AN

ESSAY

ON

THE GENERAL STUDY

OF

EXPERIMENTAL

PHILOSOPHY,

AND THE UTILITY

OF

CHEMISTRY:

INTRODUCTORY

TO A COURSE OF LECTURES ON THE PHILOSOPHY OF CHEMISTRY, AND THE CONNEXION OF THAT SCIENCE WITH THE ARTS AND THE OTHER SCIENCES.

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Thomas Kerr Esq.
from his sincere friend
The Author

AN ESSAY,

&c.

BEFORE any one undertakes the study of a science, he must have some hope that the attainment of it will repay the labour of the investigation. I think it necessary, therefore, previous to the commencement of a course of lectures on the Philosophy of Chemistry, which I propose to deliver, to present the public with a view of the advantages which may be expected from them.

History affords us no example of any period in which the sciences, and the useful arts, have flourished in a degree superior to their present state. Chemistry, indeed, has so rapidly improved, that, to use the words of a venerable Philosopher, "Every year of the "last twenty or thirty has been of more im-"portance to that science, than any ten in "the preceding century *." Much of this improvement has, undoubtedly, proceeded from the more general cultivation of all the sciences in the present age. Emerging from the college and the cloister, they have obtained admission into the habitations of the thinking part of every class of society, and have excited an interest equal to the improvement they have gained. The absurd opinion, that the acquirements of Literature and Philosophy are incompatible with the pursuits of the man of business, and the domestic engagements of the female world, is daily losing ground. Knowledge of a speculative kind is eagerly sought after; and the manufacturer and the artist find, that the more they possess of it, the more capable are they to avail themselves of natural powers and agents in executing their plans. By reducing to practice the speculations of science, their productions become more valuable and perfect; and, with the increase of their profits, they have an enjoyment unknown to their predecessors, in the possession of a store of useful and elegant information.

Many obstacles, however, oppose themselves

* Priestley's Defence of the Doctrine of Phlogiston, p. 2.

selves to the majority of manufacturers and artists, who would wish to improve their productions by the aid of philosophy. To become acquainted with that branch only of it, which is intimately connected with their particular art, requires an acquaintance with the general principles of the whole, which the time and attention required by their other avocations prevent. They are disgusted and disappointed; and, instead of endeavouring to improve, follow, contentedly, in the usual routine, without knowing why, or being able to give any reason for their different operations. Hence, if the abode of science be approached by an ascent too toilsome and rugged for ordinary travellers, the discovery of a more accessible path must be an object of much importance.

The easiest method, by which a general knowledge of science may be obtained, is attendance on public lectures.

This form of conveying instruction was practised by the ancients, especially the Greeks. In Ethics, the chief science which they taught, each Philosopher delivered the opinions of his sect; and each sect, according to the name of its founder, or the manner in which its tenets were delivered, received its appellation; as the Platonists, the Epicureans, and the Peripatetics*. Such a method of extending knowledge was peculiarly suitable at a time, when copies of books could only be multiplied by the greatest labour; but it, also, possessed other advantages, which, after the invention of printing, insured the continuance of it as the best mode of conveying elementary, and general information. Till lately, however, science was considered too sacred to be approached by any but the learned. Lectures were confined to universities, and delivered in a language which the learned only understood: they were loaded too, particularly those on Chemistry, with a technical jargon, which served only to fatigue the memory, and disgust the enquirer. Happily these evils no longer exist. The torch of science gleams on every walk of life; and the familiar style of public lectures recommends them as the easiest mode of receiving general knowledge. The

labour

* The Peripatetics received their name from the custom of walking up and down while delivering their instructions;

"In sylvas academiæ quærere verum." HORACE.

labour of study to the man of business is greatly lessened; for the trouble of listening only, he sees at one view, the information that has been drawn from numerous sources, and he becomes possessor of the results of long continued, and severe study.

In an experimental science, such as Chemistry is, this mode of teaching is still more beneficial. Where every proposition must be proved by an appeal to the senses, little can be gained from the study of books; for, although, from the perspicuity of a description, the student is able to comprehend an experiment which an author relates, yet, some doubts will remain which seeing the experiment performed, or performing it himself, can only remove. To illustrate this by an example:—Suppose a person, who is beginning the study of Chemistry, to read, that two fluids, whose individual temperatures do not raise the mercury in Farenheit's Thermometer above 40°, shall on being mixed raise the mercury to 180° or 200°; and that this is owing to the capacity of the compound for heat being less than that of the components. He may conceive, very correctly, the effect of the experiment, and understand the terms used in the explanation of it; but a result so different from that which he has been accustomed to observe, leaves a doubt on his mind, and gives something of the air of mystery to the narration, which an appeal to the senses would instantly dissipate. How little satisfaction, therefore, can a student receive from the perusal of authors who describe the complex operations of Chemistry. Experiments, when seen, are the most convincing proofs of the propositions of natural philosophy; they have, besides, a power of arresting the attention of the indifferent observer by a display of striking and extraordinary phenomena; and they awaken curiosity to search further into the nature of the subject which they illustrate. In pursuing the enquiry, other appearances, equally impressive as the first, will present themselves, and augment the ardour of research; and, thus, many persons, who by no other means could have been induced to follow out a long chain of reasoning, are led, step by step, to the knowledge of general principles, and obtain possession of the most useful and most brilliant truths in science.

Public lectures, especially those on experimental philosophy, tend to enlarge the

minds,

minds, and improve the taste of the fair sex; and, therefore, add much to the enjoyments of social intercourse.

Whatever increases our knowledge of the objects which surround us will necessarily strengthen, and summon into action, the energies of the mind. The confusion, that, to the uninformed, appears to exist in the material world, is removed by experimental science; which exhibits throughout the whole universe the utmost beauty and regularity of disposition, and the best association of action among the various parts for their mutual support and preservation. The vegetable system is admired by the ignorant, for the beauty of the colours and variety of form of its leaves and blossoms. The pleasures which these properties of plants afford to the sense of sight is equally enjoyed by the scientific observer; and he receives, besides, a much higher additional pleasure from an acquaintance with the laws by which their economy is regulated; from viewing the vegetable kingdom as the balance, in the opposite scale of things, to the animal; and from knowing that the individual existence of animals and vegetables depends on the joint existence of both. In support of these observations, I cannot refrain from quoting the words of a favourite author, whose memory is not less dear to this country, than to the lovers of literature in every part of the civilized world. "The characters of na-"ture," says Burke, "are legible it is true; "but they are not plain enough to enable "those who run to read them. We must "make use of a cautious, I had almost said, "a timorous method of proceeding. We "must not attempt to fly, when we can "scarcely pretend to creep. In considering "any complex matter, we ought to exa-"mine every distinct ingredient in the com-"position, one by one; and reduce every "thing to the utmost simplicity; since the "condition of our nature binds us to a strict "law and very narrow limits. We ought "afterwards to examine the principles of "the effect by the composition, as well as "the composition by that of the principles. "We ought to compare our subject with "things of a similar nature, and even with "things of a contrary nature; for discoveries "may be and often are made by contrast, "which would escape us on the single view. "The greater number of comparisons we

"make, the more general and more certain
"our knowledge is likely to prove, as built
"upon a more extensive and perfect in-
"duction.

"If an enquiry, thus carefully conducted, "should fail at last of discovering the truth, "it may answer an end perhaps as useful, in "discovering to us the weakness of our own "understanding. If it does not make us "knowing, it may make us modest. If it "does not preserve us from error, it may at "least from the spirit of error; and may "make us cautious of pronouncing with posi- "tiveness or with haste, when so much la- "bour may end in so much uncertainty*."

The possession of experimental knowledge must improve taste, as it developes the principles from which the objects of taste are composed. Indeed the habit of close and attentive observation is of itself a great source of improvement. Many natural productions, generally neglected, or looked upon as trifling, afford the experimentalist much pleasure and instruction. He considers no work of nature too mean for his inquiry; but finds

* Vide Treatise on the Sublime and Beautiful. Preface.

every where marks of the wisdom and power of the great first cause; and acknowledges the truth of the observation, said to have been made by Heraclitus, to certain persons who came to see him, and found him warming himself in a kitchen. "The meanness of the "place occasioned them to stop; upon which "the Philosopher thus accosted them—*Enter* "(says he) *boldly, for here too there are* "*Gods**."

Experimental philosophy, besides refining the taste for natural productions, supplies new materials for improving and encreasing the works of fancy. These form a part in our amusements, and embellish our habitations; and, from the degree of their progress to perfection, a just opinion may be formed of the state of civilization of a people: for a taste for the cultivation of the fine arts, more than the pursuit of serious and useful occupations, gives a character to national manners. Indeed, the forcible impression they make on the popular mind, and the bias they give, according to their nature, to virtue or to vice, render them in some cases very powerful engines of government.

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* Quoted in Hermes, from Aristot. de Part. Animal. lib. 1. c. 5.

The productions of fancy have great influence on the character of the most important and most amiable part of society. The impression which they stamp on the manners of the fair sex is so much greater, as the female mind is more susceptible of lively feelings. On the proper regulation and improvement of these, how much depends. We have long been agreed with regard to the importance of the moral character of the fair sex, and moral and religious instruction has been considered as the best means for securing it; but what root can any thing take in an unprepared soil? Till lately, no attempts were made to improve by a proper education the female understanding; its capacity was very long depreciated; and women have been prevented from attaining the rank in society to which they are most justly entitled.* This neglect, and the consequent deficiency of intellectual sources of enjoyment, led them to seek pleasure in frivolous amusements, and trifling

* Perhaps it is not generally known, that, in one part of this island, women are still employed to perform the roughest and most laborious parts of agricultural occupations. In Caithness, in Scotland, the women carry the manure to the fields, in baskets, upon their backs, and spread it upon the ground. T.

trifling conversation. Their whole attention was absorbed in inventing personal decorations, which, in general, served only to render more obvious their want of a just taste, by the monstrous and deformed figures they created. In the present age, however, some women have appeared, whose attainments in literature, and true philosophy, have done honour to their sex; and whose example has produced a very important revolution in their education. They have proved that the female understanding is susceptible of the highest cultivation, and have effected, a purpose truly interesting, the union of beauty, virtue, and intelligence. How much the knowledge of experimental philosophy, especially that part of it which relates to Chemistry, is calculated to prove an useful acquisition to the fair sex, is very obvious. By making them acquainted with the objects of the material world, it diverts their attention from the perusal only of works addressed solely to the imagination, which frequently draw false views of human nature, and create an artificial and vitiated sensibility, highly prejudicial to domestic happiness. It also extends their knowledge for supplying the necessaries

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and elegancies of the table, and the other articles of domestic economy. These are not the observations of conjecture. The improvement in female manners, which, within the space of a very few years, has resulted from the delivery of popular lectures on experimental philosophy at Edinburgh and Glasgow, has been very generally remarked.

Perhaps it may be hinted as an objection to this form of study, that, by giving a superficial knowledge of science, it may be the origin of many disputes. In Metaphysics and Ethical science disputes from this cause may be dreaded. In experimental philosophy, however, disputes can arise only from a difference of opinion with regard to the theory of the various operations; and these cannot excite much interest, except among those who make very deep researches. Public lectures are not calculated to convey this kind of information. They only put the hearers in possession of a large collection of facts, which scarcely admit of dispute; and, when any does arise with regard to the result of an operation, the doubt may be instantly removed by the performance of the experiment.

Upon the whole, from what has been said,

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it may be concluded, that public lectures are well adapted for enriching the manufacturer and the artist with very valuable information; that they are the best means for satisfying the rational and elegant curiosity of every enquirer into the works of nature; and, therefore, add much to the private enjoyments of every individual, and render more firm and durable the supports of national prosperity*.

Let us now look a little into the nature of the science of Chemistry; examine its peculiar utility to the arts; and the advantages it presents to the general enquirer.

Chemistry may, in some degree, be considered both as a science and as an art. As a

* An excellent plan for the general improvement of the arts, by instructing artists in the knowledge of experimental science, has been lately submitted to the government of France by Monsieur Chaptal; and which, if adopted, is likely to cause the productions of French manufactures to make great advances to perfection. "Cependant les arts "de fabrique," says the author, "ont leurs principes; les "bases de toutes leurs opérations sont fixées par la science; "les artistes, comme membres de la société, ont droit à l'in-"struction: ils peuvent la réclamer; et il est du devoir, "comme de l'intérêt du gouvernement, de faire disparoître "cette lacune dans le système de l'enseignement public."

Essai sur le Perfectionnement des Arts Chimiquè in France. P. 17.

science

science it may be said to be of modern date; as an art its origin is nearly coeval with that of society. Many chemical operations owe their invention to the immediate wants of man; and are employed for useful purposes, although the principles by which the results are produced are unknown. Thus the combustion of inflammable matter to procure an artificial heat for the body, and for the cooking of food, is a chemical operation which was known to men in the rudest state of society, but the cause of combustion, and the alterations produced by it in inflammable substances, were developed only a few years ago; and form one of the most beautiful discoveries of chemical science.

The early use of chemical art, which accident or the necessities of mankind induced, flattered the pride of chemists, and led many of them to trace the science from a very remote antiquity. Tubal Cain, Hermes, Moses, Democrites, and Cleopatra, were said to have been acquainted with Chemistry*; and

* I do not recollect that Lycurgus has been noticed as a chemist by any of the advocates for the antiquity of the science. Plutarch relates, that he ordered the Lacedæmonian iron money when red hot, and just stamped, to be quenched in vinegar, in order to render it unmalleble.

Life of Lycurgus.

even the fables and allegories of the ancients were viewed as relating the mysteries of that science. The use of metals, and the methods of separating them from their ores, and of working them, were indeed very early known; and, in Egypt, various other chemical arts, as the dying of purple, blue, and scarlet; the composition of perfumes; the making of glass (an invention of the Phœnicians); and tinging it with various colours; and the art of imitating precious stones; were also practised. But the priests, in whose hands the learning, and the arts, of this ancient people were retained, handed them to their successors veiled in hieroglyphical mystery. From this source, however, the Grecians derived their chemical knowledge, which they afterwards taught to their conquerors the Romans. With them it was pretty successfully cultivated, as far as related to the arts, and the production of the luxuries of the table. They understood the preparation of wines, and ardent spirits; knew the application of manures; and used asbestos to prepare an incombustible linen, for preserving the ashes of the dead distinct from those of the wood of the pile, in the performance of funeral rites. Driven from Eu-

rope

rope by the inroads of the Barbarians, Chemistry obtained an asylum with the Arabians, who improved the art; and Rhazes, physician to the hospital of Bagdad, applied it to medicine: but, owing to their attachment to magic, and the occult sciences, they increased the mystery in which it was already involved. Thence arose alchemy, or the art of transmuting various metals into gold. This extravagant delusion began about the commencement of the fourth century; and, as it held out a bait to satisfy avarice, it soon acquired a numerous train of followers. The research was begun with an ardour which no disappointment could damp. Intoxicated with the idea of the boundless wealth that would reward success, the great object of every chemist's experiments was the possession of the philosopher's stone. From one country the mania spread into others. In Egypt it attracted the attention of the government. Dioclesian, apprehensive that the alchemists might realize their dreams, and that his subjects might in consequence become rich and rebellious, ordered all their books to be burnt. During the crusades alchemy travelled into Europe, where it engendered, in the heated imaginations of its partisans, another object of pursuit equally absurd, the Elixir Vitæ. About the middle of the sixteenth century, this folly rose to its utmost extravagance. After this period it was strongly opposed by several able and learned men; but it still kept its ground; and, even in this country, occasioned immense sums of money to be squandered*. At length, it sunk with the celebrated Dr. Price † in the begining of the eighteenth century.

The examination of the effects which the study of alchemy produced on the minds of the ignorant, in giving support to astrology, and the belief of the agency of supernatural beings, would be a subject of much curiosity. The adherents of alchemy were supposed to hold

* The second Duke of Buckingham is said to have wasted between thirty and forty thousand pounds sterling on alchemy.

† Price, in the account of his experiments, relates the effects of two powders which he possessed. One of them red and the other white. The addition to mercury of one of them, when subjected to a certain process, produced forty or fifty times its weight of gold; of the other, the same quantity of silver. Poor Price committed several acts of lunacy before his death.

hold intercourse with the devil; and many of them were persecuted on the supposition. Roger Bacon, who lived in the thirteenth century, and was the inventor of gunpowder, was excommunicated by the pope, and confined ten years for supposed dealings with the devil. Paracelsus was thought to have an evil spirit confined in the pommel of his sword; and Van Helmont, who lived ninety years after him, was thrown into the prison of the Inquisition as a magician. Indeed many of the alchemists endeavoured to enforce the belief of charms and spells; and sought from the study of the occult science, the attainment of the object of their favourite pursuit. Paracelsus, the most impudent of these, wrote a book 'de Zilphis et Pigmeis,' to prove the existence of spirits; and asserted that no man could understand the nature of a disease, or cure it, without a knowledge of the stars. He boasted the possession of the Elixir Vitæ; styled himself *primus medicorum*; and promised immortality, in this world, to his followers: but his premature death exposed his vanity, and blasted their hopes. The persecution of those who were supposed to possess the philosopher's stone was not confined to Europe. Mahomet

Bey, king of Tunis, was dethroned by his subjects, for having the reputation of the secret: he was restored by the Dey of Algiers upon promising to communicate it to him. Mahomet sent a plough with great pomp and ceremony, intimating that agriculture is the strength of a kingdom, and that the only philosopher's stone is a good crop, which may be easily converted into gold.

From this imperfect sketch of the rise and progress of chemical art it will be readily conjectured, that, owing to the great number of experiments which were performed, many valuable discoveries must have been made. Such was actually the case; and the alchemists, unintentionally, collected a rich store of chemical facts of very great importance. If they did not succeed in drawing gold from their furnaces, they produced those materials on which the true science of Chemistry was afterwards erected: for as yet it did not exist.

At the end of the seventeenth century, Chemistry began to assume a scientific form. The studies of Lord Verulam, and the discoveries of the Honourable Mr. Boyle, and of Sir Isaac Newton, paved the road to the certain attainment of natural knowledge, and diffused a just taste for experimental philosophy. The scattered chemical facts were collected, arranged, and reduced to principles. Becher sketched out a system that was afterwards filled up by Stahl, and embellished and improved by succeeding chemists, till the discoveries of Black* in heat, those of Priestley in airs, and of Lavoisier in every part of Chemistry, shewed its errors, and formed the system which at present prevails. In rearing this beautiful fabric, the aid of other sciences was sought; the experiments already known were repeated; new ones performed; and their results examined with severe

* In mentioning the name of Black, I cannot go on without paying my small tribute of applause to his memory. From him I received the first rudiments of my chemical knowledge; and shall ever consider the circumstance as the most fortunate of my life. Like the aspect of this venerable philosopher, his manners were mild and elegant: his style of lectures was simple, but neat, perspicuous, and energetic; his delivery chaste, and the tone of his voice musical and persuasive. He performed the experimental demonstration with the utmost correctness, and with great grace; for Black was as much a chemist in his hands, as in his head. His discoveries speak for themselves. Every century produces men of shining genius, and great philosophers; but Black was one of those comets in the scientific world which returns only in many thousand years. T.

vere philosophical accuracy. With the abolition of the barbarous alchemical language, the obscurity that had long pervaded the chemical atmosphere was dispelled; truth dawned upon its horizon, and the science rapidly advanced to that meridian splendor, which now ranks it as the most useful and interesting branch of Natural Philosophy. Chemistry is that science which makes us acquainted with those properties of bodies that depend on the composition and action of their constituent particles; and discovers the changes of composition and of action, that occur among these particles, by mixing different bodies.

This definition displays how widely extended are the limits of chemical science; and it also points out the mode by which it should be investigated. To develope the laws which regulate the combinations of matter that form the substance of this globe, or are attached to its surface, requires observation and experiment; and therefore by their assistance chemical knowledge is attained. Thus observation teaches us, that the burning of a candle, or the breathing of an animal in a limited portion of air, diminishes its bulk;

and the candle is extinguished, and the animal dies. Experiment explains the nature of this portion of the air, necessary for combustion and respiration; detects its existence in a variety of other bodies; and points out that to its presence in their composition many of them owe their most active and useful qualities. In a similar manner we know, from observation, that water may become ice; but experiment has convinced us, that this fluid assumes the solid form only when a great portion of its heat its abstracted; and that it does not depend, as was long imagined, on the introduction of frigorific particles.

A science may be denominated beautiful, the effects of the operations of which afford pleasure to the senses, or, as they tend to elevate the imagination by the developement of the secrets of nature; and useful, in so far as these effects improve the necessaries, and add to the comforts of life. Both of these appellations are applicable to Chemistry. The chemist begins his enquiries where those of the natural historian and the natural philosopher terminate. The first of these examines bodies with a view of assigning them their proper place in the system of nature, and arranging them into classes, genera, and species, according as they possess certain qualities of similitude. The second investigates the general properties of objects, such as their figurability, density, elasticity, &c.; and calculates the forces of their mechanical actions. The chemist looks into the more intimate structure of substances, separates their heterogeneous particles from one another, and examines distinctly the nature of each. He recombines principles in proportions different from those in which they were combined in the bodies from which he obtained them; and unites them with other substances, with a view of making himself more perfectly acquainted with their various effects under different circumstances, and of forming new and useful compounds. Chemistry may be therefore understood to have nearly the same relation to many other branches of knowledge that geometry has. It furnishes materials by which many otherwise dark and intricate points are easily explained; and in this way it throws light upon a great number of nature's grand operations.

Although man, by a knowledge of the laws of nature, is capable of producing, at his

pleasure,

pleasure, particular effects on material objects, and of usurping in a certain degree the powers of nature, yet there are many incidents at all times occurring in the system of creation, of which he is only an observer. The beauty of chemical science is most conspicuous in the aid which it affords for the explanation of these phenomena. Many appearances in the economy of nature, that cannot be understood from an acquaintance with natural philosophy only, are easily comprehended by those who possess a joint knowledge of that science and of chemistry. This is particularly the case in those events, proceeding in part from the operation of heat and light, the two most universal chemical agents.

Bodies under certain circumstances excite a sensation, which is known by the name of heat. It has long been a subject of dispute, whether the cause that imparts to bodies the property of producing this sensation be a substance, or only a peculiar affection of the particles which constitute the heated bodies. To enter on an examination of these different theories is foreign to the purpose of this Essay; and therefore, to avoid them both, I shall substitute the name of the effect for that of the

 cause.

cause. Heat enters more or less into the composition of every material substance; and can be transferred from one body to another. According to the quantity of it contained in any body, is the degree of force of cohesive attraction between the particles of the body, so that it assumes the solid, the fluid, and the aeriform state. A certain degree of heat assists the union of all substances with one another; and many without it cannot unite. Two solids cannot act chemically on one another. Without heat the union between vital and inflammable air cannot be effected; which with it is so perfect, as to destroy the gaseous form of both airs, and produce water. With these, and with the other properties of heat the chemist makes himself acquainted; and takes advantage of them in conducting his operations. He observes attentively the effects produced by the introduction and the abstraction of heat, on the minute subjects of his experiments; traces these to their causes; and applies his theories to explain the sublime phenomena of the universe. Thus, he finds, that the same proximate cause which operates in breaking a glass vessel when boiling water is suddenly poured into it, and in giving the quilled form that starch assumes in drying when manufactured, acts also in the formation of the immense basaltic structures * that are to be seen on many different parts of the surface of the globe. By observing that a few drops of water spilt upon a stone quickly disappear, he is led to the knowledge of spontaneous evaporation, and the property of air for dissolving water; thence to the developement of the causes of the formation of dews, of fogs, and of clouds; their condensation into rain; and the appearance of aqueous meteors. The doctrine of some bodies retaining heat in such a quantity as to preserve in very low temperatures their fluidity, unveils to him the cause which renders water serviceable to plants and animals, and in beautifying the face of nature; which enables the stream that refreshes our meadows to ripple o'er its pebbly channel; the swelling torrent from the mountain to foam along its rocky bed, and precipitate the cataract that stuns our hearing with the thunder of its fall; and the enormous mass of ocean itself to be tossed in engulphing billows by the tempest.

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* Such as the Giant's Causey, in the county of Antrim, in Ireland; Fingal's Cave, in the Isle of Staffa; and the Rock of Perencire, near St. Sandoux, in Auvergne. T.

The investigation of the nature of light is equally important with that of heat. The sense of sight informs us of the superficial extension, the figure, and the colours of bodies by the intervention of a material medium, which is light. The examination of the projectile impetus with which it is thrown off from its source; the manner in which the pencils of rays form a picture of the visible object on the retina; and the actions of the visual organ itself in producing ideas; belong to the natural philosopher, the optician, and the physiologist: but the chemist, by his experiments, aids these in their enquiries. He also finds, that on light depends the colour, taste, and smell of vegetables; and the power their leaves have of decomposing water, and purifying atmospherical air, by giving it that part of its composition so necessary for preserving animal life. Were light withdrawn, nature would sicken, and animation cease.

But the explanation of these sublime phenomena by means of Chemistry is not limited to the satisfying of a laudable curiosity. As much as natural and moral philosophy it elevates our conceptions of the Supreme Being, by exhibiting certain proofs of design in the

universe.—

universe.—" The truths of natural religion," says an elegant writer*, " gain an accession " of evidence from every addition that is " made to the stock of human knowledge. " Hence, in the case of those individuals who " devote themselves, with fair and candid " minds, to the pursuits of science, there is a "gradual progress of light and conviction, " keeping pace with the enlargement of their " information and of their views; and hence, " a strong presumption that the influence " which these truths have, even in the pre- " sent state of society, on the minds of the " multitude, will continually increase, in " proportion as the order of the material uni- " verse shall be more fully displayed by the " discoveries of philosophy, and as the plan " of Providence, in the administration of hu- " man affairs, shall be more completely un- " folded in the future history of our species."

In the present state of society, however, that knowledge by which the grand and extensive operations of nature are unveiled to the eye of genius, and which elevate the human mind to look beyond a present state of existence, is not denominated useful. This term

* Dugald Stewart's 'Outlines of Moral Philosophy,' p. 175.

term is generally applied to those pursuits which are more connected with the satisfying of our immediate wants and appetites. In following these, theoretical and practical knowledge is too often improperly separated from each other. Owing to the abuse of the former, by some men of more imagination than judgment, the cultivation of it by the artist has been considered as an obstacle to his improvement, and as certain to occasion the ruin of his fortune. The best argument in refutation of this opinion is, that, notwithstanding the number of artists is so much greater than that of scientific men, the most important improvements in the arts have been made by those unconnected with the practice of them. Indeed many very useful inventions, which have afforded abundant wealth to the artist and manufacturer, have arisen from the ashes of the consumed fortune of the theorist.

In the pursuit of the useful arts the theories of chemistry admit of universal application. Many of the arts, indeed, are entirely chemical, although they are conducted by men unacquainted with the science. The possession of chemical knowledge, therefore, by such men, would afford the best means of advanc-

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ing to perfection their production; and consequently of opening a path to the attainment of riches and honour.

Let us now, therefore, briefly examine the general nature of a few of those arts which may be denominated chemical; and the improvements which have resulted from an application of chemical knowledge, to particular operations, in those that do not rank under this title.

Metals form a class of substances of general utility. The extraction of them from their ores; assaying, or the art of discovering the quantity of metal in a small portion of ore, so as to ascertain the value of newly discovered veins before working them; and the method of combining different metals, when wrought, to render them more useful for the various purposes of life, are truly chemical processes. In the state of ores, metals are combined with earths, and other substances, which give them a variety of appearances. From a general want of knowledge to discover them in these forms, many valuable metals are lost or overlooked. An instance of this occurred some time ago in Cornwall, where a rich vein of cobalt was discovered in the Wherry mine, near Penzance.

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There "every substance that does not possess
"the characteristics of the tin or copper, for
"which they are in search, is thrown away
"among the rubbish. This was the case with
"the cobalt vein, when a gentleman of more
"knowledge than the proprietors happened to
"observe it*."

By the chemical union of an alkali with silicious sand, glass is produced. From this happy discovery, we possess a material for making many of our most useful utensils, in which are combined the beauty of transparency, and an elegance of form that render them highly ornamental. It also supplies us with the means of enjoying light in our habitations, while the inclemency of the weather is excluded. The improvements in a kindred art, pottery; and the perfection to which the manufacture of porcelain in this country has attained, by the philosophical and chemical researches of the celebrated Wedgwood, prove how much the arts may be benefited by a proper application of the general doctrines of chemistry. Brewing, distilling, dying, bleaching, soap-boiling, the making of paper, tanning of leather, preparation

* Vide 'Philosophical Magazine,' vol. i. p. iii.

ration of perfumes, cooking, and many other arts, have all their foundation in chemistry.

In various arts beside those that can be strictly denominated chemical, important improvements have been made by the labours of chemists.

The attention which has been given to examine the nature of soils is the chief cause of the present advancement of agriculture. Vegetables are organic bodies which, from a few principles, form a great variety of compounds. On the presence of a certain degree of light, heat, and moisture, and of a peculiar principle, in the soil, that has been named carbon, depend their nourishment, growth, and production of fruits and seeds for the perpetuating of their species, and as food to animals. Chemistry has demonstrated that the carbonaceous matter, with which growing vegetables are nourished, is separated by the decomposition of decaying plants. It is said to remain dissolved in the oily, extractive, resinous, or alkaline principle* ; in which form water takes it up, and conveys it into the system of the vegetable. The art of agriculture, therefore, in a great measure, consists

* Chaptal. Memoires de l'Institut National. Tom. 1.

sits in correcting such soils as retain moisture in too great, or too small a quantity; the selecting of manures that contain the nutriment of vegetables in most abundance; and supplying materials to hasten and render more perfect the decomposition by which it is separated. How important, then, chemical knowledge is to the farmer must be obvious to every one who considers, attentively, the nature of his employment. No set of men, however, have hitherto valued less the theoretical part of their art; or followed more faithfully the practical steps of their predecessors, without enquiring why they did so. A few of them, indeed, of superior understandings, have deviated a little from the usual routine of practice; but, till lately, no important innovation was attempted. In support of these observations, the following extract, from the travelling notes of Mr. Donald Stewart, who has made a general mineralogical survey of Ireland, is a striking instance. "I was enabled," says he, "by discovering rich "quarries of limestone and marle, in several "estates where they were never before known "either to tenant or landlord, to be accessary "to the fertilization of the most barren lands.

"In

"In the estates of Lord Palmerton and "Ormby Jones, Esq. in the county of Sligo, "I afforded the greatest pleasure and ad- "vantage to the poor inhabitants, by de- "monstrating to them that the great rocks "which they called Serpent Rocks*, and "which they were gazing at with stupid or "superstitious admiration for ages, contained "most excellent lime. These quarries are at "their doors; whereas formerly they carried "the scanty pittance of lime they were able "to procure from nine or ten miles distance. "Having turf at home in abundance, they "are now supplied with lime at as cheap a "rate as any people in Europe." The advancement of agriculture, not less than the extension of commerce, tends to establish the prosperity of Britain. Indeed commerce may overgrow its strength, and be the means of its own destruction; a circumstance which cannot result from any exertions to improve agriculture. May we not, therefore, anticipate the happy effects of a continuance of the present spirit of improvement?

From the application of the general doctrines of heat to the arts, very important improvements

* "There may be," says Mr. Stewart, "one twentieth part "of the whole rock composed of petrified fish or serpents."

provements have resulted. The knowledge of its effect of expanding fluids has given rise to the invention of thermometers; and of its opposite effect on pure clay, to the ingenious discovery of Mr. Wedgewood's Pyrometer, by which the most intense heat of the potter's furnace can be ascertained. The improvements in those arts, where great mechanical force is required, by the use of the steam engine, are very generally known. Effects have been accomplished by simple means, that could not have been obtained from the combined strength of any number of men. An important use has also been made of the observation, that the temperature of steam, under the ordinary pressure of the atmosphere, never exceeds 212°, in the manufacture of muslin. By wrapping the fabric round a metallic cylinder through which steam is made to pass, it can be well dried, independent of the weather. The arts of the painter, the engraver, and the printer, owe much of their present perfection to chemistry.

But to medicine, more than any other art, has the most important aid been received from chemistry. The discovery of the use of the function of respiration for oxygenating the blood, and the production of animal heat; of the chemical quality of the gastric juice, which the stomach secretes for the solution and digestion of the aliment; and the investigation of the nature of the various secretions that take place from the blood in its course through the body; have thrown a new light upon the researches of the physiologist. The chemical knowledge of the nature of remedies, and particularly of factitious airs, has greatly extended the power of the physician over diseases; and is likely to open a path to the attainment of that certainty in medicine, which must render it an acquisition of the first magnitude to mankind.

Chemistry has also opened a new mode of enquiry, of which to have spoken two centuries ago would have been considered almost a proof of madness. By the decomposition of water, a substance is furnished about ten times lighter than atmospheric air; so that by confining a large portion of it in a light covering, it is possible to carry up heavy substances. Man is, as it were, thus supplied with wings that enable him to soar in the tract of the eagle,

'——— bestride the lazy-pacing clouds,
'And sail upon the bosom of the air.' SHAKESPEAR.

He

He can examine the nature of the atmosphere, and take a view of the globe at an immense distance from its surface.

This account of the application of the doctrines of chemistry, with a view to the improvement of the sciences and the arts, is indeed very limited. It is, however, I hope of sufficient extent to impress a conviction of the utility of chemistry, and recommend the attentive and general study of the science.

OUTLINES

OUTLINES

OF THE

LECTURES

ON THE

PHILOSOPHY OF CHEMISTRY,

&c.

LECTURE I.

INTRODUCTION ;---general view of Chemistry. Bodies may be mechanically mixed---examples of mechanical mixture ; ---they may be chemically mixed---examples. Solids do not act on solids---fluids act on fluids---both act on each other ; experiments to shew the varieties of chemical action. Chemical attraction---different from the attraction of gravity. Attractions of aggregation---of composition ;---laws of chemical attraction :---solution---precipitation---crystallization ; ---illustration of these by experiments.

LECTURE II.

ANCIENT opinion of elements---modern. Of heat ;---heat can be transferred from one body to another ;---expansion an effect of heat on solid, fluid, and aeriform substances ;--- cause why glass vessels break when warm water is suddenly poured into them ;---theory of the formation of basaltes ;--- why clocks go faster in winter than in summer ;---this effect of heat applied to the art of fitting hoops round wheels :--- the invention of thermometers ;---Sanctorio's thermometer---

Mr. Boyle's---Dr. Halley's :---method of proving thermometers ;---difference of the thermometrical scales in present use. Expansion is not in all cases an effect of heat ;---water when freezing expands---ice swims in water ;---this effect explains many natural phenomena :---several metals also expand in passing from the fluid to the solid state. Heat seemingly contracts some bodies---cause of this ;---Wedgewood's pyrometer.

LECTURE III.

Heat rarifies elastic fluids ;---the ventilation of mines and of rooms ;---method of constructing vents to prevent smoke in apartments ;---Montgolfier's balloon. Fluidity is almost an universal property of bodies ;---it is an effect of heat ;---water at rest remains fluid although its temperature be lower than the freezing point ;---boiling water poured on melting ice remains at the freezing point till all the ice be melted ;---invention of the calorimeter ;---doctrine of latent heat ;---artificial generation of cold ;---water taken from a very deep well, in frosty weather, emits vapour when first drawn ;---smiths sometimes apply the doctrine of latent heat in lighting their fires ;---different capacities of fluids for containing heat.

LECTURE IV.

Evaporation is an effect of heat :---some substances pass immediately from the solid state to that of vapour ;---sublimation ;---cause why water under the ordinary pressure of the atmosphere cannot be heated above 212° ;---important utility of this fact in the arts. Steam is condensed in a degree of heat less than 212° ;---distillation ;---Papin's digestor ;---great public use that has been, lately, made of it ;---the elastic force of confined vapour is very great ;---invention of the steam engine;---reason why a drop of water rolls off heated metals;---congelation of water by the evaporation of æther.

LECTURE V.

Spontaneous evaporation;---it is accelerated by heat, the electrical fluid, the agitation of the air. Formation of clouds;---theory of dews, rain, aqueous meteors;---method of making ice in Bengal;---invention of hygrometers;---cause of very deep lakes not freezing in the latitude of Britain;---theory of the superior and inferior currents in the Straits of Gibraltar.

LECTURE VI.

The cause of heat, named by the French philosophers *Caloric*;---considered by some as an imponderable, pure, expansible fluid;---its materiality denied by others;---merits and defects of both theories pointed out. Coldness is a sensation produced by the abstraction of caloric. Caloric may be chemically combined with substances. Bodies conduct caloric with more or less celerity according to the nature of their textures;---application of this to various phenomena in common life.

LECTURE VII.

Light is a material substance;---it produces the sensation of sight;---its motion is very rapid;---opaque bodies absorb or reflect it;---by transparent, it is transmitted, and refracted;---Sir Isaac Newton's conjecture regarding the diamond and water. Light is not a simple body;---it produces colours;---cause of the black colour of the negro, and copper colour of the Indian. New theory of the author regarding the effect of different colours on diseased eyes. Cause of the atmosphere's want of transparency in very dry weather;---

effects of light on vegetation ;---connexion between heat and light ;---Bolognian phosphorus ;---ignition ;---radiated heat ; ---reflecting mirrors ;---improvements of Count Rumford in heating rooms.

LECTURE VIII.

Of the Atmosphere ;---the physical properties of its air ;---invention of the barometer. Air dissolves water ;--- the atmospherical air is composed of two airs ; oxygenous and azotic gas. Of oxygenous gas ;---discovered by Dr. Priestley ;---it is given out by plants in light ;---contained in a great variety of substances ;---is heavier than atmospherical air ;---it is a triple compound ;---it supports combustion and animal life. Theory of combustion ;---mankind derive many important advantages from heat and light being set free during combustion :---cause why the solar rays extinguish a fire. Function of respiration ;---production of animal heat. Effect of light in destroying metallic colours ;---conjecture why the old paintings appear so brilliant.

LECTURE IX.

Of Azotic Gas ;---it is lighter than common air ; animals die in it ;---flame is extinguished by it ;---it is a constituent part of several substances ;---contained in the air bladder of fishes. Method of ascertaining the purity of atmospherical air ;---invention of the Eudiometer ;---its importance in hospitals and crowded assemblies ;---instances of the effects of impure air in producing diseases.

LECTURE X.

Of Combustible Bodies. They are decomposed, and become oxydated, by undergoing the process of combustion.

Of the Diamond.

Hydrogen

Hydrogen Gas :---it is an invisible inflammable substance; a treple compound ;---it is insoluble in most substances ;---capable of dissolving many ;---is thirteen times lighter than common air ;---invention of balloons filled with this air, first suggested by Dr. Black of Edinburgh. It is produced in great abundance in mines ;---method that the miners take of firing it ;---produced also on stagnant pools. Cause of those meteors called shooting stars. Fire-works made with this gas. It is one of the basis of ammoniac. Formation of water ;---by whom discovered ;---celebrated experiment of the French chemists ;---decomposition of water. Hydrogen gas may be used as an eudiometer.

LECTURE XI.

Of Sulphur ;---art of separating and purifying it from the substances with which it is found combined in nature. It is susceptible of two kinds of combustion. Effects of its combination with various substances ;---pyrites ;---sulphurated hydrogenous gas ;---sulphureous mineral waters. Production of sulphuric acid. Utility of sulphur in the arts ;---manufacture of gun-powder ;---matches ;---paste for taking impressions of engravings on stone ;---it is used for whitening of silks, destroying of colours, stopping fermentation of wines.

Phosphorus ;---combustion of it very brilliant ;---forms phosphoric acid ;---reduction of this acid. Phosphorus is never found pure in a native state ;---action of various substances on it ;---phosphorated hydrogen gas ;---use of phosphorus.

LECTURE XII.

Of Carbon. It is the combustible part of coals. Charcoal when burnt yields a heavy gas named carbonic acid gas ;---quality of this air ;---it can be obtained from many

other

other sources;---effects it produces on lime water;---obnoxious to animal life;---Chalybeate springs;---charcoal decomposes water when heated;---carbonated hydrogen gas. Reduction of acids;---decomposition of the neutral salts. Charcoal is of great use in the arts;---deprives new silk of its disagreeable odour:---fuel.

Of Alcohol. Whence procured;---when pure it cannot be frozen. Effects of it under different circumstances;---combustion of alcohol;---olethean gas;---action of different substances on it;---æthers;---theory of their formation. Uses of alcohol and æthers in the arts. Engraving. Alcohol has been used in the steam engine.

LECTURE XIII.

Of Oils. They are all composed of Carbon and Hydrogen. Combustion of oils. Aromatic or essential;---test of their purity;---effects of different substances on them;---enumeration of substances which rank along with these oils;---their uses in the arts. Unctuous oils;---differ from essential;---qualities;---whence obtained;---substances that rank along with them;---their uses in the arts. Empyreumatic oils;---whence obtained;---uses. Bitumens;---how procured;---origin of bitumens;---enumeration of them;---they are of very great importance in the arts. Electric quality of amber.

LECTURE XIV.

Of Salts in general. They are sapid and soluble in less than 200 times their weight of boiling water;---some are crystallizable, others not;---water of crystallization;---efflorescence.---They are reckoned to be simple and compound. The simple are divided into two classes---alkalies and acids.

Of Alkalies.---They are acrid, and pungent to the taste;---they turn most of the blue vegetable colours to green;---theory of this effect. Alkalies are divided into three species. 1. Vegetable alkali or potash;---characters; origin;---with oil it forms soft soap;---uses of potash in the arts. 2. Mineral alkali---soda;---characters;---origin;---with oil it forms hard soap;---art of the soap boiler;---uses of soda in the arts, and in domestic economy. 3. Volatile alkali---ammoniac;---characters;---composition; theory of its production;---its effects in curing the bite of the Copra Capello;---uses in the arts.

LECTURE XV.

Of Acids;---their general characteristics. They unite with alkalies;---effervescence. Basis of acidity. Acids possess two states of acidity. Some acids may be decomposed, others cannot. Enumeration of the substances that decompose acids;---theory of their decomposition. Acids may be arranged into four classes.

Class A.---Acids with known simple radicals.

Species *a*. *Sulphuric acid.* Character;---production;---its affinity with water;---production of heat; theory:---production of cold; theory:---affinity with alkalies---compounds;---with oils. Sulphureous acid;---uses of these acids in the arts.

LECTURE XVI.

Species *b*. *Nitric acid.* Character;---production;---union with water;---art of the engraver. This acid acts violently with oils:---theory:---affinity with caloric; nitrous air;---properties of this air:---affinity of this acid with alkalies;---nitre. Uses in the arts. Nitrous acid.

Species c. *Carbonic acid*; to be noticed when treating of lime.

d. *Phosphoric acid*;---character;---production;---affinity with alkalies;---phosphoric air;---properties. Uses of this acid. Phosphorous acid.

e. *Arsenic acid*;

f. *Tungstenic acid*;

g. *Molybdenic acid*; belong to the first class of acids. They shall be noticed when the metals which form their radicals are spoken of.

LECTURE XVII.

Class B. Includes acids of which the radicals are not ascertained to be simple.

Species *a. Muriatic acid*;---production;---character;---affinity with oxygen;---oxygenated muriatic acid;---qualities of this acid;---art of bleaching. Union of muriatic acid with alkalies;---culinary salt;---manufacture of sea salt; salt marshes and springs; rock salt; manufacture of sal ammoniac. Union of the oxygenated acid with alkalies;---detonating powder; effects of oxygenated muriatic gas on inflammable bodies.

b. *Fluoric acid*; to be noticed when treating of the earths.

c. *Boracic acid*;---its crystalline form;---origin; union with alkalies. Borax;---whence procured; ---character;---use in the arts.

Class C. Acids with binary compound radicals;---formation and general character.

Species *a*. Succinic acid;---*b*. Citric acid;---*c*. Gallic acid;---*d*. Malic acid;---*e*. Benzoic acid;---*f*. Tartarous acid;---*g*. Oxalic acid;---*h*. Camphoric

phoric acid ;---*i.* Pyrotartarous acid ;---*k.* Pyromucous acid ;---*l.* Pyroligneous acid ;---*m.* Acetous acid ; to be treated of under vegetable productions.

Class D. Acids with ternary compound radicals ; general character.

Species *a.* Lactic acid ;---*b.* Saccholactic acid ;---*c.* Sebacic acid ;---*d.* Lithic acid ;---*e.* Formic acid ; ---*f.* Bombic acid ;---*g.* Prussic acid ; to be noticed under animal productions.

LECTURE XVIII.

Of Earths.---General view of the distribution of earthy bodies in the globe ;---primary and secondary rocks ;---of the formation of strata ;---of the agency of fire and water in the formation of the earth ;---theories of the earth---they display more the ingenuity than the judgment of their authors :---Cosmogeny of Moses---it is not so inconsistent with the known laws of nature as is generally supposed.

Earth was considered an element by the ancients ;---incombustibility of it.---Enumeration of the different species of earths.

LECTURE XIX.

Of Calcarious Earth, or Lime. Origin ;---never found in an uncombined state in nature ;---marble ;---calcarious crystals and petrifactions :---marles ; theory of their origin :---of the formation of limestone.

Calcarious earth unites with acids :---of sulphate of lime :---gypsum very useful in the fine arts :---nitrate of lime :---muriate of lime ; its refrigerating power ; use in the arts :---lime also forms compounds with all the other acids. Pure lime renders mild alkalies caustic. Action of heat on calcarious earth :---quicklime ;---theory of the production of heat in slacking it :---lime water. Formation of ammoniacal gas from ammoniacal salts by quicklime ;---manufacture of pure ammoniac ;---theory.

LECTURE XX.

Production of carbonic acid gas from marble, &c. ;---its qualities ;---Grotto del Cano ;---medicinal acidulous waters ;---theory of petrifying springs :---uses of this gas. Lime is of extensive use in the arts. Of Derbyshire spar ;---fluoric acid ;---art of engraving on glass.

LECTURE XXI.

Of Barytes. It is found united with the sulphuric and carbonic acids :---calcined barytes absorbs water rapidly and heat is given out ;---it is soluble in water, and crystallizable ;---properties of its crystals. Sulphate of barytes ;---preparation of the Bolognian phosphorus. Carbonate of barytes. Muriate of barytes ;---use in the arts.

Of Strontites :---generally found united with the carbonic acid ;---calcined it absorbs water and gives out heat :---soluble in water. Sulphate of strontites :---nitrate of strontites :---muriate of strontites. Pure strontites decomposes all the sulphates.

Of Magnesia :---generally found as a constituent part of stoney substances as talc, soap stone, steatites, asbestus, &c. It is well known in the form of a white powder used in medicine. Carbonate of magnesia more soluble than the pure earth :---phosphorescent effect on being thrown into an acid ;---sulphate of magnesia ;---preparation of Epsom salts. Nitrate of magnesia. Muriate of magnesia. Uses of magnesia in medicine :---in the arts.

LECTURE XXII.

Of Argillaceous Earth, or Alumine :---found in a pure state at Halle only ;---when pure it is not soluble in water ;---contracts on being subjected to heat ;---unites without effervescence with acids ;---sulphate of alumine ;---alum ;---found native near volcanoes ;---manufacture of alum ;---use in the arts. Sulphuret of alum. Pyrophorus of Homberg. Alumine unites with the nitric and muriatic acids ;---acetite of alumine :---art of printing calico. Clays: Manufacture of porcelain. Of the adamantine spar.

LECTURE XXIII.

Of Silex. It is a copious production of nature ;---natural history of it ;---insoluble in water ;---soluble in one acid only ;---unites with alkalies ;---manufacture of glass :---Reaumer's porcelain ;---liquor of flints ;---art of preserving writings from fire. Silicious earth is deposited in incrustations from the water of the Geyser in Iceland ;---theory. Silicious petrifactions ;---theory.

Circon Earth :---character ;---it forms a glass with borax.

Glucine Earth :---character ;---saccharine nature of its salts.

LECTURE XXIV.

Of Compound Stones :---the emerald :---the ruby :---the garnet :---shorl :---felt spar---used in the manufacture of porcelain :---one species has a property of curiously refracting light. Lapis lazuli ;---character ;---manufacture of ultramarine. Granate ;---opinion that it forms the primordial nuclus of our globe :---of the agency of fire in its formation. *Porphyry. Basaltes* or *Whin stone* :---character ;---vitrification of whin stone ;---vitrified forts of the ancient Caledonians :---discovery of soda in the composition of basaltes. *Lava.* History of volcanoes ;---theory :---lava when cooled in small quantity assumes the form of glass ;---theory.

LECTURE XXV.

Of Metals. Ores :---they are found in veins combined with earthy matters. Method of treating ores :---art of essaying. Of Pyrites :---general characteristics of metals :---some are malleable, others fragile :---alloys :---art of gilding, silvering, tinning, soldering :---oxydation of metals :---metallic colours :---the art of making artificial gems :---of enamelling ;---enamel and porcelain painting ;---glazing of pottery. Reduction of the oxyds of metals ;---theory. Metals are soluble in acids. Metals are divided into perfect and imperfect.

LECTURE XXVI.

Of Gold :---character :---natural history of it :---solution of gold in aqua regia :---precipitations of it :---aurum fulminans ;---theory. Amalgams :---nature of a mixture of gold and iron. Cupellation. Quartation. Tin precipitates gold of a purple colour.

Of Silver :---character :---natural history :---solution of it in the acids :---precipitation :---lunar caustic :---fulminating silver ;---theory :---arbor Dianæ :---affinities of silver with other metals.

Of Platina :---character ;---only lately known in Europe. Soluble in the oxygenated muriatic acid only :---precipitated by alkalies. Combination of platina with other metals.

LECTURE

LECTURE XXVII.

Of Mercury :---its fluid form :---natural history :---rendered solid and ductile by very intense artificial cold :---soluble in heated sulphuric acid :---very soluble in nitric acid :---precipitates ;---exploding powder ;---theory. Combination of mercury and sulphur---cinnabar. Mercury amalgamates with many of the metals :---manufacture of looking glasses. Preparation of the silver tree.

Of Lead :---character :---natural history :---granulation of it :---manufacture of shot. Oxydation ;---massicot ;---minium ;---letharge ;---glass of lead. Lead soluble in the nitric acid :---in the acetic acid ;---sugar of lead. Oil dissolves oxyds of lead ;---oil colours. Combination with the other metals.

LECTURE XXVIII.

Of Copper :---character :---natural history. Beauty of its oxyds ;---it rusts in moist air ;---solution in acids. Manufacture of verdigrise ;---precipitates. Alkalies dissolve copper. Oils and sulphur dissolve it. Combination with the other metals :---bronze :---tombach. Ancient uses of copper.

Of Iron :---character :---natural history. Method of rendering it malleable :---cementation :---steel. Magnetic power of iron. Action of acids on iron :---cocolthar ;---manufacture of English brown red. Chalybeate springs. Manufacture of Prussian blue :---of ink. Union of iron with other substances :---pyrites.

LECTURE XXIX.

Of Tin :---natural history :---fuses at a low temperature :---putty. Tin does not properly rust :---tinning of metal vessels. Action of acids on tin ;---use in the dying of scarlet.

let. Smoking liquor of Labavious, Combinations of tin with other substances. Aurum musivum ;---its use in painting, japanning, &c. Pewter :---bell-metal :---manufacture of speculums.

Of Arsenic. White oxyd of arsenic, a violent poison. Action of the acids on arsenic. Acid of arsenic. Combination of arsenic with sulphur :---realgar :---orpiment :---manufacture of King's yellow. Scheele's green colour.

Of Nickel :---character :---natural history.

Of Cobalt :---character :---oxyds :---smalt. Action of acid on cobalt :---sympathetic ink. Combination of cobalt with other substances.

Of Zinc :---character :---oxydation. Philosophical wool. Action of acids on zinc. Lead tree. Combination of zinc with other substances :---brass :---pinchbeck :---princes metal. Art of tinning of brass pins.

LECTURE XXX.

Of Antimony :---character :---action of acids on it. Union of it with other substances :---type metal :---Naples yellow. Preparations of antimony much used in medicine.

Of Manganese :---character :---oxyds of it :---their use in making of glass, and glazing pottery. Union of this metal with various substances :---mineral chamælion.

Of Molybdena :---character, &c. Richter's blue carmine.

Of Wolfram. Of Uranium. Of Titanium. Of Tellurium. Of Chromium.

LECTURE XXXI.

Of the Formation and Nature of Vegetable Substances. Extractive matter :---muscus :---sugar :---essential salt :---fixed oil :---volatile oil :---aroma :---cam-

phire :—

phire :---resin :---balsams :---gum resin :---fecula :---gluten : colouring matter :---elastic gum :---wood :---spontaneous destruction of vegetable matter.

LECTURE XXXII.

Of Animal Substances. Blood :---milk :---bile :---fat :---animal fibre :---spontaneous destruction of animal matter :---observations on contagion.

LECTURE XXXIII.

History of the rise and progress of Chemistry.

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