PLATE I.

Dr. Wollaston's Scale of Chemical Equivalents

Fig 1

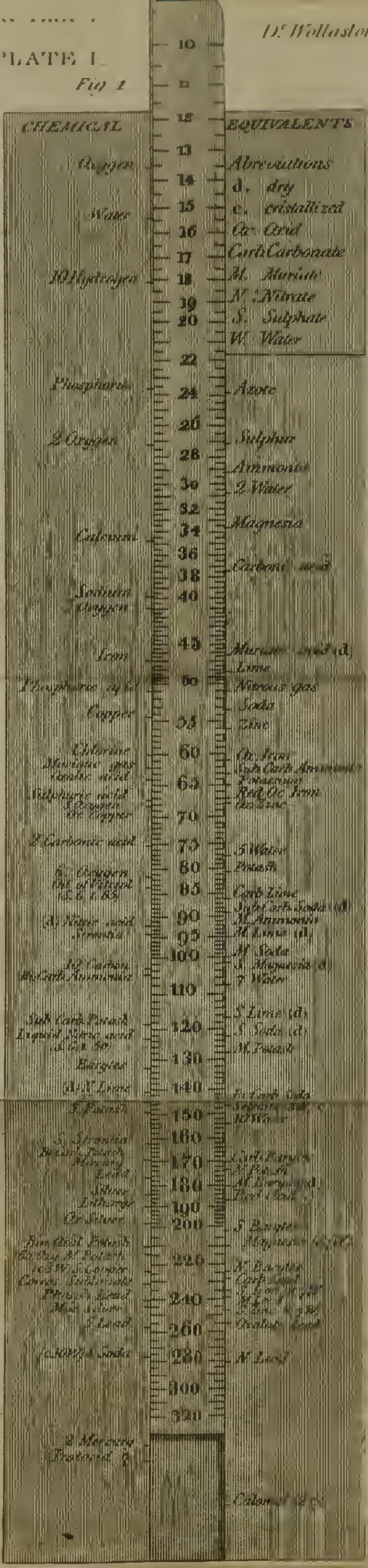
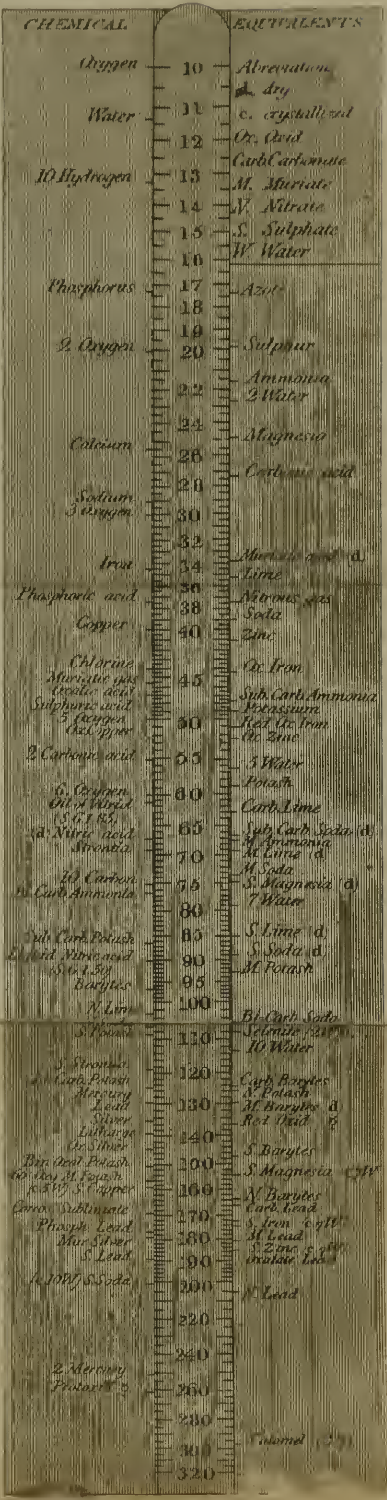


Fig 2.



AN

INTRODUCTION

TO

CHEMISTRY,

WITH

PRACTICAL QUESTIONS:

DESIGNED FOR

BEGINNERS IN THE SCIENCE.

FROM THE

LATEST AND MOST APPROVED AUTHORS.

TO WHICH IS ADDED

A Dictionary of Terms.

BY JOHN RUGGLES COTTING,

LECTURER ON NATURAL AND EXPERIMENTAL PHILOSOPHY, CHEMISTRY AND BOTANY.

BOSTON:
PUBLISHED BY CHARLES EWER....NO. 51, CORNHILL.
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May, 1822.

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1822

DISTRICT OF MASSACHUSETTS...TO WIT:

District Clerk's Office.

BE IT REMEMBERED, That on the Eighteenth day of May, A. D. 1822, in the forty sixth Year of the Independence of the United States of America, JOHN RUGGLES COTTING, of the said District, has deposited in this Office, the Title of a Book, the right whereof he claims as Author, in the words following, *to wit:*

"*An Introduction to Chemistry, with Practical Questions: designed for Beginners in the Science. From the latest and most approved Authors. To which is added, A Dictionary of Terms, by John Ruggles Cotting, Lecturer on Natural and Experimental Philosophy, Chemistry and Botany.*"

In conformity to the Act of the Congress of the United States, entitled "An Act for the encouragement of Learning, by securing the Copies of Maps, Charts and Books, to the Authors and proprietors of such Copies, during the times therein mentioned:" and also to an Act entitled, "An Act supplementary to an Act, entitled An Act for the encouragement of Learning, by securing the Copies of Maps, Charts and Books, to the Authors and Proprietors of such Copies during the times therein mentioned; and extending the Benefits thereof to the Arts of Designing, Engraving and Etching Historical, and other Prints."

JNO. W. DAVIS. { *Clerk of the District of Massachusetts*

....
TRUE & GREENE......*Printers.*
....

PREFACE.

THE science of chemistry is considered as a part of a polite and liberal education for both sexes, and is taught in most of the literary institutions of our country. Its utility and the interest which it is calculated to excite, cannot fail to recommend it to the attention of every inquisitive mind. It is so intimately connected with the physical sciences in general, that no one of them can successfully be cultivated entirely independent of it.

Chemistry is not confined to one department of nature, it takes a wide range through all the works of creation, and subjects all material bodies to its laws. "The solid matters comprising the terrestrial mass of the globe we inhabit; the aqueous fluids which penetrate its cavities or float on its surface; the more gaseous fluids which surround this ponderous mass; the agencies of heat, light and other fleeting substances expanded through the mighty space, are subjects upon which the chemical philosopher may dwell with infinite profit and delight."

Chemistry extends itself into the minute concerns of active life, and is the fostering hand of innumerable important arts, and the various discoveries made in the science are so many acquisitions to those arts.

The science is no longer, as formerly, confined to the laboratory of the artist, but it ranks among the first in philosophical research. It has been enriched, and is continually undergoing improvements by philosophers, in every part of Europe. Works on chemistry are daily issuing from the press, which are excellent in themselves, and have a tendency to advance the student in the knowledge and improvement of the science. But there are few that are calculated, in every respect, for beginners.

The *Conversations on Chemistry, by Mrs. Bryan*, is a very useful and popular work, and has been through many editions both in Europe and America. The subjects are treated in a very pleasing and familiar manner. Great obligations are due to the amiable authoress for the good she has done to the cause of the science. But the expediency of adapting this as an elementary work, at the present time is questioned by many instructors, as great improvements and discoveries have been made in the science since that work was written; many subjects are there inserted which have no relation whatever to this country, and the colloquial manner of treating the subjects necessarily occupies a great portion of the book, which might otherwise be appropriated to subjects of more importance.

Works which treat of the rudiments of chemistry should be perspicuous, as it embraces a variety of subjects, and those, owing to the revolutions which the science is continually undergoing,are too often involved with other matters, not immediately connected with first principles. The consequence of which is, the student finding many objects arresting his attention, at once, all equally gratifying and attractive, looses sight of those elements, by which only, a permanent foundation can be laid. The author is no advocate for those who pretend to display all the elegance of the temple of science at once, into which the *novice* is introduced without preparation or ceremony, where idleness and industry are permitted to participate equally in the same rewards. He believes that the candidate for excellence must proceed with caution, perseverence and labour; that there is but one road to science, which at first is rugged, steep and difficult; that as we advance, we acquire strength to encounter new difficulties, till finally we are qualified to relish the sublime beauties that await the persevering and industrious.

We ought always to bear in mind the maxim,

"Radix doctrinae amara fructus dulcis."

An attempt has been made in the following work; to bring the principles of chemistry into as small a compass as possible, and in a concise manner to exhibit the various subjects treated of by the most eminent chemical writers of the present day.

The work is designed for beginners in the science, it became therefore, necessary to consult the interests both of the instructor and pupil. Few chemical works appear to have had this object in view. Authors have gone upon the supposition that the learner has already become acquainted with the elements, and is qualified to pursue it, through all the intricate subjects, in the elaborate works of the present day. The consequence is, that either much time is lost in attempting to acquire a knowledge of the subject, or an aversion is contracted which ends in a total neglect of this useful and pleasing science. To obviate these inconveniences is the design of the author in the following pages; whether he has succeeded in his object, he leaves to a candid and impartial public to judge.

With regard to imparting instruction, the author considers the plan he has adopted in this work as preferable. From long experience as an instructor, he feels a confidence in recommending the interrogatory method, as attended with the greatest utility. Questions at the end of each chapter very much assist the learner ; and are likewise convenient for the instructor. Each question having a reference to a particular section, the answer may be easily committed to memory ; by which means the remarks of the author are readily comprehended, and much time saved, which is too often employed in turning over the leaves of a book, searching for the object, without a suitable guide to direct to the place ; this has a tendency to discourage rather than promote exertion.

No pretensions are made to originality in the following pages ; the work is a compilation. Neither is it designed to supersede any other. It is an introduction for the purpose of enabling students to commence with more pleasure and success those excellent works of Gorham, Thomson and Henry, which should follow this where a correct knowledge of the science is desirable. In this compilation, recourse has been had to the works of various chemical writers ; from which such extracts have been made as were thought necessary for an introduction. If the subjects have been properly arranged, and treated in a clear and perspicuous manner, the author will be rewarded by a consideration that he has performed an important task ; but this he dares not flatter himself that he has been able, fully, to accomplish.

Some, perhaps, may object that remarks have been made, and passages inserted, which will not be easily understood by beginners, particularly in the chapter on *Chemical Equivalents and the Atomic Theory* ; but the author is not conscious of inserting any thing which is not admitted by the most eminent of the European chemists, and which he is confident is conformable to the most accurate and rigid experiments, as well as to just theory. In examining the remarks of authors on the above subject, for the purpose of making a selection, being limited as to the size of the work, he found that he must either omit the articles altogether, or treat them agreeably to the plan of the authors from whose works they have been extracted. The atomic theory has been adopted, under various modifications, by most scientific men of the present day; and most treatises of chemistry that have been published within the last ten years have a reference to it, especially in the proportions of the different compounds; the work, therefore, in his opinion, would have been very defective without some notice of the theory; especially as one of the principal objects in the compilation was to prepare the pupil, by a knowledge of the first principles of the science, to enter upon fuller and more elaborate treatises, it became, therefore, necessary to treat the subjects not only in a concise manner, but conformably to the present exalted state of the science. Should any, however, be disposed to omit the chapter on chemical equivalents in the instruction of very young persons, it may be done without any derangement of the other parts.

As some acquaintance with what is called Natural and Experimental Philosophy is necessary, previously to entering on the study of chemistry, the work is commenced with some of the rudiments of that science; but brevity was absolutely necessary, as the limits assigned to the work would not admit otherwise. J. R. C.

Boston, May 10th, 1822.

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ABBREVIATIONS

AND

ARITHMETICAL SIGNS.

USED IN THE FOLLOWING WORK.

A small (o,) placed at the right hand, over a figure, denotes degrees.

F. at the right hand of a figure or figures, signifies Farenheit's thermometer. W. Wedgwood's pyrometer. R. Reaumer's thermometer,

The sign + signifies that the figure to which it is prefixed is to be added.

The sign — signifies that the figure which it precedes is to be subtracted. When prefixed to degrees of the thermometer, it signifies that the temperature is so many degrees below *zero.*

The sign × signifies that the figures between which it stands are to be multiplied together.

The sign ÷ signifies that the figure preceding it is to be divided by the figure which comes after it.

The mark =, called the sign of equality, signifies that the amount of the figures preceding are equal to the succeding.

:, : :. Signify that the figures between which they stand are proportional.

DIRECTIONS FOR THE BINDER.

Plate	1.	Table of Cher [illegible] ivalents, to face	Title.
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AN

INTRODUCTION TO CHEMISTRY.

CHAPTER I.

Definition, &c.—General Laws of Matter.

1. Chemistry is the science which investigates the combinations of matter, and the agencies of those general forces whence these combinations are established or subverted.

2. The subjects of Chemical inquiries are particles of matter, both the magnitude and form of which, and the distances within which they act upon each other, are wholly incapable on account of their extreme minuteness to be estimated.

Observation. Authors are not agreed with regard to the etymology of the word Chemistry ; it is generally thought to be of Arabian origin.

3. Matter is the first principle of all natural things, from the various combinations and arrangements of which all bodies are formed.

4. Substance is that which supports the different forms and appearances which are presented to our senses. In common language it means a distinct or definite portion of matter, whether solid or fluid

Observation. The word substance is compounded of the Latin preposition *sub*, under, and *sto* to *stand ;* it differs from matter, because it implies a determinate figure, whereas, matter implies a more general and confused idea of solidity and extension, without any regard to figure.

5. Every kind of substance has certain characteristic properties, such as Solidity, Divisibility, Mobility and Inertia.

6. By solidity or impenetrability, in common language is to be understood the property of not being easily separated into parts.

Observation. If a piece of wood or stone occupy a certain space, they must first be removed before another body can be put in the place ; and though fluids, from their nature, appear at first to oppose such resistance, yet in proper circumstances they will be found to retain the property in an equal degree.

Exp. 1. Put some water into a tube closed at one end, and insert into it a piston, a piece of wood, or metal, which exactly fit the bore of the tube ; then try to push the piston to the bottom, you will find it impossible, even by the force of the greatest pressure.

Exp. 2. Pour the water from the tube, which will be empty as it is called in common language, but in reality, filled with atmospheric air. In attempting to push the piston to the further end, you will meet with the same resistance as before.

7. We derive our idea of impenetrability from the resistance which we meet with in bodies, whether they be solid or fluid.

8. *Divisibility* is that property by which matter is capable of being divided into parts, and those parts separated from each other.

Observation. This divisibility is evident in bodies of sensible magnitudes ; we can never by subdividing arrive at a part so small, but we can conceive that it consists of two halves, but how far this actual division may be carried, whether to infinity or whether we should at last arrive at ultimate atoms, which from their nature, are not capable of subdivision, is a point not ascertained.

The actual division of matter may be carried to an amazing extent, so as to approximate to our ideas of infinity.

Illustration 1. A grain of gold is hammered by the gold beaters until it is the thirty thousandth part of a line in thickness, and will cover fifty square inches.—Each square inch may be divided into two hundred strips, and each strip into two hundred parts, which may be seen with the naked eye; consequently a square inch contains forty thousand visible parts, which multiplied by fifty, the number of square inches which a grain of gold will make, give two million parts, which may be seen with the naked eye.

2. It has been calculated that sixteen ounces of gold, which, in the form of a cube, would not measure one inch and a quarter in its side, will completely gild a quantity of silver wire sufficient to surround the globe.

Exp. 1. Put into a quart of water a small piece of nitrate of silver, *lunar caustic*, not larger than a common pin's head, it will impart a uniform milky colour to the whole liquor.

Exp. 2. Into a pint of water put a small piece of sulphate of copper, *blue vitriol*, not more than the one hundredth of a grain, it will impart a sensible blue colour to the whole liquid.

9. Mobility is that property by which bodies are capable of being moved from one place to another.

10. *Inertia* is a tendency which bodies possess of continuing in the state in which they are placed, whether of rest or motion, unless prevented by some external force.

Illustration 1. A man standing in a boat while it is pushed from the shore, will be in danger of falling backwards, but he will gradually acquire the motion of the boat, and if it be suddenly stopped, he will fall forwards, because his tendency will be to continue in motion.

2. A man riding on full gallop, if the horse suddenly stop, is in danger of falling over the animal's head, his body having acquired the motion of the horse.

11. Space has no limits or bounds; it consists of parts, which may be divided by the mind, but are not capable of actual separation. Its parts are only distinguished by bodies placed in them.

12. Space is either absolute or relative.

13. Absolute space is mere extension, it has no limits or bounds, and is itself immoveable.

14. Relative space is that part of absolute space that is occupied by any body, and is compared by any part occupied by any other body.

15. Motion is either absolute or relative.

16. Absolute motion is the actual motion which bodies possess, independant of each other, and only with regard to the parts of space.

17. Relative motion is the degree and direction of the motion of one body compared with that of another.

Illustration. By this imperceptible motion plants and animals grow, and the greatest number of compositions and decompositions throughout the globe take place.

The temperature of bodies is constantly varying, consequently the particles must be in continual motion, in order to adapt themselves to the size of the body.

18. Accelerated motion is, when the velocity of motion continually increases.

19. Retarded motion is, when the velocity continually decreases.

20. The velocity of uniform motion is estimated by the time employed in moving over a certain space, or by the space moved over in a certain time.

21. To ascertain the velocity, divide the space run over by the time.

22. To know the space run over, multiply the velocity by the time.

23. In accelerated motion, the space run over is as the square of the time, instead of being directly as the time, as in uniform motion.

Illustration. A body falling from a height, moves at the rate of 16 1-12 feet in a second of time, and acquires a velocity of twice that, or 32 1-6 in a second. At the end of the next second it will have fallen 64 1-3 feet.—The space being as the square of the times, the square of 2 is 4, and 4 times 16 1-12 is 64 1-3. And so on.

24. By velocity is meant what bodies would acquire if they should fall through a space where there was no air. Its resistance diminishes considerably their velocity in falling. Therefore in estimating the velocity of bodies, this circumstance must be taken into consideration.

25. A body acted upon by one force will always move in a straight line.

26. Bodies acted upon by two uniform forces, whether equal or unequal, must form a straight line. But if one of the forces be not uniform, that is, either accelerating or retarding, the moving bodies will describe a curve line.

Illustration. If a ball be projected from a cannon, it receives an impulse, which, if there were no resistance from the air, and if it were not acted upon by gravity, would cause it to move always in a straight line, but as soon as it leaves the mouth of the cannon, gravity acts upon it, and causes it to change its direction to that of a curve.

27. The momentum of a body is the force with which it moves, and is in proportion to the weight or quantity of matter, multiplied into its velocity.

28. All bodies appear to possess attraction and repulsion, the causes of which are totally unknown.

29. There are various kinds of attraction, viz. the attraction of cohesion; of gravitation; electricity; magnetism; and chemical attraction or affinity.

30. All the phenomena of chemistry arise from the attractions and repulsions exerted between the particles of matter.

31. Attraction of cohesion acts only at very small distances. It is by this attraction that bodies preserve their forms, and are prevented from falling to pieces.

Exp. 1. If two leaden bullets have a little scraped from each, so as to make them fit exactly in those parts, and they be put together with a twist, they will adhere so strongly as to require a considerable force to separate them.

Illustration. Hardness, softness, brittleness, ductility and malleability depend upon different modifications of the attraction of cohesion.

32. When a body is in solution, and the attraction of cohesion is exerted suddenly, the particles unite indiscriminately and form irregular masses. But when it acts more slowly, the particles assume a particular arrangement, and form masses of regular figures. This is termed *crystallization*, and the regular figured masses are denominated *crystals.*

33. Attraction of cohesion is the cause of the forms in which different bodies exist, and the regular figures which many of them assume.

34. The attraction of gravitation or gravity is the tendency of bodies towards each other, which is exerted at all distances.

35. Every particle of matter in the universe gravitates towards every other particle.

Illustration 1. By the attraction of gravitation, the heavenly bodies are retained in their orbits by their mutual action ; and by this, a stone dropped from a height falls to the surface of the earth.

2. The planets and comets all gravitate towards the sun and towards each other as well as the sun towards them, and that in proportion to the quantity of matter in each.

36. All terrestrial bodies tend towards a point, which is exactly or very nearly the centre of the earth, consequently bodies fall every where perpendicular to the surface, and on opposite sides in opposite directions.

Observation. If two bodies of equal quantity of matter were placed at ever so great a distance from one another, and left at liberty in free space, and if there were no other bodies in the universe to affect them, they would fall equally swift towards one another, and would meet in a point which was half way between them at first.

37. Gravitation decreases from the surface of the earth upwards as the square of the distance increases.

33. We know nothing of gravity but by its effects.

39. Electric attraction is that exerted by amber, sealing wax, and some other substances when rubbed.

Illustration. When amber and sealing wax are rubbed with a silk handkerchief, they attract feathers, dust, &c. from small distances.

40. Magnetic attraction is that exerted by the load stone on iron.

Illustration. The tendency of the needle to the pole is an instance of this attraction.

PRACTICAL QUESTIONS.

What is Chemistry ?
What are the subjects of Chemical inquiries ?
What is matter ?
What is substance ?
What are the characteristic properties of matter ?
What is understood by solidity ?
Do fluids possess solidity ?
Illustrate this by experiment.
How do we obtain our ideas of impenetrability ?
What is divisibility ?
Illustrate this.
What experiment can you exhibit to confirm it.
What is mobility ?
What is inertia ?
Illustrate it.
What is space ?
How is space divided ?
What is absolute space ?
What is relative space ?
How many kinds of motion are there ?
What is absolute motion ?
What is relative motion ?
Illustrate it.
What is accelerated motion ?
What is retarded motion ?
How do you estimate the velocity of retarded motion ?
How do you estimate the space run over ?
How is the space in accelerated motion ?
Illustrate this.
What is meant by velocity ?
How will a body move that is acted upon by one force ?
How if acted upon by two forces ?
Illustrate it.

What is the momentum of a body ?

What do all bodies appear to possess ?

How many kinds of attraction are there ?

From what do all the phenomena of Chemistry arise ?

What is attraction of cohesion ?

Illustrate this.

What is the effect when the attraction of cohesion is exerted suddenly.

What is the cause of the forms of different bodies ?

What is the attraction of gravitation ?

How does every particle of matter gravitate ?

How is it with regard to the planets and comets ?

How with regard to terrestrial bodies ?

What would be the consequence suppose there were only two bodies in the universe, and they placed at a distance from each other ?

How does gravitation decrease from the surface of the earth ?

What do we know of gravity ?

What is electric attraction ?

Illustrate it.

What is magnetic attraction ?

Illustrate it.

CHAPTER II.

Of elements or simple bodies—Chemical attraction or affinity.

1. In a Chemical sense, substances are divided into two kinds, viz. simple and compound, the former of which are sometimes called *elements.*

2. Simple bodies are those which have not been separated into others more simple, nor reproduced by artificial means.

Observation 1. The ancients considered four substances as simple and uncompounded, which they denominated elements, viz. earth, air, fire and water. These have all been decomposed, and their constituent parts well ascertained.

Observation 2. It would perhaps be presumption to assert that we are acquainted with any simple body. Those which we now call elementary may hereafter be found to be compounded. Many that were supposed to be simple twenty years ago have been decomposed, and their component parts clearly exhibited to the senses ; such are earths and alkalies.

3. The term, *elements*, should be considered as denoting the last term of the analysis, according to the present state of knowledge.

4. The number of simple substances is constantly changing, as new discoveries are made. Those which rank under that term, at present, are *fifty*.

5. Excepting the more general agents of nature, heat, light, and electricity, it is thought by some, that the simple bodies may ultimately be resolved into metallic substances, but this is doubted by others ; and no experiment on any one of the simple substances, tends to confirm the hypothesis.

6. The simple substances are at present divided into two classes ; the one called combustible or inflammable ; and the others, supporters of combustion, because in combining with the first class, much light and heat are developed.

7. Should the experiments of the French chemists prove correct, with regard to some of the newly discov-

ered substances, the present division between the combustible bodies and those which support combustion, will hardly be warranted.

8. Some of those which support combustion, appear to act the part of both, combustibles and supporters.

Illustration. Sulphur gives light and heat to a certain extent, in its combination with some of the metals, and also when it combines with oxygen, with which as an inflammable body it forms an acid. In the opposite characters, like chlorine and iodine, it forms an acid with hydrogen, which is termed the hydrosulphuric acid.

9. Some suppose that phosphorus, carbon and azote, have a property similar to that of sulphur.

10. Most of the simple combustibles have been proved to be metals, and hydrogen is believed by some to be a metal in an elastic form.

11. Those bodies whose metallic natures have not yet been fully ascertained, appear to possess the property of combining more strongly with inflammable bodies, than the metals with each other in forming alloys.

12. The combinations of metals with those that are not metallic,are generally conspicuous and always definite.

13. All the simple substances combine and form compounds, and from these, combined in different ways, an indefinite number of substances are produced.

14. Chemical attraction, or the attraction of composition, commonly called *Chemical affinity*, is a tendency which bodies of a different nature have to unite with one another, and form substances which are different from the bodies that have been combined.

15. The attraction of aggregation is that which takes place between parts of the same substance, or between bodies of the same kind, and differs not materially from the attraction of cohesion.

16. An aggregate is a coherent body, and must be distinguished from a *heap*, for though a heap consists of parts all of a similar nature, yet those parts have no cohesion with each other.

Illustration. A mass of rock is an aggregate, where particles cohere, but a mass of sand is a *heap*, being composed of distinct and separate particles.

17. A *mixture* is a mass of substances of a different nature.

Illustration. Gunpowder composed of charcoal, sulphur and nitre.

18. There are several kinds of aggregation, as 1. The solid, as wood, metal, sulphur 2. The soft, as in glue, meat, jellies. 3. The liquid, as in water and oil. 4. Aeriform, as in air and vapour.

Illustration. Wax and tallow, when in a temperature of 50° are solid, at 80° soft, at 160° fluid, and between 300 and 400° vapourized or aeriform.

19. Every effort that tends to separate the particles of bodies, tends to destroy the attraction of aggregation. In all cases the force applied, must be more than equal to the force of attraction.

Illustration. Grinding, cutting, pounding, &c.

20. If the aggregation of a body be diminished, it exhibits a greater surface.

Illustration. A lump of sugar or salt when broken into bits, will present a larger surface than when whole.

Observation. By this means the energy of chemical agents is increased ; thus fluate of lime, (Derbyshire spar) is scarcely affected by sulphuric acid in the lump ; but let it be first ground into powder, and a rapid decomposition takes place ; the fluoric acid is disengaged in the form of gas, it being compounded of this acid and lime ; in the decomposition, the sulphuric acid combines with the lime, forming what is called sulphate of lime.

21. The force of this attraction is estimated by the power required to overcome it.

Illustration. Hence arises the difficulty of cutting marble, flint, and the diamond ; hence also the different degrees of exertion required to separate the several kinds of timber.

22. Different degrees of heat are required to overcome the several kinds of aggregation.

23. Hot liquids not only dissolve substances quicker, but in much larger quantities ; when, however, the liquor cools, part of the substance falls to the bottom of the vessel, in regular crystals.

Exp. Take an ounce of glauber's salt, *sulphate of soda*, which has been dried over the fire and become a white powder, dissolve it in two ounces of boiling water ; when cold, the original crystals will be seen in the fluid, notwithstanding the salt was reduced to powder.

24. Chemical attraction differs from the attraction of aggregation in this ; the former unites bodies of different natures, while the latter only those of the same.

Illustration. Sand and alkali exposed to a strong heat, combine and form a substance called glass. In this state it is a uniform whole, which no mechanical efforts can again separate into sand and alkali, and the properties of glass are not only different from those of sand and salt, but in many respects quite contrary. It is transparent and insipid.

Exp. 1. Put a small quantity of mercury and sulphur into a crucible, an ounce of each, and stir them together over a fire, till the sulphur is completely melted, then pour the mixture on a piece of glass or marble, previously greased or warmed. The substance obtained from this composition, is *sulphuret of mercury*, and has neither colour, brilliancy, inflammability, nor volatility of either of its component parts. Neither can the ingredients be separated from each other by any mechanical means.

2. Dissolve mercury in nitric acid, for which it has a strong affinity, to the point of saturation, that is, when it will dissolve no more, every particle of acid has attracted a particle of mercury. The liquid has lost its acid taste, and acquired that of a metallic one, if it be slowly evaporated, a salt will be formed, which in its properties and appearance is entirely different from its ingredients.

3. The burning acid nature of quicklime and sulphuric acid is well known; if we mix a small quantity of each together, the corrosive nature of both is destroyed, and the substance produced from this union is called *Plaster of Paris*, or *gypsum*; in chemical language, it is *sulphate of lime*.

4. A spoon-full of salt thrown into water and dissolved, diffuses itself through the whole of the fluid, and the salt is said to be combined with the water; the water and the salt have a certain affinity for each other, they cannot be separated by any mechanical means; but if another substance be added to which water has a greater affinity than it has to the salt, it will quit the salt to unite with this third substance. If therefore alcohol be added, the water will leave the salt to join the spirit; and the salt, by its superior gravity, will fall to the bottom of the vessel.

5. Dissolve camphor in alcohol, the solution is perfectly clear, which is another instance of chemical affinity; but the spirit has a stronger affinity for water than for camphor, and if a little of that be added, the camphor will fall down in white flakes, or in a solid form.

6. Put some acetate of soda into a retort, add muriatic acid and distil the mixture to dryness; the fire will drive

off the acetic acid, but will have no effect on the muriatic acid, while in combination with the soda, which proves that the soda has a greater affinity for the muriatic acid than for the acetic. If now nitric acid be added to the muriate of soda, and heat applied, the muriatic acid will be driven off, the nitric acid is combined chemically with the soda, and the substance is a nitrate of soda; to which, if sulphuric acid be added, and heat applied, the nitric acid will be expelled, and the sulphuric acid will unite with the soda, forming a true sulphate of soda. These changes take place in consequence of chemical affinity.

25. Decomposition and division are very different in their operations; the latter simply reduces a body into parts, while the former separates the various ingredients of which it is composed.

Illustration. When we break with a hammer a piece of marble, we merely divide it, each part still retaining all its constituents, and this may be done without any knowledge of chemistry; but when the chemist attempts to analyze it, he finds it composed of carbonic acid and lime, for this purpose he applies a third substance which has a greater affinity for lime than the carbonic acid has, by this means he separates the constituents, this is called *decomposition.*

26. When we decompose a substance, we resolve it into its constituent parts; when we divide it, into integrant parts; hence the difference between *elementary* and *integrant* particles.

27. Bodies are decomposed by chemical attraction, by adding a third substance which has a greater affinity for one of its constituents than the other, in this way it unites with one, and the other is set at liberty.

Illustration. This may be illustrated by three letters, A. B. C. Let the two ingredients be A and B ; present to this compound the third ingredient C. which has a greater affinity for B. than that which unites A and B. it follows that B. will quit A. to unite with C. ; therefore C. has effected a decomposition of A. B. A. has been dismissed, and B. and C. form an union.

Exp. Dissolve some nitrate of copper in water, and immerse in it a piece of clean bright iron. A decomposition takes place, the nitric acid having a stronger affinity for the iron than it has for the copper, attacks the iron and setting at liberty the copper, it is precipitated in its metallic form.

28. Chemists have established certain principles called *Laws of affinity.* The *first* is, that it acts only in the union of bodies of different natures, and forms a third substance totally different from either of the constituents.

Illustration. Sulphuric acid and soda when combined, form glauber's salt, or sulphate of soda.

Second. Chemical affinity acts only between the minute particles of bodies.

Exp. A lump of sulphur thrown into alcohol, will cause no action ; but if the sulphur be minutely divided, the bodies will unite, and the solution be perfectly transparent. The union is thus effected ; put some pounded sulphur into a cucurbit A. Plate 2, fig. 2, suspend within it a phial B. containing alcohol ; and when the whole is covered with the head C. and the joinings well luted, heat the apparatus by means of the lamp F. The sulphur will soon rise up in small particles, and will unite with the particles of alcohol which will likewise be driven off by the heat, and will be collected in the matrass X.

To prove that the sulphur has united with the alcohol, add some distilled water for which the alcohol has a stronger affinity than for the sulphur, the latter will be precipitated.

Third. Attraction may take place between several bodies; thus two, three, or more metals may be fused together, so as to produce compounds, the properties of which are very different from those of the constituent parts.

Exp. Melt eight parts of bismuth, five of lead, and three of tin together, and when united, the compound is so fusible, that a spoon made of it will melt in boiling water. This property none of the metals possess separately. A composition of equal parts of lead, zinc and bismuth is so fusible, that it may be kept in fusion on a paper held over the flame of a candle.

Fourth. Bodies will not unite chemically, unless one of them, at least, be in a fluid or aeriform state.

Illustration. Neither sugar nor salt will combine with ice; but they both unite with water.

Fifth. When two or more bodies unite by affinity, their temperature suffers a change at the instant of union.

Exp. 1. In a wine glass half filled with cold water, pour some sulphuric acid very gradually, a heat will be immediately perceived, which by the addition of the acid may be increased above that of boiling water.

2. Hold in one hand a phial containing some pulverized muriate of ammonia, sal ammoniac, upon which pour cold water, and shake the mixture, a sensation of great cold will be immediately produced.

Sixth. By chemical affinity some bodies acquire properties very different from those which the compounding bodies had previously.

Illustration: Iron and tin when combined by fusion, lose the property of malleability and ductility.

Exp. Drop concentrated sulphuric acid gradually into a saturated solution of muriate of lime, a solid will be formed from the two fluids.

Seventh. The action of two compound substances, by which they mutually decompose each other, and produce two or more new substances, is called compound affinity.

Exp. 1. If to a solution of sulphate of ammonia, there be poured nitric acid, no action takes place, because the sulphuric acid has a greater affinity for ammonia than nitric acid. But if instead of nitric acid, a solution of nitrate of potash be poured in, a double decomposition takes place, and by evaporation, two new bodies are obtained, a sulphate of potash and nitrate of ammonia. In this case, the sulphuric acid of the sulphate leaves the ammonia to unite with the potash; and the nitric acid is disengaged and unites with the ammonia.

Exp. 2. If the sulphate of alumina be mixed with the acetate of lead in solution, a mutual decomposition takes place; the acetic acid of the acetate unites with the alumina, and the sulphuric acid with the lead.

29. The cause of chemical affinity or attraction of composition has not been fully ascertained.

Observation. In 1803, Berzelius and Hisinger discovered the law respecting the agency of the galvanic battery in the decomposition of bodies, viz. "That oxygen and acids are accumulated round the positive pole; while hydrogen, alkalies, earths and metals, are accumulated round the negative pole." From this general law Berzelius deduced the consequence, that the decompositions in such instances were owing to the attractions subsisting between the bodies and the respective electricities. This opinion was extended by Sir H. Davy, with which Berzelius afterwards coincided. According to these celebrated chemists, chemical affinity is identical with electrical attraction, and bodies which unite chemically, possess different kinds of electrical attractions. Every body, in their opinion, possesses a permanent electric state, either resinous or vitreous. Two bodies in the same state of electricity have no affinity for each other, consequently, the *attraction of cohesion* which takes place between substances of the same nature, cannot be the same as electric attraction.

According to the above theory, bodies in opposite states have an affinity, and the strength of this affinity is in proportion to the degree of intensity of the different electricities in the two bodies; in order to make bodies separate from each other, we have only to bring them into the same electric state by making them both vitreous or both resinous. It remains for future discoveries to ascertain whether this hypothesis be founded in truth; but there can be no question that electricity has great influence in the combination of bodies.

We shall consider this subject further, under the article, *electricity* and *galvanism.*

PRACTICAL QUESTIONS.

How are substances divided in chemistry ?

What are simple bodies ?

How did the ancients consider this subject ?

How should the term elements be considered ?

What are the number of simple substances ?

Into what may the simple bodies be resolved ?

Enumerate them.

Into how many classes are these substances divided ?

But may not this division be incorrect ?

Do any substances act the part of combustibles and supporters ?

Illustrate this.

What is thought of carbon, phosphorus and azote ?

What is carbon and azote believed to be ?

What has been proved with regard to the simple combustibles ?

What do those bodies which have not been proved metalic, appear to possess ?

How is the combination of metalic with non-metalic substances ?

How is the combination of simple substances ?

What is chemical attraction ?

What is the attraction of aggregation ?

How does an *aggregate* differ from a *heap* ?

Illustrate this.

What is a mixture ?

Illustrate it.

How many kinds of aggregation are there ?

Illustrate it.

How is the attraction of aggregation destroyed ?

If the aggregation of a body be diminished, what does it exhibit ?

How do you illustrate this ?

How do you estimate the force of this attraction ?

What is required to overcome the different kinds of aggregation ?

What effect have hot liquors to dissolve substances ?

How does chemical attraction differ from aggregation ?

Illustrate it.

What is the difference between decomposition and division ?

Illustrate it.

What do we, when we decompose a substance ?

How are bodies decomposed ?

Illustrate it.

What have been established by chemists with regard to attraction?

What is the first law?

Illustrate it.

What is the second law?

Illustrate it by experiment.

What is the third law?

How would you illustrate it?

What is the fourth law?

Illustrate it.

What is the fifth law?

Illustrate it by experiment.

What is the sixth law?

Illustrate it.

What is the seventh law?

Illustrate it by an experiment.

What is the cause of chemical attraction?

What observations have you to make on this subject?

CHAP. III.

Theory of Atoms,—Definite proportions—Chemical Equivalents, &c.

1. The atomic theory is the manner of explaining the composition and decomposition of bodies by considering their ultimate atoms or particles as peculiar and distinct elementary solids, never changing in their figure, weight, or volume, and utterly incapable of being divided.

2. By means of this theory which is now generally admitted under certain modifications, by the most scien-

tific Chemists, Chemistry has been elevated to the rank of a mathematical science, and made to occupy one of the most distinguished places in the field of philosophical research.

3. Sir Isaac Newton seems to have had an idea of the theory of atoms, or ultimate particles, by the following sentence. After speaking of the laws of chemical attraction, he proceeds as follows. "All these things being considered, it seems probable to me that God in the beginning formed matter in solid, massy, hard, impenetrable, immoveable particles, of such sizes and figures, and in such proportions to space, as most conduced to the end for which he formed them; and these primitive particles being solids, are incomparably harder than any porous bodies compounded of them; even so very hard as never to wear or break in pieces; no ordinary power being able to divide what God himself made one in the first creation. While the particles continue entire, they may compose bodies of one and the same nature and texture in all ages; but should they wear away, or break in pieces, the nature of things depending upon them would be changed. Water and earth composed of worn out particles, and fragments of particles would not be of the same nature and texture, now, with water composed of entire particles in the beginning. And therefore, that nature may be lasting, the changes of corporeal things are to be placed only in the various separations and new associations and motions of these permanent particles, compound bodies being apt to break, not in the midst of solid particles, but where those particles are laid together, and only touch in a few points."

4. Mathematicians conceived matter to be infinitely divisible, but, in nature its divisibility was thought to be limited to the hard and impenetrable atoms.

5. The idea of atoms appears to have been first promulgated in any chemical work in 1790, by Mr Higgins, and by J. B. Richter, of Berlin, in 1792. Very little notice was taken of the subject by chemists until Mr. John Dalton of Manchester, Eng. published his system of definite proportions, since which it has received additional support and improvements by the most celebrated chemists in different parts of Europe.

6. The French chemists have adapted the atomic theory under another form, which agrees with the language given by Berzelius, viz that of *volume.*

7. Dr. Wollaston introduced into the science, the term chemical equivalents, to express the different ratios in which the corpuscular subjects of this science reciprocally combine, referred to a common standard which is reckoned unity.—Plate 1.

7. He assumed oxygen as a standard, from its being almost universally combined in chemical matter.

8. If oxygen be made unity, we shall have in the following table, their ratios reduced to their lowest terms in which the equivalents will be prime ratios or proportions.

The lowest ratio, or equivalent prime of oxygen being	1,000
That of hydrogen will be	0,125
Of fluor?	0,375
Of carbon,	0,750
Of phosphorus,	1,500
Of azote,	1,750
Of Sulphur,	2,000
Of calcium,	2,550
Of sodium,	2,950
Of potassium,	4,950
Of copper,	8,00

Of barium, - - - -	8,75
Of lead, - - - - -	13,00 &c.

9. The substances in the above table, susceptible of reciprocal saturation, can combine with oxygen, or with each other, not only in proportions corresponding with these numbers, but frequently in multiple or submultiple proportions, as in 1 and 1 : 1 and 2, &c. from this have been adduced two general proportions of vast importance to the science—viz. 1st. The mutual action ofthe saturating porportions.—2d, The multiple and submultiple proportions of prime equivalents in which any one body may unite with any other body to constitute successive binary compounds.

10. The first of these laws was inferred from the remarkable and well established fact, that two neutral salts in decomposing each other, produce two new saline compounds perfectly neutral.

Illustration.—Sulphate of soda being added to muriate of lime will produce perfectly neutral sulphate of lime and muriate of soda.

11. Richter drew the following conclusion.—1st, That the quantity of two alkaline bases, sufficient to neutralize equal weights of any one acid, are proportionable to the quantities of the same bases sufficient to neutralize the same weights of every other acid.

Illustration.—Six parts of potash or 6 of soda, will neutralize 5 of sulphuric acid, and 4.4 of potash will saturate 5 of nitric acid. Therefore to find the quantity of soda equivalent to the saturation of this quantity of nitric acid, it may be computed by the proportional rule of Richter without having recourse to experiment, in the following manner, as 6 : 4.4 : : 4 : 2.93 ; that is, as the potash equivalent to the sulphuric acid, is to the potash equivalent to the nitric acid, so is the soda equivalent to the first, to the soda equivalent to the second.

2. 6.5 potash, saturate 5 of muriatic acid gas, what proportion of soda by Richter's rule, will be required to produce the same effect? We say 6 : 6.5 : : 4 : 4.3.

3. If 10.9 potash combine with 5 of carbonic acid, how much will be equivalent to that effect. Now, 6. 10.9 : : 4 : 7.26. Here we have found, that if 6 potash be equivalent to 4 soda, in saturating 5 of sulphuric acid, this ratio of 6 to 4, or 5 to 2, will pervade all the saline combinations ; so that whatever be the quantity of potash requisite to saturate 5, 10, &c. of any other acid, two thirds of that quantity of soda will suffice.

4. In the same manner let us find out for five of sulphuric acid, or of any one standard acid, the saturating quantity of ammonia, magnesia, lime, strontites, barytes, peroxide of copper, and the other bases; then their proportions to potash, thus ascertained, for this acid, will, by arithmetical calculation, give their saturating quantity of every other acid, whose relation to potash, or any other of these bases is known.

12. The verification of the above important law occupied Richter from the year 1791, to 1802. With indefatigable zeal he examined each acid in its relation to the bases, and then compared the results with those given by calculation, which he arranged in an extensive series of tables. But all his tables have since been reduced into a single one, of 21 numbers, divided into two columns, by means of which, every question relating to the included articles might be solved by the rule of three, or a sliding scale.—Plate 1.

The following table was composed from Richter's last tables.

Bases.		Oxygen =1.	Acids.		Ox'gen=1
Alumina,	525	2.625	Fluoric,	427	7.135
Magnesia,	615	3.075	Carbonic,	577	2.885
Ammonia,	672	3.36	Sebacic,	706	3.530
Lime,	793	3.965	Muriatic,	712	3.560
Soda,	859	4.245	Oxalic,	755	3.775
Strontian,	1229	6.645	Phosphoric,	679	4.895
Potash,	1605	8.025	Formic,	988	4.94
Barytes,	2222	1.111	Sulphuric,	1000	5.000
			Succinic,	1209	6.045
			Nitric,	1405	7.025
			Acetic,	1480	7.400
			Citric,	1483	8.415
			Tartarous,	1694	8.470

The object of the above table was to give directly the quantities of acid and alkali requisite for mutual saturation. For example, 1605 opposite to potash is the quantity of that alkalic equivalent to neutralize 427 fluoric acid 527 carbonic, 712 muriatic, 100 sulphuric, &c. Each column affords also progressive increasing numbers. Those nearest the top have the greatest acid or alkaline energies as measured by their powers of saturation. Hence the first columns, give, as far as analysis would justify, in the time of Richter, a table of the relative weights of atoms.

14. Two chemical constituents frequently unite in different proportions, forming distinct and often dissimilar compounds.

Illustration. Oxygen and nitrogen unite and constitute in one proportion nitrous oxide ; in a second proportion nitric oxide. In a third nitrous acid, and in a fourth nitric acid. The law by which these various compounds are regulated, is the doctrine of definite proportions.

15. By this law bodies are supposed to be composed of primitive atoms, which combine with each other to form

the different compounds. These atoms are supposed to be spherical, and can only combine 1 atom to 1, 1 to 2, 1 to 3, and so on. The number of the atoms of one element being some multiple to the atoms of the other.

16. Hence it follows that bodies unite together in certain definite proportions by weight, that certain weights of some bodies combine with certain weights of other bodies.

17. Substances in a gaseous state have been demonstrated to combine with reference to their *bulk or volume*, that is, one volume of one gas always combines with one or more similar volumes of another, and not with any odd fractional parts. The volume or bulk of the resulting compound, if it happens to be gas, always bears a similar relation to the original volumes of its component gases.

18. The same weights of the same resulting compounds are formed when bodies unite in a gaseous state according to their *volume*, as when they unite in any other manner according to their weight.

Illustration. 1 volume, (say 100 cubic inches) of muriatic gas will unite with 1 volume, 100 cubic inches of ammoniacal gas, and form the same weight of the same compound, viz. muriate of ammonia, as if 39,183 grains, the absolute weight of 100 cubic inches, of muriatic acid, united with 18.003 grains; the absolute weight of 100 cubic inches of ammonia; the two numbers 39.183 and 18.003 being to one another as 1.273 : 5900, or as 37 : 17. The specific gravities and the weights of these two substances respectively.

19. If the hypothesis and data are correct, it follows that the weights of the atoms of bodies are to one another as the specific gravities of the same bodies in a state of gas.

20. If hydrogen be taken as unity, as is the case in

Dalton's experiments, then the weights of the atoms of all bodies will be multiples of this unit: this is verified partly by experiment, and partly by hypothesis.

21. The above opinion has been formed upon the following grounds.—1st, The specific gravity of ammoniacal gas, according to Sir H. Davy, is 590164, common air being 1,000. According to Riot and Arrago it is a fraction greater; hence Dr. Prout infers it to be 5902 as the specific gravity of this gas. The specific gravity of nitrogen, he assumes as 9722, common air being 1,000. Now as ammonia is known to be composed of one volume nitrogen and three volumes hydrogen, condensed into two volumes, the specific gravity of hydrogen, according to these data must be 0694.

22. Atmospheric air is admitted to be universally composed of about 21 per cent of oxygen, and 79 per cent of nitrogen, which so nearly corresponds with one volume of oxygen, and four volumes of nitrogen, or 20 of the former to 80 of the latter, that it is inferred to be its true composition. Now the weight of the atom of oxygen being supposed to be so, and that of the atom nitrogen 17.5 the specific gravity of oxygen gas, accordingly, will be 1.1111 and that of nitrogen 9722. These numbers are multiples of 0694, for 1. 1111, divided by 0694=16 and 9722 divided by 0694=14.

23. There are some substances whose specific gravities do not correspond with the weight of their atoms. Thus the specific gravity of oxygen is 16 times that of hydrogen, while the weight of its atom, or its combining weight is only half or eight times that of hydrogen, but the specific gravities are always some multiples of the weight of the atom.

24. When the specific gravity is double the weight of the atom, as that of oxygen, we must suppose that the

particles are nearer each other in the proportion of 2 to 1, or that two particles come together, and are surrounded by the caloric which belongs to one of them in their single state.

25. It appears that the oxygen puts on this single state of existence in the formation of carbonic oxide, because that gaseous body contains only 1 atom of oxygen; hence its specific gravity is the same as if formed from a gaseous oxygen of half the real specific gravity united to an atom of carbon without any change of volume, the same as takes place when sulphur or carbon is burnt in oxygen gas. Hence the great tendency which oxygen possesses of combining in double doses with bodies, as is the case with carbon, sulphur, phosphorus, iron and many others.

26. We have also an instance of a compound gaseous body becoming double the specific gravity which would be expected, in olefiant gas, which is composed of 1 atom carbon and 1 atom hydrogen. The specific gravity, hydrogen being 1, ought to be $1\times5.4=6.4$: whereas, in fact, it is about double of this. Hence we should conclude that the repulsion between the particles is halved, or that the compound atoms have united in pairs by which the density is doubled.

27. The quantity of acid, according to Gay Lussac, which the different metallic oxides require for saturation, is in direct ratio to the quantity of oxygen which they respectively contain. This principle was discovered by observing the mutual precipitation of the metals, from their solution in acids.

Experiment. 1. When we precipitate a solution of acetate of lead by a plate of zinc, a beautiful vegetation is formed, known under the name of the *tree of Saturn* and which arises from the reduction of the lead by a galvanic process. At the same time we obtain a solution of acetate of zinc equally neutral with that of the lead, and entirely exempt from it. Very little if any hydrogen is disengaged during the precipitation, which proves that the whole quantity of oxygen necessary for the solution of the zinc and saturation of the acid, has been furnished to it by the lead.

2. If we put into a solution of sulphate of copper, slightly acidulous, bright iron turnings in excess, the copper is almost instantly precipitated; the temperature rises and no gas is disengaged. The sulphate of iron which we obtain is that in which the oxide is at a *minimum*, and the acidity is exactly the same as that of the sulphate of copper employed.

3. Similar results may be obtained by decomposing the acetate of copper by lead, particularly by the aid of heat. But since the zinc precipitates the lead from its acetic solution, we may conclude that it would also precipitate copper, from its combination with acetic acid.

4. Copper precipitates with facility silver, from its nitric solution. All the oxygen necessary for its solution is furnished to it by the oxide of silver, for no gas is disengaged, and the acidity is not changed.

5. The same thing happens with copper in regard to nitrate of mercury; and to cobalt with respect to silver. In these examples, as well as the preceeding, the precipitating metal is furnished with all the requisite oxygen from the metal, while it precipitates, all that is necessary for its oxidizement and for neutralizing to the same degree the acid of the solution.

23. M. Gay Lussac has shewn with regard to the same metals, at their different states of oxidizement, that they require of acid a quantity precisely proportional to the quantity of oxygen they may contain, or that the acids in the salts are exactly proportional to the oxygen in the ox-

ides. This law affords a ready way of determining the proportions of all the metallic salts. The proportions of one metallic salt, and the oxidation of the metals being given, we may determine those of all the salts of the same genus, or the proportions of acid and of oxide of all the metallic salts; and the oxidation of a single metal being given, we can calculate the oxidation of all the rest, since the peroxides require the most acid, we can easily understand how the salts containing them should, in general, be more soluble than those with the protoxide.

29. Berzelius, a Swedish chemist, contributed essentially to the science of chemical ratios. He assumed oxygen as the unit of proportion.

30. Dr. Wollaston's scale of chemical equivalents, Plate 1, fig. 1, has contributed more to facilitate the general study and practice of chemistry, than any other invention.

31. Dr. Wollaston discovered a series of numbers denoting the relative primary proportions or weights of the atoms of the principal chemical bodies, both simple and compound. These were determined from a general view of the most exact analysis of other chemists as well as his own.

32. The list of substances which Dr. Wollaston has estimated, are arranged on one or other side of a scale of numbers, in the order of their relative weights, and at such distances from each other, according to their weights, that a series of numbers placed on a sliding scale, can at pleasure be moved, so that any number expressing the weight of a compound, may be brought to correspond with the weight of that compound in the adjacent column. The arrangement is such, that the weight of any ingredient in its composition, of any reagent to be employed, or precipitate that might be obtained in its analysis, may be found opposite the point at which the respective name is placed.

33. If the slider be drawn upwards until it corresponds with the muriate of soda, the scale will then show how much of each substance contained in the table is equivalent to two of common salts; viz. 26,8 dry muriatic acid, and 53.4 of soda, or 39.8 sodium, and 13.6 oxygen; or if viewed as chloride of sodium it contains 60.2, chlorine, and 39.8 sodium. With respect to seagents, it may be seen that 389 nitrate of lead containing 191 of litharge employed to separate the muriatic acid, would yield a precipitate of 237 muriate of lead, and that there would then remain in solution nearly 146 of nitrate of soda. It may at the same time be seen that the acid in this quantity of salt, would serve to make 232 corrosive sub limate, containing 185.5 red oxide of mercury, or make 91.5 muriatic of ammonia, composed of 62 muriatic gas, and 29.5 ammonia.

34. The scale shews also that for the purpose of obtaining the whole of the acid in distillation, the quantity of sulphuric acid required is nearly 84, and that the residum. of this distillation would be 122 dry sulphate of soda, from which might be obtained by crystallization, 277 glauber's salts containing 153 water of chrystallization.

Observation.—These and many other similar examples may be performed by motion of the slider, either up or down, so as to correspond with its place in the adjacent column, which must be of incalculable advantage to the operative chemist.

35. When we wish to reduce analytical results, as usually given for two parts, to the equivalent prime ratios, or in other words to the atomic proportions, we must proceed on the following principles.

1. As in all reasoning, we must proceed from what is known or determinate, to what is unknown or indeter-

minate, so in every analysis, there must be one ingredient whose prime equivalent is well ascertained. This is compared as the common measure, and the proportions of the rest are compared to it.

Take fluate of lime to determine the unknown number that should denote the prime of fluoric acid.

In the first place 2 primes oxygen =2, combine with 1 of carbon=0.75, to form the compound prime 2.75 carbonic acid. We likewise know that carbonate of lime consists of 43.6 carbonic acid×54,4 lime. We therefore make this proportion to determine the prime equivalent of lime

43.6 : 54.4 : : 2.75 : 356= prime of lime.

2. It has been ascertained that 100 parts of dry sulphate of lime, consists of 41.6 lime, and 58.4 acid. Hence to find the prime of sulphuric acid, we make this proportion.

41.6 : 58.4 : : 3.565 :=prime of sulphuric acid.

There has been obtained from 100 of fluor spar or fluate of lime in powder, acted on by sulphuric acid, and ignited 175.2 grains of sulphate of lime. Now since 100 grains of sulphate of lime contain as above 41.6 of lime we have this proportion.

100 : 41.6 : : 175.2 : 72.88 = lime corresponding to 175.2 grains of sulphate, and previously existing in the 100 grs. of fluor spar. If from 100 we substract 72.88, the difference 27.12 is the fluoric acid, or the other ingredient of the fluor, which saturated the lime. Now to find its prime equivalent, we say,

72.83 : 356 : : 27.12 : 1.325=the atom of fluoric acid.

Observation—According to Dr. Thomson, the number 3.625 represents the atom of lime, consequently the atom of fluoric acid would be 1,3015.

36. M. Vauquelin found that 33 parts of lime saturat-

ed with sorbic acid, and carefully dried, weighed 100 grs. Hence the difference, 67 grains, was acid. To find its equivalent prime, we say

33 : 67 : : 3.56 = the prime of lime : 7.23 = the prime of the acid. But as he brought it to absolute neutrality by a small portion of potash, we may, according to Dr. Ure, take 7.5 for the acid.

37. M. Vauquelin subjected the acid, as it exists in the dry sorbates of lead and copper, to an analysis by fire, and obtained the following results :

Hydrogen,	16.8
Carbon,	28.3
Oxygen,	54.9
	100.0

Now such an assemblage of the primes or atoms of these elements, must be found as will form a sum total of 7.5 ; and at the same time be to each other, in the above proportions. The following rule is given for the solution, and by a sliding rule it may be found by inspection.

Multiply each proportion per cent. by the compound prime, and compare the products by the multiples of the constituent primes. The number of each prime requisite to compose the whole, can then be estimated thus,

		Theory.	Experiment.	
0.168×7.5=1.2600 or	10 hydrogen	=1.25	16.7	16.8
0.283×7.5=2.1225	3 Carbon	=2.25	30.0	28.3
0.519×7.5=4.1175	4 Oxygen	=4.00	53.3	54.9
		7.50	100.0	100.0

If on Dr. Wollaston's scale, we mark with a pencil 2h, 3h, and up to 10h ; 2c, 3c, 4c, 5c ; and 2n, 3n, 4n ; respectively opposite to twice, thrice, &c. the atoms of hydrogen, carbon and nitrogen, we shall have ready approximations to the prime components, by inspection of the scale. Move the sliding part, so that one of the quantities per cent, may stand opposite the nearest estimate of a multiple prime of that constituent. Thus we know that hydrogen, carbon and oxygen bear relation to each other of 4, 6, 8 ; of course the latter two that of 3 to 4. But 54.9 oxygen being more than one half of 100, the weight of oxygen in the compound prime is more than the half of 7.5, and therefore points to 4. Place 54.9 opposite 4 oxygen, we shall find 18 opposite 10 hydrogen, and 30.7 opposite 3 carbon. Here we see that the proportions of carbon and hydroygen are both greater than by Vauquilin's analysis. Try 51 opposite 4 oxygen, then opposite 3 carbon, we have 28.7, and opposite 10 hydrogen 16.9.

39. If the weight of the compound prime is not given, then we must proceed to estimate the nearest prime proportions, after inspection of those per cent.

40. Chemists differ with regard to their equivalent numbers. There are three systems at present used in England ; 1st, That having oxygen as the root ; 2nd, That having one volume of hydrogen as the root ; 3d That having two volumes of hydrogen as the root, on the hypothesis of Dalton, that two volumes of hydrogen contain the same number of atoms, as one volume of oxygen, but this supposition wants proof.

Since the volume of hydrogen is equal in weight to 1.6th the weight of the volume of oxygen, the two first systems are mutually convertible by multiplying the number for oxygen, in the oxygen ratio, by 16, or 4×4 to obtain the number in the hydrogen scale, and inversely, it may be re-converted, or by dividing by 16, or by 4×4.

41. Dr. Wollaston's scale, and Sir H. Davy's proportional numbers are adapted to the idea that water is a compound of 1 hydrogen × 7.5 oxygen by weight, or 15 × 1 by volume. Their mutual conversion is therefore very easy, for by adding to Dr. Wollaston's number its half, the sum is Sir H. Davy's; consequently, if we subtract from the number of the latter, its third, the remainder is Dr. Wollaston's number.

PRACTICAL QUESTIONS.

What is called the atomic theory?

What has this theory done for chemistry?

What was Sir I. Newton's opinion of atoms?

How is divisibilty thought to be limited?

When, and by whom was the atomic theory first promulgated?

Have the French chemists adapted the atomic theory?

What did Dr. Wollaston introduce into chemistry?

What does he assume as a standard?

What two important propositions have been adduced?

From what was the first of these laws inferred?

How do you illustrate this?

What conclusions did Richter draw?

Illustrate it.

How long was Richter occupied in verifying this law?

Do the chemical constituents ever unite in different proportions?

Illustrate it.

How are bodies supposed to be composed by this law?

What follows from this?

What is formed when bodies unite in a gaseous state. according to their volume.

Illustrate it.

If this hypothesis and data be correct, what follows?

If hydrogen be taken as unity what follows?

Illustrate this by atmospheric air.

Are there any substances whose specific gravities do not correspond with the weights of their atoms?

What must we suppose when the specific quantity is double the weight of the atoms, as that of oxygen?

When does it appear that oxygen puts on this single state?

What instance have we of a compound gaseous body becoming of double the specific gravity?

What is the quantity of acid which the different metallic oxides require for saturation according to M. Gay Lussac?

Illustrate this by experiment.

What has M. Gay Lussac shewn with regard to the same metal?

What does Berzelius assume as the unit of proportion?

Has Dr. Wollaston's scale been of any advantage to chemistry?

How did Dr. Wollaston proceed?

Give a description of this scale.

Illustrate the utility of the scale by an example.

What does the scale shew with regard to distillation?

In what manner do you proceed when you wish to reduce analytical results to equivalent prime ratios?

What is the complex problem of Vauquelin?

And what rule is given for its solution?

How would you proceed on Dr. Wollaston's scale?

Suppose the weight of the compound prime is not given, how would you proceed?

Have all chemists adapted the same equivalent numbers?

How will you adapt the same scale to the two first systems?

To what idea is Dr. Wollaston's scale and Sir H. Davy's proportional numbers adapted?

CHAP. IV.

Of Light.—Caloric.

1. We know little of light but by its effects. It is considered by most philosophers as a material substance, immediately emanating from the sun and from all luminous bodies, with inconceivable velocity, in right lines, in all directions.

2. Some have considered light as vibrations propagated through an elastic medium which is diffused through all space, and in which luminous bodies have the power of exciting those vibrations, in the same manner that sonorous ones produce vibratory motions in the air.

3. It best comports with our ideas of its effects, to suppose light composed of certain particles of matter.

4. "On the supposition that it be matter, its particles must be inconceivably minute, and endowed with mutual and highly repulsive energies."

5. The velocity of light is equal to 195,000 miles in a second of time.

6. A ray of light projected from the sun is about eight minutes in passing from that luminary across the semidiameter of the earth's orbit, or a space equal to 95,000,000 of miles.

Observation. The fixed stars are at least 400,000 times farther from us than the sun; and it has been calculated that a ray of light emitted from one of those luminaries, would be nearly six years in reaching us, so that if one of those stars were struck out of existence at this moment, we should still continue to see it for that space of time to come.

7. The momentum of the particles of light are unappreciable, for if they amounted to $\frac{1}{1000}$ of a grain, the force which they must necessarily acquire in moving through so vast a space, would be superior to that of a ball, discharged from a musket with a velocity equal to 1700 feet in a second of time, and sufficient to reduce to powder any obstacle upon which they impinged.

8. It has been calculated that the momentum of light is equal to that of a ball of iron, one quarter of an inch in diameter, moving at the rate of one inch in many millions of millions of Egyptian years !

9. Such must be the minuteness of the particles, that if, according to Mr. Bowditch, they were placed in a row so as to form a line one inch in length, and a person at the creation had commenced counting them, at the rate of 120 in a minute, he would have enumerated at the present time a sufficient number to have constituted only a 300,000th part of an inch !

9. Light is not homogeneous, it is composed of different coloured rays, possessing different refrangibility.—The prismatic colours have been divided into seven, viz. red, orange, yellow, green, blue, indigo and violet. Red is the least, and violet the most refrangible.

10. The rays of light must be extremely rare, for they cross each other in all possible directions, without the least apparent disturbance.

Illustration. A variety of objects may be seen at the same time through a small pin hole in a piece of paper. Now the light, proceeding from these objects, must pass at the same instant through the hole in a great variety of directions, before they arrive at the eye ; yet the vision is not in the least disturbed by it.

11. The rays differ from each other in their illuminating power. Dr. Herschel found that the most intense light existed in the middle of the spectrum of green ray, and diminished towards each extremity.

12. The violet rays possess the power of imparting the magnetic property to steel.

Exp. Intercept all the rays except the violet, and having collected them into a focus by a lens, throw it on a needle, and carry it towards the extremity. This is to be repeated several times, and always towards the same extremity ; after some time the needle acquires polarity.

13. Light is considered as constituting an important part of all inflammable substances. In every instance of combustion, light is disengaged, and is thought to depend on the combustible body.

Illustration. Examples have been adduced to prove that light depends on the combustible body. The colour of the light emitted is peculiar to the body burned, this would scarcely happen unless the light depended on it ; as the oxide of copper exhibits a green light ; indigogene, a blue ; hydrogen, a greenish blue ; sulphur, a pale blue ; phosphorous, a white, &c.

14. Bodies which possess the property of emitting light, either spontaneously or by combustion, so as not to decompose them, are called *phosphorescent.*

Illustration. Many chemical compounds possess this property in an eminent degree. In some cases it is excited by heat, or by the solar ray ; in others, spontaneously, as in dead animals and vegetable substances : in the latter, it probably owes this property to incipient decomposition.

Exp. Put half an ounce of herring or mackerel into a phial capable of holding four ounces, with two ounces of water, holding in solution half a drachm of common salt; place the phial in a dark place, and in two or three days, a ring of light will appear on the surface of the liquid, and by agitation, the whole liquid becomes luminous, and continues in that state for some time. A moderate heat increases the luminous quality, but a boiling one destroys it.

15. The light emitted from animal and vegetable substances in a state of decomposition produces no effect on the most delicate thermometer; hence, it is inferred, that light constitutes a component part of these substances, and that it is the first which is extricated, when the substance containing it, is beginning to be decomposed; or when the putrefactive fermentation commences.

16. Some living animals possess the phosphorescent power in different parts of their bodies.

Illustration. The glow worm and fire fly.

17. The chemical agency of light is very striking in many of its effects. The beauty of colour and fragrance of vegetables, appear to depend on it entirely; and it has even an influence on their health and vigour.

Illustration 1. If light be excluded from a growing vegetable for any length of time, it shoots out rapidly at first, seeming in quest of its great supporter; but if denied it, it turns pale, sickens and dies.

2. It is a well known fact, that plants kept in pots in houses, will, in a short time, turn their heads to that quarter whence the light proceeds; if they are turned round, or their position be changed, they will immediately begin to return to their former situation; and if the light

proceed only from above, they will shoot up perpendicularly.

18. Plants which grow in the shade, lose in a great measure their inflammable power; hence, light seems necessary to the very existence of combustible bodies.

19. Light appears to have an influence on the colour of animals, as well as vegetables.

Illustration. That part of fish which is exposed to the action of the sun's rays, becomes black, or of a dark colour, while the lower part is white. The plumage of birds is much more beautiful and variegated, in those parts of the world where the sun's rays are the most powerful. Thus birds possessing the most variegated and vivid colours, are found within the tropics. The hair of animals, living in high latitudes, turns white during winter.

20. The solar rays have been divided into three different kinds. 1. Colorific, or those producing colour.—2. Calorific, or the those producing heat. 3. Deoxydizing, expelling oxygen, and restoring the oxides of metals to their metalic state.

21. The intensity of the calorific rays increases as their refrangibility decreases. The deoxydizing increase with their refrangibility.

22. Almost all bodies have the property of absorbing the rays of light, but only a few emit it again. They do not, however, absorb all rays indiscriminately; some absorb one coloured ray; others, another, while they reflect the rest; which is the cause of the different colours of bodies. What is called a green body, depends for its colour on the reflection of the green rays of light; red bodies reflect the red rays, while they absorb the others, and so of the rest. Hence the inference, that the different colours of bodies depend upon the affinity

of each for some particular ray, and its want of affinity for the others.

23. The different sources from which light is emitted in a visible form, are 1. The sun and fixed stars. 2. *Combustion*, which is the act of combination of the combustible with oxygen ; of course, the light emitted must have existed previously combined with the combustible or with oxygen. 3. Heat, when the body becomes luminous by being heated in the fire, it is said to be *red hot ;* and it is found that all bodies that are capable of enduring the requisite degree of heat, without decomposition or volatilization, begin to emit light at the same temperature.

Illustration. Iron is just visible in the dark : when heated to 635° of Farenheit; it shines strongly in the dark, at 752° ; it is luminous in the twilight, just after sunset, when heated to 884° ; and it shines even in broad day light, if its temperature be about 1000°.

24. *Percussion*, or the striking together of two bodies, is another source of light.

Illustration. When flint and steel are struck together, light is produced, which is capable of inflaming tinder, gunpowder, &c. The spark is a small particle of the iron, which takes fire during its passage through the air. This is an instance of combustion. But light is emitted when two quartz stones are smartly struck against each other, though the substances are clearly incombustible.

OF CALORIC.

25. What is denominated heat is a sensation produced by a substance called caloric, which penetrates all bodies, diminishes the attraction of their several parts, and uniformly expands their dimensions.

26. By means of this powerful agent, solid metals are

fused; liquids rarified; and almost all substances in nature are converted into elastic, compressible, or aeriform fluids.

Observation. It has been asserted by Lavoisier, that all bodies of whatever kind, may exist in three different states, solid, fluid and aeriform.

27. Caloric is found to exist under a variety of forms or modifications. It is said to be *Free or radiant*, and is commonly called *heat* or temperature; it is that heat which is perceptible to our senses, and effects the thermometer, whatever may be its degree, or the source whence it is derived.

28. Combined caloric is that which does not effect the thermometer, and is not perceptible by our senses; it is retained in bodies by the force of affinity or attraction, and becomes a part of their substance.

29. Heat differs from caloric in this; one is the cause, the other, the effect. The latter means that which produces heat; while the former is merely the sensation.

30. Liquids are combinations of solids with a larger portion of caloric than they naturally contain.

Illustration. " Though caloric be the cause of liquidity and the gaseous state, still bodies in a concrete form contain much of this matter combined. This is known by such processes as lower the temperature of different bodies. So long as any substance can be cooled, so long it has the power of parting with heat; and we have yet to learn the point at which we could assert that it has parted with all it contains."

31. When caloric is added to water, it becomes vapour; and when abstracted from it, it becomes ice.

Illustration. In the case of vapour, the caloric forces itself between the particles of the water, and causes them to separate at such a distance, that the force of aggregation is destroyed.

32. Bodies which exhibit properties arising from increase or diminution of caloric, are said to be of certain temperature.

33. No substance has had its temperature reduced to 0, in the scale of heat; hence it may be inferred, that the particles of solid bodies are never in actual contract.

34. Instruments for measuring the relative degrees of heat, are called Pyrometers and Thermometers, with suitable scales attached, indicating the degrees.

35. The states in which bodies exist, admit of different degrees of density or consistence, arising for the most part, from the different degrees of caloric which they contain. Solids are of different degrees of density from that of gold to that of jelly. Liquids from the consistence of melted glue, or melted metals to that of ether. The different elastic fluids are susceptible of different degrees of density.

36. Bodies admit of different degrees of consistence without changing their state, merely by the agency of caloric.

Illustration 1. The expansion of solids is exhibited by the Pyrometer, which, in principle, is a bar of iron made to fit exactly when cold between two points, and the diameter such as barely to allow it to pass through an iron ring; when heated, it will become sensibly longer, and it will then be found incapable of passing through the ring.

2. Copper is more expansible than iron; and iron than platinum.

37. Fluids are much more susceptible of dilatation than solids.

Illustration. This fact is shewn by the expansion and contraction of mercury or spirit in a thermometer, or by immersing in water a glass ball with a long neck, and filled to a certain point with any coloured fluid.

38. The degree of expansion produced in different liquids, varies considerably.

Illustration. Water is more expansible than mercury, and alcohol than water.

Exp. 1. Provide two glass tubes, terminated at one end with large bulbs; fill the bulbs, the one with alcohol, the other with water, and let the liquids be coloured, in order the better to observe the effect. Hold the bulbs in each hand, for a few moments, you will find the alcohol dilates with the warmth of the hand, while the water remains stationary.

2. Plunge the bulbs into a vessel containing hot water, and you see both liquids rise in the tubes, though the alcohol rises much higher than the water, which shews that the former is much more susceptible of dilatation.

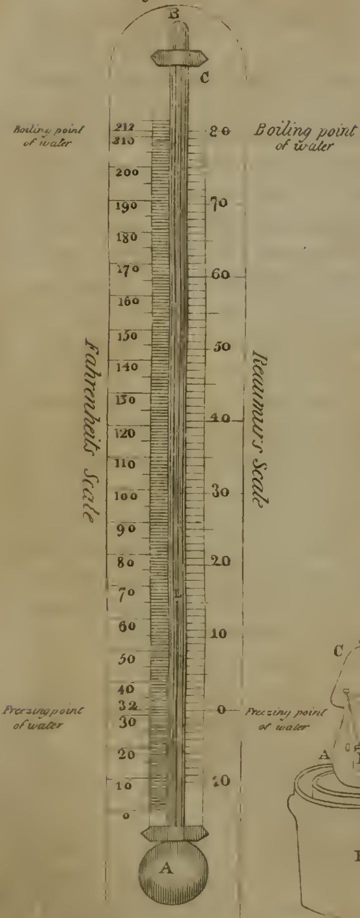
Observation. Thermometers are constructed on the same principle.

39. A thermometer consists of a tube with a bulb.—Plate 2, fig. 3 A. the glass bulb. B. the tube. C. the scale attached to the tube. D. the liquid in the tube.—The degree which indicates the boiling point, simply means, that when the fluid is sufficiently dilated to rise to this point, the heat is such, that water exposed to the same temperature will boil; which, as the scale called Farenheit's, is at 212°. When the fluid is so much condensed as to sink to the freezing point, it indicates that water begins to freeze when exposed to that temperature.

40. Thermometers are constructed in the following manner. A glass tube of a capillary bore is procured, having a small bulb at one end, which, together with

THERMOMETER

Fig. 3



Differential Thermometer.

Fig. 4.

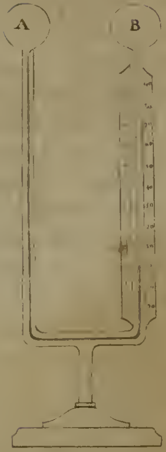
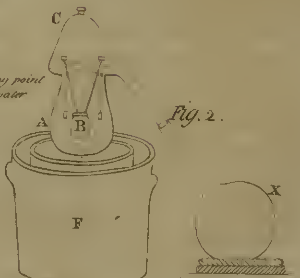


Fig. 1.

Fig. 2.



part of the tube, is filled with purified mercury, which when introduced into the tube is boiled to expel the air or moisture that might be attached to it, and at the moment it is in ebullition, the extremity of the tube, being drawn to a point by means of a blow pipe, is hermetically sealed, to prevent any air from entering the tube. Or if the scale is to be graduated only to 212°, the ball is plunged into boiling water, and the point to which the mercury ascends accurately marked. For the purpose of graduating the scale, the thermometer is plunged into melting ice, and the place where the mercury stands marked. From the freezing to the boiling point on Farenheit's scale, is 180°, or equal parts ; and similar parts are taken above and below, for extending the scale.

Observation. Farenheit's thermometer is the one commonly used in this country and Great Britain. The space between the freezing and boiling points is divided into 180° ; but the scale begins at that point of temperature which is produced by a mixture of pounded ice and muriate of ammonia, or muriate of soda, which is 32° lower, making the whole distance 212°.

41. The centigrade thermometer is divided into one hundred degrees, between the freezing and boiling points. The freezing point is marked 0, and the boiling 100°.

42. In Reaumur's thermometer, the space between the freezing and boiling points is divided into eighty degrees. The freezing point is marked 0, the boiling 80°.

43. The Russian thermometer commonly called De Lisle's, begins its graduation at the boiling point and increases towards the freezing. The boiling point is marked 0, the freezing 150.

Other fluids besides mercury, are sometimes used, such as linseed oil and alcohol ; the latter is used particularly for measuring low degrees of temperature, where mercury would become solid.

For nice chemical experiments, an air thermometer is sometimes used. The bulb of air thermometers is filled with common air only, and its expansion or contraction is indicated by a small drop of any coloured liquor, which is suspended within the tube, and moves up and down according as the air within the bulb or tube expands and contracts.

Observation.—In general, air thermometers however sensible to the changes of temperature, are by no means accurate in their indications.

44. The air thermometer of Mr. Leslie, is of a peculiar construction; it is in the form of a double thermometer inverted, (Plate 2, fig. 4,) the tube is bent at right angles, placed on a stand, (C.) and has a large bulb at each end, (A. B.) filled with air, the liquor, which is sulphuric acid coloured, is confined to a portion of the tube, and indicates, by its motion, the comparitive dilatation or contraction of the air within the bulb which points out the relative temperature.

Exp. Heat the bulb (A) with the hand, the fluid will rise toward the bulb (B) and *vice versa.*

If both bulbs be placed in the same temperature, the coloured liquor suffers an equal pressure on each side, and no change is effected.

45. This thermometer cannot indicate the temperature of any particular body, or of the medium in which it is immersed. Its use is to point out the difference of temperature between the two bulbs, when placed under different circumstances. It has therefore obtained the name of "Differential thermometer."

46. When the temperature of a body is above the boiling point of mercury, it cannot be measured by a

common thermometer, because the mercury beginning to be volatilized, would burst the tube. Therefore, when any very high temperatures are to be measured, an instrument called a pyrometer is used for the purpose, that of Wedgwood's has been considered as the most convenient, it is made of a certain composition of baked clay, which has the peculiar property of contracting by heat, so that the degrees of contraction indicate the temperature to which it is exposed.

Observation.—In Wedgwood's pyrometer, the dimensions of a piece of clay are measured by a scale graduated on the side of a tapered groove, formed in a brass ruler; the more the clay is contracted by the heat, the farther it will descend into the narrow part of the groove.

47. All elastic fluids whatever undergo the same degree of expansion from equal augmentations of temperature.

48. Elastic fluids vary in density more than liquids or solids; the uniformity of their expansibility, may be easily accounted for, on the following principle. If the different susceptibilities of expansion of bodies arise from their various degrees of attraction of cohesion, no such difference can be expected in elastic fluids, since in them the attraction of cohesion does not exist, their particles, on the contrary, being possessed of an elastic or repulsive power; they will, therefore, all be expanded by equal degrees of caloric.

49. Uncombined caloric has a tendency to any equilibrium; any number of different bodies, at various degrees of temperature, if placed under similar circumstances of exposure, acquire a common temperature.

Illustration—If there be placed in an atmosphere of

55°, iron filings made red hot, boiling water, and other substances of different degrees of temperature, they will all soon become of the same temperature, which may be indicated by the thermometer.

50. Cold is a negative quality, and implies the absence of heat.

Illustration.—Some bodies appear cold to the touch, as quicksilver, marble, &c. This consists in the loss of caloric, which that part of the body sustains which comes in contact with the cold body, in an attempt to bring the temperature to an equilibrium.

51. According to a late theory, caloric is composed of particles perfectly separate from each other, every one of which moves with great velocity in a certain direction. These directions vary infinitely, the result of which is, that there are rays or lines of these particles, moving with immense velocity, in every possible direction. Caloric then is universally diffused, so that when any portion of space happens to be in the neighbourhood of another, which contains more caloric, the colder portion receives a quantity of calorific rays from the latter sufficient to restore an equilibrium of temperature. This radiation not only takes place in free space, but extends also to bodies of every kind. Thus you may suppose that every body whatever, is continually sending forth rays, when the body is surrounded with an elastic medium, or in a vacuum.

52. These rays are capable of reflection and refraction.

Observation. It is well known that the concentration of the solar beams, by means of a concave mirror, is capable of producing an intense heat.

53. Rays capable of producing heat with or without light, proceed from substances on the surface of the globe,

as well as from the sun, under peculiar existing circumstances.

Exp. 1. The effect is observed by placing two concave mirrors one above the other, between which are an ignited body and the thermometer.

Exp. 2. Place the concave mirrors opposite each other, with the edges of their faces perpendicular to the surface of the earth,and place an iron bullet about two inches in diameter, heated to a degree not sufficient to render it luminous, in the focus of one of the mirrors, in the focus of the second mirror, place one of the bulbs of the differential thermometer, the rays which fall on the first mirror, are reflected in a parallel direction so as to fall on the other mirror, which may be placed at the distance of about ten feet, thence they converge to a focus, and affect very sensibly the thermometer.

Exp. 3. Remove the thermometer and place instead of it a wax candle with a small piece of phosphorus in the wick, and after heating the ball, place it in its former place, the candle is immediately lighted.

Exp. 4. Substitute a wax taper instead of the bullet, with a view to separate the light from the caloric; for this purpose interpose a transparent plate of glass between the mirrors, for light passes with great facility through glass, whilst the transmission of caloric is almost wholly impeded by it. But in this experiment, some few of the calorific rays, together with the light, pass through the glass as the thermometer rises a little, but as soon as the glass is removed, it will rise considerably higher.

54. In cases where no light is emitted from a hot body, the effect of the radiation of caloric by the mirrors may still be produced.

Exp. Let a vessel of boiling water be placed in the focus of the upper mirror; place a thermometer in the focus of the lower one, a considerable increase of temperature will be indicated.

55. The manner in which bodies are affected by rays producing heat, differ in different substances, and is very much connected with their colours.

56. Bodies that absorb the most light and of course radiate heat, are heated the most when exposed to the solar or terrestrial rays.

Illustration 1. Black bodies in general are more heated than red, red more than green, green more than yellow, yellow more than white.

2. Metals are less heated than earthy or stony matters, or than animal or vegetable matters. Polished and bright surfaces are less heated than rough ones.

57. Bodies that have their temperature most easily raised by the action of rays producing heat, are those most easily cooled by their radiation, or at the same temperature emit the most caloric.

58. Metals radiate less heat than glass, glass less than some vegetable substances, and charcoal possesses the highest radiating power of any substance hitherto submitted to experiment.

Observation. Mr. Leslie has made a variety of experiments on the radiating powers of different substances: he found by assuming 100 for the radiating power of lamp black, the following substances radiated in proportion, viz.:

Sealing Wax,	95
Crown Glass,	90
China Ink,	88
Minium,	80
Isinglass,	80
Plumbago,	75

Tarnished Lead,	45
Polished Iron,	15
Tin Plate, Gold, Silver and copper,	12

59. Vessels that are intended to contain much heat, should be well polished and bright. Steam or air pipes intended for warming rooms, should be polished in those parts where the heat is not intended to be communicated, and covered with some radiating substance, such as lamp black or plumbago, in those rooms intended to be heated. Vessels for the kitchen should be blackened and not polished in those parts intended to receive heat. The heated surfaces of stoves and fire places should not be metallic, but of stony or earthy materials; in this way much more heat may be communicated by radiation.

60. The following principles are deduced from the observations of Mr. Leslie.

1. The quantity of heat which radiates from any body, depends in a great part on the surface of the body. If the body be covered with black paint, paper, &c. it will radiate eight times as much heat as if the surface were metallic.

2. If the bulb of a thermometer be covered with tin foil, the impression of radiant heat upon it is only 1-5 of what it would be on the glass-surface of the thermometer.

3. A metallic mirror reflects ten times as much heat from an ordinary fire, or from any heated body, as a similar glass mirror does, the last reflects the heat from the anterior surface and not from the silvered one. This circumstance exhibits the difference between solar and culinary heat. From these facts it seems that metals are eminently disposed *to reflect* radiant heat, and of course not to absorb it, whereas black paint, paper, glass, &c. are *disposed to absorb* and not to reflect it; but when the

temperature is increased, they are eminently disposed to radiate heat.

4. Screens of glass being interposed between the radiating body and reflector, completely interrupt the radiant heat; but when heated by the direct radiant heat, the thermometer will be affected by their radiation, The heat radiated from hot water does not seem capable of being transmitted through glass like the solar heat.

5. Radiant heat suffers no sensible loss in its passage through the air, a greater or less radiant body produces the same effect, provided it subtends the same angle, at the reflector, agreeing with light in this respect.

6. The intensity of reflected heat diminishes inversely as the distance, that is, the density of heat reflected from a concave mirror in any point of the focus, is inversely as the distance of the hot body from the mirror, whereas in regard to light, the density is known to be uniformly the same, or subject to no change on account of distance. The focus of heat differs from that of light, being nearer the reflector. The heating effect diminishes rapidly in going out, but slowly inwards towards the reflector.

7. The quantity of heat which a strong radiating surface throws off, is somewhat more than that which is carried off by the atmosphere. This however is contradicted by some.

PRACTICAL QUESTIONS.

What is light?

How have some considered light?

What best comports with our ideas of it?

What follows on the supposition of its being matter?

What is its velocity?

How long is it in passing a semi-diameter of the earth's orbit?

What are the momenta of the particles of light?

What calculations have been made with regard to the momenta?

What with regard to the minuteness of the particles?

Is light homogeneous?

What is the rarity of the rays of light?

Illustrate this.

Do the rays differ from each other in their illuminating power?

Does it have any effect on inflammable substances?

Give an illustration.

What are *phosphorescent bodies?*

Give an illustration.

How will you prove it?

What is the light emitted from animal and vegetable substances in a state of decomposition?

Do any living animals possess this property?

What is the chemical agency of light?

Give an illustration.

What effect does the shade have on plants?

Has light any influence on the colour of animals?

Illustrate it.

How have the solar rays been divided?

What is their intensity?

What effect have almost all bodies on the rays?

What are the sources of light?

Give an illustration.

Give an illustration of percussion.

What is denominated heat?

What is effected by this powerful agent?

What are the states in which caloric exists?

What is combined caloric?

How does heat differ from caloric?

Give an illustration.

What effect has it on water ?

Illustrate it.

What is called temperature ?

How do you infer that the particles of solid bodies are not in contact ?

What instruments have been invented for measuring the degrees of heat ?

What do the states in which bodies exist admit of ?

How can bodies be of different degrees of consistence, without changing their state ?

Give an illustration.

How do you prove that fluids are more susceptible of dilatation than solids ?

Is the degree of expansion the same in different liquids ?

Illustrate this by experiment.

What does the boiling point mean in a thermometer ?

How are thermometers constructed ?

How is the centigrade thermometer divided ?

How is Reaumur's ? How the Russian ?

What fluids have been used for thermometers ?

Describe air thermometers.

Describe Mr. Leslie's air thermometer ?

Why is it called a differential thermometer ?

Will mercury answer for all temperatures ?

Describe Wedgwood's pyrometer.

In equal augmentation of temperature, what do elastic fluids undergo ?

How do you account for the uniformity of their expansibility ?

What tendency has uncombined caloric ?

Illustrate this.

What is cold ?

Give an illustration.

What is the theory of radiation ?

Of what are these rays capable ?

Whence do rays, capable of producing heat with or without light, proceed ?

Illustrate this by experiments.

What is the effect in cases where no light is emitted from a hot body ?

Illustrate this by experiment.

What is the manner in which bodies are affected by rays producing heat ?

When are bodies which absorb the most light, heated the most ?

Give an illustration.

What bodies are most easily cooled by their radiation ?

What is the degree of radiation of different substances ?

What is the radiating power of different substances ?

How should vessels be made that are designed to contain much heat ?

What are the observations deduced from Mr. Leslie's experiments ?

CHAP. IV.

Continuation of Caloric.

1. All bodies are, in a greater or less degree, conductors of caloric.

2. Bodies with respect to caloric are divided into two kinds, good and bad conductors.

Illustration 1. Metals and liquids are good conductors of caloric, but silk, cotton, wool, wood, feathers, down, &c. are bad conductors.

2. A short poker or other piece of iron put into the fire at one end, will very soon become hot at the other; but a piece of wood or cane of the same length, placed in precisely the same circumstances, may be burnt to ashes at one end, without producing scarcely a sensation of warmth at the other.

3. The facility with which bodies are cooled or heated, is in proportion to their conducting power.

Illustration. A silken purse containing money, when held to the fire, scarcely becomes warm, while the money becomes so hot as hardly to be touched, without burning the hand.

4. Brittle bodies are in general bad conductors of heat; hence the surface to which heat is suddenly applied by inordinate expansion, produces fracture.

Observation. On this account, vessels made of glass and used over lamps, or exposed in any way to the naked fire, should be as thin as possible, provided they be of sufficient strength to bear their contents.

5. Solid bodies transmit caloric in all directions.

Exp. Provide an iron or any other metallic substance, having bars or radii, proceeding from a centre, heat this centre, and you will find that the radii are equally heated.

6. Some bodies conduct caloric more rapidly than others, and this conducting power is not fully accounted for. It has been conjectured that a certain union takes place between the caloric and the particles of the body through which it passes. If this union be strong, the body retains the heat, and parts with it slowly; if slight, it parts with it rapidly. The conducting power of a body is, therefore, inversely as its tendency to unite with caloric.

Exp. 1. Coat rods of iron and glass, of equal length, with wax at one end, and expose the other ends to the same temperature, the wax will melt much sooner at the end of the iron than the glass, which shews that iron conducts heat more rapidly than glass.

Exp. 2. Take rods of different metals and other substances, and place them in the same circumstances as in the above experiment, or place them in a tin vessel filled with oil, and provided with holes to receive the uncoated ends; apply a lamp under the vessel and as the liquid begins to heat, and consequently the rods, you will find that they all possess different conducting powers, the wax beginning to melt at different periods.

7. Good conductors both give and receive caloric quicker, and in a given time more abundantly, than bad conductors, which is the cause of their feeling hotter or colder; though they may be in fact of the same temperature, as indicated by the thermometer.

Illustration 1. Different substances in the same room, at equal distances from the fire, are of the same temperature; a mahogany table will feel much colder to the hand, than a woollen carpet, but as the table is the best conductor of caloric, it will absorb the heat from the hand more rapidly, and of course feel much colder than the carpet, which is a very bad conductor.

2. If the table and carpet were heated an equal number of degrees above the temperature of the body, the table would feel the hottest; for as it took the heat more rapidly in the first instance from the hand, it will now impart it more rapidly to it. Because a body which is a good conductor of caloric affords it a free passage, so that it penetrates through that body more rapidly than through one which is a bad conductor, consequently, if it be colder than the hand, there is more caloric lost, and

if it be hotter, more is gained by the hand, than with a bad conducter of the same temperature.

8. If different conductors be heated to the temperature of the body, they will all feel equally warm, because the exchange of caloric between bodies of the same temperature is equal.

9. Flannel clothing is warmer in winter than linen, because flannel being a bad conductor keeps in the heat; and when the atmosphere is of a higher temperature than our bodies, it would be equally efficacious in keeping their temperature at the same degree, as it would prevent the free access of external heat by the difficulty with which it conducts it.

Illustration. On the above principle it is that ice may be kept in warm weather longer wrapped up in woollen cloths, than in linen.

10. In general, the most dense bodies are the best conductors of heat; probably, because the denser the body, the more the number of points that come in contact with caloric.

Illustration. At the common temperature of the atmosphere, a piece of polished metal will feel much colder than wood; and wood than a piece of woollen cloth; this, than flannel, and flannel than *cider down*, which is one of the worst conductors of caloric known.

11. Air is a bad conductor of caloric, hence porous bodies being filled with air, become bad conductors.

12. The conducting power of fluids of different densities varies, hence the reason why water feels much colder than spirits.

Illustration. Mercury to the touch feels remarkably cold, but when a thermometer is applied to it, it is found to be of the same temperature as the surrounding atmosphere.

13. Fluids have the power of transporting caloric, in consequence of which, they acquire heat much more rapidly than solids, independent of any conducting power.

14. Fluids necessarily contain more latent or combined heat than solids, but as the capacity of bodies for caloric is increased, their conducting power seems to be diminished, as in the case of liquids and gases, which appear to be such bad conductors of heat, that Count Rumford supposed this power was only communicated by the interchange of heated particles.

Exp. 1. Hot water on the surface of cold water in a tube, will remain long at the same temperature, but when disposed at the bottom, the whole becomes heated.

2. Place a flask of cold water over the flame of a lamp, the heat expands and renders the water of less specific gravity, at the bottom of the vessel, which portion of water ascends to the top, while another of equal volume being colder and consequently heavier, bulk for bulk, falls to the bottom, and in this way there is a constant circulation from the bottom to the upper part of the vessel hence the theory of ebullition.

3. Place a quantity of ice on the surface of a vessel of hot water, it becomes very soon melted ; but when placed at the bottom, it requires eighty times as long to fuse it.

15. Freezing is a disengagement of that portion of caloric which is necessary to keep a substance in the state of liquidity.

16. The quantity of caloric disengaged during the congelation of any substance is extremely slow.

17. The constant emission of caloric from the freezing substance, operates favourably, for in this way the severity of the frost is mitigated, and its progress retarded.

Observation 1. On this principle it is, that it often feels warmer after a great fall of snow.

2. On the other hand, if the return of caloric to the frozen body of water were not equally slow, sudden inconveniences would be occasioned in those countries where large masses of ice were collected, at the approach of summer.

18. Deep lakes do not freeze in winter.

Illustration 1. This is owing to the circumstance of cold air being constantly presented to the surface of the lake, which causes a portion of water to lose its temperature, and thus becoming heavier, falls gradually to the bottom, while the warmer water from below ascends, forming a new surface in its place.

2. The temperature of the whole bulk of water in a deep lake is lowered, but only the surface descends to the freezing point. The diminution of heat produces a contraction in liquids as well as solids. This effect, however, does not take place in water below 40 degrees, which is 8 degrees above the freezing point. At that temperature, the internal motion occasioned by the increased specific gravity of the condensed particles ceases; for when the water at the surface no longer condenses, it will not descend, of course, a fresh portion will not be exposed to the atmosphere; the surface alone will be further exposed to the severity, and will soon be brought down to the freezing point, when it becomes ice, which being a bad conductor of heat, preserves the water for a long time from being further affected by the external cold.

19. Water swells on being frozen, in consequence of the extrication of a portion of air which it held in solution, and which is disengaged in freezing. This air forms those numerous cavities which are found in ice;

and from the frozen particles receiving a different arrangement and requiring more room.

20. Water in freezing, crystallizes in angles of 60° and 120°.

Illustration. On this principle trees and rocks are split. A spherule of water,one inch in diameter, expands on freezing, with a force equal to thirteen and a half tons weight.

Exp. Fill a phial with water, cork it and secure the cork with a pack thread ; on freezing, the phial is broken.

21. The chemical effects of caloric in melting or fusing metals, earths, and other solid bodies, are equally striking with its effects in expanding or heating fluids.

22. No substance can be expanded beyond a certain limit, during which time its specific gravity diminishes, and its temperature increases.

Exp. Expose ice and ice cold water to the same degree of heat, the ice will not become hotter, but the water will. When, however, the ice is entirely melted, it will increase in its temperature with the water.

23. In bodies which expand, there is a regular increase and contraction of bulk, according to the degree of heat.

24. All solids which are not decomposed by caloric alone, fuse at a determinate point, which point is termed their melting point. No two substances fuse at the same temperature.

25. All bodies require a certain temperature for their liquidity. Many are solid at that of the atmosphere.

Illustration. Solids when fused by an excess of heat, gradually concrete on being exposed to the ordinary atmosphere.

26. Some bodies, such as earths, stones, &c. melt into masses like glass, this is called *vitrification*. But reducing metals from a solid to a fluid, is called *fusion*.

27. Caloric dissolves water and converts it into vapour or steam, by insinuating itself between the particles which are so minutely divided as to become invisible.

Illustration. When vapour of boiling water first issues from the vessel, it is invisible, because it is then completely dissolved by caloric. But when it comes in contact with the cold air, it is condensed, in consequence of a part of the caloric being imparted to the air. The particles of caloric being in a great measure deprived of their solvent, gradually collect, and become visible in the form of steam, and when further deprived of caloric return to their liquid state.

28. The atmosphere dissolves water by means of the caloric which it contains. This is called *evaporation*, and differs from *vaporization*, which is caused by culinary heat.

29. The point at which a fluid is converted into vapour depends upon a certain degree of temperature, called the boiling point; the boiling point of water on Fahrenheit's scale is at 212°, and the freezing at 32°.

30. The tendency of free caloric to an equilibrium, together with its solvent powers, are connected with the phenomena of rain, dew, &c.

31. Dew is a deposition of watery particles, or minute drops from the atmosphere, precipitated by the coolness of the evening.

Illustration 1. Dr. Wells has shewn by a series of ingenious experiments, that the deposition of dew is owing to the cooling of the surface of the earth, which he has proved, takes place previously to the cooling of the atmosphere; on examining the temperature of a plot of grass just before the dew fell, he found that it was considerably colder than the air a few feet above it, from which the dew was afterwards precipitated.

2. The earth being a great radiator of caloric, parts with its heat more readily than the air. When the solar heat declines and entirely ceases in the evening, the earth rapidly cools by radiating heat towards the skies; whilst the air has no means of parting with its heat, but by coming in contact with the cool surface of the earth, to which it communicates its caloric. The solvent power being thus reduced, the water is deposited in small drops called dew.

32. Some liquids contain so great a quantity of caloric that they may be rapidly converted into vapour without any increase of temperature, by removing the pressure of the atmosphere. It is that alone which keeps them in a liquid state; for the caloric they contain is sufficient to overcome the attraction of cohesion.

Exp. 1. Pour a little sulphuric ether into a cup, and place it under the receiver of an air pump, together with a small thermometer, and on exhausting the air, the ether has the appearance of boiling, and the thermometer descends.

2.. Take two watch glasses, and having placed one over the other with a few drops of water between them; fill the uppermost glass with ether, and place them in the room of the cup as in the above experiment; work the pump for two or three minutes, and a thin layer of ice will be found between the glasses. The water freezes in consequence of yielding its caloric to the ether.

33. In order that a liquid may boil, there are two forces to be overcome; the attraction of aggregation, and the weight of the atmosphere.

Illustration. On high mountains much less heat is necessary to cause liquids to boil, than at the bases, where the pressure of the atmosphere is less.

Exp. Take a Florence flask about half full of water, and when in the act of boiling take it from the fire, wrap a cold wet linen cloth round the upper part of it, or cork it, plunge it into cold water, and it will immediately begin to boil.

Illustration. The upper part of the flask being filled with vapour, this was condensed by its caloric being compelled to unite with that of the water, of course a vacuum being produced, it boiled in a much lower temperature.

34. If water can be prevented from going off by steam, it will acquire a degree of heat equal to that of metals when red hot.

Illustration. A vessel used for this purpose is called Papin's digester, and is a copper vessel half filled with water. The vessel is furnished with a safety valve, loaded with weights. When the water is so hot as to send off vapour, its escape is prevented until it has acquired force almost great enough to burst the vessel, when it raises the valve, which prevents it. Lead and tin have been fused in the water of this vessel, and bones have been totally dissolved.

35. Water does not become hotter by being boiled long in the common way; after arriving at the boiling point, the heat gradually converts a portion of the water into vapour, and the additional heat applied, goes off with the vapour.

36. Ignition is that emission of light which is produced in bodies at a very high temperature, and which is the effect of accumulated caloric.

37. Ignition is independent of combustion. When a body burns, the light emitted is the effect of caloric alone, and no other change but that of temperature is produced in the ignited body.

Illustration. All solid bodies and liquids are susceptible of ignition, or of being heated so as to become luminous.

PRACTICAL QUESTIONS.

What bodies are conductors of caloric ?

How are bodies divided with respect to caloric ?

Give an illustration.

What is the facility with which bodies are cooled or heated ?

Illustrate this.

How do solid bodies transmit caloric ?

What is the conducting power of some bodies ?

Illustrate this by an experiment.

What is the cause of good conductors of caloric feeling hotter or colder ?

Illustrate this.

Why is flannel clothing warmer in winter than linen ?

What bodies are the best conductors of heat, and why ?

Illustrate this.

Why are porous bodies bad conductors ?

Is the conducting power of all fluids the same ?

Illustrate this.

Why do fluids acquire heat quicker than solids ?

Illustrate this.

What experiments can you shew to prove the truth of the proposition ?

What is freezing ?

What effect does the constant emission of caloric, from the freezing body, have ?

Why is it that deep lakes do not freeze in winter?

Why does water swell on being frozen?

How does water crystallize in freezing?

Illustrate this.

How are the chemical effects of caloric?

How far can substances be expanded?

How is the increase and contraction of bulk in bodies, that expand?

What do bodies require for their liquidity?

How is water converted into vapour or steam?

Illustrate this.

How does the atmosphere dissolve water?

Upon what does the conversion of a fluid into vapour depend?

With what is the tendency of caloric to an equilibrium attended?

What is dew?

Explain this on Dr. Wells' theory?

How can liquids that contain a large portion of caloric be converted into vapour?

What is neccessary in order to a liquid's boiling?

Illustrate this.

What will be the effect, if boiling water be prevented from going off in steam?

Illustrate this.

Can water be made hotter by being continued boiling?

What is ignition?

How does ignition differ from combustion?

CHAP. V.

Of combined Caloric—Specific and Latent Heat.

1. Bodies of a different nature, heated to the same temperature, do not contain the same quantity of caloric.

2. In order to raise the temperature of different bodies the same number of degrees, different quantities of caloric are required.

Illustration. If lead, chalk and milk of each equal weights be placed in a hot oven, or furnace, they will be gradually heated to the temperature of the oven; but the lead first, the chalk next, and the milk last. This is probably owing to the different capacities of bodies for caloric.

3. *Capacity for caloric* is a certain disposition of bodies to require more or less caloric for raising their temperature to a certain degree.

Illustration. The meaning is pretty nearly the same as when the term is applied to vessels; in these, the capacity is greatest in that which will contain most; so it is with regard to caloric. Thus iron has a less capacity for caloric than wood, and quicksilver has a less capacity for it than water; because it requires a smaller quantity of it to raise its temperature to a given degree on the thermometer.

4. The caloric that is employed in filling the capacity of a body is not free caloric, but is combined in the body, and is, therefore, imperceptible.

Illustration. If you lay your hand on a hot body, you feel only the caloric that leaves it and enters your hand. The thermometer in the same manner is affected only by the free caloric which a body transmits to it.

5. Specific caloric is the relative quantity of caloric which different species of bodies of the same weight and temperature are capable of containing; it is often called *heat of capacity.*

Illustration 1. In the case of the lead, chalk and milk, the two latter having a greater capacity for caloric than the lead, a greater proportion of that fluid became insensible in those bodies.

2. The difference could not proceed from the different *conducting* powers in those bodies, for if the different times they took in heating proceeded from their different conducting powers, they would each have acquired an equal quantity of caloric. This we shall shew is not the case.

Exp. Plunge the lead, chalk and milk, into three equal quantities of water, each of the same temperature, on examining the three vessels of water you find the one in which the lead was immersed to be least heated, and that which contained the milk to be most heated of all.

5. The thermometer indicates no specific heat of bodies, for it can only be affected by *free caloric* which raises the temperature of bodies.

Exp. 1. Mix two fluids of different temperatures, let the one be 50° and the other 100°. If the two bodies happen to have the same capacity for caloric, the temperature will be 75°.

2. Mix a pound of mercury at 50°, and a pound of water at 100°, the capacity of the two substances not being equal, the temperature of the mixture will be 80°, so that the water will have lost only 12 degrees, and the mercury will gain 38 degrees. Hence it may be inferred that the capacity of mercury for heat is less than that of water.

6. Latent heat is that portion of caloric which is employed in changing the state of bodies, or in converting solids into liquids, or liquids into vapour.

Observation. By most chemists it is used in the same sense as specific caloric.

7. When a body changes its state from a solid to a liquid, or from a liquid to a solid, its expansion occasions a sudden and considerable increase of capacity for heat, consequently it immediately absorbs a quantity of caloric, which becomes fixed in the body which it has transformed, and as it is perfectly concealed from our senses, it has obtained the name of *latent heat.*

8. The difference between specific and latent heat is this, the former is that which is employed in filling the capacity of a body for caloric in the state in which this body actually exists; latent heat is that which is employed only in effecting a change of state.

Exp. The mercury of a thermometer plunged into a vessel filled with pounded ice will immediately descend to 32° If then the vessel be immersed in boiling water, the mercury will not rise during the whole time that the ice is liquefying.

Illustration. The heat which is continually flowing into the ice does not affect the thermometer, because it is all employed in converting ice into water As the ice melts, the caloric becomes latent in the new formed liquid, therefore cannot raise its temperature, consequently the thermometer will remain stationary until the whole of the ice be melted. It will then begin to rise because the caloric no longer remains latent, but free.

9. The capacity of water for caloric is greater than that of ice, more heat is therefore required to raise a thermometer plunged into water than when placed in ice or snow.

Exp. Put some snow or pounded ice which has been cooled 7 or 8 degrees below the freezing point into a glass vessel, in which there is a thermometer ; apply the heat of a lamp and the mercury will rise gradually to 32°, where it will remain stationary until the whole is melted, when it will again rise, though much slower. It continues to rise until the water begins to boil, when it again becomes stationary. The caloric is now no longer free to affect the thermometer, but is employed in converting the water into steam, in which it becomes stationary. This is sometimes called caloric of *fluidity*, or *evaporation.*

10. When a body passes from a liquid to a solid, or from vapour to a liquid, the latent caloric is evolved and becomes free.

Illustration. When water, as in the slacking of lime, is converted from a liquid to the solid state, the caloric which caused the water to continue fluid is evolved and the sensible or free caloric is increased.

11. When a body is condensed or has its volume diminished, whether by mechanical force, as in condensing the air in the receiver of an air pump, metals under the hammer,&c. or by chemical combination, in which concentration takes place, the latent caloric is pressed out, and consequently, the sensible or free caloric is increased.

Exp. Fill a wine glass about half with water, and pour upon it sulphuric acid, a very high temperature is produced, which is caused by the disengagement of latent caloric.

2. Pour into a phial containing a solution of muriate lime, a few drops of *oil of vitriol*, sulphuric acid, the whole will be converted into a solid mass, at the same time the bottle becomes very much heated.

3. A cold bar of iron, by hammering on an anvil, may be made red hot.

4. Prepare a hot saturated solution of sulphate of soda, Glaubers salts, in a flask; when it is hot, cork it, and keep it in this situation until cold. Then take out the cork and let the air into the vacuum made by corking it when the salt will suddenly crystallize, while at the same time, sensible heat is disengaged.

12. When a body is rarefied or has its volume increased, as in exhausting the air from the receiver of an air pump, the caloric is absorbed and the sensible heat is diminished.

PRACTICAL QUESTIONS.

Do all bodies contain the same quantity of caloric?

How are different bodies raised to the same degree of temperature?

Give an illustration.

What is capacity for caloric?

Illustrate it.

What is the caloric that is employed in filling the capacity of a body?

Illustrate it.

What is specific caloric?

Illustrate it?

May not the difference proceed from the different powers of those bodies in conducting caloric?

Illustrate this by experiment.

Does the thermometer indicate the specific heat of bodies?

What is latent heat?

Why is it called latent heat?

What is the difference between specific and latent heat?

What is the capacity of water and ice for caloric?

Illustrate this by an experiment.

When does the latent caloric become free in bodies?
When is the sensible or free caloric increased?
Illustrate this by experiment.
When is the sensible heat diminished?

CHAP. VI.

Of Oxygen and its combinations.

1. Oxygen is the principle upon which most of the chemical phenomena of atmospheric air depend.

Observation. Oxygen was discovered by Mayow, in 1674, and called by him *igneo-aerical spirit.* It was named dephlogisticated air by Dr. Priestley, who examined it in 1774. Scheele in 1777, called it empyreal air; Condorcet *vital air;* and Lavoisier, oxygen, which term is now universally adapted by chemists.

2. Oxygen has never been procured in an uncombined state. Its greatest purity is that of oxygen gas.

3. The term *Gas* is given to any fluid capable of existing in an aeriform state, under the pressure and temperature of the atmosphere.

4. Oxygen has never been made solid by any degree of cold, and therefore differs in this respect from vapours which may be condensed into a liquid, and converted into a solid.

5. Sir H. Davy thinks that gases owe their permanently elastic state to the presence either of positive or negative electricity.—(see electricity.)

6. Oxygen and oxygen gas are used as synonymous, though stricktly speaking, oxygen is the base of the gas known by that name.

7. Oxygen is one of the most important agents in nature, it has a share in almost every process, either natural or artificial.

To procure oxygen gas in large quantities proceed as follows: Take an iron bottle or retort, (B. Plate 3, fig. 1,) and having charged it with powdered black oxide of manganese, place it in the furnace, (A.) on a small stand above the grate, lute to the beak of the retort a tube (E.) passing under the jar (D.) which is filled with water standing on a shelf in the pneumatic cistern or water bath, C. Kindle a fire in the furnace, when the retort becomes red hot, the gas passes over and rises in the jar in the form of bubbles, displacing the water.

Observation. Instead of the black oxide of manganese, the red oxide of lead may be used, in that case a glass retort, and Argand's lamp may be substituted for the above, fig. 2, E F the lamp, C the retort, D the stand—e. e. e. rings with screws for holding the different vessels necessary in the use of this furnace.

8. Oxygen gas is permanently elastic, compressible, inodorous, transparent and insipid. 100 cubic inches at 60° F; barometer at 30 inches weighs 33.82.

9. The specific gravity of oxygen in relation to water, is as 0.00135 to 1.00000; and in relation to hydrogen as 15 to 1. In relation to an equal volume of atmospheric air as 1.1088 to 10000.

10. Its specific caloric or capacity for heat is 0.8848 to an equal bulk of atmospheric air as 1.0000.

11. The specific heat of water being unity, that of oxygen will be 0.2361.

12. Oxygen gas is a supporter of combustion. The quantity of caloric liberated during combustion depends entirely on the quantity of oxygen gas combined in a given space of time with the combustible body.

Exp. 1. Immerse an inflamed taper in oxygen gas, it burns with great splendour, and is much more rapidly consumed than in atmospheric air.

2. Blow out the taper and when the wick is merely glowing, immerse it in oxygen gas, it is immediately rekindled with a slight explosion.

3. Bend a small steel or iron wire spirally, attach to it a piece of lighted tinder, and having placed it in a jar filled with oxygen gas, the metal will burn with great brilliancy and throw off beautiful white scintillations which are iron combined with one portion of oxygen now called *protoxide of iron.*

4. If sulphur, phosphorus or charcoal be burned in oxygen gas, the combustion will be intensely vivid, and acids will be produced, of greater or less strength, according to the proportion of oxygen they contain.

Illustration. Phosphorus with a small portion of oxygen forms an oxide of phosphorus ; with a larger portion, phosphorus acid, and with the largest, phosphoric acid.

13. Oxygen gas is the only one that can be breathed by animals for any length of time, with impunity. The power of atmospheric air in supporting respiration is owing to the oxygen.

14. In respiration a quantity of atmospheric air is taken into the lungs, the oxygen disappears and a quantity of carbonic acid gas equal in bulk is formed in its stead. A reciprocal influence is exerted between this aerial fluid and the circulating blood, and the continuance of life is dependent upon the due exercise of this influence which appears by the conversion of oxygen into carbonic acid.

15. Animals confined in oxygen gas will live four or

five times longer than when confined in atmospheric air.

16. It may be breathed by men for some time without producing any other effect than a sensation of warmth and slight stricture of the chest.

17. Oxygen forms about 22 *per cent* of the atmospheric air, the rest is nitrogen or azotic gas, except perhaps a small quantity of carbonic acid.

18. With hydrogen it forms water in the proportion of eighty five oxygen, and fifteen hydrogen. Water which is perfectly insipid contains more oxygen than any of the acids to which it is essential.

Illustration. When any fluid capable of undergoing fermentation is exposed to the atmosphere and in a moderate temperature, it absorbs oxygen and is changed to an acid.

19. Oxygen is separated from many of its combinations by the influence of the solar rays; especially from water.

Exp. Place a tumbler of clear spring water in the rays of the sun for a few minutes, small bubbles of oxygen gas will be formed on the bottom and sides.

20. Oxygen combines with all the metals, and in that state they are called metallic oxides, depriving them of their metallic lustre, and giving them an earthy or rusty appearance.

21. Some of the metals become oxidized, or are rusted by mere exposure to a damp atmosphere.

Exp. Iron exposed to the weather soon becomes rusty by attracting oxygen from the air or water.

22. All oxides are heavier than the metal, in proportion to the quantity of oxygen with which they are combined.

23. Many of the metals are capable of combining with different proportions of oxygen. Those with one

portion are called *protoxides ;* of two, *Deutoxides ;* those of three, *tritoxides.*

24. A metal combined with the greatest proportion of oxygen is called *peroxide.*

25. In general the least simple bases unite with oxygen in the greatest variety of proportions.

26. Oxygen undergoes various changes in its properties by its union with many oxidizable substances. The compounds are fluid, solid, opaque, coloured, incapable of supporting inflammation, and deleterious to animal and vegetable life.

27. Oxygen has a powerful effect on vegetable colours, producing the various tints of shade which we behold in this department of nature.

Illustration 1. Yarn when first taken from the blue vat, is green, but on exposure to the air, it imbibes oxygen, and is changed to a deep blue.

2. The *Buccinum*, which is employed in dying purple, undergoes a remarkable change in contact with oxygen, the liquor naturally yellow, becomes oxidized on exposure to the sun and air; it passes through various shades of yellow, green, crimson, &c. at length it becomes purple.

3. It is well known to dyers that they cannot produce a good black without exposing their stuffs to the air.

28. Vegetable colours fade on exposure to the sun, which is probably owing to this principle; the oxygen which previously existed in the colouring matter in a solid form, is rendered aeriform by the rays of the sun, and is evolved in the form of gas.

29. Oxygen gas of great purity may be obtained from the green leaves of plants ; Ingenhouz first obtained it

from these substances for some of his most brilliant experiments.

30. It is obtained in the greatest purity from chloride of potassium, by simply decomposing it with a very gentle heat. This, however, is not an economical method.

PRACTICAL QUESTIONS.

What is oxygen ?

Who discovered it, and what was it named ?

Has oxygen been obtained in its pure state ?

What is gas ?

How does it differ from vapour ?

To what does Sir H. Davy suppose that gases owe their permanently elastic state ?

What is oxygen, strictly speaking ?

Of what use is oxygen in nature ?

How is oxygen gas produced ?

What are the characteristics of oxygen gas ?

What is its specific gravity ?

Is oxygen gas a supporter of combustion ?

On what does the quantity of caloric, during combustion, depend ?

Illustrate it by experiment.

What is the supporter of respiration ?

Describe the process.

What effect does oxygen gas have on animals, when confined in it ?

What effect on man ?

What proportion does it form of the atmosphere ?

What proportion does it form of water ?

How is oxygen separated from many of its combinations ?

Does it combine with the metals ?

How are some of the metals oxidized ?

What is the weight of the oxides?

Do the metals combine with different portions of oxygen, and what are those combinations called?

What is the greatest metallic oxide called?

Does oxygen undergo any changes in its combinations?

Has oxygen any effect on vegetable colours?

Illustrate it.

Why do vegetable colours fade, on exposure to the sun?

How can this gas of great purity be obtained?

From what is it obtained in the greatest purity?

CHAP. VII.

Of Azote or Nitrogen.

1. Nitrogen is the basis of the nitric acid; it exhibits itself in its simplest state as a gas.

Observation. This gas was discovered by Dr. Rutherford, in 1772, and by Mr. Scheele, 1776. It was formerly called azote, because it was destructive to animal life.

2. Nitrogen constitutes about 0.78 parts in bulk of atmospheric air.

3. The use of nitrogen in atmospheric air is to dilute the oxygen gas, in order to render it adequate for the several functions which it is destined to perform in the economy of nature; thus mollifying the activity of the latter, which in its pure state, would be too powerful.

4. It may be readily obtained from atmospheric air, by removing the oxygenous part of it.

Exp. 1. If a portion of iron filings and sulphur moistened with water, be put into a flask filled with common air, the oxygen will, in a short time, be absorbed by the metal and sulphur, while the nitrogen gas will remain.

2. Phosphorus inclosed in a similar vessel with common air, will produce a similar effect. The phosphorus will be oxidized or converted into phosphoric acid, while the nitrogen will remain.

3. Under a bell glass which is full of atmospheric air, standing over water, introduce some sulphuret of potash, which in a few days will absorb all the oxygen and leave the nitrogen pure.

4. Any kind of muscular flesh cut small, and put in a retort with some diluted nitric acid, will, by the application of heat, produce nitrogen gas.

5. Nitrogen gas when pure is permanently elastic, inodorous and insipid. It converts vegetable blues to green. It is fatal to animals confined in it.

6. Nitrogen immediately extinguishes flame.

Exp. Procure a jar of nitrogen gas and immerse in it a burning taper. It is immediately extinguished, as effectually as if thrust into a vessel of water.

7. When nitrogen gas is mixed with oxygen in the proportion of four parts of the former to one of the latter, it produces a mixture resembling atmospheric air.

8. The specific gravity of nitrogen to that of water is, as 0.0012 to 1.0000, and to that of hydrogen as 13 to 1.

9. It dissolves phosphorus and carbon in small quantities.

10. Nitrogen has been thought by some to be a compound of hydrogen and oxygen, containing a less proportion of oxygen than water, composed of 6 atoms hydrogen, and 1 oxygen, or by weight of 44.4 of the former, and 55.6 of the latter. But this fact, if it be one, has not been fully demonstrated.

11. Nitrogen constitutes an ingredient in animal substances, and this in some measure distinguishes them from vegetable ones, where it is very rarely found.

12. Nitrogen unites with oxygen in two states; in mixture, they constitute atmospheric air; in chemical combination, the *nitric acid.*

13. Nitrous acid is nitric acid holding nitrous gas in solution, and is the *aqua fortis* of the shops.

14. There are two combinations of nitrogen and oxygen in a gaseous state, viz. nitrous oxide and nitrous gas.

15. Nitrogen combines with hydrogen and forms ammonia.

PRACTICAL QUESTIONS.

What is nitrogen?

Who discovered it, and when?

What proportion of the atmosphere does it constitute?

What is its use in the atmosphere?

How can it be obtained?

What are its characteristics?

Will it support flame?

How can you form atmospheric air?

What is the specific gravity of hydrogen?

What does it dissolve?

What has it been considered to be by some?

How are animal substances distinguished from vegetable, with regard to nitrogen?

In how many states does nitrogen unite with oxygen?

What is nitrous acid?

How many chemical combinations are there of nitrogen with oxygen?

What is ammonia?

CHAP. VIII.

Of Hydrogen.

1. Hydrogen united to caloric is one of the constituents of water; it has never been obtained but in combination with caloric, with which it forms nitrogen gas.

Observation. Its properties were first examined in 1756 by Mr. Cavendish.

2. It is one of the most abundant principles in nature; it forms about 1-9 of all the water of the globe, and is a constituent of oil, bitumen, ardent spirits, ether, alcohol, and of all the component parts of animal and vegetable substances.

3. Hydrogen is invisible and elastic, and between 12 and 13 times lighter than common air; hence its use in filling balloons.

Exp. Fill a bladder with hydrogen, having a small aperture with a stop cock; prepare a strong solution of soap in water, and having fitted a tobacco pipe to the stop cock, dip it in the soap and water, and take up a few drops, having turned the cock, squeeze out some of the gas so as to form a bubble, which, when disengaged, will ascend rapidly to the ceiling of the room, like air balloons.

4. This gas has a smell resembling garlic. It is utterly unfit to support respiration or combustion.

Illustration. Although it may be taken into the lungs, it cannot be breathed by man for more than a minute; small animals die in it, in a much shorter time.

5. Its specific gravity to that of oxygen is as 1 to 16.

6. Water is composed by weight of oxygen, 88.24, hydrogen, 11.76 in the 100, and may be obtained by

combustion, in this way hydrogen combines with the oxygen, and their opposite electricities are disengaged in the form of caloric; by the loss of caloric the two gases are condensed into a liquid.

Illustration. In this process, the two gases are chemically combined and not mixed as is the case with oxygen and nitrogen in atmospheric air.

7. Hydrogen is obtained by the decomposition of water; the best way of obtaining it for experiments is, as follows. Take sulphuric acid diluted with five or six times its weight of water, and pour it on a quantity of iron or zinc filings in a gas bottle, plate 2. fig. 3, connected with a pneumatic cistern. An effervesence takes place, and the hydrogen is evolved, which may be collected in a jar over water, while the oxygen unites with the metal and becomes solidified. The water is decomposed in consequence of the great affinity of the metal for oxygen. If the metal be taken out and dried, it will be found to have gained in weight equal to the oxygen absorbed.

Observation. It has been conjectured that hydrogen is a metal in an aerial form.

8. Water may be decomposed by electricity, or the action of the voltaic battery.

Exp. 1. Fill a piece of glass tube with water, plate 3, fig. 3, and cork it at both ends; through one of the corks introduce the positive wire of the battery, and the negative through the other, let the ends of the wires be about 1-8th of an inch apart. Each wire decomposes the water, the positive by combining with its oxygen, which is negative, and the negative with the hydrogen, which is positive. The bubbles which appear to proceed from the positive wire, are the result of the decomposition of water by that wire. For the positive electricity having

PLATE III.

Fig.4.

Fig.1.

Preparation of oxygen gas

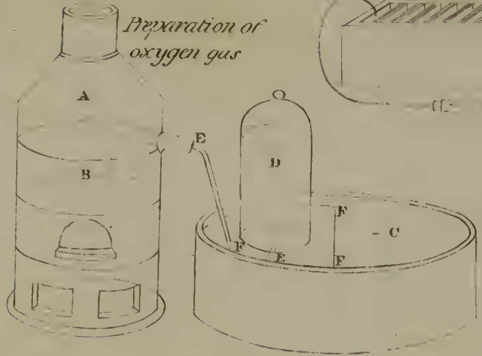


Fig.3

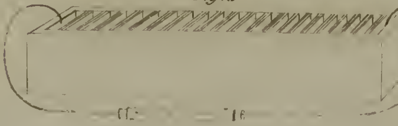


Fig.2.

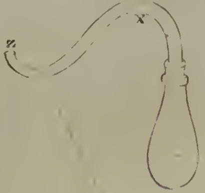
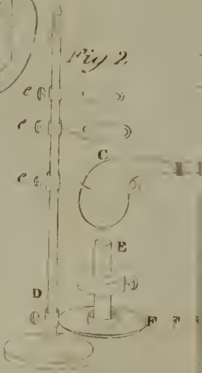


Fig 2.



combined with some of the oxygen of the water, the particles of hydrogen which were combined with that portion of oxygen, are set at liberty and appear in the form of small bubbles of gas. The negative fluid having in the same manner combined with some of the hydrogen of the water, the particles of oxygen that were combined with it are set free, and emitted in a gaseous form.

Observation. The wires used in this experiment should be made of platina, which does not combine readily with oxygen, otherwise the oxygen would combine with the metal, and the hydrogen only would be disengaged.

Exp. 1. The gases in the above experiment were mixed, but they may be collected separately, in the following manner. Instead of one tube, let two be used, fig. 4, e. d. both tubes being closed at one end and open at the other ; fill these tubes with water, and place them standing in a glass of water e. with their open end downwards ; connect the wires a. b. which proceed from the interior of each tube, the one with the positive, and the other with the negative end of the battery ; the water in the tubes will be decomposed, hydrogen will be given out round the wire in the tube connected with the positive end of the battery, and oxygen in the other ; the gases will be evolved exactly in the proportion of two measures of hydrogen to one of oxygen.

Exp. 2. Water may be decomposed by means of heat in the following manner. Place a gun barrel across a furnace, inclining a little. To the extremity, lute on a small glass retort, containing a quantity of water, and to the other end is to be luted a tube connected with a pneumatic cistern. Two fires are now to be lighted, one in the furnace, sufficient to keep the gun barrel red hot and the other in a lamp under the retort. When the water boils, the vapour will pass through the tube, where it will be decomposed; the oxygen is attracted by the metal and the hydrogen is evolved and passes out of the tube, where it may be caught in jars, or inflamed at the mouth of the tube.

9. From the combustion of oxygen and hydrogen, water is produced.

Exp. Take the gases collected by the voltaic experiment No. 2, that is to say, two volumes of hydrogen, and one of oxygen, and having mixed them, set fire to them by an electric spark, both gases will entirely disappear, and a small quantity of water will be obtained.

10. Hydrogen gas in combustion has the property of producing very peculiar sounds in glass.

Exp. Provide a phial with a cork stopper, through which, pass a glass tube or piece of the stem of a tobacco pipe; into this pipe, half filled with water, put a quantity of iron filings, to which, add of sulphuric acid a quantity equal to one third of the water. Replace the cork, and the hydrogen gas will be liberated through the tube, to which after the atmospheric air is disengaged, apply the flame of a candle, the hydrogen will immediately take fire and burn with a clear flame. This has been named the philosophical candle.

If a piece of glass tube about two feet in length and one inch in diameter, open at both ends, be placed over the flame, a noise similar in some measure to an Eolian harp will be produced

Illustration. The cause of this is probably owing to a quick vibrating motion of the glass, occasioned by the successive formation and condensation of small drops of water on the sides of the glass tube, and the air rushing in to replace the vacuum formed.

11. The flame of a candle or lamp is produced by the hydrogen which is contained in the wax, tallow or oil, which being converted into gas by the heat of the candle, combines with the oxygen of the atmosphere, and flame and water result from the combination. The candle must come in contact with some ignited body in order to give the first impulse to the combustion, it afterwards goes on of itself, because the candle finds a supply of caloric in the successive quantities of heat which result from the union of the two electricities, given out by the gases during their combustion.

12. Flame, in general, is owing to the formation and combustion of hydrogen gas, or rather hydro-carbonate, which is an union of hydrogen with carbon.

13.. The regular tapering shape of flame, is owing to the stream of hydrogen gas, which issues from the burning body; the combustion of the gas is completed at the point where the flame terminates, it is there converted by its union with oxygen into aqueous vapour.

Exp. Invert a tumbler over the flame of a candle, in a few minutes the inside becomes covered with vapour.

14. Hydrogen gas when inflamed burns gradually, but when mixed with atmospheric air or oxygen, it detonates violently.

Exp. 1. Fill a bladder, having a stop cock, with hydrogen gas, adjust to the cock a small pipe, dip this in soap suds, and having blown up bubbles, apply to them a burning taper, and a loud detonation will ensue.

2. Fill a small jar or phial with a mixture of one part of oxygen and two parts of hydrogen, and apply the mouth to the flame of a candle or taper, it will explode with a loud noise.

Illustration. By the application of flame, the hydrogen is decomposed or burnt, and forms water by its chemical union with oxygen.

15. Hydrogen forms a constituent in pit coal, and may be disengaged or combined with carbon, called carburetted hydrogen gas.

16. Gas lights are produced from carburetted hydrogen gas, conveyed through a tube of a very small bore, at the extremity of which, it is kindled and burns as long as the supply continues, without wick or any other substance whatever, except the gas.

Exp. Pulverize a small quantity of coal and put it into the bowl of a tobacco pipe, cover the coal closely over with clay and place the bowl in the fire. In a few minutes a stream of carburetted hydrogen gas will issue from the end of the pipe, which may be inflamed with a lighted taper, and will burn for a considerable time.

Observation. On a large scale, the carburetted hydrogen gas is obtained from coal in iron retorts, the gas at its formation is made to pass through two or three large vessels of water, in which it deposits foreign ingredients which are carried over with it from the retort, thence it is conveyed with uniform velocity by means of pressure, to the destined places.

17. The gas produced in coal mines commonly called *fire damp*, which, until within a few years occasioned the destruction of so many lives in the mines of England, is *light carburetted hydrogen*; this gas being inflammable when it is approached with a candle, takes fire and produces violent explosions.

18. It has been found that this gas will not inflame by iron wire heated red hot; so that if a lamp be inclosed in a wire gauze of certain dimensions, it may be made to subserve all the purposes of affording light to the men in the mines without danger of explosions. On this principle, Sir H. Davy's safety lamp is formed

19. Hydrogen unites with sulphur, phosphorus and carbon. It is then called sulphuretted, phosphuretted and carburetted hydrogen gas.

20. Phosphuretted hydrogen gas possesses the property of being inflamed, when exposed to atmospheric air.

Exp. Introduce into a retort a diluted solution of caustic potash, with a small piece of phosphorus, plunge the beak of the retort into water, heat the retort by means of a lamp until the liquor boils, bubbles will pass out of the retort, which, as soon as they reach the surface, will inflame.

Observation. This is one of the most interesting experiments in chemistry.

21.. Sulphuretted hydrogen gas is produced by the decomposition of animal and vegetable substances.

Observation. It is this gas which causes the fetid effluvia which arises from vaults and drains. It is likewise found in some mineral waters.

22. Hydrogen united with oxygen in certain proportions, produces the most intense heat hitherto known; for this purpose it has been applied in an instrument, called an *oxy-hydrogen blow pipe.*

PRACTICAL QUESTIONS.

What is hydrogen?

Does it exist in great quantities in nature?

What are its characteristics?

What other properties has it?

Can it be taken into the lungs?

What is its specific gravity?

What portion has it, in the composition of water?

How does it form water?

Is it by mixture, or chemical combination?

How is hydrogen obtained ?

How do you decompose water by electricity ?

Of what should the wires in this experiment be made ?

How can you collect the gases separately by electricity ?

How do you decompose water by means of heat ?

What experiment have you to shew, that water is formed by combustion ?

What peculiar effect does hydrogen, in combustion, have on glass ?

How do you perform this experiment ?

How do you account for this ?

How is the flame of a candle or lamp produced ?

To what is flame, in general, owing ?

Why is it regular and tapering ?

How do you produce a detonation with hydrogen ?

What is the gas obtained from pit coal ?

How are gas lights produced ?

How can you imitate the gas lights ?

How is this gas obtained on a large scale ?

What is *fire damp ?*

On what principle is Sir H. Davy's safety lamp constructed ?

What is sulphuretted, phosphuretted and carburetted hydrogen ?

What property does phosphuretted hydrogen gas possess ?

How would you illustrate this by experiment ?

How is sulphuretted hydrogen gas produced ?

What is the consequence of the union of oxygen and hydrogen ?

CHAP. IX

Of Sulphur.

1. Sulphur or brimstone is sometimes found in a state of purity, but more frequently mixed with other substances; particularly with metals.

2. In the state of combination, the several metallic substances combined with sulphur, were called Pyrites; by the new nomenclature, sulphurets.

Illustration. Sulphur united with iron, forms martial pyrites; united with copper, copper pyrites; or sulphuret of iron, or copper.

3. Sulphur also exists in vegetables, and it is emitted from animal substances in a state of putrefaction, combined with hydrogen.

4. Sulphur is obtained by roasting or exposing metals to heat, sufficient to drive off the sulphur which is condensed on the top of the furnace.

5. The characteristics of sulphur are, it is brittle, electric, fusible at 220° Farenheit, burns with a pale blue flame at 302°, and a bright white one at 370°.

6. Its specific gravity is 1.99 to 2.325.

7. When sulphur is kept melted in an open vessel for some time, at about 300° F. it becomes thick and viscid, and if it be then poured into a bason of water, it appears of a red colour and ductile, like wax.

8. The substance sold under the name of *flowers of sulphur*, is merely sulphur sublimed or minutely divided by means of heat.

Exp. Place some lumps of sulphur in the cucurbit, such as was used for alcohol and sulphur. Plate 2, fig. 4. And having placed the head upon it, set it in a sand bath, which must be gently heated. The sulphur soon begins to melt and immediately a thick white smoke rises, which is gradually deposited within the head, where it condenses against the sides somewhat in the form of vegetation, whence its name. When first formed, it is of a pungent and offensive smell.

9. Sulphur in combustion in close vessels, combines with the oxygen within the vessel, and forms a compound totally different from sulphur in its pure state.

Exp. Put a small quantity of the flowers of sulphur into a tea cup, and place it in a saucer filled with water, with a hot iron set fire to the sulphur. It burns with a faint bluish flame, invert over it a bell glass, white fumes will arise from the sulphur and fill the vessel, at the same time the water will rise in the receiver: the water absorbs the gas and acquires acid properties which did not previously exist in the sulphur

Illustration. Sulphur in the state of vapour absorbs the oxygen in the receiver, and assumes the form of an elastic fluid of a pungent and offensive smell. A chemical combination of oxygen and sulphur takes place, and a true gas is formed which would continue so under the pressure and temperature of the atmosphere, if it did not combine with the water to which it imparts its acid taste and all its acid properties. The oxygen in this case is the acidifying principle.

10. Sulphur combines with oxygen in four definite proportions, forming an interesting class of acids, viz. : *The sulphurous, hypo sulphurous, sulphuric and hypo-sulphuric.* From these combinations it is inferred that the prime equivalent of sulphur is 2, and the density of its vapour is 1.111, equal to that of oxygen.

Observation. In the last experiment the acid formed was the sulphurous, which is the weakest degree of acid ification; when fully satutrated it is the sulphuric and hyposulphuric.

Exp. Provide a large glass receiver with a glass stopper at top, and having filled it with oxygen gas in the pneumatic cistern, slide it off the shelf into a plate containing water, then introdnce a piece of sulphur into the receiver through the opening at the top and with it a small piece of lighted tinder. It burns with a very brilliant blue light, and quickly fills the receiver with vapour, which is condensed in the water below and forms sulphuric acid diluted, which may be condensed by evaporation.

11. Sulphur has hitherto been considered as a simple substance, but recent experiments seem to shew that it is combined with a small portion of hydrogen and perhaps of oxygen.

Illustration. Sir H. Davy observed, on submitting sulphur to the action of the voltaic battery, that the negative wire gave out hydrogen; and by the combustion of sulphur, a small quantity of water was produced which indicated the presence of hydrogen.

12. Sulphur combines with the metals, earths and alkalies, forming hard substances called *Sulphurets*.

Exp. 1. Heat an iron bar red hot, and apply to it a roll of sulphur, the latter becomes melted, and the drops that fall will be found to be a sulphuret of iron.

2. Boil muriate of ammonia, lime and sulphur together, the compound will be soluble in water.

13. Oil of turpentine, and other essential oils, dissolve a considerable proportion of sulphur when hot, the greatest part of which is deposited in crystals when cooled slowly.

14. The fat oils unite with sulphur by boiling, and acquire a deep yellowish brown colour; and a strong fetid odour.

15. Sulphur combines with chlorine forming a peculiar compound called chloride of sulphur, having the following characteristics. It is a fluid appearing red by reflected, and yellowish green by transmited light. Specific gravity 1. 7. In the air it fumes and emits a peculiar odour somewhat resembling sea weeds. Its taste is acrid, hot, acid and bitter. Water decomposes it, the sulphur is precipitated, and the liquor is found to contain sulphuric and muriatic acids.

When added to nitric acid a mutual decomposition takes place with violence, nitric oxide gas and chlorine are evolved and sulphuric acid is formed.

Exp. This may be formed in the following manner. Pass a current of chlorine over flowers of sulphur, or having filled a retort with chlorine gas or oxymuriatic acid gas, heat flowers of sulphur in it until they sublime.

16. Sulphur unites with cyanogen, or prussine, forming a substance called sulpho-cyanic acid by some, by others sulphuretted chyazic acid.

17. The characteristics of this substance are. It is a colourless and transparent fluid, specific gravity 1.022, of a pungent smell like strong acetic acid. It combines with salefiable bases, and forms salts called sulpho-cyanates. They are soluble, deliquescent and crystallizable. According to Dr. Thomson, it is composed of 1 atom cyanogen and 3 atoms sulphur.

Exp. The following method has been adopted to obtain it. Three or four parts of prussian blue added in small quantities at a time, are boiled in a solution of one part of sulphuret of potash in water; a transparent, colourless and neutral liquid is obtained, to which after being filtered, sulphuric acid must be added, in sufficient quantities to give it decidedly acid properties. The liquid is kept for a short time at a temperature near a boiling point, and afterwards allowed to cool. On the addition of a little finely pulverized oxide of manganese, the solution acquires a fine crimson colour, and after filtration it is decomposed by pouring into it two parts of sulphate of copper, and three parts sulphate of iron in water, until the crimson colour disappears, a white precipitate, composed of sulpho cyanic acid, and oxide of copper is formed; the former of which is transferred to potash when boiled in the solution. To the filtered liquid is added sulphuric acid in excess, and by subsequent distillation the sulpho-cyanic acid passes over into the receiver, mixed with a little sulphur and sulphuric acid, from which it may be freed by saturating the liquid with carbonate of barytes.

18. Sulphur unites with phosphorus, and when combined may be made to contain various proportions of its elements, and exhibit different phenomena. The compounds are exceedingly inflammable and more fusible than either of their elements.

Exp. 1 proportion of phosphorus and 3 of sulphur, congeal at 100° F. 2 of phosphorus and 1.5 of sulphur remain liquid at 40°; and 8 of phosphorus and 1 of sulphur at 68° F.

19. Sulphur combines with carbon forming a compound long known by the name of alcohol of sulphur, possessing the following properties. Its taste pungent and disagreeable; smell stronger than sulphuretted hydrogen. It boils at the temperature of 110 to 115°. The elasticity of its vapour at 55° is such as to support 7.25 inches of mercury. Water at the same temperature supports 4.3; alcohol 1.23, and ether 11 inches. By evaporation it produces a greater degree of cold than ether. It may be cooled down to 50° without freezing; it readi-

ly dissolves sulphur, but if to the solution be added ether or alcohol, the excess of sulphur is precipitated, and the two liquids combine.

Exp. It may be obtained by subliming sulphur through ignited charcoal in a porcelain tube. The first product is a liquid of a yellowish colour, which colour is owing to the presence of a little sulphur. By distillation in a glass retort, a colourless product is obtained which is the pure sulphuret of carbon.

20. Sulphur is applied to many important uses. It is employed in medicine, it enters into the composition of sulphuric acid, of gun powder, and of the common composition for paying the bottom of ships. Its fumes are employed in bleaching of silk and wool, and checking the progress of vinous fermentation. Common matches, for lighting fires are tipped with sulphur.

PRACTICAL QUESTIONS.

In what state is sulphur found?

What is the mineral combination called?

Does sulphur exist in any other substance but minerals?

How is sulphur obtained?

What are the characteristics of sulphur?

What is its specific gravity?

What is the effect when sulphur is kept melted for some time in an open vessel?

What are flowers of sulphur?

Illustrate this by experiment.

When sulphur combines with oxygen in combustion, what is the compound?

What experiment illustrates this?

Explain the process.

How many proportions of oxygen is sulphur capable of combining?

How would you form sulphuric acid?

Is sulphur a simple substance?

How is this proved?

With what does sulphur combine?

Illustrate this by experiment.

Can sulphur be dissolved in essential oils?

What effect do fat oils produce on sulphur?

What is chloride of sulphur?

How do you form it?

What is sulpho-cyanic acid?

Relate the method for procuring it.

What is sulphuretted phosphorus?

What phenomena do the different proportions of sulphur exhibit?

What are the characteristics of sulphuretted carbon?

How can it be obtained?

What are the uses of sulphur?

CHAP. X.

Of Phosphorus.

1. Phosphorus is a substance which exists in many animal and some vegetable substances, and may be obtained by decomposing the bones of animals.

2. It is never found in its simple state, but always in combination, from which it cannot be separated but by a chemical process.

3. Its characteristics are. It is semi-transparent, solid, slightly brilliant, and of the consistence of wax. Specific

gravity 1.77. Taste somewhat acrid and disagreeable, smell resembling in some measure garlic.

4. It is brittle under 32°, fracture vitreous, brilliant and sometimes lamellated.

5. Above 32°, it softens a little, at 90° it becomes ductile, melts at 99°, becoming transparent like a white oil at 180° begins to be vaporized, and boils at 550.

6. It is highly inflammable, when heated in the air it takes fire at the temperature of 148° and burns with a very bright flame, emitting a large quantity of vapour or smoke.

Exp. 1. If a small bit of phosphorus be put upon the outside of a Florence flask, and hot water be put into the flask, the phosphorus will immediately take fire and exhibit a beautiful appearance.

Exp. 2. Put 30 grains of phosphorus into a Florence flask with four ounces of water; cause the liquor to boil over a lamp, balls of fire will soon be seen to issue through the water, after the manner of an artificial fire work, attended with the most beautiful corruscations.

Exp. 3. Rub cotton in pulverized rosin, and wrap it round a small piece of phosphorus, then place the whole under the receiver of an air pump, after exhausting the receiver, the cotton will take fire and display a very beautiful appearance on the admission of the air.

Exp. 4. Take a bit of phosphorus about the bigness of a large pin's head, and having wiped it upon blotting paper, put it into the middle of a piece of dry cotton, strike it with a hammer and it will inflame.

7. Phosphorus in combustion in oxygen gas, absorbs it and consumes nearly once and a half its own weight, and phosphoric acid is produced equal in weight to the oxygen and phosphorus consumed.

Exp. 1. Attach a bit of phosphorus to a small spoon [illegible] it into a receiver containing oxygen gas; it produces the most brilliant white light imaginable; concrete white flakes adhere to the sides of the receiver which will be found to be phosphoric acid.

8. Its combustion in oxygen gas furnishes results different from all other combinations, viz. phosphoric and phosphorous acids or oxide of phosphorus.

Exp. Into a retort that will hold about a pint, put half a pint of water, and then add a small bit of phosphorus, place it over a lamp and when it gets warm, stars of fire resembling sky rockets will be seen shooting about the water in a most beautiful manner, and adhering to the sides of the retort. If the lamp is withdrawn when the water boils, a curious appearance resembling the aurora-borealis, is seen at the surface of the water. If the heat be continued, a stream of light is seen to issue from the mouth of the retort, which returns into the retort when taken away.

9. Phosphorus combines with oxygen at a lower temperature than most other substances, whence its great attractive power for this principle; hence the facility with which it takes fire.

Exp. Put a piece of phosphorus into a quill and write with it on the wall of a dark room; the words thus written will appear as if brilliantly illuminated. It is by slow combustion, in consequence of the rapid absorption of oxygen, that the light is produced.

10. In open air phosphorus undergoes a slow combustion at 43° emitting light in the dark without the production of sensible heat, absorbing a portion of oxygen and producing *phosphorous acid.*

Exp. Provide a glass funnel, place it in the mouth of a bottle, then take sticks of phosphorus enclosed in glass tubes to prevent their contact, and place them round the inside of the funnel. Put a little distilled water into the receiver and suffer the apparatus thus arranged to remain 24 hours, a quantity of phosphorous acid will be formed.

Observation. It may at first appear singular that phosphorus should burn at so low a temperature in atmospheric air, when heat must be applied for its combustion in oxygen gas But this circumstance seems to be owing to the nitrogen gas of the atmosphere. This gas dissolves small particles of phosphorus, when in contact with it, which being thus minutely divided and diffused in the atmospheric air, combines with the oxygen and undergoes a slow combustion. The reason why the same effect does not take place in oxygen gas is, that oxygen is not capable of dissolving phosphorus. It is therefore necessary that heat should be applied to effect that division of the particles which in the last case is effected by nitrogen.

11. Phosphorus combines with sulphur and forms a compound, which takes fire in contact with atmospheric air.

Observation. It is this composition which forms what is called phosphoric matches.

Exp. Mix one part of flowers of sulphur with eight parts of phosphorus, and dip a splinter of pine wood into the mixture. Rub the end against a piece of cork or wood, and a flame will be immediately produced.

12. Phosphorus is soluble in fixed, essential oils, and ether.

Exp. 1. Dissolve some phosphorus in sulphuric ether, this solution when poured in small quantities into hot water exhibits a beautiful appearance.

13. At the temperature of 70° F. phosphorus combines with oil, and forms a compound, which in contact with atmospheric air becomes luminous in the dark.

Exp. Put one part of phosphorus into six parts of good olive oil, or oil of cinnamon, which is preferable. Digest it in a gentle sand heat until the phosphorus is dissolved, on which, immediately cork the bottle. If this oil be rubbed on any thing, it becomes luminous in the dark, and yet has not sufficient heat to burn the substance.

14. Phosphorus combines with lime and forms a compound which has the singular property of decomposing water, by being thrown into it; which is owing to its absorbing oxygen from the water; called phosphuret of lime.

Exp. Put half an ounce of phosphorus cut small into a glass tube about a foot in length, and half an inch in diameter, closed at one end and filled up with quicklime grossly pulverized, stop the tube loosely. Heat that part of the tube which contains the lime until it becomes red hot, and then apply the heat of a lamp to the part containing the phosphorus, which will sublime and mix with the lime. When thrown into water, a decomposition takes place, phosphuretted hydrogen gas is evolved, and rises in bubbles to the surface where it immediately inflames.

15. Phosphorus combines with many of the metals and forms peculiar compounds; with iron it forms what Smiths' call *cold short*.

16. Phosphorus is usually obtained from the phosphoric acid which exists in the bones of animals.

Exp. Calcine bones to whiteness in an open fire, and having pulverized them, put them into a stone ware pot, pour gradually upon the powder diluted sulphuric acid, continually stirring the mixture, until it is reduced to the consistence of cream, after the powder has subsided, pour off the clear liquor, reserving it, and add water, pour this to the former liquor, and throw the sediment on a filtre, then add hot water until it passes through the filtre, tasteless. This fluid must be gradually evaporated in a glass vessel to the consistence of syrup. It is then mixed with an equal weight of charcoal powder and submitted to distillation in an iron or earthen retort. Instead of a receiver, the neck of the retort should be immersed in a vessel of water to a small depth, and the phosphorus as it comes over, will fall in drops to the bottom. It may be purified by a second distillation.

PRACTICAL QUESTIONS.

What is phosphorus ?

Is it ever found in its simple state ?

What are its characteristics?

What is its state under 32° of temperature?

What is it above 32°.

What is its appearance at the temperature of 99° ?

Illustrate this by an example.

What are the phenomena of the combustion of phosphorus in oxygen gas?

What are the results of the combustion?

At what temperature does phosphorus combine with oxygen ?

What does phosphorus undergo in the open air?

How do you form phosphorous acid ?

How do you explain the cause, that phosphorus inflames spontaneously in atmospheric air, and not in oxygen gas ?

What is the compound of phosphorus with sulphur ?

Is phosphorus soluble in oils ?

At what temperature does phosphorus combine with oil, and what is the compound ?

What is phosphuret of lime ?

How do you prepare it ?

Does phosphorus combine with metals ?

How is phosphorus prepared ?

CHAP. XI.

Of Carbon.

1. Carbon is the base of the carbonic acid ; in its greatest state of purity; it exists only in the diamond.

2. Charcoal in a state of purity, that is, unmixed with any foreign substance, is carbon.

3. Carbon forms a considerable portion of the solid matter of all organized bodies ; but it is most abundant in the vegetable creation, and it is principally obtained from wood. It is prepared by charring or burning in close vessels wood, which, when deprived of the water and oil, is charcoal.

Exp. 1. Expose wood of any kind, stripped of its bark, to a red heat in a close vessel, till vapours cease to issue ; a black, opaque, shining, brittle substance will be obtained, which is charcoal. Pulverize this substance, and digest it in diluted muriatic acid, and afterwards apply repeated affusions of cold water and then dry ; it in a heat approaching to redness, it may be obtained sufficiently pure for general purposes. Common charcoal dried in the above heat, will answer for common purposes.

4. The characteristics of good charcoal are. It is fixed in the fire, no heat being able to volatilize any considerable portion of it. It forcibly attracts and strongly retains a small quantity of water. Its antiseptic qualities are very great, and for this purpose it is used in purifying and cleansing many foul and fetid substances.

Illustration 1. It is employed in correcting the bad smell of corrupted water, of oiled silk bags, of ill conditioned ulcers, and for cleansing the teeth.

2. An excellent dentifrice may be prepared by pulverizing together in a common mortar, a piece of charcoal, a lump of chalk, and a bit of gum-mirrh, and sifting it through muslin.

Exp. Throw a quantity of well prepared charcoal in powder into water, which has been long kept, or which has become foul by being in contact with putrid substances, and the water will become perfectly sweet in the course of a few hours.

Illustration 1. The properties of charcoal in resisting putrifaction, have suggested its application to casks containing water during long voyages. The inner surface of the casks should be charred, when they are manufactured.

2. Piles or stakes driven into the ground, will last much longer, if they be charred in the same manner.

5. The most perfect carbon that can be prepared by art, contains about five per cent of hydrogen.

6. Well burnt charcoal is a conductor of electricity, though wood simply deprived of moisture by baking, is a non-conductor; but it is a very bad conductor of caloric.

Observation. Sir H. Davy is of opinion, that if we could obtain carbon free from foreign ingredients, it would be metallic, in common with other metallic substances.

7. Diamond is carbon in a crystallized state; but we are ignorant of the means which nature employs to crystallize it.

8. Diamond is combustible, and it is in consequence of this property, that its chemical nature has been ascertained.

Illustration. Apply a degree of heat excited by the blow pipe and a stream of oxygen gas, the product will be pure carbonic acid.

Exp. Charcoal will answer instead of diamond. Procure some oxygen gas, having made the charcoal red hot, place it on a dish and introduce it into the jar. It will burn with great brilliancy. When combustion ceases, pour into the glass a small portion of tincture of litmus, and it will be converted to a red, intimating the formation of an acid during the combustion of the charcoal. If newly made lime water be poured into the jar, a pellicle will immediately form on the surface of the water, which is a proof that the jar contains carbonic acid.

9. Carbonic acid is not a condensible vapour, but a permanently elastic fluid, which always remains in the state of gas under any temperature and pressure; it was formerly called *fixed air.*

10. Less light and heat are given out during the combustion of carbon in oxygen gas, than in that of most other substances; because the oxygen, instead of entering into a solid or liquid combination, is employed in forming another elastic fluid; it therefore parts with less caloric.

11. If we take into consideration the quantity of oxygen that carbon absorbs during combustion, and observe the proportion which the caloric bears to it, we may ascertain the degree of solidity in which oxygen is combined with it.

12. Carbonic acid has a great tendency to combine with other substances; the compounds are called *carbonates.* It is also combined with water.

Illustration. It is this product which gives the agreeable zest to beverages, which are the results of fermentation; bottled cider and beer, and champaign owe their grateful taste to the diffusion of carbonic acid. It contains all the antiseptic properties of its base, carbon; hence the great importance of it in putrid diseases.

13. Carbonic acid united with lime, forms chalk, marble, and most of the stones used in making lime.

14. It is nearly twice as heavy, bulk for bulk, as atmospheric air; and where it exists in the atmosphere, occupies a space nearest the surface of the earth.

Illustration. Hence the reason, why dogs and other small animals are suffocated in caves, containing this gas, while man may walk upright with impunity.

Exp. Balance a large funnel of paper in a pair of scales, and pour carbonic acid into it from a spout of a jar, when that end of the balance will descend; this shews that it is heavier than atmospheric air.

15. Carbonic acid does not support respiration nor combustion.

Exp. 1. Fill a jar with carbonic acid gas, and put into it a mouse, the animal will be instantly suffocated.

2. Pour the gas from a bottle on a lighted candle, it will be instantly extinguished, as though water had been poured upon it.

16. When plants are made to grow in carbonic acid gas, they absorb the base of the acid, a decomposition takes place, and pure oxygen is evolved.

17. Carbonic acid gas precipitates lime combined with water, and is an excellent test to discover the presence of lime in that fluid.

Exp. Having prepared some lime water, breath into it from a pipe, and a pellicle will immediately be formed on the surface of the water, which is, carbonate of lime.

18. Carbon may be converted into a gas by uniting with a smaller proportion of oxygen than is sufficient to form the carbonic acid gas; it is called carbonic oxide, *or gaseous oxide of carbon.*

19. Carbon is capable of decomposing water, when heated to redness, it then separates oxygen from hydrogen.

Illustration. A small quantity of water thrown on a red hot fire will increase the heat; for the coals or wood decompose the water, and thus supply the fire, both with oxygen and hydrogen gases.

Exp. Substitute a porcelain tube, containing charcoal, in place of the gun barrel, plate 3, fig. 1. A lamp being placed under the retort, containing water, is caused to boil, the vapour is gradually conveyed through the red hot charcoal, by which it is decomposed, and the hydrogen gas which results from the decomposition, is collected in the receiver. This gas is not pure hydrogen, but is combined with a small portion of carbonic acid, which gives it peculiar properties; it is known by the name of *carbonated hydrogen gas.* It obtains the carbonic acid from the union of the oxygen with the carbon.

20. Carbon is frequently combined with hydrogen in a state of solidity, as in coals, which owe their combustibility to those two principles.

Illustration. The flame of coals is produced in consequence of the carburetted hydrogen which they contain; when this gas is consumed, the carbon continues to burn without flame.

21. Carbon is a non-conductor of heat; charcoal is therefore used in the construction of *refrigerators*, for keeping liquors and other substances cool in warm weather, and likewise for coating furnaces and other chemical apparatus.

22. Plumbago, commonly called black lead, is a combination of iron with carbon, and contains about five per cent of iron. This substance is called carburet of iron, and approaches as near the diamond as any other substance known.

23. Steel is a combination of iron with carbon; the combination of carbon varies in different species, in all it is very small, amounting from 180 to 140 parts by weight.

24. The essential constituent principles of oils and fat, both vegetable and animal, are carbon and hydrogen; the difference of their appearance arises from the different proportions of these substances, and from other ingredients, that are not chemically combined with them.

25. The difference of *fixed oils* and *essential, or volatile oils*, consists in the various proportions of carbon and hydrogen. The essential oils contain nearer proportions of carbon and hydrogen, and are volatilized or evaporated without being decomposed; whereas fixed oils cannot be without a decomposition.

26. The facility with which oil burns is owing to the combustibility of its constituents.

27. The difference between wax and tallow is principally owing to the degree of the purity of the compound; both have the same essential ingredients; but tallow contains animal matter.

28. The combustion of a candle and lamp, both produce carbonic acid gas and water.

Illustration. In this case, the fixed oil is decomposed as the combustion proceeds, the carbon unites with a portion of oxygen from the atmosphere, and carbonic acid gas is formed; whilst the hydrogen combines with another portion of oxygen, and water is produced.

29. Carbon and hydrogen acidified by oxygen, form the constituents of all vegetable acids; likewise gum, starch, sugar are composed of these ingredients, and are called by some chemists, vegetable oxides.

30. In chemical operations, carbon is of essential service, by combining with the oxygen, from the very great affinity which it has for that substance.

Illustration. Many of the metallic oxides are deoxygenated, or restored to their metallic state, by mixing them with charcoal.

Exp. Take red lead, *tritoxide*, which is lead in the third state of oxidizement, and mix it with a quantity of powdered charcoal in a crucible; subject it to heat in a furnace for about an hour, then suffer it to cool, and a small button of metallic lead will be found at the bottom of the crucible.

PRACTICAL QUESTIONS.

What is carbon ?

What is charcoal ?

How is carbon or charcoal obtained ?

What are the characteristics of good charcoal ?

How do you illustrate this ?

What does the most perfect carbon, that can be prepared, contain ?

Is charcoal a conductor of electricity ?

What is Sir H. Davy's opinion on this subject ?

What is diamond ?

How has its chemical nature been ascertained ?

Illustrate this by experiment.

What is carbonic acid ?

Why is it that less light and heat are given out during the combustion of carbon in oxygen gas, than that of any other substance ?

How can we ascertain the degree of solidity in which oxygen is combined with carbon, during combustion ?

What are carbonates ?

What gives the agreeable zest to beverages ?

What is chalk and marble ?

How heavy is carbonic acid gas ?

What is the reason that small animals are suffocated in caves ?

Does carbonic acid gas support combustion and respiration ?

Illustrate it by experiment.

What effect do growing plants have on carbonic acid ?

What effect does it have on lime water ?

Illustrate it by experiment.

What is carbonic oxide ?

Can water be decomposed with carbon ?

In what manner ?

What is the gas formed ?

Can carbon be combined with hydrogen in a state of solidity ?

Illustrate it.

Why is charcoal used in refrigerators, and in coating furnaces ?

What is plumbago ?

What is steel ?

What are the constituents of oil and fat ?

What causes the difference in their consistence ?

What causes the difference between fixed and essential oils ?

To what is the facility with which oil burns owing?

To what is the difference between wax and tallow owing?

What does the combustion of a candle and lamp produce?

Illustrate this.

What forms the constituents of all vegetable acids?

What are vegetable oxides?

What use is carbon in chemical operations?

Illustrate this.

CHAP. XII.

Of Alkalies.

1. Alkalies are a class of bodies distinguished by the following properties. They impress the tongue with a peculiar acid taste, which has been termed caustic or urinous; a sensation commonly considered as contrary to sour. They have a strong affinity for water, with which they combine with great rapidity, and in great quantity. They change blue vegetable colours to green, the brown to yellow, and the yellow to orange. They corrode and dissolve animal substances. They unite with the oils and fats, and form compounds called soaps. They combine with many chemical agents, particularly the acids; with which they form the neutral salts. They are capable of being fused and volatilized by heat.

Observation. Some of the above properties are discovered in two or three of the earths; barytes and strontian have been considered as alkalies by Vauquelin and Fourcroy, and some other French chemists. But this arrangement has not been very generally received; because, as has been observed, if we admit these amongst the alkalies, there is hardly any good reason for excluding lime, magnesia, and some other of the earthy substances; and because the greater solubility and fusibility of the alkalies sufficiently distinguish them from all these substances, which have also properties common to themselves.

2. The cause of alkalies being caustic, is the strong affinity which they possess for the constituents of animal matter. In their pure state, they have a powerful attraction for water, hydrogen and carbon, which are the constituent principles of oil, and it is principally by absorbing these substances from animal matter, that they effect its decomposition; for when diluted with a sufficient quantity of water, they lose their causticity.

Illustration. Caustic potash in solution is unfit for washing, but when incorporated with oil, it forms the well known substance called soap, which is universally used as a mild and excellent cleanser of the hands and face.

3. Whenever acids are in contact with alkalies or alkaline earths, they unite with avidity and form compounds totally different in their properties from either of the constituents; these bodies are called *neutral* or *compound salts.*

Exp. To aqua fortis add carbonate of ammonia, (sal volatile) to the point of saturation; that is, until all effervescence ceases, or until fixed air ceases to be disengaged; the acid loses its acidity, and the ammonia its pungency.

4. The alkalies are divided into two kinds, *fixed* and *volatile.*

5. The fixed are those which do not evaporate on exposure to the air ; these are potash, soda and lithia.

Note.—There are a number of newly discovered vegetable alkalies, which will be treated of in the vegetable department.

6. The volatile alkali evaporates on exposure to the air, in the form of gas ; this is ammonia. It contains no oxygen.

7. Potash derived its name from the *pots*, in which the vegetables from which it is obtained, used formerly to be burnt ; the alkali remained mixed with ashes at the bottom, and was thence called potash.

8. It exists in nature in a great variety of forms and combinations, but is never found in a state of purity ; it is combined with carbonic acid, with which it exists in every part of the vegetable kingdom, and is most commonly obtained from the ashes of vegetables, which is the residue when all the other parts are volatilized by combustion.

9. Potash is obtained in the arts from wood ashes by lixiviation and evaporation.

10. Potash, as prepared in the manufactory, contains water, which is not easily separated by heat ; 100 parts usually contain about 17 parts of water. It may, therefore, properly be called *an hydrate of potash.*

11. Potash deliquesces or becomes liquid in the air, in consequence of its strong affinity for aqueous vapour.

12. It dissolves in one half its weight of water at 58°, and during the solution, heat is evolved.

Exp. Take a small quantity of potash in a phial, and holding it in one hand, add to it a little water, as the solution goes on, a sensible warmth is communicated to the hand.

Illustration. This phenomenon may probably be accounted for, by supposing that a solution of potash in water has a less capacity for heat than either of them in a separate state.

13. The specific gravity of pure potash, 1.7.

14. A perfectly pure solution of potash will remain transparent, on the addition of lime water; shew no effervescence with dilute sulphuric acid, and do not give any precipitate on blowing air from the lungs through it by means of a tube.

15. Potash in its caustic state is often used by surgeons, under the name of *potential cautery*, to open abcesses and destroy excrescences. And it was formerly used in medicine, diluted with broths, in cases of stone and gravel.

16. In an intense heat, it becomes greenish and may be vaporized, but is perfectly incombustible.

17. It may be crystallized into long compressed, quadrangular prisms, truncated by sharp pyramids.

18. It combines with carbonic acid, forming a substance called pearl ash, in commerce; and when purified, *salt of tartar.*

Exp. Heat common potash to redness in a reverberating furnace, many of the impurities will be driven off, and it becomes much whiter than before; when cool, it will be found to contain carbonic acid, and is properly a sub carbonate of potash, or potash not fully saturated with carbonic acid.

19. Potash is sometimes employed to produce a frigorific mixture, or artificial cold.

Exp. Mix quickly four parts of caustic potash in powder, and one of fine light snow in flakes, it will become liquid, and in the act of liquefying, a large quantity of caloric is absorbed; of course, cold is produced.

20. Potash converts all animal matter into a saponaceous jelly, in consequence of its attraction for water and oil.

Exp. Take caustic potash and olive oil, of each equal parts, having dissolved the potash in its own weight of water, add the oil and agitate it for a few moments, a saponaceous compound will be formed, which is perfectly miscible with water.

21. Potash fused with silex, forms glass; silex is composed of sand and flint, it is infusible by itself, but when mixed with potash, it melts, when exposed to the heat of a furnace, combines with the alkali and runs into glass, which differs in its properties according to the proportions used, the quality of the ingredients and the manner of conducting the process.

Exp. Fuse three or four parts of potash with one part of silex in a crucible, the result will be a soft brittle kind of glass, which is soluble in water; this solution is called siliceous potash, or liquor of flints.

22. Potash readily unites with sulphur, and forms the compound called *sulphuret* of potash, formerly *liver of sulphur.*

Exp. Melt two parts of potash and one of sulphur together, in a crucible, a liver brown substance will be obtained.

23. Potash is obtained not only from vegetables, but it is found on the surface of the earth, mixed with various minerals, especially with earths and stones, whence it is supposed to be conveyed into the vegetables by the roots of the plants. It is also met with, though in very small quantities, in some animal substances.

24. Potash changes the colour of blue vegetable infusions to a green.

Exp. Put into a wine glass a small quantity of tincture of red cabbage, which is of a blue colour, add to it a few drops of the solution of caustic potash, and a dark sea green colour will be produced.

25. Potash combines with all the acids, some of which are of essential service in the arts, such as its combination with nitric acid, called *salt petre;* with oxymuriatic acid, &c. It likewise combines with phosphorus, sulphuretted hydrogen, and earths; it is used as a reagent in analysis, and it is the basis of all soft soaps.

26. Potash may be considered as the hydrated deutoxide of potassium.

OF SODA.

27. Soda is the basis of sea salt, or that used for culinary purposes, which is *muriate of soda.*

28. Soda has been known by the name of mineral alkali, and is found in various parts of the earth; in minerals, sea water, and many lakes and springs. When thus found, it is called natron.

29. Soda may be obtained from common salt, but the best and usual way of obtaining it in Europe is by the combustion of marine plants, from the ashes of which it is produced in a manner similar to that for potash. It is likewise obtained by the decomposition of sulphate of soda.

30. It derives its name from a plant called sal sola soda; by the Arabians, kali, the ashes of which affords it in great abundance.

31. Soda in taste, action on vegetable colours, oils and animal matter, resembles potash, but its specific gravity is not so great.

32. When exposed to heat, it melts below ignition, and in the state of an hydrate, has the appearance of effervescence.

33. It is a non conductor of electricity.

34. Soda has so great an affinity for water that it cannot be obtained free from it but at a very high temperature, what is commonly called pure soda contains 23 *per cent* of water.

Exp. To prepare pure soda, proceed as follows. Dissolve any quantity of carbonate of soda in twice its weight of boiling water, and add to the solution while hot, an equal weight of quicklime, mixed with water to a thin paste. Boil the mixture in an iron vessel, adding as much water as is necessary to reduce the mass to the consistence of cream; boil and stir it for one hour. Then separate the liquid alkali either by filtration or subsidence, and boil it to dryness in a silver dish. Pour on the dry mass as much pure alcohol as is necessary to dissolve it. Put the solution into a phial until the insoluble part has subsided, then decant the clear liquor and distil off the alcohol. Evaporate what remains in the retort to dryness, fuse it in a silver crucible, and pour it into a silver dish. When cool, break the mass into small pieces and preserve them in a phial closely stopped.

35. Soda thus prepared will be of a greenish white colour, of a urinous taste and great causticity, acting with great violence on animal matter. Water when thrown upon it is absorbed with great violence, and much heat is evolved accompanied with an alkaline smell.

36. Potash and soda are used for the same purposes in the arts, such as in the manufacture of glass, soaps, &c.

OF LITHION OR LITHIA.

37. Lithia is a substance discovered in 1818, in some minerals in Sweden, and has been classed with the fixed alkalies

Observation. It was first discovered in the mineral called *Petalite*, in the proportion of 3 *per cent*, afterwards in the *Lepidolite*, in the proportion of about 4 *per cent;* and in the *Triphane* or *Spodomene*, in the proportion of 8 *per cent.*

38. It is readily obtained by fusing the mineral with potash, dissolving the whole in muriatic acid evaporating to dryness, and digesting in alcohol. The muriate of lithia being soluble, is taken up while the other salts remain, and by a second evaporation and solution it will be procured in a pure state.

39. Lithia differs from potash and soda. 1. By the fusibility of its salts. 2. By the great deliquescent property of its chloride, or the compound of lithia and chlorine. 3. By the comparative insolubility of its carbonate. 4. By its great capacity for acids, by which it surpasses magnesia.

40. Lithia is found to contain a metallic base analogous to potassium and sodium, and may be obtained in the same manner. This has been called Lithium.

41. Lithia unites with sulphur. Sulphuret of Lithia has a yellow colour, dissolves readily in water, and is decomposed by acids in the same way as the other alkaline sulphurets.

42. Phosphorus decomposes water with the help of caustic lithia.

Exp. Heat in a retort, phosphorus, with a solution of caustic lithia in water, phosphuretted hydrogen gas is disengaged which takes fire when it comes in contact with the air.

43. Lithia dissolves only in small quantities in alcohol of specific gravity 0.85. When weak alcohol is added to an aqueous solution of lithia in a well stopped phial, no change takes place at first, but after some

hours, the lithia precipitates in the form of a white powder.

44. Caustic lithia appears not to be much more soluble in hot than cold water. Heat is evolved during its solution in water.

OF AMMONIA.

45. Ammonia is the name given to a substance formerly called volatile alkali.

46. This substance is distinguished from the fixed alkalies by its comparative volatility, which is such that in common temperatures it can be retained in its liquid state only, by its combination with water.

Observation. This substance was unknown to the ancients ; that which they called ammonia or volatile alkali, was ammonia combined with muriatic acid.

47. Ammonia is caustic but does not corrode animal matter like potash and soda.

48. Its most simple state is that of ammoniacal gas or vapour, which is lighter than atmospheric air, but not so light as hydrogen gas.

Exp. To procure ammoniacal gas, mix one ounce of powdered sal ammoniac with two ounces of quick lime, put the mixture into a common flask, and apply a lighted lamp or candle to the bottom, ammoniacal gas will rise in abundance.

Illustration. Sal ammoniac is composed of ammonia and muriatic acid, in this experiment a decomposition takes place, the muriatic acid quits the ammonia and unites with the lime, for which it has a stronger affinity than for the ammonia ; and ammoniacal gas is evolved.

49. All animal and vegetable substances disengage ammonia when in a state of putrefaction.

50. It is procured in the large way, by distilling or burning bones, horns, and other animal substances, hence sal ammoniac has been called hartshorn. It was thought formerly, that this substance existed only in the horns of the Deer and Stag.

51. Ammoniacal gas has so strong a tendency to unite with water that it cannot be procured in the usual way, over water, in a pneumatic trough, because it would be absorbed by the water, but in order to collect it, a mercurial bath is used.

52. Water impregnated with this gas is called *hartshorn*, commonly, when spirit is used instead of water, *spirit of hartshorn*, it is the ammoniacal gas issuing from water or spirit, that causes the pungent smell, for if a phial containing it be left uncorked, the water soon becomes inodorous.

53. Water diminishes in density by being impregnated with ammoniacal gas; and this augmentation of bulk increases its capacity for caloric.

54. By incorporating with water, the ammoniacal gas is liquefied and gives out its latent caloric. The condensation of the gas more than counterbalances the expansion of the water.

55. Ammoniacal gas mixed with ice or snow produces cold.

Illustration. In this case the water or melted ice is rarefied by the impregnation of the gas, heat of course is absorbed, and cold is produced.

66. Ammonia in the state of vapour combines with sulphur and hydroguretted sulphuret of ammonia is produced.

Exp. To form this substance, distil a mixture of five parts of sal ammoniac, five parts of sulphur, and six of quick lime together.

57. Ammoniacal gas unites with muriatic acid gas;

forms the substance called muriate of ammonia, or sal ammoniac.

Exp. Into a small retort put a mixture of two parts of quicklime, and one of sal ammoniac, both in powder; apply the heat of a lamp, and having collected the gas into a large receiver, convey into it some muriatic gas; from these two invisible gases, a solid substance will be obtained in small white flakes.

58. Ammonia is considered as composed of three volumes of hydrogen and one volume of nitrogen condensed into two volumes.

59. Its specific gravity compared with that of common air is 0.590; 100 cubic inches at a mean temperature and pressure weigh 18 grains; and the weight of its atom is 21.25; that of oxygen being considered as 10.

PRACTICAL QUESTIONS.

What are alkalies, and how are they distinguished?

Do the earths possess any of these properties?

What is the cause of alkalies being caustic?

How is caustic potash rendered useful for washing?

What is the effect of the union of acids and alkalies?

How are the alkalies divided?

What are they?

Why was potash so named?

Where is it found?

How is potash prepared?

What effect does the air have on caustic potash?

What quantity of water will dissolve it?

Why is heat evolved in dissolving it?

What is its specific gravity?

What are the properties of a pure solution of caustic potash?

Under what name do surgeons use it?

What appearance does it assume in an intense heat?

Can it be crystallized?

What is pearl ash?

Illustrate it.

Is potash ever employed in freezing-mixtures?

Illustrate this by an example.

What effect does potash have on all animal matter?

What forms glass?

Does potash unite with sulphur?

Is potash found any where but in vegetables?

What effect has potash on blue vegetable colours?

Illustrate it by experiment

With what does potash combine?

What may potash be considered to be?

What is soda?

Where is it found?

How may soda be obtained?

What are the properties of soda?

What effect has heat on this substance?

Has it any affinity for water?

How do you prepare pure soda?

What will be the properties of soda thus prepared?

What is Lithia?

In what was it first discovered?

How is it obtained?

How does lithia differ from potash and soda?

What is the base of lithia called?

Does lithia unite with sulphur?

What effect has phosphorus on water when united with caustic lithia?

Does lithia dissolve in alcohol?

Is lithia more soluble in hot than cold water?

Is heat evolved during the solution?

What is Ammonia?

How is it distinguished from the fixed alkalies?

Does ammonia corrode animal substances?

In what form is its most simple state?

How do you procure ammonical gas?

Explain this process.

When do animal substances disengage ammonia?

How is ammonia manufactured?

Why cannot ammoniacal gas be produced in the usual way?

What are water and spirit impregnated with this gas called?

What effect does it have on water?

What is the theory of its producing heat in combining with water?

What does it produce when mixed with ice and snow? Why?

Does ammonia combine with sulphur?

How is sal ammoniac formed?

Illustrate this by an experiment?

Of what is ammonia composed?

What is its specific gravity?

CHAP. XIII.

Of the decomposition of the Alkalies and Earths.

1. When Sir H. Davy first turned his attention to the agency of the voltaic battery, he tried its power on a variety of compound bodies, and gradually brought to light a number of new and interesting facts, which led the way to more important discoveries. The facility with which compound bodies yielded to voltaic electricity im-

duced him to make trial of its effects on substances hitherto considered as simple, but which he suspected of being compound, and his researches were soon crowned with the most complete success.

2. The body which he first submitted to the voltaic battery, and which had never yet been decomposed, was potash. This substance gave out an elastic fluid at the positive wire of the galvanic apparatus, and at the negative wire small globules of a very bright metallic lustre, resembling in appearance mercury. Thus proving that potash which had hitherto been considered as a simple incombustible body, was in fact a metallic oxide, and that its incombustibility proceeds from its being combined with oxygen.

Observation. The wires used in the experiment must be platina, for if iron were used, the oxygen would have combined with the wires instead of appearing in the form of gas.

3. The base of potash is called *potassium*, and in order to preserve it, it must be immersed in naptha.

4. The properties of potassium are. It is brittle and crystallized in its section. It is lighter than water. Specific gravity between 8 and 9; water being 10. It is very soft and easily moulded between the fingers. At the temperature of 150° it is perfectly fluid, very much resembling quicksilver. It is volatatilized in a heat a little below that of redness. It is perfectly opaque; exposed to the air, it rapidly attracts oxygen, and becomes tarnished. It attracts oxygen much more rapidly from water than from air. When thrown upon water, it acts with great violence, the water is found to be alkaline, and to contain potash.

Exp. Throw a piece of potassium about the size of a pin's head, on the surface of water, it swims and burns

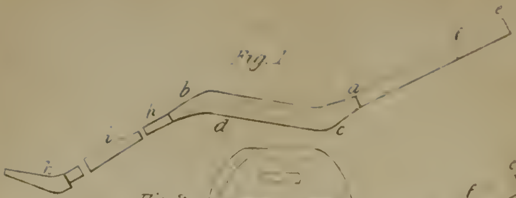


Fig. 1

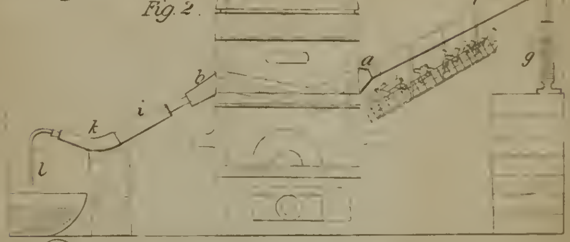


Fig. 2.

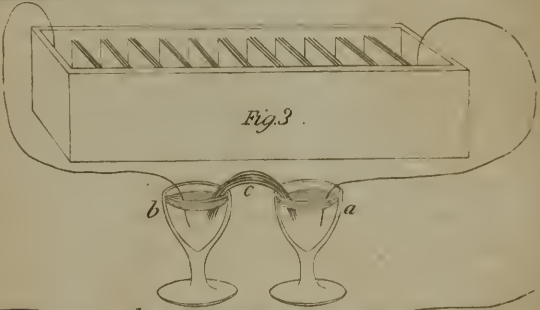


Fig. 3.

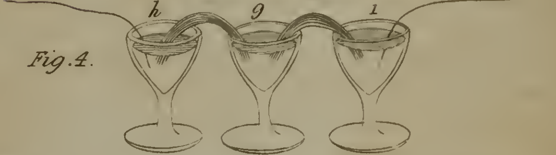


Fig. 4.

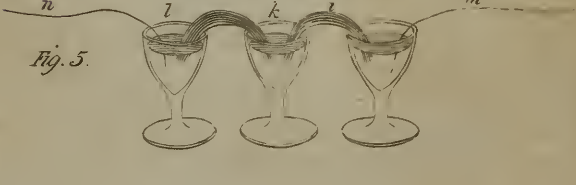


Fig. 5.

with a beautiful light, mixed with red and violet.

5. It burns spontaneously in chlorine with great brilliancy and red light, and forms chloride of potassium.

Exp. Drop a very small piece into a jar containing chlorine, it will immediately inflame.

6. It inflames spontaneously in the vapour of iodine, and consumes with a violet coloured flame; during the inflammation, it absorbs oxygen and sends off hydrogen.

7. It is soluble in hydrogen gas, forming hydroguret of potassium, which becomes inflammable in atmospheric air.

8. When potassium is heated in nitrous oxide, it burns vividly and potash is formed.

9. It inflames spontaneously in nitric oxide and upon the surface of nitric acid, the products being nitric oxide and potash, the potash immediately combines with the undecompounded acid to form a *nitrate.*

10. Potassium and sulphur combine with great energy when heated together, producing much heat and light and forming a sulphuret of potassium.

11. Sulphuret of potassium is of a grey colour, and appears to consist of 30 parts of sulphur and 70 of potassium.

12. Potassium combines readily with sodium in various proportions. A small quantity renders sodium very soft and brittle, at a common temperature potassium is rendered fluid and its specifiic gravity is considerably diminished.

13. Potassium may be obtained by chemical means, without electricity.

Exp. If turnings of iron be heated to whiteness in a curved gun barrel, plate 4, fig. 1 and 2, and if melted potash be made slowly to come in contact with the turnings, air being excluded, potassium will be formed and will collect in the cool part of the tube: it may likewise be produced, by igniting potash with charcoal.

The above method of decomposition was invented by M. M. Gay Lussac and Thenard. Fig. 1, is a gun barrel bent somewhat in the form of the letter S. Before the curvatures are given to it, the internal surface must be cleaned by stopping one end, introducing into the other, diluted sulphuric or muriatic acid, and shaking the barrel, so that every part may be exposed to the action.—After the liquid is poured out, the barrel is to be well washed with water, dried by linen or bibulous paper, and stopped at both ends.

The part which is to be exposed to heat from *a.* to *b.* is to be covered with a lute, which should be formed of fine clay and sifted sand, in the proportion of 1 to 5, thoroughly incorporated, and rendered so little plastic by the quantity of sand as to be applied with some difficulty. The lute should contain as little water as possible. The thickness of the lute over the iron should be about $\frac{63}{100}$ of an inch. It should, after the application, be allowed to dry for a few days in the shade, and then in the rays of the sun or a gentle heat; after which, the rents, if there be any, should be filled with fresh lute.—The space from *c.* to *a.* should be filled with clean iron turnings, and the barrel is to be laid across a reverberatory furnace, fig. 2, having its internal diameter equal to about 11 1-2 inches; the barrel at *a.* supporting itself on the furnace, and at *b.* being supported on a piece of brick. The two openings through which the barrel passes, are to be carefully closed with lute; which, on the inside, should consist of that which is the most infusible. The cork is then to be drawn from *e.* and 3 1-2 to 4 1-2 ounces of fused potash in fragments are to be introduced into the barrel and pushed down to *c.* fig. 1. Thus the space from *f.* to *c.* will be filled with potash, while that from *f.* to *e.* will be empty. As there is a large quantity of gas extricated in this operation, and the other end of the tube is liable to be obstructed, a passage is given to the gas by fitting a curved glass tube into *e.* and causing its mouth to open into a vessel *g.* nearly filled with mercury, and supported on a stand. Fire is then to be lighted in the furnace, and when the flame appears at the dome, pieces of linen, moistened with water, are to be applied to the part containing the potash, to prevent it from melting; a recipient is to be adopted to the gun barrel at *h.* fig. 1.

This consists of two pieces or tubes *i. k.* of copper, the mouth of the barrel being inserted into *i.* and the other extremity of *i.* embracing *k.* from which passes a curved tube that may be made to open under the surface of mercury, as seen in fig. 2. The joinings of the tubes are to be luted. Then, by means of a double bellows, the heat in the furnace is to be raised as high as possible; when this is effected, a semi-cylindrical pan is to be suspended below the barrel, reaching from *e.* to *a.* The portion of the barrel from *a.* to *e.* fig. 1, is to be heated by live coals; the potash contained in it will be melted and flow into that part which is intensely heated. A great quantity of hydrogen gas will be disengaged, and a portion of potassium will be formed and condensed at the extremity *h.* and in the recipient *i. k.* When the gas nearly ceases, another portion of the potash higher up in the barrel is to be heated; the gas will again come over, and these processes are to be repeated until the gas has been extricated from the whole.

Care must be taken that too much potash should not be melted at one time, otherwise the temperature in the first part of the barrel would be reduced too low to effect the decomposition of the potash; hence the reason why the alkali is used in fragments and not in a single piece. The best sign that the experiment goes on well, is the rapid production of gas without the disengagement of very thick vapours at the extremity of the glass tube.—The duration of the experiment, from the time of the melting of the first portion of potash, should be more than an hour.

When it is finished, the tube at *e.* should be withdrawn from the mouth of the barrel, and that of the tube at *l.* be closed with lute. The barrel is withdrawn from the furnace and cooled by the affusion of cold water, which detaches the lute.

In order to obtain the potassium which is condensed at *h.* and flows for the most part into the recipient *i. k.* the lute is removed at *h.* the mouth is closely stopped; a little oil of naptha is poured into the recipient, the two pieces are separated and the metal contained in them is made to fall into another portion of naptha. The potassium thus obtained, is commonly pure, and may be best preserved by giving it a spherical form and keeping it in naptha. By cutting off the barrel at *b.* and plunging the end in naptha, the potasssium in it may be obtained by introducing into it a cylindar of iron, nearly of the same diameter, and detaching it from the surface.

It happens that, generally, only about half of the potash is consumed in the experiment.

The nature of the lute, and its application and drying, are circumstances which have an important influence upon the success of the experiment. If it do not contain sufficient sand, or if it be badly applied or dried, it either vitrifies and runs, or it falls off and exposes the iron to oxidizement and fusion.

Several attempts have been made to simplify the above process, and to substitute a more economical one. Professor Gorham succeeded in procuring very good potassium in the following manner.

The lower part of a gun barrel properly closed, and about 16 inches in length, was luted; a mixture of dry potash and clean iron filings was introduced into it; a tube of copper was then placed in it, but out of reach of the strongest heat, and a glass tube was connected with the mouth and opened under oil of turpentine. Heat was applied until the lute and part of the barrel began to melt. On cooling it, 30 or 40 grains of good potassium were found condensed in the tube, and as much of an alloy of iron and potassium in the barrel itself. He repeated this experiment five times, in two of which, he was successful, and in three, unsuccessful.*

14. Sodium, the base of soda, is obtained in the same way as potassium, only a rather higher degree of heat is required. In appearance, it resembles silver; it is of great lustre, and is a conductor of electricity.

15. It is fusible at 200° F.

16. It is not volatilized at a heat that melts flint glass.

17. Its specific gravity is 0.97223, water being 1.

18. It absorbs oxygen from the atmosphere, and burns at an high temperature with bright sparks.

19. Sodium decomposes water with effervescence, and is inflamed in contact with nitric acid.

20. Sodium readily unites with phosphorus and sulphur, and forms compounds, less inflammable than those with potassium.

21. When heated with oxygen or chlorine, it burns with great brilliancy.

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* Gorham's elements of chemical science, vol. ii. p. 516.

22. Sodium combines with two proportions of oxygen The one is that which constitutes soda. The other is of a deep orange colour, it is formed by burning sodium in oxygen gas, an excess of the gas being present.

23. The peroxide of sodium fuses at a much less heat than soda; if thrown into water, one proportion of oxygen escapes in the form of gas, leaving soda, which dissolves in the water.

24. Sodium combines with many of the metals forming peculiar alloys.

25. When sodium is united with potassium in a small proportion, it forms an alloy which is more fusible than either of the metals. The compound is of less specific gravity, which is not common with other metallic alloys; and serves to prove that there is not a great affinity between the metals.

26. One part of sodium renders 40 of mercury solid at the common temperature of the atmosphere; when these combine, heat is disengaged.

27. Alloys of the metals and sodium when exposed to the air, separate the sodium in consequence of its combination with oxygen.

28. When potassium or sodium is heated in ammoniacal gas, the metal becomes changed to an olive green colour, and loses its metallic lustre; at the same time a portion of the gas is absorbed, and a quantity of hydrogen is emitted exactly equal to the quantity that would be evolved, if the potassium or sodium were put into water.

29. If the olive green matter be heated, it gives out three-fifths of the ammonia absorbed, two-fifths in the state of ammoniacal gas, and one-fifth in the state of hydrogen gas and azote.

30. If the olive coloured matter be placed in contact with a very little water, it is converted into potash or soda and ammoniacal gas, and the gas is just equal to what the metal had absorbed.

31. If it be placed in contact with a metal and heated, an alloy of the metal with potassium or sodium is obtained.

Observation. Dr. Thomson is of opinion, that these curious facts shew that potassium and sodium have the property of decomposing ammonia and combining with its azote, and the *azoturet*, or compound of sodium or potassium, formed, combines with a portion of the undecomposed ammonia.

The facts, however, best accord with the opinion that an unknown compound of azote and hydrogen unite with the alkaline metal, while the compound thus formed, combines with a portion of undecomposed ammonia.

32. From analogy, it has been inferred by some chemists, that ammonia contains a metallic base combined with oxygen, and many interesting experiments have been instituted to ascertain the fact; further discoveries are necessary in proof of the hypothesis.

33. Some of the earths in like manner have been decomposed and found to be oxides of metals. With these, metallic alloys have been formed with other metals.

PRACTICAL QUESTIONS.

How were the alkalies decomposed ?

What was the first alkali tried, and what was the process ?

Why could not iron wire be used in this experiment ?

What is the base of potash called ?

What are the properties of potassium ?

How can you form chloride of potassium ?

What effect has the vapour of iodine upon it?

What effect has hydrogen gas in contact with it?

What is it in nitrous oxide?

What in nitric oxide?

What phenomena do potassium and sulphur exhibit, when heated together?

What are the constituents of sulphuret of potassium?

What are the combinations of potassium with sodium?

How can potassium be obtained without electricity?

Describe Gay Lussac's and Thenard's apparatus?

Will any hydrogen gas be disengaged?

How do you give a passage to the gas?

Is it essential to attend to the quantity of potash?

Why?

How do you know that the process goes on well?

How do you obtain the potassium, after the experiment?

How can it be preserved?

How much of the potash is consumed in this experiment?

Is there any alloy formed?

What should be the nature of the lute?

Has this process been simplified?

Describe Professor Gorham's process?

How much good potassium did he obtain?

Was there any alloy?

How is sodium obtained?

At what temperature is it fusible?

When is it volatilized?

What is its specific gravity?

Does it absorb oxygen from the atmosphere?

Does sodium unite with phosphorus and sulphur?

What is the effect, when heated with oxygen or chlorine?

With how many proportions of oxygen does sodium combine, and what are their properties?

What are the phenomena attending the peroxide of chlorine?

Does sodium combine with any of the metals?

What is the compound of sodium with potassium?

What effect has sodium on mercury?

What effect does the air have on alloys of metal, with sodium?

What effect has ammoniacal gas on sodium and potassium?

When the olive green matter is heated, what does it exhibit?

What, when placed in contact with water?

When placed in contact with a metal and heated, what does it exhibit?

What is the opinion of Dr. Thomson, on this subject?

How do chemists infer that ammonia has a metallic base?

Have the earths been decomposed?

CHAP. XIV.

On the Earths.

1. The term earth in chemistry is applied to those bodies, which, until the 19th century, were all regarded as simple substances, and from the different combination of which, all those substances are formed, which are usually classed as earths and stones.

2. The number of substances classed under the name of earths, hitherto discovered, are ten, viz.

1. Barytes,
2. Strontian,
3. Lime,
4. Magnesia,
5. Alumina,
6. Yttria, or Ittria,
7. Glucina,
8. Zirconia,
9. Silica,
10. Thorina.

3. From recent discoveries, some have been led to conclude, that all earths are metallic oxides; but this has not been ascertained.

4. Their properties are; they do not combine with metals, but have an affinity for some of the metallic oxides.

5. They are divided by some chemists into two classes, viz. those which possess merely the characteristics of earths, which are insoluble in water or alcohol, or nearly so. When perfectly pure, they are in the form of white powder, destitute of smell or taste, infusible, and unalterable in the air.

6. The second class are those, which not only possess the above properties, but likewise those of an alkaline nature, having a strong taste, soluble, in some measure, in water and alcohol, and changing vegetable blues to green.

7. According to Sir H. Davy, the earths found in plants, are four, viz. silica, or the earth of flints; alumina, or pure clay; lime and magnesia. The lime is usually combined with carbonic acid.

8. Lime and silica are much more common in the vegetable kingdom than magnesia; and magnesia more than alumina.

9. The earths form a principal part of the matter of the ashes of plants, insoluble in water. The silica is distinguished by its insolubility in acids. The calcareous earth, unless the vegetable substance be very strongly ignited, dissolves with effervescence in muriatic acid.—Alumina is distinguished from the other earths, by being

acted upon very slowly by acids, and by forming salts very soluble in water, and difficult of crystallization.

10. It is on the principle of the incombustibility of earth, that its power of producing such an intense heat when mixed with other substances, arises, as in *turf* or *peat*, &c.

11. Turf is composed of roots, grass, the remnants of animal and vegetable substances, together with alumina, lime, silex, and sometimes magnesia.

12. In combustion, it is not the earths that burns, but the vegetable and animal substances. The caloric which is produced by this combustion, causes the earth to become *red hot*, and this being a bad conductor of heat, retains its caloric a long time; but the earth does not absorb oxygen or undergo any alteration in the fire. It is, however, an excellent radiator of heat, and owes its utility, when mixed with fuel, solely to that property.

Illustration. On this principle, Count Rumford recommended balls of incombustible substances to be arranged in fire places, and mixed with the coals, by which means the caloric disengaged by combustion of the latter, is more perfectly radiated, and an expense of fuel is saved.

13. Precious stones are composed of a number of earths, sometimes salts, and even metals.

14. The earths are often found crystallized in precious stones, which must have been a slow and regular work of ages.

Illustration. To account for the slow and gradual crystallization of earths in precious stones, seeing they are almost insoluble in water, we may imagine, that when water holding in solution some particles of earth, filters through the crevices of hills and mountains, and at length, drops into some cavern, each successive drop may be slowly evaporated, leaving behind it the particle of earth which it held in solution. Crystallization is more regular and perfect in proportion to the evaporation of the solvent; in this case, nature has an advantage over the artist; she carries on her operations unlimited by time, nor retarded in her gradual progress.

15. In examining the earths, we must take them as they are usually found in nature, and not when wrought or modified by art.

OF BARYTES.

16. Barytes has its name from its weight; it is the heaviest of the earths. It is usually found in the state of a sulphate.

17. The characteristics of pure barytes are, great weight, strong alkaline properties, such as turning some blue vegetable colours to green, destroying animal substances, and shewing a powerful attraction for acids.

18. Its affinity for the sulphuric acid is so great, that it will always detect its presence in any substance or combination whatever, by immediately uniting with it and forming a sulphate.

Exp. 1. Dissolve in a glass of water one grain of sulphate of soda, and add to it a few drops of nitrate of barytes in solution, white clouds will be immediately formed.

Illustration. Barytes has a stronger affinity for sulphuric acid than any other body, forming with it, in this instance, a sulphate of barytes, which is one of the most insoluble substances, and the soda unites with the water. This property of barytes renders it an excellent test for detecting the presence of any quantity, however small, of sulphuric acid.

Exp. 2. To shew its alkaline properties on vegetable colours, tinge water with Brazil wood, by an addition of a small quantity of a solution of barytes, the red will be changed to violet.

Exp. 3. In a glass of distilled water, rendered slightly blue by the tincture of red cabbage, drop a few grains of the solution of barytes, the blue will be changed to green.

19. Barytes combines with sulphur, when they are mixed together and heated in a crucible.

20. Sulphuret of barytes is of a reddish yellow colour, and when dry, without smell. When thrown into hot water, a powerful action takes place. The water is decomposed, and two new products are formed, viz. *hydro-sulphuret*, and *hydroguretted sulphuret of barytes.* The first, crystallizes as the liquor cools ; the second, remains in solution.

21. The hydro-sulphuret of barytes contains 9.7 of barytes, and 2.125 sulphuretted hydrogen.

22. The crystals are white scales, have a silky lustre, are soluble in water, and yield a solution having a greenish tinge. Taste acrid, sulphurous, and when mixed with the hydroguretted sulphuret, is corrosive. It rapidly attracts oxygen from the atmosphere, and is converted into sulphate of barytes.

23. The hydroguretted sulphuret is a compound of 9.70 barytes and 4.125 *bisulphuretted hydrogen;* or hydrogen with two proportions of sulphur ; it is contaminated with sulphite and hyposulphite in unknown proportions.

24. Barytes combines with phosphorus. It may be easily formed by exposing the constituents together, to heat in a glass tube. Their reciprocal action is so intense as to cause ignition.

25. Like phosphuret of lime, it decomposes water, and causes the disengagement of phosphuretted hydrogen

gas, which spontaneously inflames in contact with the air.

26. Barytes has been decomposed and found to contain a metallic base, called barium. It is of a dark grey colour, with a lustre inferior to that of cast iron. It is fusible at a red heat; its density is superior to that of sulphuric acid. When exposed to air, it instantly becomes covered with a crust of barytes, and when gently heated, burns with a deep red light. It effervesces violently in water, converting this liquid into a solution of barytes.

27. Barium combines with oxygen in two proportions, forming, 1st. barytes, and 2d. deutoxide of barium.

28. The salts of barytes are white, and more or less transparent. They are all poisonous except the sulphate; hence the counterpoison is the sulphuric acid diluted for the carbonate, and sulphate of soda, for the soluble salts of barytes.

OF STRONTIAN.

29. Strontia or strontian is so named from a place in Scotland, where it was first discovered.

30. Pure strontian is of a greyish white colour, and a pungent acrid taste. Its specific gravity is nearly that of barytes, being about 1.6. It is soluble in 200 times its weight of water at 50°, but little more than six times its weight at 212°. On cooling, it deposits flat rhomboidal crystals. It is likewise soluble in small proportions in alcohol. Exposed to heat, these crystals undergo aqueous fusion, and become dry; in this dry state, it requires the heat of the oxyhydrogen blow pipe to fuse it.

31. Strontian differs from barytes in being infusible, but at a very intense temperature, much less soluble, of a different form, weaker in its affinities, and not poisonous. Its saline compounds afford differences much more distinguishable.

32. The basis of strontian is strontium. It is fixed, difficulty fusible, and not volatile. It is converted into strontian on exposure to the air, and when thrown into water, decomposes it with great violence, producing hydrogen gas and a solution of strontian. Strontian is considered as composed of about 86 strontian + 14 oxygen in 100 parts.

33. Strontian when mixed with inflammable substances, causes a flame of a beautiful red colour.

Exp. 1. Take 40 parts dry nitrate of strontian, 13 parts of finely powdered sulphur, 5 parts oxymuriate of potash, (chlorate) and 4 of sulphuret of antimony. Pulverize the oxymuriate of potash, and sulphuret of antimony separately in a mortar, and then mix them together on paper; after which, add them to the other ingredients, previously powdered and mixed. Rub them together on paper, and a beautiful red flame of great brilliancy will be produced.

Exp. 2. Add a little of the solution of muriate of strontian to alcohol, kindle it, and red flames will be produced.

Exp. 3. Sprinkle a little of powdered muriate of strontian on the flame of a candle, and the flame will assume a carmine colour.

34. Strontian is slightly caustic, acting feebly on animal matter. It differs from barytes, in being infusible, much less soluble, of a different form, weaker in its affinities, and not poisonous.

OF LIME.

35. Lime is the oxide of calcium, a name given to the base of lime. It is generally combined with carbonic acid in lime stone, marble and chalk, and is essential to the constitution of marles.

36. When deprived of carbonic acid, it possesses a caustic and corrosive quality, and is called *quick lime.*

Exp. Expose carbonate of lime to a strong heat in a crucible, carbonic acid and water is disengaged, and the result is quick lime.

37. Carbonate of lime loses by calcination 40 per cent of its weight.

38. Pure lime has such an affinity for carbonic acid and water, that it cannot be preserved for any length of time but in glass vessels, closely stopped.

39. When water is added in small quantities to quick lime, the water is solidified, and heat is evolved.

Exp. Pour a little water on a lump of quick lime; the water immediately disappears, and heat is produced.

Illustration. The heat proceeds not from the lime, but from the water, and is the *latent* which causes the liquidity of the water.

40. Lime requires nearly 700 times its weight of water for its solution; in this state, it is called *lime water.*—When first made, it is perfectly clear and colourless; but it soon attracts carbonic acid from the atmosphere, and a pellicle is formed on the surface.

Exp. 1. Expose lime water in a glass, for a few minutes, to the air, the lime separates from the water, and appears on the surface in the form of a white film, which is carbonate of lime or *chalk.*

Exp. 2. Breathe into a glass of lime water, the carbonic acid which is mixed with the air expired, will separate the lime as in the last experiment.

41. Carbonate of lime is soluble in carbonic acid, but not soluble in water.

42. Lime water possesses alkaline properties, for when poured into blue vegetable infusions, they turn green.

43. Lime water, mixed with mild alkali in solution, disengages the carbonic acid, and precipitates the lime in a white powdery form, and the alkali is left pure.

44. The specific gravity of lime is 2.3.

45. It requires an intense degree of heat for its fusion, and has not been volatilized. Its taste is caustic, astringent and alkaline.

46. Slacked lime is called hydrate of lime, in consequence of its combination with water. Its solubility is not increased by heat.

47. Slacked lime is a compound of 3.56 parts lime, and 1.125 water.

48. Lime combines with phosphorus, and forms a compound of a dark brown colour, called *phosphuret of lime;* which, when thrown into water, disengages phosphuretted hydrogen gas in small bubbles, that explode in succession, at the surface of the water.

Exp. Provide a glass tube sealed at one end, into the sealed end put a small bit of phosphorus; the middle part must be filled with pieces of lime, about the size of peas. After heating the latter with a lamp, apply another lamp to the end containing the phosphorus, and cause the vapour to pass through the lime, the combination will be completed.

49. Sulphur combines with lime, by fusing the constituents together in a covered crucible. It is called sulphuret of lime.

50. It possesses the following properties. It is of a reddish colour, and very acrid. It deliquesces on exposure to the air, and becomes of a greenish yellow hue.—When it is put into water, hydroguretted sulphuret of lime is immediately formed. It acts corrosively on animal bodies, and is a powerful reagent in precipitating metals from their solutions.

51. Lime combines with chlorine and forms a substance called chloride of lime or calcium. When lime is heated in contact with chlorine, oxygen is expelled, and chlorine is absorbed.

52. It is a semi-transparent crystalline substance, fusible at a strong red heat; a non-conductor of electricity; has very little taste; rapidly absorbs water from the atmosphere, and is very soluble in water.

53. Lime has a metallic base, called *calcium;* it is of a bright silvery appearance, and combines with oxygen only in one proportion, which is lime. It burns when gently heated, producing dry lime.

54. The most important applications of lime are in agriculture and building.

55. Quicklime is found to be injurious to plants, but in its combination with carbonic acid, it is an important ingredient.

56. Lime acts as a cement in two ways; in its combination with water, and in that of carbonic acid.

57. When quicklime is rapidly made into a paste with water, it soon loses its softness; the water and the lime form together a solid coherent mass, which consists of 1 part of water to 3 parts of lime. When hydrate of lime, whilst it is consolidating, is mixed with red oxide of iron, alumina, or silica, the mixture becomes harder and more coherent, than when lime alone is used.

Illustration. This is owing to a certain degree of chemical attraction between hydrate of lime and these bodies, and they render it less liable to decompose by the carbonic acid in the air, and less soluble in water.

58. The basis of all cements that are used for works which are to be covered with water, must be formed from lime.

59. *Puzzolano* is composed principally of silica, alumina and oxide of iron; and it is used, mixed with iron, to form cements intended to be employed under water.

60. *Tarras*, is basaltes decomposed, two parts of slacked lime, and one of tarras, form the cement used in constructing the great dykes in Holland.

PRACTICAL QUESTIONS.

To what is the term earth applied?

What are the names and number of the earths?

What are the earths considered to be?

How are they divided by some chemists?

What do these classes include?

What are the earths found in plants?

Which are the most common in vegetables?

What part of the ashes of plants do they form?

From what does the power of producing intense heat in turf and peat, arise?

Of what is turf or peat composed?

What use are earths in combustion?

What was Count Rumford's recommendation?

Of what are precious stones composed?

In what state are the earths found in precious stones?

How do you account for this?

How must you proceed in examining the earths?

What is barytes?

What are its properties?

How is its affinity for sulphuric acid?

What experiment can you adduce to prove this?

Illustrate the principle.

How do you shew its alkaline properties on vegetables?

Will barytes combine with sulphur?

What are the properties of sulphuret of barytes?

What are the constituents of hydrosulphuret of barytes?

What are the properties of the crystals of the hydrosulphuret?

What is the hydroguretted sulphuret?

How may phosphuret of barytes be formed?

What are its properties?

What are the characteristics of *barium?*

In how many proportions does it combine with oxygen?

What property do the salts of barytes possess?

What is strontian?

What are the characteristics of strontian?

How does it differ from barytes?

What is the basis of strontian, and its properties?

What effect has strontian on inflammable substances?

How would you illustrate this by experiment?

Is strontian caustic?

What is lime?

What does it possess, when deprived of carbonic acid?

How much does carbonate of lime lose by calcination?

How can you preserve pure lime?

What is the effect, when small quantities of water are added to quicklime?

Illustrate this.

How much water does lime require for its solution?

How will you prove that water attracts carbonic acid from the atmosphere?

In what is carbonate of lime soluble?

How do you prove that lime water possesses alkaline properties?

What effect has mild alkali on water?

What is the specific gravity of lime?

Can lime be fused and volatilized?

What is slacked lime called?

Of what is it compounded?

What is the combination of lime with phosphorus?

How would you prepare phosphuret of lime?

How is sulphur combined with lime?

What properties does it possess?

What is chloride of lime?

What are its properties?

What is the base of lime?

What are the most important applications of lime?

What effect has it on vegetation?

How does lime act as a cement?

What is the effect of quicklime, when rapidly made into a paste with water?

Is there any way to render mortar harder and more coherent, than when lime alone is used?

To what is this owing?

Of what must be the basis of all cements that are covered with water?

What is Puzzolana?

What is Tarras?

CHAP. XV.

Of Magnesia—Alumina—Yttria—Glucina—Zirconia—Silica, and Thorina.

1. Magnesia is never found pure in nature, but is usually procured from the sulphate of magnesia, *Epsom salt*, which exists in sea water, and in mineral springs.

Exp. Dissolve the sulphate of magnesia in water, and add to it half as much in weight of pure potash; a decomposition takes place, the sulphuric acid of the sulphate unites with the potash in consequence of superior affinity, and the magnesia is precipitated. Wash the precipitate several times with pure water, and the magnesia in a state of an hydro-carbonate will be obtained. To procure it pure, calcine it in a crucible, until it will no longer effervesce with distilled vinegar.

2. Magnesia, when pure, is destitute of smell, and has a slight alkaline taste. It converts vegetable blues to green, gives out heat like lime, on the affusion of water. It is very sparingly soluble in water, requiring for its solution 2000 times its weight. It forms with acids extremely soluble salts.

3. The specific gravity of magnesia is 2.3.

4. It is infusible, except by the oxyhydrogen blow pipe. It has scarcely any taste or smell.

5. When precipitated from the sulphate, it is combined with water, constituting an *hydrate*, which separates by a red heat.

6. This hydrate contains about one fourth its weight of water.

7. When magnesia is exposed to the air, it very slowly attracts carbonic acid.

8. Magnesia combines with sulphur, forming a sulphuret.

9. The magnesia of commerce is often found mixed with carbonate of lime; if this be the case, sulphuric acid will detect the fraud; it dissolves the magnesia, while the lime falls to the bottom.

Exp. Take a small quantity of magnesia, and add a little sulphuric acid, diluted with five or six times its weight of water; if the solution be transparent, it is pure, but if there be a sediment, it may be considered as mixed with lime.

10. The base of magnesia is called magnesium, and may be obtained by passing potassium in vapour through it, heated to whiteness in a tube of platinum, out of contact of the air, and then introducing a small quantity of mercury, and heating it gently in the tube; an amalgam is obtained, which must be distilled, excluded from the atmosphere, a dark grey metallic film will be obtained, which is infusible at the point at which plate glass softens, and which in the process of the distillation with the mercury, renders the glass black at its point of contact with it.

11. The film as above obtained, burns with a red light when strongly heated, and becomes converted into a white powder, which is magnesia.

12. When exposed to the air, magnesium absorbs oxygen, and is converted into magnesia.

13. According to late experiments, magnesia consists of 60 parts magnesium, and 40 oxygen.

14. Magnesia is found to exist in *talc*, *asbestos*, *amianthus* slate, and in a certain limestone, which contains it in very great quantities.

15. Its principal use is in medicine, chiefly to combine with, and neutralize the acids found in the stomach.

OF ALUMINA.

16. Alumina derives its name from the compound salt called alum, or more properly sulphate of alumina, of which it forms the base. The purest native alumina is found in the sapphire and ruby.

Exp. Dissolve alum, *sulphate of alumina*, in 20 times its weight of water, and add to it a little of the carbonate of soda, to throw down any iron that there may chance to be combined with it; then pour the *supernatant liquid*, a little at a time, into the water of ammonia, taking care not to add so much as to saturate the ammonia ; the ammonia will unite with the sulphuric acid of the alum, and the earthy basis of the latter is separated in a white spongy precipitate. This must be thrown on a filter, washed with pure water, and then dried.

17. Alumina thus obtained, possesses the following properties. It is white, soft to the touch, adheres to the tongue, forms a smooth paste without grittiness in the mouth, insipid, inodorous, produces no change in vegetable colours, insoluble in water, but mixes with it readily in every proportion, and retains a small quantity with considerable force. It is infusible in the strongest heat of a furnace, becoming merely more compact and hard. It is fusible in small quantities by the oxyhydrogen blow pipe.

18. In the state of powder, its specific gravity is 2.000.

19. From analogy, we are led to conclude, that the base of alumina is a metal possessing similar properties as other earthy bases ; but this subject has not been fully investigated.

20. Alumina is a constituent of every soil, and almost every rock. It is the basis of pottery, bricks and crucibles.

21. In the state of clay, it forms large strata of the earth, gives consistency to the soil of valleys, and of all low and damp spots, such as swamps and marshes.

22. The solid compact soils, such as are fit for corn, owe their compactness in a great measure to alumina. This earth is therefore used to improve sandy or chalky soils, which do not contain a sufficient quantity of water for the purpose of vegetation.

23. Combined with silex and water, which harden it, alumina forms bricks and porcelain; the silex renders it

capable of a degree of *vitrification*, and makes it perfectly fit for its various purposes.

24. Bricks consist of baked clay, silex, or common sand, and an oxide of iron to which they owe their red colour.

25. The common earthen ware is made of clay and sand.

26. For porcelain, the purest kind of sand is used, with the best kind of clay; it owes its *semi-transparency* to a kind of vitrification of the sand.

27. Earthen ware and porcelain are covered with a glazing, to render them more beautiful, and to prevent their being corroded by a variety of substances.

28. The glazing for porcelain consists of enamel, a fine white opake glass, formed of metallic oxides, sand, salt, and such other materials as are susceptible of vitrification.

29. The glazing of common earthen ware is made principally of the oxide of lead, or sometimes merely of common salt, as for stone ware; this, at a certain temperature, will run into an opake glass.

30. The colours used for painting porcelain are all metallic oxides, capable of enduring a great degree of heat without injury; by undergoing different degrees of oxidation, the colours are strengthened and developed.

Illustration. The oxide of gold is employed for purple, red is given by the oxide of iron, yellow by the oxide of silver, green by copper, and blue by cobalt.

31. Alumina has a strong affinity for vegetable colouring matter, and is used as a mordant by the dyer and calico printer.

32. Alumina is found combined in different proportions, in various gems and other minerals. Many of the

precious stones are almost wholly formed of alumina, coloured with some metallic oxide.

Observation. Such as ruby, oriental, sapphire, amathysts, &c.

33. *Fuller's earth* is a compound of alumina and silex. It is of great importance in scouring cloth, and in taking out spots of grease from the floor and other substances, from the affinity which alumina manifests for greasy substances.

34. On the principle, that the bulk of alumina diminishes in proportion to the heat to which it is exposed, is founded the pyrometer of Mr. Wedgwood, for measuring high degrees of temperature.

35. The salts of alumina possess the following characters.

1. Most of them are very soluble in water, and their solutions have a rough sweetish taste.

2. Ammonia precipitates their earthy base, even though they have been previously *acidulated* with muriatic acid.

3. At a strong heat, they give out a portion of their acid.

4. Phosphate of ammonia gives a white precipitate.

5. Hydriodate of potash produces a flocculent precipitate of a white colour, passing into a permanent yellow.

6. These salts are not affected by oxalate of ammonia, tartaric acid, ferroprussiate of potash, or tincture of galls; by the first two tests they are distinguished from yttria, and by the last two from that earth and glucina.

7. If bisulphate of potash be added to a solution of an aluminous salt, moderately concentrated, octahedral crystals of alum will form.

OF YTTRIA, OR ITTRIA.

36. Yttria is an earth, discovered in 1794, in a stone from Ytterby in Sweden, by professor Gadolin.

37. It is perfectly white, when not contaminated with oxide of manganese, from which it is not easily freed.—Its specific gravity is 4.842. It has neither taste nor smell. It is infusible by itself, but when mixed with borax, melts into a transparent glass. It is insoluble in water and caustic fixed alkalis, but is soluble in carbonate of ammonia. It is soluble in most of the acids.

38. Yttria is considered as having a metallic base similar in its properties to the bases of the other earths, and is called *Yttrium.*

OF GLUCINA.

39. Glucina is an earth obtained from the beryl or emerald, a transparent stone of a green colour, found crystallized in the mountains of Siberia. It was discovered by Vauquelin.

40. Glucina derives its name from the Greek word signifying sweet, because it imparts a saccharine taste to all the acids with which it unites, and forms salts.

41. It is a white soft powder, light, insipid and adhering to the tongue. It does not change vegetable blues. It does not harden by heat, and is infusible. It is insoluble in water, but forms with it a slight ductile paste. It is dissolved by potash, soda and carbonate of ammonia, but not by pure ammonia. It unites with sulphuretted hydrogen. Its salts have a saccharine taste, with somewhat of astringency.

42. Glucina is considered as a compound of oxygen and a certain metallic base called *Glucinum.*

OF ZIRCONIA.

43. Zirconia is a substance found in the zircon or jargon, and the hyacinth.

44. It possesses neither taste nor smell. It is infusible before the blow pipe, but when subjected to a very high temperature in a charcoal crucible, it undergoes a sort of imperfect fusion, acquires a greyish colour, and a porcelaneous appearance. It is insoluble in water, or in the alkaline solutions. Its specific gravity is 4.3.

45. Zirconia has a considerable affinity to water, and when precipitated from its acid solutions, it is called an *hydrate*, which has the appearance of rosin or glue.

46. The hydrate contains more than 20 *per cent* of water, which may be expelled by heat.

47. Zirconia is considered as a compound of a metal and oxygen. Potassium when brought into contact with zirconia, ignited to whiteness, is, for the most part, converted into potash; and dark particles, which, when examined by a magnifying glass, appear metallic in some parts, of a chocolate brown in others, are found diffused through the potash and the decompounded earth.

OF SILICA.

48. Silex or silica abounds in almost all fossils and precious stones, particularly those which strike fire with steel. It exists nearly pure in transparent quartz or rock crystal.

Exp. To obtain silica, ignite powdered quartz with three parts of pure potash in a silver crucible, dissolve the fused compound in water, add to the solution a quantity of acid, sufficient to saturate the alkali, then evaporate to dryness, a fine gritty powder will be obtained, which being well washed with distilled water, and ignited, will leave pure silica.

49. It is a white powder, of a harsh and gritty feel. Specific gravity 2.66. It is fusible only by the oxyhydrogen blow pipe. It is acted upon by no acid, but the fluoric, and appears to be insoluble in water, although nature by some process dissolves it, and crystallizes it in the form of *rock crystal.*

50. The value of siliceous earth in many arts is very extensive. It is used in the manufacture of glass, pottery, bricks, porcelain, &c. It likewise forms one of the ingredients of the most durable mortars and cements.

51. Silica and potash, or soda fused together, form glass. It is of different qualities, according to the ingredients used.

Illustration. Flint glass is formed of soda or potash, flints, and an oxide of lead. Window glass is composed of an alkali and fine sand. Bottle glass of kelp and common sand; its green colour is owing to the presence of iron.

Exp. Take one part of pure white sand, and three parts of potash, mix them into a paste, and fuse them in a crucible, the result is glass.

52. Silica is considered as a compound of a peculiar combustible principle with oxygen. By passing the vapour of potassium over silica in an ignited tube, Sir H. Davy obtained a dark coloured powder, which contained silicon, or the basis of silica.

53. It is capable of sustaining an high temperature, without any change; water of potash seems to form with it an olive coloured solution. But as this basis is decomposed by water, it is not possible to wash away the potash by this liquid. Berzelius and Stromeyer tried to form a compound of silicon with iron, by exposing

to the strongest heat of a blast furnace, a mixture of 3 parts of iron, 1.5 silica, and 0.66 charcoal. It was in the state of fused globules. These freed from the charcoal, were white and ductile, and their solution in muriatic acid evolved more hydrogen, than an equal weight of iron. The specific gravity of the alloy was from 6.7 to 7.3, while that of the iron used was 7.8285. Nothing definite, however, can be inferred from these experiments.

54. Sir H. Davy found that more than three parts of potassium were necessary to decompose one of silica.— Hence it may be inferred, that 100 parts of silica contain about 60 of oxygen.

55. Silicon is insoluble in alcohol, ether, or the oils, at any temperature, and is a non-conductor of electricity.

56. Silica forms with fluorine, a substance which though not sour, seems to partake of the properties of an acid, and called *fluo-silicic acid*, or *silicated fluoric acid.*

OF THORINA.

57. Thorina is a new earth, discovered in 1816, by Berzelius. He found it in small quantities in the gadolinite, and two new minerals, which he named the deuto-fluate of cerium, and the double fluate of cerium and yttria.

58. It has the appearance of a gelatinous semi-transparent mass. When washed and dried it becomes white, absorbs carbonic acid, and dissolves with effervescence in acids. When dissolved in muriatic acid, the solution has a yellowish colour, but it becomes colourless when mixed with water.

59. It differs from all other species of earths, except zirconia ; in this, that the neutral solutions have a pure-

ly astringent taste, which is neither sweet, saline, bitter, nor metallic.

60. When dissolved in sulphuric acid, with a slight excess of acid, and subjected to evaporation, it yields transparent crystals, which are not altered by exposure to the air, and which have a strong *styptic taste.*

61. It is soluble in nitric and muriatic acids, and combines with avidity with carbonic acid.

62. Thorina differs from zirconia by the following properties. 1. After being heated to redness, it is still capable of being dissolved in acids. 2. Sulphate of potash does not precipitate it from its solution, while it precipitates zirconia containing even a considerable excess of acid. 3. It is precipitated with oxalate of ammonia, which is not the case with zirconia. 4. Sulphate of thorina crystallizes readily, while sulphate of zirconia, when free from alkali, forms, when dried, a gelatinous transparent mass, without any trace of crystallization.

63. The supposed metallic base of thorina, is called *Thorinum.* It has not yet been extracted.

PRACTICAL QUESTIONS.

How is magnesia procured ?

Illustrate it by experiment.

What are the properties of magnesia ?

What is its specific gravity ?

Is it fusible ?

What is the hydrate of magnesia ?

How much water does it contain ?

What is the effect on magnesia when exposed to the air ?

With what is the magnesia of commerce mixed, and how is the fraud detected ?

How is the base of magnesia obtained ?

How do you prove that this film is magnesia ?

Of what does magnesia consist ?

Where is magnesia found to exist ?

What is the use of magnesia ?

What is alumina ?

How do you procure pure alumina ?

What are the properties of alumina thus obtained ?

What is its specific gravity ?

How do you conclude that the base of alumina is a metal ?

Of what is alumina the constituent ?

What does it form in the state of clay ?

What use is this earth in agriculture ?

Of what use is silex in forming bricks and mortar ?

Of what do bricks consist ?

Of what is common earthen ware made ?

What is used for porcelain ?

What is the use of glazing earthen ware and porcelain ?

Of what does the glazing for porcelain consist ?

Of what is the glazing of common earthen ware and stone ware made ?

What are the colours used for painting porcelain ?

Why is alumina used as a mordant ?

Where is alumina found ?

What is fuller's earth, and why does it remove grease spots ?

On what principle is Wedgwood's pyrometer formed ?

What are the characteristics of the salts of alumina ?

What is yttria ?

What are its characteristics ?

Has it a metallic base ?

What is glucina ?

From what does it derive its name ?

What are its characteristics ?
What is glucina considered to be ?
What is zirconia ?
What are its properties ?
Has it any affinity for water ?
How much water does the hydrate contain ?
How is it proved that zirconia has a metallic base
Where is silex or silica found ?
How do you obtain it pure ?
What are its properties ?
Is silica of any value ?
Of what is glass composed ?
What is silica considered to be ?
What are the properties of its base ?
How much potassium is requisite to decompose it ?
Is silica soluble in alcohol, ether and oils ?
What does silica form with fluorine ?
What is thorina, and where found ?
What are its characteristics ?
How does it differ from other species of earths ?
What is the sulphate of thorina ?
Is it soluble in other acids ?
How does thorina differ from zirconia ?
What is the base of thorina ?

CHAP. XVI.

Of Acids.

1. Acids are the most important class of all chemical compounds ; they consist of a certain base, called a radical, and an acidifier.

2. The general properties of the acids are, 1. Their taste is, for the most part, *sour*, as their name denotes; and in the strongest, it is acrid and corrosive. 2. They generally combine with water in every proportion, with a condensation of volume and evolution of heat. 3. With a few exceptions, they are volatilized and decomposed by heat. 4. They usually change the purple colours of vegetables to a bright red; and 5. They appear to unite in definite proportions, with earths, alkalies, and metallic oxides, forming *salts*.

3. Until within a few years, oxygen was considered to be the only acidifier, whence its name; but late experiments have led some to doubt the correctness of the hypothesis, and to consider other substances as acidifiers.

4. By the new nomenclature, acids are distinguished by the name of the base, and its degree of oxidation, or the quantity of oxygen it contains, by the termination of that name, in *ous* or *ic*.

Illustration. Sulphur*ous* acid is that formed by a proportion of oxygen combined with sulphur: sulphur*ic*, that which results from the combination of sulphur with another quantity of oxygen.

5. Several of the *radicals* are capable of combining with a quantity of oxygen so small as not to impart to them the properties of acids; in these cases they are converted into oxides.

Exp. Expose sulphur to the atmosphere with a degree of heat that will not produce inflammation, it will absorb a quantity of oxygen, and will assume a red or brown colour. This is the first degree of oxygenation; the second is the sulphurous acid; the third hypo sulphurous; the fourth the sulphuric; and if there be another, it will be the *super oxygenated* sulphuric acid, or the hypo sulphuric.

6. Some of the acids are susceptible of only one degree of oxygenation, others of two or three , there are very few that will admit of more.

7. The class of acids has been distributed into three orders, by many chemists, viz. the mineral, vegetable and animal acids. But a more specific difference is now necessary. They have also been arranged into those which have a single, and those of a compound basis, or radical. This arrangement, however, is not only vague, but liable in many other respects to considerable objections.

8. The chief object of classification is to give general views to beginners in the study, by arranging together such substances as have analogous properties, or composition.

9. The number of acid substances hitherto discovered are seventy-five, and may be arranged in the following divisions and subdivisions. 1. Acids from inorganic nature, or which are procurable without having recourse to animal or vegetable products. 2. Acids obtained by means of organization.

The first division is subdivided into three families ; 1st. Oxygen acids. 2d. Hydrogen acids. 3d. Acids destitute of both these supposed acidifiers.

Division 1st.—Acids from inorganic nature.

First family—Oxygen acids.

Section 1st, Non-metallic.

1. Boracic.
2. Carbonic.
3. Chloric.
4. Perchloric.
5. Chloro-carbonous.
6. Nitrous.
7. Nitric.
8. Iodic.

9. Hypophosphorous.
10. Phosphorous.
11. Phosphoric.
12. Hyposulphurous.
13. Sulphurous.
14. Sulphuric.
15. Hyposulphuric.
16. Cyanic ?

Section 2d, Oxygen acids.—Metallic.

1. Arsenic.
2. Arsenious.
3. Antimonious.
4. Antimonic.
5. Chromic.
6. Columbic.
7. Molybdic.
8. Molybdous.
9. Tungstic.

Second family—Hydrogen acids.

1. Fluoric.
2. Hydriodic.
3. Hydrochloric.
4. Ferroprussic.
5. Hydroprussic.
6. Hydrosulphurous.
7. Hydrotellurous.
8. Sulphuroprussic.

Third family—Acids without oxygen or hydrogen.

1. Chloriodic.
2. Chloroprussic.
3. Fluoboric.
4. Fluosilicic.

Division 2d.—Acids of organic origin.

1. Aceric.
2. Acetic.
3. Amniotic.
4. Benzoic.
5. Boletic.
6. Camphoric.
7. Caseic.
8. Citric.
9. Formic.
10. Fungic.
11. Gallic.
12. Kinic.
13. Laccic.
14. Lactic.
15. Lampic.
16. Lithic.
17. Malic.
18. Meconic.
19. Menispermic.
20. Margaric.
21. Melassic.
22. Mellitic.
23. Moroxylic.
24. Mucic.
25. Oleic.
26. Oxalic.

27. Purpuric.
28 Pyrolithic.
29. Pyromalic.
30. Pyrotartaric.
31. Rosacic.
32. Saclactic.
33. Sebacic.
34. Suberic.
35. Succinic.
36. Sulphovinic ?
37. Tartaric.
38. Zumic.

10. The acids of organic origin are all decomposable at a red heat, and afford generally carbon, hydrogen, oxygen, and in some few cases, nitrogen.

11. The acids of simple and known radicals are capable of being decomposed by combustible bodies, to which they yield their oxygen.

Exp. Drop a little sulphuric acid on a piece of bright iron, a black spot will be produced, which is an oxide formed by the oxygen of the acid, combining with the iron.

12. Acid added to a compound combustible substance, will combine with one or more of the constituents of that substance, and occasion a decomposition.

Exp. Take a dry piece of pine wood and pour upon it some sulphuric acid, in a short time the wood becomes black.

Illustration. Wood is composed of hydrogen and carbon, the oxygen of the acid combines with the hydrogen of the wood, to form water, and the carbon remaining, appears of its usual black colour.

13. When vegetable acids are poured on wood, they do not produce the same effect as mineral acids, because their bases are composed of hydrogen and carbon; the oxygen, therefore, will not easily quit the radical where it is already united with hydrogen. The strongest vegetable acids may, perhaps, yield a little of their oxygen to the wood, and produce a stain, but the carbon will not be sufficiently exposed to assume its black colour.

14. Mineral acids possess the power of charring wood in different degrees.

15. *Boracic acid* is obtained from borax, a substance brought from the East Indies and South America ; it is crystallizable in the form of thin irregular hexagonal scales, of a silvery whiteness, having some resemblance to spermaceti. It has a sourish taste at first, and then a bitterish cooling one, and at last an agreeable sweetness. It has no smell, but when sulphuric acid is poured upon it, its odour resembles that of musk. Its specific gravity in the form of scales is 1.479 ; after it has been fused, 1.803. It is not altered by light. In its crystallized state, it is composed of 57 parts of acid, and 43 of water.

16. The radical of the boracic acid is *boron*. It is solid, tasteless, inodorous, and of a greenish brown colour. Its specific gravity is somewhat greater than water.

17. Carbonic acid is formed by the combustion of carbon, whether in the form of charcoal, or in its purest form of diamond.

Exp. Light a piece of charcoal and suspend it under a receiver in a water bath; after the charcoal is extinguished, examine the air and it will be found to be carbonic acid.

18. Carbonic acid may be separated from the air with which it is mixed, by introducing into a receiver, containing carbonic acid, a little caustic lime or caustic potash, which soon attracts the whole of the carbonic acid to form a carbonate, the alkali is found increased in weight, and the volume of the air is diminished by a quantity equal to that of the carbonic acid which was mixed with it.

19. Carbonic acid abounds in great quantities in nature, and appears to be produced in a variety of circum-

stances. It composes $\frac{44}{100}$ of the weight of limestone, marble, calcareous spar, and other calcareous substances.

20. Water at low temperature and at common pressure, absorbs somewhat more than its bulk of *fixed air*, and then constitutes a weak acid. Heated water absorbs less; if water impregnated with this acid be exposed on a brisk fire, the rapid escape of the gas in bubbles affords an appearance as if the water were at the point of boiling, when the heat is not equal to 100°.

21. No degree of cold has exhibited this acid in a condensed state of fluidity.

22. Carbonic acid gas is emitted in large quantities from bodies in the state of the vinous fermentation. On account of its great weight, it occupies the upper part of the vessels in which the fermenting process is going on.

Exp. 1. Dip a lighted taper or candle into the empty space of a vessel, containing a liquor undergoing the vinous fermentation, it will be immediately extinguished, and the smoke remaining in the carbonic acid gas renders its surface visible, which may be thrown into waves, by agitation, like water.

Exp. 2. If a dish of water be immersed in this gas and quickly agitated, it soon becomes impregnated, and acquires a pungent taste.

Exp. 3. If a candle or small animal be placed in a deep vessel, the former becomes extinct, and the latter expires in a few seconds, after the carbonic acid gas is poured from another vessel upon them, though the eye is incapable of distinguishing any thing that is poured.

23. Carbonic acid reddens infusion of litmus; but the redness vanishes on exposure to the air, as the acid flies off.

24. Light, passing through carbonic acid, is refracted, but it does not effect any sensible alteration in it, though it appears from experiment, that it favours the separation of its principles by other substances.

25. The specific gravity of carbonic acid compared with that of atmospheric air, is as 1.5236 to 1.0000.

26. Water by absorbing its volume of this gas, acquires a specific gravity of 1.0015. By pressure and by means of forcing pumps, water may be made to absorb two or three times its volume of this gas. When there is a little soda added, it becomes the aerated, or *soda water* of the shops. 100 cubic inches of oxygen weighs 33.8 grs. and 100 cubic inches of carbonic acid, 46.5 grs. ; hence the weight of combined charcoal in 100 cubic inches of carbonic acid is 12.7 grs.

27. Carbonic acid unites with the alkalies, earths, and some of the metallic oxides, forming salts called *carbonates*, which possess peculiar properties.

28. Carbonates are composed either of one prime of the acid, and one of the base, or of two of the acid and one of the base ; the former are called carbonates, the latter bi-carbonates.

29. Carbonic acid gas is not respirable, yet it is formed in the lungs ; so that the air which we *expire*, always contains a certain proportion of carbonic acid, which is much greater than that which is found commonly in the atmosphere.

Exp. Prepare some lime water, and breath into it through a tube or pipe, the water immediately becomes turbid in consequence of the union of the lime with the carbonic acid of the lungs.

PRACTICAL QUESTIONS.

Of what do acids consist ?

What are the general properties of the acids ?

Is oxygen the only acidifier ?

How are acids distinguished by the new nomenclature ?

Illustrate it.

Suppose the oxygen should not produce an acid, what would you call it ?

Of how many degrees of oxygenation are the acids capable ?

How are the class of acids distributed ?

What is the object of classification ?

What are the number of acids ?

Name the acids.

How are the acids of organic origin decomposable ?

How are acids of simple and known radicals decomposable ?

Illustrate by experiment.

Why does sulphuric acid turn wood black ?

Why do not vegetable acids produce the same effect ?

Do mineral acids possess the power of charring wood equally ?

What is boracic acid, its specific gravity and properties ?

What is its base ?

How is carbonic acid formed ?

How do you form it in experiment ?

How can you separate carbonic acid from the air with which it is mixed ?

Where is carbonic acid found ?

What effect has water upon it ?

Can it be condensed into fluidity ?

Is it emitted from vinous fermentation ?

Prove it by experiment.

Has it any effect on vegetable colours ?

What effect has it on light ?

What is its specific gravity ?

What specific gravity does water acquire by absorbing this gas ?

With what does carbonic acid unite ?

What are carbonates and bi-carbonates ?

Is this gas respirable ?

CHAP. XVII.

Continuation of Acids.

1. Muriatic acid is that obtained from sea salt, *Muriate of soda*, by distillation with sulphuric acid. It is procured in the form of gas and absorbed in water.

2. When this gas is received in glass jars over mercury, it is invisible and possesses all the mechanical properties of air. Its odour is pungent and peculiar. Its taste acrid and corrosive. It will not support respiration or combustion, is changed in bulk by alteration of temperature.

Exp. Fill a jar with the gas and immerse in it a lighted taper, it is immediately extinguished.

3. Muriatic gas consists of chlorine and hydrogen united in equal volumes, and by the new nomenclature, called *hydro chloric acid.*

Exp. When potassium, tin or zinc, is heated in contact with this gas over mercury, one half of the volume disappears, the remainder is found to be pure hydrogen, and the solid residue is found to be a metallic chloride.

4. Muriatic acid gas has a very strong affinity for water, as is evident, from its forming a white cloud in contact with the atmosphere, which proceeds from its combination with aqueous vapour.

5. The solution of this gas is commonly of a pale yellow colour ; it may be rendered colourless by repeated distillations.

6. The cause of the colour is not known.

7. Its specific gravity as commonly obtained, is about 1.170, in which state it contains about 25 *per cent* of dry acid.

8. No liquid acid appears capable of existing when the proportion of gas is much more than four or five hundred times the volume of water employed in its preparation. At this strength, it appears to contain about 48 per cent of the acid gas. Its specific gravity is 1.5, and its boiling point 60°.

9. Its boiling point gradually lessens with a less proportion of gas, till it arrives at 12 *per cent* of gas, when it boils at 232°.

10. When the acid gas is in greater proportion than 12 *per cent*, the gas escapes until it arrives at that standard ; and when in a less proportion, the water escapes, to reduce it to the same standard.

11. Muriatic acid combines with earths, alkalies, and metallic oxides, forming substances called muriates.

12. Muriates, when in a state of dryness, are chlorides, being a combination of the base with the chlorine of the acid, but the least moisture causes them to pass to the state of muriates or *hydrochlorides*. Chlorides, properly speaking, contain neither an acid nor an alkali.

13. Chloric acid has the same base as muriatic, namely, *chlorine*.

Exp. When a current of chlorine is passed for some time through a solution of barytic earth in warm water, a substance called hyperoxymuriate of barytes is formed as well as some common muriate. The latter is separated by boiling some phosphate of silver in the compound solution. The former may then be obtained by evaporation in fine rhomboidal prisms. When a few drops of sulphuric acid diluted is added, the liquid becomes sensibly acid. By continuing to add sulphuric acid with caution, an acid liquid entirely free from sulphuric acid which has united with the barytes, will be obtained, which is chloric acid dissolved in water.

14. Its properties are ; it has no sensible smell. Its solution in water is perfectly colourless. Its taste is very acid, and it reddens litmus without destroying the colour. It produces no alteration on solution of indigo in sulphuric acid. Light does not decompose it. It may be kept a long time exposed to the air, without sensible diminution. When concentrated, it has something of an oily consistence. When exposed to heat, it is partly decomposed into oxygen and chlorine, and partly volatilized without alteration.

15. Chloric acid is decomposed by muriatic, sulphurous acid, and sulphuretted hydrogen. Combined with ammonia, it forms a fulminating salt. It does not precipitate any metallic solution. It readily dissolves zinc, disengaging hydrogen ; but it acts slowly on mercury.

16. Chloric acid forms salts with the alkalies and earths, called chlorates, or *hyperoxymuriates.*

17. Perchloric acid is procured by pouring three parts of sulphuric acid on one of chlorate of potash in a retort, perchlorate of potash will be obtained, and by adding sulphuric acid, at 280° perchloric acid is produced.

It seems to consist of 7 parts of oxygen, combined with 1 of chlorine, or 7.0 + 4.45.

18. *Chloro carbonous* acid is composed of chlorine and protoxide of carbon.

Observation. Experiments made by Dr. John Davy, go to prove that chlorine and carbonic oxide unite rapidly, when exposed to the direct solar beams, and one volume of each is condensed into one volume of the compound. The resulting gas possesses very peculiar properties, approaching to those of an acid. From the peculiar influence of the sun beams in effecting this combination, Dr. Davy called it *phosgene gas.*

19. Its properties are; it does not fume in the atmosphere. Its odour is different from that of chlorine. It affects the eyes in a peculiar manner, producing a rapid flow of tears, and occasioning painful sensations.—It reddens dry litmus paper; and condenses four volumes of ammonia into a white salt, while heat is evolved.—Neither sulphur, phosphorus, oxygen, nor hydrogen, though aided by heat, produce any change on the acid gas; but oxygen and hydrogen together, in due proportion, explode in it. On exposure to water, it is converted into muriatic and carbonic acid gases.

20. According to Thenard, chloro carbonous acid is a compound of muriatic and carbonic acids, resulting from the mutual actions of the oxymuriatic acid and carbonic oxide.

21. Nitrous acid was formerly called *fuming nitrous acid.* It is in the form of an orange coloured liquid. It is so volatile as to boil at the heat of 82°.

22. Its specific gravity is 1.450.

23. When mixed with water it is decomposed, and nitrous gas is disengaged, with effervescence.

24. It is composed of one volume of oxygen, united with two of nitrous gas. It appears to form a distinct genus of salts, called *nitrites.*

25. Nitric acid is composed of oxygen and nitrogen, which are the constituents of the atmosphere, and differs in nothing from the air we breathe, except in the proportion of the ingredients, and in their complete chemical union.

Exp. 1. Mix the two gases in a glass tube, and pass through them a number of electric explosions, the gases will combine, and nitric acid will be formed about the inside of the tube. This method of proving the composition, is called the *synthetic.*

Exp. 2. Place a porcelain tube across a furnace, and adjust the apparatus as in the decomposition of water, when the tube becomes red hot, pass the acid through it, it will be found to consist of nitrogen and oxygen gases. This method is called the analytical method of proving it.

26. This acid contains a large proportion of oxygen, but retains it with very little force. It is therefore very corrosive, and destroys, or burns, all kinds of organized matter.

Exp. Take strong nitric acid and pour a few drops into a glass, containing oil of turpentine, a violent inflammation immediately ensues. This experiment succeeds best when a little sulphuric acid is added with the nitric.

27. The properties of nitric acid are ; it is clear and colourless, like water. Its smell pungent. Its taste exceedingly acid, and it imparts a yellow stain to the skin.

28. Nitric acid dissolves or oxidates almost all metals in consequence of the facility with which it parts with its oxygen.

29. Nitric acid is generally obtained from *nitre*, or *salt petre*, by distillation with sulphuric acid. When diluted, it is called *aqua fortis*. Nitric acid combines with alkalies, earths and metallic oxides, forming a genus of salts called *nitrates*.

30. *Iodic acid* is obtained from the action of sulphuric acid on the iodate of barytes, made by causing barytic water to act on iodine.

31. Iodic acid, when pure, has a strong acid astringent taste, but no smell. Its density is considerably greater than that of sulphuric acid. It melts, and is decomposed into iodine and oxygen, at a temperature of about 620°. It consists of 15.5 iodine, 5. oxygen.

32. Iodic acid deliquesces in the air, and is very soluble in water. It first reddens, and then destroys the blues of vegetable infusions. It blanches other vegetable colours. It appears to form combinations with all the fluid or solid acids, which it does not decompose.

33. Hypophosphorous acid is obtained from the phosphuret of barytes, by means of sulphuric acid.

34. It has a very sour taste, reddens vegetable blues, and does not crystallize. The hypophosphites have the property of being all soluble in water. The hypophosphorous acid is probably composed of 2 primes of phosphorus $= 3. + 1$ of oxygen.

35. Phosphorous acid is obtained from the action of phosphorus and corrosive sublimate, in an elevated temperature. In a liquid state it consists of 80.7 acid $+$ 19.3 water. Its prime equivalent is 2.5.

36. It has a very sour taste, reddens vegetable blues, and forms salts with the salifiable bases. When heated strongly in open vessels, it inflames, phosphuretted hydrogen is evolved, and phosphoric acid remains.

37. *Phosphoric acid* abounds in the mineral, vegetable and animal kingdoms.

38. Its general characters are ; it is soluble in water in all proportions. It produces heat when mixed with water. When pure, it has no smell, its taste is sour, but not corrosive. When perfectly dry it sublimes in close vessels. When considerably diluted with water and evaporated, the aqueous vapour carries up a small portion of the acid. With charcoal or inflammable matter, in a strong heat, it loses its oxygen and becomes converted into phosphorus. Its composition appears to be 100 phosphorus + 134.5 oxygen, whence its equivalent is 3.500.

39. Phosphoric acid for general purposes is extracted from bones, which are phosphate of lime ; when calcined, sulphuric acid is added to them in powder, a decomposition ensues, sulphuric acid combines with the lime, and the phosphoric acid is set at liberty.

40. Hyposulphurous acid has been obtained from a class of salts, formed by an acid of sulphur, having a proportion of oxygen less than that of sulphurous acid.

Observation. Mr. Herschel mixed a diluted solution of hyposulphite of strontites, with a slight excess of diluted sulphuric acid, and after agitation, poured the mixture on three filtres. The first was received into a solution of carbonate of potash, from which it expelled carbonic acid gas. The second portion being received successively into nitrates of silver and mercury, precipitated the metals copiously in the state of sulphurets, but produced no effect on solutions of copper, iron or zinc.—The third, being tasted, was acid, astringent and bitter. When fresh filtered, it was clear, but became milky on standing, depositing sulphur, and coloured sulphuric acid. A moderate exposure to air or heat, caused its entire decomposition. The prime equivalent of this acid is found to be 59.25. It is composed of 20 sulphur + 10 oxygen·

41. Hyposulphurous acid unites with alkalies and earths, forming compounds called *hyposulphites.*

42. *Hyposulphuric acid* is obtained by passing sulphurous acid gas over the black oxide of manganese; a combination takes place, the excess of the oxide of manganese is separated by dissolving the hyposulphate of manganese in water. Caustic barytes precipitates the manganese and forms with the new acid a very soluble salt, which freed from the excess of barytes by a current of carbonic acid, crystallizes regularly.. To this salt in solution, sulphuric acid is cautiously added, which throws down the barytes, and leaves the hyposulphuric acid in the water.

43. It has the following properties. It is decomposed by heat into sulphurous and sulphuric acids. It forms soluble salts with strontites, barytes, lime, lead and silver. The hyposulphates yield sulphurous acid, when their solutions are mixed with acids, if the mixture becomes hot of itself or by artificial heat. They disengage a large quantity of sulphurous acid at an high temperature, and are converted into neutral sulphates.. It is composed of 8 sulphur + 10 oxygen.

44. *Sulphurous acid* may be obtained by heating sulphuric acid with mercury, or bits of copper in a glass retort.

Exp. Put two parts of sulphuric acid and one of mercury into a glass retort, and apply to it the heat of an Argand's lamp, the mixture effervesces, and throws off a gas, which should be received over mercury, this gas is sulphurous acid.

45. Sulphurous acid in a state of gas is colourless and invisible. It is incapable of maintaining combustion, and deleterious to animal life. It possesses a strong suffocating odour; 100 cubic inches weigh about 68 grains. Its specific gravity, when compared with hydrogen, is as 30. to 1. It whitens many animal and vegetable substances.

46. Water at 61° absorbs 33 times its volume, and when saturated, acquires the specific gravity of 1.6513 at 68°.

47. It is decomposed by hydrogen, carbon, and sulphuretted hydrogen gas, when assisted by heat. It oxidizes iron and zinc.

48. It consists of sulphur 68
Oxygen 32
———
100

49. Sulphuric acid so named from its being prepared from sulphur, has been long known by the name of *oil of vitriol*, from its oily appearance, and *vitriolic acid* from its being first prepared from iron.

50. Sulphuric acid has a strong affinity for water, and when combined with it, which is the state we meet within it, is properly an *hydro sulphuric.*

51. It is composed of sulphur, oxygen and water, and when good, its specific gravity should be 1.8485.

52. It is slightly viscid, transparent and colourless; destitute of smell, of a strong acid taste. When diluted with an equal weight of water, it freezes at — 38° F. and boils at 580°. It absorbs water rapidly from the atmosphere. When water is mixed with it, the temperature is suddenly increased.

Exp. Take a small quantity of water in one glass, and about twice as much by measure of sulphuric acid in another, let them both be of the common temperature of the atmosphere ; suddenly mix them, and the heat will be increased to the boiling point of water.

Illustration The bulk of the two bodies when mixed is less than when they were in a separate state ; this accounts for the sudden extrication of caloric.

53. Diluted acid having a specific gravity of 1.6321, has suffered the greatest condensation ; 100 parts in bulk have become 92.14. If either more or less acid exist in the compound, the volume will be increased. The cause of the maximum condensation at this particular point of dilution is unknown.

54. Sulphuric acid is decomposed, when mixed with inflammable bodies.

Exp. 1. If a piece of charcoal made red hot be immersed in common concentrated sulphuric acid, the acid will be decomposed and part of its oxygen is attracted by the charcoal forming carbonic acid, while part of the acid goes off in thick white fumes.

Exp. 2. Phosphorus, with the aid of heat, decomposes the sulphuric acid by absorbing a part of its oxygen.

Exp. 3. Immerse bits of straw in this acid, they become black.

Illustration. Vegetables are composed of carbon, hydrogen and oxygen ; the hydrogen of the vegetable combines with the oxygen of the acid, and leaves the straw in a carbonized state.

55. Sulphuric acid decomposes water, and the hydrogen gas is evolved.

Exp. Pour sulphuric acid diluted with water on some filings of iron or zinc, a violent action takes place ; the hydrogen of the water is disengaged in the form of gas, while the oxygen combines with the metal and forms an oxide.

56. Sulphuric acid does not oxidize gold, platinum, tungsten, or titanium.

57. Sulphuric acid unites with all the alkalies and earths, except silica, and with many of the metallic oxides, forming a peculiar kind of salts, called sulphates.

58. Sulphuric acid, in its concentrated state, consists, in 100 parts, of 30 sulphur, 45 oxygen, 25 water.

59. It is employed in a variety of manufactures, in dyeing ; in medicine and pharmacy ; and is therefore of considerable importance.

60. Cyanic acid, hydrocyanic acid, is usually called prussic acid, and is an acid obtained from the beautiful blue pigment, called Prussian blue, which is a compound of prussic acid with iron and alumina.

Exp. To a quantity of powdered prussian blue diffused in boiling water, let red oxide of mercury be added in successive portions, until the blue colour is destroyed. Filter the liquid and concentrate by evaporation, until a pellicle appears. On cooling, crystals of prussiate or cyanide of mercury will be formed. Dry these and put them into a tubulated glass retort, to the beak of which, is adopted a horizontal tube, about two feet long and fully half an inch wide at its middle part. The first third part of the tube next the retort is filled with small pieces of white marble, the two other thirds with fused muriate of lime. To the end of this tube is adopted a small receiver, which should be immersed in ice. Pour on the crystals, muriatic acid, in rather less quantity than is sufficient to saturate the oxide of mercury which formed them. Apply a very gentle heat to the retort. Hydrocyanic acid will be evolved in vapour, and will condense in the tube. If muriatic acid passes over, it will be obstructed by the marble, while the water will be absorbed by the muriate of lime. By means of a moderate heat applied to the tube, the acid may be made to pass successively along, and after being left sometime in contact with muriate of lime, it may be, finally, driven into the receiver. As the carbonic acid evolved from the marble by the muriatic is apt to carry off some of the prussic acid, care should be taken in conducting the distillation.

61. Prussic acid is a colourless liquid, possessing a strong odour of *peach blossoms ;* when snuffed up the nose, it may produce sickness, or fainting. Its taste is cooling at first, then hot, and operates as a most virulent poison, producing almost instant death on animals. Its specific gravity at 44½° is 0.7058 ; at 64° it is 0.6969.—It boils at 81½° and congeals at about 3°. It then crystallizes regularly, sometimes in the fibrous form of nitrate of ammonia. The cold which it produces, when reduced to vapour, even at the temperature of 68°, is sufficient to congeal it.

Exp. Put a small drop on a piece of glass tube or slip of paper, it will become solid.

62. The specific gravity of its vapour, *experimentally compared*, to that of air, is 0.9476 to 1.0000. By calculation from its constituents, it is 0.9360.

63. The small density of prussic acid compared with its great volatility, furnishes a proof that the density of vapours does not depend upon the boiling point of the liquids that furnish them, but upon their peculiar constitution.

64. This acid, when procured for experiment or medicinal purposes, must be made use of as soon as possible, as it cannot be preserved, even in close stopped phials, for any length of time, without decomposition.

65. Prussic acid has a strong affinity for metallic oxides, and precipitates the solution of iron in acids, of a blue colour, which is called *Prussian blue.*

66. To form Prussian blue, the peroxide of iron should be used, as the protoxide produces a pale blue colour, which will not be deep or permanent, unless exposed for some time to the air, whence it imbibes oxygen.

Exp. Take a solution of green sulphate of iron, and add to it a solution of prussiate of potash, a dirty green precipitate will be formed, which, on exposure to the air, assumes a pale blue colour. If we now pour nitrous acid upon it, the Prussian blue colour will be immediately produced, as the acid yields its oxygen to the precipitate.

67. Prussic acid is composed of hydrogen, nitrogen and carbon ; not a trace of oxygen has ever been found in it.

PRACTICAL QUESTIONS.

What is muriatic acid ?

What are the properties of the gas ?

Of what does it consist ?

Has it any affinity for water ?

What is the colour of a solution of this gas ?

What is the cause of the colour ?

What is its specific gravity ?

When is the liquid acid capable of existing ?

When it contains 48 per cent of the acid gas, what is its specific gravity ?

What is its boiling point ?

What phenomena attend the boiling of this acid ?

With what does it combine and form ?

What are muriates ?

What is chloric acid ?

How do you form it ?

What are its properties ?

How is it decomposed ?

What does it form with the alkalies and earths ?

How is perchloric acid obtained ?

Of what is chloro-carbonous acid composed ?

What are its properties ?

What is the opinion of Thenard with regard to its composition ?

What is nitrous acid ?

Of what is it composed ?

Of what is nitric acid composed ?

How do you prove it synthetically and analytically ?

What is the cause of its corrosive and burning quality ?

What are the properties of nitric acid ?

Why does it oxidate metals ?

How is it obtained ?

What does it form with earths and alkalies ?

How is iodic acid obtained ?

What are its properties ?

What effect does the air and water have upon it, and how does it effect vegetable colours ?

How is hypophosphorous acid obtained ?

What are its properties ?

How is phosphorous acid obtained ?

What are its properties ?

Where is phosphoric acid found ?

What are its characters ?

How is it obtained ?

How is hyposulphurous acid obtained ?

How did Mr. Herschell obtain it ?

Does it unite with salifiable bases ?

How is hyposulphuric acid obtained ?

What are its properties?

How can sulphurous acid be obtained?

What are its properties?

How much will water absorb?

What will decompose it?

Of what does it consist?

What is sulphuric acid?

Has sulphuric acid any affinity for water?

Of what is it composed?

What are its properties?

Why is caloric extricated when this acid is mixed with water?

Why does it turn wood black?

When added in a diluted state to iron filings, what is decomposed?

What does it form with the alkalies, earths and metallic oxides?

Of what does it consist?

Is it much used?

What is cyanic acid, or hydrocyanic acid?

How do you form it?

What are its characteristics?

What is the specific gravity of its vapour?

What proof does its small density furnish?

Is it easily decomposed?

Has it any affinity for metallic oxides?

What should be used to form Prussian blue?

Of what is it composed?

CHAP. XVIII.

Of Oxygen Acids—Metallic.

1. Arsenic acid is formed from a metal called arsenic.

2. It is obtained from the white substance called arsenic of the shops, which is the oxide of arsenic, by heating it with nitric acid.

3. It does not crystallize, but attracts the moisture of the air, has a sharp caustic taste, reddens blue vegetable colours, is fixed in the fire, and is a violent poison. Its specific gravity is 3.391. It appears to consist of 100 metal, and from 52 to 53 oxygen.

4. Combustible substances decompose this acid.

Exp. If two parts of arsenic acid be mixed with one of charcoal, the mixture introduced into a glass retort, coated, and a matrass adopted to it, and the retort then gradually heated in a reverberatory furnace till the bottom is red; the mass will be violently inflamed, and the acid reduced and rise to the neck of the retort in the metallic state, mixed with a little oxide and charcoal powder; a few drops of water will be found in the receiver.

5. The arsenic acid combines with the earthy and alkaline bases, forming salts, called *arseniates*; they are decomposable by charcoal, which separates the arsenic from them by means of heat.

6. Arsenic acid does not act on gold or platinum, nor on mercury or silver, without the aid of a strong heat; but it oxidizes copper, iron, lead, tin, zinc, bismuth, antimony, cobalt, nickel, manganese, and arsenic.

7. Arsenious acid is the white arsenic of the shops, which is a compound of the metal with oxygen.

8. It is a most virulent poison. It reddens some of the blue vegetable colours, and turns the syrup of violets green. When thrown on burning coals, it emits white fumes, which have a strong smell of garlic. It is acted upon by hydrogen and carbon, which deprive it of its oxygen at a red heat, and reduce the metal; the former forming water, the latter carbonic acid, with the oxygen.

9. Its specific gravity is 3.7. It is composed of metal 9.5. oxygen $+$ 3. Its prime equivalent is 12.5.

10. It is soluble in thirteen times its weight of boiling water, but requires eighty times its weight of cold.

Exp. When a mixture of arsenious acid with quicklime is heated in a glass tube, at a certain temperature, ignition suddenly pervades the whole mass, and metallic arsenic sublimes. As arseniate of lime is found at the bottom of the tube, we infer that a portion of the arsenious acid is robbed of its oxygen to complete the acidification of the rest.

11. Arsenious acid is used in numerous instances in the arts, and some in medicine. It has lately been used as an *alterative*, with advantage, in chronic rheumatism.

12. Antimonious acid is obtained from the metal of that name, and is the *tritoxide*, or third degree of oxygenation of the metal, by immediate combustion. It was formerly called, from its white appearance, *argentine flowers of antimony.* It may also be formed by digesting hot nitric acid on the metal.

13. Antimonious acid when fused with one fourth of antimony, loses one portion of its oxygen, and is converted into the deutoxide of antimony.

14. Antimonious acid forms salts with different bases, called antimonites.

15. It consists of 78.6 antimony, and + 21.4 oxygen.

16. Antimonic acid is the peroxide of antimony.

17. It is formed when the metal in powder is ignited with six times its weight of nitre in a silver crucible.—The excess of potash and nitre being afterwards separated with hot water, the antimoniate of potash is then to be decomposed by muriatic acid, when the antimonic acid, of a straw colour, will be obtained.

18. It is insoluble in water, but reddens vegetable blues. It does not combine with acids. At a red heat, oxygen is disengaged, and antimonious acid is produced.

19. *Chromic acid* has been obtained from the chromate of lead, or the red lead ore of Siberia, and from the chromate of iron, an abundance of which, exists near Baltimore, in Maryland. The acid is the tritoxide of chrome.

20. It is soluble in water, and crystallizes by cooling and evaporation, in long prisms of a ruby red. Its taste is acrid and styptic. Its specific gravity is not exactly known, but it always exceeds that of water. It powerfully reddens the tincture of turnsole.

21. The chromic acid readily unites with alkalies, and is the only acid that has the property of colouring its salts. The salts are called chromates.

22. Chromic acid causes different coloured precipitates with the metallic oxides.

Exp. 1. Precipitate mercury from its solution in nitric acid, by chromic acid, a dark cinnabar coloured substance will be thrown down.

Exp. 2. Add chromic acid to a solution of nitrate of silver, a precipitate is formed, which, at first is of a beautiful carmine, but becomes purple by exposure to light.

Exp. 3. With nitrate of copper, it gives a chesnut red precipitate.

Exp. 4. With solutions of sulphate of zinc, muriate of bismuth, muriate of antimony, nitrate of nickel, and muriate of platina, chromic acid produces yellowish precipitates.

Exp. 5. With muriate of gold, it produces a greenish precipitate.

Exp. 6. If paper be impregnated with the acid and exposed to the sun a few days, it assumes a green colour, which remains permanent in the dark.

23. *Columbic acid* is an acid obtained from a metal called columbium, or tantalium, or *yttro-tantalite.*

24. It is in the form of a white powder, which is insoluble in nitric and sulphuric acids, but partially in muriatic.

25. It forms with barytes an insoluble salt. Its proportions are inferred to be 100 metal, and 5.485 oxygen.

26. Molybdic acid is a substance obtained from the metal, called Molybdenum.

27. It changes vegetable blues to red ; unites with the alkalies, forming salts, called molybdates, and precipitates the metals from their solutions. Its specific gravity is 3.460 ; and its prime equivalent is 9, consisting of 3 of oxygen + 6 of metal.

28. Molybdous acid is the deutoxide of molybdenum. It is of a blue colour, and possesses acid properties. It reddens vegetable blues, and forms salts with the bases.

29. Air or water when left to act sometime on the metal, convert it into this acid.

30. It consists of 100 metal, and 34 oxygen, nearly.

31. Tungstic acid has been found only in two minerals, the one formerly called tungsten, tungstate of lime,

the other is composed of tungstic acid, oxide of iron, and a little oxide of manganese, called *Wolfram*.

32. The tungstic acid is tasteless and does not redden vegetable blues. It unites and forms salts with the bases, such as earths, alkalies, and metallic oxides.

33. It is composed of 100 parts metallic tungsten, and 25, or 26.4 oxygen.

PRACTICAL QUESTIONS.

How is arsenic acid obtained ?
What are its properties ?
What effect have combustible substances on this acid ?
With what does it combine ?
Does it act on the metals ?
What is arsenious acid ?
What are its properties ?
What is its specific gravity ?
What is its solubility ?
Is arsenious acid of much use ?
How is antimonious acid obtained ?
What phenomena does it exhibit when fused ?
What does it form ?
Of what does it consist ?
What is antimonic acid ?
How is it formed ?
What are its properties ?
Of what is it composed ?
From what has chromic acid been obtained ?
What are its properties ?
Does it unite with alkalies ?
What effect does it have on metallic oxides ?
What is columbic acid ?
What are its characteristics ?
What is molybdic acid ?

What are its characteristics ?
What is molybdous acid ?
What effect have air and water on the metal ?
Of what does it consist ?
Where has tungstic acid been found ?
What are its characteristics ?
Of what is it composed ?

CHAP. XIX.

Continuation of Acids.—Hydrogen Acids.

1. Fluoric acid is obtained from the fluate of lime, known by the name of Derbyshire spar, or *fluor spar*, a name acquired from the circumstance of its being used to render the ores of metals more fluid, when fused.

2. The spar has been long known, and in use for a variety of ornamental and other purposes ; but its real nature was not ascertained until Scheele discovered that it consisted of lime, united with a peculiar acid, which has obtained the name of *fluoric acid.*

3. It may be prepared by placing powdered fluor spar in a retort of lead or silver, with a receiver of the same metal adopted, if its weight of sulphuric acid be then poured upon it, the fluoric acid will be disengaged by the application of a moderate heat.

4. This acid gas readily combines with water, for which purpose it is necessary that the receiver should be half filled with that fluid.

5. When the receiver is surrounded with pounded ice, and no water put into it, the acid condensed is an intensely active fluid. It has the appearance of sulphuric

acid, but is much more volatile, and emits white fumes when exposed to the air. Its specific gravity is only 1.0000. When applied to the skin, it instantly corrodes it, and produces wounds very difficult to heal. When potassium is introduced into it, it acts with intense energy, and produces hydrogen gas and a neutral salt. When lime is made to act upon it, a violent heat is excited, water is formed, and the same substance as fluor spar is produced. With water in a certain proportion, its density is increased to 1.25. When it is dropped into water, a hissing noise is perceived, with much heat, and an acid fluid, not disagreeable to the taste, is formed, if the water be in sufficient quantity. It instantly corrodes and dissolves glass, in consequence of its great affinity for silex.

Exp. Coat a piece of common window glass with wax, and then with a pin draw any figures on it you please, by scratching the wax through to the glass; pour over it fluoric acid, and it will corrode the glass only where the wax has been removed, and produce a representation similar to an engraving. Or the glass may be placed on a cup containing the sulphuric acid and fluor spar; the cup placed in a temperature of 212°, the gas which arises will corrode equally as well as the liquid acid.

6. Fluoric acid is regarded as a compound of hydrogen, and a principle which acts the part of an acidifier, and which is found only in the fluates, called *fluorine.*

7. *Hydriodic acid* resembles the muriatic in being gaseous in its insulated state.

8. It may be prepared in the following manner.—Mix 4 parts of iodine with one of phosphorus, in a small glass retort, apply a gentle heat, and add a few drops of water from time to time, a gas comes over, which must

be received over mercury; or it may be condensed with water in the same manner as muriatic acid.

9. In the state of gas, its specific gravity is 4.4; 100 cubic inches weigh 134.2 grains. It is elastic and invisible, but has a smell somewhat similar to muriatic acid. It is composed of iodine and hydrogen, by weight 8.61 iodine, 0.0694 hydrogen.

10. Hydriodic acid is partly decomposed at a red heat, and its decomposition is complete; if oxygen be present, water is formed, and iodine separated.

11. *Ferroprussic acid* is obtained in the following manner. Into a solution of what is usually called prussiate of potash, pour hydrosulphuret of barytes as long as any preceipitate forms. Throw the whole on a filtre, and wash it with cold water. Dry it, and having dissolved 100 parts in cold water, add gradually 30 of concentrated sulphuric acid, agitate the mixture, and set it aside until the liquor becomes clear; this is ferroprussic acid, or *ferruretted chyazic acid.*

12. It has a pale lemon yellow colour, but no smell. Heat and light decompose it. Hydrocyanic acid is then formed, and white ferroprussiate of iron, which soon becomes blue.

13. Its affinity for the salifiable bases enables it to displace acetic acid without heat from the acetates, and to form ferroprussiates.

14. The base of this acid is prussine, or that which generates blue, which is united to hydrogen as its acidifier.

15. *Hydrosulphurous acid* is sulphurous acid combined with hydrogen.

16. Hydrotelluric acid is a combination of tellurium with hydrogen. It combines with the alkalies. Its smell is very strong and peculiar.

17. *Sulphuroprussic acid*, or sulphuretted chyazic acid is a transparent and colourless liquid, possessing a strong odour, somewhat resembling acetic acid. Its specific gravity is 1.022. It dissolves a little sulphur at a boiling heat, it then blackens nitrate of silver, but the pure acid throws down the silver white. By repeated distillations, the sulphur is separated, and the acid decomposed.

18. It combines with the earths and alkalies, and forms salts, called *sulphuroprussiates.*

ACIDS WITHOUT OXYGEN OR HYDROGEN.

19. Chloriodic acid was formed, by Sir H. Davy, by admitting chlorine in excess to known quantities of iodine, in vessels exhausted of air, and repeatedly heating the sublimate. Operating in this way, he found that iodine absorbed less than one third of its weight of chlorine.

20. It is of a bright yellow colour ; when fused, it becomes of a deep orange, and when rendered elastic, it forms a deep orange coloured gas. It is capable of combining with much iodine, when they are heated together ; its colour becomes in consequence deeper, and the chloriodic acid and the iodine rise together in the elastic state.

21. A triple compound of this acid and sodium may exist, according to Sir H. Davy, in sea water, and in common soot.

22. Chloro-prussic acid, or chloro-cyanic acid, was formerly called oxy-prussic acid; it is found, however, not to contain oxygen, but is a compound of chlorine and prussic acid.

23. When hydro-cyanic acid is mixed with chlorine, it acquires new properties. Its odour is much increas-

ed. It no longer forms Prussian blue with solutions of iron, but a green precipitate, which becomes blue by the addition of sulphurous acid.

24. It consists, according to M. Gay Lussac, of equal volumes of chlorine and prussine, or the base of the prussic acid.

25. *Fluoboric acid* is obtained from fluor spar and vitreous boracic acid, by mixing together one part boracic acid, two fluor spar, and twelve oil of vitriol, and distilling in a glass retort. It is obtained in the form of gas.

26. 100 cubic inches of this gas weigh 73.5 grains. Its density is to that of air as 2.371 to 1.000. It is colourless, its smell is pungent, resembling that of muriatic acid. It will not support respiration or combustion. It reddens strongly the tincture of turnsole. It attacks violently animal and vegetable substances. Exposed to a high temperature, it is not decomposed. It is condensed by cold without changing its form. When it is put in contact with oxygen or air, it suffers no change, except seizing, at ordinary temperatures, the water which they contain, and becomes a liquid, emitting extremely dense fumes. It operates in the same way with all the gases, which contain moisture. However little they may contain, it occasions in them very perceptible vapours.

27. Fluoboric acid gas is very soluble in water. It can combine, according to Dr. Davy, with 700 times its own volume, or twice its weight at the ordinary temperature and pressure of the atmosphere. The liquid has a specific gravity of 1.770.

28. Fluo-silicic acid is a combination of fluorine with silicon. It contains in 100 parts 61.4 silicon.

Exp. If the mixture of fluor spar and sulphuric acid be distilled in glass vessels, the glass would be acted upon, and a peculiar gaseous substance be produced, which must be collected over mercury.

29. This gas is very heavy, 100 cubic inches of it weighs 110.77 grains ; its specific gravity is to that of air as 3.632 to 1.000. It is about 48 times denser than hydrogen. When brought into contact with water, it instantly deposites a gelatinous substance, which is hydrate of silica. It produces white fumes when suffered to pass into the atmosphere. It is not affected by any of the common combustible bodies; but when potassium is strongly heated in it, it takes fire and burns with a deep red light, the gas is absorbed, and a rose coloured substance is formed, which yields alkali to water, with slight effervescence, and contains a combustible body.

PRACTICAL QUESTIONS.

How is fluoric acid obtained ?
Who ascertained the real nature of fluor spar ?
How may fluoric acid be prepared ?
What are its properties ?
What is fluoric acid considered to be ?
What does hydriodic acid resemble ?
How may it be prepared ?
What are its characteristics ?
How is it decomposed ?
How is ferroprussic acid obtained ?
What are its characteristics ?
What enables it to displace acetic acid ?
What is its composition ?
What is hydrosulphurous acid ?
What is hydrotellurous acid ?
What is sulphuroprussic acid ?
With what does it combine ?
What is chloriodic acid ?

What are its characteristics ?

Where may a triple compound of this acid and sodium exist ?

What is chloroprussic acid ?

What is the effect when hydrocyanic acid is mixed with chlorine ?

Of what does it consist ?

From what is fluoboric acid obtained ?

What are its characteristics ?

Is it soluble in water ?

What is fluosilicic acid ?

What is its weight and properties ?

CHAP. XX.

Acids of organic origin.

1. Acids of organic origin are those obtained from animal and vegetable substances. Those which have hitherto been discovered, amount to thirty-eight.

2. Aceric acid is a peculiar acid, said to exist in the juice of the maple, (*acer saccharinum.*) It is decomposed by heat, like the other vegetable acids.

3. Acetic acid is the same acid, which, in a diluted state, is called vinegar, and formerly *acetous acid.*

4. This acid is found combined with potash in the juice of many plants. It is the result, likewise, of spontaneous fermentation, to which liquid, vegetable and animal matters are liable.

5. The varieties of acetic acid known in commerce, are four. 1. Wine vinegar. 2. Malt vinegar, or that obtained from beer. 3 Sugar vinegar, or the result of

the acetic fermentation of saccharine solutions. 4. Wood vinegar or *pyroligneous acid.*

6. Acetic acid enters into combination with the salifiable bases, and forms substances called *acetates.*

7. They are characterized by the pungent smell of vinegar which they exhale on mixing them with sulphuric acid. They are all soluble in water; many of them cannot be crystallized. About 30 different acetates have been formed.

8. Acetic acid when highly concentrated is pungent and acrid, and corrodes animal substances.

9. Amniotic acid is obtained from the *liquor amnii* of the cow, by evaporation and crystallization.

10. These crystals when washed in cold water, are white and shining, slightly acid to the taste, redden litmus paper, and are a little more soluble in hot than cold water. They are likewise soluble in alcohol. This acid forms with the alkalies, very soluble salts. When thrown on burning coals the crystals of the acid swell, turn black, give out ammonia and prussic acid, and leave a bulky coal.

11. Benzoic acid was so named because it was first obtained from the resin of benzoin. It is found in a variety of substances. If we concentrate the urine of horses and cows, and pour muriatic acid on the mass, a copious precipitate of benzoic acid will be formed. It is used in medicine under the name of *flowers of Benjamin.*

12. Benzoic acid is a very fine, light substance, in needle-form crystals. It combines with alkalies, earths, and metallic oxides, forming benzoates. It is soluble in boiling water, and also in alcohol, in the latter case it is precipitated by the addition of water.

13. Boletic acid is extracted from the expressed juice

of the *boletus pseudo-igniarius*, a species of mushroom

14. Boletic acid, when properly prepared, consists of crystals of irregular four sided prisms, of a white colour, permanent in the air. Its taste resembles cream of tartar. At the temperature of 68° it dissolves in 180 times its weight of water, and in 45 of alcohol. It reddens vegetable blues. It precipitates the red oxide of iron, and the oxides of silver from their solutions in nitric acid. It sublimes, when heated, in white vapours, and is condensed into a white powder.

15. Camphoric acid is obtained from camphor, by distilling it with nitric acid, it is in the shape of crystals.

16. These are in the form of parallelopipedons, but of so delicate a structure, that they efflorecse in the air. They are of a slightly acid taste, and redden vegetable blues. The acid forms camphorates with alkalies, earths and metallic oxides,

17. Caseic acid is the name given to the acid found in cheese to which the flavour has been ascribed.

18. The citric acid is obtained from the juice of lemons and limes; it is also found in several other fruits.

19. It crystallizes in beautiful prisms, is extremely acid and very soluble in water. It combines with the earths and metallic oxides, forming salts called *citrates.*

20. It is much used in calico printing, and in medicine.

21. Formic acid is obtained from ants, either by distillation or infusion in boiling water.

22. It has a very sour taste, and continues liquid at a low temperature. Its specific gravity is 1.1158 at 68°. It has been used by quacks as a remedy for the toothache.

23. Fungic acid is obtained from several species of mushrooms.

24. It is a colourless, uncrystallizable and deliquescent mass, of a very sour taste. It precipitates from a solution of acetate of lead, a flocculant mass which is soluble in distilled vinegar. It unites with alkalies and earths, and forms salts called *fungates.*

25. Gallic acid is obtained from nutgalls, and from the bark of other trees in which the astringent principle resides.

26. Its most distinguishing characteristic is its great affinity for metallic oxides, so, as when combined with tannin, to take them from powerful acids. The more readily the metals part with their oxygen, the easier they are alterable by gallic acid.

Exp. To a solution of Gold, gallic acid imparts a green hue, and a brown precipitate is formed, which readily passes to the metallic state, and covers the solution with a shining golden pellicle. A similar effect is produced with a solution of nitrate of silver. Mercury is precipitated of an orange colour, copper brown; bismuth of a brown colour; lead, white; iron, black.

27. The gallic acid is of extensive use in dying, as it constitutes one of the principal ingredients in all the shades of black, and is employed to fix or improve several other colours. It is a well known ingredient in ink.

28. Kinic acid is a peculiar acid obtained from cinchona, or Jesuit's bark; when concentrated it yields regular crystals.

29. It is decomposed by heat, while it forms a soluble salt with lime, it does not precipitate silver or lead from their solutions.

30. Laccic acid is obtained from a substance called *Stick Lac.*

31. It crystallizes, has a wine yellow colour, has an

acid taste, and is soluble in water, alcohol and ether. It precipitates lead and mercury white; but it does not affect lime, barytes or silver in their solutions. It throws down the salts of iron white. With lime, soda, and potash, it forms deliquescent salts soluble in alcohol.

32. Lactic acid is obtained from sour whey or milk.

33. When pure, it has a brown yellow colour and a sharp sour taste, which is much weakened by diluting it with water. It is without smell in the cold, but emits when heated, a sharp sour odour. It cannot be made to crystallize, and does not exhibit the slightest appearance of a saline substance, but dries into a thick and smooth varnish, which slowly attracts moisture from the air. It is very easily soluble in alcohol. With earths, alkalies and metallic oxides it affords peculiar salts, and those are distinguished by being soluble in alcohol, and drying into a mass like gum, which slowly becomes moist in the atmosphere.

34. *Lampic acid* is formed from the slow combustion of ether.

35. Lampic acid, when first procured, is a colourless fluid of an intensely sour taste and pungent smell. Its vapour, when heated, is extremely irritating and disagreeable. Its specific gravity varies according to the care with which it has been procured, from less than 1.000 to 1.008. It unites with alkalies, earths and metallic oxides, forming compounds called *lampates.*

36. *Lithic acid* was discovered about the year 1776, by Mr. Scheele. in analyzing the human calculi, in many of which it constitutes a greater part, and in some it forms almost the whole. It is often called uric acid.

37. Its colour is yellow, and it has a cool, bitter taste. It dissolves readily in water and in alkaline solutions,

from which it is not precipitated by acids. It is sparingly soluble in alcohol. It combines with alkalies and earths, forming salts called *lithates.*

38. Malic acid, is that taken from apples, and appears to be the same as the sorbic acid.

39. Meconic acid is a constituent of opium, and is prepared from that drug.

40. It has a strong sour taste, which leaves behind it an impression of bitterness. It dissolves readily in water alcohol and ether. Reddens vegetable blues, and changes the solution of iron to a cherry red colour. It unites with the alkalies and forms compounds called *maconiates.*

Menispermic acid is obtained from the seed of the *menispermum cocculus.*

42. It occasions no precipitate with lime water, with nitrate of barytes it yields a grey precipitate ; with nitrate of silver it yields a deep yellow ; and with sulphate of magnesia a copious precipitate.

43. *Margaric acid* is an acid obtained from soap made of pork grease, and potash. It is procured in the form of pearly white crystals.

44. It has no taste. Its smell is feeble, a little resembling that of melted wax. Its specific gravity is inferior to water. It melts at 134° F. into a very limpid colourless liquid, which crystallizes on cooling, into brilliant crystals of the purest white. It is insoluble in water, but very soluble in alcohol. Specific gravity 0.800. Cold margaric acid has no action on litmus when cold, but when heated so as to soften without melting, the blue is reddened. It combines with the salifiable bases and forms neutral compounds called *margarates.*

45. *Melascic acid* is that which at present is procured from Molasses, which is thought to be a peculiar acid by some.

46. Mellitic acid is obtained from the *Mellite*, or honey stone, and is thought to be of vegetable origin.

47. It crystallizes in fine needles, or small prisms. Its taste is at first of a sweetish sour, which is followed by a bitterness. On a plate of hot metal it is readily decomposed and dissipated in copious grey fumes, leaving behind a small quantity of ashes, that do not change either red or blue litmus. It unites with some of the alkalies and forms *mellitates*.

48. *Moroxylic acid* was obtained from a white substance found on the bark of the white mulberry, growing in the botanic garden of Palermo. It is considered as resembling nearly the succinic acid, but its characters have not been fully examined.

49. *Mucic acid* was formerly called *saccholactic acid*, because it was obtained from sugar of milk; but as all the gums appear to afford it, and the principal acid in the sugar of milk is oxalic, it is, in general, distinguished by the name of *mucic acid*.

50. It is obtained from gum in the form of a pulverulent mass. It is soluble in about 60 parts of hot water, and by cooling, a fourth part separates in the form of scales that grow white in the air. It decomposes the muriate of barytes and both the nitrate and muriate of lime. It forms with the metallic oxides, salts scarcely soluble. It precipitates the nitrates of silver, lead and mercury. It consists, according to Berzelius,

of Hydrogen,	5.115
Carbon,	33.430
Oxygen,	61.465
	100.000

51. *Oleic acid* is obtained from hog's lard.

52. It is an oily fluid without taste or smell. Its spe-

cific gravity is 0.914. It is generally soluble in its own weight of boiling alcohol, of the specific gravity 0.7952. 100 of the oleic acid saturates 16.58 of potash; 10.11 of soda, 7.52 of magnesia, 14.83 of zinc, and 13.93 of protoxide of copper.

53. *Oxalic acid* is the acid which abounds in wood sorrel, and which, combined with a small portion of pot ash which exists in that plant, has been sold under the name of *salt of lemons.* It is obtained in quantities from sugar.

54. This acid exists in the form of crystals; they have a strong acid taste, and act powerfully on vegetable colours. The acidity is so great, that when dissolved in 3600 times their weight of water, it reddens litmus paper. These crystals dissolve in twice their weight of water. They effloresce in the air. It combines with earths, alkalies and metallic oxides, and forms salts, known by the name of *oxalates.* It is capable of oxidizing lead, copper, iron, &c. It has a great affinity for iron; on this principle it is employed for removing ink spots from linen. It is used as a test to detect the existence of lime in solution.

Exp. Drop a little of the acid into water supposed to contain lime; if there be any, a white powder is immediately precipitated.

55. Purpuric acid is found in some of the *urinary calculi.*

56. It usually exists in the form of a very fine powder, of a slightly yellowish, or cream colour. It possesses no smell or taste. Its specific gravity is greater than that of water. It is scarcely soluble in water. One tenth of a grain boiled in 1000 grains of water, was not entirely dissolved. The water, however, assumed a

purple tint. It is insoluble in alcohol or ether. It unites with the alkalies, and forms *purpurates.*

57. Pyrolithic acid is obtained from *uric acid concretions*, by distillation.

58. It is obtained in the shape of acicular crystals.—They are soluble in four parts of cold water, and the solution reddens vegetables blues. Boiling alcohol dissolves the acid, but on cooling, it deposits it in fine white grains. Nitric acid dissolves it without changing it. At a red heat it is decomposed. 100 parts consist of

Oxygen	44.32
Carbon	28.29
Azote	16.84
Hydrogen	10.
	99.45

59. *Pyromalic acid* is obtained from malic or sorbic acid, by distillation ; when pure, it is in the form of crystals.

60. These crystals are permanent in the air, they melt at 118° F. and on cooling, they form a pearl coloured mass of diverging needles, when thrown on coals they evaporate, and the smoke produces cough. Exposed to a low heat in a retort, they are partly sublimed in needles and are partly decomposed. They are very soluble in strong alcohol and in double their weight of water at ordinary temperatures. The solution reddens vegetable blues, and forms with alkalies neutral salts, called *pyromalates.*

61. Pyrotartaric acid is obtained from tartar, by distillation. The word *pyro*, signifying when prefixed to the name of an acid, that it is prepared by heat.

62. It has a very sour taste, and reddens powerfully the tincture of *turnsole.* Heated in an open vessel, the

acid rises in a white smoke. It is very soluble in water, from which it is separated in crystals by evaporation. It combines with the salifiable bases, forming *pyrotartrates.*

63. *Rosacic acid*, an acid obtained from the sediment found in the urine of persons, labouring under intermittent fevers. This sediment is of a rose colour, occasionally in reddish crystals.

64. This acid is solid, of a lively cinnabar colour, without smell, with a faint taste, but reddening litmus very sensibly. On burning coals, it is decomposed into a pungent vapour. It is very soluble in water, and even attracts humidity from the atmosphere. It is soluble in alcohol, and combines with the salifiable bases.

65. *Sebacic acid* is obtained from hog's lard ; it is in the form of crystals of small white needles.

66. It is inodorous, of a slight taste, but it perceptibly reddens litmus paper. Its specific gravity is greater than that of water. Exposed to heat, it is decomposed, melts like fat, and is partially evaporated. The air has no effect upon it. Alcohol dissolves it abundantly at ordinary temperatures. It unites with the alkalies, and forms salts.

67. Sorbic acid is obtained from the berries of the mountain ash, *sorbus*, or *pyrus aucuparia.* It appears that sorbic and pure malic acids are the same.

68. It unites with the alkalies, and forms salts called *sorbates.*

69. Suberic acid is obtained from cork, by means of nitric acid.

70. When pure, it is white and pulverulent, having a feeble taste and little action on litmus. It is soluble in 80 parts of water at 55½°, and in 38 parts at 140°. It is more soluble in alcohol, from which water throws down

a portion of the suberic acid. It unites with the alkaline bases, and forms *suberates.*

71. Succinic acid is obtained from amber by sublimation. It is, when pure, in white transparent crystals of a prismatic form. Their taste is somewhat sharp, and they redden powerfully tincture of turnsole. Heat melts and partially decomposes succinic acid. Air has no effect upon it. It is soluble in both water and alcohol. It forms salts with the earths and alkalies, called *succinates.*

72. *Sulphovinic acid* is a name given to a class of acids, which may be obtained by digesting alcohol and sulphuric acid together, with heat. It seems probable, that this acid is the hyposulphuric combined with a peculiar oily matter.

73. Tartaric acid is an acid obtained from tartar, which is a hard substance, adhering to the casks in which wine is kept. It may be procured in needle or laminated crystals, by evaporation.

74. Its taste is extremely sour and agreeable ; it is often used in making punch, instead of lemon juice. It is very soluble in water. Burnt in an open fire, it leaves a coaly residuum ; in close vessels, it gives out carbonic acid, and carburetted hydrogen gas. By distilling nitric acid off the crystals, they may be converted into oxalic acid, and the nitric acid passes to the state of nitrous.—It unites with the salifiable bases and forms *tartrates.*

75. Zumic acid is obtained from sour rice, putrefied juice of beet roots, from the sour decoction of carrots, peas, &c.

76. It is without colour, does not crystallize, has a very acid taste. It forms with alumina a substance resembling gum, and with magnesia, one unalterable in the air, in little granular crystals, soluble in 25 parts of

water at 66° F. It forms salts, possessing peculiar characteristics, with the other salifiable bases.

PRACTICAL QUESTIONS.

What are acids of organic origin ?
What is acetic acid ?
Where is it found ?
What are the varieties of acetic acid ?
What are acetates ?
How are they characterized ?
How is acetic acid when highly concentrated ?
From what is amniotic acid obtained ?
What are its characteristics ?
What is Benzoic acid ?
What are its characteristics ?
From what is boletic acid obtained ?
What are its characteristics ?
What is camphoric acid ?
What are its characteristics ?
What is caseic acid ?
What is the citric acid ?
What are its characteristics ?
Is it much used ?
From what is formic acid obtained ?
What are its properties ?
From what is fungic acid obtained ?
What are its characteristics ?
From what is gallic acid obtained ?
What are its characteristics ?
Is it much used ?
What is kinic acid ?
What are its properties ?
From what is laccic acid obtained ?
What are its properties ?

From what is lactic acid obtained?
What are its properties?
What is lampic acid?
What are its properties?
What is lithic acid?
What are its characteristics?
What is malic acid?
What is meconic acid?
What are its characteristics?
What is menispermic acid?
What are its properties?
What is margaric acid?
What are its properties?
What is melassic acid?
From what is mellitic acid obtained?
What are its properties?
From what is moroxylic acid obtained?
What is mucic acid?
What are its properties?
What is oleic acid?
What are its properties?
What is oxalic acid?
What are its characteristics?
What is purpuric acid?
What are its characteristics?
From what is pyrolithic acid obtained?
What are its characteristics?
How is pyromalic acid obtained?
What are its properties?
From what is pyrotartaric acid obtained?
What are its characteristics?
What is rosacic acid?
What are its characteristics?
From what is sebacic acid obtained?

What are its characteristics ?
What is sorbic acid ?
From what is suberic acid obtained ?
What are its characteristics ?
What is succinic acid ?
What is sulphovinic acid ?
What is tartaric acid ?
What are its characteristics ?
From what is zumic acid obtained ?
What are its characteristics ?

CHAP. XXI.

Of Chlorine.

1. The term chlorine, which signifies a yellowish green colour, is applied to a substance, which was formerly called *oxymuriatic acid gas ;* it is obtained by mixing muriatic acid with oxide of manganese.

2. The merit of this discovery is justly due to Sir H. Davy, who, after submitting the gas to a variety of experiments, pronounced it to be an elementary substance.

3. Sir H. Davy submitted to the action of muriatic acid gas, potassium ; by which, more than one third of its volume of hydrogen was produced. He states that muriatic acid can in no instance be procured from oxymuriatic acid, unless water be present ; or from dry muriates, unless water or its elements be present.

According to the experiments of M. M. Gay Lussac and Thenard, muriatic acid gas contains one quarter of its weight of water, and oxymuriatic acid is not decomposable by any substance but hydrogen, or such as can form triple combinations with it.

4. One of the most singular facts is, that charcoal, even when ignited to whiteness in oxymuriatic or muriatic acid gases, by the voltaic battery, effects no change in them, if it has been previously freed from hydrogen and moisture, by intense ignition *in vacuo*.

Observation. The above experiment lead Sir H. Davy to doubt the existence of oxygen in oxymuriatic gas, which has been supposed to contain it above all others, in a loose and active state. He then proceeded to a very rigorous investigation of nature, which terminated in an entire conviction that oxymuriatic acid gas was a simple substance, which he placed in the same rank with oxygen, and removed it from the class of acids. This opinion is now pretty generally embraced by all the most celebrated chemists, although most of the phenomena attending the action of this substance, may be accounted for on the supposition that chlorine be a compound body.

Exp. 1. If oxymuriatic acid gas be introduced into a receiver exhausted of air, containing a little tin, and the metal be gently heated, the tin and the gas disappear, and a limpid *fluid*, called the *liquor of Libavius*, is formed. If this substance be a combination of muriatic acid and oxide of tin, the oxide will be separated from it, by means of ammoniacal gas.

Exp. 2. Admit ammoniacal gas over mercury to a small quantity of the liquor of Libavius, it will be absorbed, and much heat will be extricated, and no gas generated ; a solid result is obtained, which is of a dull white colour, when heated, the whole is volatilized, producing dense pungent fumes.

5. When oxymuriatic acid and ammonia are made to act upon each other, water is not formed. This undoubtedly would be the result, if the oxymuriatic acid was a compound body, as the two substances would contain the elements of that fluid.

6. When chlorine is acted upon by nearly an equal volume of hydrogen, a combination takes place between them and muriatic acid gas is the result.

7. When oxymuriatic acid gas is acted on by mercury, or any other metal, oxymuriatic acid, or chlorine is attracted from the hydrogen by the stronger affinity of the metal, and an oxymuriate is produced.

6. As oxymuriatic acid is not known to contain oxygen, its name appears absurd, and ought to be erased from the chemical nomenclature, and that of chlorine or some other appropriate term substituted.

9. Chlorine combines with inflammable bodies to form simple binary compounds; and in those cases, when it acts upon oxides, it either expels their oxygen, or causes it to act upon new combinations.

10. The oxygen does not arise from the decomposition of the oxymuriatic acid, but from the oxide, as is evident from its being exactly equal to the quantity contained in the oxide used.

11. It appears pretty evident that there is no acid property in oxymuriatic acid, combined with oxygen, because if it were so, it ought to be exhibited in the fluid compound of one proportion of phosphorus, and two of oxymuriatic gas; on the old hypothesis, it would consist of muriatic acid, and phosphorous acid; but this substance has no effect on litmus paper, and does not act under common circumstances, as fixed alkaline bases, such as dry lime, or magnesia.

12. Oxymuriatic acid, like oxygen, must be combined in large quantities, with peculiar inflammable matter, to form acid matter.

Illustration. In its union with hydrogen, it instantly reddens the driest litmus paper, though a gaseous body; contrary to acids, it expels oxygen from protoxides and combines with peroxides.

13. When potassium is burnt in chlorine, a dry compound is obtained.

14. The bleaching properties of chlorine was accounted for on the old theory, by supposing that it destroyed colours by parting with its oxygen, but by the new, the oxygen is derived from the water, with which it must always be combined, in order to produce the effect, by a double affinity, that of hydrogen for chlorine, and of the colouring matter for oxygen.

15. Chlorine is not capable of being condensed at a low temperature, nor crystallized.

16. The solution of chlorine in water, freezes more readily than pure water; but the pure gas dried with muriate of lime experiences no change whatever, at a temperature of — 40° F.

17. Chlorine is of a greenish yellow colour. Its odour and taste are disagreeable, which is one of its distinguishing characteristics, as it is impossible to mistake it for any other gas. When breathed, even when much diluted with air, it occasions a sense of strangulation, constriction of the *thorax*, and a copious discharge from the nostrils. If respired in larger quantities, it excites violent coughing and spitting of blood, and if continued, would speedily destroy the individual, in violent distress. Its specific gravity is 2.4733. In its perfectly dry state, it has no effect on dry vegetable colours; with the aid

of a little moisture, it bleaches them into a yellowish white.

Exp. 1. If a lighted wax taper be immersed in this gas, it consumes very fast, with a dull reddish flame and much smoke.

Note.—The taper will not burn at the surface of the gas.

Exp. 2. Immerse a small quantity of sulphuret of antimony, powdered into a jar containing chlorine, it will immediately take fire and burn spontaneously, the result will be chloride of antimony. The same effect will take place with copper, tin, arsenic and zinc, in powder.

Exp. 3. If phosphorus be immersed, as above, it will take fire at ordinary temperatures, and chloride of phosphorus will be formed.

18. Chlorine combines with alkalies, and forms salts, possessed of various properties; that with potash is most generally known. It was formerly called *hyper-oxymuriate of potash*, now chlorate.

Exp. 1. Put two grains of chlorate of potash in powder into a mortar, and add one grain of sulphur. Mix them very accurately by gentle triture, and then having collected the mixture to one part of the mortar, press the pestle upon it suddenly and forcibly, a loud detonation will ensue.

Exp. 2. If the mixed ingredients be wrapped in some strong paper, and then struck with a hammer, a still louder report will be produced.

Exp. 3. If five grains of this salt be mixed with half the quantity of powdered charcoal, in a similar manner, and the mixture be strongly triturated, it will inflame, but with little noise.

Exp. 4. Mix a small quantity of sugar with half its weight of the salt, dip a glass rod into sulphuric acid, and let a drop fall on the mixture, an instantaneous inflammation will take place.

Exp. 5 Lay two trains, one of gunpowder, and the other of chlorate of potash, in such a manner, as that they may touch at one end, and diverge at the other, in the form of an *acute angle ;* then apply an ignited coal at the point of contact; both will be inflamed at the same time, but the gunpowder will burn comparatively slow.

19. Chlorine is capable of combining with two proportions of oxygen, which are very interesting in their properties, called the *protoxide* and *deutoxide* of chlorine, or chlorous and chloric oxides.

Exp. Put chlorate of potash into a small retort, and pour in twice as much muriatic acid as will cover it, diluted with an equal volume of water, by the application of a gentle heat, the gas is evolved ; it must be collected over mercury.

20. Its tint is much more lively, and more yellow than chlorine ; from this circumstance, Sir H. Davy called it *Euchlorine.* Its smell is peculiar, and approaches to that of burnt sugar. It is not respirable. It is soluble in water, to which it gives a lemon colour. Water absorbs 8 or 10 times its volume of this gas. Its specific gravity is to that of common air, nearly as 2.40 to 1.

21. This gas must be collected and examined with great care, and in very small quantities. A gentle heat, even that of the hand, will cause its explosion, with such force as to burst thin glass. In the act of explosion, the elements are separated with great violence and some light.

22. The metals which act upon chlorine, will not act upon this at common temperatures ; but when the oxygen is separated, they inflame in the chlorine.

Exp. Let a little gold leaf be introduced into a bottle filled with the protoxide of chlorine, it will undergo no change; but if a heated glass tube be applied to the gas, in the neck of the bottle, a decomposition takes place, and the oxygen and chlorine will be detached from each other, and at the same moment, the leaf will inflame and burn with great brilliancy.

23. The deutoxide of chlorine or chloric oxide is formed by mixing fifty or sixty grains of chlorate of potash with a small quantity of sulphuric acid in a wine glass, very little effervescence takes place, but the acid gradually acquires an orange colour, and a dense yellow vapour, of an agreeable smell, floats on the surface. If this be put into a retort, and heated, by means of hot water, a gas is obtained, which may be received over mercury.

24. Water absorbs more of it than of the protoxide. Its taste is astringent. It destroys vegetable blues without reddening them. When phosphorus is introduced into it, an explosion takes place. When heat is applied, the gas explodes with more violence, and produces more light than the protoxide. When thus exploded, two measures of it are converted into nearly three measures, which consist of a mixture of one measure chlorine, and two measures oxygen. Hence it is composed of 1 atom chlorine, and 4 atoms oxygen.

25. When chlorine is passed through a solution of nitrate of ammonia, the gas is rapidly absorbed, and a film appears on the surface, which soon collects into yellowish drops, that sink to the bottom of the liquor.

26. This is the most powerful detonating compound known. When gently warmed, it explodes with such violence, as to be attended with very great danger. It explodes in certain circumstances, with or without heat.

Exp. If a globule of the fluid be thrown into olive oil, turpentine, or naphtha, it explodes without heat, and so violently as to shatter the glass vessel in which it takes place.

PRACTICAL QUESTIONS.

To what is the term chlorine applied ?

To whom is the merit of the discovery due ?

What method did Sir H. Davy take to prove that this was an elementary substance ?

What effect does charcoal produce on chlorine ?

What did Sir H. Davy infer from these ?

What other experiments can you adduce, illustrative of the hypothesis ?

Is water formed by the action of oxymuriatic acid and ammonia ?

What is formed by the action of chlorine and hydrogen ?

What is the effect of the action of mercury on oxymuriatic acid ?

What phenomenon is produced,when oxymuriatic acid acts on inflammable bodies ?

Whence does the oxygen arise in this case ?

How does it appear that there is no acid property combined with oxygen in oxymuriatic acid gas ?

What is necessary in order that oxymuriatic acid gas may form acid matter ?

In its union with hydrogen, what is its effect ?

What is obtained from the combustion of potassium in chlorine ?

How do you account for the bleaching properties of chlorine ?

Can chlorine be condensed ?

What are the characteristics of chlorine ?

What is the combination of chlorine with alkalies ?

Illustrate the properties of chlorate of potash by experiments ?

What are the combinations of chlorine with oyxgen ?

What are the properties of protoxide of chlorine ?

Does this substance easily explode ?

Will metals act upon this gas ?

How is the deutoxide of chlorine formed ?

What are its properties ?

Does chlorine unite with nitrogen ?

What are the characteristics of the compound ?

CHAP. XXII.

Of Iodine.

1. Iodine is a name given to an elementary substance. It was accidentally discovered by M. De Courtois, a manufacturer of salt-petre, at Paris, in 1812. In his process of procuring soda from the ashes of sea weed, he found the metallic vessels much corroded; and in examining into the cause he made this important discovery. It derived its first illustration from M. M. Clement, and Desormes, who named it iodine from the Greek word signifying *like a violet*, from the violet coloured vapour which it formed.

2. Iodine has been found in the following sea weeds, *Fucus cartilagineus ; F. membranaceus ; F. filamentosus ; F. rubens ; F. nodosus ; F. serratus ; F. siliquosus ; F. palmatus ; F. filum ; F. digitatus ; F. saccharimus ; Ulva umbilicalis ; U. pavonia ; U. linza ; and in sponge.*

3. It is from the ashes of sea weed, or kelp, that Io-

dine, in quantities, is to be obtained The following method of extracting it, is given by Dr. Wollaston. Dissolve the soluble part of kelp in water. Concentrate the liquid by evaporation, and separate all the crystals that can be obtained. Pour the remaining liquid into a clean vessel and mix with it an excess of sulphuric acid. Boil this liquid for some time. Sulphur is precipitated, and muriatic acid driven off. Decant the clear liquid and strain it through wool. Put it into a small flask, and mix with it as much black oxide of manganese, as sulphuric acid. Apply at the top a glass tube shut at one end. Then heat the mixture in the flask. The iodine sublimes into the glass tube.

4. Iodine, when properly prepared, is a solid of a greyish black colour and metallic lustre. It is often in the form of scales, sometimes in rhomboidal plates very large and very brilliant. Its fracture is lamellated, and it is soft and friable to the touch. Its taste is very acrid, though it be very sparingly soluble in water. It is a deadly poison. It gives a deep brown stain to the skin, which soon vanishes by evaporation. In odour and power of destroying vegetable colours, it resembles very dilute aqueous chlorine. Its specific gravity at 62 1-2° is 4.948. It dissolves in 7000 parts of water. The solution is of an orange yellow colour, and in small quantities tinges starch of a purple hue, which is the most delicate test. When this substance is put into a liquid containing the iodine, in a state of liberty, it detects the presence of so small a quantity as the $\frac{1}{450000}$th by the blue colour which it forms.

It evaporates quickly at ordinary temperatures. Boiling water aids its sublimation. The specific gravity of its violet vapour, is 8.678. It is a non-conductor of electricity,

5. Iodine is incombustible, but with azote it forms a curious detonating compound; and in combining with several bodies the intensity of mutual action is such as to produce the phenomena of combustion.

6. When iodine and oxides act upon each other in contact with water; the water is decomposed, its hydrogen unites with iodine to form hydriodic acid, while its oxygen produces with iodine, iodic acid. All the oxides however, do not produce the same results; only such as potash, soda, barytes, strontian, lime and magnesia. The oxide of zinc, precipitated by ammonia, from its solution in sulphuric acid, and when well washed, gives no trace of iodate or hydriodate.

7. Iodine dissolves in carburet of sulphur, producing in very minute quantities, a fine *amethystine tint* to the liquid.

8. If iodine and hydrogen be heated in dry hydrogen gas, an expansion of its volume takes place, an acid gas is formed which is very absorbable by water; and acts so powerfully on mercury that it cannot be preserved for any length of time over that metal.

9. Iodine combines with the metals and forms substances called *iodides*.

PRACTICAL QUESTIONS.

What is iodine?

In what is iodine found?

How is it procured?

What are its properties?

Is iodine incombustible?

What is the phenomena of the action of iodine and oxides?

What effect has carburet of sulphur on iodine?

What is the effect of heating iodine and sulphur together?

What are iodides?

CHAP. XXIII.

Of Salts in general.

1. The term salt is usually employed to denote a compound in definite proportions, of acid matter, with an alkali, earth or metallic oxide.

2. When the proportion of the constituents are so adjusted that the resulting substance does not change the colour of litmus or red cabbage it is called a *neutral salt.*

3. When the predominance of the acid is evinced by the reddening of those infusions, the salt is said to be acidulous, and the term *super* or *bi* is prefixed to indicate the excess of acid.

4. If the acid matter appears to be short of the quantity necessary for neutralizing the base, the salt is then said to be with excess of base, and the term *sub* is prefixed to the name.

5. There are many substances known by the name of salts to which the above observations will not strictly apply, as the muriates, prussiates, and fluates, for they contain neither acids nor alkaline bases.

6. Only those acids which are compounds of oxygen and inflammable bases appear to enter into combination with the alkalies and alkaline earths, without alteration, and it is impossible to define the nature of the arrangement of the elements in their neutral compounds.

Observation. The phosphate and carbonate of lime have much less of the characters attributed to neutral saline bodies, than chloride of calcium, *muriate of lime*, and yet this last body is not known to contain either alkaline or acid matter.

7. The most important characteristic in salts is their solubility in water. In this they are usually crystallized, and by its agency they are purified and separated from one another.

8. We may obtain a perfectly saturated solution of salts in the two following ways. 1. By heating the water with the salt and allowing it to cool to the temperature whose solubility is wanted. 2. By putting into cold water, a great excess of salt, and gradually elevating the temperature. In each case it is requisite to keep the temperature constant for at least two hours, and to stir the saline solution frequently, in order to make sure of its perfect saturation.

9. Saturation in a saline solution of an invariable temperature, is a point at which the solvent, always in contact with the salt, can neither take up any more, nor let go any more.

10. Every saline solution which can part with salt without any change of temperature is *supersaturated.*

11. In general supersaturation is not a fixed point. The cause which produces it, is the same which keeps water liquid below the temperature at which it congeals. That is, absolute rest, or the want of sufficient agitation.

12. A salt that contains no water is said to be anhydrous.

13. Salts that consist of an acid and two bases are called *triple salts*, and take the name of both bases.

14. When the bases of a metallic salt contains an ex-

cess of oxygen, it is distinguished by the abbreviation *oxy*, as oxy sulphate of iron.

15. When salts are composed of acids ending in *ous*, they take a termination in *ite* instead of *ate*.

Illustration. Lime combined with phosphorous acid., is called *phosphite of lime*, but when combined with the stronger, or phosphoric acid, it is called *phosphate of lime*.

16. The general characteristics of the *muriates* are,—When heated, they melt and are volatilized. They are soluble in water. They effervesce with sulphuric acid, and white acrid fumes are disengaged. When mixed with nitric acid, they exhale the odour of chlorine.

17. The general characteristics of sulphates are. They have a bitter taste. They are soluble in water but not in alcohol. Alcohol precipitates them from water in a crystallized form. When heated to redness with charcoal, they are converted into sulphurets.

Exp. Put a tea spoonful of sulphate of magnesia into some water, after it is dissolved, and the solution quite clear, add some alcohol to it, and the salt will be precipitated.

18. The carbonates are soluble in water. When sulphuric acid is poured upon them, they effervesce violently, emitting carbonic acid gas.

19. The nitrates are characterized by their being soluble in water, and capable of crystallizing by cooling. When heated to redness with combustible bodies, a violent detonation is produced. Sulphuric acid disengages red fumes from them. When heated with muriatic acid, chlorine is exhaled.

20. The general characters of metallic salts are,—When they are strongly heated, they are volatilized and

dissipated. Hydro sulphuret of potash occasions a black precipitate from the solution. Muriatic acid when poured into a solution of them in water, usually occasions a white precipitate. Gallic acid occasions a yellow precipitate. A plate of copper plunged into a solution of mercurial salts, gradually precipitates running mercury.

21. When a warm solution of salt deposits on cooling, regular shaped masses, it is said to crystallize. These all differ in different salts, so that by knowing the form of the crystal, the class to which it belongs may be ascertained.

Exp. Take half an ounce of Glauber's salt in crystals, dissolve it in the same quantity of hot water; on cooling, crystals of the same shape will be formed.

PRACTICAL QUESTIONS.

What is the term salt usually employed to denote?

What is a neutral salt?

How do you express the excess of an acid in a salt?

How do you express the excess of base?

Do these observations apply to all substances known by the name of salts?

What acids appear to enter into the composition of alkalies and alkaline bases to form salts?

What is the most important characteristic of salts?

What methods are used to obtain a complete saturated solution of salts?

What do you understand by saturation?

What is meant by super saturation?

Is supersaturation a fixed point?

When is a salt said to be anhydrous?

What are triple salts?

How is a metallic salt distinguished when its base contains an excess of oxygen ?

How are salts distinguished whose acids end in *ous ?*

What are the general characteristics of the muriates ?

What are the characters of the sulphates ?

What are the general characters of the carbonates ?

How are the nitrates characterized ?

What are the general characters of metallic salts ?

What is crystallization.

CHAP. XXIV.

Of Electricity.—Voltaic Electricity.

1. Electricity is supposed to be a fluid which pervades almost all substances, and when undisturbed remains in a state of equilibrium.

Observation. The phenomena produced by rubbing a piece of amber, constitutes the first physical fact recorded in the history of the science.

2. The certain portion which every body is supposed to contain is called its *natural share*, and so long as it contains neither more nor less than this quantity, it seems to produce no effect.

3. When a body is by any means possessed of more or less than its natural share, it is said to be electrified or charged.

4. If it possess more than its natural quantity it is, said to be positively electrified ; if it contain less, *negatively* electrified.

5. Bodies through which the electric fluid passes freely, are called conducters, or *non-electrics.* Those bodies which oppose the passage are called non-conductors, or electrics.

6. Two bodies, both positively, or both negatively electrified, repel each other, but if one body be positive and the other negative, they will attract each other.

Exp. Take a small phial and rub it hard with a silk handkerchief, it will attract dust and other light substances, when placed near them.

7. When two bodies approach each other sufficiently near, one of which is electrified *positively* and the other negatively, the superabundant electricity rushes violently from one to the other, to restore the equilibrium between them. This effect takes place if the two bodies are connected by a conducting substance.

8. The motion of electricity in passing from one body to another, is so rapid that it appears to be *instantaneous.*

9. Electricity is produced by the mutual friction of all solid bodies, and of many fluids against solids, provided one of the bodies be of such a nature as to obstruct the speedy diffusion of the electric influence.

10. The following is a list of conducting substances, arranged in the order of their conducting powers.

1 Copper
2 Silver
3 Gold
4 Iron
5 Tin
6 Lead
7 Zinc
8 Platinum
9 Charcoal
10 Plumbago
11 Strong acids
12 Soot and Lampblack
13 Metallic ores
14 Metallic oxides
15 Dilute acids
16 Saline solutions
17 Animal fluids
18 Sea water

19 Water
20 Ice & snow above 0°
21 Living vegetables
22 Living animals
23 Flame
24 Smoke
25 Vapour
26 Salts
27 Rarefied air
28 Dry earths
29 Massive minerals, metallic.

11. The following is a list of non-conductors, in the order of their insulating power.

1 Shel lac
2 Amber
3 Resins
4 Sulphur
5 Wax
6 Asphaltum
7 Glass and all vitrified bodies, comprehending diamond and crystallized transparent minerals.
8 Raw silk
9 Bleached silk
10 Dyed silk
11 Wool, hair and feathers
12 Dry gases
13 Dry paper, parchment and leather
14 Baked wood and dryed vegetables
15 Porcelain
16 Marble
17 Massive minerals, not metallic
18 Camphor
19 Caoutchouc
20 Lycopodium
21 Dry chalk and lime
22 Phosphorus
23 Ice below 0° F.
24 Oils, of which the denser are best
25 Dry metallic oxides, including fixed alkalies and earthy hydrates.

12. Electricity is excited in the fusion of inflammable bodies.

Exp. If melted sulphur be poured into an insulated metallic cup, after it has become solid, the sulphur and cup will be both electrified; the former positive, the latter negative.

13. Electricity is produced by *evaporation.*

Exp. If we place a metallic cup on an electrometer, containing a small quantity of water, and plunge into it a red hot iron, the instrument will indicate electrical phenomena.

14. Electricity is produced by the disengagement of gas.

Exp. If into a platinum cup resting on the top of an electrometer, we put a little dilute sulphuric acid, and then throw in some iron filings, or chalk, when the effervescence increases, the instrument will indicate electrical phenomena.

15. Electricity is produced by the tearing asunder of solid bodies, probably owing to the friction among the particles.

Exp. If we suddenly tear asunder pieces of mica, break across a stick of sealing wax, split up a piece of dry and warm wood, or scrape it with a piece of glass, the electrical equilibrium will be disturbed.

16. Electricity is produced by contact of dissimilar bodies.

Exp. If we take two flat plates, one of silver or copper, the other of zinc, each two or three inches in diameter, furnished with glass handles, and bring them into contact by their flat surfaces, we shall find on separating them, that they are both electrified. If we touch a cake of sulphur, gently heated, with the insulated copper plate, the effect will be more striking. Acid crystals, touched with metallic plates, indicate electrical phenomena.

When crystals of oxalic acid are brought into contact with dry quicklime, electricity is developed.

17. On the excitation of electricity by contact of dissimilar chemical bodies, is founded the principle of galvanic action, and the construction of the voltaic battery.

18. Galvanism, or Voltaism, is occasioned, as appears, by the chemical action of bodies on each other.

19. Galvanism, so named from the person who first promulgated it, appears to have been discovered by accident. Galvani, a professor of natural philosophy, at Bologna, being engaged in some experiments on muscular irritability, observed, that when a piece of metal was laid on a nerve of a frog, recently dead, whilst the limb, supplied by that nerve, rested on another piece of metal, the limb suddenly moved, on a communication being made between the two pieces of metal.

20. This communication may be made, either by bringing the two metals into contact, or by connecting them by means of a metallic conductor.

Exp. Take a piece of zinc, and place it *under* the tongue, and a piece of silver on the tongne, letting the metals project a little ; then make the projecting part of the metals touch each other, and a singular sensation will be produced. The effect is probably the same as that produced on the *frog*.

21. Galvani supposed that the virtue of this new agent resided in the frog, but Volta, who paid particular attention to the subject, shewed that the phenomena did not depend upon those organs, but upon the electrical agency of the metals, which is excited by the moisture of the animal. Consequently, the saliva of the mouth answers the same purpose, and produces the sensation in the above experiment.

22. It is not necessary that the fluids used in these experiments should be of an animal nature. Acids, very much diluted with water, are found to be the most effectual in the developement of electricity in metals ; and accordingly, the original apparatus, which Volta first constructed for this purpose, consisted of a pile, or suc-

cession of plates of zinc and copper, each pair of which was connected by pieces of cloth or paper, moistened with water. This, however, was found inconvenient, as well as of little power, which gave rise to the construction of the present Voltaic battery. (Plate 3, fig. 3.) In this, the plates of zinc and copper are soldered together in pairs, each pair being placed at regular distances in wooden troughs, and the interstices filled with fluid.

23. The action of the fluid on metals, whether water or acid be used, is entirely of a chemical nature. But whether electricity be excited by this chemical action, or, whether it be produced by the contact of the two metals, is a point upon which philosophers do not perfectly agree.

24. Volta and Sir H. Davy explain the action of the voltaic battery on the principle of the contact of the two metals; but many philosophers entertain doubts on the truth of the theory. The principal difficulty is, that two such plates shew no signs of different states of electricity whilst together, but only on being separated, after contact. Now in the voltaic battery, those plates that are in contact, always continue so, being soldered together; they cannot, therefore, receive a succession of charges. Besides, if we consider the mere disturbance of the balance of electricity, by the contact of the plates, as the *sole cause* of the production of voltaic electricity, it remains to be explained, how this disturbed balance becomes an inexhaustible source of electrical energy, capable of pouring forth a constant and copious supply of electrical fluid, though without any means of replenishing itself from other sources.

The theory least liable to objection, appears to be that, first proposed by Dr. Bostock, called the *chemical theory.*

This theory supposes the electricity to be excited by the chemical action of the acid upon the zinc. All metals having a strong attraction for oxygen, and this element being found both in the water and the acid. The action of the diluted acid on the zinc, consists in its oxygen, combining with the metal, and oxidating its surface.

25. It appears that all metals are united with the positive electricity, and that oxygen is the source of the negative.

26. In the galvanic action, the oxygen does not appear to act on the copper, because the zinc has a stronger affinity for oxygen than the copper ; the energy of the acid is, therefore, only exerted upon the zinc.

27. If a plate of zinc be placed opposite to one of copper, or any other metal less attractive of oxygen, and the space between them, suppose of half an inch in thickness, be filled with an acid, or any fluid capable of oxidating the zinc, the oxidated surface will have its capacity for electricity diminished, so that a quantity of electricity will be evolved from the surface. This will be received by the fluid in contact ; by which it will be transmitted to the opposite metallic surface, the copper, which is not oxidated, and is therefore disposed to receive it, so that the copper plate will become positive, while the zinc plate will be in the negative state.

Observation. This evolution of electricity will be very limited, for as these two plates admit of but very little accumulation of electricity, and are supposed to have none with other bodies ; the action of the acid, and farther developement of electricity will be immediately stopped.

28. In order that the acid may act freely on the zinc, and the two electricities given out without interruption,

some method must be devised by which the plates may part with their electricities as they receive them. If the wires connected with either plate are made to meet, the two electricities will then be brought together, and will combine and neutralize each other, as long as this communication continues; the two plates will dispose of their respective electricities, and the action of the acid will be continued.

29. The intensity of the electricity is increased by increasing the number of plates. If we take four plates, two of zinc, and two of copper, placed alternately in a trough, filled with diluted nitrous acid, and the two central ones be soldered together, as in the voltaic battery, so as to form but one plate, two dissimilar surfaces will be afforded, the one of copper, the other of zinc. Now a quantity of electricity being evolved from the first zinc plate, in consequence of the action of the acid, is conveyed by the interposed fluid to the copper plate, which thus becomes positive. This copper plate communicates its electricity to the zinc plate, to which it is joined, in which some communication of electricity takes place. When, therefore, the fluid in the next cell acts upon the zinc plate, electricity is extricated from it, in larger quantity, and in a more concentrated form than before. This concentrated electricity is again conveyed by the fluid to the next pair of plates, when it is further increased by the action of the fluid in the third cell, and so on to any number of plates of which the battery may consist; so that the electrical energy will continue to accumulate, in proportion to the number of double plates; the first zinc plate of the series being the most negative, and the last copper one, the most positive.

30. If the battery remain undisturbed, the action will soon stop, unless some vent be given to the accumulated

electricities. This is easily done, however, by establishing a communication by means of the wires (plate 3, fig. 3,) between the two ends of the battery; these being brought into contact, the two electricities meet, and neutralize each other, producing the shock and other phenomena of electricity; and the action goes on with renewed energy, being no longer obstructed by the accumulation of the two electricities.

31. The great superiority of the voltaic battery consists in the large *quantity* of electricity which passes; but in regard to the rapidity or intensity of the charge, the common electrical machine greatly surpasses it. It appears that the shock or sensation depends chiefly upon the intensity; whilst on the contrary, for chemical purposes, it is *quantity* which is required. In the voltaic battery, the electricity though copious, is so weak as not to be able to force its way through the fluid which separates the plates; whilst that of a common machine will pass through any space of water.

32. The action of the voltaic battery may actually be increased, until it equals a weak electrical machine, so as to produce a visible spark when accumulated in a Leyden jar. But it can never be raised sufficiently to pass through any considerable extent of air, because of the ready communication through the fluids employed.

33. The intensity is increased by increasing the number of plates of a battery, whilst by enlarging the dimensions of the plates, the quantity is increased; and as the superiority of the battery over the common electrical machine, consists entirely in the quantity of electricity produced, it was at first supposed that it was the size, rather than the number of plates, that was essential to the augmentation of power. It was, however, found by experiment, that the quantity of electricity produced by

the voltaic battery, even when at the rate of a very moderate size, was sufficiently copious, and that the chief advantage in this apparatus was obtained by increasing the intensity, which, however, still falls short of that of the common machine.

34. A battery may be formed to shew the galvanic effect on a small scale, in the following manner. It consists of a row of cups or tumblers, containing salt and water, or nitrous acid and water. Into each of these, is plunged a plate of zinc, and another of copper. These plates are made to communicate with each other by means of a thin platina wire, fastened so that the copper of the first glass is connected with the zinc of the second, the copper of the second with the zinc of the third, and so on through the whole row of glasses ; when one hand is dipped into the first glass, and another in the last, the shock is perceived. But this battery is not convenient, on account of the great space which it must necessarily occupy.

35. The battery of the royal institution, (London) constructed by Mr. Children, is the most powerful in the world, in calorific effect. It consists of 2000 pairs of plates, of 32 inches each, exposing a surface of 128,000 square inches. This battery, when the cells were filled with 60 parts of water, mixed with one part of nitric acid, and one of sulphuric acid, afforded a series of brilliant and impressive effects.

Exp. 1. When pieces of charcoal, about an inch long, and one sixth of an inch in diameter, were brought within 1-80th or 1-40th of an inch of each other, a bright spark was produced, and more than half the volume of charcoal was ignited to whiteness, and by drawing back the points a little from each other, a constant discharge took place, through the heated air, in a space equal at least to four inches, producing a most brilliant ascending arch of light, expanded and conical in the middle. When any substance was introduced into this arch, it instantly became ignited.

Exp. 2. Platinum melted in it, like wax in the flame of a common candle. Likewise quartz, sapphire, magnesia and lime. Fragments of diamond, and points of charcoal and plumbago, rapidly disappeared, and seemed to evaporate in it, even when the connection was made in an exhausted receiver, but there was no evidence of their previously having undergone fusion.

36. When the communication between the points, positively and negatively electrified, was made in air rarefied in the receiver of an air pump, the distance at which the discharge took place increased as the exhaustion proceeded, and when the atmosphere in the vessel supported only an inch of mercury in the barometrical gauge, the spark passed through a space of nearly half an inch. By making the points recede from each other, the discharge was made through 6 or 7 inches, producing a most beautiful coruscation of purple light; the charcoal became intensely ignited, and some platinum wire attached to it, fused with beautiful scintillations, and fell in large globules on the plate of the pump. All the phenomena of chemical decomposition were produced with intense rapidity, by this combination.

Exp. When the points of charcoal were brought near each other in non-conducting fluids, such as oils, ethers, and chloriodic compounds, brilliant sparks occurred, and elastic matter was generated.

37. There are no fluids known except such as contain water, which are capable of being made the medium of connexion between the metals, or metal of the voltaic apparatus; and it is probable that the power of water

to receive double polarities, and to evolve oxygen and hydrogen is necessary to the constant operation of the connected apparatus.

38. It is probable that acids, or saline substances, increase the action of the battery, by affording elements which possess opposite electricities to each other when mutually excited.

39. The following simple experiment shews the manner in which aqueous fluids propagate electrical polarity among their particles. Cut narrow filaments of tin foil into lengths of almost half an inch, and place them in a line on the surface of an oblong trough of water. On plunging into the water at each end, wires connected with the two extremities of an active voltaic battery, the metallic filaments will immediately acquire polarity. Their positive and negative poles will become regularly opposed to each other, the first depositing oxide, and the last evolving hydrogen. The analogy with magnetic actions is here very complete.

40. That the decomposition of the chemical agents is connected with the energies of the pile, is evident from all the experiments that have been made. No sound objection has been urged against the theory, that the contact of the metals destroys the electrical equilibrium, that the chemical changes restore it, and, consequently, that the action exists as long as the decomposition continues.

41. Salts, as well as other substances, may be decomposed by electricity, and their elements thus ascertained.

42. If we dissolve a quantity, however small, of any salt, in a glass of water, and plunge into it the extremities of the wires which proceed from the two ends of the voltaic battery, the salt will be gradually decom-

posed, the acid being attracted by the positive, and the alkali by the negative wire. If pieces of paper, stained with certain vegetable colours, which are altered by the contact of an acid, or an alkali, be placed in the glasses, the colours will be changed, agreeably to the above phenomena.

Illustration Blue vegetable preparation of litmus becomes red, when touched by an acid; and the juice of violets becomes green by the contact of an alkali.

43. The experiment can be made in a much more distinct manner, by receiving the extremities of the wires into two vessels, so that the alkali shall appear in one vessel, and the acid in another.

44. Let the two vessels be connected together by some interposed substance, capable of conducting electricity, as a piece of moistened cotton thread. Plate 4, fig. 2. c. Put into each of the glasses, a little sulphate of soda, which consists of an acid and an alkali, then fill the glasses with water, which will dissolve the salt.—Now connect the glasses by means of the wires, c. d. with the two ends of the battery. Bubbles soon begin to rise from the decomposition of the water. In order to render the separation of the acid from the alkali visible, pour into the glass, a. which is connected with the positive wire, a few drops of a solution of litmus, and into the other glass, b. which is connected with the negative wire, a few drops of the syrup of violets. The litmus immediately begins to turn red, and the violet solution, green.

Exp. 1. Take three glasses, plate 4, fig. 3, a. b. c. connected together by wetted cotton, but the middle one only contains a saline solution, the two others containing distilled water, coloured as before, by vegetable infusions; yet on making the connection with the battery,

General Table of Metals.

NAMES.	Sp. gr.	Precipitants.	Colour of precipitates by Ferroprussiate of potash.	infusion of galls	Hydrosulphurets.	Sulphuretted hydrogen.
1 Platinum	21.47	Mur. ammon.	0	0		Bl'k. met.pow.
2 Gold	19.30	Sulph Iron Nit.mercury	Yel'wish white	Green ; met.	Yellow	Yellow
3 Silver	10.45	Common salt	White	Yellow-brown	Black	Black
4 Palladium	11.8	Prus. mercury	Deep orange		Blackishbrown	Black-brown
5 Mercury	13.6	Common salt Heat	White passing to yellow	Orange yellow	Brownish bl'ck	Black
6 Copper	8.9	Iron	Red-brown	Brown	Black	Do.
7 Iron	7.7	Succin. soda with perox.	Blue, or white passing to blue	Perox. 0 Perox-black	Black	0
8 Tin	7.29	Corr. sublim	White	0	Protox. black Perox. yellow	Brown
9 Lead	11.35	Sulph soda	Do.	White	Black	Black
10 Nickel	8.4	Sulph. potash ?	Do.	Grey-white	Do.	0
11 Cadmium	8.6	Zinc	Do.	0	Orange yellow	Orange yellow
12 Zinc	6.9	Alk.carbonates	Do.	0	White	Yel'wishwhite
13 Bismuth	9.88	Water	Do.	Yellow	Black-brown	Black brown
14 Antimony	6.70	Water Zinc	With dilute solutions, white	White from water	Orange	Orange
15 Manganese	8.	Tartr. Pot.	White	0	White	Milkiness
16 Cobalt	8.6	Alk.carbonates	Brown yellow	Yellow white	Black	0
17 Tellurium	6.115	Water Antimony	0	Yellow	Blackish	
18 Arsenic	8.35 ? 5.76 ?	Nitr. lead	White		Yellow	Yellow
19 Chromium	5.90	Do.	Green	Brown	Green	
20 Molybde'm	8.6	Do ?	Brown	Deep brown		Brown
21 Tungsten	17.4	Mur. lime ?	Dilute acids			
22 Columbium	5.6 ?	Zinc or inf.gals	Olive	Orange	Chocolate	
23 Selenium	4.3 ?	Iron Sulphite am.				
24 Osmium	?	Mercury		Purple passing to deep blue		
25 Rhodium	10.65	Zinc ?	0			
26 Iridium	18.68	Do ?	0	0	0	
27 Uranium	9.0	Ferroprus.pot.	Brown-red	Chocolate	Brown-yellow	0
28 Titanium	?	Inf. galls	Grass-green	Red brown	Grass-green	0
29 Cerium	?	Oxal amm.	Milk-white	0	White	0
30 Wodanium	11.47	Zinc	Pearl-grey	0		
31 Potassium	0.865	Mur plat. Tart. acid	0	0	0	0
32 Sodium	0.972					
33 Lithium						
34 Calcium						
35 Barium						
36 Strontium						
37 Magnesium						
38 Yttrium						
39 Glucinum						
40 Aluminum						
41 Thorinum						
42 Zirconium						
43 Silicium						

the alkali will appear in the negative glass c. and the acid in the positive glass a. though neither of them contained any saline matter. The acid and alkali are conveyed right and left, from the central glass.

45. Voltaic electricity is of extensive use in chemistry. It has, of late years, brought to light many important facts, a knowledge of which, would probably never have been obtained, independent of this powerful agent.

PRACTICAL QUESTIONS.

What is electricity?

What is called the natural share of a body?

When is a body said to be electrified or changed?

When is it positively and negatively electrified?

What are called conductors and non-conductors?

When do bodies repel each other?

What is the effect when two bodies approach each other, the one being positively, and the other negatively electrified?

How great is the motion of electricity?

How is electricity produced?

What are the conducting substances?

What are the non-conducting substances?

Is electricity ever excited by fusion?

Illustrate it.

Is electricity produced by evaporation?

Illustrate it.

Does the disengagement of gas produce it?

Illustrate it.

Does the tearing asunder of solid bodies produce it?

Illustrate it.

Is electricity produced by contact?

Illustrate it.

What principle is founded on this?

How is galvanism occasioned ?

How was it discovered ?

How may the communication be made ?

Illustrate by an experiment.

Where does the agency reside ?

Must the fluids used, be of an animal nature ?

Of what nature is the action of the fluid ?

What is supposed to be the cause of the action of the voltaic battery ?

What is the theory least liable to objection ?

What is the source of the positive and negative electricity ?

Why does not the oxygen act on the copper in the galvanic battery ?

What will be the effect, if a plate of zinc be placed opposite to one of copper, and the space between them filled with any fluid ?

What is necessary in order that the two electricities may be given out without interruption ?

How do you increase the intensity of electricity ?

If the battery remain undisturbed, will the action stop ?

In what does the great superiority of the voltaic battery consist ?

Can the electricity of the voltaic battery be collected in a Leyden jar ?

How may the quantity of electricity be increased ?

How can you shew the action of the voltaic battery on a small scale ?

Describe the battery of the Royal Institution.

Rehearse some experiments.

What fluids are capable of being made the medium of communication ?

On what principle do acids or saline substances act ?

How do you shew electrical polarity among aqueous particles?

With what is the decomposition of chemical agents connected?

How can salts be decomposed by electricity?

Relate the different methods.

Is voltaic electricity of any use?

CHAP. XXV.

Of Metals.

1. Metals are the most numerous class of undecompounded chemical bodies; and are distinguished by the following properties. 1. They possess a peculiar lustre, which continues in the streak, and in their smallest fragments. 2. They are fusible by heat, and in fusion, retain their lustre and opacity. 3. Except selenium, they are all excellent conductors of caloric and electricity. 4. Many of them may be extended under the hammer, and are called *malleable;* or under the rolling press, and are called *laminable;* or drawn into wire, and are called *ductile.*

Observation. This capability of extension, depends in some measure, on a tenacity peculiar to the metals, and which exists in the different species with very different degrees of force.

2. When the saline combinations of the metals are electerized, the metal separates at the negative pole.

3. When exposed to the action of oxygen, chlorine, or iodine, at an elevated temperature, they generally

take fire, and combining with one or other of these three elementary solvents in definite proportions, are converted into saline or earthy looking bodies, void of metallic lustre and ductility, called oxides, chlorides, or iodides.

4. They are capable of combining in their melted state, with each other, in almost every proportion, constituting the important order of alloys, in which the characteristic lustre and tenacity are preserved.

5. From their brilliancy and opacity, they reflect the greater part of the light which falls on their surfaces; in consequence of this property they form excellent mirrors for telescopes and other purposes.

6. Most of them combine in definite proportions with sulphur and phosphorus, forming bodies frequently of a semi-metallic aspect, others unite with carbon, hydro gen and borax, giving rise to peculiar gaseous or solid compounds.

7. Many of the metals are capable of assuming, by particular management, crystalline forms, which are, for the most part, either cubes or octahedrons.

8. The metals have been variously classed by different chemists; it is a task of no small difficulty. The following is the arrangement of Dr. Ure, of Glasgow. It commences with those metals which possess the obvious qualities of unalterability by common agents; tenacity and lustre. This order indicates very nearly, their relations to oxygen; and as we descend the series, the influence of that element increases. Among the substances near the head, powers of oxygen are subjugated by the metallic constitution, but among those near the bottom, it is very predominant, which the pile of Volta can only disengage; but the metal soon re-unites with oxygen.

9. The first twelve, together with the 31st, 32d, and 33d, are malleable.

10. The first 16 yield oxides which are neutral salifiable bases.

11. The metals, 17, 18, 19, 20, 21, 22 and 23, are acidifiable by their combining with oxygen. The remaining ones from the 31st form with oxygen, the alkaline and earthy bases. The oxides of those from the 23d to the 31st are but little known.

12. Metallic alloys may be analyzed in the following manner, which is a beautiful experiment to show the order of affinities.

Exp. Take an alloy composed of silver, copper, lead, bismuth and tin. Let it be dissolved by the aid of heat in an excess of nitric acid, of the specific gravity 1.23. Evaporate the solution almost to dryness and pour water on the residuum. We shall thus obtain a solution of silver, copper and lead, while the oxides of bismuth and tin will be precipitated. By exposing this precipitate to the action of nitric acid, the oxide of bismuth will be separated from that of tin. To determine the proportions of the other metals, pour, first, into the hot and pretty diluted solution, muriatic acid, which will throw down the silver. After filtration, add sulphate of soda to separate the lead; and finally carbonate of potash to precipitate the zinc. The quantity of each metal may now be deduced from the weight of each precipitate, according to its specific nature.

PRACTICAL QUESTIONS.

How are metals distinguished?

What is the consequence of electerizing the saline combinations of the metals?

What is the effect of exposing them to the action of oxygen, chlorine and iodine?

Are they capable of combining with each other?
Is their brilliancy and opacity of any use?
Do they combine with sulphur and phosphorus?
Do they ever assume a crystalline form?
How are the metals classed?
Name the metals and their specific gravities?
Which of them are malleable?
Which are acidifiable?
Give an example of analysis?

CHAP. XXVI.

Of Platinum—Gold—Silver—Palladium—Mercury.

1. Platinum or Platina, in the Spanish language, signifies *little silver.* It is of a greyish colour, almost black when polished, insipid, inodorous, softer than iron, and less ductile than Gold. It is the heaviest of all metals hitherto discovered.

2. It is most difficult of fusion, for this purpose it requires a degree of heat equal to about 175° of Wedgwood, or 11560 Farenheit. It readily conducts electricity.—It is unalterable in the air.

3. Muriate of tin is a delicate test of platinum.

Exp. 1. A single drop of the recent solution in muriatic acid, gives a bright red colour to a solution of muriate of platinum scarcely distinguishable from water.

Exp. 2. If the muriatic solution of platinum be agitated with ether, the ether will become impregnated with the metal. It is of a fine pale yellow, does not stain the skin, and may be precipitated by ammonia.

Exp. 3. If the muriatic solution of platinum be precipitated by lime, and the precipitate digested in sulphuric acid, a sulphate of platinum will be formed.

4. Platinum does not combine with sulphur directly, but is soluble by the alkaline sulphurets, and precipitable from its nitro muriatic solution by sulphuretted hydrogen.

5. Platinum may be united with phosphorus by projecting small bits of phosphorus on the metal heated to redness, in a crucible, or by exposing to heat four parts each of concrete phosphoric acid, and one of charcoal powder.

6. The phosphuret of platinum is of a silvery white, very brittle and sufficiently hard to strike fire with steel. It is more fusible than the metal itself, and a strong heat expels the phosphorus.

7. Platinum unites with most other metals.

Exp. Added in the proportion of 1 12th to gold, it forms a yellowish white metal, highly ductile, and of considerable tenacity, having the spcific gravity of 19.013.

8. Platinum renders silver harder, but its lustre duller.

9. Copper is much improved by alloying with platinum.

Exp. If 1-6th or 1-25th be added to copper, it becomes of a golden yellow colour, much harder, of a finer polish, smoother grained and much less liable to rust.

10. There are two oxides of platinum, the protoxide which may be obtained by pouring a solution of neutral nitrate of mercury into a dilute solution of muriate of platinum. A dark brown, or olive green precipitate is formed, which must be well washed and heated, so as to expel the mercury.

The protoxide consists of

Platinum,	100.00
Oxygen,	4.423

11. The peroxide appears to contain three prime proportions. It is obtained by treating the muriate of platinum with sulphuric acid at a distilling heat, and decomposing the sulphate with *aqua potassae.* It is a yellowish brown powder, easily reducible at a red heat, to the metallic state.

12. It unites with chlorine in two proportions, forming the proto chloride and the bichloride. The former is soluble in water, while the latter is insoluble.

The bichloride appears to consist of

Platinum, 100 or 1 prime	23.73
Chlorine, 27.932.	9.00

13. The salts of platinum have the following general characters. 1. Their solution in water is yellowish brown. 2. Potash and ammonia determine the formation of small orange coloured crystals. 3. Sulphuretted hydrogen throws down the metal in a black powder. 4. Ferroprussiate of potash and infusion of galls occasion no precipitate.

14. Fulminating Platinum is formed in the following manner. Into a solution of the sulphate in water, aqueous ammonia is poured, and the precipitate which falls, being washed, is put into a matrass with potash ley, and boiled for some time. It is then filtered, washed and dried. A brown powder is obtained, which is the fulminating platinum. It explodes violently when heated to 400°; but does not detonate by friction or percussion. It is a non-conducter of electricity. With sulphuric acid it forms a deep coloured solution. Chlorine and muriatic acid gas decompose it.

15. From its hardness, infusibility, and difficulty of being acted upon by most agents, platinum is of great use in the fabrication of many chemical utensils.

16. Gold is a yellow metal, very soft, ductile, tough and malleable, unalterable and fixed in the air, or the strongest heat of a furnace. The electric shock converts it into a purple oxide. It melts at 32°, W. Its colour, when melted, is of a bluish green, and the same colour is exhibited when light is transmitted through gold leaf. Its ductility is so great that it may be beaten into leaves of $\frac{1}{282000}$ part of an inch in thickness.

17. It is soluble in nitro-muriatic acid and aqueous chlorine.

18. Gold may be precipitated from its solution by lime, magnesia and the alkalies.

19. There is a strong affinity between the oxide of Gold and muriatic acid. The theory of its solution is the nitric acid of the nitro-muriatic furnishes oxygen soon as to the gold, and the muriatic acid dissolves that oxide as formed.

20. There are two oxides of gold, the protoxide which is of a purple colour, and the peroxide which is yellow.

These may be decomposed by heat.

The protoxide seems to consist of 100 metal + 4 oxygen.

The peroxide of 100 metal + 12 oxygen.

The prime equivalent of gold appears to come out 25.

21. Gold combines with a great number of metals and forms with them a variety of alloys. It will combine also with phophorus, forming with it a phosphuret of gold, which is brittle, whitish, and has a cyrstallized appearance.

Exp. 1. A leaf of Gold introduced into a jar of chlorine will take fire and burn.

Exp. 2. Solution of gold gives a purple colour to the skin. It is used for staining ivory, feathers, porcelain, &c.

Exp. 3. The oxide of gold combined with ammonia makes fulminating gold, which explodes with great violence by means of heat.

Exp. 4. Ribands moistened with the dilute solution of gold, and exposed to a current of hydrogen gas, will be gilt. By means of a camel's hair pencil, dipt in the solution and applied to different parts of the ribands, figures in gold may be given to them which will be very permanent.

Exp. 5. A sheet of tin immersed in a solution of gold, precipitates the gold of a purple colour, which, when collected, forms a powder much used in enamelling.

Exp. 6. If ether be added to a solution of muriate of gold, the gold will leave the acid and float on the surface, combined with ether.

22. Green sulphate of iron is a good test for gold.

Exp. To a solution of gold add a solution of sulphate of iron, a precipitate will be formed of a brown colour.

23. Mercury has a strong affinity for gold, with which it unites in all proportions and forms an amalgam, which is softer the larger the proportion of mercury.

24. Gold coins and medals are alloys of gold and copper, and in all cases the degree of purity of the gold is expressed by the number of parts of that metal contained in twenty-four parts of any mixture.

Illustration. Gold, which in twenty-four parts called carats, contains twenty-two of pure metal, is said to be twenty-two carats fine, and absolutely pure gold is said to be twenty-four carats fine.

25. Silver is the whitest of all metals. It is harder than gold, very ductile and malleable, but less so than gold, silver leaf is more than one third thicker than gold; in this state it does not transmit light. It ignites before melting, and requires a strong heat to fuse it.

It is vitrified by the heat of a very powerful lens.

26. In the electric circuit of a powerful galvanic battery, silver leaf may be made to burn with a beautiful green light.

27. The air has very little effect on it, though it obtains a purple or black coating in contact with sulphureous vapours, which are emited from animal substances in a state of decomposition. This coating is found to be a sulphuret of silver.

28. There seems to be only one oxide of silver, which is formed by intense ignition in an open vessel, when an olive coloured glass is obtained, or by adding a solution of caustic barytes to one of nitrate of silver, and heating the precipitate to dull redness. It consists of 100 silver and +7. 3 oxygen.

29. Silver combines with chlorine, and was formerly called *luna cornea, or horn silver.* It may be formed by adding a solution of muriate of soda to one of nitrate of silver.

30. Fulminating powder may be formed with silver, which may be very terrible in its effects. It is made by pouring lime water into a solution of the pure nitrate and filtering, washing the precipitate, and then digesting on it liquid ammonia for twelve hours. The ammonia must be cautiously decanted from the black powder, which is to be dried in minute portions, and with great caution, on bits of filtering paper or card.

31. If struck, even in its moist state with a hard body,

it explodes; and if in any quantity when dry,the fulmination is tremendous.

32. If the decanted ammonia be gently heated, it effer-verces from disengagement of azote, and small crystals appear in it when it cools. These possess a still more formidable power of detonation, and will scarcely bear touching even under the liquid. It appears to be a compound of oxide of silver and azote.

33. The sudden extrication of the condensed gas is the cause of the detonation.

34. Silver is soluble in sulphuric acid at a boiling heat, when concentrated. Nitric acid dissolves more than half its weight of silver. It destroys and corrodes animal substances very powerfully. When crystallized, melted and cast into sticks it forms the *Lunar caustic* of the shops.

35. Nitrate of silver may be decomposed by other metals; a plate of copper to which it is applied becomes plated with silver.

Exp. Spread a few drops of nitrate of silver upon a piece of window glass by means of a camel's hair pencil; at the bottom of it in contact with the fluid, place a small brass or copper wire; let it remain undisturbed; and in a short time, it will begin to shoot into apparent vegetation.

36. For silvering of dial plates, scales of barometers, thermometers, &c. The muriate of silver is chiefly used, from which the silver is precipitated and unites with the coppery surface.

27. A useful solvent of silver is formed by dissolving one part of nitrate of potash, by weight in eight or ten parts of concentrated sulphuric acid. This compound called nitro-sulphuric acid, when heated below the temperature of boiling water, dissolves a sixth or even a fifth

of its weight of silver, with an extrication of nitrous gas, and leaves the copper or other metal with which the silver may be combined. This is of great use in extracting silver from plated articles.

38. The beautiful representation called Diana's tree, may be made in the following manner. Take three drams and a half of pure silver, and half as much mercury; dissolve them separately in sufficient quantities of pure nitric acid, then mix the solution and add to them five or six ounces of distilled water. This is to be poured upon rather less than half an ounce of an amalgam of silver, which is put into a spherical glass vessel. In the course of twenty four hours the silver tree will be formed.

39. Silver is found in various parts of the world, in a metallic state, a sulphuret and an oxide.

EXPERIMENTS.

1. Add a few drops of muriatic acid to some nitrate of silver, a white curdy or flaky precipitate falls down in great abundance, this precipitate is decomposed by light, for if exposed to the direct rays of the sun, its colour becomes darker.

2. If one part of muriate of silver be mixed with three parts of carbonate of soda and fused in a crucible, the silver will be reduced and found at the bottom of the crucible.

3. A solution of the nitrate of silver stains animal substances of a deep black: It has been applied to the staining of the human hair.

4. White paper when stained with a solution of nitrate of silver, in the proportion of ten parts of water and one

of the salt, and exposed to the light, acquires colour and passes through all the changes to black.

5. Let a slip of ivory be immersed in pure nitrate of silver, till it acquires a bright yellow colour; then remove it into a glass of distilled water, and expose it to the direct light of the sun; it will, after two or three hours, become black, but on rubbing it a little, the surface will be changed into a bright metallic one.

40. Palladium is a new metal first found by Dr. Wollaston, in ores of Platina. It is scarcely distinguished from the crude platina, though much harder.

41. Palladium is of a greyish white colour and takes a good polish. It is ductile and very malleable; and being reduced into thin strips is flexible, but not very elastic. Its fracture is fibrous, and in diverging striae, exhibiting a kind of crystalline arrangement. In hardness it is superior to wrought iron. It is a less perfect conductor of caloric than most metals, and less expansible, though in this it exceeds platina. On exposure to a strong heat its surface tarnishes a little and becomes blue, but an increased heat brightens it again. It requires more heat than that of gold for its fusion, but if touched when hot with a small bit of phophorus, it runs like zinc. The sulphuret is whiter than the metal itself, and extremely brittle.

42. It is soluble in nitric acid, which soon acquires a fine red colour, but the quantity dissolved is small. Nitrous acid acts on it more quickly and powerfully. Sulphuric acid by boiling, acquires a similar colour, dissolving a small portion. Muriatic acid acts much in the same manner. Nitro-muriatic acid acts upon it powerfully, and assumes a deep red.

43. Alkalies and earths throw down a precipitate of a fine orange colour. Recent muriate of tin precipitates

it of an orange or brown colour, or a beautiful emerald green. Green sulphate of iron precipitates the palladium in a metallic state. Sulphuretted hydrogen, dark brown. All the metals, except gold, silver and platina, precipitate it in a metallic state.

44. Mercury has derived several names from its similarity to silver; as *quicksilver*, *argentum vivum*, and *hydrargyrum.*

45. It is distinguished from all other metals, by its extreme fusibility; it is not solid until cooled down to the 39 — 0 of Farenheit; of course, it is always fluid in our climate. Its colour is white, and rather bluer than silver. In the solid state, it is malleable. It is volatile, and rises in small portions in the common temperature of the atmosphere. It boils at the temperature of 656°. When exposed to a heat of 600°, it gradually acquires oxygen, and is converted into a red powder, or oxide, which is said to be the tritoxide. This was formerly known by the name of *precipitate per se.* From its volatility, it is commonly purified by distillation.

46. There have been reckoned three oxides of mercury. 1. The protoxide, when the mercury is converted into a black powder by agitation, formerly called *ethiops per se.* 2. When it is dissolved in nitric acid without the assistance of heat, the deutoxide is formed.— 3. When exposed to the heat of 600° for a considerable length of time, the peroxide is formed.

47. Mercury combines with sulphur and phosphorus very readily.

Exp. If two parts of sulphur by weight, and one of mercury, be triturated together in a mortar, the mercury gradually disappears and the mass assumes a black colour. In this state, it was formerly called *ethiops mineral*, but it is now found to contain mercury, sulphur, and sulphuretted hydrogen, and on that account, is denominated *hydro-sulphuret of mercury.* The sulphur imbibing hydrogen from the moisture of the atmosphere.

48. If hydro-sulphuret of mercury be heated, part of the sulphur is dissipated, and the compound assumes a deep violet colour.

49. Vermillion is composed of mercury and sulphur, united by fusion and sublimed. It is obtained in a fine red cake, and in this state it was called cinnabar ; it is the red sulphuret of mercury.

50. *Phosphuret of mercury* is formed from phosphorus and the black oxide of mercury, or *protoxide*, melted in a retort filled with hydrogen gas. This latter substance prevents the combustion of the phosphorus. This substance being formed of the oxide and not of the pure mercury, has been called black phosphuretted oxide of mercury.

51. The following metals are soluble in mercury, when mixed in sufficient quantities. Gold, lead, bismuth, osmium, silver, tin, zinc.

52. On the amalgamating property of mercury, the silvering of looking glasses depends.. An amalgam is formed, by pouring mercury on tin foil, laid perfectly smooth on a marble slab, and the glass slided on it, and kept down by weights.

53. Sulphuric acid will not act upon mercury, when cold ; hence, it has been used to purify mercury from foreign materials, for barometers and thermometers.

54. Muriatic acid does not sensibly act on metallic mercury, except by long digestion, when it oxidates a part, which is immediately dissolved. It readily dissolves the oxides.

55. Nitric acid acts with great energy on mercury, and during the operation, nitrous gas is disengaged.—

The nitrate contains a greater or less proportion of oxygen, as it is prepared with or without heat.

56. All the nitrates of mercury are very caustic, and form a deep purple, or black spot on the skin. They afford crystals, which differ according to the state of the solution.

57. When the crystals of nitrate of mercury are submitted to a long continued heat, they give out a portion of nitric acid, and are converted into a bright red oxide, called red precipitate.

58. Mercury combines with chlorine, and forms two well known compounds, viz. calomel, or the *proto chloride*, and corrosive sublimate, or the perchloride, called by some, the deutochloride.

59. The perchloride of mercury consists of

Mercury,	25	73.53
Chlorine,	9	26.67
		100.00

The protochloride of

Mercury,	25	84.746
Chlorine,	4.5	15.254
		100.000

60. Mercury is extensively used in the arts and in medicine.

PRACTICAL QUESTIONS.

What is platinum and its characteristics?

Is it easily fusible?

What is a test of platinum?

Does platinum combine with sulphur?

Can platinum be united with phosphorus?

What are the properties of phosphuret of platinum?

Does platinum unite with any of the metals?

What effect does it have on gold?

What on silver ?

What on copper ?

What are the oxides of platinum ?

How is the peroxide obtained ?

In how many proportions does it unite with chlorine ?

What characters do the salts of platinum possess ?

How is fulminating platinum prepared ?

What are its properties ?

What is gold, and what are its properties ?

In what is it soluble ?

What will precipitate it from its solution ?

What is the theory of the solution of gold in nitro-muriatic acid ?

How many oxides of gold are there ?

Does gold combine with any other metals ?

What test have you for gold ?

Has mercury any affinity for gold ?

What are gold coins and medals ?

Illustrate this.

What are the characteristics of silver ?

What is the phenomenon produced by electricity upon it ?

What effect has the air upon it ?

What are the oxides of silver ?

What does silver form with chlorine ?

How do you form fulminating silver ?

What are its properties ?

Is there any other fulminating compound ?

What is the cause of the detonation ?

Is silver soluble in nitric and sulphuric acids ?

How can nitrate of silver be decomposed ?

How are Dial plates, scales of barometers, &c. silvered ?

How do you form a useful solvent of silver ?

How can Diana's tree be formed ?

Where is silver found ?

What is palladium ?

What are its characteristics ?

Is it soluble in the acids ?

How is it precipitated ?

What is mercury ?

How is it distinguished ?

How many oxides are there of this metal ?

Does mercury combine with sulphur and phosphorus ?

What is the effect of heating hydro-sulphuret of mercury ?

Of what is vermillion composed ?

How is phosphuret of mercury formed ?

What metals are soluble in mercury ?

On what does the silvering of looking glasses depend ?

Will sulphuric acid act upon mercury ?

Will muriatic acid ?

What is the action of nitric acid on mercury ?

What property have the nitrates ?

How is red precipitate formed ?

Does mercury combine with chlorine ?

What are the proportions in the protochloride and the perchloride ?

Is mercury much used ?

CHAP. XXVII.

Of Copper—Iron—Tin—Lead—Nickel—Cadmium—Zinc

1. Copper is a metal of a peculiar reddish brown colour, hard, ductile, malleable and sonorous, and of considerable tenacity.

2. It melts in a heat about sufficient to melt gold, and exhibits a bluish green flame; by a violent heat it boils, and is volatilized, partly in a metallic state.

3. A wire one tenth of an inch in diameter will bear more than three cwt. without breaking.

4. Copper rusts on exposure to the air, but the corroded part is very thin, and preserves the metal below from farther corrosion.

5. There are two oxides of copper. The protoxide is of a fine orange colour, and is obtained by digesting a solution of muriate of copper with copper filings in a close vessel. The colour passes from green to dark brown, and grey crystalline grains are deposited. The solution of these yields, by potash, the protoxide. It consists of 8 copper, and + 1 oxygen.

6. The peroxide is of a black colour, and is procurable by heat, or by drying the hydrated oxide, precipitated by potash from the nitrate. It consists of 8 copper + 2 oxygen.

7. Copper combines with chlorine in two proportions, forming the protochloride and the perchloride.—The protochloride consists of

Chlorine,	36	or 1 prime = 4.45	35.8
Copper,	64	1 prime = 8.00	64.2
	100	12.45	100.0

The perchloride consists of

Chlorine,	53	or 2 primes = 8.9	52.7
Copper,	47	1 prime = 8.0	47.3
	100	16.9	100.0

8. It unites with iodine, forming insoluble substances of a dark brown colour, called iodides of copper.

9. When copper is exposed to a stream of oxygen and hydrogen gases, it takes fire and burns with great brilliancy, emitting a lively green light, of such intensity as to be scarcely endured by the eye. Copper leaves, or wire, may be burned by the galvanic fluid.

10. Copper unites with sulphur and phosphorus.—The sulphuret may be formed readily, by mixing copper filings with sulphur, and making them into a paste with water.

11. The phosphuret may be formed by fusing together sixteen parts of copper, sixteen parts of phosphoric glass, and one of charcoal.

12. Copper unites with the metals and forms alloys, which are of considerable importance; an alloy of copper and platinum takes a fine polish, and is not liable to rust; on this account, it has been used in reflecting telescopes.

13. Sulphuric acid, when concentrated and boiling, dissolves copper. If water be added to the solution, it assumes a blue colour, and on evaporation, produces crystals, called *blue*, or *Roman vitriol*, and by the present nomenclature, *sulphate of copper*. These are much more beautiful, if a little nitric acid be added to the solution.

14. The nitric acid acts on copper with great energy, and disengages a large quantity of nitrous gas. The solution, or evaporation affords crystals of a green colour, which are deliquescent.

15. The acetic acid acts upon copper, and forms what is called *verdigris*, which is a crude acetate. This, when dissolved in vinegar and evaporated, forms beautiful green crystals, which are subdeliquescent in the air.

16. The following acids form insoluble salts with peroxide of copper, viz. Antimonic, antimonous, boracic, chromic, molybdic, phosphoric and tungstic. The

first two are green, the third is brown, the fourth and fifth green, and the sixth is white.

17. The oxides of copper are poisonous; but *sugar* is said to be an antidote of undoubted efficacy.

18. Copper, with about a fourth of its weight of lead, forms *pot metal;* with the same proportion of zinc, it composes *brass.* Mixture of zinc and copper, in different proportions, form the various compounds of Dutch gold, Prince's metal, pinchbeck, &c. Copper and tin, with a little zinc, form *bell-metal*, or *gun-metal.* When tin is nearly one third of the alloy, it takes a beautiful polish, and is called *speculum metal*, from its being used in the construction of reflecting telescopes.

19. *Iron* is of a bluish white colour, of considerably hardness and elasticity; very malleable and exceedingly tenacious and ductile; very easily oxidized, and difficult of fusion; on which account, it is brought into different shapes by hammering. It possesses a property which no other metal does, except platina; that of being welded, or united by forging, after being brought to a white heat.

20. Iron cannot be hammered into leaves as thin as gold or silver, but it may be drawn into a wire as fine as a human hair; a wire one tenth of an inch in diameter, will sustain without breaking, nearly six cwt.

21. When iron is exposed to the action of moist air, it acquires weight by gradually attracting oxygen, and hydrogen gas escapes; a yellow rust forms on the surface, which is not a simple oxide, as it contains a portion of carbonic acid.

22. Concentrated sulphuric acid scarcely acts upon iron, unless when boiling. If the acid be diluted with two or three parts of water, it dissolves iron readily,

without the assistance of heat. During the solution, hydrogen gas escapes in large quantities.

23. Green sulphate of iron is much more soluble in hot than cold water, and therefore crystallizes by cooling, as well as by evaporation.

24. The crystals are efflorescent, and fall into a white powder by exposure to a dry air; the iron becoming more oxidized than before.

25. A solution of sulphate of iron exposed to the air, acquires oxygen, and the metal being peroxidized, falls to the bottom.

26. Sulphate of iron is decomposed by alkalies and by lime. Caustic fixed alkali precipitates the iron in deep green flocks, which are dissolved by the addition of more alkali, and form a red tincture.

27. Vegetable astringent matters, such as nut-galls, the husks of nuts, logwood, hyson and souchong tea, &c. which contain tannin and gallic acid, precipitate a fine black fecula from sulphate of iron, which remains suspended for a considerable time in the fluid, by the addition of gum arabic. This fluid is well known by the name of *ink*.

28. The beautiful pigment, well known in the arts by the name of prussian blue, is likewise a precipitate, afforded by the sulphate of iron and prussine, or cyanogen.

29. Iron is soluble in nitric and muriatic acids. The former does not afford crystals on evaporation, but deposits the oxide of a red colour.

30. Iron combines with sulphur, phosphorus and carbon, forming sulphurets, phosphurets and carburets of iron.

Exp. If equal quantities of iron filings and sulphur are formed with water into a paste, the sulphur decomposes the water, and absorbs the oxygen so rapidly, that this mixture sometimes takes fire, although buried under ground. This fact is supposed to afford an explanation of the origin of volcanoes.

Exp. 2. The phosphuret of iron may be formed by dropping small bits of phosphorus into iron filings heated red hot.

31. The carburet of iron is found native, known under the name of *plumbago*, or *black lead*. It consists of about one tenth iron, the rest is carbon.

32. Cast iron is the name given to the metal when first extracted from the ores ; by heat and hammering, it is formed into what is called wrought iron. Steel is a compound of iron and carbon.

33. Iron may be distinguished from steel, by exhibiting a whitish grey spot with nitric acid, whereas the steel becomes black, from the carbon which it contains.

34. The yellow spots, called iron moulds, which are frequently occasioned on cloth by washing ink spots with soap, may, in general, be removed by lemon juice, or the oxalic, or nitric acid, or by muriatic acid diluted with five or six parts of water ; but in this case, the cloth should be immediately washed.

35. There are two oxides of iron, the protoxide, which is black. Its composition seems to be

Iron,	100	77.82	3.5
Oxygen,	28.5	22.18	1.0
		100.00	4.5

The peroxide, which is red, it seems to be a compound of

Iron,	100	70 = 4 primes.
Oxygen,	43	30 = 3 primes.

36. Iron is found in abundance in almost every part of the world, and is the most useful of all minerals.

37. Tin is a metal of a yellowish white colour, considerably harder than lead, scarcely sonorous, very malleable, though not very tenacious. Under the hammer it is extended into leaves called *tin foil*, which are about $\frac{1}{1000}$ of an inch in thickness, and might easily be beaten to less than half that thickness.

38. It is melted at a temperature about double that of boiling water, or 430° F.

39. When exposed to the air it loses its lustre, and assumes a greyish white colour ; but when melted in an open vessel, its surface very soon becomes covered with a grey powder, which is the oxide of tin. If the heat be continued, the powder becomes yellow.

40. There are two oxides of tin, the protoxide, which is grey, and the peroxide is white.

41. The protoxide consists of 13.5 per cent of oxygen.

The peroxide is composed of

Tin,	100
Oxygen +	27.2

And if we regard it as containing 2 primes of the latter principle to 1 of metal, the prime of this will be 7.353. The mean may be taken at 7.35.

42. Tin unites with chlorine in two proportions, forming the protochloride and perchloride of tin.

43. Sulphur unites with tin in two proportions. One may be made by fusing tin and sulphur together. It is of a blue colour and lamellated texture. It consists of 7.35 tin and + 2 sulphur. The bisulphuret is made by heating together peroxide of tin and sulphur. It is of a beautiful gold colour, and appears in fine flakes. It was

formerly called *aurum musivum*, or Mosaic gold. It consists, according to Dr. J. Davy, of

7.8 tin, or 1 prime tin.
4.00 sulphur, 2 primes sulphur.

44. Tin combines with various metals and forms alloys; with mercury it forms an amalgam, which is used for electrical purposes, and silvering of mirrors.

45. The alloys of tin are used in the manufacturing of cannon, bells, and various articles made of bronze, and for reflecting telescopes.

46. Tin plates are made by dipping plates of iron, properly scoured, into melted tin.

47. Common pins are whitened, by boiling them with tin for five or six hours in water, acidulated with tartaric acid. Brass being a compound of zinc and copper, the zinc has an affinity for the tin, and in this case, forms the union.

48. Tin is soluble in all the mineral acids, and forms sulphates, nitrates, muriates, &c.

49. When nitric acid is used as a solvent, it is decomposed by the tin, and red fumes are thrown off with rapidity.

Exp. Add to the nitric solution, a solution of potash. The tin decomposes both the acid and the water, the nitrogen of the former combines with the hydrogen of the latter and forms ammonia, which is evolved in the form of gas.

50. Tin decomposes the muriate of ammonia.

Exp. Put equal parts of granulated tin and muriate of ammonia into a retort, which is to be adopted to a receiver, in a mercurial apparatus; as soon as heat is applied to the retort, a decomposition takes place; the ammonia is disengaged in the form of gas, the muriatic acid combines with the tin, forming a solid muriate of tin, which may be decomposed with water.

51. The muriate of tin is employed in the process of dyeing ; it is the basis of the scarlet dye. In glazing, and in the forming of Plumber's solder, tin is used.

52. Lead is a bluish white metal, very soft and flexible, not very tenacious, and consequently incapable of being drawn into fine wire, but is easily extended into thin plates under the hammer. In a strong heat it boils and emits fumes, during which time, its oxidation proceeds with considerable rapidity, if exposed to the air. It congeals in a crystalline form. It is not much altered on exposure to the air, though the brightness of its surface soon tarnishes.

53. There are two, if not three combinations of lead with oxygen. 1. The powder precipitated from the nitrate with potash, forms the yellow protoxide. When somewhat vitrified, it constitutes *litharge*, and combined with carbonic acid, *white lead.* 2. When massicot has been exposed for about 48 hours to the flame of a reverberating furnace, it becomes red lead, or minium. This substance has a specific gravity of 8.94. At a red heat, it gives out oxygen and passes to the protoxide. It consist of 100 lead + 11.08 oxygen. 3. If upon 100 of red lead, we digest nitric acid of specific gravity 1.26, 92.5 parts will be dissolved. But 7.5 of a dark brown powder will remain insoluble. This is the peroxide of lead, and consist of 100 lead, and + 15.4 oxygen.

54. Lead combines with chlorine and iodine ; with the former, it forms a greyish white powder ; with the latter, a fine yellow.

55. The salts of lead have the protoxide for their base.

56. Most of the acids attack lead; but the sulphuric requires a boiling heat for the purpose. Nitric acid attacks lead with violence. Muriatic acid acts directly on lead by heat, oxidizing it, and dissolving part of its oxide.

57. The acetic acid dissolves lead and its oxides; when evaporated, the solution affords needle formed crystals, called *sugar of lead*, from its sweet taste.

58. The common sugar of lead is an acetate; and *Goulard's extract*, made by boiling litharge in vinegar, a *subacetate*. The acetate crystallizes in needles, the subacetate in plates.

Exp. Dissolve one part of sugar of lead in forty parts of water, in a phial, suspend in it a little ball of zinc, and leave it undisturbed. The zinc will soon be covered with a moss like substance, which increases gradually, shooting out into a sort of leaves, resembling in some measure, the form of a tree. The phenomenon of this depends on galvanism.

59. Oils dissolve the oxide of lead, and become thick and consistent, in which state, they are used as the basis of plasters, cements, for water works, &c.

60. Sulphur readily dissolves lead in the dry way, and produces a brittle compound, of a deep grey colour and brilliant appearance.

61. The phosphoric acid exposed to heat, together with charcoal and lead, becomes converted into phosphorus, which combines with the metal. This combination does not differ much from ordinary lead; it is malleable, and easily cut with a knife; but is more easily tarnished, when exposed to the air.

62. Oxide of lead decomposes muriate of soda, and is formed into a pigment called *Patent yellow*.

Exp. Mix two parts of finely powdered red lead, with one of common salt, and form the whole into a paste with water, the alkali will be disengaged and the acid will unite with the oxide of lead. If the alkali be washed off, and the mass dried and fused in a crucible, a hard heavy yellow substance will be formed.

63. Lead unites with most of the metals and forms alloys.

64. Lead is generally found in veins of rocks, combined with silver, antimony, sulphur, bismuth,&c. When combined with sulphur, it is called *galena.*

65. Nickel is a metal extremely hard, of a uniform texture, and of a colour between silver and tin, very difficult to be purified, it is magnetical. It even acquires polarity. It is malleable both cold and red hot, and is scarcely more fusible than manganese.

66. There are two oxides of nickel, the dark ash grey, and the black. The protoxide is a compound of 100 metal and 28 oxygen. The prime equivalent of the metal will be 3.6. That of the protoxide 4.6.

67. The salts of nickel have usually a green colour, and yield a white precipitate with ferro-prussiate of potash. Ammonia dissolves the oxide of nickel. Sulphuretted hydrogen and infusion of galls occasion a precipitate. Their composition has been very imperfectly ascertained.

68. Nickel is soluble in the nitric and nitro-muriatic acids. The nitric solution has a dark green colour, and carbonate of potash throws down a green precipitate, which assumes a dark grey colour when heated

69. Nickel combines with gold, copper, iron, tin and lead. Its oxide gives a beautiful dark green colour to porcelain.

70. Cadmium is a new metal discovered by Mr. Stromger; in 1817, in some carbonate of zinc which he was examining, in Hanover.

71 It is a fine white metal with a slight bluish grey, approaching to that of tin, which metal it resembles in lustre and susceptibility of polish. Its texture is compact and its fracture hackly. It crystallizes on cooling, and presents on its surface the appearance of leaves of fern. It is flexible and yields readily to the knife. It is harder and more tenacious than tin, and stains paper and the fingers. It is ductile and malleable, but when long hammered flies off in scales. It melts and is volatilized at a red heat. Its vapour may be condensed in drops like mercury, and exhibits traces of crystallization.

72. There is but one oxide of Cadmium, which consiststs of 100 of metal combined with 14.352 of oxygen.

73. It is soluble in liquid ammonia and the acids.

74. Cadmium unites easily with most of the metals and forms alloys ; which are brittle and colourless.

75. Zinc is a metal of a bluish white colour, somewhat brighter than lead, of considerable hardness and so malleable as not to be easily broken by the hammer. It is very easily extended by the rollers of the flatting mill. When broken by bending, its texture appears as though composed of cubical grains. It melts at about 700° F. and soon after it becomes red hot, it burns with a dazzling white flame of a bluish yellow tinge, and is oxidized with such rapidity that it flies up in the form of white flowers called *flowers of zinc.*

76. There is but one oxide of zinc which consists of 100 metal + 2.41 oxygen. The prime equivalent appears to be 4.1.

77. Zinc combines with chlorine and forms a substance of a whitish grey colour, and semi-transparent.

78. Most of the acids dissolve zinc and form salts; sulphate of zinc or *white vitriol* is much used in the arts.

79. Zinc will decompose nitric acid.

Exp. Put some granulated zinc in a Florence flask, and pour over it weak nitric acid; a strong effervescence ensues, and nitrous gas is disengaged.

80. Zinc is obtained from *Lapis Calaminaris* and other minerals.

81. It is used in making brass, in forming amalgams for electrical purposes, &c. Zinc filings are mixed with gunpowder to produce the brilliant stars in artificial fireworks.

PRACTICAL QUESTIONS.

What is Copper?

What heat is required to melt and cause it to boil?

How much will a wire 1 10th of an inch in diameter bear?

What effect does the air have on copper?

What are the oxides of copper?

What is the pertoxide?

How many chlorides are there?

What is the iodide?

What is the effect when copper is exposed to a stream of oxygen and hydrogen gases?

Does copper unite with sulphur?

How do you form the phosphuret?

Does copper unite with the metals?

Does sulphuric acid dissolve copper?

What effect has nitric acid on copper?

What is the action of acetic acid on copper?

What acids form insoluble salts with peroxide of copper?

Are the oxides of copper poisonous?

What are the different alloys of copper?

What is iron?

What is the ductility of iron?

What is the effect of moist air on iron?

Does concentrated sulphuric acid act upon iron?

What is the solubility of green sulphate of iron?

What effect does air have on sulphate of iron?

How is sulphate of iron decomposed?

What effect has vegetable astringents on iron?

What is Prussian blue?

Is iron soluble in nitric and muriatic acids?

Does iron combine with sulphur, phosphorus and carbon?

What is Plumbago?

What is *Cast iron?*

How do you distinguish iron from steel?

How can *iron mould* be removed from cloth?

How many oxides of iron are there?

What are their compositions?

Where is iron found?

What is tin?

What heat is required to melt it?

What effect does the air and heat have upon it?

How many oxides are there?

What are their proportions?

How many combinations has tin with chlorine?

How many proportions with sulphur?

Is tin alloyed with any of the metals?

For what are the alloys used?

How are tin plates made?

How are pins whitened?

Is tin soluble in the mineral acids?

What effect has tin on the nitric acid?

Does tin decompose ammonia?

Illustrate it.

What use is the muriate of tin?

What is lead?

How many oxides of lead are there?

Does lead combine with chlorine and iodine?

What have the salts of lead for their base?

Have the acids any effect on lead?

What is sugar of lead?

How is a lead tree formed, and what is the cause?

What effect have oils on the oxides of lead?

What effect has sulphur on lead?

What effect has the phosphoric acid?

What is Patent yellow?

Does lead unite with the other metals?

Where is lead found?

What is Nickel?

How many oxides of nickel are there?

What do the salts of nickel exhibit?

In what acids is nickel soluble?

With what does nickel combine?

What is Cadmium?

What are its properties?

How many oxides are there?

In what is it soluble?

Does it unite with the metals?

What is zinc?

What are the oxides of zinc?

Does zinc combine with chlorine?

Do the acids dissolve zinc?
From what is zinc obtained?
For what is it used?

CHAP. XXVIII.

Of Bismuth—Antimony—Manganese—Cobalt—Tellurium.

1. Bismuth is a metal of yellowish, or reddish white colour, little subject to change in the air. It is somewhat harder than lead, and is not malleable. Its fracture exhibits large shining plates, disposed in a variety of positions; thin pieces are sonorous. It melts at a temperature of 480° F. and its surface becomes of a greenish grey or brown oxide. A stronger heat ignites it, and causes it to burn with a small blue flame, at the same time a yellowish oxide known by the name of *flowers of bismuth* is sublimed. This oxide appears to rise in consequence of the combustion, for it is very fixed, and runs into a greenish glass when exposed to heat alone.

2. This oxide consists of 100 metal+11.275 oxygen. Its prime equivalent will be 9.87, and that of the metal itself, 8.87. The specific gravity of the metal 9.85.

3. The sulphuric acid has a slight action on bismuth, when it is concentrated and boiling. Sulphurous acid gas is evolved, and part of the bismuth is converted into a white oxide. A small portion combines with the sulphuric acid and forms a deliquescent salt in the form of small needles.

4. The nitric acid dissolves bismuth with the greatest rapidity and violence; at the same time, much heat

is extricated, and a large quantity of nitrous oxide is disengaged. The solution when saturated, affords crystals as it cools. The salt detonates weakly and leaves a yellow oxide behind, which deliquesces in the air.

Exp. When the nitric solution is diluted with pure water, the metal falls down in the form of a white oxide called, formerly, *Magestery of bismuth* This affords a test by which bismuth is distinguished from the other metals.

5. The muriatic acid does not readily act upon bismuth.

6. Chlorine acts so violently on bismuth as to cause it to take fire. The substance formed is chloride of bismuth, formerly called *butter of bismuth.*

7. Iodine combines with bismuth and forms an iodide of an orange yellow colour.

8. Sulphur combines with bismuth in two proportions, forming sulphurets.

9. Bismuth combines with most metals and renders them more brittle.

10. Bismuth is used in the formation of printers' small types, and to make pewter. It forms the bases of a sympathetic ink. In this experiment the acetic acid must be employed for the solution of the metal. Characters written with this solution become visible, when exposed to sulphuretted hydrogen.

11. The term Antimony is used to denote in commerce a metallic ore consisting of sulphur combined with the metal. It consists of about 26 *per cent* of antimony.

12. Antimony when pure, is of a dusky white colour, very brittle, and of a plated or scaly appearance, the plates crossing each other in every direction.

13. It may be obtained in the form of a metal from

the sulphuret, by fusing three parts in a covered crucible, with one of iron filings; or by fusing it with animal charcoal.

The product was formerly called *regulus of Antimony.*

15. It requires for its complete fusion a heat nearly 450° F.

15. There are three if not four combinations of antimony with oxygen.

			In 100 parts.
The protoxide consists of			
	11 metal	+1 oxy. or	$91\frac{2}{3}+8\frac{1}{3}$
Deutoxide	11	+2	84.6+15.4
Tritoxide	11	+3	78.6+21.4
Peroxide	11	+4	73.4+36.6

16. Antimony looses its lustre in the air; but it is not altered by being kept under water. When steam is made to pass over red hot antimony, it is decomposed so rapidly that a violent detonation ensues.

17. When the native sulphuret is slowly roasted, it gradually loses its sulphur, the metal attracts oxygen, and is converted into a grey oxide, this being fused by a strong heat, runs into a glassy substance and is called the *glass of antimony.*

18. If the native sulphuret be reduced to powder and boiled with pure potash, the solution deposits on cooling an hydro-sulphuret, formerly called *kermes mineral.* A similar compound with a larger proportion of sulphur was formerly called *golden sulphur of antimony.*

19. Antimony combines with other metals and forms alloys; between six and seven parts of lead and one of antimony form an alloy of which printer's types are made. Sometimes, however, a less quantity of antimony is used.

20. Antimony combines with the acids and forms salts which have been much used in medicine, especially that of tartaric acid and antimony called *tartar emetic*, (tartrate of antimony.) The white deutoxide of antimony is the bases of this salt.

21. The empirical medicine called *James' powder* is a compound of which antimony is the principal ingredient.

22. Antimony is obtained from an ore which is abundant in some parts of the world, prrticularly in Germany and Norway.

23. Manganese is a metal of a dull whitish colour when broken, but which soon grows dark by oxidation from the action of the air.

24. It is hard, brittle, though not pulverizable, and rough in its fracture. It is so difficultly fusible, that no heat, hitherto exhibited, has caused it to run into masses of any considerable magnitude. When broken into pieces it falls into powder by spontaneous oxidation.

25. Manganese heated in oxygen or chlorine, takes fire and forms an oxide or chloride.

26. Chemists differ with regard to the number of combinations with oxygen. Sir H. Davy has two, M. Thenard, four, Mr. Brande, three, and Berzelius, five. The black oxide is the state in which it is usually found.

27. Manganese is soluble in the acids, but most readily in the nitric. It is precipitated by alkalies in the form of white powder. It combines with the other metals and is scarcely ever found, but when mixed, more or less, with iron.

28. When powdered manganese and nitrate of potash are mixed together and thrown into a red hot crucible,

the nitrate is decomposed, and a highly oxidized manganese with potash is obtained, which has the following properties. It exhibits different colours, according to the quantity of water that is added to it. A small quantity gives a green solution, a little more changes it to blue; some more gives it a purple. The experiment may be varied by putting equal quantities of this substance into two glass vessels, and pouring on the one hot, and on the other cold water, the same material with water of different temperatures assumes various shades of colours, and on that account it has been called the *chameleon mineral.*

29. Manganese in a state of oxide has been found in different parts of the World. It is very abundant in some parts of the United States, and is of an excellent quality. It is used in bleaching and in the manufacture of glass.

30. Cobalt is a brittle, somewhat soft but difficultly fusible metal, of a reddish grey colour, of little lustre. It melts at 130° Wedg.

31. Cobalt is susceptible of magnetism, but in a lower degree than that of nickel.

32. Oxygen combines with cobalt in two proportions, forming a dark blue protoxide, and a black peroxide.

The first dissolves in acids without effervescence.

It consists of cobalt,	5.4	100	84.33
oxygen,	1.0	18.5	15.62
			100.00

The peroxide, cobalt,	5.1	100	73
oxygen,	2.0	37	27
			100

33. When cobalt is heated in chlorine it takes fire and forms the chloride.

34. The best solvents of this metal are the nitric and nitro-muriatic acids. From these solutions sympathetic inks are formed.

Exp. Digest one part of cobalt in a sand heat for some hours, with four parts of nitric acid, to the solution one part of the muriate of soda is to be added, and four parts of water. Write with this solution, when cold they will be illegible; but on applying a gentle heat they assume a beautiful blue or green colour.

35. Cobalt combines in small proportions with most of the acids, also with ammonia, phosphorus and most of the metals. It is found mineralized with arsenic.

36. Cobalt is found in England, Germany and the United States.

37. *Tellurium* is a metal found in the state of an ore in Transylvania.

38. Pure tellurium is of a tin white colour, verging to lead grey, with a high metallic lustre; of a foliated fracture, very brittle, so as to be easily pulverized. It melts before ignition, at a temperature nearly that at which lead fuses. It burns on charcoal, before the blow pipe, with a vivid blue flame, greenish on the edges, and is dissipated in greyish white vapours, of a pungent smell which condense into a white oxide.

39. Tellurium is oxidized and dissolved by the principal acids.

40. It unites with sulphur, and forms a lead coloured striated sulphuret.

41. Tellurium and hydrogen combine to form a gas, called *telluretted hydrogen.* It may be formed in the following manner. Hydrate of potash and oxide of tellurium are ignited, together with charcoal, and the mixture

acted upon by diluted sulphuric acid, in a retort connected with a mercurial pneumatic apparatus; an elastic fluid is generated, consisting of hydrogen holding tellurium in solution. The telluretted hydrogen is soluble in water and forms a claret coloured solution. It combines with the alkalies. It burns with a bluish flame, depositing oxide of tellurium. Its smell is very strong and peculiar, resembling in some measure, sulphuretted hydrogen. Its specific gravity is 2.2916.

PRACTICAL QUESTIONS.

What is bismuth, and its properties ?
What is the proportion of oxygen in bismuth ?
Does the sulphuric acid act on bismuth ?
What action has the nitric acid ?
Does the muriatic acid act upon it ?
What is the action of chlorine ?
Of iodine ?
Does sulphur combine with bismuth ?
Does bismuth combine with any of the metals ?
What is the use of bismuth ?
What is antimony ?
What are its properties ?
How can it be obtoined from the sulphuret ?
What heat does it require for its fusion, and how many combinations has it with oxygen ?
Does the air have any effect upon it ?
What is the glass of antimony ?
What is *Kermes' Mineral ?*
Does antimony combine with any other metal ?
Does autimony combine with acids ?
What is *James's powder ?*
From what is antimony obtained ?
What is manganese ?

What are its characteristics ?

What is the effect of heating manganese in oxygen or chlorine ?

What are the number of combinations with oxygen ?

Is manganese soluble in the acids ?

How is the *chameleon mineral* formed ?

Where is manganese found ?

What is cobalt ?

Is it susceptible of magnetism ?

How many combinations of oxygen are there ?

What is the effect of heating cobalt in chlorine ?

What are the solvents of this metal ?

How is a sympathetic ink prepared with cobalt ?

Does cobalt combine with the acids and alkalies ?

Where is cobalt found ?

What is tellurium ?

What are its characteristics ?

How is tellurium oxidized and dissolved ?

Does it combine with sulphur ?

What is the combination of tellurium and hydrogen ?

CHAP. XXIX.

Of Arsenic—Chromium—Molybdenum—Tungsten—Columbium—Selenium—Osmium.

1. *Arsenic* is a metal of a bluish white colour, subject to tarnish, and grow first yellowish, then black, by exposure to the air. It is brittle, and when broken exhibits a lamellated texture. In close vessels it sublimes entire at 356° F. but burns with a small flame in contact with oxygen.

2. What is called arsenic in the shops is a white oxide of arsenic.

3. Arsenic is among the most combustible of the metals; it burns with a bluish flame, exhales the smell of garlic, and sublimes in the state of arsenious acid.

4. Concentrated sulphuric acid does not attack arsenic when cold ; but if it be boiled upon this metal, sulphurous acid gas is emitted, a small quantity of sulphur sublimes, and the metal is reduced to an oxide.

5. Nitrous acid readily attacks arsenic, and converts it into arsenious acid, or if it be employed in considerable quantities into arsenic acid.

6. Boiling muriatic acid dissolves arsenic, but affects it very little when cold. This solution affords precipitates on the addition of alkalies. The muriatic solution when condensed in a close vessel and sublimed, forms *butter of arsenic.* Thrown in powder into chlorine, it burns with a bright white flame, and is converted into a chloride.

7. None of the earths or alkalies act upon it unless it be boiled a long time, in a fine powder, in a large proportion of an alkaline solution.

8. Arsenic readily combines with sulphur by fusion and sublimation, and forms a yellow compound, called *orpiment*, or a red, called *realgar*.

9. Arsenic is soluble in fat oils in a boiling heat. It unites with metals, and forms alloys.

10. Iodine and arsenic unite, and form an iodide of a dark purple red colour, possessing the properties of an acid. It is soluble in water, and its solution forms a soluble compound with potash.

11. A mixture of oxymuriate of potash and arsenic forms a compound, which takes fire with great rapidity.

Exp. Mix the oxymuriate and oxide of arsenic by stirring them together on paper, with the point of a knife. If two trains be laid on the table, one of gunpowder, the other of this mixture, and then brought in contact with each other at one end, so that they may be fired at once, the arsenical mixture burns with the rapidity of lightning, while the gunpowder comparatively slow.

12. Arsenic destroys the magnetic property of iron and nickel.

13. Arsenic in its metallic state enters into the composition of several alloys for the formation of specula.—It is used in making small shot, to render the lead more capable of running into grains. It is employed like many other metals, in dyeing and calico printing; it enters into composition of some sorts of glass, and it forms several excellent pigments.

14. Arsenic is a most deadly poison, the best antidote for which, is the sulphuret of potash.

15. Chromium is a metal extracted either from the native chromate of lead, or iron. The latter being most abundant, is generally used.

16. It is a porous mass of agglutinated grains. It is very brittle, and of a greyish white, intermediate between tin and steel. It is sometimes obtained in needle formed crystals, which cross each other in all directions. It is susceptible of a feeble magnetism. It resists all the acids except the nitro-muriatic, which, at a boiling heat, oxidizes it and forms a muriate.

17. Chromium is capable of combining with three portions of oxygen.

18. The protoxide is green, infusible, undecompounded by heat, reducible by voltaic electricity, and not acted upon by the air.

19. The deutoxide is a brilliant brown powder, insoluble in acids,-and scarcely soluble in alkalies. Muriatic acid digested on it, exhales chlorine.

20. The peroxide is the chromic acid.

21. The chromic acid is found combined with iron in considerable quantity, near Baltimore ; from this, the beautiful pigment, called chromic yellow is prepared.

22. *Molybdenum* is a metal which has not yet been reduced into masses of any magnitude ; but has only been obtained in small separate globules, in a blackish brilliant mass.

23. The globules are grey, brittle, and extremely infusible. By heat it is converted into a white oxide, which rises in brilliant needle formed flowers, like those of antimony. Nitric acid readily oxidizes and acidifies the metal. Nitre detonates with it, and the remaining alkali combines with its oxide.

24. Molybdenum unites with several of the metals, and forms brittle or friable alloys. No acid acts upon it but the nitric and nitro muriatic ; but several acids act on its oxide, and afford blue solutions.

25. When molybdate of ammonia is ignited in a crucible with charcoal powder, it is converted into the protoxide of the metal, of a brown colour, crystallized appearance. The deutoxide is the molybdous acid, and the tritoxide the molybdic acid.

Exp. A small rod of zinc or pure tin is acted upon by a solution of the acid, which becomes blue in consequence of the loss of a portion of the oxygen.

26. *Tungsten* is a metal obtained from a mineral found in Sweden ; in its metallic state, it is somewhat like iron, and is rather brilliant. It is one of the hardest of all metals, and the heaviest, except gold and platinum. It requires a very high temperature for its fusion.

It is not acted upon by the magnet. When heated in an open vessel, it absorbs oxygen from the atmosphere, and is converted into an oxide.

27. There are two oxides of tungsten, the brown and the yellow, or tungstic acid.

28. The brown or protoxide has a flea brown colour, and when heated in the air, it takes fire and burns like tinder, passing into *tungstic acid.* The protoxide consists of

Tungsten,	100
Oxygen,	16.6

29. When heated with chlorine, tungsten burns with a deep red light, and forms an orange coloured volatile substance, which, when decomposed with water, forms the yellow oxide and muriatic acid.

30. *Columbium* is a metal first discovered in a mineral found in the British Museum, said to have been sent from Massachusetts, with some ores of iron. The mineral is said to be a columbiate of iron, that is, to consist of one part oxide of iron, and three parts of a white coloured substance, which possesses the properties of an acid, called columbic acid.

31. It is procured from the oxide in the form of metallic grains, which are so hard as to scratch glass, and are easily pulverized. Neither nitric, muriatic, nor nitro muriatic acids have any action upon it, though digested on it for several days. It has been alloyed with iron and tungsten.

32. Columbium is known to be the same as the metal found in *yttro tantalite*, a mineral of Sweden, and formerly called *tantalium.*

33. *Selenium* is an elementary body, extracted by M. Berzelius from the pyrites of Fahlun, which, from its chemical properties, he places between sulphur and tel-

lurium, though it has more properties in common with the former than the latter substance.

34. When selenium, after being fused, becomes solid, its surface assumes a metallic brilliancy of a very deep brown colour. Its fracture is conchoidal, vitreous, of the colour of lead, and perfectly metallic. Its powder has a deep red colour, but it sticks together readily when pounded, and then assumes a grey colour and smooth surface, like antimony and bismuth. In very thin pieces it is transparent, with a ruby red colour. When heated, it softens; and at 212° it is semi-liquid, and melts completely at a temperature a few degrees higher. During its cooling it retains for a long time a soft state. In this state it may be kneaded between the fingers and drawn out into long threads, which have considerable transparency; if viewed by transmitted light, they are red; but by reflected light, they are grey, and have the metallic lustre.

35. Selenium is not a good conductor of caloric. It is also a non-conductor of electricity.

36. Its affinity for oxygen is feeble, when heated in the air, without coming in contact with a burning body, it is volatilized with a strong smell of horse radish. The odorous substance is a gaseous oxide of selenium.

37. By heat in a large flask, filled with oxygen, selenium combines with the oxygen, and forms a substance which possesses the property of reddening litmus paper, called *selenic acid*.

38. Sulphur, phosphorus, the earths, and the metals, combine with selenium, forming *seleniurets*.

39. *Osmium* is a metal discovered in the ore of platina, which has a peculiar and pungent odour, resembling that of chlorine gas, whence it had its name.

40. It is of a dark grey or blue colour, of some metallic lustre, infusible when excluded from the air, but easily oxidized, when heated in contact with it. It is not soluble in any of the acids. Its oxide forms a yellow solution with potash.

41. The pure metal forms with gold and silver malleable alloys.

42. The best test for the oxide of osmium is an infusion of galls, which soon becomes of a purple colour, and afterwards changes to a vivid blue.

PRACTICAL QUESTIONS.

What is arsenic ?

Is this the arsenic of the shops ?

Does sulphuric acid act on arsenic ?

What effect has the nitrous acid ?

What effect has muriatic acid ?

Do the earths and alkalies act upon it ?

Does it combine with sulphur ?

Does it unite with the oils and metals ?

Does it unite with iodine ?

What is the effect of mixing oxymuriate of potash with arsenic ?

What effect does it have on iron ?

Of what use is arsenic ?

What is an antidote for its poison ?

What is chromium ?

What are its characteristics ?

With how many portions of oxygen will chromium combine ?

What is the protoxide ?

What is the deutoxide ?

What is the tritoxide or peroxide ?

Where is it found ?

What is molybdenum ?
What are its properties ?
Does molybdenum unite with any of the metals ?
What are the oxides of molybdenum ?
What is tungsten ?
What are the oxides of tungsten ?
What is the protoxide ?
What is the effect of heating tungsten with chlorine ?
What is columbium ?
How is it procured ?
What is selenium ?
Is selenium a conductor of caloric and electricity ?
What is its affinity for oxygen ?
What is selenic acid ?
What are seleniurets ?
What is osmium ?
What are its characteristics ?
Does it unite with the metals ?
What is the best test for osmium ?

CHAP. XXX.

Of Rhodium—Iridium—Uranium—Titanium—Cerium—Wodanium.

1. *Rhodium* is a metal discovered in the ore of platinum.

2. It is not malleable. It unites with all the metals, except mercury. When alloyed with three times its weight of bismuth, copper or lead, the substances may be completely dissolved in a mixture of two parts by

measure of muriatic acid, and one of nitric. When lead is used, it is reduced by evaporation to an insoluble muriate, which then exhibits the *rose colour ;* from which circumstance, the name of the metal is derived. It is soluble in alcohol.

3. Iridium is likewise extracted from the ore of platinum, and is so named from the variety of colours exhibited in the oxide. It has been obtained in a state of purity, by heating the muriate, which expelled the acid and oxygen. It is of a white colour, and perfectly infusible.

4. It unites with many of the metals, forming alloys.

5. It unites with sulphur and forms a sulphuret, which is of a black colour, and consists of 100 iridium and 33.3 sulphur.

6. *Uranium* is a metal discovered in a mineral, called *Pechblende*, where it exists in a state of sulphuret. It likewise occurs in the state of an oxide in green mica, and in the uranochre.

7. Uranium is of a dark grey colour inclining to brown ; it is obtained in grains, forming a porous mass. It requires a stronger heat to fuse it than manganese.

8. There is probably but two oxides of uranium ; the protoxide, which is greyish black ; and the peroxide, which is yellow.

9. The oxide is soluble in dilute sulphuric acid, gently heated, and affords lemon coloured prismatic crystals. Its solution in muriatic acid, in which it is but imperfectly soluble, affords yellowish green rhomboidal tablets. Phosphoric acid dissolves it, but after some time, the phosphate falls down in a floculent mass, of a pale yellow colour.

10. It combines with vitrifiable substances, and gives them a brown or green colour. With the usual flux, on porcelain, it produces an orange colour.

11. *Titanium* is a metal originally discovered in Cornwall, Eng. and first called *Menachanite.* It is found also in a mineral, called *red schorl*, or *titanite.*

12. It is in the form of agglutinated friable masses.—Crystallized, internally of a brilliant red. Infusible, unalterable by water. Soluble in boiling sulphuric, muriatic and nitric acids.

13. It tarnishes on exposure to the air, and is oxidized when heated in contact with it.

14. Titanium combines with three portions of oxygen. The protoxide is blue, the deutoxide red, and the peroxide white.

15. It unites with phosphorus, forming a pale white compound of a metallic lustre, of a brilliant and granulated texture. It unites with iron, and forms an alloy.

16. *Cerium* is a metal discovered by Hisinger and Berzelius, in a mineral found in a Swedish copper mine.

17. To procure the oxide of cerium is easy ; but all attempts to reduce that oxide to a metallic state have failed. The metal appears to be volatile, and is dissipated by a violent heat, while a moderate heat is not sufficient to reduce it.

18. Cerium appears to be white and brittle.

19. It is capable of two stages of oxidation, the white and the red.

20. Alkalies do not act upon it ; but caustic potash in the dry way, takes part of the oxygen from the red oxide, so as to convert it into the white, without altering its nature.

21. The oxides of cerium are soluble in the mineral acids, and form salts, which are of a white or yellow colour, and a sweetish taste.

22. The white oxide unites directly with tartaric acid, but requires an excess to render it soluble.

23. *Wodanium* is a metal recently discovered in *Wodan pyrites*, a mineral of Hungary, and so named from Woden, or Wodan, an ancient German deity.

24. It has a bronze yellow colour. It is malleable; its fracture is hackly; it has the hardness of fluor spar; and is strongly attracted by the magnet.

25. It is not tarnished by exposure to the atmosphere at a common temperature; but when heated, it is converted into a black oxide.

26. The solution of this metal in acids is colourless, or at least has only a wine yellow tinge. Its hydrated carbonate is white. The hydrate precipitated by carbonate of ammonia is indigo blue.

27. Neither the alkaline phosphates nor arseniates, occasion any precipitate, when dropped into a saturated solution of the metal in an acid. Infusion of galls, likewise, produces no precipitate. A plate of zinc throws down a black metallic powder from the solution of this metal in muriatic acid. Prussiate of potash throws down a pearl grey precipitate.

28. Nitric acid dissolves with facility both the metal and its oxide, and the solution yields colourless needle form crystals, which readily dissolve in water.

PRACTICAL QUESTIONS.

What is rhodium ?
What are its characteristics ?
What is iridium ?
Does it unite with any of the metals ?
Does it unite with sulphur ?
What is uranium ?
How many oxides are there of uranium ?

In what is the oxide soluble ?
With what does the oxide combine ?
What is titanium ?
What are its characteristics ?
What effect has the air upon it ?
How many oxides are there of titanium ?
With what does it unite ?
What is cerium ?
Is it procured in a metallic state ?
What are its characteristics ?
With how many portions of oxygen does it combine ?
Do alkalies act upon it ?
In what are the oxides of cerium soluble ?
Does the white oxide unite with tartaric acid ?
What is wodanium ?
What are its characteristics ?
What effect has the air upon it ?
What are the solutions of this metal in acids ?
How is it precipitated from its solutions ?
What effect has nitric acid upon it ?

CHAP. XXXI.

Of Prussine, or Cyanogen.

1. Prussine, or prussic gas, is what M. Gay Lussac terms cyanogen ; a word derived from the Greek, and literally signifies a *producer of blue.* But the production of blue can never be the effect of this substance on any other single body ; but an indirect operation of it in conjunction with iron, hydrogen and oxygen. This action has not been fully explained.

2. As this substance does not directly produce blue with iron, many chemists have relinquished the term cyanogen, and as this substance, like chlorine and iodine, by its action on potassium produces flame, and like them is acidified by hydrogen, the term prussine is thought to be more appropriate.

3. This substance was discovered and examined by M. Gay Lussac.

4. By digesting red oxide of mercury with prussian blue, a cyanide or prusside may be obtained, perfectly neutral, which crystallizes in long four sided prisms, truncated obliquely. By repeated solutions and crystallizations, it may be freed from a small portion of iron which adheres to it Or it may be boiled with red oxide of mercury and the iron will be precipitated. The excess of oxide of mercury must be saturated with a little prussine or muriatic acid. The prusside thus formed is decomposed by heat to obtain the radical.

5. When the cyanide is boiled with the red oxide of mercury, it dissolves a considerable quantity of the oxide, becomes alkaline, crystallizes no longer in prisms but in small scales, and its solubility in water appears a little increased. When evaporated to dryness, it is very easily charred, on this account it is necessary to employ the heat of a water bath.

6. When the compound is decomposed by heat, it gives abundance of prussine mixed with carbonic acid gas. The prusside of mercury, when neutral and very dry, produces prussine; but when moist, it furnishes only carbonic acid, ammonia and a large quantity of prussic acid vapour.

7. When the prusside is used with excess of the peroxide, the same products are obtained, but in differ-

ent proportions, together with azote and a brown liquid.

8. To obtain pure prussine, the neutral prusside must be used in a state of perfect dryness. The other mercurial compound, is not, however, a sub prusside simply; but a compound of the oxide of mercury and the prussine; analogous to the brick coloured precipitate obtained by adding a little potash to the deuto-chloride of mercury, corrosive sublimate, which is a triple compound of chlorine, oxygen and mercury; or a binary compound of oxide of mercury and a chloride of that metal. These compounds may be called oxy-prusside and oxy-chloride of mercury.

9. When the neutral simple mercurial prusside is exposed to heat in a small glass retort, or a tube closed at one end, it soon begins to blacken; appears to melt like an animal matter, and the prussine is disengaged in abundance. This gas, from the commencement of the process to the end, is pure; care must be taken, however, not to raise the heat too high, so as to melt the glass; in that case a little azote will be disengaged.

Observation. In this process mercury is sublimed with a considerable quantity of prussine, and there remains a charry matter, very light, and spongy, of the colour of soot.

10. The prusside of silver gives out prussine when heated, but that of mercury is preferable and is more economical.

11. Prussine is a permanently elastic fluid. Of a peculiar and penetrating smell. Soluble in water and imparts to it a very sharp taste. The gas is combustible, and burns with a bluish flame, mixed with purple. Its specific gravity compared with that of air is 1.8064. 100 cubic inches weigh 55.1295 grains.

12. Prussine is capable of sustaining a pretty high temperature without decomposition.

13. Water absorbs about 4 1-2 times its volume.

14. Sulphuric acid and oil of turpentine dissolve prussine in the same quantity as water.

15. Prussine reddens tincture of litmus. On heating the solution the gas is disengaged, mixed with a little carbonic acid, and the blue colour of the litmus is restored. It is probable that the carbonic acid proceeds from decomposition of a small quantity of prussine and water.

16. Prussine destroys the colour of red sulphate o manganese, a property which is not possessed by prussic acid. Which is a proof of the superior activity of its elements. In the dry way, it separates the carbonic acid from the carbonates.

17. Phosphorus, sulphur and iodine may be sublimed in prussine without producing any change on it. Its mixture with hydrogen was not altered by the same temperature, or by passing electric shocks through it.

18. Copper and gold do not combine with prussine; but iron, when heated almost to whiteness, partially decomposes it. The metal is covered with a slight coating of charcoal and becomes brittle. The undecompounded portion of the gas is mixed with nitrogen. It constituted in one trial 0.44 of the mixture; but in general it was less.

Platinum which had been placed at the side of the iron did not undergo any chunge; neither its surface nor that of the tube was covered with charcoal.

19. Potassium acts but slowly on prussine in the cold, because a crust is formed on its surface which prevents the mutual action. On applying to the substance a spirit lamp, the potassium speedily becomes incandescent,

the absorption of the gas commences, the inflamed disc gradually diminishes, in a few seconds it disappears entirely, and the absorption is at an end.

20. If a quantity of potassium be employed which will disengage 50 parts of hydrogen from water, it will be found that 48 or 50 parts of hydrogen will have disappeared. On treating the remainder with potash, there usually remains 4 or 5 parts of hydrogen, sometimes 10 to 12.

21. The compound of prussine and potassium is yellowish. It dissolves in water without effervescence and the solution is strongly alkaline. Its taste is the same as hydro cyanate of potash, of which it partakes of the properties.

22. Prussine is very inflammable when exploded with about 2½ times its volume of oxygen.

The detonation is very powerful, and the flame is bluish, like that of sulphur burning in oxygen.

23. If 100 parts of prussine be exploded, a diminution of volume takes place, which, when measured, is found to be from four to nine parts. When the residuum is treated with potash or barytes, it diminishes from 195 to 200 parts, which are carbonic acid gas. The new residuum analyzed over water by hydrogen, gives from 94 to 98 parts of nitrogen, and the oxygen which it contains, added to that in the carbonic acid is nearly equal to that which has been employed.

24. From the above experiment it may be inferred that prussine contains a sufficient quantity of carbon to produce twice its volume of carbonic acid gas; that is, two volumes of the vapour of carbon with one of nitrogen condensed into a single volume.

25. If the above supposition be correct, the density of the radical derived from it ought to be equal to the den-

sity derived from experiment; but supposing the density of air to be 1.00 twice that of the vapour of

		By experiment.
Carbon is	0.8320	0.8332
Nitrogen	0.9691	0.9722
	1.8011	1.8054

26. By adding a volume of hydrogen to a volume of prussine, we obtain two volumes of prussic acid vapour, in the same way as by adding a volume of hydrogen to a volume of chlorine we obtain two volumes of muriatic acid gas. The same proportions hold with regard to the vapour of iodine, hydrogen and hydriodic acid. Hence it follows that the specific gravities of these acids are exactly equal to half the sum of the densities of their respective bases and hydrogen.

27. M. Gay Lussac having introduced prusside of mercury into a glass tube, covered it with brown oxide of copper, and then raised the heat to a dull red. On heating gradually the part of the tube containing the prusside it was gradually disengaged, passed through the oxide and the metal was completely reduced. On washing the gaseous products with a solution of potash, at different parts of the process, he obtained only from 0.19 to 0.30 of azote; instead of 0.33, which ought to have remained, according to his former analysis. Presuming that some nitrous compound had been formed, he repeated the experiment, covering the oxide with a layer of copper filings which he kept at the same temperature as the oxide. With this new arrangement, the results were very singular, for the smallest quantity of nitrogen which he obtained during the whole course of the experiment was

32.7 for 100 of gas, and the greatest was 34.4. The mean of all the trials was

Nitrogen	33.6	or nearly	1
Carbonic acid	66.4	"	2
	100:00		

This shews that prussine contains two volumes of the the vapour of carbon, and one volume of azote or nitrogen.

28. In another experiment of Gay Lussac's instead of passing the prussine through the oxide of copper, he made a mixture of one part of the prusside of mercury, and 10 parts of the red oxide; after introducing it into a glass tube closed at one end, he covered it with copper filings, which he raised first to a red heat. On heating the mixture successively, the decomposition went on with facility, the proportions of the gaseous mixure were less regular than in the preceeding experiment.

Their mean was

Nitrogen	34.6	instead of	33.3
Carbonic acid	65.4	"	66.7
	100.0		

In another experiment he obtained

Nitrogen	32.2
Carbonic acid	67.8
	100.0

Now the mean of these results gives

Nitrogen	33.4
Carbonic acid	66.6
	100.0

This shows that what has been considered as a prussiate of mercury, is in fact a prusside.

29. When a pure solution of potash, not too concentrated, is introduced into prussine, a rapid absorption takes place. If not quite saturated, it is scarcely tinged of a lemon yellow colour. But if the prussine be in excess, we obtain a brown solution, apparently carbonaceous.

30. On pouring potash combined with prussine into a solution of protoxide of iron, and adding an acid, we obtain Prussian blue. At first it appears that the prussine is decomposed in this experiment, at the moment that it combines with potash, but this is doubted, for when this body is really decomposed by means of an alkaline solution, carbonic acid is produced, together with prussic acid and ammonia. But in pouring a solution of barytes into a solution of prussine in potash, no precipitate is formed, which shews that no carbonic acid is present. On adding an excess of quicklime, no trace of ammonia is perceptible. And since no carbonic acid nor ammonia have been formed, water has been decomposed, consequently, no prussic acid is evolved.

31. The instant an oxide is poured into a solution of prussine in potash, a strong effervescence of carbonic acid is produced, and at the same time a strong smell of prussic acid.

Ammonia is likewise formed which remains combined with the acid employed, but when quicklime is added, it is made sensible. Since, therefore, we are obliged to add an acid in order to form a prussian blue, it is evident the prussine is not decomposed when added to potash.

32. Soda, barytes and strontites produce the same effect as potash. Hence we may conclude that prussine forms particular combinations with the alkalies, which

are permanent, till some circumstance determines the formation of new products.

33. These combinations are true salts, which may be regarded analogous to those formed with acids. In fact, prussine possesses acid characters. It contains two elements of azote and carbon, the first of which, according to M. Gay Lussac, is strongly acidifying. Prussine reddens the tincture of litmus, and metalizes the bases. When it unites with hydrogen it acts as a simple body, and produces an acid.

34. The metallic oxides do not seem capable of producing the same effect on prussine as the alkalies. M. Gay Lussac having precipitated proto sulphate of iron by an alkali, so that no free alkali remained, caused the oxide of iron while moist, to absorb prussine, and then added muriatic acid. But he did not obtain the slightest trace of prussian blue, though the same oxide to which he had added a little potash before adding the acid, produced it in abundance.

35. From the above experiment we are led to conclude that the oxide of iron does not combine with prussine; water impregnated with this gas never produces prussian blue with solutions of iron, unless we previously add an alkali.

36. The peroxides of manganese and mercury, and the deutoxide of lead absorb prussine but slowly, but when water is added, the combination is much more rapid. With the peroxide of mercury, a greyish white compound is formed, a little soluble in water.

37. Prussine rapidly decomposes the carbonates at a dull red heat, and prussides of the oxides are obtained.

38. When prussine is passed through the sulphuret of barytes, it combines without disengaging the sulphur,

assumes a brownish black colour and is very fusible. When thrown into water, a colourless solution is obtained which gives a greenish brown colour to muriate of iron. That which remains insoluble contains considerable sulphate which is probably formed during the preparation of the sulphuret of barytes.

39. When prussine is dissolved in the hydroguretted sulphuret of barytes, sulphur is precipitated, which is again dissolved, it becomes saturated with prussine and a liquid is obtained having a very deep brown colour.

40. Prussine and sulphuretted hydrogen combine slowly with each other. A yellow substance crystallized in fine needles is obtained, which is soluble in water, does not precipitate nitrate of lead, but produces prussian blue.

41. Whenever ammoniacal gas and prussine come in contact, they act upon each other; but some time elapses before the effect is complete. White thick vapours are at first disengaged, which soon disappear. The diminution of volume is considerable, and the glass, in which the mixture is made, becomes opaque, its inside being covered with a solid brown matter.

Exp. On mixing 90 parts of prussine with 227 of ammonia, they will combine nearly in the proportion of 1 to 1½. If thrown into water, it dissolves only in very small proportions and gives a dark brown colour to the liquid, which produces no prussian blue with the salts of iron.

42. When prussic acid is exposed to the action of a voltaic battery, with 20 pair of plates, much hydrogen gas is disengaged at the negative pole, while nothing appears at the positive. This is because prussine is evolved at that pole which remains dissolved in the acid.

43. When an animal matter is calcined with potash or its carbonate, a prusside of potash is formed. It has been proved that potash separates, by the assistance of heat, the hydrogen of the prussic or hydrocyanic acid. We cannot then suppose that the acid is formed while a mixture of potash and animal matters is exposed to a high temperature. But we obtain a prusside of *potash*, and not of potassium. For potassium, when dissolved in water, gives only prussiate of potash, which is decomposed by the acids, without producing ammonia and carbonic acid; while the prusside of potash dissolves in water without being altered, and does not give ammonia, carbonic acid, and prussic acid vapour, unless an acid be added.

Observation. The above characteristics distinguish a prusside of a metal from a metallic oxide.

44. By heating prusside of mercury in muriatic acid gas, Sir H. Davy obtained pure liquid prussic acid and corrosive sublimate. By heating iodine, sulphur and phosphorus in contact with prusside of mercury, compounds of these bodies with prussine may be formed.

45. The compound of prussine and iodine is volatile at a very moderate heat, and on cooling collects in flocculi, adhering together like oxide of zinc formed by combustion. It has a pungent smell, and very acrid taste.

PRACTICAL QUESTIONS.

What is prussine?

Why has the term cyanogen been relinquished, and that of prussine adopted?

How is prussine obtained?

How do you procure the prusside of mercury?

What is the effect when the cyanide is boiled with the red oxide of mercury?

When this compound is decomposed by heat, what is produced ?

What is the effect when the prusside is used with excess of the peroxide ?

What is necessary in order to prodnce pure prussine ?

What takes place when the neutral mercurial prusside is exposed to heat ?

Is the gas, throughout the process pure ?

Does any other metallic prusside give out prussine ?

What are the properties of prussine ?

Does heat decompose it ?

How much does pure alcohol absorb ?

What quantity does water absorb ?

Do any other substances dissolve equally as much as water ?

What effect does prussine have on tincture of litmus ?

What property does prussine possess which prussic acid does not ?

What effect has prussine on phosphorus, sulphur and iodine, when sublimed in it ?

Do the metals combine with prussine ?

Does potassium act on prussine ?

What are the properties of prussine and potassium ?

Is prussine inflammable ?

Suppose 100 parts of prussine be exploded, what takes place ?

What may be inferred from this experiment ?

What will the density of the radical be ?

When a volume of hydrogen is added to a volume of prussine, what is the result, and what do you infer?

Who first established the analogy ?

Relate the experiment of M. Gay Lussac to determine the constituents of prussine.

Relate the other experiment of the same chemist, and the result.

What does this experiment shew ?

When a pure solution of potash is introduced into prussine, what is the effect ?

How can you account for the production of prussian blue in the above process ?

What other substances produce the same effect ?

What do you infer from this ?

Do the metallic oxides produce the same effect as alkalies ?

Does the oxide of iron combine with prussine ?

What effect is produced by passing prussine through sulphuret of barytes ?

What, when it is dissolved in the dydroguretted sulphuret of barytes ?

Does prussine combine with sulphuretted hydrogen ?

Do ammonia and prussine have any effect on each other ?

What follows, when prussic acid is exposed to the action of the voltaic battery ?

What is formed when an animal matter is calcined with potash ?

What is the argument on the subject ?

How do you distinguish the prusside of a metal from a prusside of a metallic oxide ?

What facts have been discovered by Sir H. Davy ?

What are the properties of prussine and iodine in combination ?

CHAP. XXXII.

Of the nature and composition of Vegetables.

1. Organized bodies are those which are furnished by nature with various parts, calculated to perform certain functions connected with life, which bear the most striking and impressive marks of design, and are distinguished by a vital principle, from which the various organs derive the power of exercising their respective functions.

2. We know nothing of the principle of vitality but by its effects, nor by what means the organs are enabled to perform their functions either in the animal or vegetable departments.

3. The simplest class of organized bodies, is that of the vegetable world. These are distinguished from the mineral creation, not only by their more complicated nature, but by the power which they possess within themselves, of forming new chemical arrangements of their constituent parts by means of appropriate organs Though all vegetables are composed of carbon, hydrogen and oxygen, with a few other occasional ingredients, they separate and combine these principles by their various organs, in a variety of ways, and form with them different kinds of juices and solid parts, which exist ready made in vegetables, and may be considered as their immediate materials.

4. Potash, soda, lime, magnesia, silex, alumina, sulphur, phosphorus, iron, manganese, and muriatic acid, have been occasionally found in vegetables, but they occur in very small quantities, and are scarcely more entitled to be considered as belonging to them, than gold or

some other substances, which are said to have been procured from their decomposition.

5. There is no part of a plant which consists solely of one particular ingredient ; a certain number of vegetable materials must always be combined for the formation of any particular part, and these combinations are carried on by sets of vessels, or minute organs, which select from other parts and bring together the several principles required for the developement and growth of those particular parts, which they are intended to form and maintain. It is probable these combinations are carried on by chemical principles ; for it would militate against all established theories, in chemistry, to suppose that the organs of plants could cause principles to combine which have no attraction for each other, nor can superior attraction yield to those of inferior power.—The organs of plants, probably, act mechanically by bringing into contact those principles in such proportions, as will, by their chemical combination, form the various vegetable products.

6. As long as a plant is in a growing state, the three principal constituents, carbon, hydrogen and oxygen, are so nicely adjusted and connected together, that they are not susceptible of entering into other combinations, but no sooner does the principle of vitality cease, than this state of equilibrium is destroyed, a decomposition commences, and new combinations are formed, and an order of attraction succeeds, similar to what takes place in unorganized matter ; and plants eventually all return to their simple elements.

7. In a chemical point of view there are two kinds of analysis, of which vegetables are susceptible. First, that which separates them into their immediate materials ; such as sap, resin, mucilage, &c. Secondly, that

which decomposes them into their primitive elements, as carbon, hydrogen and oxygen. By the first analysis, we obtain the following products from vegetables.

8. *Sugar* is obtained in the greatest abundance from the sugar cane. It is likewise procured from the sugar maple, beets, parsnips, carrots, and from the stalks of Indian corn, zea maze. It crystallizes, is insoluble in water and alcohol. Taste sweet. Soluble in nitric acid, and yields oxalic acid.

9. *Sarcocol*, a concrete juice brought from Arabia and Persia. It does not crystallize. Soluble in water and alcohol. Taste sweetish bitter. Soluble in nitric acid, and yields oxalic acid.

10. *Asparagin*, a substance obtained from asparagus. Crystallizes. Taste cooling and nauseous. Soluble in hot water; insoluble in alcohol. Soluble in nitric acid, and convertible into bitter principle and tannin.

11. *Gum* does not crystallize. Taste insipid. Soluble in water, and forms mucilage. Insoluble in alcohol. Precipitated by silicated potash. Soluble in nitric acid, and forms mucous and oxalic acid.

12. *Ulmin*, a substance obtained from the elm. It does not crystallize. Taste insipid. Soluble in water, and does not form mucilage. Precipitated by nitric and oxymuriatic acids in the state of resin. Insoluble in alcohol.

13. *Inulin* is a substance obtained from elecampane. It is a white powder. Soluble in boiling water; but precipitates unaltered after the solution cools Insoluble in alcohol. Soluble in nitric acid, and yields oxalic acid.

14. *Starch* is obtained from grain, horse chesnuts, burdock roots, &c. It is a white powder. Insoluble in cold water. Taste insipid. Soluble in hot water; opaque

and glutinous. Precipitated by an infusion of galls. Precipitate redissolved in a heat of 120° F. Insoluble in alcohol. With nitric acid yields oxalic acid and a waxy substance.

15. *Indigo* is a substance obtained from a plant growing in various parts of the world, called *indigofera tinctoria*. It is a blue powder. Taste insipid. Insoluble in water, alcohol and ether. Soluble in sulphuric acid.—Soluble in nitric acid, and converted into bitter principle and artificial tannin.

16. *Gluten* is a substance resembling gelatine, principally found in the flour of wheat. It forms a ductile elastic mass with water. Partially soluble in water; precipitated by infusion of nutgalls and chlorine. Soluble in acetic and muriatic acid. Insoluble in alcohol.—By fermentation becomes viscid and adhesive, and then assumes the properties of cheese. Soluble in nitric acid, and yields oxalic acid.

17. *Albumen* is a substance found in the green feculæ of some plants, particularly those of the cruciform order. It is soluble in cold water. Coagulated by heat, and becomes insoluble in hot water. Insoluble in alcohol. Precipitated by infusion of nutgalls. Soluble in nitric acid. Soon putrifies.

18. *Fibrin* is a peculiar substance, found in vegetables and animals. It is tasteless. Insoluble in water and alcohol. Soluble in diluted alkalies, and in nitric acid. Soon putrifies.

19. *Bitter principle.* Colour yellow or brown. Taste bitter. Equally soluble in water and alcohol. Soluble in nitric acid. Precipitated by nitrate of silver.

20. *Extractive matter.* Soluble in water and alcohol. Insoluble in ether. Precipitated by chlorine, muriate of

tin, and muriate of alumina; but not by gelatin. Dyes fawn colour.

21. *Tannin.* Taste astringent. Soluble in water and alcohol of specific gravity 0.810. Precipitated by gelatin, muriate of alumina, and muriate of tin.

22. *Fixed oils.* No smell. Insoluble in water and alcohol. Form soaps with alkalies. Coagulated by earthy and metallic salts. Do not boil in a less temperature than 600° F.

23. *Wax.* Insoluble in water. Soluble in alcohol, ether and oils. Forms soaps with alkalies. Fusible.

24. *Volatile oils.* Strong aromatic smell. Insoluble in water. Soluble in alcohol. Liquid. Volatile. Oily. By nitric acid inflamed, and converted into a resinous substance.

25. *Camphor.* Strong odour. Crystallizes. Very little soluble in water. Soluble in alcohol, oils and acids. Insoluble in alkalies. Burns with a clear flame, and volatilizes before melting.

26. *Birdlime.* Viscid. Taste insipid. Insoluble in water. Partially soluble in alcohol. Very soluble in ether. Solution green.

27. *Resins.* Solid. Melt when heated. Insoluble in water. Soluble in alcohol, ether and alkalies. Soluble in acetic acid. By nitric acid converted into artificial tannin.

28. *Guaiacum,* possesses the character of resins; but dissolve in nitric acid, and yields oxalic acid, but no tannin.

29. *Balsams,* possess the characters of the resins, but have a strong smell; when heated, benzoic acid sublimes. It sublimes also when they are dissolved in sulphuric acid. They are converted by nitric acid into artificial tannin.

30. *Caoutchouc*, or *India rubber.* Very elastic. Insoluble in water or alcohol. When steeped in ether reduced to a pulp, which adheres to any substance in contact. Fusible. Very combustible.

31. *Gum resins*, form milky solutions with water, transparent with alcohol. Soluble in alkalies. With nitric acid converted into tannin. Strong smell. Brittle. Opake. Infusible.

32. *Cotton*, composed of fibres. Tasteless. Very combustible. Insoluble in water, alcohol and ether. Soluble in alkalies. Yields oxalic acid with nitric acid.

33. *Suber*, or *cork*, burns bright, and swells. Converted by nitric acid into suberic acid and wax. Partially soluble in water and alcohol.

34. *Wood*, composed of fibres. Tasteless. Insoluble in water and alcohol. Soluble in a weak alkaline lixivium. Precipitated by acids. Leaves much charcoal when distilled in a red heat. Soluble in nitric acid, and yields oxalic acid.

35. *Emetin* is a substance obtained from Ipecacuanha. It has no smell. Taste bitter and acrid. Soluble both in water and alcohol. Insoluble in ether. Not crystallizable. Precipitated by corrosive sublimate. Acts as a powerful emetic.

36. *Fungin* is the fleshy part of mushrooms. It seems to be a modification of woody fibre.

37. *Hematin* is the colouring principle of logwood.—Soluble in boiling water, and forms an orange red, which becomes yellow as it cools. Excess of alkali converts it first to purple, then to violet, and lastly to brown.—Unites with metallic oxides, forming a blue coloured compound. Precipitated by gelatin. Reddens by peroxide of tin and acids.

38. *Nicotin* is obtained from tobacco. Colourless. Has the taste and smell of the plant. Soluble both in water and alcohol. Volatile. Poisonous. Precipitated from its solution by tincture of galls.

39. *Pollenin* is a substance obtained from the pollen of flowers. It is yellow. Destitute of taste and smell. Insoluble in water, alcohol, ether, fat and volatile oils, and petroleum. Burns with flame. Soon becomes putrid on exposure to the air.

The following substances are considered as new vegetable alkalies.

1. Aconita is a poisonous principle, extracted from the *Aconitum napellum*, or Wolfsbane.

2. Atropia is an alkaline principle, extracted from *Atropa Belladona*, or deadly night-shade. It is white, brilliant, crystallizes in long needles. Tasteless. But little soluble in water or alcohol. Resists a moderate heat. With acids, forms a neutral salt, and is capable of neutralizing a considerable portion of acid.

3. *Brucia*, or *brucine* is a substance extracted from the false *angustura*, or *Brucea anti dysenterica*. Soluble in 500 times its weight of boiling water, and in 860 of cold water. Taste exceedingly bitter, acrid and durable in the mouth. Permanent in the air. Unites with the acids, and forms salts.

4. Cicuta is a vegetable alkali, obtained from hemlock.

5. *Datura* is another alkaline substance, obtained from the *Datura stramonium.*

6. *Delphinia* is an alkaline substance, obtained from *stavesacre*, or *Delphinium staphy sagria.* Taste bitter and acrid. When heated, melts, and on cooling becomes hard and brittle, like resin. Soluble sparingly in water.

Soluble in alcohol and ether. Forms soluble neutral salts with acids.

7. *Hyosciama* is an alkali, obtained from *Hyosciamus nigra*, or henbane. Crystallizes in long prisms. Soluble in sulphuric or nitric acid, and forms characteristic salts. Vapour prejudicial to the eyes. Very poisonous.

8. *Morphia* is an alkali, extracted from opium, of which it constitutes the narcotic principle. Soluble in 82 times its weight of boiling water, in 36 times its weight of boiling alcohol, and in 42 times its weight of cold alcohol. Changes the infusion of brazil wood to a violet, and the tincture of rhubarb to a brown. It is soluble in the acids, and forms salts.

9. *Picrotoxia* is the bitter and poisonous principle of *cocculus indicus*, obtained in four sided crystals, of a white colour. Taste intensely bitter. Soluble in water, alcohol and sulphuric ether. Unites with the acids, and forms salts. It acts as an intoxicating poison.

10. *Strychnia* is a substance from *strychnos nux vomica*. Crystallizes in very small four sided prisms, terminated by four sided low pyramids. Colour white. Taste bitter. Destitute of smell; is not altered by exposure to the air. Neither fusible nor volatile, previous to decomposition. When taken into the stomach, it acts with great energy.

11. *Veratria* is an alkali, obtained from *veratrum sabatilla*, or *cevadilla*, *veratrum album*, or white hellebore, and *colchicum autumnale*, or meadow saffron. White. Pulverulent. Destitute of odour. Excites violent sneezing. Very acrid, but not bitter. Scarcely soluble in cold water.

PRACTICAL QUESTIONS.

What are organized bodies ?

Do we know any thing of the principle of vitality ?

What is the simplest class of organized bodies ?

How are these distinguished ?

What substances have been found in vegetables ?

Does any part of a plant consist of one particular ingredient ?

Why do not carbon, hydrogen and oxygen enter into other combinations while the plant lives ?

How many kinds of analysis of plants are there ?

What are the properties of sugar ?

Of Sarcocol ?

Of Asparagin ?

Of Gum ?

Of Ulmin ?

Of Inulin ?

Of Starch ?

Of Indigo ?

Of Gluten ?

Of Albumen ?

Of Fibrin ?

Of Bitter principle ?

Of Extractive matter ?

Of Tannin ?

Of fixed oils ?

Of Wax ?

Of volatile oils ?

Of Camphor ?

Of Birdlime ?

Of Resin ?

Of Guaiacum ?

Of Balsam ?

Of Caoutchouc ?

Of Gum Resin ?
Of Cotton ?
Of Suber ?
Of Wood ?
Of Emetin ?
Of Fungin ?
Of Hematin ?
Of Nicotin ?
Of Pollenin ?
What are the new vegetables alkalies ?
What are the properties of Aconita ?
Of Atropia ?
Of Brucia ?
From what is Cicuta obtained ?
From what is Datura obtained ?
What are the properties of Delphinia ?
Of Hyosciama ?
Of Morphia ?
Of Picrotoxia ?
Of Strychnia ?
Of Veratria ?

CHAP. XXXIII.

Of Colouring Matter—Decomposition of Vegetables—Fermentation.

1. The colouring part of vegetables is that used for dyeing, calico printing, and the like.

2. It is not found separate, but is combined with extractive matter ; with gum, in which case, it is soluble in water. With farina, in this case, it is most soluble in

sulphuric acid and with resins, when it requires alcohol, oil, or an alkali for solution.

3. Colouring matter has a great affinity for alumina and the oxides of tin; on which account, the solutions of these substances readily precipitate the infusion of colouring matter in water.

4. The modes of obtaining and transferring the colouring matter from one substance to another, so that it shall be fixed, constitute the art of dyeing.

5. The great variety of colours observed in dyed substances are reduced to four simple ones, viz. *blue*, obtained from indigo; the *red*, afforded by madder, archil, brazil wood, cochineal, and some other substances; *yellow*, obtained from quercitron bark, sumach, tumeric, &c. and the *black*, obtained from a combination of iron with gallic acid.

6. In dyeing, some colours are permanently attached to the fabric by merely boiling or dipping it in them, while others leave a mere stain, not permanent.

7. These are to be fixed through the medium of a proper basis. The principal bases are alumina, and some of the metallic oxides in combination with several acids.

8. Colours not permanent, are called *adjective* colours; and those which are permanent, *substantive.*

Exp. Take a little of the solution of indigo in sulphuric acid, and add to it an equal quantity of carbonate of potash. Dip into it a piece of white cloth, it will become of a fine blue. Yellow cloth dipped into it will be changed to green, and red will be converted to a fine purple.

9. *Cochineal* is naturally of a red colour, but it is used for scarlet dyeing; to obtain the scarlet hue, a tartrate of potash is used as a base, and the basis by which

it is fixed to the cloth is oxide of tin. It is an adjective colour.

Exp. 1. Put a piece of white cloth into a decoction of cochineal, it will be simply stained. But add to it some tartrate of potash, and a little nitro muriate of tin, and it will afford a permanent scarlet colour.

Exp. 2. The decoction of quercitron bark is an adjective colour; but by the aid of alumina as a base, we get a bright yellow. With the oxide of tin, all the shades from a pale lemon to a deep orange are formed; and with the oxide of iron it gives a drab colour.

Exp. 3. To a solution of carbonate of potash, add an equal quantity by weight of nitrate of iron. This will produce the permanent *buff colour* of the calico printer.

Exp. 4. Equal parts of arnatto and potash of commerce, will give the nankeen dye.

Exp. 5. Take a piece of dark brown cloth, which has been dyed with fustic, and with a camel's hair pencil draw some figures on it with a solution of muriate of tin, the figures will quickly appear yellow, instead of brown.

10. To dye any kind of stuff, it should first be cleared of all glutinous and greasy matters, by being washed. In some cases, it is to be whitened; it is then to be dipped into a *mordant*, which is an intermediate substance, that has a greater affinity for the colouring matter than the cloth has, such as the *muriate of tin*, sulphate of *alumina*, &c. and then it is to be passed through the colouring liquid.

11. Mordants are employed to give lustre, as well as durability to the colour. They must be so contrived as to have an affinity both for the colouring matter and the stuff itself. By a decomposition both of the mordant and the substance which holds the colouring matter in solu-

tion, the colour is precipitated on the base of the mordant, and adheres to it.

12. *Decomposition* of vegetables takes place after the death of the plant. When vegetables cease to be productive, they cease to live, and decomposition immediately ensues, which eventually resolves them into their constituents, hydrogen, carbon and oxygen. This process is slowly and gradually performed, during which time, a variety of new combinations are successively established and destroyed; but in each of these changes the ingredients of vegetable matter tend to unite in a more simple order of compounds, till they are ultimately brought to their elementary state, or, at least to their most simple order of combinations. Thus vegetables are finally reduced to water and carbonic acid, the hydrogen unites with one portion of the oxygen to form water, while the carbon combines with another portion to form carbonic acid.

13. Vegetables are susceptible of undergoing certain changes previously to the state of putrefaction, which is the last term of decomposition. The vegetable decomposition is always attended by a violent internal motion, occasioned by the disengagement of one order of particles, and the combination of another. This is called fermentation. There are several periods at which this process stops, so that a state of rest appears to be restored and a new order of compounds fairly established. Means must be used to secure these new combinations in their active state, or their duration will be transient; and a new fermentation will take place, by which the compound last formed will be destroyed, and another and less complex order will succeed.

14. Fermentation appears to be only the successive steps by which a vegetable descends to its final dissolution.

15. There are several circumstances required to produce fermentation. Water and a certain degree of heat are both essential to this process, in order to weaken the force of cohesion of the particles and cause them to separate, that the new chemical affinities may be brought into action.

16. The several fermentations derive their names from their principal products, as the *saccharine*, the *vinous*, the *acetous*, and *putrefactive.*

17. The saccharine fermentation is not confined to the decomposition of vegetables, as it commonly takes place in plants in a living state.

18. Sugar is not secreted from sap in the same manner as fecula, mucilage, oil and other ingredients of vegetables, but it is formed rather from these materials than the sap itself, and it is developed at particular periods, as fruits, which do not become sweet until ripe, sometimes even after they have been gathered. Hence it appears that life is not essential to the formation of sugar, but proceeds from the destruction of the previous order of combinations, which must depend upon fermentation, while mucilage, fecula and other vegetable materials are secreted from sap by appropriate organs, consequently; depend upon the vital principle.

19. The ripening of fruits is their first step towards decomposition as well as their last towards perfection.

20. A change analogous to the saccharine fermentation takes place during the cooking of certain vegetables, as parsnips, carrots, &c. in which sweetness appears to be developed during heat and moisture. The same process also takes place in seeds previously to their sprouting. The materials of the seed must be decomposed, and the seed disorganised before a plant can sprout from it.

21. Seeds contain fecula, oil and a little mucilage; these substances are destined for the sustenance of the future plant, it is necessary that they undergo some change before they become fit for this function. The seeds when buried in the earth with a certain degree of moisture and temperature absorb water, which dilates them, separates their particles, and commences a new order of attractions, the product of which is sugar. The substance of the seed is thus softened, sweetened and converted into a milky pulp, appropriated to the nourishment of the embryo plant.

22. The saccharine fermentation of seeds is produced for the purpose of malting.

Exp. A quantity of barley is soaked in water for two or three days, the water being afterwards drained off, the grain heats spontaneously, and sometimes artifical heat is employed; it swells, bursts, sweetens, shews a disposition to germinate, and actually sprouts sometimes, to the length of an inch in one night. The process is then stopped by putting it into a kiln, where it is dried by a gentle heat. In this state it constitutes the substance called *malt*.

23. The saccharine fermentation takes place likewise in hay, in stacks, and sugar is the product; on this principle it is that old hay is more nourishing for cattle than new.

24. The second kind of fermentation is the *vinous*, so called from wine being its product.

25. The saccharine fermentation appears to be favorable if not absolutely necessary to the vinous fermentation, so that if sugar be not developed during the life of the plant, the saccharine fermentation must be artificially produced before the vinous can take place. This is the case with barley, which does not yield any sugar until it is made

into malt; and it is in that state only, that it is susceptible of undergoing the vinous fermentation by which it is converted into beer.

26. The consequence of the vinous fermentation is the decomposition of the saccharine matter, and the formation of a spirituous liquor from the constituents of the sugar.

27. In order to promote this fermentation, not only water and a certain degree of heat are necessary, but also some other vegetable ingredients besides sugar,as fecula, mucilage, acids, salts, extractive matter, &c. all of which seem to contribute to this process, and give to the liquor its peculiar taste.

Illustration. On this principle it is that wine is not obtained from the fermentation of pure sugar; but fruits are chosen for that purpose, as they contain the vegetable ingredients which promote the vinous fermentation and give its peculiar flavour.

28. It is the proportion in which sugar is mixed with other vegetable ingredients that influences the production and qualities of wine.

Observation. It is found that the juice of the grape not only yields the greatest proportion of wine, but of the most grateful flavour.

29. The following changes happen during the vinous fermentation.

The sugar is decomposed and its constituents are recombined into two new substances; the one a peculiar liquid substance called *alcohol, or spirits of wine*, which remains in the fluid; the other, carbonic acid gas, which escapes during the fermentation. Alcohol, therefore appears to constitute the essential part of wine. And the varieties of strength and flavour of different kinds of wine are to be attributed to the different qualities of fruits from which they are obtained, independently of the sugar.

30. The principal difference between alcohol and sugar consists in this. Sugar is composed of carbon, hydrogen and oxygen; during the formation of alcohol, carbonic acid is extracted from this, consequently alcohol contains less carbon and oxygen than sugar does, of course hydrogen is the prevailing principle; which accounts for the lightness and combustible property of alcohol, and of spirits in general, all of which consist of alcohol variously modified.

31. At the commencement of the vinous fermentation heat is evolved, and the liquor swells considerably, in consequence of the formation of carbonic acid. If the fermentation be checked by putting the liqour into casks before the whole of the carbonic acid is evolved, the wine is brisk, like champagne,from the carbonic acid, vulgarly called *fixed air*, its taste is sweet, from the sugar not being completely decomposed.

32. During the decomposition and recomposition attending fermentation, a quantity of caloric may be disengaged, sufficient both to develope the gas, and to effect an increase of temperature; when the formation is completed, the liquor cools and subsides, the effervescence ceases, and the thick, sweet, sticky juice of the fruit is converted into a clear, transparent, spirituous liquor, called wine.

33. When wine of any kind is submitted to distillation, it is found to contain brandy, water, tartar, extractive colouring matter, and some vegetable acid.

34. Brandy is a mixture of alcohol and water, the alcohol may be separated by re-distilling the brandy.

35. Brandy in its pure state is colourless, but in commerce it is of a reddish yellow tint, sometimes made so

by art, and at other times it extracts a colouring matter from the casks. It is usually coloured with a little burnt sugar. Brandy may be obtained from malt in a state of fermentation.

36. Rum is distilled from the juice of the sugar cane which contains so great a quantity of sugar that it yields more alcohol than almost any other vegetable. Molasses which is extracted from the bruised cane by means of water, after it has been pressed for making sugar, is fermented and submitted to distillation, the product of which is *rum.*

37. *Arrack* is the product of the distillation of fermented rice

38. Gin and whiskey are extracted from fermented grain. The peculiar flavour of gin is owing to juniper berries, which are distilled with the grain. Whiskey is likewise obtained from potatos in a state of fermentation.

39. The lees of wine consist of tartrate of potash and extractive matter; tartar exists in the juice of the grape and many other vegetables, and is developed only by the vinous fermentation; during which it is precipitated, and deposits itself on the internal surface of the cask. When purified from foreign ingredients it is called *cream of tartar*, which is much used in medicine and the arts.

PRACTICAL QUESTIONS.

What is the colouring part of vegetables?

How is it found?

Has it any affinity for other substances?

What constitutes the art of dyeing?

How many simple vegetable colours are there?

Are colours permanently attached to the fabric in dyeing?

How are colours to be fixed on the stuffs?

What are adjective and substantive colours?

For what is cochineal used?

What is the process of dyeing any kind of stuff?

What is the use of mordants?

When does decomposition take place in vegetables?

Do vegetables undergo any change previously to the state of putrefaction?

What is fermentation?

What is requisite for fermentation?

What are the several fermentations?

Is the the saccharine fermentation confined to the decomposition of vegetables?

Is sugar secreted from sap?

What is the first step towards decomposition?

How are seeds appropriated to the nourishment of the embryo plant?

What is malting?

Does saccharine fermentation take place in hay?

What is the second kind of fermentation?

What appears necessary to the vinous fermentation?

What is the consequence of the vinous fermentation?

What is necessary to promote this fermentation?

What influences the production and quality of wine?

What changes happen during the vinous fermentation?

What is the difference between alcohol and sugar?

What phenomena takes place during fermentation?

Why is heat evolved during this operation?

What is wine found to contain?

What is brandy ?

Whence is the yellow tint of brandy obtained ?

Whence is rum obtained ?

What is arrack ?

From what are gin and whiskey obtained ?

Of what do the lees of wine consist ?

What is tartar when purified ?

CHAP. XXXIV.

Continuation of Fermentation.

1. In order to obtain alcohol perfectly free from water, it is necessary that it be *rectified* several times ; after which some muriate of lime should be added, in order to absorb any water that may remain. This should be added until it ceases to be moistened, in consequence of the absorption of water. After which it should be redistilled in a water bath.

2. As alcohol is much lighter than water, its specific gravity is adapted as the test of its purity.

3. The chemical properties of alcohol are important and numerous. It is one of the most powerful chemical agents, and is particularly useful in dissolving a variety of substances which are not soluble by water nor heat. It dissolves volatile oils, and forms what are called *essences*. It dissolves copal and mastic, and forms varnishes.

4. Alcohol has a great tendency to combine with water, and this is so strong that when water is added to a

solution of gum in alcohol, the alcohol combines with the water and the gum is precipitated.

Observation. On this principle it is that if water be added to tinctures and elixirs, they immediately become turbid; as when added to a solution of camphor.

5. The addition of water to alcohol produces heat and a diminution of bulk, which is supposed to be caused by a mechanical penetration of particles, by which latent heat is forced out.

6. Alcohol is extremely combustible; and will burn at a moderate temperature.

7. Alcohol in combustion produces much flame but no smoke, which arises from its combustion being complete. The great quantity of flame proceeds from the combustion of carburetted hydrogen. It will also burn in a lamp without a wick, it takes fire at so low a temperature that this assistance is not required to concentrate the heat and volatilize the fluid. The rapidity of the combustion of alcohol may be much increased by first volatilizing it, as is exhibited in the self acting blow pipe.

8. The products of the combustion of alcohol consist, in a great proportion, of water, and a small quantity of carbonic acid; there is no smoke, or fixed remains, whatever.

Illustration. The oxygen which the alcohol absorbs in burning, converts its hydrogen into water, and its carbon into carbonic acid gas, and in this way it is completely consumed.

9. If 100 parts of alcohol be burnt in a chimney, which communicates with the worm pipe of a distilling apparatus, the product which is condensed will be found to be 136 parts of water.

10. If one part of alcohol be mixed in a retort, with four of sulphuric acid, and exposed to a moderate heat, a

gas is produced which is called heavy carburetted or per-carburretted hydrogen, called also *olefiant gas.* Its specific gravity is 0.978. 100 cubic inches weigh 28.80 grains.

11. It possesses all the mechanical properties of air. It is invisible and void of taste and smell, after being washed. When passed through a porcelain tube, heated to a cherry red, it lets fall a portion of charcoal, and nearly doubles its volume. At a higher temperature it deposits more charcoal, and augments in bulk. At the greatest heat to which we can expose it, it lets fall almost the whole of its carbon,and assumes a volume 3½ times greater than it had at first. These remarkable results have led to the conclusion that hydrogen and carbon combine in many successive proportions.

12. The transmission of a series of electric sparks through olefiant gas, produces a similar effect with that of simple heat.

13. Olefiant gas burns with a splendid white flame. When mixed with three times its bulk of oxygen, and kindled by a taper or electric spark, it explodes with great violence, and four volumes are converted into two volumes of carbonic acid.

14. Ether is a substance obtained from alcohol,of which it forms the lightest and most volatile part. In order to obtain it, the alcchol must be decomposed; a certain proportion of carbon must be extracted, which is effected by the action of some acid on the alcohol. The acid and carbon remain at the bottom of the vessel, whilst the decarbonized alcohol flies off in the form of a condensible vapour, called *ether.* That which is mostly used is obtained by the action of sulphuric acid on alcohol.

Exp. When strong sulphuric acid is poured on an equal weight of alcohol, the fluids unite with a hissing noise, and the production of heat, at the same time that a fragrant vegetable smell is perceived, in some measure resembling that of apples, which is ether.

15. Sulphuric ether is a very fragrant, light and volatile fluid. Its evaporation produces extreme cold. It is highly inflammable, and burns with a more luminous flame than alcohol. It freezes at — 46° F. It dissolves essential oils, resins, camphor and caoutchouc readily.— It boils in the atmosphere at 98° F. and in vacuo at — 20°. The density of its vapour is 2.586, that of air being 1. Ether admitted to any gas standing over mercury, doubles its bulk at atmospheric temperatures. If oxygen be thus expanded with ether, and then mixed with three times its bulk of pure oxygen, it explodes on being kindled, forming carbonic acid and water. By detonating such a mixture, M. de Saussure has inferred ether to consist of

Hydrogen	14.40
Carbon	67.98
Oxygen	17.62
	100.00

These proportions *per cent*, correspond to

Olefiant gas	80.05
Water	19.95
	100.00

16. By passing ether through an ignited porcelain tube, it is resolved into olefiant gas, a viscid volatile oil, a little concrete oil, charcoal and water.

17. Ten parts of water combine with one of ether.

18. Sulphuric acid converts ether into *sweet oil of wine.*

19. If a very little ether be thrown into a large bottle containing chlorine, a white vapour soon rises, followed by explosions and flame. Charcoal is deposited and carbonic acid is formed.

20. If a few drops of ether be poured into a wine glass, and a fine platina wire be coiled and heated almost to redness, then held suspended in the glass, close to the surface of the ether, the wire soon becomes intensely *red hot*, and remains so until the ether be exhausted. On this principle is constructed the *Aphlogistic lamp*, or lamp without flame.

Illustration. This is owing to a very peculiar property of the vapour of ether, and many other combustible gaseous bodies. At a certain temperature, lower than that of ignition, these vapours undergo a slow and imperfect combustion, in which light is not emitted in any sensible degree, yet a quantity of caloric is extricated sufficient to react upon the wire and make it red hot; the wire in its turn keeps up the effect as long as the emission of vapour continues.

Observation. To perform the above experiment, platina wire is absolutely necessary, because iron or steel being much better conductors of heat than platina, the heat is carried off too fast by those metals to allow the accumulation of caloric necessary to produce the effect.

21. Alcohol is extensively used in pharmacy, chemistry and the arts, and ether in medicine, though when taken in excess, it produces effects similar to those of intoxication.

22. Acetous fermentation is so called, because it converts wine into vinegar, by the formation of acetous acid, which is the basis, or radical of vinegar.

23. As the acidifying principle is oxygen, the contact of air is essential to this fermentation. In order to obtain pure acetous acid from vinegar, it must be distilled and rectified by certain processes. A good way is to expose vinegar to a temperature of about 20° for one night, and after separating the ice, distil the liquor.

24. Vinegar may be obtained from wood; it was formerly called *pyroligneous acid*, but it is found when purified to be common vinegar; for this purpose it should be mixed with sulphuric acid, manganese, and common salt, and afterwards distilled over.

25. Whenever a vegetable substance turns sour, it has ceased to live; the acetous acid is developed by means of the acetous fermentation, in which the substance advances a step towards its final decomposition.

26. Any substance that has undergone the acetous fermentation, will readily excite it in one that is susceptible of that process. Thus, if vinegar be added in small quantities to wine, that is intended to be acidified, it will absorb oxygen more rapidly, and the process be completed much sooner than if left to ferment spontaneously. Thus *yeast*, which is the product of the fermentation of beer, is used to excite and accelerate the fermentation of malt, which is to be converted into beer, as well as that of paste, which is to be made into bread.

27. Bread, by undergoing the acetous fermentation, acquires a certain savour which serves to correct the heavy insipidity of flour, and may be considered as the first stage of acidification; if the process were carried further, the bread would become decidedly acid.

Observation. Some chemists do not consider the fermentation of bread as the acetous, but suppose that it is a fermenting process peculiar to that substance, which they have denominated *panary fermentation*.

28. The putrid fermentation is the final operation of nature. It is the last step towards reducing bodies to their simplest combinations.

29. To effect this decomposition, a certain degree of moisture is necessary, and a sufficient degree of heat, together with access of air. For it is well known, that dead plants may be preserved by drying, or by the total exclusion of air for any length of time.

30. If we attend minutely to the decomposition of plants from their death to their final dissolution, we shall generally find a sweetness developed in the seeds, and a spiritous flavor in the fruits, which have undergone the saccharine fermentation, previously to the disorganization and separation of the parts.

Illustration. Apples, when *over ripe*, have a kind of spirituous taste, just before they become rotten. This is occasioned by the vinous fermentation, which has succeeded the saccharine, and if we follow up these changes attentively, we shall find the spirituous taste followed by acidity, previously to the fruit passing to the state of putrefaction. Leaves which fall in autumn, do not immediately undergo a decomposition, but are first dried; but when the rain sets in, fermentation commences, their gaseous products are evolved into the atmosphere, their fixed remains are mixed with the earths, they soon mingle with the dust, and afford a *pabulum* for future plants.

31. The *dry rot*, which attacks beams of houses, may at first sight, be thought to be an objection to the above theory, because a current of air prevents it. But this must not be in such proportion to the moisture as to dissolve the latter, and this is generally the case, when the rotting of wood is prevented or stopped by the free access of air. But *dry rot*, is not a true process of putrefaction. It is supposed to depend on a peculiar kind

of vegetation, which, by feeding on the wood, gradually destroys it.

32. The process of making *compost manure*, depends upon the putrid fermentation. Straw and other vegetable matters undergo the putrid fermentation much more rapidly when mixed with animal substances ; much heat is evolved during this process, and a variety of volatile products are disengaged, as carbonic acid, hydrogen gas, and sulphuretted hydrogen. When all these gases have been evolved, the fixed products, consisting of carbon, salts, potash, &c. form a kind of vegetable earth, which is composed of those elements which form the immediate materials of plants, and is much more active than *dung* in its recent state.

33. Petrified vegetables, as they are called, are really stone, consisting principally of silex. The process is this, when a vegetable substance is buried under water, or in wet earth, it is gradually decomposed. As each successive part of the vegetable is destroyed, its place is supplied by a particle of silicious earth, conveyed thither by the water. In process of time the vegetable is entirely destroyed, and its place supplied by the silex, having assumed its form and apparent texture, producing an appearance, as if the vegetable was turned to stone.

Observation. It is impossible that either vegetables or animals should be turned to stone. They may be reduced by decomposition to their constituent elements, but cannot be changed to elements that do not enter into their composition.

34. When vegetables are buried in the sea, or in the earth, totally excluded from the air, they are subject to a peculiar change, by which they are converted into a new class of compounds, called *bitumens.*

35. Bitumens are vegetables so far decomposed as to retain no organic appearance ; but their origin is easily detected by their oily nature, their combustibility, the products of their analysis, and the impression of the form of leaves, grains, fibres of wood, and even of animals, which are frequently exhibited in different specimens of coal.

36. Bitumens are sometimes of an oily liquid consistence, as the substance called *naphtha*. But they are more frequently solid, as *asphaltum* and *jet.*

37. *Naphtha* is a light, thin, colourless oil, and highly odoriferous. It is found on the surface of water in certain springs in Italy, and on the shores of the Caspian Sea. It is about one quarter lighter than water. It is very inflammable, and burns with a penetrating smell, and much smoke. By long exposure to the air, it becomes thick, and passes to the state of *petroleum.* It appears to be composed of carbon 82.2 and + hydrogen 14.8

38. Naphtha being destitute of oxygen, renders it the most proper liquid for preserving potassium ; because it has so great an affinity for oxygen, that it seizes it whenever it comes in contact with it.

39. *Asphaltum* is a smooth, hard, brittle, black or brown substance, which breaks with a polish, melts easily when heated, and when pure, burns without leaving any ashes. It is found in different parts of the world, but in the greatest quantity on the shore of the Dead Sea.

Observation. The Egyptians used asphaltum in embalming the dead, under the name of *mumia mineralis*, for which it is well adapted. It was used for mortar at Babylon.

40. *Jet* is harder than asphaltum, and susceptible of so high a polish, that it is used for many ornamental purposes. It is composed of

Carbon	75
Bitumen	22
Earth	2
Water	1
	100

Its specific gravity is 1.3.

41. *Petroleum* is a bituminous substance, thicker than naptha, has a greasy feel, is wholly, or in part, transparent, and a little heavier than naptha. It is very highly inflammable, and has the property of combining with fat and essential oils, with resins, camphor and sulphur; and when rectified, it dissolves caoutchouc.

42. *Mineral tar* is thicker and more viscid than petroleum, and of a reddish or blackish brown colour; in its chemical properties, it resembles petroleum.

43. *Mineral pitch* is extremely inflammable, of a brownish or blackish colour; it is nearly twice as heavy as that of water.

44. *Coal* is a bituminous substance, which seems to be composed of mineral and animal substances. It appears to consist principally of vegetable matter, mixed with the remains of marine animals and marine salts.—It occasionally contains a quantity of sulphuret of iron, commonly called *pyrites*.

45. *Coke* is a kind of fuel, artificially prepared from coals, by means of charring or burning in close vessels, to expel the volatile parts. It is composed of carbon with some earthy or saline ingredients.

46. Amber is considered as a bitumen, called by the ancients, *Electrum*, whence the term *electricity*, because

it is *peculiarly*, and was once supposed to be *exclusively* electric.

47. It is found in mines in some parts of Prussia, and sometimes floating on the sea.

48. It is a hard, brittle, tasteless substance, sometimes perfectly transparent, but mostly semi-transparent or opaque, and of a glossy surface. It is found of all colours, but chiefly yellow or orange. Its specific gravity is from 1.065 to 1.100. Its fracture is even, smooth and glossy. It is fusible at 550° F. It consists of an oil and an acid, the former is called *oil of amber*, the latter succinic acid.

Observation. By some experiments made on the effects of light on amber, Dr. Brewster has been led to conclude that it is an *indurated vegetable juice.*

49. *Peat* or *turf*, is composed of the remains of vegetable organization, and consists in a great measure of the fibres of mosses, with the branches and roots of trees.—It is extremely inflammable in the open air, and when distilled in close vessels, yields products similar to those of coal.

PRACTICAL QUESTIONS.

How can pure alcohol be obtained?

What is adopted as the test of the purity of alcohol?

What are the chemical properties of alcohol?

Has alcohol any affinity for water?

What is the effect of adding water to alcohol?

Is alcohol combustible?

What are the phenomena of the combustion of alcohol?

What are the products of the combustion of alcohol?

How much water will 100 parts of alcohol produce by combustion?

How is olefiant gas formed?

What are its properties?

How can a similar effect, as that of simple heat, be produced on olefiant gas?

What appearances are produced in the combustion of olefiant gas?

What is ether?

What are the properties of sulphuric ether?

What is the effect of passing ether through an ignited porcelain tube?

How many parts of water combine with ether?

Into what does sulphuric acid convert ether?

What is the effect of chlorine on ether?

How do you perform the experiment which illustrates the principle of the *aphlogistic lamp?*

Why will not iron and steel answer?

Is alcohol much used?

What is the acetous fermentation?

What is necessary for this fermentation?

How do you obtain it pure?

Can vinegar be obtained from wood?

When is the acetous acid developed?

How can the acetous fermentation be excited?

What does bread acquire by the acetous fermentation?

What is the putrid fermentation?

What is necessary to effect this decomposition?

What shall we generally find by attending minutely to the decomposition of plants?

How do you illustrate this?

Is not the *dry rot* an exception to this theory?

Upon what does the process of making *compost* depend?

What are petrified vegetables?

What is the effect of burying vegetables in the sea, or at great depths in the earth?

What are bitumens?

Are they of different consistencies?

What is naptha?

Why is naptha best calculated for preserving potassium?

What is asphaltum?

What is jet?

What is petroleum?

What is mineral tar?

What is mineral pitch?

What is coal?

What is coke?

What is amber?

What is peat or turf?

CHAP. XXXV.

Of Vegetation.

1. The most obvious difference between animals and vegetables is, that the former are in general capable of conveying themselves from place to place; whereas vegetables being fixed in the same place absorb by means of their roots and leaves, such support as is within their reach. This appears to be air and water.

2. The greatest part of the support of animals are the products formed in the vegetable department. The products of these two departments in the hands of the chemist, are remarkably different.

3. One of the most distinctive characters appears to be the presence of nitrogen or azotic gas, which may be extricated from animal substances by nitric acid, and enters into the composition of ammonia, afforded by destructive distillation.

4. It was long supposed that ammonia was exclusively confined to the animal department, but it is now found that certain plants afford it.

5. The nutrition or support of plants appears to require water, earth, light and air. Various experiments have been instituted to shew that water is the only aliment which the root draws from the earth.

Illustration. Von Helmont planted a willow weighing fifty pounds, in a certain quantity of earth, covered with sheet lead It was watered for five years with distilled water, and at the end of that time, the tree weighed 169 pounds, three ounces, and the earth in which it had vegetated was found to have suffered a loss of only three ounces. Mr. Boyle repeated the same experiment upon a plant, which at the end of two years weighed fourteen pounds more; and the earth in which it vegetated, lost no perceptible portion of its weight.

6. Duhamel and Bonnet supported plants with moss, and fed them with pure water. The vegetation was of the most vigorous kind, and the flowers were more odoriferous, and the fruit of a better flavour Mr. Tillet raised plants of the gramineous kinds in the same manner, with this difference only, his supports were of pounded glass, or quartz in powder.

7. Hales has observed, that a plant that weighed three pounds, gained three ounces after a heavy dew.

8. Hyacinths, and other bulbous and gramineous plants, are sometimes raised in saucers or bottles filled with water.

9. Braconet caused mustard seed to germinate, grow, and produce plants that came to maturity, flowered and ripened their seed in litharge, flowers of sulphur, and very small unglazed shot.

10. All plants do not require the same quantity of water, and nature has varied the organs of the same individuals, agreeably to the necessity of their being supplied with this food.

11. Plants which transpire little, such as the mosses and lichens, have no need of a great quantity of water; accordingly, they are placed on dry rocks, and have scarcely any roots; but plants which require a larger quantity, have roots which extend to a great distance, and absorb humidity throughout their whole surface.

12. The leaves of plants have likewise the property of absorbing water, and of extracting from the atmosphere the same food which the root draws from the earth. Such are some species of *aloes*, and the *cacti*, which will live and flourish in dry earth for a great length of time, and when much water is added to the earth, they soon sicken and die.

13. Plants which live in the water, receive the fluid at all their pores, and have but very little need of roots; we find that the *fucus*, the *ulva*, &c. have no roots.

14. The manure not only affords the alimentary principles, but likewise favours the growth of the plant, by that constant and steady heat, which its decomposition produces.

15. From the above circumstances it appears, that the influence of the earth in vegetation is almost totally confined to the conveyance of water, and probably, the elastic products, from the putrifying substances in the plant.

16. Vegetables cannot live without air. From the experiments of Priestley, Ingenhousz and Sennebier, it is ascertained, that plants absorb the azotic part of the atmosphere ; and this principle appears to be the cause of the fertility which arises from the use of putrefying matter, in the form of manure. The carbonic acid is likewise absorbed by vegetables, when its quantity is small. But in large quantities it proves fatal.

17. According to Chaptal, the carbonic acid predominates in the *fungus* and other plants, when excluded from the light. But by causing these vegetables, together with the body upon which they were fixed, to pass, by imperceptible gradations, from an almost absolute darkness, into the light, the acid very nearly disappeared; the vegetable fibres being proportionally increased, while the resin and colouring principles were developed, which he ascribes to the oxygen of the same acid. It has been observed, that when plants are watered with water, impregnated with carbonic acid gas, they transpired an extraordinary quantity of oxygen, which likewise indicates a decomposition of the acid.

18. Light appears to be essential to the growth of plants. In the dark, they grow pale, languish and die.

Observation. The affection of plants for the light is manifest in such vegetation as is conducted in an apartment of the house ; where the light is admitted on one side, the plants all turn in that direction. If the light proceed from two sides, they will turn to that which is the strongest ; and if the light proceed from above, they will grow upright. In a thick wood, where but very little light proceeds from any direction but perpendicularly, the trees are much taller, straighter, and have fewer and smaller branches than those which grow in the open field, which is owing to the same cause.

19. Whether the matter of light be condensed into the substance of plants, or whether it act merely as a stimulus or agent, without which the other requisite chemical processes cannot be effected, is uncertain.

20. The processes in plants serve, like those in animals, to produce a more equable temperature, which is for the most part above that of the atmosphere.

Observation. Dr. Hunter observed by keeping a thermometer plunged in a hole made in a sound tree, that it constantly indicated a temperature several degrees above that of the atmosphere, when it was below the 56° of Farenheit ; whereas the vegetable heat in hotter weather, was several degrees below that of the atmosphere.—The same philosopher has observed, that the sap, which out of the tree, would freeze at 32°, did not freeze in the tree, unless the temperature was as low as 17°.

21. The vegetable heat may increase or diminish by several causes, of the nature of disease ; and it is said, may become perceptible to the touch in very cold weather.

22. Germination is the vital developement of a seed, when it first begins to grow.

23. In order to understand the nature of germination, we must be acquainted with the different parts of which a seed is composed.

24. The seed is formed of an external covering, called the *parenchyma*, which is to constitute its first nourishment ; this imbibes nourishment from the earth, elaborates it, and does not transmit it to the inclosed germen, until it is reduced into proper nutriment.

25. The seed is divided into compartments, called *lobes* or *cotyledons*, as is observed distinctly in the garden bean, which is a good example for illustration. Plate 5, fig. 1 and 2, A. or the dark coloured kind of string which

PLATE V

Fig. 1.

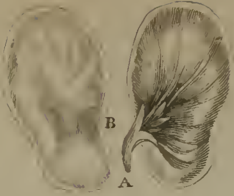

Fig. 2.

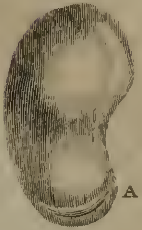

Fig. 3.

Fig. 4.

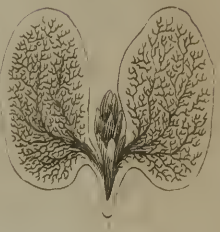

Fig. 5.

Fig. 6.

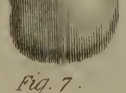

Fig. 7.

Wormwood.

Fig. 8.

divides the lobes, is called the radicle, because it forms the root of the plant. B. is the *plumula* which is enclosed within the lobes, and is that part from which the stem arises. At the thick end of the bean there is a small hole visible to the naked eye as in fig. 2 A. immediately over the radicle, in order to give it a free passage into the soil. The plumula and the radicle in colour and consistency are much alike. Fig. 7, is a transverse section of the bean.

26. Within the radicle there is a substance called the seminal root, which divides into three branches; the middle one runs directly up to the plumula; the other two pass into the lobes on each side, and send forth smaller branches, till their ramifications become quite minute on the surface of the lobes, as in fig. 4. Fig. 5, is a transverse section of the radicle. Fig. 6, a transverse section of the plumula, shewing the organs or vessels of the seminal root.

27. When a seed is placed in a situation favorable to vegetation, it very soon changes its appearance. It imbibes water, which softens and swells the lobes. It then absorbs oxygen, which imbibes some of its carbon, and is returned in the form of carbonic acid. This loss of carbon increases the comparative proportion of hydrogen and oxygen in the seed, and excites the saccharine fermentation, by which the parenchymatous matter is converted into a kind of sweet emulsion. In this form, it is conveyed into the radicle by vessels appropriated to that purpose; and in the mean time, the cotyledons are rent asunder, the radicle strikes into the ground, and becomes the root of the future plant; hence the fermented liquid is conveyed to the plumula whose vessels have been previously distended by the heat of the fermentation.— The plumula being thus swelled, as it were, by the

emulsive fluid raises itself up to the surface of the earth, bearing with it the cotyledons, which, as soon as they come in contact with the air, spread themselves and are transformed into leaves, as in fig. 3.

28. As soon as a plant derives nourishment from the soil, it requires leaves, which are the organs by which it throws off its superabundant fluid. This transpired fluid consists of a little more than water. The sap, by this process is converted into a fluid of a greater consistence, which is appropriated to its several parts.

29. When the leaves of plants are destroyed by accident, it not only diminishes the transpiration, but also the absorption by the roots. The quantity of sap absorbed being always in proportion to the quantity of fluid thrown off by transpiration. Hence it is necessary that a young plant should unfold its leaves as soon as it begins to derive nourishment from the earth.

30. Seeds will not germinate unless moisture be present. Water, therefore, appears to be essential to germination, too much however, is no less prejudical than none at all. Water is the vehicle which carries into the plant, the various salts and other ingredients required for the formation and support of the vegetable system. Part of the water itself is decomposed by the organs of the plant, the hydrogen becomes a constituent part of oil, of extract, of colouring matter, &c. whilst a portion of the oxygen enters into the formation of mucilage, fecula, sugar and vegetable acids. But a greater part of the oxygen is converted into a gaseous state by the caloric disengaged from the hydrogen, during the condensation in the formation of the vegetable materials. In this state the oxygen is transpired by the leaves of the plant, when exposed to the sun's rays.

31. Seeds will not germinate even though supplied

with a suitable portion of moisture, unless they are placed in a proper degree of temperature. No seed of which we are acquainted, will vegetate in a temperature below 32° F. notwithstanding a degree of cold below zero, will not destroy the germinating power, unless moisture be present, but there must be a certain point of temperature in order for germination; this varies with different seeds. Every plant seems to require a degree of heat peculiar to itself, at which point its seeds begin to germinate; for we find that every seed of a plant which grows spontaneously has a peculiar season when it springs from the earth, and this season varies with the temperature of the climate. Thus seeds of the same plant, sown at the same time in different countries, will germinate sooner in a warm than a cold one.

32. Seeds although supplied with moisture and placed in a proper temperature will not germinate, provided atmospheric air be completely excluded from them. It is supposed to be owing to this circumstance, that seeds do not germinate when buried at great depths in the earth. Mr. Scheele, found that beans would not vegetate unless oxygen gas were present. No seed will germinate in pure nitrogen, or carbonic gas. Hence it apears that it is not the whole of the atmosphere, but the oxygen that causes the germination of seeds.

33. It has been ascertained that seeds germinate more rapidly when steeped for a short time in chlorine. This substance is well known for the facility with which it decomposes water, and sets at liberty the hydrogen.

Observation. Chlorine seems to augment the vegetative power of seeds. Those which could not be made to sprout even in green houses, have been found to germinate when steeped in chlorine. By this process Mr. Humbolt succeeded in making the seeds of many plants which he found in South America, to grow in Vienna, which not all the art of the gardeners was able, previously to effect.

30. Different opinions have been entertained with respect to light on seeds. From experiments, it appears injurious, in consequence of the heat which the rays of light impart to seeds, for if proper care be taken to intercept the direct rays of the sun, seeds germinate as well in the light as the shade.

31. When a seed is placed in favorable situations, it gradually imbibes moisture, and very soon emits a quantity of carbonic acid gas, even though no oxygen be present in a separate state, but the process soon terminates and no germination takes place, but if there be a sufficient supply of oxygen gas, a portion of it is converted into carbonic acid gas.

32. From experiments it appears that if seeds be left to germinate in a determinate portion of oxygen gas, the bulk is not altered, the carbonic acid gas being equal to the oxygen gas which has disappeared. Hence it is inferred that the carbonic gas, contains exactly the quantity of oxygen gas consumed.

33. No oxygen gas is absorbed by the seed, at least if it be absorbed, none of it is retained, it being thrown off in combination with the carbon.

34. The quantity of oxygen thus changed into carbonic acid by the germination of the seed, is in some measure proportional to the weight of the seed.

Observation. From the experiment of M. De Saussure, it appears that wheat and barley, weight for weight, consume less oxygen than peas, while peas consume less than common beans and kidney beans. The oxygen consumed by wheat and barley amounted to $\frac{1}{2000}$ of their weight, while that of common beans and kidney beans, amounted to $\frac{1}{100}$ of their weight.

35. It is probable that a portion of water is formed by the union of its constituents, previously existing in the grain.

36. In some plants the cotyledons do not rise above the earth, but in that case they perform the same office as those which do, that is to prepare the nourishment for the sustenance of the young plant.

37. It does not apppear that there is any communication between the cotyledons and the plumula, the nourishment therefore must pass into the plumula, from the radicle, accordingly, we find that the plumula does not begin to vegetate until the radicle has made some progress. But since the plant has ceased to vegetate, if the cotyledons be removed before the plumula is developed, the radicle must be sufficient of itself to carry on the process of vegetation, and the cotyledons are continued for the purpose of performing a part, that is, they prepare the food which the root at first is unable to do.

38. When the cotyledons assume the form of leaves, the nourishment, which was originally deposited in them for the support of the embryo plant, is exhausted, but they still continue necessary. They must therefore receive the nourishment which is imbibed by the root, produce some change in it to render it suitable for the purposes of vegetation, and then send it back to be transmitted to the plumula.

39. When the plumula has just ascended from the ground, if the radicle leaves be cut off, the plant does not cease to vegetate, but it seems to be deficient in nourishment, and scarcely ever arrives at maturity.

40. When the plumula has arrived at a certain size, and completely expanded its leaves, the cotyledons may be removed without detriment to the plant, and they very soon decay of themselves. It appears then that the office

of the cotyledon is performed by that part which is above ground.

41. The bark is composed of the *epidermis*, the parenchyma and the cortical layes.

42. The epidermis is the external covering of the plant. It is a thin transparent membrane, consisting of a number of slender fibres, crossing each other and forming a kind of net work.

When of a white glossy nature as in several species of trees, in the stems of rye and wheat and of seeds, it is composed of a thin coating of silicous earth, which is no doubt designed to protect those slender stems from injury.

Illustration. Two rattan canes struck against each other in the dark emit sparks of fire.

In evergreens the epidermis is mostly resinous, and in some plants, it is formed of wax. This from its want of affinity for water, tends to preserve the plant from the weather, to which these species of vegetables are peculiarly exposed.

43. The *perenchyma* is immediately beneath the epidermis, and is usually green. It is not confined to the stem or branches, but extends over every part of the plant; it forms the green matter of the leaves,. and is composed of tubes filled with a peculiar juice.

44. The cortical layers are immediately in contact with the wood. They abound with tannin and gallic acid, and consist of small vessels through which the sap descends after being elaborated in the leaves. These layers are renewed every year.

45. The sap ascends through the tubes of the alburnum or wood, which is immediately beneath the cortical layers.

46. The wood is composed of woody fibres, mucilage and resin.

The fibres are disposed of in two ways, some of them longitudinally, and these form what is called silver grain of the wood, as in fig. 8. The others, which are concentric, are called the spurious grain. These last are disposed in layers, from the number of which the age of the tree may be computed, a new one being produced every year, by the conversion of bark into wood. The oldest and most internal part of the alburnum is called *heart wood*, in this no vital functions are discovered. It is through the tubes of the white part of the wood that the sap rises. These spread into the leaves, and there communicate with the extremities of the vessels of the cortical layers into which they pour their contents.

47. The tubes of the *parenchyma* are supposed to perform the important office of secreting from the sap the peculiar juices from which the plant more immediately derives its nourishment. These juices are very conspicuous, as the vessels which contain them are much larger than those through which the sap circulates.

48. The peculiar juices of plants differ much in their nature, not only in different species of vegetables, but frequently in different parts of the same individual plant. They are sometimes saccharine, as in the sugar cane, maple, &c. sometimes resinous, as in firs and evergreens, and sometimes of a milky appearance, as in the laurel. *

49. Vegetables possess a peculiar heat, analogous to animal heat, and is considerably above that of unorganized matter in winter, and below it in summer. The wood of a tree is about 60° when that of the atmosphere is

about 70° or 80°. And the bark is seldom below 40° in winter.

50. It is from the sap after it has been elaborated by the leaves, that vegetables derive their nourishment; in its progress through the plant from the leaves to the root, it deposits in several vessels with which it communicates, the materials on which the growth and nourishment of each plant depends. It is in this way that the various peculiar juices are formed, such as the saccharine, oily, mucous, acid and colouring; as also the more solid parts, fecula, woody fibre, tannin, resin, concrete salts. All the materials of vegetables, as well as the organized parts of plants, which, besides the power of secreting these from the sap for the general purpose of the plant, have also that of applying them to their own particular nourishment.

51. The reason why plants vegetate at one season of the year more than at another, seems to be this. The warmth of spring dilates the vessels of plants and produces a kind of vaccuum into which the sap, which had remained in a state of inaction in the trunk during winter, rises. This is followed by the ascent of the sap contained in the roots, and room is thus made for fresh sap, which the roots in their turn pump up from the soil. This process goes on until the plant blossoms and bears fruit, which terminates its summer career; but when the cold weather sets in, the fibres and vessels contract, the leaves wither, and can no longer perform their office of transpiration, and as this secretion stops, the roots cease to absorb sap from the soil. If the plant be an *annual*, its life then terminates; if not, it remains in a state of torpid inaction during the winter; or the only internal motion which takes place, is that of a small quan-

tity of resinous juice, which slowly rises from the stem into the branches, and enlarges their buds during the winter.

PRACTICAL QUESTIONS.

What is the most obvious difference between animals and vegetables?

From what does the greatest part of the support of animals arise?

What is one of the most disitinguishing properties of animal substances?

Is ammonia exclusively confined to the animal department?

What does the nutrition of plants require?

Do all plants require the same quantity of water?

What plants require the least water?

What property do the leaves of plants possess?

What plants have the least need of roots?

What office does manure perform?

To what is the influence of earth confined in vegetation?

Can vegetables live without air?

Is carbonic acid absorbed by vegetables?

In what plants does the carbonic acid predominate?

Is light essential to the growth of plants?

How does light act upon plants?

What do the processes in plants serve to produce?

How can the vegetable heat increase or diminish?

What is germination?

What is necessary in order to understand the nature of germination?

What is the external covering of the seeds?

How is the seed divided?

What is found within the radicle?

What takes place at the commencement of germination?

What does a plant require when it derives nourishment from the soil?

What is the effect of destroying the leaves of a plant?

Is water essential to germination?

Is a proper degree of temperature necessary to germination?

Is atmospheric air necessary?

Has chlorine any effect on the germination of seeds?

What effect has light on seeds?

What gas is emitted when seeds are placed in a favourable situation?

Is the bulk of oxygen gas altered by germination?

Is any oxygen gas absorbed by the seeds?

What proportion does the oxygen that is changed into the carbonic gas bear?

Is any water formed?

Do the cotyledons in all cases rise above the earth?

How does the plant obtain its nourishment?

Are the cotyledons necessary when they assume the form of leaves?

What is the effect if the radicle leaves be removed when the plumula has just ascended from the ground?

Of what is the bark composed?

What is the epidermis?

What is the parenchyma?

Where are the cortical layers situated?

How does the sap ascend?

Of what is the wood composed?

Do the peculiar juices of plants differ in their nature?

Do vegetables have a peculiar heat?

From what do vegtables derive their nourishment?

Why do plants vegetate at one season of the year and not at another?

CHAP. XXXVI.

Of the Animal Department.

1. The bodies that form the subjects of chemical research have all undergone a variety of combinations and decompositions previously to our commencing an examination. This process in animal matter is called *animalization.* Which is performed on substances which enter as nourishment into the animal system. It is performed by peculiar organs, and is analogous in some measure to the chemical process in vegetables.

2. Animal as well as vegetable bodies, may be considered as constituting a peculiar apparatus, for carrying on a determinate series of chemical operations. Vegetables seem capable of operating with fluids only, and nearly at the temperature of the atmosphere. But most animals have a provision for mechanically dividing solids by mastication; which performs the same office as grinding, pounding or levigating does in chemistry; in this way the surfaces are enlarged to be acted upon by solvents.

3. The process carried on in the stomach, seems to be analogous to that which we distinguish in chemistry by the name of *digestion.*

4. The bowels, whatever other functions they may perform, evidently constitute an apparatus for filtering or conveying off the fluids ; while the more solid parts of the elements which are probably incapable of being converted into fluids, but by an alteration which would perhaps destroy the texture of the machine, are rejected as uselsse

Organized beings are so contrived, that their existence continues, and all their functions are performed as long as the vessels are supplied with materials, to occupy the place of such as are carried off by evaporation, from the surface or otherwise ; as long as no great change is made, either by violence or disease, in those vessels or the fluids they contain. But as soon as the process is deranged in any considerable degree, the arrangements are altered ; the temperature in land animals is changed, the minute vessels are acted upon and destroyed, and this struck by new combinations and decompositions returns to the general mass of unorganized matter, with a rapidity which is usually greater, the more complicated its construction.

5. Animal and vegetable substances approach each other by insensible gradations, so that there is scarcely any simple product in the one, which is not found in a greater or less quantity in the other. There is one principle however, which abounds in animals, which is rarely, and in very small quantities found in vegetables ; this is *nitrogen.* There exists likewise in animal substances a larger and more uniform proportion of phosphoric acid, and other saline matters. But these are not essential to animal matter.

6. Animal substances afford ammonia by destructive distillation; this does not exist in the substance ready formed, but appears to be produced by the combination of hydrogen and nitrogen, during the changes produced either by fire or the putrefactive process.

7. The fundamental principles of animal compounds, appear to be carbon, hydrogen, oxygen and nitrogen.—Sulphur, phosphorus, lime, magnesia and soda, are occasionally combined with these. Metals are also found in very minute quantities in animals.

8. The analysis of animal substances are both difficult and imperfect; for as they cannot be examined in their living state, and are liable to alteration immediately after death, it is probable that when submitted to chemical investigation, they are always, more or less altered, in their combinations and properties, from what they were in a living state.

9. The following are peculiar chemical products of animal organization, viz. Gelatine, albumen, fibrin, caseous matter, colouring matter of the blood, mucus, urea, picromel, osmazome, sugar of milk, and sugar of diabetes. The compound animal products are the various solids and fluids, whether healthy or morbid, found in different animals, as a variety of acids, muscle, skin, bone, blood, urine, tears, bile, morbid concretions, brain, gastric juice, &c.

10. *Gelatine*, or *jelly* is the chief ingredient of skin, and of all the membranous parts of animals. It may be obtained from these substances by means of boiling water, under the forms of glue, size, isinglass, and transparent jelly.

11. It is soluble in water, and is capable of assuming a well known elastic, and tremulous substance by cooling, when the water is not too abundant, and liquifiable

again on increasing its temperature. This last property distinguishes it from albumen, which becomes consistent by heat. It is precipitated in an insoluble form by tannin, and it is this action of tannin on gelatine that is the art of tanning leather. In its solid state, it is a semi-transparent substance, without taste or smell.

12. Leather can be produced only from gelatine in a membraneous state, the texture of the skin being necessary to the purposes of leather.

13. Glue is extracted from the skin of animals.

14. Size is obtained either from skin in its natnral state, or from leather.

15. Isinglass is gelatine procured from a species of fish called the sturgeon, and is called *Ichthyocolla.*

16. Gelatine may be obtained from almost any animal substance. Bones produce it in considerable quantities, as they consist of phosphate of lime, cemented by gelatine. Horns yield abundance of gelatine.

17. It is from the gelatine of bones that ammonia is produced. By the simple action of water and heat, the gelatine is separated; and to procure the ammonia, the bones are distilled, by which means, the gelatine is decomposed, and the hydrogen and nitrogen combine in the form of ammonia. The first is a mechanical separation of the ingredients, but the latter, a chemical decomposition.

18. Gelatine may be precipitated from its solution in water by alcohol. The alcohol combining with the water, while the gelatine is set at liberty.

Exp. Take a glass of warm jelly, and add a few drops of alcohol, the gelatine falls down in an insoluble mass.

19. Gelatine is composed of

Carbon,	47.881
Oxygen,	27.207
Hydrogen,	7.914
Nitrogen,	16.998
	100.000

20. *Albumen* derives its name from the latin, and signifies the *white* of an egg, in which it exists abundantly, and in its purest natural state is one of the principal constituents of all animal solids. It abounds in the serum of blood, the vitreous and crystalline humours of the eye, and the fluid of dropsy.

21. It is coagulable by heat. It is soluble in cold water, previously to coagulation, but not afterwards.—Pure alkalies dissolve it, even after coagulation. It is precipitated by muriate of mercury, nitro muriate of tin, acetate of lead, nitrate of silver, muriate of gold, infusion of galls and tannin. The acids and metallic oxides coagulate albumen.

22. Solid albumen may be obtained by agitating white of egg with ten or twelve times its weight of alcohol. This seizes the water which held the albumen in solution, and this substance is precipitated under the form of white flocks or filaments, which are rendered insoluble by cohesive attraction.

23. Albumen thus obtained is like fibrine, solid, white, insipid, inodorous, denser than water, and without action on vegetable colours. It dissolves in potash and soda more easily than fibrine, and more difficult in acetic acid

24. 100 parts of pure albumen consist of

Carbon,	52.883
Oxygen,	23.872

Hydrogen,	7.510
Nitrogen,	15.705
	100.000

25. Fibrine is another animal substance; it is found also in vegetables. It is a soft solid, of a greasy appearance, insoluble in water, softens in the air, and becomes viscid, brown and semi-transparent. On hot coals it melts, throws out greasy drops, crackles, and evolves the smoke and odour of roasting meat. It exists in chyle, it enters into the composition of blood; it forms the principal part of muscular flesh, and may be regarded as the most abundant constituent of the soft solids of animals.

26. It may be obtained by beating blood as it issues from the veins, with a bunch of twigs. Fibrine soon attaches itself to the twigs, under the form of long reddish filaments, which become colourless by washing them with cold water.

27. It is solid, white, insipid, without smell, denser than water, does not change the infusion of litmus or violets. When moist, it possesses a species of elasticity.—It becomes yellowish, hard and brittle, by drying.

28. It is composed of

Carbon,	53.360
Nitrogen,	19.934
Oxygen,	19.685
Hydrogen,	7.021
	100.000

29. *Caseous matter* is a substance procured from milk. Cheese is obtained from milk by means of *rennet*, which is a watery infusion of the coats of the stomach of a sucking calf. It possesses the property of coagulating milk, which is supposed to be owing to the gastric juice with

which it is impregnated. What remains after the separation of the curds is called whey, from which may be obtained a substance, by evaporation, called *sugar of milk.* This substance is sweet to the taste, and is susceptible of undergoing the vinous fermentation. Whey, by combining with oxygen, is capable of being acidified and of forming the lactic acid.

30. The nature and flavour of cheese depend on the cream or oily matter, and likewise, it is said, on a peculiar acid, called *caseic acid.* If both these substances be removed from the cheese, it becomes insipid and totally unfit for food.

31. Colouring matter of blood is a peculiar compound; it does not exist in any other organized body. To obtain it pure, mix blood with 4 parts of sulphuric acid, previously diluted with 8 parts of water, and expose the mixture to a heat of about 160° for 5 or 6 hours, filter the liquid while hot, and wash the residue with a few ounces of hot water. Evaporate the liquid to one half, and add ammonia, till the acid be almost but not entirely saturated. The colouring matter falls. Decant the supernatant liquid, filter and wash the residuum from the ammonia. When it is well drained, dry it in a capsule.

32. When solid, it appears of a black colour, but becomes wine red by diffusion through water; in which, however, it is not soluble. It is destitute of taste and smell. It is soluble both in alkalies and acids. It approaches to fibrine in its constitution, and contains iron in a peculiar state. One third per cent of the oxide may be obtained by calcination, according to Dr. Ure. The incinerated colouring matter weighs 1-80th of the whole, and the ashes consist of 50 oxide of iron, 7.5 sub-phos-

phate of iron, 6 phosphate of lime with traces of magnesia, 20 pure lime, 16.5 carbonic acid.

Observation. Berzelius thinks that none of these bodies existed in the blood, but only their bases, iron, phosphorus, calcium, carbon, &c. and that they were formed during the incineration.

33. The *buffy coat* of inflamed blood is fibrine, from which the colouring matter has been precipitated, from the greater liquidity or slowness of coagulation during the disease.

34. *Mucus* is one of the primary animal fluids, perfectly distinct from gelatine. The subacetate of lead does not affect gelatine ; on the other hand, tannin, which is a delicate test of gelatine, does not affect mucus. Both these reagents, however, precipitate albumen ; but the oxymuriate of mercury, which will indicate the presence of albumen dissolved in 2000 parts of water, precipitates neither mucus nor gelatine. Thus we have three distinct and delicate *tests* for these three different principles.

35. *Urea* is an animal substance, prepared from urine. It crystallizes in four sided prisms, which are transparent and colourless, with a slight pearly lustre. It has a peculiar, but not urinous odour. It does not affect litmus or tumeric papers. It is permanent in the atmosphere. In damp weather it deliquesces slightly. In a strong heat it melts, and is partly decomposed and partly sublimed without change. The specific gravity of the crystals is about 1.35. It is very soluble in water. Alcohol at the temperature of the atmosphere, dissolves about 20 *per cent* ; when boiling, considerably more than its own weight. It is decomposed by fixed alkalies and alkaline earths. It unites with most of the metallic oxides, and

forms crystalline compounds with the nitric and oxalic acids.

36. Urea is composed, according to Dr. Prout, of

Hydrogen,	10.80
Carbon,	19.40
Oxygen,	26.40
Nitrogen,	43.40
	100.00

37. *Picromel* is the characteristic principle of bile.—It resembles inspissated bile. Colour greenish yellow. Taste intensely bitter at first, which is succeeded by an impression of sweetness. It is not affected by an infusion of galls. The salts of iron and subacetate of lead precipitate it from its aqueous solution. By destructive distillation it affords no ammonia; hence nitrogen appears not to be a constituent part of this substance.

38. *Osmazome* is a peculiar substance, extracted from the brain of animals. It is a soft solid brownish yellow substance, of a greasey glutinous feel, and of a brilliant appearance, like satin. It melts on exposure to heat, though it does not become softened like tallow. Its aqueous solutions afford precipitates, with infusion of galls, nitrate of mercury, and nitrate and acetate of lead.

34. *Sugar of milk* is a substance obtained from the whey of milk.

40. It is soluble in five parts of cold, and two and a half of boiling water. It is white, of a sweetish taste, and inodorous. It is insoluble in alcohol and ether; by the addition of a small quantity of sulphuric acid, it may be dissolved in alcohol. It is soluble in acetic and muriatic acids, and absorbs muriatic acid gas, forming a grey powder. It is decomposed by chlorine and solution of

caustic potash. By nitric acid it is converted into saclactic acid. It is decomposed by heat and affords a residuum of charcoal.

41. According to Berzelius, it consists of

Carbon,	45.267
Oxygen,	48.348
Hydrogen,	6.385
	100.000

42. *Sugar of diabetes* is a substance obtained from the urine of diabetic persons. It may be procured by pouring into the urine a solution of *Goulard's extract of lead*, filtering and evaporating the liquid to the consistence of syrup. After some time, it precipitates. The proportions of urine vary at different times from 1-30 to 1-17 of the whole weight. The disease is supposed to be owing, in some measure, to vegetable diet. When heated with nitric acid, it yielded the same proportion of oxalic acid as an equal quantity of common sugar would have done, allowing for the saline substance present.—From experiment, it appears that this substance is not analogous to sugar of milk, but nearer common sugar in its properties. It crystallizes in a similar manner as sugar of grapes.

43. The beautiful pigment, called *Prussian blue*, is obtained commonly from animal matters, such as blood, horns, hoofs, skin, hair, wool, &c.; but it may be formed without the presence of any animal matter, and may likewise be obtained from a variety of vegetables.—When formed from animal substances, they are first charred, then mixed with potash, and the mixture calcined in a covered crucible, the alkali attracts the acid from the coal, and forms with it a *prussiate of potash*, which being mixed in solution with sulphate of iron, for

which the prussic acid has a greater affinity than for the alkali, produces the Prussian blue.

44. The *muscles* consist of bundles of fibres which terminate in a kind of string or ligament, by which they are fastened to the bones. They are the organs of motion; by their power of dilatation and contraction they put into action the bones, which act as levers in all the motions of the body, and form the solid support of its various parts.

45. The muscles are of various degrees of strength or consistence, in different species of animals. The mammiferous tribe seem, in this respect, to occupy an intermediate place between birds and cold blooded animals, such as reptiles and fishes.

46. The muscles of different animals differ very much in their appearance and properties; at least, as articles of food. According to Thouvenal, the flesh of the *ox* contains the greatest quantity of insoluble matter, and leaves the greatest residuum when dried; the flesh of the *calf* is more aqueous and mucous; the land and water *turtle* yields more matter to water, than the muscle of the ox; *snails* yield to water a quantity of matter intermediate between that given by *beef* and *veal*; the muscles of *frogs*, *cray fish*, and *vipers*, agree nearly with snails, in their yielding a quantity of matter to water; but the muscles of fresh water fish, yield a considerably smaller proportion.

47. When meat is boiled, the gelatine, the extractive, and a portion of the salts will be separated, while the coagulated albumen and fibrine will remain in a solid state; hence the flavour and nourishing nature of soups, which is derived from the extractive and gelatine.

48. The flavour of roasted meat is owing to the presence of the gelatine, extractive matter, and salts.

49. The *skin* is that strong thick covering which envelopes the whole external surface of animals. It is formed of two parts, a thin white elastic layer on the outside, called *epidermis*, or *cuticle ;* and a much thicker layer, composed of a great many fibres, closely interwoven, and disposed in different directions, called the *cutis*, or *true skin.*

Note.—The *epidermis* is that part of the skin which is raised in blisters.

50. The cuticle is transparent, as well as porous, through which the mucous membrane, or true skin is seen, which in the European and American is white or brown, and in the negro, black.

51. The extremities of the nerves are spread over the true skin, so that the sensation of feeling is transmitted through the cuticle.

52. The cutis, or true skin, appears to be a peculiar modification of gelatine, calculated to resist the action of water, partly by the compactness of its texture, and partly by the viscidity of the gelatine.

53. It is from the skin or cutis, that leather is formed ; and the goodness of leather, or at least its strength depends, in some measure, on the roughness of the hides. Those easily soluble, as seal skins, afford a weaker leather than those which are more difficultly soluble in water. The process by which the skins of animals are converted into leather, is called *tanning.*

54. The cavities between the muscles and skin are usually filled with fat, which lodges in the cells, and imparts to the external form, in the human figure, that roundness, smoothness and softness, which is so attractive, ornamental and beautiful.

55. Bone is the solid, well known substance which gives firmness and strength to animal bodies. The tex-

ture of bone is sometimes dense, at other times cellular and porous, according to the situation.

56. Bones consist of phosphate of lime, cemented by gelatine, to which it owes its great firmness and solidity.

57. Calcined human bones, according to Berzelius, are composed, in 100 parts, of

Phosphate of lime,	81.9
Fluate of lime,	3
Lime,	10
Phosphate of magnesia,	1.1
Soda,	2
Carbonic acid,	2
	100.0

58. Fourcroy and Vauquelin found the following to be the composition of 100 parts of ox bones.

Solid gelatine,	51
Phosphate of lime,	37.7
Carbonate of lime,	10
Phosphate of magnesia,	1.3
	100.0

According to Berzelius, they are composed, as follows,

Cartilage,	33.3
Phosphate of lime,	55.35
Fluate of lime,	3
Carbonate of lime,	3.85
Phosphate of magnesia,	2.05
Soda,	2.45
	100.00

59. The earthy salts are retained in their respective places, or interstices, by a membranous or cartilaginous substance, which is found to be indurated albumen.

60. The bones of animals acquire a red tinge, in consequence of taking madder with their food. The bones of young pigeons will thus be tinged, of a rose colour, in twenty-four hours, and of a deep scarlet, in three days. The bones most remote from the heart are the longest in acquring this tinge.

61. Bones are of extensive use in the arts. In their natural state, or dyed of various colours, they are made into handles of knives and forks, and numerous other articles. They are also used for the preparation of the volatile alkali, or ammonia, and for making of jelly.

62. Blood is the fluid which first presents itself to observation, when the parts of living animals are divided or destroyed, and which circulates through the veins and the arteries to every part of the body.

33. Recent blood is uniformly fluid, and of a saline taste. Under the microscope, it appears to be composed of a great number of red globules swimming in a transparent fluid. After standing for a short time, its parts separate into a thick red matter, or *crassamentum*, and a fluid, called *serum*.

64. Blood usually consists of about 3 parts serum to 1 of *cruor*.

65. The serum is of a pale greenish yellow colour. Its specific gravity is about 1.029, while that of blood itself is 1.053. It changes syrup of violets to a green, from its containing free soda. At 156° serum coagulates and resembles boiled white of egg. When this coagulated albumen is squeezed, a muddy fluid exudes, which has been called the *serosity*.

66. According to Berzelius, 1000 parts of the serum of bullock's blood consist of

Water	905
Albumen	79.99
Lactate of soda and extractive matter	6.175
Muriate of soda and potash	2.565
Soda and animal matter	1.52
Loss	4.75
	1.000

1000 parts of serum of human blood consist of

Water	905
Albumen	80
Muriate of potas and soda	6
Lactate of soda with animal matter	4
Soda, phosphate of soda with animal matter	4.1
Loss	9
	1000.0

67. There is no gelatine in serum.

68. The cruor has a specific gravity of 1.245. By making a stream of water flow upon it, till the water runs off colourless, it is separated into insoluble fibrine, and the soluble colouring matter. A little albumen has likewise been found in cruor. The proportions of the former two are 64 colouring matter and 36 fibrine in 100.

69. *Urine*, in its natural state, is transparent, of a yellow colour, a peculiar smell and saline taste Its production as to quantity, and in some measure quality, depends on the seasons, and the peculiar constitution of the individual, and is likewise modified by disease. It is observed that prespiration carries off, more or less of the fluid of the body which would otherwise have passed off

by urine; so that a profusion of the former is attended by a diminution of the latter.

70. Urine is composed of the following parts.

Water	1
Urea	2
Phosphoric acid	3
Phosphate of lime	4
———— of magnesia	5
———— of soda	6
———— of ammonia	7
Lithic acid	8
Rosacic acid	9
Benzoic acid	10
Carbonic acid	11
Carbonate of lime	12
Muriate of soda	13
——— of ammonia	14
Gelatine	15
Albumen	16
Resin	17
Sulphur	18

71. The urine undergoes considerable changes by diseases, a knowledge of which is of importance. In inflammatory diseases it is of a red colour, small in quantity and peculiarly acrid, but deposits no sediment on standing. Corrosive muriate of mercury throws down from it a copious precipitate; towards the termination of the disease, it becomes more abundant, and deposits a copious pink coloured sediment consisting of rosacic acid, with a little phosphate of lime and uric acid.

72. In jaundice the urine is of a deep yellow colour, capable of staining linen. Muriatic acid renders it green, and this indicates the presence of bile.

73. In hysterical affections it is copious, limpid and colourless, containing much salt, but scarcely any *urea* or gelatine.

74. In dropsy the urine is generally loaded with albumen, so as to become milky, or even to coagulate by heat, or on the addition of acids.

75. In dropsy from *diseased liver* no albumen is present, but the urine is scanty high coloured, and deposits the pink coloured sediment.

76. In dyspepsy or indigestion, the urine abounds in gelatine, and putrefies rapidly.

77. In rickets the urine contains a great quantity of calcareous salt, which is found to be the oxalate of lime.

78. In diabetic patients, the urine is sometimes so loaded with sugar as to be capable of being fermented into a vinous liquor. Sometimes, however, the urine is not sweet, but insipid.

79. Urine has been employed for making phosphorus, volatile alkali and sal-ammoniac. It is used in a putrid state for scouring woolens.

80. Tears compose that peculiar fluid which is appropriated to lubricating the eye, and which is emitted in considerable quantities when we express grief by weeping.

81. This liquid is transparent and colourless like water; it has scarcely any smell, but its taste is always perceptibly salt. Its specific gravity is somewhat greater than that of distilled water. It gives to paper stained with the juice of violets, a permanently green colour, hence we infer the presence of a fixed alkali. It unites with water, whether cold or hot, in all proportions. Alkalies unite with it readily and render it more fluid. The mineral acids produce no apparent change upon it. Ex-

posed to the air, it gradually evaporates and becomes thick.

82. Tears are composed of 1 Water,
2 Mucus,
3 Muriate of soda,
4 Soda.
5 Phosphate of lime,
6 Phosphate of soda.

The saline parts of tears amount only to about 0.01 of the whole.

83. *Bile* is a bitter liquid of a yellowish or greenish yellow colour, more or less viscid. Specific gravity greater than that of water, common to a great number of animals, the peculiar secretion of their liver. It is the prevailing opinion of physiologists, that the bile is separated from the venous, and not from the arterial blood. The veins which receive the blood distributed to the abdominal viscera, unite into a large trunk called the *vena porta*, which divides into two branches, that penetrate into the liver, and divide into innumerable ramifications. The last of these terminate partly in the biliary ducts, and partly in the hepatic veins, which restore to the circulation that portion of blood which is not necessary for the formation of bile. This liquid passes directly into the duodenum, when the animal has no gall-bladder; but when it has one, as more frequently happens, the bile flows back into it by the cistic duct, and remaining there for a longer or shorter time, experiences remarkable alterations. Its principal use seems to be, in promoting digestion, in concert with pancreatic juice.

84. Ox bile is usually of a greenish yellow colour, rarely deep green. It is at once very bitter and slightly sweet. Its taste is scarcely supportable. Its smell,

though feeble, is easily recognizable, and approaches somewhat to the nauseous odour of some fatty matters when they are heated.

Its specific gravity is about 1.026 at 43° F.

Ox bile is composed of

Water	7.00
Resinous matter	05
Picromel	69.00
Yellow matter	4.00
Soda	4.00
Phosphate of soda	2.00
Muriate of soda	3.5
Sulphate of soda	0.8
Phosphate of lime	1 2
Oxide of iron a trace	
	93.0

86. *Brain* is a soft pulpy substance, with little or no smell. Exposed to a gentle heat, moisture evaporates, it shrinks to about a fourth of its original bulk, and becomes a tenacious mass of a greenish brown colour; when completely dried, it becomes solid and friable like old cheese. In its natural state, or moderately dried, it readily forms an emulsion by trituration with water, and is not separated by filtration. This solution lathers like soap suds, but does not turn blue vegetable infusions green.

87. Its constituents, according to Vauquelin, are, in 100 parts,

Water	80
White fatty matter	4.53
Reddish fatty do.	0.7
Albumen	7.0
Osmazome	1.12

Phosphorus	1.5
Acids, salts and sulphur	5.15
	100.00

88. The *medulla oblongata* and nerves have the same chemical composition as the brain.

89. *Gastric Juice* is separated by glands placed between the membranes which line the stomach ; and from these it is emitted into the stomach itself. It reduces the aliment into a uniform mass, even when out of the body. It acts in the same manner on the stomach after death ; which proves that the action is chemical, and not dependent on vitality.

90. The gastric juice affects the solution of aliments included in tubes of metal, consequently defended from any trituration.

91. Though there is no trituration in *membraneous* stomachs, this action powerfully assists the effect of the digestive powers in animals with muscular ones, such as fowls.

92. The gastric juice acts by its solvent power, and not as a ferment This appears evident from there not being any disengagement of air in ordinary digestion ; neither is there any inflation, or increase of heat, nor any other of the ordinary phenomena of fermentation.

PRACTICAL QUESTIONS.

What is animalization ?

How may animals as well as vegetables be considered ?

Can the animal process be compared with that of the chemical ?

To what do you compare the process in the stomach ?

What kind of apparatus do the bowels constitute?

How are organized bodies contrived?

Do animals agree with vegetables in their composition?

What do animal substances afford by distillation?

What are the fundamental principles of animal compounds?

From what cause arises the difficulty of analizing animal substances?

What are the peculiar products of animal organization?

What is gelatine?

What are its properties?

From what is leather produced?

From what is glue obtained?

From what size?

What is isinglass?

From what can gelatine be obtained?

From what is ammonia obtained?

How can gelatine be separated from its solution?

Of what is gelatine composed?

What is albumen?

What are its properties?

How can solid albumen be obtained?

What are the properties of solid albumen?

What is fibrine?

How can it be obtained?

What are its peculiar properties?

Of what is it composed?

What is caseous matter?

On what does the nature and flavour of cheese depend?

How do you obtain the colouring matter of blood?

What are its characteristics?

What is the buffy coat of inflamed blood?

How do you distinguish mucus from gelatine and albumen?

What is Urea; and what are its properties?

Of what is it composed?

What is Picromel?

What is osmazome?

What are its properties?

What is sugar of milk?

Of what does it consist?

What is sugar of diabetes?

From what is prussian blue obtained?

Of what do muscles consist?

Whence does roasted meat derive its flavor?

Of what is skin formed?

How is the sensation of feeling transmitted through the cuticle?

With what are the cavities between the muscles and the skin filled?

What is bone?

To what do bones owe their great firmness and solidity?

Of what are calcined human bones composed?

Of what do ox-bones consist?

Of what is that composed which appears to retain the earthy salts in their places?

What is the consequence of giving madder to animals in their food?

Are bones of any use in the arts?

What is blood?

What appearance has recent blood?

Of what does blood consist?

What are the properties of serum?

Of what does it consist?

What is said of cruor?

What are the properties of urine?

Of what is it composed?

Does urine undergo any change by disease?

How is it in jaundice?

How in hysterical affections?

How in dropsy?

How in dyspepsia?

How in rickets?

How in diabetic patients?

Is urine employed in the arts?

What are the properties of tears?

Of what are tears composed?

What are the properties of bile?

What are the properties of ox-bile?

Of what is it composed?

What is brain?

Of what is it composed?

What is the gastric juice and its office?

Does the gastric juice act by its solvent powers or by trituration?

How do you prove that this action is not by fermentation?

CHAP. XXXVIII.

Of Respiration.

1. Respiration is a function in animals which consists in the alternate inhalation of a portion of air into an organ called the lungs, and its subsequent exhalation.

2. In order to form any determinate opinion of the phenomena of respiration, there are two things to be considered in the first place, viz. the *mechanical* and the *chemical* part of the process.

3. The mechanism of breathing depends on the alternate expansions and contractions of the chest. When the chest dilates, the cavity enlarges, and the air rushes in at the mouth,to fill up the vacuum formed by this dilatation, when it contracts, the cavity is diminished and the air again forced out.

4. The lungs likewise contract and expand in breathing, in consequence of that of the chest. The lungs, together with the breast and largest blood vessels, in a manner fill up the cavity of the chest; it must therefore previously expand in order for the dilatation of these organs. When it contracts, it presses on the lungs and forces the air out of them, in a manner similar to bellows.

5. The chest is a large cavity in the upper part of the body, contained within the ribs, the neck and the diaphragm.

6. The diaphragm is that membrane which separates the chest from the lower part of the body, which is muscular and capable of great dilatation and contraction. When this contracts the space within the chest is diminished, and of course the air is pressed out from the lungs. On the other hand, when the membrane dilates, the cavity is enlarged, and the external air rushes in to keep up the equilibrium, so that as long as this action of the diaphragm continues, respiration is carried on.

7. Besides the motion of the diaphragm, there is also a muscular motion of the ribs, which contribute towards enlarging or diminishing the cavity of the chest. These are alternately drawn edgewise to assist the contraction,

and stretched out like hoops of a barrel, to contribute to the dilatation of the chest.

8. These two muscular contractions, viz. of the diaphragm and the ribs, are to be considered as the causes of the contraction and expansion of the chest ; and the air rushing into and being expelled from the lungs, is only the effects of those actions.

Illustration. Open the mouth without any action of the chest, the air will not rush in until by an interior muscular action, a vacuum be produced.

9. In general, this alternate action of dilatation and contraction, in a healthy person, is between fifteen and twenty times in a minute.

10. Previously to our proceeding to the chemical effects of respiration, it is necessary that we should understand the theory of the circulation of the blood.

11. In the system there are two kinds of blood vessels, the *veins* and *arteries*, each possessed of peculiar functions.

12. The arteries convey the blood from the heart to the extremities of the body ; and the veins bring it back to the heart.

13. The heart is a muscular cavity, which possesses a power of dilating and contracting itself, for the purpose of alternately receiving and expelling the blood, in order to carry on the process of circulation.

14. The blood in the arteries is of a beautiful red colour, but when it passes into the veins it becomes purple. This change depends upon various circumstances. In the first place, the blood, during its passage through the arteries undergoes a considerable alteration, some of its constituent parts are gradually separated from it, for the purpose of nourishing the body, and of supplying the various secretions. Consequently, the florid arterial col-

our of the blood changes by degrees to a deep purple, which is its constant colour in the veins. During the return of the blood through the veins, it is renewed by fresh chyle or imperfect blood, which has been produced by food. It receives also lymph from the absorbant vessels. In consequence of these several changes, the blood returns to the heart in a state different from that in which it left it. It is charged with a greater proportion of hydrogen and carbon, and is no longer fit for the nourishment of the body, or other purposes of circulation.

15. The heart is divided into two cavities, called the right and left *ventricles.* The left ventricle is the receptacle for the pure arterial blood, previously to its circulation ; whilst the venous or impure blood, which returns to the heart, after having circulated, is received into the right ventricle, previously to its purification.

16. As the blood conveys nourishment to the body in the course of circulation, there must be some process by which it can be supplied with the means of imparting this nourishment ; this is by respiration, or the chemical part of it.

17. When the venous blood enters the right ventricle of the heart, this organ contracts by its muscular power and throws the blood through a large vessel, called the *pulmonary artery*, into the lungs, which are contiguous, and through which it circulates by innumerable small branches. It is here brought in contact with the air which we breathe.

18. The venous blood which enters the lungs from the pulmonary artery, is charged with carbon, to which it owes its dark purple colour. When the oxygen of the atmosphere is applied to the interior of the air vesicles of the lungs, it combines with the carbon of the blood,

forms carbonic acid, which, to the amount of from 4.5 to 8 per cent of the bulk of the air inspired is immediately exhaled.

19. It does not appear that any oxygen or nitrogen, the two constituents of the atmosphere, are absorbed by the lungs during respiration ; for the volume of carbonic acid generated, is exactly equal to that of the oxygen which disappears ; now we know that carbonic acid contains its own volume of oxygen.

20. The change of the blood from the purple venous to the bright red arterial, seems owing to the discharge of the carbon, with which it is impregnated during the circulation, in consequence of its affinity for oxygen.

21. An ordinary sized man, in health, consumes about forty-six thousand cubic inches of oxygen in a day, which is equal to one hundred and twenty-five cubic feet of atmospheric air. The same quantity of carbonic acid is expelled.

22. About twenty respirations are made in a minute, or, a man breathes twice for every seven *pulsations.*

23. It has been found that after swallowing intoxicating liquors, the quantity of carbonic acid formed in respiration was diminished. The same thing is said to happen under a course of mercury, nitric acid, or vegetable diet.

24. Carbon appears to exist in a greater proportion in blood, than in any other organized animal matter.—By this means, the blood, after supplying its various secretions, becomes loaded with an excess of carbon, which is carried off by respiration ; and the formation of new chyle from the food, affords a constant supply of carbonaceous matter.

PRACTICAL QUESTIONS.

What is respiration ?

What is necessary in order to form a correct opinion of respiration ?

On what does the mechanism of breathing depend ?

Is the expansion and contraction of the chest in consequence of that of the lungs ?

What is the chest ?

What is the diaphragm ?

What office does it perform ?

What office do the ribs perform ?

How are these muscular contractions of the diaphragm and ribs to be considered ?

How do you illustrate this ?

How often is this alternate dilatation and contraction ?

How many kinds of blood vessels are there ?

What are their offices ?

What is the heart ?

How is the blood in the veins and arteries, what are the changes produced, and the causes of those changes ?

How is the heart divided ?

What is the process by which the blood can be supplied with the means of affording nourishment to the system ?

How is the blood brought in contact with the air which we breathe ?

To what does the blood owe its purple colour ?

Is oxygen or nitrogen absorbed by the lungs ?

To what is the change of the blood from the purple to the red arterial owing ?

How much oxygen do we consume in a day ?

How many respirations are made in a minute ?

How is the quantity of carbonic acid diminished in respiration ?

How is it that the blood acquires such a quantity of carbon ?

CHAP. XXXVIII.

On Animal Heat, &c.

1. During respiration, heat is disengaged. It has been calculated that the heat produced by respiration in twelve hours, in the lungs of a person in health, is such, as would melt about one hundred pounds of ice.

2. Venous blood has been found by experiment to have less capacity for heat than arterial blood ; and the blood in passing from the arterial to the venous state during circulation, parts with a portion of caloric, by means of which, heat is diffused through every part of the body.

3. The heat of animals is various, according to the variety of species of animals, the difference of seasons and climates, and the state of the same animal, at different periods.

4. Animals have been very properly divided into hot and cold blooded animals ; reckoning those to be hot which are near our own temperature ; and all others cold, whose heat is much below ours, or which give us the sensation of cold ; such as most insects. Though the heat of a swarm of bees raised a thermometer to 97°, indicating a degree of heat but little, if any inferior to our own. To this class, belong muscles and oysters, snails, frogs, serpents, &c.

5. The human kind forms the lowest gradation in the class of hot animals; the mean heat of the human body as deduced from a variety of experiments, is about 97°.

6. With respect to quadrupeds, the heat of their bodies will raise the thermometer three or four degrees higher than those of the human kind; and the bodies of birds are still warmer.

7. It appears from a variety of experiments and observations, that those animals which are furnished with lungs, and which continually receive the fresh air in great quantities, have a power of keeping themselves at a temperature considerably higher than the surrounding atmosphere; but animals that are not furnished with respiratory organs, are very nearly at the same temperature with the medium in which they live.

8. Among the hot animals, those are the warmest which have the largest respiratory organs; consequently breathe the greatest quantity of air in proportion to their bulk.

Illustration. The respiratory organs of birds are greater, in proportion to their bulk, than those of any other animals; and birds are known to have the greatest degree of animal heat.

9. From observations and experiments made by Dr. Crawford, it appears that the production of animal heat depends on a process analogous to chemical affinity, and which is on the following principles. Oxygen gas contains more specific heat in proportion to its temperature and weight, than carbonic acid gas. The blood is returned to the lungs impregnated with the carbonaceous principle, but has less attraction for that principle than oxygen has. In the lungs, therefore, the carbon quits the blood to unite with the oxygen which is inhaled from the atmosphere. By this combination, the oxygen

gas is changed into the carbonic acid gas, and deposits part of its heat. The capacity of blood for heat is, at the same time, increased ; the blood, therefore, receiving that portion of heat which was detached from the air.

10. The arterial blood in its passage through the capillary vessels, is again impregnated with the carbon and the hydrogen, by which its capacity for heat declines ; it, therefore, in the course of the circulation, gradually gives out the heat which it had received in the lungs, and diffuses it over the whole body. Thus it appears, that in its circulation through the lungs, the blood is continually discharging carbon and absorbing heat, and that in its passage through the other parts of the body, it is imbibing carbon and emitting heat.

11. By the different capacities which blood possesses for heat in its different states, it is capable of supplying the different parts of the body with warmth, while its own temperature remains the same.

12. If this difference of capacity for caloric did not exist, the extremities of the body could not be properly supplied with heat from the lungs, unless the lungs themselves were exposed to a degree of heat, which would be prejudicial, and perhaps such as no organized being could support, without destruction.

13. It has been proved, by a variety of experiments, that when an animal is placed in a cold medium, the venous blood acquires a deeper hue, that a greater quantity of air is vitiated in a given time, consequently that more heat is absorbed by the blood.

14. Perspiration prevents an accumulation of heat in the system beyond what is salutary ; if this be stopped, the heat increases. This is probably the principal cause of heat in fevers, the pores being closed there is no vent

for the heat which is generated, which occasions those burning sensations.

15. One of the most considerable secretions is insensible perspiration; this is constantly conveying from the body heat in its latent state.

16. In violent exercise, the caloric is increased, but in a healthy person, it is carried off by the perspiration which succeeds.

17. In consequence of the economy of perspiration, persons are enabled in all climates, and in all seasons, to preserve their bodies of an equal temperature, that is with regard to the blood and the internal parts of the body; for those parts of the body which are in immediate contact with the atmosphere will occasionally become warmer or colder, than the internal or more sheltered parts. But if the ball of a thermometer be applied under the tongue, it will be found to indicate scarcely any difference in the state of the blood, whatever may be the changes in the atmosphere.

Illustration. Persons have been known to remain some minutes in a heat little inferior to that of boiling water, without increasing in any great degree the internal heat of the system. In some instances, the heat has been much greater than boiling water.

PRACTICAL QUESTIONS.

Is any heat disengaged during respiration?

Has venous and arterial blood the same capacity for heat?

How is heat diffused through every part of the body?

Is the heat of animals the same at all times?

With regard to heat, how have animals been divided?

What gradation do the human kind form in the class of hot animals?

How is it with regard to quadrupeds ?

What animals have the power of keeping their temperature above that of the atmosphere ?

What animals are the warmest ?

What is Dr. Crawford's theory of animal heat ?

What office does the arterial blood perform ?

How does the blood supply the different parts of the body with heat while its temperature remains the same ?

What is the effect of placing an animal in a cold medium ?

What prevents a too great accumulation of heat in the system ?

What is the cause of heat in fevers ?

What is one of the most important secretions ?

Violent exercise increases heat ; does it not cause fever ?

How is it that persons in all climates and seasons are capable of preserving an equality of temperature ?

A

DICTIONARY OF TERMS.

A.

Absorption, the conversion of a gaseous fluid into a liquid, or solid, on being united to another substance.

Abstraction, a term used to denote when an acid or other fluid is repeatedly poured upon any substance and distilled off, with a view to change the state or composition.

Acerates, salts formed by the union of aceric acid with a base.

Aceric acid, a substance obtained from the juice of the maple, having acid properties.

Acescent, a term applied to those substances which become sour spontaneously.

Acetates, substances formed by the union of acetic acid with salifiable bases.

Acetic acid, concentrated vinegar.

Acetous, of, or belonging to vinegar.

Acid, a substance, which, when united with alkalies, earths and metallic oxides, forms salts.

Acidifiable, capable of being converted into an acid.

Acidules, a term applied by the French chemists to those salts which we denominate by the term *bi*, or *super*.

Adhesion. See cohesion.

Adopter, a vessel with two necks placed between a retort and receiver, to increase the length of the former.

Aerial acid. Carbonic acid.

Aerometer, an instrument for ascertaining the mean bulk of the gases.

Affinity. See attraction.

Agaricus, the mushroom, a genus of the order *Fungi.*

Agaricus mineralis, one of the purest species of carbonate of lime.

Aggregate. When two bodies are united together, the mass is called an aggregate, and preserves the chemical properties of its constituents.

Air, the permanently elastic fluid which surrounds the globe; the term is now exclusively confined to the atmosphere; that of gas to other invisible and elastic fluids.

Alabaster, sulphate of lime.

Albumen, the white of egg, and one of the constituent principles of all animal solids.

Alburnum, the inner white bark of trees.

Alcohol, a term applied to pure spirit.

Alembic, a still.

Alkahest, the pretended universal solvent of the ancients.

Alkali, a term derived from the word *kali*, the Arabic name of a plant, from the ashes of which, one species of alkaline substances may be obtained.

Alkalescent, any substance in which alkaline properties are beginning to be developed.

Alloy. When an inferior metal is added to a precious one, the part added is called the alloy. Thus when copper is added to gold, the former is the alloy.

Aludel, a vessel used in sublimation.

Alum. Sulphate of alumina.

Alumina, one of the primitive earths, constituting the plastic principle of all clays, loams, &c.

Acetate of alumina, a combination of acetic acid with a salifiable base.

Amalgam, a combination of mercury with other metallic substances.

Amber, a hard, brittle, tasteless substance, sometimes perfectly transparent, but mostly semi-transparent, or opaque, and of a glossy surface. It is chiefly of a yellow or orange colour.

Ammonia, volatile alkali, a substance prepared from animal matter ; its constituents are hydrogen and nitrogen. When pure, it is an invisible gas, having a very pungent odour.

Analysis, the art of separating the constituents of bodies, so as to discover their properties.

Anhydrous, a term applied to salts when destitute of water.

Antimony, a word used in commerce, to denote a metallic ore, consisting of sulphur combined with the metal. The latter is properly called metal by chemists.

Apyrous. Bodies which sustain the action of a strong heat for a length of time, without change of figure or other properties, have been called *apyrous*, or refractory.

Aqna fortis, a name given to an impure and weak nitric acid, commonly used in the arts.

Aqua regia, so named from its property of dissolving gold, now called nitro-muriatic acid.

Aqua vitae. Spirit of the first distillation ; the distillers call it, *low wines*.

Archil, a species of moss growing upon rocks in the Cape Verd and Canary Islands, of which a rich purple tincture is made.

Aromatics, plants which possess a fragrant smell, united with pungency, and at the same time are warm to the taste, are aromatics.

Arsenic, a metal of a bluish white colour, subject to tarnish, and turns first yellowish, then black, on exposure to the air. It sublimes in close vessels, and burns with a small flame, if oxygen be present.

Athanor, a furnace used by ancient chemists; now fallen into disuse.

Atmometer, an instrument to measure the degree of exhalation from a humid surface in a given time.

Atmosphere, the invisible elastic fluid which surrounds the earth.

Atropa, a poisonous vegetable principle, probably alkaline, lately extracted from the *Atropa Belladonna*, or deadly night shade.

Attraction, the tendency which bodies possess to approach each other.

Aurum Musivum, a combination of tin and sulphur, the bi-sulphuret of tin.

Azote. Nitrogen gas.

B.

Balloon, a glass receiver of a spherical form.

Balsams, substances of a resinous nature, which spontaneously become concrete, and are capable of affording benzoic acid when heated alone, or with water.

Balsam of sulphur, a solution of sulphur in oil.

Baldwin's phosphorus, ignited nitrate of lime.

Barium, the metallic basis of the earth barytes.

Barilla, a term given in commerce to the impure soda, imported from Spain and the Levant.

Barolite. Carbonate of barytes.

Base, or *basis*, a chemical term usually applied to alkalies, earths and metallic oxides, in their relation to acids and salts. It is sometimes also applied to the particular constituents of an acid or an oxide, on the supposition that the substance combined with the oxygen, &c. is the basis of the compound to which it owes its particular qualities.

Bath, a vessel partly filled with sand, water, or some other substance, in order to produce a uniform heat to retorts and other glass vessels, in some operations.

Beer, a liquor made of malt and hops.

Bell metal, a composition of tin and copper.

Benzoic acid, an acid obtained from Benzoin.

Bi, a term used to express an excess of some ingredient in many chemical compositions.

Bile, a bitter liquid of a yellowish colour, the peculiar secretion of the liver of some animals.

Bismuth, a metal of a yellowish or reddish white colour, little subject to change in the air; somewhat harder than lead, and very little malleable.

Bistre, a brown pigment consisting of the finer parts of wood soot, separated from the grosser by washing.

Bittern, the water which remains after the crystallization of common salt in sea water, or the water of salt springs. It abounds with sulphate and muriate of lime.

Bitumen, this term includes a number of inflammable mineral substances burning with flame in the open air, such as Naphtha, Petroleum, Barbadoes tar, &c.

Black Jack, an ore of zinc.

Black Lead, Plumbago.

Black Wadd, an ore of manganese.

Bleaching, a chemical art by which the various articles used for clothing are deprived of their natural dark colour, and rendered white.

Blende, an ore of zinc.

Boron, the combustible basis of boracic acid.

Brandy, a spirit distilled from wine.

Brass, a compound metal consisting of copper combined with about one third of its weight of zinc.

Brimstone. Sulphur.

Bronze, a mixed metal, consisting chiefly of copper, with a small proportion of tin, and sometimes other metals.

Brucine, a new vegetable alkali, lately extracted from the bark of the false angustura. *Brycea antidysenterica.*

Brunswick green, an ammoniaco-muriate of copper, used as a pigment.

Butters of the metals, now called chlorides.

C.

Cadmium, a new metal, discovered in 1817, in a carbonate of zinc; and the *silicates* of zinc. The name was formerly applied to zinc.

Caffein, a name given to a substance obtained from unroasted coffee.

Cajeput oil, a volatile oil obtained from the leaves of the cajeput tree.

Calamine, a native carbonate of zinc.

Calcareous, partaking of the nature of lime.

Calcareous spar, crystallized carbonate of lime.

Calcination. The fixed residues of such matters as have undergone combustion, are called *cinders* in common language, and *calces* or oxides, by chemists; the operation when considered with regard to these, calcination.

Calcium, the metallic basis of lime.

Calculus, a name usually given to all hard concretions not partaking of bone, formed in the bodies of animals.

Caloric, the matter of heat, or the agent to which the phenomena of heat and combustion are applied.

Calorimeter. An instrument contrived to measure the heat given out from bodies in cooling, from the quantity of ice it melts.

Cameleon Mineral. When pure potash and black oxide of manganese are fused together in a crucible, a compound is obtained, whose solution in water,at first green, passes spontaneously through the whole series of coloured rays to the red; from this cirumstance the name *cameleon* has been given to it.

Carbon, the pure inflammable part of charcoal, or the diamond.

Carbonates, compounds of carbonic acid with salifiable bases.

Carburets, compounds of carbon with any other substance, as carburet of iron, steel.

Carmine, a red pigment prepared from cochineal.

Caromel. The smell exhaled from burnt sugar.

Case hardening, when the surface of iron is converted to steel by being inclosed in a box with animal or vegetable charcoal, and subjected to the heat of a forge.

Causticity, the power which some bodies possess to combine with the principle of organized substances, so rapidly as to destroy the parts.

Cement. Whatever is employed to unite things of the same, or of different kinds; as lute, glue, solder, &c.

Cementation, a chemical process which consists in surrounding a body in the solid state, with the powder of some other bodies, and exposing the whole for a time in a closed vessel, to a degree of heat not sufficient to fuse the contents.

Cerasin, a name given to the gummy substances which swell in cold water, but do not readily dissolve in it.

Cerin, a peculiar substance which precipitates on evaporation from alcohol, which has been digested on grated cork. The term is also applied to common wax which dissolves in alcohol.

Cerium, the name of a metal found in *cerite*, a mineral of Sweden.

Ceruse. Subcarbonate of lead.

Cetine. Spermaceti.

Chalk. Carbonate of lime.

Charcoal, the residuum of vegetable substances burnt in close vessels.

Chlorates, compounds of the chloric acid with salifiable bases.

Chlorides, compounds of chlorine with combustible bodies.

Chlorine, a simple substance, the base of what was formerly called oxymuriatic acid gas.

Chlorophyle, the green matter of the leaves of plants.

Chromium, the name of a metal extracted from the native chromate of lead or iron.

Cinchonin, a substance obtained from cinchona or the *peruvian bark.*

Cinnabar. Mercury united to sulphur.

Cistic oxide, a variety of urinary calculi.

Citric acid, the acid obtained from limes and lemons.

Clarification. The process of freeing a fluid from heterogeneous matters.

Clay, a plastic substance whose basis is alumina.

Coake, the residuum of the combustion of coals in close vessels.

Coal, an inflammable mineral substance well known.

Coal-gas. Carburetted hydrogen.

Coating, a substance applied to the bottom of retorts to defend them from the too great action of heat.

Cobalt, a brittle, somewhat soft, but difficultly fusible metal of a reddish grey colour and of little lustre; so called from *Cobalus*, the demon of mines.

Cochenilin, the red colouring matter of cocheneal.

Cohesion, that power by which the particles of bodies are held together.

Cohobation, redistillation of the same liquid from the same materials.

Colcothar. The brown red oxide of iron, which remains after distilling the acid from sulphate of iron.

Cold. The privation of heat.

Columbium, a metal of a dark grey colour, resembling in lustre iron.

Combination. The intimate union of the particles of different substances by chemical attraction, so as to form a compound possessed of new and peculiar properties.

Combustible, a body which in its rapid union with others, causes a disengagement of heat and light.

Combustion. The disengagement of heat and light which accompanies chemical combinations.

Congelation, the abstraction of heat from bodies, in such quantities as to cause them to assume solid forms.

Copper, a metal of a peculiar reddish brown colour, hard, sonorous, very malleable and ductile, and of considerable tenacity.

Copperas. Sulphate of iron.

Corrosive sublimate, perchloride of mercury.

Cream of tartar, bitartrate of potash.

Crocus Martis. The reddish yellow oxide of iron.

Cyrophorus, an instrument invented to demonstrate the relation between evaporation at low temperatures, and the production of cold.

Crystal, a regular geometrical figure, formed when fluid substances are suffered to pass with adequate slowness to the solid state.

Cupel, a shallow earthen vessel resembling a cup, made of bone ashes and used in assaying.

Cupellation. The refining of gold by scorification with lead on a cupel.

Cyanogen. The compound base of prussic acid. Now called *Prussine*.

D.

Daphnin, the bitter principle of *Daphne Alpina*.

Datura, a vegetable alkali obtained from *Datura Stramonium*.

Decantation, the act of pouring off the clear liquor from a precipitate or sediment.

Decoction, the operation of boiling. The term is also used to denote the product of the operation itself.

Decomposition, the separating of the component parts or principles of a substance.

Decrepitation. The crackling noise which several salts make when suddenly heated, accompanied with a violent exfoliation of their particles.

Delphinia, a vegetable alkali dicovered in *Stavesacre*.

Deliquescence, the spontaneous assumption of the fluid state by certain saline substances when left exposed to the air, in consequence of their affinity for water.

Dephlegmation, any method by which bodies are deprived of water.

Dephlogisticated, deprived of phlogistion or the inflammable principle.

Dephlogisticated air. The same with oxygen gas.

Derbyshire spar, fluate of lime.

Destructive Distillation, is when a substance is exposed to distillation, until it has undergone the whole power of the furnace.

Detonation, a sudden combustion and explosion.

Dew, the moisture insensibly deposited on the surface of the earth, from the atmosphere.

Digestion, the slow action of a solvent upon any substance.

Digestive salt, muriate of potash.

Digester, a vessel invented to prevent the loss of heat by evaporation; by which the solvent power of water is greatly increased.

Distillation. The vaporization and subsequent condensation of a liquid, by means of an alembic, or still and refrigeratory; or of a retort and receiver.

Docimastic Art, the art of assaying metals.

Dragon's blood, a brittle dark coloured resin, imported from the East Indies.

Ductility, that property or texture of bodies, which renders them capable of being drawn out in length, while their thickness is diminished; this term is almost exclusively applied to metals.

Dyeing, the art of fixing upon cloth of various kinds any colour, in such a manner as that they shall not be easily altered by those agents to which the cloth maybe exposed.

E.

Edulcoration. The purification of a substance by washing with water.

Effervescence,the commotion produced in fluids by some part of the mass suddenly taking the elastic form and escaping in numerous bubbles.

Efflorescence, the effect which takes place when bodies spontaneously become converted into a dry powder. It is almost always occasioned by the loss of the water of crystallization in saline bodies.

Elain, the only principle of solid fats.

Electricity, so named from electron amber, a simple substance supposed to pervade all nature.

Eliquation, an operation whereby one substance is separated from another by fusion.

Elutriation, the process of washing, by which the lighter parts are carried off, while the heavier metallic ones subside to the bottom.

Emetin, a substance prepared from ipecacuanha root.

Emulsion, an imperfect combination of oil and water.

Empyreuma, a peculiar disagreeable smell arising from the burning of animal matters in close vessels.

Epidermis, when used with respect to animals, the scarf skin, with respect to vegetables the external covering of the bark.

Epsom salt. Sulphate of magnesia.

Equivalents, a term used to express the system of atoms or definite proportions.

Essences. Solutions of volatile oils in alcohol.

Ether, a very volatile fluid produced by the distillation of alcohol with an acid.

Ethiops mineral. Protosulphuret of mercury.

Evaporation, a chemical operation usually performed by applying heat to any compound substance in order to dispel the volatile parts.

Extract, is a term used to denote the substance of the consistence of a paste, obtained by decoction of some vegetable substance.

F.

Fecula. Starch.

Fermentation, an internal motion in fluids by which they undergo spontaneous changes ; and carbonic acid is disengaged.

Ferrocyanates, combinations of ferroprussic acid with salifiable basis

Ferruretted Chyazic Acid, ferroprussic acid.

Fribrin, a peculiar organic compound found both in vegetables and animals.

Filtration, an operation by means of which a fluid is mechanically separated from particles mixed with it.

Firedamp, carburetted hydrogen.

Fixed air, carbonic acid gas.

Fixity, the property by which bodies resist the action of heat, so as not to rise in vapour.

Flake white, the oxide of bismuth.

Flowers, an old term used to signify all those bodies that have received a pulverulent form by sublimation.

Fluates, compounds of the salifiable bases with fluoric acid.

Fluidity, the state of bodies when their parts are very readily moveable in all directions with respect to each other

Fluoborates, compounds of the fluoboric acid with the salifiable bases.

Fluor, fluate of lime, or Derbyshire spar.

Fluorine, the radicle of the fluoric acid.

Flux, a substance, or mixture added to assist the fusion of metals.

Formiates, compounds of the formic acid with salifiable bases.

Fuligenous. Vapours which possess the quantity of smoke.

Fulmination. Thundering or explosion with noise.

Fungates, compounds of the fungic acid with salifiable bases.

Fungin, a substance obtained from mushrooms.

Fusibility, that property by which bodies attain the fluid state.

Fusion, the act of fusion; also the state of a fused body.

G.

Galena, the black ore of lead.

Gall of animals. Bile.

Gallates. Salts formed by the combination of any base with gallic acid.

Galls, the protuberances formed by the puncture of an insect on plants and trees of different kinds.

Galvanism, the chemical action of bodies on each other. It is a method of exciting electricity or disturbing the equilibrium of the electrical fluid.

Gamboge, a concrete vegetable juice, partly of a gummy and partly of a resinous nature.

Gangue, the stones which fill the cavities, that form the veins of metals, are called the gangue, or matrix of the ore.

Gas, a name given to all permanently elastic fluids, simple or compound, except the atmosphere, to which term air is appropriated.

Gelatine, a chemical term for animal jelly.

Geology, a description of the structure of the earth.

Glauber's salt. Sulphate of soda.

Glimmer, a name occasionally applied to micacious earths.

Glucina, one of the ten substances known by the name of earths.

Gluten, a vegetable substance somewhat similar to animal gelatine.

Gold, the most precious of all metals, of a yellow colour, specific gravity 19.3.

Goulard's Extract, a saturated solution of subacetate of lead.

Granulation, the operation of pouring a melted metal into water, in order to divide it into small particles for chemical purposes

Gravity, that property by which bodies move towards each other in proportion to their respective quantities of matter.

Gum, the mucilage of vegetables.

Gum Elastic. Caoutchouc.

Gunpowder, a substance well known, it consists of 75 parts by weight of nitre, 16 of charcoal and 8 of sulphur, intimately mixed together.

H.

Heat. Caloric.

Hematin, the colouring principle of logwood.

Hepar Sulphuris, a name given to alkaline and earthy sulphurets, from their liver brown colour.

Hepatic gas, an old name for sulphuretted hydrogen.

Hermetically, a term applied to the closing of the orifice of a glass tube, so as to render it air tight.

Hydrogen, one of the constituent parts of water.

Hydrocarbonates, combinations of carbon with hydrogen.

Hyperoxygenized, a term formerly applied to substances which are charged with the largest quantity of oxygen.

J. & I.

Jargon, see zircon.

Icthyocolla. Fish glue, or isinglass.

Ice. The natural state of water, or water in its crystallized form.

Incineration, the burning of vegetables for their ashes.

Indigo, a blue colouring matter, extracted from a plant called *Anil*.

Indigo-gene, the colouring principle of indigo.

Ink, a liquid used for writing or printing.

Insolation, a term sometimes used to denote that exposure to the sun, which is made in order to promote the chemical union of one substance with another.

Intermediates, a term used when speaking of chemica affinity.

Iodine, an undecompounded principle.

Irridium, a metal found in the ore of platinum.

Iron, a metal well known, of a bluish white colour, of considerable hardness and elasticity.

Isinglass, ichthyocolla, almost entirely composed of gelatine.

K.

Kali, a genus of marine plants, which is burnt to procure mineral alkali, by lixiviating the ashes.

Kaolin, the Chinese name for porcelain clay.

L.

Laboratory, a place fitted up for the performance of chemical operations.

Lactates, compounds of lactic acid with salifiable bases.

Lacquer, solution of lac in alcohol.

Lake, a species of colour formed by precipitating colouring matter with some earth or oxide.

Lead, a white metal of a bluish tinge, very soft and flexible, not very tenacious, and incapable of being drawn into fine wire, though it is easily extended into thin plates.

Lens, a glass convex on both sides for concentrating the rays of the sun.

Levigation, the mechanical process of grinding the parts of bodies to a fine paste, by rubbing the flat face of a stone, called a *muller*, upon a table or slate, called the stone.

Lime, oxide of calcium, one of the primitive earths.

Liquefaction, the change of a solid to the state of a fluid, by the absorption of caloric.

Lithia, a new alkali, discovered by Arfredson, in the laboratory of Berzelius.

Lixiviation, the application of water to the fixed residues of bodies, for the purpose of extracting the saline part.

Lixivium, a solution obtained by lixiviation.

Lunar Caustic. Nitrate of silver.

Lute, a chemical term, used to express the cement for joining of broken vessels, or two vessels together.

M.

Maceration, the steeping of a body in cold liquor.

Magistery, a term originally applied to precipitates.

Magnesia, one of the primitive earths, possessed of a metallic basis, called magnesium.

Malates, salts formed by the composition of malic acid with a salifiable basis.

Malleability, the power of being extended under the hammer.

Maltha. Mineral tallow.

Manganese, a metal of a dull whitish colour when broken, but which soon grows dark by oxidation, from the action of the air.

Manures, animal and vegetable matters introduced into the soil, to accelerate vegetation, and increase the production of crops.

Marble. Carbonate of lime.

Massicot, yellow oxide, or the deutoxide of lead.

Matrix, the earthy or strong matters which accompany ores, or surround them in the earth.

Mellates, compounds of the mellitic acid with salifiable bases.

Mephitic gas. Carbonic acid.

Menstruum, a word synonymous with solvent.

Metallic oxides, metals combined with oxygen.

Minium, the red oxide of lead, commonly called red lead.

Mordants, substances which have a chemical affinity for vegetable colours.

Mother Waters, or *Mothers* the liquors which are left after the crystallization of any salt.

Mucites, salts formed by the combination of any base with the mucous acid.

Mucus, one of the primary animal fluids, perfectly distinct from gelatine.

Muffle, a small earthen oven, to be fixed in a furnace for the purpose of cupellation.

Must, the juice of grapes, composed of water, sugar, jelly, gluten, and bitartrate of potash.

Myricin, the ingredient of wax which remains after digestion in alcohol.

N.

Naphtha, a native combustible liquid, of a yellowish white colour, perfectly fluid and shining.

Naples yellow, lead calcined with antimony and potash.

Natron, native carbonate of soda.

Neutralization. When acid and alkaline substances are added together in such proportions that the compound does not change the colour of litmus or violets, they are said to be neutralized.

Nickel, a metal of great hardness, of uniform texture and colour, between silver and tin, it is said to be magnetical.

Nicotin, a peculiar principle obtained from tobacco.

Nitrates, compounds of the nitric acid with the salifiable bases.

Nitre, one of the names of nitrate of potash.

Nitrogen, or *azote*, an important elementary or undecompounded principle. It constitutes four fifths of the volume of atmospheric air.

O.

Oil of vitriol. Sulphuric acid.

Olefiant gas. Carburetted hydrogen.

Opacity, the faculty of obstructing the passages of light.

Ores. Bodies from which metals are extracted.

Orpiment. Sulphuret of arsenic.

Osmium, a metal discovered in the ore of platinum.

Oxalates, compounds of oxalic acid with salifiable bases.

Oxidation, the process of converting metals, or other substances into oxides, by combining with them a certain portion of oxygen.

Oxides, substances combined with oxygen, without being in the state of an acid.

Oxygen gas. Vital air.

Oxymuriatic acid. Chlorine.

Oxyprussic acid. Chloro-prussic acid.

P.

Paste, glass made in imitation of gems.

Pellicle, a thin skin which forms on the surface of saline solutions and other liquors, when boiled down to a certain strength.

Phosphates, salts formed by the combination of any base with the phosphoric acid.

Phosphorus of Baldwin. Ignited muriate of lime.

Phosphorus of Canton. Oyster shells calcined with sulphur.

Phosphorus of Bologna. Sulphate of barytes.

Phosphuret, a compound of phosphorus with a combustible, or metallic oxide.

Phlogisticated acid. Nitrogen.

Phlogisticated alkali. Ferroprussiate of potash.

Phlogiston, inflammable principle of the old chemists.

Picromel, the characteristic principle of bile.

Picrotoxia, the bitter and poisonous principle of *cocculus indicus.*

Pinchbeck, an alloy of copper.

Platina, one of the metals.

Plumbago. Carburet of iron—black lead.

Pneumatic. Any thing relating to the airs and gases.

Potash, the hydrated deutoxide of potassium.

Potassium, the metallic base of potash.

Potential cautery. Caustic potash.

Prussiates, combinations of prussic acid with salifiable bases.

Prussine, *prussic gas*, or *cyanogen.* The base of the prussic acid.

Pyrites, native metallic sulphurets.

Pyrometer, an instrument for measuring very high temperatures.

Pyrophorus, a compound substance, which heats of itself, and takes fire on the admission of atmospheric air.

Q.

Quartation, is an operation by which the quantity of one thing is made equal to a fourth part of a quantity of another.

Quartz, a name given to a variety of silicious earths, mixed with a small portion of lime or alumina, and generally containing some metallic oxide.

Quercitron. The bark of the yellow oak.

Quicksilver. Mercury.

R.

Radical, that which is considered as the distinguishing part of an acid, by its union with the acidifying principle, which is common to all acids.

Rancidity, the change which oils undergo by exposure to the air.

Re-agents, certain bodies used for detecting principles in solution.

Realgar. Sulphuret of arsenic.

Receivers, chemical vessels, which are adapted to the necks or beaks of retorts, into which the liquid when distilled is received.

Reduction, or *Revivification*, the restoration of any substance to its natural state, or which is considered as such; it is usually applied to operations by which metals are restored to their natural state.

Refrigeration. The act of cooling.

Regulus, a term applied to metallic substances when separated from others by fusion.

Respiration, a function of animals, which consists in the alternate inhalation of a portion of air into an organ called the lungs, and its subsequent exhalation.

Retort, a vessel employed for many distillations, and most frequently for those which require a degree of heat superior to that of boiling water.

Rhodium, a metal discovered among the grains of crude platinum.

Rochelle salt. Tartrate of potash and soda.

S.

Sal Ammoniac. Muriate of ammonia.

Sal Catharticus Amarus. Sulphate of magnesia

Sal Diureticus. Acetate of potash.

Sal Glauberi. Sulphate of soda.

Sal Martis. Green sulphate of iron.

Sal Polychrest. Sulphate of potash.

Salifiable Bases, the alkalies and those earths, and metalic oxides, which have the power of neutralizing acidity, entirely or in part, and producing salts.

Salt, the union of an acid with an alkali, earth, or metalic oxide.

Sanguification, that process of the animal economy by which chyle is converted into blood.

Saponaceous, partaking of the nature of soap.

Saturation. When a fluid holds as much of one substance in solution as it can dissolve, it is said to be saturated.

Selenium, a new elementary body, discovered by Berzelius, which he ranks between sulphur and tellurium.

Sebat, a neutral compound of sebacic acid, with a base.

Silica, one of the primitive earths.

Silicon, the base of silica.

Silver, the whitest of all metals, harder than gold, very ductile and malleable.

Silvering, the art of covering metals and some other substances with a coating of silver.

Soda. Mineral alkali.

Sodium. The base of soda.

Solder, an alloy used for uniting metallic bodies together.

Sorbates, compounds of sorbic acid, or malic, with the salifiable base.

Spelter, the commercial name for zinc.

Starch, a white insipid combustible substance, insoluble in cold water, but forming a jelly with boiling water.

Steatites, a mineral, composed of iron, silex and magnesia.

Steel, a carburet of iron.

Strontia, one of the substances usually called earths.

Strontium. The metallic base of strontia.

Strychnia, a vegetable alkali found in the *strychnus nux vomica.*

Suber. Cork.

Sublimation, a process by which volatile substances are raised by heat and again condensed in a solid form.

Subsalt, a salt having an excess of base beyond what is necessary for saturating the acid; as *supersalt* is one with an excess of acid, the term *bi* is now more generally used.

Succinates, compounds of succinic acid with a salifiable basis.

Sugar of lead. Acetate of lead.

Sulphates, definite compounds of sulphuric acid with the salifiable bases.

Sulphites, definite compounds of sulphurous acid with the bases.

Sulphuretted, combined with sulphur.

T.

Tannin, one of the immediate principles of vegetables, so called, from its use in tanning leather; which is effected by its characteristic property, that of forming with gelatine a tough insoluble matter.

Tanning, the art of manufacturing skins into leather.

Tantalium, one of the names of a metal commonly called columbium.

Tarras, or *Terras*, a volcanic earth used as a cement.

Tartar, a substance deposited on the inside of casks during the fermentation of wine.

Tartrate, a neutral compound of the tartaric acid with a base.

Tellurium, a name given to a metal of a tin white colour, verging to lead-grey, with a high metalic lustre; found in Transylvania.

Telluretted hydyrogen, a gas formed by a combination of tellurium and hydrogen.

Temperature, a definite term of sensible heat as measured by the thermometer.

Terra Japonica. Catechu.

Thermometer, an instrument for measuring heat, founded on the principle, that the expansions of matter are proportional to the augmentation of temperature.

Thorina, an earth, discovered in 1816, by Berzelius, of Sweden.

Thorinum, the supposed metalic basis of thorina, not hitherto extracted.

Tin, a metal of a yellowish white colour, considerably harder than lead, scarcely at all sonorous, very malleable, though not very tenacious.

Titanium, one of the metals.

Tombac, a white alloy of copper with arsenic, sometimes called white copper.

Touch stone, a variety of flinty slate.

Tritorium, a vessel used for the separating of two fluids, which are of different densities.

Trituration, a chemical operation whereby substances are disunited by friction.

Tube of Safety, a tube open at both ends, inserted into a receiver, the upper end communicating with the external air, and the lower being immersed in water. It is to prevent injury from too sudden condensation, or rarefaction, taking place during an operation.

Tungsten, the name of a metal.

Tungstates, salts formed by the combination of tungstic acid with salifiable bases.

Turbeth Mineral, sub deutosulphate of mercury.

U.

Ulmin, a substance exuding from the trunk of a species of elm, the *ulmus nigra*.

Uranium. The name of a metal.

Urates, compounds of the uric or lithic acid with any base.

Urea, a substance prepared from urine.

Ustulation, the roasting of ores to separate the arsenic, sulphur, and whatever else is of a volatile nature, that is connected with and mineralizes the metal. When the matter which flies off is preserved, the process is called sublimation, but when this matter is neglected, the process is called ustulation.

V.

Veratria, a new vegetable alkali, discovered in the *veratrum album*, white hellebore, and some other plants.

Verdigris. Crude acetate of copper.

Verditer, a blue pigment, obtained by adding chalk or whiting to a solution of copper in aqua fortis.

Vermillion. The red sulphuret of mercury.

Vinegar. Acetous acid.

Vinegar from wood. Pyroligneous acid.

Vital Air. Oxygen.

Vitrification. When certain mixtures of solid substances are exposed to an intense heat, so aa to be fused and become glass, they are said to have undergone vitrification.

Volatility, a property of some bodies which disposes them to assume the gaseous state.

W.

Wash, the technical term for the fermented liquor, of whatever kind, from which spirit is intended to be distilled.

Wax, an oily concrete matter, gathered by bees from plants.

Way, dry, a term used by chemical writers when treating of analysis or decomposition.

Way, humid, a term used in the same manner as the above, but expressive of decomposition in a fluid state.

Whiting. Chalk cleared of its grosser impurities.

Wodanium, the name of a recently discovered metal.

Y.

Yttria, a name of one of the earths.

Z.

Zaffre, the residuum of cobalt, after the sulphur, arsenic, and other volatile matters of the mineral have been expelled by calcination.

Zero, the commencement of the scale of a thermometer marked 0. Thus we say, the zero of Farenheit, which is 32° below the melting point of ice, the zero of the centigrade scale which coincides with the freezing of water. The absolute zero is the imaginary point in the scale of temperature, when the whole heat is exhausted, the term of absolute cold, or privation of caloric ; this has never been ascertained.

Zimome, the gluten of wheat, treated by alcohol, it is reduced to the third part of its bulk.

Zinc, a metal of a bluish white colour, somewhat lighter than lead.

Zircon, an earth found in the jargon of Ceylon.

Zumates, combinations of the zumic acid with the salifiable bases.

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