity; it is enough to account for attraction in general, or of attraction of the same particles, but not for that preference one particle gives to another dissimilar in itself, or "that which takes place between bodies of a different nature," properly called Effective Affinity, for this we must have more than the mere conveying and drawing powers of the point in excess: We must also take into consideration the

qualities of the particles, and the qualifying circumstances attending the combination.

What are the specific qualities of the particles, and modifying circumstances, by which we can explain and determine why certain particles combine with some, in preference to others? or rather, why they always unite and separate, in the same order, in the same circumstances. If every single particle be invested with the property of attraction, and if we can suppose any one uninfluenced by the contending attractions of surrounding particles, or of attraction without its surface, then it would follow, that the form of this particle must be Globular; and thus I think we may explain and determine the great question of the ultimate or primary form of particles; but they neither are, nor can be, so placed; they are every where influenced by the contending attractions of surrounding particles, and of this same all pervading influence which surrounds them; and must, therefore, as it draws them in one way rather than another, with a greater or less degree of force, and as they are more or less susceptible of motion, and within the sphere of action, alter this form; hence I have said, Chemical affinity depends on the quantity, intensity, and direction of this agent, which different particles are capable of imparting or receiving to each other, and these are regulated by their various degrees of capacity, solubility, gravity, and conducting power. Their differences in capacity, or power of containing or retaining, will vary the quantity. On the different degrees of solubilty, tenuity, and mobility, depends their susceptibility of forming points and angles, which will vary the facility or intensity of its being imparted by one, and received by

another; and their differences again, in specific gravity and conducting power, will not only regulate the direction, but tend still farther to increase the quantity, regulate the intensity, and fix the direction from the points imparting to those on which it is received.

Thus we perceive, that such phrases as these, "Particles of the most dissimilar nature generally have the strongest attraction," "that Chemical affinity takes place only between bodies of a dissimilar nature," come in close contact with truth, but the truth itself is this, *that Chemical affinity is the mean between the dissimilarity of the Chemical, and the similarity of the Physical qualities.* So that, instead of saying "bodies attract each other with different degrees of force," it would be more correct to say, "*that the particles of bodies always unite and separate, in the same order, in the same circumstances.*"

The dissimilarity in the Chemical qualities, conducting power, and capacity, &c. increases the negative and positive state of the particles, and the similarity in the Physical qualities, gravity, solubility, &c. preserves them in the sphere of action, and hence it is, that every new compound, being different in these respects, (in its Physical and Chemical qualities,) from its original constituents, takes a new place in the tables of Chemical attraction. And so true is this theory, that if we knew the exact qualities of the particles, we might anticipate, with mathematical exactness, the order of combination and separation, which, on these principles, they must, where they have freedom of motion, arrange themselves. The motion and union of particles are not less certain and uniform than the mo-

tion and union of celestial masses. The same grand power sustains, and moves, and regulates both.

LECTURE VIII.

Chemical Affinity continued.

That the application of heat, ("or concentration, and energetic actions of this power," *) and the act of pulverization, &c. are necessary circumstances † to be attended to, in order to induce the actions of particles on each other, is evident, from the short view we have given of that Grand Power, which, in different quantities, by its solvent and attractive properties, gives to and sustains matter, in its various states, stages, and forms of existence.

That one portion produces and preserves matter, in one form, and that an increased portion changes this form; and, in proportion to its excess, and according to the qualities of those substances on which it

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* The reasons why heat is called the concentration, or energetic actions of this power, will appear under Caloric.

† These circumstances, together with the uniform effects of Gravitation, are improperly named laws and principles.

acts, produces their separation, motion, solution, deposition, or union; always in the same order, under the same circumstances.

Let us attend to Chemical actions, or to those which take place among the particles of matter. By, as has been asserted, a certain determinate portion of this power, each species of matter assumes and preserves its different states, and stages, and forms of existence; and, consequently, increase or diminution of this quantity alters this state. In fact, all that is above the point of saturation necessary to preserve this form, has the tendency to change it, and to carry off or dissolve the particles of which it is composed; this it does by its solvent and attractive properties, and not by any separate and distinct power of repulsion; but it produces a repulsive effect, by retaining its attractive and solvent properties, in this radiating state; and this, of course, in an increased degree, in proportion to its increased quantity. It is thus, by the action of the same power, *merely increased in degree*, that cohesion is overcome; that Chemical actions are produced; that, by its determinate laws, uniform effects take place; that the particles of bodies are dissolved and separated, in the order of their solubility and levity; and this is the case, whether they are, according to the common mode of expression, dissolved in water, or air;* if in air, these particles are not only separated, but carried to distances, not by a *repulsive power*, but by the accumulation and the radiation of the excess of this same power, producing a repulsive effect. On this

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* I specially refrain, at present, from entering upon the questions of the solvent powers of water and air.

principle almost all Chemical actions depend. They depend on Gravitation, on the one hand, and this radiation, on the other, exerting their opposite influences, Gravitation carries the heavier body in one way, and this radiation the lighter one, in the contrary direction. It is thus Gravitation assists, opposes, and modifies Chemical effects, just as the particles differ, more or less, from each other, in their specific gravity and solubility; and were it not for this aggregate attraction of a mass, particles, by every excess of this power, would be scattered throughout space. For the same reason it is clear, that, to produce changes among particles on the surface of our globe, it is necessary to accumulate this power, in order that, by its tendency to radiate, which is in proportion to its excess, we may be able to counteract Gravitation, or the aggregate attraction of a mass.

In all Chemical operations, we regulate the degree of heat or concentration of this power, in order that the influence of Gravitation, and these repulsive effects, may separate the heavier and lighter parts of the constituents, of which the substance is composed, from each other, according to the nature of the substance we employ, and the new ones we wish to produce from them.

While then the positive and negative state depend on the dissimilarity of the Chemical qualities, the similarity of the physical qualities, in this way, modifies the effects, and gives rise to what may, I conceive, be considered an axiom in Chemical affinity, "that the force of Chemical action is the mean between the dissimilarity of the Chemical and the similarity of the Physical qualities of the particles." It is necessary to

be more particular; for, overlooking the influence the general force of Gravitation has upon the concentrated actions of particular parts, and the influence the concentrated actions of particular parts have upon Gravitation; Gravitation and Chemical attraction are treated as separate and distinct powers. Chemical attraction is this power, confined and concentrated in its actions to partial and detached parts of nature, often the production of art or matter, new modelled for the purpose, and cannot, therefore, be considered as bearing any relation to its unconfined and diffused action, on common masses of matter, taken in the aggregate. In Gravitation, we overlook all partial and individual peculiarities. In Chemical attraction, we attend solely to those minute differences of effect which arise from such peculiarities.

The circumstances are, therefore, widely different, and bear no analogy to each other. The one is attraction, acting on separate and determinate kinds of atoms; the other is attraction, acting on masses, consisting of atoms of every kind. In one case, it is partial and concentrated, in the other, it is general and diffused effects we have to observe. How then should Chemical attraction, by which is generally understood that of a few acids and alkalies, form any data of reasoning, or be considered, *a priori*, to bear any comparison with the unlimited operations of nature, in the immense and complicated laboratory of the universe. Still, however, experiments, made with all possible accuracy, appear to identify them.* How is it possible to imagine, that there can be any difference,

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* I allude to those of Cavendish, and others, on the attraction of the plumb line, &c. to mountains, &c.

save in the circumstances? Can we suppose that nature has formed a separate and distinct power, for the sake of the mere Chemist, in his laboratory, which waits in some corner, ready to come and to go, at his command? Hence, whatever difference appears to exist between Gravitation and Chemical Attraction, they vanish, when we consider these different circumstances,—the circumstances of differences in quantity, and of the different substances, and the situation of the substances acted upon. That the difference is not in kind, but in degree: not in the power, but in the different situation and circumstances in which these effects are produced: however distinct these separate parts of causation may seem, on a partial view, they are the production of the same infinite power of the universe.

It is from want of discrimination on the peculiarities of which a whole may consist, or from partial and imperfect views, that so much controversy and confusion have taken place on every subject, have been so fatal to truth, have produced so much misery, and reflect so much disgrace on the world.

Again, it is said, that Cohesion and Chemical affinity are antagonist powers. The attraction of Cohesion, or Aggregation, is considered as a separate and distinct branch of Chemical attraction. This, in my opinion, is artificial, arbitrary, and erroneous; for instance—"Aggregation," says a celebrated author,* "is *that attraction* which takes place where the integrant parts of the mass are all of one kind." "Chemical

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* Dr. Murray.

attraction or affinity" again "is that in which the body consists of parts different from each other." Yet, though this marked difference is made, under the head Aggregation, the whole science of Crystallization is detailed; and it is already certain, Crystals are almost all compounds. Besides, we cannot yet say, that any body is formed of one element alone, or that we have yet separated any portion of matter into its elementary parts. Indeed, such is the rapid progress of this science, that the very substance we suppose an element to-day, we find to be a compound to-morrow.

We shall, I think, perceive the imperfect views which have given rise to this distinction between Aggregation and Chemical affinity, when we consider the difference between the actions of this power in nature and art, and more particularly the difference between the actions of this power on masses and on particles of matter.

It has not been duly considered, that substances formed by art, and those formed by nature, must, from the very opposite circumstances in which they are placed, differ most essentially from each other. The slow and tedious process of every natural operation must give to the products the greatest difference and superiority, especially in density, cohesion, and aggregation.* The perfection of Crystals is in proportion to the

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* The proofs, which in my opinion are incontrovertible, of a relative diminution of water and increase of land, on our globe, are not confined to the striking indications of its having, in general, gradually receded, (I say, in general, for there are many partial appearances which indicate the

time taken for their formation. The hardness of mortar, and many other compounds, increases with time, and becomes as great as that of stone. Various animals and vegetables, &c. are found imbedded in rocks, which prove they have been formed of matter in a less solid state, which is more evidently the case with those in a state of pressure, and not exposed on the surface, as the conversion of vegetable matter into coal, &c. If then the action of this power requires an unknown lapse of time to give to masses their solidity, it must require a high degree of accumulation and concentration of the active energies of this power to dissever and dissolve such masses, and overcome cohesion, or the effects of time, just as we can, by concentration, produce radiating effects, and overcome the attraction of Gravitation, or the effects of the general diffusion of this power in masses.

It is said,* "that cohesion opposes Chemical actions, and that fusion and solution are necessary before they can take place." This is attributing the effect to one power, and giving the credit of it to another. What are "fusion and solution," but Chemical actions? Cohesion or matter in masses impedes and prevents the particles and constituents, of which one mass is composed, acting on those of another mass. To remove this, when we do not resort to mere mechanical operations, still belongs to

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contrary,) but from the quantity of matter necessary to the formation of soils, and vegetable substances, &c.; but of this in a more extended work.

* Dr. Murray.

Chemistry, and fusion and solution with their opposites, of crystallization, deposition, &c. include almost the whole of this science.

The tendency again, which some bodies have to assume the solid state, or state of cohesion,† whatever cause gives them this tendency, is one of those circumstances, which, instead of opposing Chemical action, modifies, and almost regulates the actions of affinity; hence, as the temperature diminishes, or the quantity of the liquid containing any salt in solution, the tendency to cohesion, or insolubility, or gravity, increases, and counteracts this suspending power; and the substances, in Dr. Murray's opinion, separate in this order, and not in many instances according to that which previously existed in the mixture.*

Let us consider more closely the difference in the actions of this power on solid masses, and on minute particles. It is not merely that particles continue to present a new surface, and a much larger extent of surface than solid masses, but that having a greater capacity, they possess more in quantity, and more especially during the operation of Pulverization. It is then a current is called forth on the same principle as Electricity is by the friction of the cushion of the revolving cylinder; and hence Pulverization, Agitation, &c. assist Chemical action, because they augment the power which is the cause of all Chemical action—motion and union. In Electricity, we contrive to intercept the current thus pro-

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† M. Berthollet rests nearly the whole of his theory of Chemical affinity on this fact.

* See Dr Murray's Analysis of Mineral and of Sea Water, &c.

duced, and of course, we render it more perceptible than where no such contrivances are adopted. This constitutes the sole difference between them. Again, Pulverization, in some measure, increases Chemical actions, by not merely calling forth this current, but the augmentation of capacity, and diminution of conducting power of the pulverized mass tend to retain and accumulate it. On these principles, friction of every kind, produces heat, light, and Electricity, often so abundantly on some non-conductors as to burn them; in other cases, so as to explode or detonate the substance, by rapidly and widely changing its state of existence.

The Caloric excited by friction, in all Count Rumford's experiments, is explained in the same way. It is rapidly abstracted from the surrounding medium. Nor do we see that these experiments at all favour the idea that Caloric is motion. Why should this collection of heat be more wonderful than that produced in the form of Electricity? In all these experiments nothing was employed but conductors. No means were taken to arrest that inconceivable rapidity with which nature re-establishes every disturbance in the due distribution of this power. The quantity produced is no objection. What is any partial concentration or energy that human means can effect, compared to its general diffusion and energy throughout the universe?

Agreeably to these views, I define Chemical Attraction as, *The Science which treats of some of the particular Operations and Effects of the* GRAND AGENT *of Nature:* Or, to express it in a more extended and intelligible form, *The Science which treats of the Natural and Artificial Operations*

and Effects of the separated, combined, and concentrated Forms of the GRAND AGENT *on dissimilar kinds of Matter, and of ascertaining and applying its Actions in these states.*

As this definition includes Electricity and Galvanism, as well as Caloric and Light, it will suggest the idea, that Chemical Affinity ought to have been considered before them, and immediately after the Attraction of Gravitation; or that part of the system of Natural Science which treats of some of the general operations and effects of this power: but it would have been impossible, in these confined limits, to have done this with sufficient clearness and precision, without the anticipation, and, of course, the repetition, of our ideas on Electricity and Galvanism.

I wish these definitions to be each descriptive of parts belonging to one whole; and to present the mind, when they are seen together, with a connected and combined view of the different Objects of Science, or of the Operations, Changes, and Phenomena of Nature. An artist would not call separate limbs and features, put together regardless of proportion and harmony, a correct portrait; and still less do those definitions and views of different branches of science, which include too much or too little, give, however joined together, any correct representation of nature: it would, however, be equally unfair to judge of the one or the other in an unfinished form. Without entering at present, therefore, on any defence of this definition, I shall merely state, that, on considering the views already given, particularly the distinctions between Gravitation and Chemical Attraction, it will be found appropriate.—Chemical Affinity, in my opinion, includes the whole of Chemistry, according to the common

acceptation of the word, as "*the Science which treats of the minute and "intricate Changes of Nature;*" but I have defined it as "*the Science "which investigates the Movements and Changes of the Universe, and "which endeavours to ascertain the Nature and Properties, together with "the Laws and Principles, and modifying Circumstances, of that* POWER "*by which they are produced.*" Chemical Affinity is distinguished from this, by having to investigate the *particular*, and not the general operations and effects of this power. I repeat, that all operations and phenomena in nature and art, arise not from any powers differing in kind, but from differences in the degree, in the purity, in the circumstances, and in the substances in or on which the properties and energetic actions of one power are exerted and applied.

"As Electricity," says Sir Humphry Davy, "appears to result from the general powers and agencies of matter, a number of important phenomena must depend on its operation." If matter is invested with its own "general powers and agencies," it has no occasion to be indebted to Electricity for its "important phenomena." Here Electricity is made both a cause and an effect, and at the same time excluded from the title of either. I did not, however, quote this passage for the *idle* purpose of criticism, but to ask, if a "number of important phenomena" depend on its operation, why not all? There can be no occasion for introducing the principle of division of labour into the operations of nature. He instances Chemical effects, Meteorological effects, such as the formation of clouds, &c.—the phenomena of thunder and lightning, &c.—he mentions also vegetation, &c. Do not these include every thing? At

any rate, if all these depend on its agency, what are the effects we shall assign to some other power? The connection of "Chemical effects with Electrical powers," is an expression perpetually recurring in Sir H. Davy's Elements. In fact, on this subject, contradictory reasonings occur in most writings. Sometimes it is said, Chemical effects are the cause of Electricity; at others, Electricity is the cause of Chemical effects. The fact is, Electrical appearances are the phenomena attending the operation of a cause which produces these effects. It is, however, true, that Electrical and Chemical effects are the causes of other effects; while they, at the same time, are themselves only links in the grand chain of operations resulting from the actions of one power. Is not the power which produces Electricity and Attraction the same? What line of separation can be drawn between them? Or how shall we distinguish them from each other? Do not those bodies which possess the strongest Electrical power, possess the strongest attractive energy? In fact, are not Electricity, Galvanism, Caloric, and Light, different forms of the same power? And hence they are given out or absorbed in one form or the other, in proportion to the extent, and the rapidity, and the nature of the substance on which the change is produced. Hence, as it thus passes from one substance to another in greater or less quantity, in a more or less concentrated state, or with substances more or less dissolved in it, it assumes these different forms of Electricity, Galvanism, Caloric or Light. Thus changes and phenomena differ not in kind, but in degree; not in the power producing them, but in the nature and circumstances of its actions. It is admitted, that the power producing minute and stupendous changes

is Attraction. Which, pray, are those intermediate changes produced by some other powers? Or is there not in this view a beautiful gradation in the chain of effects which excludes them? Or what more is necessary in order to explain them?

Those atoms which have the strongest Chemical attraction for each other, are always first selected by a stream of Electricity or Galvanism, if they should be contained in a solid mass of matter; nor can any circumstances whatever make them deviate from this uniformity. If this identity of operation and effect does not prove the identity of the cause, by what process of reasoning, I ask, can we prove it? or, rather, how shall we identify any power? How, unless by the certainty of the same appearances and effects always recurring on the application of the same cause, and never in one solitary instance without it?

When the power of Electricity, or Galvanism, is concentrated upon a compound, consisting of an Acid and an Alkali, it is decomposed; and yet Acids and Alkalies are among the strongest agents of decomposition which we possess. The Oxydes of Metals, also, are re-vivified by this power; and they, also, are placed on the head of every column in the Tables of Chemical Affinity. Can a power which is less overcome that which is greater than itself? Yet Chemical Writers say, that Electricity and Galvanism overcome Chemical Affinity by a repulsive power, and this they call the Chemical Agencies of Galvanism. How many Chemical agents, in this sense, will they tell us there are, and how their work is divided among them; how much is apportioned to one, and how much to another; will they inform us, when this agent commences its action,

and when another terminates the operation? What Chemical agent is there but that power we have hitherto named, Attraction? The experiments of the three cups, in which solutions of Acids and Alkalies are held, having their communication with the Acids and the Alkalies alternately, formed with Asbestos, prove, in my opinion, in the most unequivocal manner, that this power is Attraction. Its attraction is superior to all others. It ought, at all events, to be placed at the head of the list in every Table of Attraction. It is, in my opinion, the first and last of the re-agents of nature, to whom all others are indebted for any powers they possess.

Is it not feeble and undecided language to say, after this, that the Chemical changes which Electricity or Galvanism effect, cannot be traced? They are as distinctly traced as any effect or change, however produced. It is evident, when these powers are accumulated, and their energetic actions concentrated, the constituents of bodies unite or separate according to the laws and circumstances already detailed under Chemical Affinities. It is not, therefore, enough to say, Chemical Affinities are suspended by this power—there is more than suspension. Nor is it enough to say, that it communicates to the particles of matter both attractive and repulsive powers, by which their affinities are enabled to operate. It does more than communicate—it is the absolute power itself, the all-pervading energy of nature.

From imperfect views on this subject, have arisen the most confused descriptions of effects produced by this power, such as we have already mentioned, with many others; as, for instance, Electricity and Galvan-

ism produce Chemical changes as much from their repulsive powers as from the affinities they exert. Can we have any idea of the exertion of affinities and repulsive powers at one and the same time, unless it be an affinity for the power which produces this repulsion? In which case it is most obvious it is not repulsion as a cause, but merely a repulsive effect. Is it not much better to say at once, that Electricity, or Galvanism, is the power which produces Chemical changes, than to say that it separates and suspends the particles, and then suddenly stops short, for the purpose of allowing some undefined occult power to step in and finish the operation; and this, after the most important part, nay, in fact, the whole has been accomplished? This is, in truth, attributing the effect to one power, and giving the credit of it to another—a common way of treating things meritorious. But this energetic power is, in fact, Chemical Affinity itself; that power which begins, continues, and ends the process; and we only favour and facilitate its action, by attending to those circumstances which least oppose its operations, and are best fitted to augment its intensity, quantity, and circulation: this is our humble province.

Sir H. Davy introduced the Theory of Electrical Energies, which he explains in this way. There are two different kinds of Electricity; every body has one or other of these; and from this arises their power to combine, owing to the disposition or attraction two Electricities have to combine with each other; and on this all the phenomena of Chemical Affinity and Attraction, he supposes, may depend. This is not saying more than was said before, "that different bodies attract each other with different degrees of force," except substituting the word Electricity for bodies.

That, in fact, Attraction depends on the operation of that which is not itself Attraction—depends on the operation not of one but of two contending powers. This view is at present taken of the operations of nature, that Attraction and Repulsion are two powers invested with antagonist properties to carry on perpetual war against each other. Now, if they are exactly balanced, there can be no motion; and if they are not balanced, the one must overcome the other, and, of course, cease to exist. If this is the case, Attraction loses her dignity, and acquires a new meaning. She is, in fact, dashed from the high eminence to which Newton had exalted her, and that indiscriminately among the immense mass of common effects. But this theory is very amply contradicted by the very beautiful statement of facts by Sir H. Davy. The wonderful precision and labour in accumulating facts on which the greatest reliance may be placed, more pre-eminently distinguish this great Chemist than perhaps any other Philosopher of this day.

He states, that "the Attractive and Repellent states depend entirely on the actions of the two substances, and not on any power peculiar to or inherent in each." That is, on the existing relative states of the two substances, and "not on any power peculiar to or inherent in each." The same substance, excited in a different manner, becomes negative in one instance and positive in another. Now this is in complete contradiction to two Electricities, and the theory formed upon them. The fact, in my opinion, is this:—Negative and positive are mere relative states of existence:—the substance that is negative in one situation, in the neighbourhood of one body, will be positive in another situation, connected

with another body:—they are then mere relative terms; and the bodies which are positive when rubbed with one substance, are negative when rubbed with another; and sometimes by mere alterations on the surface, if it is rendered less smooth, or rubbed over with grease, chalk, &c.:—all which, with an immense number of other methods, by changing the relative capacity, conducting and attractive power, makes it either the point from which this fluid is abstracted, or that on which it is accumulated; and this law is always observed, that the body will be positive which has least conducting power, and the other which has more will be negative:—hence, if the rubbing body be the best conductor, the thing which is rubbed will be positive, while that which rubs will be negative; that is, Electricity will be abstracted from that which is the best conductor, and imparted to that which is the worst, where it will be received, retained, and, of course, accumulated. The phenomena of Attraction and Repulsion, with all their variety and complexity, may, on these principles, be readily pointed out. Bodies are drawn, or carried, in any direction, in proportion as they are either in excess or deficient, and are surrounded by any thing from which they can either receive or make up their deficiency, or to which they can impart their excess; and they do this in proportion as they are near, are relatively more or less negative or positive, or are more or less conductors.

It is on these principles there is one continual round of composition and decomposition, of decomposition and composition. Matter assumes new forms and colours; the destruction of one order of beings tends to the conservation of another; solution and consolidation, decay and re-

novation, are connected—they are mere exchanges of this power—it is imparted by one, and received by another—one substance is precipitated from it, and another is dissolved in it: it is thus, while every part of the system continues in a state of fluctuation and change, the common and established order and harmony remain, or recur, with their general aspect unchanged.

Elements combine in every proportion, producing endless varieties, all convertible into each other. Every process in nature is reciprocally subservient to another:—fermentation, combustion, and animal respiration produce Carbonic Acid Gas, the principal food of vegetation; vegetation evolves Oxygene Gas, equally necessary to combustion and animal life;—what is obnoxious in one way to animals, is in another way food for vegetables; vegetables return the loan, and furnish support to animals. Thus relation and connection are everywhere established, and on their balance depends the perfection so striking in the general order and sublime harmony of nature. No part of this balance is left imperfect, as the work of moral industry, allotted to the delegated powers of man to complete.

It is the same power by which water is raised from the ocean, separated from the salts it contains, carried through the air in the form of vapour, gives rise to the phenomena of clouds, and, if still more highly rarified and elevated, becomes part of the transparent sea which floats on the surface of our intervening atmosphere. By the same power it is again condensed into vapour, which, gradually increasing and thickening, foretells the coming rain; the water that was raised again returns to

the earth in dew or rain, with or without thunder, according to the degree of the deranging causes; fitted, with the purified air of the atmosphere, to become the richest nourishment to the soil; and, by the wonderful properties of this power, the universal life of nature bursts forth with all her varied charms of vegetation and animal existence. Thus, by the agency of this power, solids become fluids, and fluids gases or airs; and by the same power they constantly change their place. The oceans of air and of water, besides their tides, flow from the Equator to the Poles, and from the Poles to the Equator;—vapour and rain are formed and carried to every part of the earth;—and these effects, while, on the same beautiful principles, they moderate the changes of season and of climate, clothe every part of the globe with its varied appearances of complicated grandeur.

Thus we see the elements of matter, in consequence of their different relations to this power, and its actions on them, combine in every proportion, producing endless varieties, (the principles on which these combinations take place we have already explained) all convertible into each other. They combine in different aggregates;--in their simpler combinations, they are distinguished by their beauty and regularity of form;—in more complicated arrangements, they bear the higher characters of organization, and are rendered subservient to the purposes of vitality, and constitute the varieties of animal and vegetable existence.

The different states of existence, and all the different changes of nature, summer and winter, day and night, light and darkness, heat and cold, and all the extremes and irregularities of climate;—the extremes,

too, of youth and age, of sleeping and waking, of life and death, either in vegetables or in animals, are but changes resulting from modifications produced in the operations of this power by alterations of circumstances; and these do but produce changes which themselves renew, keep up, or increase the vigour of the operations of this power. It is, in fact, the effect of its own operations to derange itself: changes produce changes—one effect follows another—so that the tendency to restore the distribution is always exerted, but can never be fully effected: hence this ceaseless motion not only in bodies and the particles of bodies, but in systems and of systems throughout space.

When great derangements in the actions of this power take place, we have inflammation, combustion, explosion, thunder, lightning, storms, hurricanes, earthquakes, volcanoes; all produced by, and depending on this power changing the state of existence of substances, either to or from the solid, liquid, or gaseous state; by which actions and changes it is concentrated upon, or radiated from them, with different degrees of force and of purity, in proportion to the power of the deranging causes, and the nature of the substances on which the resulting actions are applied; in proportion to the degree with which the different forms of matter are rapidly and widely changed in their state of existence: so that, if water is elevated and forms a transparent sea, if it is again condensed into rain, if fire is extricated in thunder and lightning, if winds and hurricanes, if earthquakes and volcanoes—if the frame of nature herself circles and re-circles her eternal course, we see the agency of the same power, the

exhibition of the same wisdom; simple in principle, stupendous in operation, supremely majestic, and sublimity itself in the combined results!

LECTURE IX.

Caloric.

Though the words Caloric, Fire, and Heat, are all at present used by Chemists and Philosophers, as expressive of the cause, and of the effect that cause produces; yet, in all their writings and lectures on this subject, they confine their attention so exclusively to the phenomena of heat and flame, as, in the most unequivocal manner, proves, they conceive these appearances are its proper form and nature: that, in fact, Caloric, abstractly considered, is something in its own nature hot and fiery.

This, I conceive, is an erroneous and very imperfect conception of its nature and of its actions; and hence on this subject there has been so much controversy and confusion of opinion. As, for instance, from whence is it derived? Whither does it proceed? Why is there frequently heat without light? Why, again, do they generally appear together? Whether they are in reality separate and distinct powers?—Many contend they are mere properties of matter, and nothing in themselves. Some, that they are only the effects which the vibratory motion of the

particles of matter produces. And before any one of these questions is answered, almost all our modern Philosophers have either been exerting themselves with all their might to prove, or have admitted as proved, that this heat and light, while they have a repulsion for their own particles, possess not only an attraction for each other, but for all kinds of matter; and this is said by those who affirm that this heat and light are nothing in themselves, mere properties of matter, or the mere vibrations of its particles.† Nor have these various opinions and contending theories at all diminished, since the Lavoisierian theory of combustion; proving, in my opinion, that our views of the nature of this power, and of its actions, are still erroneous and imperfect: and, in fact, it is now admitted, that this theory does not account for the heat and flame which appear in many instances; and I conceive it is very imperfect in its application to all of them.

Now, according to the theory already briefly, and, consequently, from

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† Is this multiplication of powers, this gratuitous assumption of properties, this confusion of one contending explanation after another, the boast of modern Philosophy? Is this the eminence from which modern pride looks down on the ancients with so much contempt? We charge them with jargon and unintelligible abstruseness. With what propriety might they retort upon us one less to our honour, and incomparably more just. Let us understand them and ourselves, before we condemn the one or praise the other.—[See the articles Vindiciæ, Antiquæ, and Science of the Egyptians and Chaldeans, in the Classical Journal.]

its brevity, imperfectly detailed as it is, it will, I conceive, appear evident, that this heat and flame are the mere *effects* and *phenomena* which attend the more energetic operations of a power on which every motion, change, effect, or phenomena, throughout nature depend; and though we do not apply the word Caloric as the cause of those changes which are more slowly produced, the power and its principles of operation are the same, differing not in kind but in degree.

I am anxious to be understood, and shall therefore be more particular: for, on the subject of Caloric, I must evince, my claims were not groundless, when I asserted, " That I conceive the Attraction of Gravitation, Chemical Affinity, Electricity, Galvanism, Magnetism, Light, &c. may all be clearly explained as the mere diversified phenomena or modifications which different circumstances produce on the actions of one Grand Agent in nature. That this I will endeavour to support, by a full explanation and exposition of facts, by pointing out the circumstances, and in what way those circumstances operate, which, in my decided opinion, give simple and well-defined views of each of those sciences in particular, and of the whole combined as one undivided, sublime, and majestic fabric of nature."—If I fail to make myself as intelligible as could be wished, it arises from the difficulty there is in condensing so extensive a view, and of rendering that view, under these restrictions, at once plain and comprehensive.--It is very different, to have in our own minds the clearest perception of a subject, and the fullest conviction of its truth, and to be able to produce the same effect on another. Nor need we wonder at this, when we reflect on the amazing length of time and

degree of labour, even stimulated by an enthusiasm which cannot be transferred, to produce this effect on ourselves.

Agreeably to these views, I define Caloric, as " *The science* * *which treats of some of the particular and more striking operations and effects of the* GRAND AGENT *of nature, on specific kinds of matter.* Or to express it in a more extended and intelligible form : *The science which treats of those natural and artificial operations and effects of the* GRAND AGENT, *on dissimilar kinds of matter, which are attended with heat and sometimes flame, and of observing and applying its actions in these states, in order to ascertain its nature, and produce other effects.*

It will now be obvious, why I conceive the definition, usually given of chemistry, to be partial and defective, and have ventured to suggest one more extensive ; and why I have said, the correctness of these definitions will be best seen in connection as parts belonging to one whole ; my reason too for including these views under the title of CHEMICAL PHILOSOPHY, is not only that the consideration of Electricity, Galvanism, Caloric, Light, &c. are at present more particularly investigated by the Chemical Philosopher, but also because I believe the word Chemistry had originally the most extensive meaning. The ancients considered Heat and Flame as the most prominent features in the operations of a power, on which every

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* For the sake of brevity, I have said in each of these definitions " The science which, &c." meaning, as will be obvious from many observations, that part of our knowledge of nature the object of which is to treat of, &c.

motion, change, and phenomenon depended, and hence it received innumerable names, all expressive of heat or flame, separately or combined; in this way all descriptive names are given, and the reason this power has had such an infinite number applied to it, is that all we can know of this grand cause is through the infinite number of effects which it produces: and hence the mind of man has been directed to one part of its operations at one period of the world, and to another part at some other time. It was in this way that the words Attraction and Repulsion were introduced, and have been more particularly adopted in modern times, because the mind was directed to Newton's Theory of Planetary Motions, as well as to that of Chemical Affinity: it is from these causes there appears, on a superficial view, so much contradiction in the different systems that have prevailed in the world; this contradiction, however, arises not so much from direct and absolute error, as from divisions and separations of that which is true. It is from dividing that which ought to be joined—from some men, at one period, directing their attention to one part of the operations of this power in particular, while others at another time have had their thoughts directed to an opposite point, and this not merely to the exclusion of a comprehensive view of the whole, but each of these parts have been and still are carried by both parties to the utmost extreme: this must remain the fate of science and of every other subject, so long as terms which originally were descriptive of some partial and particular effect or peculiarity continue to be applied to a whole, of which they form only a part, for tho' these terms were received as descriptive, they are soon considered as expressive of the nature and essence of the power, &c. of which they are

thus arbitrarily adopted as signs. Newton saw this, in adopting the word Attraction, and which has, notwithstanding his anxiety to guard others against it, become its present meaning in the common acceptation of the word. It is from considerations of this nature, that I have preferred the terms, "The GRAND AGENT," "The GRAND POWER." The reasons why I conceive the word Chemistry had originally been applied in the same way, are not merely that such words as Chamiah, Shemiah, Lama, Flamma, &c. and an immense number of other words, all expressive of Heat and Flame, singly or jointly, throughout Asia and Europe, have such a striking resemblance to each other, and in fact, identity, considering the different shades of pronunciation which substituting the letters, s, c, g, k, ch, sh, w, v, p, f, b, &c. for each other, occasions: but there are several considerations, connected with the ancient views of the subject and notions of the general principles of science. I am aware of this view differing in some measure from that given in Dr. Thomson's History of Chemistry, in the last edition of his system, and indeed from any hitherto adopted; I have not ventured to state this, however, without grounds, and grounds so extensive, that it would be literally impossible to state them in this place. To trace the connection of words with each other, their relation to science and mythology, and all this connected with the men of ancient times, is too alluring, too important, and too mighty a subject to enter upon lightly, —at any moment, and in any place. I say this, for the sake of asserting, that what I have said about others, or about names and definitions, has arisen from feelings and motives very different from the vain, flippant, carping, fastidious, and wanton spirit of criticism, than which nothing can be

more contemptible, but from a conviction which no man has a right to controul or withstand, that of Truth.

In the mean time, I shall only remark on this subject, that I conceive the Arabians, who gathered their notions from the eastern parts of the world, were led to believe that, as the power expressed by the word *chamiah* (to burn) was that which prevaded nature, and produced all its transformations, they could, by discovering its secret principles of operation, perform any transmutation they chose; and hence they called it, by way of distinction, *alchamiah*. Indeed, in the present day, notwithstanding the partial definition given of this science, and its affected separation from other branches of natural knowledge, every description we have of its powers, its objects, and its applications, presents it, not as an insulated portion of human knowledge, but as that, the professed object of which is, to remove the veil from the face of nature, and unfold the nature, properties, and changes of matter, and to make us acquainted with that wonderful power which produces them. These are the Elements of Science; Here is the centre and circumference of a mighty circle, wherein all Science is included.

What then, it will be asked, is the nature of this power? And why in its actions does it produce such diversified effects and phenomena? for I have ventured to assert, "That I conceive, one subtile and all prevading power produces all the phenomena of nature and of art; is the sole agent which creates or destroys, unites or separates, preserves or diversifies the forms of matter; that, to its agency, we owe not merely the subdivisions and convertibility of matter into solids, liquids, and gases; their appearance in one

state, and disappearance in another; their union with this substance, and their separation from that species of matter; but all their various degrees of density, of colour, of quality, of form, and of arrangement; that, in fact, it is the grand attractive agent, the universal solvent, that energy which pervades the universe, and modifies all the powers and properties of matter, which, in one quantity determinate in each species of matter, binds and unites it together, and is therefore its principle of aggregation or bond of union; which, increased in quantity, produces all its movements and changes, and is therefore the principle or power, which alternately destroys or renews every state of its existence."

The GRAND POWER, which, in different quantities, by its solvent and attractive properties, gives to and preserves matter in its various states, stages, and forms of existence; which binds and unites its particles together, and by which also they are separated and carried from one point to another.

This power, therefore, I have defined, as "*That which produces all the motion and union of matter.*" This definition, without presuming to explain in full detail its essence, exhibits some idea, in the mean time, of its powers, its properties, and its actions, and points it out, as the GRAND POWER, the cause, alike, of the inconceivably minute, and infinitely extended movements and changes throughout nature. The more extended effects require a more enlarged treatment than this work will admit: the full explanation of these views cannot at present, therefore, be expected, nor any thing like a complete answer to these questions: What is the nature of this power? How can the same power produce such diver-

sified effects? and, Why should its operations be attended with such diversified appearances? Yet they are questions of such high importance, that we may be excused, if we should consider them at greater length than a mere abridged view would seem to warrant; for what in science can be of more importance than clear views on the nature of this power? if we are imperfect in our conceptions here, all that follows will tend only to lead us into further controversy and confusion; and this must be the case, if it be true, that there are no separate and distinct causes for each of our artificial and arbitrary divisions of science. And is it not certain, that if this power has the properties and qualities we have assigned it, then, every effect and every phenomenon can only be modifications which different circumstances and kinds of matter produce on its actions? that, in fact, if we have distinct views of its varied attractive relation to substances, and of its solvent powers, by which in different quantities it changes or preserves their states of existence, then shall we not only know the effects it produces, but perceive its principles or mode of operation, by which these effects are produced, and also, why certain phenomena attend their production? It is because I firmly believe this to be the case, that I have defined it, "*The power which produces all the motion and union of matter.*" A definition which is brief and comprehensive, which includes every other, and I conceive it ought not to do less, for it is a definition of the cause which includes every other cause, if these phenomena and effects can with propriety be called causes, which though they produce other phenomena and effects, merely result from or attend the various degrees of energy, or extent, or nature of those actions, arising from differences in its quantity,

intensity, and direction, and the substances on which and circumstances in which it operates.

If then it be the GRAND POWER which, in different quantities, by its solvent and attractive properties, gives to and sustains matter in its various states, stages, and forms of existence, and if, during these changes it produces appearances as diversified as these changes themselves differ in their nature, we shall not only perceive why one portion produces and preserves matter in one form, and an increased portion changes this form; or, why every substance varies in the relative quantity it requires to preserve it in one state, or change it into another; but also, why, when we apply its concentrated actions (or heat, according to its common acceptation) to substances, or when we mix bodies together, or change their relative position, this power effects their separation, motion and deposition, or their solution and union, invariably in the same order, and as invariably attended with the like appearances, when the circumstances are exactly alike: and hence I said, "it is not only the power which binds and unites the particles of matter together, but that also by which they are separated and carried from one point to another."

If then, I again repeat, different quantities are required for each species of matter, and if these quantities be relative as well as appropriate shares, then we perceive why every increase or diminution of this power, every change of position and arrangement, every solution of one substance in another, must alter these relative quantities, must take so much from one particle and give so much to another, and thus one body is precipitated from it, and another is dissolved in it, so that, "*all changes are mere ex-*

changes of this power," separating from one substance and entering into combination with another; and hence we have by the above artificial means, as well as in nature, their separation, motion and deposition, or their solution and union, &c. as they are, relatively to each other, more or less soluble in it, or relatively require more or less for any given state of existence. The power then that accounts for minute changes, such as are in general exclusively considered under chemical affinity, is the same as that which produces the more obvious and striking changes; and they differ in effect and appearance because the extent and rapidity with which they are produced are infinitely varied both in their nature and their degree.

The power, therefore, which we designate by the words, fire, heat, or caloric, is very improperly restricted by modern philosophers to the mere solitary effects of perceptible heat and visible flame, effects and appearances which, I repeat, depend on the nature and the degree of rapidity and extent of those alternate subversions and formations, transformations and transmutations, of the various forms of matter which it produces; and hence its combination and concentration, disunion and radiation, its rapid movements in this combined and condensed form, during these actions, produce, as well as these changes themselves, that also which is the most useful of all its effects, and that which is the most beautiful of all its phenomena, HEAT and FLAME.

I wish to be understood that I do not conceive this power of nature is Caloric, in the common acceptation of the word; on the contrary, that this heat and flame are *mere effects*, indicating some specific mode, degree, or

or extent, or nature of those changes it produces on the different forms, and states, and stages of material existences; when, in combining with, or separating from them, in a more or less perfect manner, and in a greater or less degree, according to the nature of the substances on which, and the circumstances in which it operates, it assumes either the appearances of Electricity, Galvanism, Caloric, and Light; so true is this, that it may be reduced to the form of an axiom: "*That this power is either given out, or absorbed, in one form or the other, in every change, and this in proportion to the extent, rapidity, concentration, and the nature of the change produced.*"

From a partial view of this, applied to Caloric, in its usual acceptation, Dr Black formed this axiom:—"*That whenever a body changes its states, it either combines with, or separates from Caloric.*" This has been found true, to a much greater extent than was ascertained during the time of Dr Black: His attention, in forming this conclusion, seems to have been chiefly directed to changes, from the Solid to the Liquid, and from the Liquid to the Gaseous states; and from the Gaseous to the Liquid, and from the Liquid to the Solid states; but, it is now clearly shown, that, however slight the change in any one of these states, and however produced, whether mechanically, or chemically, whether by compression or by removal of pressure, in almost all instances, in mixing substances together, and in the solution of substances in Liquids, and in all where the resulting density of the compound is not the mean between them, in their separate states, a proportionate quantity of this power in one form or the other, is given out or absorbed; *substances give it out, or demand*

it, in proportion as they are, relatively to each other, in excess or defective. Is it not most evident then, that all " changes *are mere exchanges of this power ;*" passing from one substance to another ; separating from this, in order to dissolve and combine with some other species of matter; and in proportion to their relative degrees of solubility, they are united or separated from each other; and, during their changes, this power, which produces them, is itself separated from them in a more or less perfect and striking manner, in a greater or less degree, according to the nature of the substances and the extent of the changes produced?

LECTURE X.

Caloric and Light.

Thus, from the solvent properties, from the tenuity, and from the effects this power produces, I infer that all movements and changes are the result of this first sublime command or fiat of the Creator :

Let one Power be diffused throughout the Universe; and let every kind, and state, and form of material existence, have its own appropriate and relative share.

This is the Universal Law of Nature, which is equally applicable to solar systems, as it is to the particles of matter. Whenever this distribution of " appropriate and relative share" is disturbed, or, in other words, accumulated on one point, and abstracted from another; this

power of nature, this wonderful Agent of Creation, instantly obeys this GRAND LAW; the one point as readily parts with its excess, as the other receives its deficiency; and this perpetual disturbance, produced by its own operations, and this constant exertion to effect a proper distribution, keeps up all the movements and changes of the Universe.

Is it not obvious this must be the case, that this action and re-action, that this disturbance, and effort to restore the Equilibrium, must take place? That, if it gives to, and preserves matter in its various states and stages, and forms of existence, then every change in these forms, and states, and stages of existence, must disturb its due and relative diffusion and distribution; must be imparted in one way, and received in another; abstracted from this, and demanded by that; by which its circulation and movements continue their ceaseless and immeasurable rounds.

I say, is it not obvious this must be the case, if, in this subtle, solvent, and attractive power, substances are more or less soluble, have capacity or power to contain, or retain it in greater or less quantity, and to conduct, or, in other words, to receive and impart it with more or less facility, and are surrounded by other substances of a similar or different nature, that then, these differences in the circumstances and the kinds of matter, must, by every alteration in these circumstances, or, in the position of the substances, or, in the quantity of this power, be deranged in a greater or less degree, in its due and relative diffusion, and, of course, call this GRAND LAW, which regulates the Agent of Nature, into action; and thus it is imparted and received from one substance to another, in

greater or less quantity, with more or less intensity, and in a certain and determinate direction.

Its quantity and intensity will depend on the nature and extent of the change, which variations in the quantity of this power, in the arrangement of the substances, and in the circumstances, produce, on different species of matter; for it is given out or absorbed in proportion to the extent of the change produced.

The errors and controversies which have existed on the doctrines of Caloric, seem to me to have arisen from overlooking this view of the subject; and more particularly the fact, that this power, when demanded, flows in from all points to supply this demand, with as much facility and rapidity, as it flows out when in excess, or when separated from substances it held in solution; and thus the heat produced by friction, explosion, &c. is easily explained. The controversies too, that Heat and Flame were, according to one party, from Hydrogene, and according to the other Oxygene, affords another example, that truth, in almost all controversies, is divided between the disputants; on these principles, it will be evident that the Heat and Flame must be from both; of this, however, afterwards.

The intensity of this quantity again depends on its being given out, or received, on some point of concentration, or in a more or less diffused manner, or in a greater or less degree of purity, or in a separate and unmixed state; which degree of purity, or separated form, is, in proportion as substances are more or less soluble in it; and the time it has to effect their dissolution; and of course in proportion to the quantity it holds in solution,

this power is more or less attenuated or condensed, and hence we find it passing through substances with more or less facility, or with a greater or less degree of rapidity; and in proportion to this resistance of its passage through them, has more or less time to produce effects upon them; and besides this detention, giving it more or less time to produce these effects, in some instances they tend to direct and fix its action, from the disposition these substances, held in solution, have to combine with others :* At other times, from the same cause, but with different substances, it becomes more or less energetic, or effectual, in its actions, in proportion as it is more or less free or unoccupied, or has time to act; so that though the energies and properties of this power appear from the effects so various, they are, in reality, always the same. Its apparent energies, however, are widely otherwise, owing to those circumstances we have enumerated, on its being more or less free or occupied to act, as Water already saturated with one kind of Salt held in solution, is less able to dissolve Salt of another kind; in fact, these observations are equally true of this power in all cases; for instance, a man has power to walk whether he moves or not; but if he carries weight, he can neither walk at the same rate, nor for the same time, nor to the same distance; the power in the abstract is the same, but part of it is occupied or employed in support of this burden. We express all this in common conversation, when we say " of what use are strength or talents, unless they are exerted? and that they are best shewn by undivided exertion;" or if

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* See Galvanism, page 8 and 9, of these Outlines.

applied to the functions of the body, we say—" If the nervous energies are occupied too much in one way, the functions of some other, if not of every other part, are either diminished or impaired."

Thus, its apparent energies and intensities are different, not merely from its being imparted and received in greater or less quantity, and with a greater or less degree of rapidity, or of purity, or separated form, but also as it is in a more or less concentrated or diffused manner: all these, and many other circumstances attending its action, are so infinitely varied in the degree and complexity of their combination, and depend on such an infinite number of causes and circumstances, and all these, in themselves, so delicate and interwoven in every possible proportion with each other, that is impossible—and, in my opinion, if it were possible, would be unprofitable—to trace them through all their diversity of form and appearance; it would be like spending our time in noting the forms produced by the Kaleidoscope; and hence, one of the, in some measure, appropriate and descriptive names, applied to it, in the Mythology of the ancients, was Proteus. Their Mythology too, let me here observe, originated in either unnecessarily multiplying the causes of things, or in improperly applying names, descriptive of partial effects and peculiarities.

I conceive all these, and many other circumstances, though they have not hitherto been noticed, not only agree with the facts and phenomena of nature, but point out, in the most beautiful manner, the causes which vary the effects and appearances of one Grand Agent in Creation: Which point out why it assumes these different forms, and produces these different effects: Why Chemical Attraction, and the Attrac-

tion of Gravitation are different: That one is the particular, and the other the general effect of the same power: That one is the local and concentrated, and the other the diffused aggregate effect of its operations: Why, in its concentrated actions, Heat and Flame appear: Why the Heat is sometimes without Light: Why they generally appear togegether: And what constitutes the apparent difference between them: Why, for instance, Galvanism exists in a lower state of intensity, than Electricity, in producing shocks: Why it is less rapid in its movements, &c.: Why, again, its power in producing Chemical effects are so much greater than Electricity*: Why, again, the Colorific rays of the prism produce Chemical effects, while the Calorific scarcely produce any: Why they are more refrangible than the heat-making rays: Colour and Light depending (as will, I trust, be evident when we come to the particular consideration of Light), on the partial solution of substances in this power, so that Heat and Light may be contrasted with each, as I have already contrasted Galvanism and Electricity; and hence as in Galvanism, the Calorific and Light-making rays, are those which, in consequence of holding something in solution, are in proportion to this, and the unequal thickness or density of substances, as drops of wa-

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* See the article, Galvanism, in the Edinburgh Encyclopædia, where some of the above questions are there stated, as questions which require answering before we can fully understand the nature of either Electricity or Galvanism.—See Electricity and Galvanism of these Outlines; where they are answered.

ter, &c. cut glass, knots of glass, a glass prism, &c. divided in their passage through them, meeting a greater or less degree of resistance, according to these variations of thickness, and their own variations of tenuity. And besides this, their Chemical relations to each other, or the mutual affinities they exert on each other, explain many apparent anomalies.—It is thus, in my opinion, these differences of refrangibility and reflection are produced, and not by differences of the size of the particles: Also, why I conceive the heating and melting effects which the disengagement of Caloric from one body, and its transference to another; or that of mixing bodies, of different degrees of temperature, together, have not correctly ascertained or measured the relative capacity bodies have for Caloric, or of the quantity they contain or retain in any state: That consequently the Tables of Capacity, are, in some instances, erroneous: That these heating and melting effects, depend not merely on its quantity, but also on the time it has to produce the effect; whether it is retained, or rapidly escapes in its pure, irresistible, attenuated, and unconfinable form.

It is thus we have stated in general terms, and, of course, in some measure, anticipated the more particular explanation of the various effects and phenomena which are produced by one power. But it is necessary to be more particular, for it is not enough to assert in general terms, "*that changes and phenomena differ not in kind, but in degree; not in the power producing them, but in the nature and circumstances of its actions.*" It is not enough merely to say, that in consequence of the solvent and attractive properties which this power has for substances, varying in each species of matter, that this variety and these circum-

stances must modify its actions, and of course occasion effects and phenomena as infinitely varied, as these circumstances and substances are themselves different; we must be still more minute: for, not duly considering these modifying causes, there have been introduced an infinite number of powers and agencies in the creation, to which very opposite and dissimilar offices have been assigned, in order either to account for the phenomena, or, as descriptive of some peculiar effects and appearances themselves; but, I am not able to perceive, that they answer any of these purposes: Let us then see how the principles I have stated, apply in detail; and, first, let us examine that of Capacity, or the relative quantities which bodies require for their respective states, and forms of existence; and see whether "this power, in different quantities, by its solvent and attractive properties, gives to, and preserves the diversified kinds of matter, in their various relative states, stages, and forms of existence; and prove this idea correct, that, as by one power, the present form, order, and harmony of creation, were evolved; so, also, by the same power, this form, order, and harmony, are preserved and supported."

LECTURE XI.

Partial application of these views, &c.

That there is "one Grand Agent in Nature, which creates or destroys, unites or separates, preserves or diversifies, the forms of matter," is evident;

every body, in changing its form of existence, changes also its capacity for heat, or for this power; or its capability to contain or retain a greater or less quantity: the difference of capacity between these different states of existence, is exactly equal to the quantity necessary to produce the change, and of course to support the change of existence it has itself produced.—For instance, if one pound of water, heated to 172°, will only melt one pound of ice, and be itself reduced to the same temperature, that of 32°, then water at 32°, contains 140° more of Caloric, than ice at the same temperature; and if so, it is evident that 140° of Caloric disappear, and become latent in the solution and conversion of ice into water; and that this 140° is the difference in the quantity required in each of these different relative states of existence—that it is the quantity necessary to produce the Liquid form, as well as to support this change of form which it has produced. The same principle is seen in the further solution and conversion of this element into vapour, steam, or gas; 950° of heat disappear, and become latent in every portion of water passing into this state; so that water and steam are both at the same temperature, 212°; yet the steam contains 950° more of Caloric, than water at that temperature; it hence becomes latent, or the energies of that quantity necessary to produce the change, are occupied or suspended in supporting it in this new state of existence it has produced. This, I conceive, is a more clear expression than latent heat; free Caloric; Caloric of temperature; capacity; &c.: For it not merely expresses the fact, but the explanation of that fact at the same time. Indeed, in this respect, Dr Black stated the fact as far as was then known to him, in such a clear and beautiful manner,

that I wonder it ever should have been a subject of controversy; and that Dr Irvine and Dr Cleghorn should think they gave any better explanation, by saying,—" that heat disappears and becomes latent, *not* in effecting the change, *but* as the effect of that change;" this, to me, is nothing more than a very confused, partial, and imperfect expression of the fact: It is necessary to apply heat to effect that change; which heat disappears, and again re-appears on the water, &c. returning to its former state: What then can be so plain as this, that the quantity necessary to produce the change, disappears or becomes latent, because it has to support the change produced. Thus, one quantity is necessary for the Solid, another for the Liquid, and another for the Gaseous state; and this quantity differing in every different species of matter, we find substances assuming the Liquid and the Gaseous forms, at every possible point of temperature: To contemplate the beauty and utility of this law, would carry us too much into detail, and inspire us too much, by the grandeur of the subject, to indulge ourselves entering upon it in these outlines. We shall therefore only mention one example: Give to ice, the quantity necessary for the production of water, the properties and active energies of this quantity are then employed in supporting this new state of existence; it cannot therefore act upon any thing else, or produce the sensation or effects of free Caloric,—it is said to be latent; so also is the case in its further conversion into steam, which, like the gases, is a simple solution of a substance in Caloric, with this difference,—that the steam is separable from its solvent Caloric, at a temperature below 212°, and of course at the common temperature of our atmosphere. To prove that this is the difference

between the permanent gases and vapour, I need only mention the fact, "that steam does not scald so much from high pressure, as from low pressure;" this seems *a priori* contrary to our expectations: but, it is a fact, that however high the temperature is raised above 212°, it will not scald or burn more than common atmospheric air heated to the same degree, because the active energies of this power are occupied and suspended by the water held in solution: it is air; but the moment it is liberated, and lets go the water, then its energies are unoccupied, it instantly becomes free Caloric, or Caloric of temperature, and scalds or burns; and as this separation much more readily takes place at a low than a high pressure (temperature), the one must scald sooner than the other; hence, in making the different gases by heat, we find the pipes in the first instance burning hot, and afterwards become comparatively cool, because the first, which is driven off, is steam, the water of which, being abstracted by the temperature of the surrounding medium, the Caloric is set at liberty to heat the pipes, or act upon any thing else that comes in its way; but when the permanent gases come over, which are not so separable, but require that we should have recourse to elective attraction to separate them, this same heat then becomes latent, and the pipes cool; and in this latent state carry heat and flame in any direction we please; when, however, as in Carburetted Hydrogene Gas, it is made to unite with Oxygene, this heat, together with that which holds the Oxygene in solution, is liberated, and produces heat and flame; thus, while some say heat and flame are from Hydrogene, and others from Oxygene, I say they are from both: how often do we find truth differing from, and

agreeing with all parties. The fact is, that the gases are formed by the solution of substances in this Caloric, exactly on the same principle, only more attenuated, as ice is melted by heat, and forms water; and consequently when they change their form of existence, they give up this power; and when, on some concentrated point, which is always the case when separated by elective attraction, heat and flame appear.

Had it not been for the impressions which the doctrines of attraction and repulsion had made on the mind, it would have been quite natural for the Chemists of the time of Lavoisier, and on the discovery of the gases, to consider and speak of the solution of substances in this power, as that which formed the Gaseous state of existence: indeed, in proof of this, we find them with great difficulty refraining from doing so; it is, of all things in this world, the most interesting to observe, how, even in the strongest minds, nature and truth struggle with prejudice and error. "It is probable,"* says Lavoisier, "that the separation of the particles of bodies, occasioned by Caloric, depends, in a similar manner, on a certain combination of attractive powers, which, in conformity with the imperfection of our knowledge, we endeavour to express, by saying—that Caloric communicates a power of repulsion to the particles of bodies." In another place, he says—"It is extremely difficult to form an accurate notion of this repulsion acting upon the very minute particles, placed at great distances from each other." In my opinion, it is utterly impossible; perhaps the common and modern notions of attraction and repulsion, either

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* See Elements, p. 25.—&c.

prevented him from seeing it distinctly, or deterred him from expressing it; but he is often obliged to come very near the truth in such passages as these:—"In each species of gas, I shall," says he "distinguish between the Caloric, which, in some measure, answers the purpose of a solvent, and the substance which is in combination with Caloric, and forms the base of the gas." Why say, in some measure, and not at once, in plain terms, it is the solvent? Indeed, almost all the Chemists of that period, notwithstanding this attachment to former views, generally speak of the solution of bodies in Caloric; and, in fact, so simple and obvious is the idea, and so evidently must it have obtruded itself on their minds, that I wonder how they could adopt any other expression. What other reasons had they for adopting the word Caloric—or how otherwise could the Lavoisierian theory of combustion be intelligible? Chaptal and Fourcroy speak of the solution of substances in fire and water, as similar: Fourcroy says—"Caloric sometimes adheres so forcibly to bodies, that it prevents their combining with others: Thus, many are dissolved into gas, or other elastic fluids, as steam; some of the former, will neither unite with other bodies, nor with one another, so long as they retain this state of invisible solution in Caloric, so that recourse must be had to double elective attractions, to effect their combinations." And again,—"The attraction of Caloric, for some substances, is so great, that it is frequently employed with advantage for separating these substances from the compounds into which they enter, and for analysing and decomposing compound bodies: This is what we do in distillation, and in all the decompositions, effected by fire alone, of Caloric applied to compound substan-

ces." The different elements of these compounds are gradually dissolved in the order of their solubility. It is evident Fourcroy considered the gases as the solution of substances in Caloric: he never speaks of the separation of the particles to a greater distance from each other, as that which constituted the Liquid or Gaseous forms. Indeed, Dr Thompson has wisely given up this in the last edition of his system: It would, therefore, be the less necessary to insist on this, were it not that, I conceive, it is preparing the way for the explanation of some cases where no theory has yet been offered at all worthy of the name; I allude to Galvanism in particular. How separating the particles of matter, by the power of repulsion, can ever produce the Gaseous or Liquid forms, is one of those things which I could never understand, nor have I yet met with one that could: Men may profess to believe what is the faith of the schools, but unless the understanding is convinced, it is mere profession. How can the mere mechanical separation of the particles change the quality of substances? But, solution and combination with a power which produces every effect, must change their properties. The argument in favour of the doctrine of repulsion, which says—" but for such a power, all bodies must be equally solid," is mere assertion, without meaning: All bodies are not the same. It is said, because some few substances can be pressed into smaller space, that the particles of matter do not touch each other, and are held in this state by the power of attraction and repulsion,* neither of which at all follow: Besides Caloric fills up the interstices, and Ca-

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* See Chemical Affinity of these Outlines.

loric is something material; it may be beat or squeezed out, as all metals in this way evolve heat. It is probable that the particles of matter themselves may not touch at all points; but why talk about these points; we neither know what they are, nor what they are like, as is too well proved by the various controversies respecting them?

"Heat," says Chaptal, "by combining with bodies, has an effect the very opposite of attraction; and we might consider ourselves as authorised to affirm, that it is a principle of repulsion, if *sound Chemistry* had not proved that it produces these effects, only by its endeavour to combine with bodies, and thereby necessarily diminish the force of aggregation, as all other Chemical Agents do; besides which, the extreme levity of Caloric produces the effect, that, when it is combined with any body, it continually tends to elevate it, and in this way overcome the force (Gravitation) which retains it, and would precipitate it towards the earth."

I am the more anxious to establish this view, because I am convinced it affords the only satisfactory explanation of the operations and phenomena of nature and art. It is necessary to prove this, and first, by an examination of Galvanism.

The Galvanic apparatus consists of alternate arrangements of Copper and Zinc Plates, the sides of which are placed in contact with an Acid solution; the Acid has a stronger attraction for the Zinc, than for the Copper; the Oxygene, too, of the water, is aided in its attraction for the Zinc, by that contained in the Acid; in this way the water and Acid are decomposed; the Oxygene of both is thus abstracted; part of it combines with the Zinc, but the greater part assumes the Gaseous form; in conse-

quence of assuming this Gaseous form, there must, it is evident, be a prodigious demand for this Caloric or ethereal power, to give and support this new state of existence which it assumes; and, at the same time, a still larger quantity of Hydrogene, the other constituent of water, is set at liberty, and of course there is here demanded a still larger quantity of this power to give it also the Gaseous form; (it has been frequently epeated, that in every change of existence, Caloric is given out or demanded,) it is this demand which expresses the effects produced by the Galvanic arrangement; the explanation is this: the demand is made through the medium of the nearest and best conductor, and in the usual arrangement this must be the copper; the copper is thus robbed of its natural quantity, (as is the negative Conductor by the revolutions of the Cylinder of the Electric Machine), and of course instantly demands "*its due and relative share*" from the earth and surrounding medium. This supply from the earth and surrounding medium is no sooner received, than it is instantly robbed by the Oxygene and Hydrogene, assuming the aeriform state; and this current, thus demanded, and put into motion during its passage, exhibits the correctness of the law already stated, that bodies are relatively to others positive when they are relatively worse conductors: the copper, the zinc, and the solution are relatively to each other in positive and negative states of existence; but though it might, and does in some measure, accumulate in the solution, on the principle of its being the worst conductor, yet this accumulation is in part prevented by the current demanded to support the changes going on, which stream or current is carried by the conducting power of the metals; so that in

this way, as I have already pointed out, there is produced, by Chemical means, a current of this power, as there is by Mechanical means in Electric contrivances; and it is evident, that on these principles the Galvanic action will continue so long as these Gaseous results require and demand this power; and this must continue so long as the surface remains susceptible of oxydation, or capable of producing, by the means described, these effects of decomposition. The cause, also, why the metal having the strongest attraction for the Oxygene, is always *positive*, while the other having less, is *negative*, is explained on the same principles. The Oxygene, after being separated from its combination with the Hydrogene, in the state of water, and when so separated, and having demanded this power to hold it in solution, is *again attracted to, and deposited on the metal, so that this solvent is here again set at liberty*: whereas, the Hydrogene, the other constituent of water, having no such attraction for the metal, the energies of this power *are not at liberty here, but are employed in holding this Hydrogene in solution, or in the Gaseous state; and hence, at this end, the current of Gas is seen to arise, while, on the other, no such current is perceived; and yet this is the positive point, the power is there, but being unoccupied, it is in its pure and most attenuated state, and of course invisible.* When wires are employed, which are not Oxydable, then Oxygene is given off at one end, and Hydrogene at the other; or rather they appear to be given off at distinct and separate ends: it can only be in appearance; for, whenever Oxygene is separated, there must Hydrogene also, each portion of water being alike composed of both; but Oxygene having a stronger affinity for all metals than Hydrogene, it is detained at

the point where this decomposition is going on, while the Hydrogene is carried to the next metal—all which is beautifully proved by the arrangement of the cups, and by many facts of Galvanism, which we must leave to be explained in a larger work. The Oxygene and Hydrogene are given off at these points, and so far occupy the energies of this power; here, consequently it will be said, as the Oxygene is not again deposited on the metal, it does not give up this power in the way just described, and therefore cannot be positive; it is not so in so high a degree; but positive and negative are mere relative states of existence: the Hydrogene occupying this power more than the Oxygene, they are *still*, relatively to each other, positive and negative, only not in so high a degree: The Hydrogene requiring thirteen times more to give it the Gaseous form, than the same weight of Oxygene requires, they still remain, to each other, positive and negative, and the Hydrogen of course *negative*. I am aware this is not the common statement of the difference of their capacity, but I conceive the methods hitherto used to ascertain the capacity, are, as I have already hinted, in some instances, fallacious, and of course that the tables are, in some instances, also, erroneous; that it is not alone the transference of heat from one body to another, or the quantities of ice which bodies will melt in cooling, but how far this power is separated in its pure and unconfinable form, and of course making its escape, without having time to produce any of these effects; but of this afterwards. This explanation of Galvanism will beautifully apply to the evolution of Gas in coal pits, where the same arrangement of matter produces the decomposition of water, abstracting the Oxygene and evolving the Hydro-

gene. It is confirmed, also, by the fact lately ascertained, that a heated atmosphere increases the power of Galvanism: It is confirmed too, by a review of these circumstances which modify the actions of this power in Galvanism, and render them so different in their effects and appearances from those which it produces in the form of Electricity, which have been already explained in the Sixth Lecture. Hence, also, the explanation of the fact, that the Electrometer becomes negative by evaporation; a current of this power is called forth, in order to give and support this new form of existence which the fluid is assuming, which current passes on by means of the metallic conductor of the Electrometer. These Electrometers ought to be considered only as ascertaining the direction of this power, or whether it is imparted or received, and not the kinds of Electricity: there can be only one kind. But we must leave the further and more particular application of these views, to a work on a different plan from this, which was merely begun as a more extended syllabus, for those who attend my Course of Lectures on the subject.

LECTURE XII.

In this Lecture, it is endeavoured to prove that these same principles are beautifully applicable to planetary motions, but which it is impossible to enter upon here; I shall therefore only observe, that it is conceived, that it is not only the same principle by which we descend and pierce

with philosophic eye into the minute movements and intricate changes of matter, in the operations of nature and art, but which shall enable us also to ascend, and not merely to calculate effects, but to ascertain the cause, its principles of operation, and even follow those operations, and that not merely in the action of an Acid or an Alkali, pith balls or leaves of an Electrometer, but in the stupendous movements of masses of matter—whose magnitude surpasses our feeble conception—whose number infinitely exceeds our calculation--and whose stability is fixed by the will of the Eternal.

I shall conclude these imperfect outlines, in the same manner as I have hitherto concluded my Lectures.

" I am sorry that I have been able only to give you so slight a glimpse of my views, on what I conceive to be a most interesting subject.-- What can be so interesting as to trace the Laws of Nature, develope the beauty that exists in that divine adaptation of one thing to another, that splendid harmony by which they all unite and conspire to form one grand result ?

" The laws and principles by which we have endeavoured to explain the operations of attraction, teach us, if aught will teach us, that true wisdom and virtue are always simple and majestic. Let those who wish to feel, to think, and act as they ought, imitate the power which guides and controls natural operations: Let us have but one principle to bind society together, the principle of attraction: Let us banish repulsion from

man, as we have from the rest of the Creation: Let us be firmly determined to effect this point, and then we shall have studied science to some purpose; and without this vain are our pretensions, useless our advances, and hateful the affectation of wisdom; we are not alone to feel, but to guide our feelings by reason: we are not alone to feel and to reason, but all these are to be applied to practice: If we all preach and Lecture for ever, we cannot *say* more; but there is room for us *all doing more*: we have all room to be wiser and better: to excite myself and you to this, is certainly not to be despised; as a motive, however imperfect in the execution, accept the one, and excuse the other."

FINIS.