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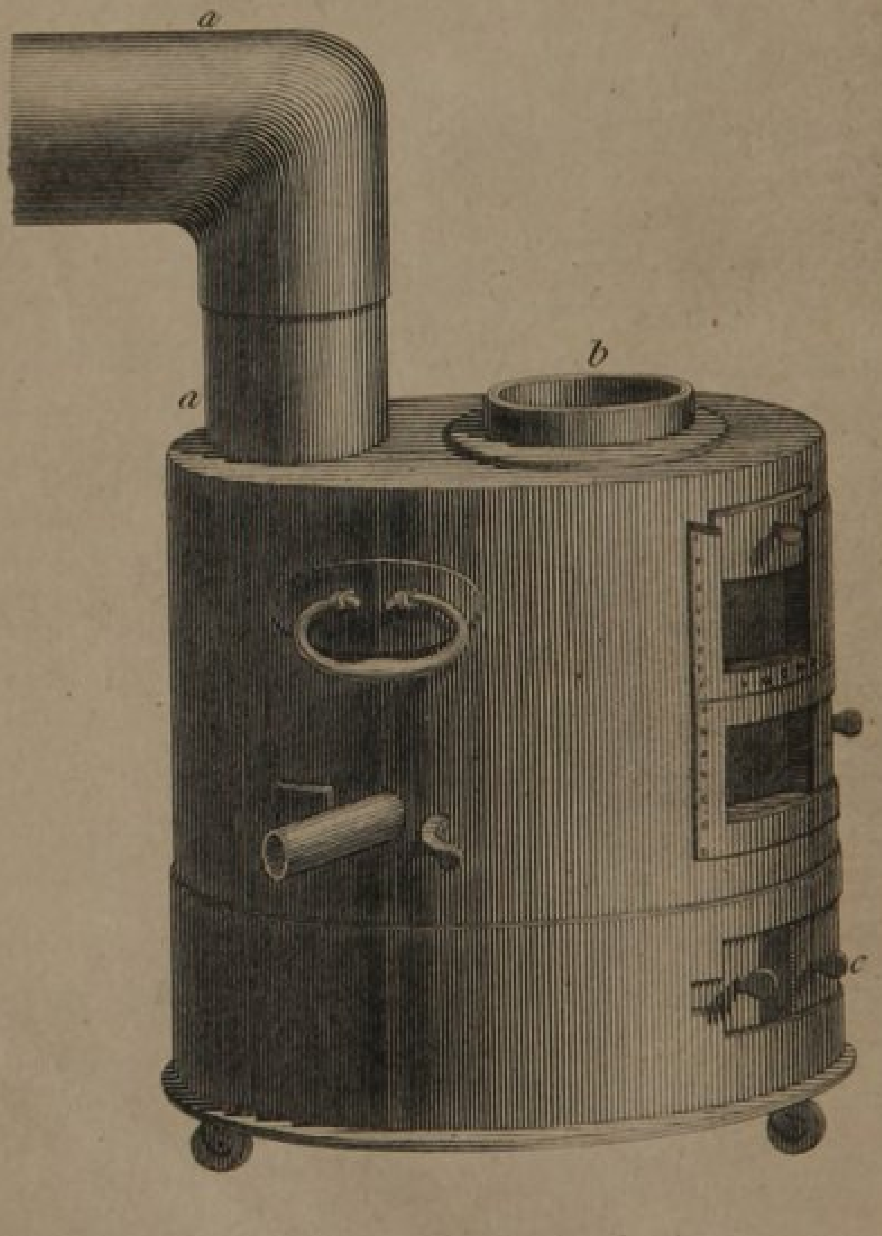
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THE PHILOSOPHY

OF

EXPERIMENTAL CHEMISTRY.

IN TWO VOLUMES.

BY JAMES CUTBUSH,

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Columbian Chemical Society, &c. &c.

VOLUME II.

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CONTENTS OF VOL. II.

PART XV.

OF METALS.

1265

PART XVI.

OF ACIDS.

PART XVII.

OF SALTS.

DIVISION I....ALKALINE SALTS.

DIVISION II....EARTHY SALTS.

DIVISION III....OF METALLIC SALTS.

PART XVIII.

OF COMPOUND COMBUSTIBLES.

EXPLANATION OF THE FRONTISPIECE, IN VOLUME SECOND.

The Frontispiece exhibits a portable universal furnace, which is made of strong wrought iron plates, and is lined with bricks bedded in fire-proof loom. The height of this furnace without its chimney *a a* is two feet. The inner diameter of the cylindrical fire place measures 12 inches. The body of the furnace is elliptical; in its upper part a circular hole is cut, for receiving an iron sand-pot *b* which may be occasionally removed, and exchanged for an iron plate. In the front of the furnace there are three openings over each other, furnished with sliding doors, and fitted with stoppers made of crucible ware. The lower opening *c* is the ash-pit of the furnace; it is composed of two register plates sliding backwards and forwards in grooves, in order to diminish or enlarge the opening for regulating the heat, by admitting or excluding air at pleasure. In the side of the furnace a hole is cut furnished with a stopper and door, for passing a tube through the fire part of the furnace, an expedient very necessary for a variety of chemical processes.

THE PHILOSOPHY

OF

EXPERIMENTAL CHEMISTRY.

PART XV.

OF METALS.

I. The metals are distinguished by certain obvious and physical properties; as,

1. Lustre. The brilliancy which the metals possess, is known by the name of *metallic lustre*. This property is occasioned by their reflecting much more light than any other bodies, which seems to depend on the closeness of their texture.

2. Opacity. Metals are perfectly opaque, or impervious to light. Newton observed, that gold leaf $\frac{1}{28000}$ of an inch thick, when held between the eye and the light appears of a lively green, and, according to him, transmits the green coloured rays. Silver leaf, however, $\frac{1}{100000}$ of an inch thick, is completely impervious to light. Metals are therefore considered opaque.

3. Fusibility. That metals may be melted by the application of heat, is a well known property. They still retain their opacity. The metals, however, differ

in their fusibility. Thus, mercury remains fluid in the common temperature of the atmosphere, and even requires intense cold to make it solid; while other metals, as platinum, cannot be melted except by the most violent heat.

4. Weight. The specific gravity of the metals is exceedingly various. The greater number of them are heavier than any other known substances.

Several of the new metals, discovered by Mr. Davy, are not so heavy as water. Thus plantinum is 23 times heavier than water, whilst the specific gravity of potassium is only 0.6, that of water being 1.

5. They are all conductors of electricity.

6. They possess different degrees of hardness; and the ingenuity of the artist has rendered some of them considerably hard by artificial means. Hence the numerous instruments made of steel.

7. Elasticity. This property depends upon the hardness of the metal, and may be increased by the same process by which their hardness is increased.

8. Malleability. The capacity of being extended and flattened when struck with a hammer, is called malleability. This is a useful property of the metals. All metals do not possess it in the same degree. Heat increases it remarkably.

9. Ductility. The capacity of being drawn out into wire, by means of a certain contrivance, is called ductility. This property is also wanting in some of the metals.

10. Tenacity. Tenacity is the power which a metallic wire, of a given diameter, has of resisting, without breaking, the action of a weight suspended from its extremity. Ductility depends, in some measure, on this property. The metals differ in this capacity. An iron wire, for instance, $\frac{1}{10}$th of an inch in diameter, will support a weight of 500 pounds. A lead wire, on the contrary, of the same diameter, will not support above 29lbs.

II. The metals at present known, including those discovered by Mr. Davy, amount to 40. Twelve of these are imperfectly known, and some philosophers have expressed their doubts of their existence. As these metals have been obtained from the alkalies and earths, we have noticed them when treating of these substances. We have to consider, therefore, the remaining metals, which are 28 in number. Seven of these were known to the ancients, and seventeen have been discovered since the year 1730 In the arrangement of the metals, Thomson has adopted the following, in four classes, each of which is characterised by some general property.

I. Malleable.

1. Gold
2. Platinum
3. Silver
4. Mercury
5. Palladium
6. Rhodium
7. Iridium
8. Osmium
9. Copper
10. Iron
11. Nickel
12. Nicolanum
13. Tin
14. Lead
15. Zinc

II. Brittle and easily Fused.

1. Bismuth
2. Antimony
3. Tellurium
4. Arsenic

III. Brittle and difficultly Fused.

1. Cobalt
2. Manganese
3. Chromium
4. Molybdenum
5. Uranium
6. Tungsten

IV. Refractory.

1. Titanium
2. Columbium
3. Cerium

Those of the first class, by way of eminence, were formerly considered perfect metals, and all the rest were called semi-metals or imperfect metals. But this distinction is disused.

The metals as they are found, are generally mineralized, by the union of sulphur, oxygen, &c. forming ores. The ores of metals have been classified or arranged in several ways.

The following arrangement of ores, is adopted by professor Cooper.*

Metallic Fossils.

I. GENUS PLATINA.

- Native platina

II. OR GOLD GENUS.

- Native gold
  - Gold yellow
  - Brass yellow
  - Grayish yellow
- Nagyag
- Graphic

III. QUICKSILVER GENUS.

- Native quicksilver
- Natural amalgam
  - *Fluid
  - *Solid
- Corneous ore
- Hepatic ore
  - Compact
  - Slaty
- Cinnabar
  - Dark red common
  - Bright red fibrous

IV. SILVER GENUS.

- Native silver
  - *Common
  - *Goldish
- Antimonial silver
- Arsenical silver
- Bismuthal
- Corneous ore
  - Common
  - Earthy
- Black silver
- Glance silver
  - Brittle
- Red silver ore
  - Dark
  - Light
- White silver ore
- Black silver ore
- *Gray silver ore

V. OR COPPER GENUS.

- Native copper
  - Vitreous
  - Compact
  - Foliated
- Variegated ore
- Copper pyrites
- White copper ore
- Grey copper ore
- Black copper
- Red copper ore
  - Compact
  - Foliated
  - Capillary
- Tile ore
  - Earthy
  - Indurated
- Copper azure
  - Earthy
  - Radiated
- Malachite
  - Fibrous

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* Introductory Lecture, 8vo. p. 213.

  - Compact
- Copper green
- Iron shot copper
  - Green
  - Earthy
  - Slaggy
- Olivine ore
- * ⎰Copper mica
- ⎱Copper emerald

VII. OR IRON GENUS.

- Native iron
- Iron pyrites
  - Common
  - Radiated
  - Hepatic
  - Capillary
  - *Magnetic
- Magnetic iron stone
  - Compact (common)
  - Iron sand
- Iron glance
- (Specular)
  - Common
  - Compact
  - Foliated
  - Micaceous
- Red iron stone
  - Red iron froth
  - Red iron ochre
  - Compact
  - Red hematite
- Brown iron stone
  - Brown ochre
  - *Frothy
  - Ochry
  - Compact
  - Hematitic
- Sparry iron stone
- Black iron stone
  - Compact
  - *Hematitic
- Clay iron stone
  - Reddle
  - Columnar
  - Granular
  - *Lenticular
  - *Jaspery
  - Common
  - Kidney
  - Pea ore
- Bog ore
  - Morass
  - Swamp
  - Meadow
- Blue iron earth
- Green iron earth
- Emeril†

VII. OR LEAD GENUS.

- Lead Glance
  - Common
  - Compact
- Blue lead ore
- Brown
- Black
- White
- Green
- Red
- Yellow
- Native vitriol of lead
- Lead earth
  - Coherent
  - *Friable

VIII. OR TIN GENUS.

- Tin pyrites
- Tin stone
- Cornish ore

IX. OR BISMUTH GENUS.

- Native
- Glance
- Ochre

---

† Omitted by Jameson.

X. OR ZINC GENUS.

- Blende
  - Yellow
  - Brown
  - Black
- Calamine
  - Compact
  - Lamellar

XI. OR GENUS ANTIMONY.

- Native
- Gray
  - Compact
  - Foliated
  - Radiated
  - Plumose
- Red
- White
- Antimonial ochre

XII. OR COBALT GENUS.

- White ore
- Gray
- Glance
- Black ochry
- Earthy
  - Indurated
- Hard black
  - Earthy
- Brown ⎫
- Yellow ⎬ ochre
- Red ⎭
  - ⎧ Cobalt crust
  - ⎨ Pulverulent
    - ⎩ Earthy
  - ⎧ Cobalt bloom
  - ⎩ Radiated

XIII. OR NICKEL GENUS.

- Kupfernickel
- Nickel ochre

XIV. OR MANGANESE GENUS.

- Gray ore
  - Radiated
  - Foliated
  - Compact
  - Earthy
- Black ore
- Red ore
- Garnet ore

XV. OR MOLYBDENA GENUS.

- Molybdena
- Sulphuret of molybdena

XVI. OR ARSENIC GENUS.

- Native
- Arsenical pyrites
  - Common
  - Silvery
- Orpiment ⎫
- Realgar ⎭
  - Red
  - Yellow

XVII. OR SCHEELE GENUS.

- Tungsten
- Wolfram

XVIII. URAN GENUS.

- Pitch earth
- Uran mica
- Uranochre

XIX. MENACAN OR TITANIUM GENUS.

- Menachanite
- *Rutile
- Nigrine
- *Iserine
- †Nadelstone

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† Jameson has not inserted the Nadelstein, nor has Brochart the Rutile or the Iserine. I have prefixed an asterisk * to the substances inserted from Jameson.

*XX. or Silvan Genus.
Native sylvan
Graphic
Yellow } ore
Black

III. The metals unite with oxygen. The most important property, common to the whole class of metals, is their susceptibility of union with oxygen. The combination of oxygen with a metal forms a *metallic oxyd*, which was formerly called a *calx*. The oxyds of metals are of various colours, according to the metal and the treatment. They may be reduced by subjecting them with charcoal powder, as well as oil, tallow, &c. in a crucible to the action of heat. The oxygen is thus carried off, and the metal resumes its original state. According to the Stahlian theory, a metal, in the act of oxydizement, loses its *phlogiston*, and is resolved into an *earth ;* for a metal according to that doctrine is a compound of earth and plogiston ; and that in the reduction of an oxyd, by employing a carbonaceous substance, phlogiston was imputed to the metal. The Lavoiserian theory explains it, by abolishing the hypothetical element of phlogiston, and asserting that in the formation of an oxyd, oxygen was absorbed, and the metal loses its metallic splendour, and that, in the reduction of an oxyd, the oxygen was disengaged, leaving the metal in its original state.

1. Mere exposure to the atmosphere, at the ordinary temperature, is sufficient to oxydize some metals, such as arsenic and manganese.

2. By an increase of temperature, and exposure to air, other metals undergo this change, but the former in these cases is absolutely necessary. Of the metals, of this kind, we may mention iron, zinc, copper, tin, &c. When made red hot they lose their metallic splendour, and are changed into oxyds of various colours. Very frequently this process takes place with an emission of heat and light, or flame. Combustion, therefore, takes place. Arsenic and zinc burn with a brilliant flame.

3. Other metals, on the contrary, as gold and platinum, are not oxydized even by the combined operation of air and an increased temperature.

By the electrical or galvanic influence, metals may be made to combine readily with oxygen. A wire of gold, silver, or platinum, for instance, is volatilized by the discharge of an electrical battery; and the metal, in this state, is oxydized by the air of the atmosphere. When beat into very thin leaves, these, and other metals burn with great brilliancy, producing at the same time different colours. These effects are produced by the discharge of a powerful galvanic combination.

4. By oxydizement, whether by the combined operation of heat and atmospheric air, or which effects the same change more readily in oxygen gas, all metals acquire weight.

5. Water will oxydize some metals, both at the ordinary temperature of the air, and in high temperatures. Thus it is, that iron filings in a moist atmosphere, or when wetted with water, become oxydized, in consequence of the decomposition of that fluid. When the vapour of water is passed through a gun barrel, heated to redness, hydrogen gas is emitted, and the metal is oxydized, the iron gaining 28 per cent. of oxygen. See Hydrogen Gas.

6. Those metals, as silver, gold, and platinum, which do not attract oxygen either from oxygen gas or atmospheric air, as well as the readily oxydizable metals are capable of taking it from acids, and thereby becoming oxydized. Thus, nitro-muriatic acid, or oxymuriatic acid, first oxydizes gold or platinum, and then dissolves the oxyd; silver, copper, &c. decompose nitric acid, in the same manner, and produce metallic salts by the subsequent solution of the oxyd. All metals before solution must be oxydized, or combined with oxygen, which must take place before, or in the act of solution.

7. The solution of a metal in an acid, is accompanied with a decomposition of the acid. Thus, nitric acid and copper, when brought into contact, occasions a disengagement of nitric oxyd, or nitrous gas. See Nitrous Gas. This evolution of gas is called *effervescence*. Again, if iron filings be added to concentrated sulphuric acid, no effect ensues; but if water be added, a rapid decomposition takes place, the water is decom-

posed, hydrogen gas is evolved, and the metal is oxydized at the expense of the water. See Hydrogen Gas. If, on the contrary, the metal be already combined with oxygen, and then added to an acid, the solution is effected without effervescence; for if the red oxyd of iron be added to sulphuric acid, this effect will take place.

8. Metals have different affinities for oxygen, and are capable of uniting with it in different proportions. These oxyds differ in their external and chemical characters, according to the degree of oxydizement. Twenty-eight parts of oxygen, for instance, and seventy-two of iron produce a black oxyd, whereas if forty-eight per cent. of oxygen be absorbed, a red ore is formed. Manganese united with one fifth of oxygen, affords a white oxyd, with one fourth, a red ore; and with two fifths, ore of a deep black colour, being the manganese of the shops. In proportion to the quantity of oxygen in these compounds, the more feeble is the affinity by which it is retained. In order to form a nomenclature for the metallic oxyds, to express the degree of oxydizement, Dr. Thomson has adopted the following method:

Prot-oxyd denotes the lowest degree, the minimum of oxydizement, or the first oxyd which the metal is capable of forming. Deut-oxyd denotes the second oxyd of a metal, or the metal combined with two doses of oxygen. He also employs the terms trit-oxyd, tetoxyd, pent-oxyd, and hect-oxyd, to express the third, fourth, fifth, and sixth degrees of oxydizement. The last term, per oxyd, signifies the largest dose of oxygen, and is used to express the highest degree, or the maximum, of oxydizement.

9. In proportion to the degree of oxydizement, the metal forms very different compounds with a given acid. Iron with 27 per cent. of oxygen gives with sulphuric, nitric, or muriatic acid, a green salt, insoluble in alcohol, and precipitated of a white colour by prussiate of potash; while the same metal with 46 per cent. of oxygen forms a reddish salt, soluble in

alcohol, and precipitated by prussiate of potash of a deep blue colour.

10. Metals retain oxygen with different degrees of force. Some metallic oxyds, as of mercury, are reduced to a metallic state by the mere application of heat, and others, as that of iron, require the addition of some substance possessing a strong affinity for that principle, as charcoal. See Carbonic Acid Gas.

The affinities of the metals for oxygen, may be shewn by exposing a mixture of oxyd of mercury and iron filings to heat; the latter will take the oxygen from the former, and become oxydized, and the mercury will re-appear in a metallic state. Or, if a glass which contains oxyd of lead be melted with metallic iron, the latter metal attracts oxygen from the former, and the lead assumes the metallic state. The separation of oxygen from a metallic oxyd, is termed the *revival* or *reduction* of a metal.

11. Metals held in solution in acids, are separated in the state of oxyds and hydrates, by the addition of alkalies. See Water. The alkali takes the place of the metal, forming a peculiar salt, whilst the latter is thrown down or *precipitated.* Owing to the different degrees of affinity of metals for oxygen, some of them are separated from the solution when another metal is presented. They are not separated, however, in the state of oxyds, but in a metallic form. See Affinity. Thus for instance, when a piece of iron is suspended in a solution of copper, the oxygen of the oxyd of copper, which is held in solution, goes to the iron, which becomes oxydized; and as fast as it is dissolved, the copper is separated, or precipitated on the iron. This precipitate is, therefore, metallic copper.

12. By the union of oxygen with metals, we are furnished with oxyds or acids. Thus, some metals when oxygenated to the minimum afford only oxyds, but if oxygenated to the maximum, produce acids. Those metals, that possess the latter property, are acidifiable. Such as chromium, arsenic, molybdenum, &c.

13. The union of sulphur with metals, are called sulphurets. All the metals, except gold and one or two others, are capable of combining with sulphur. The latter may be made to unite with sulphur in different proportions. Thus iron and copper, in particular, furnishes a sulphuret, or super-sulphuret. Some of the metals, such as tin, zinc, and manganese, even when oxydized are susceptible of union with sulphur, forming sulphuretted oxyds. Some are precipitated in this state by hydro-sulphurets. See Hydro-sulphurets.

14. With phosphorus, the metals have an affinity, forming metallic phosphurets.

15. With carbon some of them are capable of combining, forming carburets.

16. The metals are for the most part capable of uniting with each other, and the compounds that are thus formed are termed alloys.

17. As metals are seldom found native, but in combination with oxygen, sulphur, arsenic, &c. forming ores, before they can be employed for use, they are torrified or roasted, and exposed with some carbonaceous matter, as a flux, in order to deprive them of the mineralizing substances. The volatile ingredients, are separated by roasting, and the oxygen is carried off by the carbon.

18. The ores of metals, we have remarked, may be distinguished from other mineral substances by their specific gravity, which greatly exceeds that of stony substances. The specific gravity of ores, in general, are five, six, seven, or more times, heavier than water. To find the specific gravity of ores and stones, an operation is essential, which is termed weighing them hydrostatically. To accomplish this object with accuracy, it is indispensably necessary to be provided with a balance properly adjusted, and accompanied with a set of weights, above and below the grain. Mr. Nicholson's weights, for hydrostatic purposes, consist in the number of a thousand grains, and the decimal fractions of a grain. See Nicholson's Chemistry.

Such accuracy, as is of the first importance in nice experiments, is scarcely necessary for common purposes. In general, when the specific gravity is determined in whole numbers, without using the decimal fractions of a grain, it will be sufficient for ores.

Procure a specimen of the mineral, weighing a few drams, freed as much as possible from the matrix, or stony part, and suspend it from the scale of a fine ballance. The mineral must be suspended by a horse hair, or thread of silk attached to the scale, and fastened to the mineral with a loop knot, and its weight ascertained in air, an allowance being made for the weight of the thread or hair. The weight is then to be noted down. The mineral, still suspended from the scale, is to be immersed in a glass of water (which for very accurate purposes should be distilled); a diminution of weight will now ensue; then determine the number of grains necessary to restore the equilibrium. The latter will indicate the magnitude or bulk of the mineral, whilst the former, or the weight in air, will shew the absolute weight. Or, to determine the magnitude, and of course the diminution of weight in water, note down the weight in air, and ascertain its weight in water, subtract the latter from the former; and the magnitude, or quantity of water it displaces will be known. After this, the next object is to determine the specific gravity. The following general rule must now be observed. By the specific gravity of any substance is understood, the quotient of its absolute weight, divided by its magnitude. The calculation, therefore, may be readily made by knowing these two circumstances, *viz.*

1. The absolute weight, or weight in air.
2. The magnitude, or the quantity of water displaced at a given temperature.

According to the rule, let the sum of the weight in air, be divided by the sum of the weight which the body has lost during its immersion in water, and the quotient will shew the specific gravity.

Suppose a piece of mineral weighs in air 360½ grains, but when immersed in water of a stated temperature loses 60¼ grains, its specific gravity would be nearly 6.

The following is a summary of the average specific gravities of different metallic ores.[*] The specific gravity of

Crude platina reaches from	20.6 to 22.
Gold	5.7 to 11.8
Silver ores	5.8 to 10.6
Copper ores	5.2 to 6.5
Lead ores	5.1 to 7.18
Tin ores	5.3 to 6.97
Iron ores	5.6 to 8.5
Zinc ores	5.0 to 5.5
Mercury ores	5.4 to 7.75
Antimony ores	5.1 to 6.
Bismuth ores	5.8 to 8.6
Nickel ores	5.5 to 6.5
Cobalt ores	5.3 to 7.2
Arsenic ores	5.1 to 6.8
Tungsten ores	5.8 to 7.5
Tellurium ores	5.4 to 6.
Uranium ores	5.2 to 5.5
Molybdena ores	5.2 to 6.2
Chrome ores	5.3 to 6.5
Titanium ores	5.1 to 6.
Manganese ores	5.1 to 6.8
Columbium ores	5.918

Tantalium ores, not yet ascertained.

SECTION I.

OF GOLD.

Experiment 1. If the auriferous sand of certain rivers be washed with water, in order to separate those bodies of an inferior specific gravity, by which means the gold is obtained at the bottom of the vessel in the state of gold dust; or if native gold, freed as much as possible from its matrix, be reduced to a fine

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[*] Accum's Analysis.

powder and digested, by the assistance of heat, in four parts of nitro-muriatic acid, renewing the acid as it evaporates, a solution of the gold will be formed. The same process may be repeated until all the gold is extracted. Evaporate the solution to dryness, and pour upon the dry mass as much boiling distilled water as is sufficient to dissolve it. Filter the solution through paper, and add to it a solution of sulphate of iron, prepared by dissolving one part of that salt in eight or ten of boiling water, until no further change of colour ensues. Suffer the mixture to stand for a few days, and the gold will be precipitated in the form of a brown powder.

Collect the powder, which is metallic gold, introduce it into a crucible, and fuse it into a button or mass.

Rationale. The nitro-muriatic acid dissolves the gold, the solution is decomposed by sulphate of iron, and the gold is precipitated in a metallic state; the theory of which will be presently noticed.

Remark. The filamentous, dendritical, lamellated, arborescent, wire shaped gold, &c. may be analysed in the foregoing manner. Should silver exist with the gold, a white powder will be seen floating in the nitro-muriatic solution; as this is a muriate, 100 parts would indicate 75 parts of silver.

Experiment 2. If to auriferous sand, reduced by washing, or gold dust, one tenth part of mercury be added, and the mixture triturated in an iron or copper vessel containing water, the gold will be dissolved by the mercury, leaving the foreign matter behind. After some preparatory steps, the mercury is separated from the gold (and silver, if any) by exposing the alloy in an earthen retort to a heat sufficient to distil the mercury. The gold will remain in the retort.

Rationale. The mercury dissolves the gold, and, by distillation, is volatilized, leaving the gold which is not volatile in the fire, in the retort.

Remark. The gold may be further purified by cupellation, a process which will presently be described. Should silver be present, the gold may be reduced into very fine laminæ, and treated with nitric acid, which only dissolves the silver. The silver may be separated from this acid, by muriatic acid, and the muriate of silver thus formed, may be decomposed by soda in a crucible, by which means the silver is separated. Should sulphur and arsenic occur in a mixture with gold, they may be disengaged by torrefication, and then melted with iron, which unites with what remains. Metallic substances may be separated from gold by different fluxes. After having separated the sulphur, a mixture of super-tartrate of potash and nitrate of potash may be used. The gold left is afterwards purified by cupellation. Or, if the gold be first freed from sulphur, it may be melted with one and a half parts of litharge, and three parts of glass, in a crucible covered with common salt. All the heterogeneous metals will thus scorify, and set the gold free. Gold, before the blow pipe, with different fluxes, exhibits singular phenomena.*

Experiment 3. If to an ore, supposed to contain gold, nitro-muriatic acid be added, in the manner described in Experiment 1, and afterwards mixed with a small quantity of muriate of tin ; and if a purple precipitate is formed, the presence of gold may be inferred.

Remark. Gold has been known from time immemorial. When pure it is of an orange red, or reddish yellow colour. It possesses a considerable lustre. Its hardness is $6\frac{1}{2}$.† Its specific gravity is 19.3 Gold is so malleable, that, according to Magellan, its surface may be extended by the hammer 159.092 times. One grain of gold will cover $50\frac{1}{4}$ square inches, and the leaf, thus formed, is only $\frac{1}{282000}$ of an inch thick. The quantity of gold with which silver wire is covered, is above $\frac{1}{12}$th of an inch thick. An ounce of

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* See professor Bergman's Treatise on the Blow pipe, and its use in the examination of bodies, particularly minerals.

† Or that degree, according to Mr. Kirwan, which yields most difficultly to the knife.

gold upon silver wire is capable of considerable extension, so much so that it would measure, according to Lewis, more than 1300 miles in length. We are told, that 16 ounces of gold will completely gild a silver wire sufficiently long to encircle the globe. As to the tenacity of this metal, although not so considerable as some of the other metals, yet from the experiments of Sickingen it appears, that a gold wire 0.078 inch in diameter is capable of supporting a weight of 150.07lbs. avoirdupois, without breaking.

Gold melts at 32° of Wedgwood's pyrometer. It requires a violent heat for volatilization; it is therefore exceedingly *fixed*. A number of experiments have been made on this subject by different chemists, both in the heat excited by the common furnaces, as well as that produced by powerful burning glasses. After fusion, gold is susceptible of assuming a crystalline form. It has been obtained in short quadrangular pyramidal crystals.

In the arts, &c. gold is used for jewellery, for plate, and for current coin, but for these purposes it is generally alloyed. It is also employed to be spread over other metals, to preserve them from tarnishing or rusting. Pale gold, as it is called, is alloyed with silver. Gold, when pure, is considered twenty four carats fine. If twenty-two parts of gold, and two parts of copper be fused together, the gold is said to be twenty-two carats fine, or gold of twenty-two carats.

Experiment 4. If a narrow strip of gold leaf be put, with both ends hanging out between two glass plates tied together, and a strong electrical explosion passed through it, the gold leaf will appear to be consumed, and to have tinged the glass of a purple colour.

Rationale. The gold is oxydized by the agency of electricity, and the oxyd imparts colour to the glass, which is partly fused.

Remark. Dr. Franklin was the first who made this experiment, which was afterwards repeated in 1773 by Camus. It was doubted whether gold in this manner is oxydized, but it was discovered, that gold wire, by a powerful electrical battery, burns with a green coloured flame, and is completely dissipated in fumes in the state of the purple oxyd.

Experiment 5. If gold leaf be exposed to the action of the galvanic battery, it will be immediately consumed.

Rationale. In this experiment also the metal is burnt, the purple oxyd of gold being produced.

Remark. Dr. Thomson observes, that he has succeeded in consuming gold by exposing a wire of that metal to the action of a stream of oxygen and hydrogen gas mixed together and burning.

Experiment 6. If sulphuric acid be poured on gold, and even digested with the assistance of heat, the gold will remain unaltered; or,

Experiment 7. If muriatic acid be used in the same manner, no effect will take place; or,

Experiment 8. If nitric acid be employed, no solution will be formed; but,

Experiment 9. If a piece of gold, or gold leaf, be introduced into oxygenized muriatic acid, a solution will immediately be formed; or,

Experiment 10. If a thin sheet of gold be dropt into oxymuriatic acid gas, it will inflame, and muriate of gold will be formed. See the Properties of Oxymuriatic Acid Gas.

Rationale. The oxygen of the oxy-muriatic acid oxydizes the gold, which then combines with the remaining acid, forming the muriate of gold.

Experiment 11. If gold be introduced into nitro-muriatic acid, it will be dissolved.

Rationale. The action of nitro-muriatic is analogous to the oxy-muriatic acid gas; it first imparts oxygen to the metal, and then dissolves the oxyd. The effect of a mixture of the nitric and muriatic acid is apparent in the following experiment.

Experiment 12. Pour a little purified nitric acid into one wine glass, and muriatic acid in another, and drop a little gold leaf in each of them: neither of the acids will act; but mix the contents of both glasses, and the gold will be dissolved.

Rationale. The theory of the formation of nitro-muriatic acid, by the the production of which the solution is effected, will be shewn when we treat of that acid; but in the mixture, the oxygen of the nitric acid is partly transferred to the muriatic acid, and is taken from that acid by the metal, forming an oxyd, which is afterwards dissolved.

Remark. A saturated solution of gold in the nitro-muriatic or oxygenized muriatic acid, affords, by evaporation, crystals of muriate of gold, which will be afterwards noticed.

Experiment 13. To a solution of gold in nitro-muriatic acid, add a solution of potash, and a yellowish brown oxyd of gold will be precipitated.

Rationale. The potash unites with the acid, and the gold, being disengaged from the muriatic acid, is precipitated in the state of an oxyd.

Remark. Gold, thus precipitated, forms the per oxyd of that metal, which is composed of 91 parts of gold, and 9 parts of oxygen.

Experiment 14. Expose the oxyd formed in the last experiment to a moderate heat, and it will be changed into the purple oxyd of gold; but,

Experiment 15. If the same oxyd be exposed to a stronger heat, the oxygen will altogether be disengaged, and the metal revived.

Experiment 16. If gold be subjected to combustion, or to the action of electricity, the purple, or prot-oxyd of gold will be produced; or,

Experiment 17. If the per-oxyd of gold be placed in the direct rays of the sun, it will be changed into the prot-oxyd.

Remark. The oxyds of gold are but imperfectly known. Proust has lately endeavoured to shew, that the *purple oxyd* of gold is nothing more than gold in a metallic state.

Experiment 18. If a piece of tin be immersed in a solution of gold, the gold will be precipitated of a purple colour, forming the purple powder, or *precipitate of Cassius;* or,

Experiment 19. If tin be dissolved in nitro-muriatic acid, composed of two parts of nitric acid, and one of muriatic acid, and to this solution another of gold diluted in eighty times its weight of distilled water be added, the purple precipitate will be formed as in the last experiment.

Rationale. As the purple precipitate is a compound of the oxyds of gold and tin, it follows, that a decomposition of the solution of gold as well as that of the tin takes place. In order to produce the effect, it is necessary that the tin should be oxydized to the *minimum*; for the tin robs the oxyd of gold, held in solution, of a part of its oxygen, and is therefore rendered insoluble, at the same time it is precipitated along with a portion of the oxyd of tin in the form of a purple powder.

Experiment 20. If a silp of zinc be immersed in a similar solution of gold, the latter will be precipitated in a metallic state.

Rationale. The zinc takes the oxygen from the oxyd of gold, and the gold, being thus rendered insoluble, precipitates in a metallic state, whilst a portion of the zinc is dissolved in its place.

Experiment 21. Dissolve a few crystals of nitro-muriate of gold in about eight times their weight of pure water; place a thin slip of charcoal in the solution, and heat the whole by means of a sand-bath. When the solution has acquired nearly a boiling heat, the gold will precipitate itself on the charcoal, in its metallic splendour, forming a singular and beautiful appearance.

Experimeut 22. Proceed as in the last experiment, and submit the vessel with its contents to the rays of the sun. Here the metal will be reduced, and the charcoal effectually gilt as before.*

Rationale. In the first experiment the action of charcoal, assisted by the heat of a sand bath, separates the oxygen from the oxyd of gold; the metal is there-

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* Parke.

fore precipitated in a metallic state. In the latter the same decomposition ensues, assisted by the sun's rays. In the first experiment, particularly, we are presented with the fact, that metals become insoluble the moment they part their oxygen to foreign bodies. The latter is illustrative of the deoxydizing power of the sun's rays.

Experiment 23. If to a solution of gold in nitro-muriatic acid, highly rectified ether be added, the gold will be precipitated, and the precipitate afterwards dissolved, forming the *etherial solution of gold.*

Rationale. The ether would appear to abstract a portion of oxygen from the oxyd of gold, which, in consequence of a part of the oxygen necessary for the solution of the metal being removed, is precipitated, which is then redissolved by another part of the ether, forming the etherial solution. It is asserted, however, that the etherial solution, if evaporated, will afford gold in a state of absolute purity.

Remark. It was this preparation of gold, that received the name of *potable gold*, and was kept in the shops of the apothecaries. It was estimated an *universal medicine.*

Experiment 24. If any polished steel instrument or utensil be dipped in the etherial solution of gold, and instantly plunged into water, the surface will have acquired a coat of pure gold.

Remark. This appears to be a very elegant and economical mode of preserving steel from rust.

Experiment 25. If an essential oil be substituted for ether, a solution of gold will be formed similar to the etherial solution.

Experiment 26. If a white sattin ribbon be moistened with a diluted solution of gold in nitro-muriatic acid, and then exposed, while moist, to a current of hydrogen gas, the gold will be reduced and the ribbon become gilt with the metal.

Remark. If the silk be dry no effect takes place. By means of a camel hair pencil the gold may be so applied as to exhibit regular ornaments, or figures, when reduced.

Experiment 27. If a piece of silk, moistened with phosphorized ether, be immersed in the nitro-muriatic solution, its surface is immediately gilt with a fine coat of gold.

Experiment 28. If sulphuretted hydrogen be substituted for hydrogen gas, in the reduction of gold, the same effect will take place.

Experiment 29. If a piece of white silk be dipped in an aqueous solution of nitro-muriate of gold, and exposed while wet to sulphurous acid gas, the whole piece will in a few seconds be covered with a coat of reduced gold, which remains permanent.

Experiment 30. If a piece of white silk be immersed in an aqueous solution of muriate of gold thoroughly dried in the dark, and then exposed to sulphurous acid vapours, it will suffer no change; nor, if it be wetted with *alcohol* and then replaced in the vapour, will any sign of reduction appear: but if it be wetted with pure *water*, and then exposed to the vapour, metallic gold will immediately be seen on its surface.*

Remark. Various experiments of a similar kind may be found in an Essay on Combustion, by Mrs. Fulhame, and in count Rumford's paper, in the Phil. Trans. 1798, p. 449. Mrs. Fulhame has proved, that moisture is absolutely necessary for the reduction of gold. She observes, that in the experiment with ether, no reduction takes place unless water be present. She accounts very ingeniously for these phenomenæ, by supposing the water to be decomposed. The combustible combines

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* A glass funnel is a convenient apparatus for these experiments. The silk may be suspended by a thread passed through it, and made fast to the funnel with a cork. The funnel is then to be placed on a table, and by moving it a little over the edge of the table, a lighted match may be readily introduced, and when the glass is full of vapour the match may be withdrawn The vapour is confined by sliding the funnel back upon the table; and thus the phenomena of the experiment may be easily observed. See Parke's Chemical Catechism.

with its oxygen, whilst its hydrogen, by uniting with the oxygen of the gold, reproduces water.*

Experiment 31. If a solution of gold in nitro-muriatic acid be applied to bone or ivory, it will be stained of a purplish red colour.

Experiment 32. If the same solution be applied to feathers, they will be changed to the same colour as in the last experiment.

Experiment 33. If a diluted solution of gold be applied to silk by means of a brush, the places thus affected will undergo the same change.

Remark. A solution of gold, has, therefore, the property of staining animal and vegetable substances of a purplish red. After a time these stains become of a beautiful brown, and then black. As a strong affinity subsists between the oxyd of gold and the substance to which it is applied, the stain cannot be effaced.

Experiment 34. If to a saturated solution of gold in nitro-muriatic acid, diluted with three times its bulk of distilled water, liquid ammonia be gradually added, a yellow precipitate will be obtained. When washed and dried on a chalk stone, it forms the *fulminating gold.*

Rationale. The solution of gold, in which that metal exists in the state of muriate, is decomposed by the ammonia; one part of the alkali unites with the acid, forming muriate of ammonia, whilst another part combines with the gold, thus precipitated, in the form, as Dr. Thomson expresses it, of aurate of ammonia. See Ammonia.

Experiment 35. If muriate of ammonia be added to a solution of gold in nitro-muriatic acid, and a fixed alkali added, the gold will be precipitated in the state of *fulminating gold.*†

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* Professor Coxe, of the University of Pennsylvania, has lately published an Essay on Acidification, in which he has adduced several of these experiments, which are apparently anomalies, in order to modify the antiphlogistic theory.

† Gren. ii. 202.

Rationale. When muriate of ammonia is added to a solution of gold, and the mixture decomposed by potash, or soda, the fixed alkali unites with the muriatic acid, as well from the solution, as from a part of the muriate of ammonia; and the oxyd and ammonia thus disengaged unite, and form fulminating gold.

Experiment 36. If oxyd of gold be obtained, by adding lime water to a solution of gold, and afterwards treated with liquid ammonia, *fulminating gold* will be produced.

Rationale. Analogous to experiment 34.

Experiment 37. If a few grains of fulminating gold be heated on the point of a knife, a violent detonation will be produced.

Rationale. The theory of the detonation of fulminating gold is imperfectly understood. If it contain only ammonia and oxyd of gold, the following changes would ensue. When the temperature is raised, the ammonia as well as the oxyd of gold suffer decomposition. The hydrogen of the former unites with the oxygen of the oxyd of gold, and reduces the latter to a metallic state. The water thus formed, together with the azote, are liberated in a highly expanded state. The detonation is produced by the violent impulse of these aeriform bodies on the surrounding atmosphere. Mr. Accum supposes, however, that fulminating gold is a triple compound, namely, an ammoniacal oxymuriate of gold, and that, in combustion, the products are metallic gold, nitrogen gas, muriatic acid and water.

Remark. Bergman observes, that fulminating gold is composed of five parts of yellow oxyd of gold, and one part of ammonia. Basil Valentine describes the preparation of this powder. Many philosophical inquiries were instituted respecting it. Whether struck violently, triturated in a mortar, or heated to the temperature of about 250 degrees, the powder fulminates. Its force, however, is inferior to that of gun powder.

Experiment 38. If to a solution of gold in nitro-muriatic acid, a solution of sulphate of iron be added, the gold will be precipitated in a metallic form; but, *Experiment* 39. If red sulphate of iron be added in the same manner, no effect will take place.

Rationale. Gold, it must be observed, is held in solution in consequence of the metal being oxydized, which ensues in the act of solution, and that when the oxygen is abstracted, it not only becomes insoluble, but it also takes the metallic form. This abstraction of oxygen is effected by the sulphate of iron. When this is added, it seizes the oxygen of the oxyd, and the gold is precipitated in a metallic state; the sulphate changing in part to the red or oxy-sulphate. That this is the *modus operandi*, is obvious from the last experiment; for on the addition of the red sulphate, no precipitation ensues.

Experiment 40. If a piece of thread be passed through a small piece of phosphorus previously freed from moisture by immersing it in alcohol, and then suspended in an aqueous solution of nitro-muriate of gold, in a few minutes the phosphorus will become covered with pure gold. See Phosphorus.

Experiment 41. If hydrosulphuret of potash be dropt into a solution of gold, a black powder will be precipitated. See Hydrosulphurets.

Rationale. The acid of the solution unites with the alkali of the hydrosulphuret, and the gold together with the sulphur is precipitated. This precipitate, according to Proust, consists of gold and sulphur merely in the state of mixture.

Experiment 42. If some leaf gold be digested with heat, in a solution of sulphuret of potash, the metal will be dissolved; or,

Experiment 43. If three parts of sulphur, and three of potash be melted together, and one part of gold added, the same effect will take place.

Remark. Hence it is, that gold is soluble both in the dry and humid way in alkaline sulphurets. The solution is of a yellow colour, and is decomposed by acids. When an acid is dropt in, the gold is precipitated along with sulphur. This precipitate, from the experiments of Bucholz, is composed of 82 parts gold and 18 sulphur. The opinion of some chemists, that Moses dissolved the golden calf of the Israelites, as related in Exodus xxxii, by the agency of sulphur and potash, appears somewhat probable.

Experiment 44. If half an ounce of gold and an ounce of glacial acid of phosphorus be introduced into a crucible with charcoal, and exposed to an intense heat, a phosphuret of gold, according to Pelletier, will be formed.

Rationale. The charcoal unites with the oxygen of the phosphoric acid, forming carbonic acid, which is disengaged, and the phosphorus unites with the gold into a phosphuret of gold.

Remark. The phosphuret of gold is composed of twenty-three parts of gold and one of phosphorus.

Experiment 45. If an alloy, say of gold and copper, be introduced into a crucible with two parts of sulphuret of antimony, and brought to the state of fusion, the gold will be separated from the copper, or other metal, and found united to the antimony at the bottom of the crucible.

Rationale. The sulphur of the sulphuret is partly volatilized, and partly combines with the copper, if it be used, whilst the antimony unites with the gold.

Experiment 46. If the alloy of gold and antimony, the product of the last experiment, be exposed to a white heat, the gold will remain in the crucible in a separate state.

Rationale. When a white heat is applied, it volatilizes the antimony, and the gold is left in the crucible.

Experiment 47. If gold be combined with mercury, in the proportion of one forty-eighth part, and the compound exposed in a mattrass, furnished with a capillary tube, to the action of heat in a sand bath, the metals will become oxydized.

Remark. Gold, therefore, when united to mercury is easily oxydized.

Cupellation. It is necessary, as gold is frequently alloyed with copper, lead, &c. that some process should be employed to effect the separation of the gold. Gold is usually purified by a process called cupellation. A vessel of a porous nature, usually made of bone-ashes, and called a *cupel*, is used, into which is put the alloyed gold with about twice its weight of silver and some lead. Heat is now applied, which oxydizes the lead, and then vitrifies it, at the same time it forms a similar vitreous oxyd with the other metals in the alloy. The cupel then absorbs this glassy fluid, while the gold and silver, not undergoing the process of oxydizement, remain untouched. The silver is afterwards separated by another process, which will be presently noticed. We have heretofore mentioned, that gold is distinguished, with respect to its purity, by the carat standard. This is the method employed by goldsmiths and coiners. Pure gold they suppose divided into 24 parts, called carats.*

Gold of 24 carats means pure gold; gold of 23 carats means an alloy of 23 parts gold, and one of some other metal; gold of 22 carats means an alloy of 22 parts of gold, and two of another metal. The number of carats mentioned, specifies the pure gold; and what that number wants of 24, indicates the quantity of alloy. Thus gold of 12 carats would be an alloy containing 12 parts gold, and 12 of some other metal. In Great Britain the carat is divided into four grains; among the German's into 12; and by the French it was formerly divided into 32.

Parting or quartation. Gold is purified, if it should exist with silver, by the process called *parting* or *quartation.* The latter term is applied when three parts of silver are added to the alloy, and making of course a fourth part of the mixture. When they are melted, sulphur is added, which combines with the silver, and the gold falls to the bottom. Gold is purified from silver in the humid way by the nitric acid, which dissolves the latter, but has no action on the former. From the nitric acid, the silver is separated by precipitation. See Silver.

The methods of purifying gold, at large, may be seen in the 44th chapter of La Grange's Manuel, in Nicholson's Principles of Chemistry, and in the metallurgical work of Monsieur Sage.

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* Lewis's Philosoph. Commerce, p. 115.

Gold unites with most of the metals. With arsenic, bismuth, nickel, and antimony, it is rendered brittle. It unites with lead and tin, and loses in a great measure its ductility. A small portion of tin to gold, in the opinion of Mr. Alchorne, is not so injurious as workmen have imagined. Mr. Tillet, however, is of the contrary opinion. With iron, it forms a very useful alloy; and by copper, it is more fusible, and rendered of a redder colour. This alloy is employed for *coin, toys, gold-plate*, &c. It is rendered very pale by silver. This alloy forms the *green-gold* of goldsmiths. With platina, gold forms a malleable and ductile mixture.

Gilding. This is an art of spreading or covering certain bodies with gold, either in leaf or powder, or in amalgam with quicksilver. This art was known at an early period. The mode of gilding at first was very expensive. We read in Homer's Odyssey, l. iii. v. 492, that the horns of a ram bought by Nestor, as an offering to Minerva, were covered with gold. Pliny speaks of gilding; and Seneca observes (Epist. 115.) that "when we cover our houses with gold, what else do we than rejoice in deception? for we know that coarse wood is concealed under that gold." Gilding is mentioned in Exodus. There are several methods of gilding in use, viz. gilding on oily size; gilding on a water size; gilding by the fire, which is peculiar to metals; gilding of books, &c. For a particular account of the different kinds of gilding, for different purposes, I would refer the reader to Reese's Cyclopedia, article Gold and Gilding, Observ. sur les Coulumes de l'Asie (on the art of gilding on porcelain.) Handmaid to the Arts, Smith's School of Arts, Commercium Philosophico-Technicum, Beckman's History of Inventions, Philosophical Transactions of the Royal Society, Philosophical Magazine, ix. 20. Macquer's Dictionary, and Aikin's Dictionary of Chemistry, art. Gilding.

The works already mentioned contain a full description of the processes of gilding. But as the following general remarks of Mr. Accum* may prove interesting, we shall insert them.

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* Vol. ii. p. 21.

Shell gold, or gold powder,

For painting, may be obtained by uniting one part of gold with eight of mercury, and afterwards evaporating the latter by heat, which leaves the gold in the form of powder; or otherwise the metal may be reduced to powder by mechanical trituration.

Cold gilding by friction.

Steep a fine linen rag in a saturated solution of muriate of gold, till it has entirely imbibed the fluid; this rag must then be dried over a fire, and afterwards burnt to tinder. When any thing is to be gilt, it must be previously well burnished; a piece of cork is then to be dipped, first into a solution of salt in water, and afterwards into the black powder; and the piece, after being rubbed with it, must be burnished. This powder is frequently used for gilding delicate articles of silver.

Gilding of brass or copper.

Fine instruments of brass, in order that their surface may be kept longer clean, may be gilt by immersing them several times in a solution of muriate of gold, free from excess of acid, and afterwards burnishing them.

Water gilding.

This term was probably at first confined to such processes as demand the use of a solution of gold in nitro-muriatic acid, and means a chemical application of gold to the surfaces of metals. If a solution of gold be copiously diluted with ardent spirit, a piece of polished steel will be gilt by being repeatedly steeped therein.

An improved process for gilding steel.

This method, which is less known among artists than it deserves to be, may prove useful to those who have occasion to gild steel.

The first part of the process consists in pouring into a solution of gold in nitro-muriatic acid, about twice as much sulphuric ether. In order to gild iron or steel, the metal must be highly polished. The ether which has taken up the gold is then to be applied with a small brush; it evaporates, and the gold remains on the surface of the metal. In this manner all kind of figures may be delineated on steel, by employing a pen or fine brush. Lancets, razors, &c. may be gilt in this manner. See Experiment 24.

Gilding of iron, by means of heat,

Is performed by cleaning and polishing its surface, and then heating it till it has acquired a blue colour. When this has been done, the first layer of gold-leaf is put on, slightly burnished down, and exposed to a gentle fire. It is usual to give three such layers, or four at the most, each consisting of a single leaf, for common works; or two for extraordinary ones. The heating is repeated at each layer, and last of all the work is burnished.

Grecian gilding.

Is performed in the following manner: equal parts of muriate of ammonia, and muriate of mercury, are dissolved in nitric acid, and a solution of gold is made in this fluid: upon this the solution is concentrated, and applied to the surface of silver, which becomes quite black, but on being exposed to a red heat, it assumes the appearance of gilding.

Method of gilding silver, brass, or copper, by means of an alloy of gold and mercury.

Eight parts of mercury and one of gold are alloyed together by heating them in a crucible. As soon as the gold is perfectly alloyed, the mixture is poured into cold water, and is then ready for use.

Before the alloy can be laid upon the surface of the metal, this last is brushed over with diluted nitric acid, in which it is of advantage that some mercury may have been dissolved. Some artists then wash the metal in simple water, and scour it a little with the finest sand, previous to the application of the gold; but others apply it to the metal while still wet with the nitric acid. But in either case, the alloy must be laid on as uniformly as possible, and spread very even with a brass wire-brush, wetted from time to time with water. The piece is then laid upon a grate, over a charcoal fire, or in a small muffle or furnace, adapted to this purpose; the heat drives off the mercury, and leaves the gold behind. Its defects are then seen, and may be remedied by successive applications of more alloy, and additional application of heat. Expert artists however make these additional applications while the piece remains in the furnace, though the practice is said to be highly noxious, on account of the mercurial fumes. After this it is rubbed with gilders' wax, which may consist of four ounces of bees' wax, one ounce of acetite of copper, and one ounce of sulphate of copper; they then expose it to a red heat, which burns off the wax; and lastly, the work is cleansed with the scratch brush, and burnished, if necessary, with a steel tool. The use of the wax seems to consist merely in covering defects, by the diffusion of a quantity of red oxyd of copper, which is left behind after the burning.

Painting with gold upon porcelain, or glass,

Is done with the powder of gold which remains behind after driving off the muriatic acid from a solution of that metal, or by precipitating this solution by immersing plates of copper in it. It is laid on with super-saturated borate of soda and gum-water, or oil, burned in and polished.

The gilding of glass

Is commonly effected by covering the part with a solution of super-saturated borate of soda, and applying gold-leaf upon it, which is afterwards fixed by burning.

The edges of tea cups, &c.

Are frequently gilt in a less durable manner by applying a very thin coat of amber varnish, upon which gold-leaf is to be fixed, and when the varnish is dry, the gold is burnished.

The gilders of wood, and other compositions designed to supply the place of carved work, make use of gold-leaf, which is either laid on with size, or boiled oil, and afterwards burnished.

For information on *hot gilding*, *Grecian gilding*, *cold gilding*, and *wet gilding*, see Gren's Chemistry, vol. ii. p. 282. For the muriate of gold, see Salts of Gold.

SECTION II.

OF PLATINUM.

Experiment 1. If equal parts of crude platinum and super-tartrate of potash be mixed, and introduced into a crucible, and exposed for two hours to a violent heat, the platinum fuses, and if it be now exposed to a very strong heat under a muffle, the platinum will remain in a malleable state ; or,

Experiment 2. If common platinum be dissolved in nitro-muriatic acid, and the solution decomposed by muriate of ammonia; and the precipitate thus obtained be exposed to a violent heat, stamping it when of a white heat into a mass, pure platinum will be produced ; or,

Experiment 3. According to Richter, dissolve crude platinum in nitro-muriatic acid, and add potash until a precipitate begins to appear, and then sulphate of potash, till the whole is precipitated. Wash the precipitate, dry it, and mix it with 1.5 times its weight of soda, freed from its water of crystallization; introduce the mixture into a crucible, apply heat gradually, and pure platinum will be obtained ; or,

Experiment 4. According to Jannetty, triturate common platinum with water to wash off every contaminating matter that water can carry away. Mix the platina with about one-fifth part of arsenious acid and one fifteenth part of potash ; putting the whole in a proper crucible, in the following manner : having well heated the crucible and the furnace receiving it, put in one-third of the mixture, apply to this a strong heat, and add one-third more : after a renewed application of heat, throw in the last portion. After a thorough fusion of the whole, cool and break the mass. Then fuse it a second time, and, if necessary, even a third time, till it ceases to be magnetic. Break it into small pieces, and melt those pieces in separate crucibles, and in portions of a pound and a half of the platinum to each crucible, with an equal quantity of arsenious acid and half a pound of potash. After cooling the contents of the different crucibles in a horizontal position, in order to have them throughout of equal thickness, heat them under a muffle to volatilize the arsenious acid, and maintain them in this state without increase of heat, for the space of six hours. Heat them, next, in common oil, till the oil shall have evaporated to dryness. Then immerse them in nitric acid, boil them in water, heat them to redness in a crucible, and hammer them into a dense mass. They are now fit to be heated in a naked fire, and hammered into bars for the purposes of commerce.

The rationale of these different processes will be given in the course of the experiments on this metal.

Remark. Platinum, which from its colour has been called *white gold*, has been found in small grains, combined with palladium, osmium, rhodium, iridium, iron, copper, &c. It was unknown, however, as a distinct metal, before the year 1749. Many experiments were instituted upon this new metal at different periods since its discovery. Dr. Wollaston and Mr. Tennant have thoroughly investigated the subject.

Platinum, when pure, is of a white colour. Its hardness is 8. Its specific gravity, after being hammered is 23.000; it is therefore the heaviest body known. It is ductile and malleable. It possesses considerable tenacity; a wire of platinum 0.078 inch in diameter is capable of supporting a weight of 274.31lbs. avoirdupois, without breaking. It is one of the most infusible of all metals. It may be fused by the heat of a burning glass, the assistance of oxygen gas, and by the galvanic spark. When pure, its parts may be welded together, but it first must be heated to whiteness. It may be oxydized in the following manner:

Experiment 5. Dissolve platinum in nitro-muriatic acid, and add lime water until the precipitation ceases; a yellowish brown powder is thus obtained. Dissolve this powder in nitric acid, and apply heat to drive off the acid. The product is now the *per oxyd of platinum*, *Rationale.* The nitro-muriatic solution is decomposed by the lime water, and oxyd of platinum is precipitated. The metal is still further oxydized by the assistance of nitric acid, which is in part decomposed, and the metal is finally oxydized to the maximum.

Remark. The per oxyd of platinum heated to redness parts with its oxygen. It contains 87 parts of platinum and 13 of oxygen in the hundred.

Experiment 6. If the per oxyd be gradually heated, it parts with a portion of its oxygen, assumes a green colour, and, according to Chenevix, is changed into the prot-oxyd of platinum.

Remark. The prot-oxyd is composed of 93 platinum, and 7 oxygen in the hundred.

Experiment 7. If to ten parts of nitro-muriatic acid, one part of platinum be added, a violent action will ensue, and the metal will become dissolved; and,

Experiment 8. If this solution be evaporated, very small crystals of muriate of platinum will be deposited.

Rationale. The nitro muriatic acid first oxydizes the metal, and then dissolves the oxyd; the evaporation of which, in the last experiment, produces the muriate of platinum, a proof that the platinum is combined with the muriatic acid. The platinum may be precipitated from this menstruum by various bodies; as,

Experiment 9. If to a solution of platinum in nitro-muriatic acid, either soda, potash, or lime water be added, the metal will be precipitated in the form of an oxyd; but,

Experiment 10. When potash is added, it first throws down a triple compound, consisting of the oxyd of platinum, alkali, and acid. If more alkali be used, the precipitate is pure oxyd of platinum.

Experiment 11. Soda used in the same manner produces the same effect.

Experiment 12. Ammonia also, at first, precipitates a triple compound, an ammoniacal muriate of platinum, and towards the end a pure calciform powder, or oxyd of platinum.

Experiment 13. If to a solution of muriate of platinum, another of muriate of ammonia be added, a precipitate will be formed.

Rationale. As this precipitate is a sub-muriate of platinum and ammonia, a triple salt, it is obvious, that the muriate of ammonia not only separates the metal from its solution, but combines with it into an ammoniacal muriate of platinum, from which the platinum may be separated by exposing the precipitate to a strong heat, the muriate of ammonia being evolved; but,

Experiment 14. If muriate of ammonia be added to a solution of gold, no precipitate will appear. Hence by this test platinum may always be known from gold.

Experiment 15. Prepare a very dilute and colourless solution of platina by dropping a small quantity of the nitro-muriate of that metal into a glass of water. If a single drop of the solution of muriate of tin be added to this, a bright red precipitate will be instantly produced.

Remark. Hence the muriate of tin may be used as a test for platinum.

Experiment 16. If prussiate of potash be mixed with a solution of platinum, no effect will ensue; or,

Experiment 17. If sulphate of iron be used in the same manner, no precipitate will be formed; but,

Experiment 18. If tincture of galls be added, a precipitate of a dark green colour will appear, which becomes gradually paler by standing.

Remark. Should a precipitate be formed in either of the other cases, the presence of other metals may be inferred. In the latter experiment, the gallic acid in the tincture is the precipitant.

Experiment 19. If nitro-muriate of platina be mixed with a fourth part of its bulk of ether, and the mixture suffered to settle, the ethereal solution of platina will float, and may then be poured off. If polished brass and some other metals be immersed in this solution, the surface will be instantly covered with a coat of platina. This process may be applied to many useful purposes.

Remark. Mr. Stodart has discovered the above method of covering other metals with platinum. Mr. S. found, that like gold, it may be taken from its solution by sulphuric ether.

Experiment 20. If equal parts of glacial acid of phosphorus and platinum, mixed with an eighth of charcoal, be put into a crucible, and a stratum of charcoal powder put on it; and the whole exposed to an intense heat for one hour, a button of *phosphuret of platinum* of a silver white colour will be formed.

Rationale. The charcoal decomposes the phosphoric acid, carbonic acid is disengaged, and the phosphorus combines with the metal forming a phosphuret.

Remark. M. Pelletier made this preparation by exposing the phosphoric acid and platinum, mixed with charcoal, to the action of a heat equal to 32º of Wedgwood's pyrometer; or,

Experiment 21. According to Pelletier, if phosphorus be projected on red hot platinum, the metal instantly fuses, and forms with it a phosphuret of platinum.

Experiment 22. If, into an ignited crucible a mixture of phosphuret of platinum and oxymuriate of potash be thrown, a detonation will ensue, and the platinum become separated in its metallic form.*

Rationale. The oxygen of the oxymuriatic acid unites with the phosphorous, forming the phosphoric acid, which in part combines with the potash of the decomposed oxymuriate, forming phosphate of potash, and the metal is revived; or,

Experiment 23. If nitrate of potash be used in the same manner, a detonation will also ensue.

Experiment 24. If pure potash be fused in a platinum crucible, it will be found that the vessel has lost part of its weight, which is dissolved by the potash; for,

Experiment 25. If the alkali be afterwards dissolved in water, and saturated with muriatic acid, a triple salt will be obtained by evaporation, composed of platinum, muriatic acid, and potash.

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* Gren.

Experiment 26. If sulphuretted hydrogen gas be passed through a solution of platinum, or water impregnated with that gas be added, the metal will be precipitated in dark brown flakes.

Remark. Proust is of opinion, that the precipitate occasioned by sulphuretted hydrogen, is a true sulphuret of this metal. See Hydrosulphurets.

Platinum combines with most of the metals. With gold it forms an alloy of different colours, according to the quantity of the platinum. Thus, an alloy of one part of platinum with four parts of gold can scarcely be distinguished in appearance from pure platinum. The colour of the gold becomes predominant when it constitutes eight ninths of the alloy.

Various experiments have been made on this subject by Vauquelin, Hatchett, and Klaproth.*

Dr. Wollaston has discovered, that platinum is a remarkably slow conductor of caloric; for he found that when equal pieces of silver, copper, and platinum, were covered with wax, and heated at one end, the wax was melted 3¼ inches on the silver; 2½ on the copper; and 1 inch only on the platinum. Its expansion by heat is considerably less than that of steel.

SECTION III.

OF SILVER.

Experiment 1. If sulphuretted or vitreous silver ore be roasted, and then melted with lead and borax, or some other flux to assist the fusion, metallic silver will be obtained.

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* Vauquelin, *Manuel de l'Essayeur* p. 44, &c. Hatchett on the alloys of gold, &c. *Phil. Trans.* 1803. Klaproth, *Journ. de Chim.* iv. 29.

Rationale. The roasting separates the sulphur, which is altogether disengaged, if any should remain, by the subsequent operation; but, as the silver is generally alloyed with other metals, it is separated from them by cupellation, or fusion with lead or bismuth.

Remark. The extraction of silver from its ores is different in different countries, and the process is varied according to the nature of the ore. In South America the silver is separated, after the mineral has been pounded, roasted, and washed, by trituration with mercury. The alloy thus formed is washed, then strained through leather, and exposed to heat to drive off the mercury. The silver is then melted, and cast into bars or ingots. An enumeration of the different ores of silver may be found in the classification of ores. Pure silver may be obtained in the following manner:

Experiment 2. Dissolve the silver of commerce in nitric acid, and precipitate with a diluted solution of sulphate of iron; or precipitate with common salt, and form the precipitate into a paste with soda, and fuse it with a brisk heat. This process gives a button of pure silver.

Rationale. The nitric acid dissolves the silver, forming a nitrate of silver, and, in the process with common salt, the muriatic acid precipitates it in the form of a muriate of silver, whilst the nitric acid passes to the soda, forming nitrate of soda. When the precipitate, or muriate of silver, is exposed with soda to the action of heat, the muriatic acid quits the silver, and unites with the soda.

Experiment 3. If to a silver ore soluble in nitric acid, that acid be added, and the solution decomposed by muriate of soda, every 100 parts of the precipitate will indicate 75 of silver; but,

Experiment 4. If the ore should be insoluble in nitric acid, which is the case with the corneous silver ore, it may be decomposed, and the silver obtained from it, by treating it with carbonate of soda in a crucible, as stated in Experiment 2.

Rationale. The muriated or corneous silver ore is decomposed by the carbonate of soda, muriate of soda is formed, and the silver is separated.

Experiment 5. If the solution of silver should contain lead, as that metal is also precipitated by muriate of soda, the silver may be separated by immersing into it a strip of copper, which precipitates it in a metallic state.*

Remark. Silver, like gold, has been known from the earlier ages. It is a white metal. When melted its specific gravity is 10.474; when hammered 10.510. It is very malleable. It may be beat into leaves of $\frac{1}{100000}$ inch thick. It is so ductile, that it may be drawn out into a wire much finer than a human hair. A single grain may be extended about 400 feet in length. A wire of silver 0.078 inch in diameter is capable of supporting a weight of 187.13lbs. avoirdupois, without breaking.

When completely red hot, silver melts, and increases in splendour. The temperature necessary for the fusion of silver is 22° of Wedgwood. When exposed for a long time to heat, it gradually loses in weight.

Experiment 6. If silver be melted, and its surface gradually cooled; and if the liquid part of the metal be poured out as soon as the surface congeals, crystals of silver may be obtained.

Remark. By this method Tillet and Mongez, junior, procured silver in four sided pyramids, both insulated and in groups.

Experiment 7. If silver be dissolved in nitric acid and the solution decomposed by adding lime water, an oxyd of silver will be precipitated.

Remark. Silver unites with oxygen by precipitation, although it is asserted, that if silver be melted and long exposed to the air it will absorb oxygen, but the proportion is small. Klaproth found the oxyd pro-

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* For the different methods of analysing silver ores, see Klaproth's Essays, i. p. 554, &c.

duced by precipitation to contain 89 parts of silver, and 11 parts of oxygen. Thomson considers it the per-oxyd. The prot-oxyd, according to Proust, may be formed in the following manner:

Experiment 8. Dissolve silver in nitric acid, and then heat the solution in contact with a portion of the metal in the state of powder.*

Experiment 9. If the precipitate obtained by adding lime water to a solution of silver in nitric acid, be mixed with liquid ammonia, and stirred till it assumes a black colour, and the product then dried in the air, the *fulminating silver* of Berthollet will be formed.

Rationale. The oxyd of silver unites with a part of the ammonia, forming an ammoniated oxyd of silver.

Remark. This powder is so extremely dangerous, that when once prepared it cannot be touched without danger. It explodes by the mere touch of any substance. A single grain is sufficient to shew its effect.

In the fulmination of this powder, by the slightest friction, or the application of heat, the oxygen of the oxyd unites with the hydrogen of the ammonia forming water, whilst the silver is reduced, and azotic gas emitted. The aqueous vapour, as well as the gas being considerably augmented in volume by the caloric which is disengaged, accounts for the extreme power of the powder. It is said that the oxyd of silver, combined with the ammonia, contains more oxygen than the oxyd of gold in the preparation of fulminating gold, to which some attribute its superior power.

Experiment 10. If the liquor which is separated from the precipitate, be slowly evaporated, crystals are formed, which explode more violently than the powder.

Experiment 11. If oxymuriate of alumina, formed by passing oxymuriatic acid gas through water containing alumina, be digested on phosphate of silver,

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* Nicholson's Journal, xv. 376.

and the mixture gradually evaporated, hyper-oxymuriate of silver, or Chenevix's fulminating silver will be formed. The phosphate of silver is prepared, by decomposing phosphate of soda with nitrate of silver.

Rationale. When oxymuriate of alumina is decomposed by phosphate of silver, the phosphoric acid unites with the alumina, whilst the oxymuriatic acid in its turn combines with the silver, forming the fulminating silver of Chenevix. If a single grain of this powder, added to two or three of sulphur, be gently rubbed, a violent explosion ensues. The following process for preparing fulminating silver, is given by professor Silliman.*

Experiment 12. Pulverise 100 grains of the common lunar caustic of the shops, (nitrate of silver) Add to it one ounce of alcohol, and one ounce of nitric acid. If these agents are good, there will be a violent action. But this will not happen with these fluids as they are commonly found, and generally it will be necessary to apply a very gradual heat, which must be removed as soon as the action comes on. Very soon a thick white precipitate will appear; distilled water may then be thrown on to check the action, if becoming too violent; the precipitate must be washed in distilled water, after having been separated by the filter, or, by decantation, and will fulminate powerfully by heat or friction. A convenient way of exploding it is to place a grain or two of it on the blade of a knife, and hold it over a candle.

Experiment 13. If silver be dissolved in nitric acid, and the solution evaporated until it becomes thick, and then poured into moulds, the *lunar caustic* of the shops will be formed. See Salts of Silver.

Rationale. The nitric acid first oxydizes the silver, and then dissolves the oxyd, forming nitrate of silver. If the solution be suffered to stand, it will form into tabular crystals.

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* Notes to Henry's Chemistry.

Experiment 14. If paper be written on with a weak solution of nitrate of silver, the writing will be invisible until exposed to the sun's rays; hence the formation of the silver sympathetic ink. See Light.

Experiment 15. If a solution of nitrate of silver be applied to any animal or vegetable substance, it will be stained of a black colour.

Experiment 16. If half an ounce of nitrate of silver be dissolved in 16 ounces of distilled water, the solution for *blacking hair* will be formed.

Remark. This is applied to the hair once or twice a-day, and when it has been used for a few days, the hair will become of a durable black colour.

Experiment 17. If a solution of silver be applied to a slip of ivory, till it has acquired a bright yellow colour, then exposed to the sun's rays in a glass of water, the ivory will be stained black. After two or three hours have elapsed, it may be gently rubbed, and its surface will exhibit a coat of silver. See Light.

Experiment 18. If white paper be wetted with a solution of nitrate of silver, prepared by dissolving one-part of the nitrate in 10 of water, and then exposed to the light, it gradually acquires colour, and passes through a succession of changes to black. The common beams passing through red glass, have very little effect upon it; yellow and green are more efficacious; but blue and violet produce the most powerful effects This property has been taken advantage of by Mr. T. Wedgwood, for copying paintings on glass, and transferring them to leather or paper.* See Light.

Remark. Nitrate of silver may be employed for staining marbles and jaspers.

Experiment 19. Prepare two glasses of rain water, and into one of them drop a single drop of sulphuric acid. Pour a little *nitrate of silver* into the other glass, and no change will be perceptible. Pour some of the

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* See Nicholson's Journal, 8vo. iii. 167.

same solution into the first glass, and a white precipitate will appear.

Experiment 20. Prepare two glasses as in the last experiment, and into one of them put a drop or two of *muriatic acid*. Proceed as before, and a precipitate will be produced.

Experiment 21. Take two glasses, as in experiment 19, and into one of them put a drop of sulphuric acid, and a drop or two of muriatic acid: proceed as before with the *nitrate of silver*, and a mixed precipitate will be produced.

Experiment 22. Take the glass containing the mixed precipitate of the last experiment, and give it, by means of a lamp, the heat of boiling water. The sulphate of silver, if there be a sufficiency of water, will now be re-dissolved, and the muriate of silver will remain separate at the bottom of the vessel. This experiment exhibits a method of separating these metallic salts whenever they occur in a state of mixture.*

Rationale. The sulphuric acid, in the 19th experiment, decomposes the nitrate of silver, and precipitates the metal in the form of a sulphate. In the 20th experiment, the muriatic acid precipitates the silver in the form of a muriate. In the 21st experiment, a precipitate, consisting of muriate and sulphate of silver, is produced. The 22d experiment shews the solubility of the sulphate, and the insolubility of the muriate of silver. See Salts of Silver.

Experiment 23. If some of the crystals of nitrate of silver be thrown on ignited charcoal, the metallic salt will immediately deflagrate, throw out the most beautiful scintillations that can be imagined, and the surface of the charcoal will have acquired a coat of metallic silver.

Rationale. The charcoal decomposes the nitrate; the oxygen of the nitric acid as well as of the oxyd of silver, with which the acid is combined, is disen-

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* Parke.

gaged in union with a portion of the carbon in the form of carbonic acid, whilst the silver is reduced.

Experiment 24. Dissolve dry nitrate of silver in pure water; add a little oil of turpentine, shake the mixture, and cork it close, Submit the phial with its contents to the heat of boiling water for an hour, when the metal will be revived, and the inside of the phial, where the oil reposed on the aqueous solution, will be beautifully silvered, the revived metal forming a metallic ring, extending quite round the phial.

Rationale. The turpentine, assisted by the temperature of boiling water, decomposes the nitrate of silver, by which the silver is revived.

Experiment 25. If writing, performed with a solution of nitrate of silver, be exposed over a vessel containing a hot solution of sulphuret of ammonia, although before invisible, will appear very distinct. The silver will be revived.

Rationale. Analogous to the former reductions.

Experiment 26. If standard silver be dissolved in nitric acid, and the solution afterwards diluted, the *silver test* for detecting counterfeit silver coin will be formed.

Experiment 27. If charcoal be treated with nitrate of silver, in the same manner as described under the article of gold, the solution will be decomposed, and the metal revived on the coal. See Gold.

Experiment 28. If a diluted solution of nitrate of silver, thickened with a little gum arabic, be applied to linen, wearing apparel, &c. it will communicate an indelible stain. Hence a solution of nitrate of silver has been used as an *indelible* or *permanent marking ink.* Or,

Experiment 29. If to a solution of nitrate of silver or lunar caustic, prepared by dissolving about 60 grains in four or six ounces of water, half an ounce of tincture of galls be added, the marking ink improved by Dr. Woodhouse will be formed.

Remark. Different modes have been employed for using the ink. In the kind sold in the shops, the place on which the mark is to be applied is first wetted with a solution of carbonated alkali, and then dried, after which the solution or marking ink is put on. Then by a double exchange of principle, carbonate and oxyd of silver is fixed on the stuff, while the nitrate of potash also formed, may be washed off. By using the tincture of galls, it is asserted, that a gallate of silver is formed; to which as well as to the carbonate of silver, which is produced, the indelible property of the ink of Dr. Woodhouse is attributed. Various formulæ have been published for preparing the indelible writing ink.

Experiment 30. If muriatic acid be digested on silver, no solution will be formed; but,

Experiment 31. If that acid be added to nitrate of silver in solution, the metal will be precipitated in the form of a muriate, as before noticed.

Experiment 32. If the muriate of silver, thus formed, be exposed to the sun's rays, it will be changed from a white colour to brown, and afterwards to black. See Light.

Experiment 33. If muriate of silver be fused in a crucible, it acquires a semi-transparent appearance and the consistency of horn; hence it was formerly called *horn silver*.

Experiment 34 If one part of muriate of silver be mixed with three of soda freed from water, and exposed in a crucible to a white heat, pure silver will be obtained. See Experiments 2 and 4.

Rationale. The muriatic acid unites with the soda, forming muriate of soda, whilst the silver is left pure.

Experiment 35. If one part of silver filings be put into a retort with six of concentrated sulphuric acid, and heat applied, the silver will combine with the acid forming the sulphate of silver. See Salts of Silver.

Rationale. The sulphuric acid first oxydizes the silver, and then combines with the oxyd, at the same time sulphurous acid gas is disengaged. If the residue be dissolved in a large quantity of boiling water, and the solution filtered and evaporated, crystals of sulphate of silver may be obtained.

Experiment 36. If a few drops of a solution of silver in nitric acid, be put upon a piece of slate, by means of a camel's hair pencil or feather; and if a copper or brass wire be placed at the bottom of it in contact with the fluid, and the whole suffered to remain undisturbed in a horizontal position, a beautiful vegetation of the silver will be formed. If a microscope be used for viewing the phenomena, it will appear in a beautiful manner.

Rationale. The copper, or brass, has a greater affinity for oxygen than the silver; consequently the nitrate is decomposed, and the silver precipitated

Experiment 37. If one part of silver leaf, and seven of mercury be triturated in a mortar, an alloy posessing but little consistence will be produced.

Experiment 38. If, according to Lemery, one part of fine silver be dissolved in weak nitric acid to saturation, the solution diluted with about twenty parts of distilled water, and two parts of mercury added, the arbor Dianæ, or Dianæ's tree will be formed; or,

Experiment 39. According to Baume, mix together six parts of a solution of silver and four of a solution of mercury, both made with nitric acid, and completely saturated: add to them a little distilled water, and put the mixture into a conical vessel, into which have been previously introduced six parts of an alloy made of seven parts of mercury and one of silver; or,

Experiment 40. Dissolve three drachms and forty-eight grains of pure silver, and half as much mercury, seperately, in a sufficient quantity of pure nitric acid. Mix the solution and add to it five or six ounces of distilled water. This must be poured upon seven drachms and twelve grains of an amalgam of silver of the consistence of butter, which has been previously put into a spherical vessel of glass. The vessel must be kept undisturbed, and in about 24 hours a very beautiful silver tree will be formed; or,

Experiment 41. According to Homberg, make an alloy in the cold, of four parts of silver leaf and two parts of mercury; dissolve this alloy in a sufficient quantity of nitric acid, and add to the solution distilled water. If we put into this liquor a small ball of soft alloy of silver, a precipitation of silver immediately takes place.

Rationale, In all these experiments the silver is separated by means of the mercury. In experiment 40, the mercury held in solution, attracts that of the amalgam, and the silver in like manner, attracts that which is held in solution. The consequence is, that the silver is precipitated. The mercury in the amalgam being more abundant than would be necessary for precipitating the silver of the solution, has a tendency also to combine itself with the silver.

Experiment 42. If thin plates of silver and sulphur be laid alternately above each other in a crucible, they melt readily in a low red heat, and form sulphuret of silver.

Remark. According to the analysis of Klaproth, it is composed of,

85	silver
15	sulphur
100	

Hence 100 parts of silver unite with about 17.6 parts of sulphur.

Silver contracts, when long exposed to the air, especially in frequented places, as churches, theatres, &c. a covering of a violet colour, which deprives it of its lustre and malleability. This covering, which forms a thin layer, can only be detached from the silver by bending it, or breaking it in pieces with a hammer. It was examined by Mr. Proust and found to be sulphuret of silver.

On the principle of silver combining with sulphur, Mr. Hatchett informs us, is practised a deception in England by diminishing the current silver coin. It is done, says he, in the following manner: They expose the coin to the fumes of burning sulphur, by which a black crust of sulphuretted silver is soon formed, which, by a slight but quick blow, comes off like a scale, leaving the coin so little affected, that the operation may sometimes be repeated twice or thrice, without much hazard of detection.

Experiment 43. If the sulphuret of silver obtained according to the foregoing process be exposed to heat, the sulphur will be disengaged from the silver.

Experiment 44. If the sulphuret be detonated with nitrate of potash, the silver will remain unaltered.

Experiment 45. If silver be fused with a fixed alkaline sulphuret, it is dissolved, and may be rendered miscible with water.

Experiment 46. If to this solution, an acid be added, the silver is precipitated, in the state of an hydrosulphuret. See Hydrosulphurets.

Experiment 47. If one ounce of silver, one ounce of phosphoric glass, and two drams of charcoal be mixed together, and heated in a crucible, phosphuret of silver is formed.

Rationale. The charcoal decomposes the phosphoric glass, or phosphoric acid, and the phosphorus thus disengaged, unites with the silver into a phosphuret. It is composed of four parts of silver and one of phosphorus.

Experiment 48. If the phosphuret, thus formed, be exposed to heat, the phosphorus will be disengaged, leaving the silver pure.

Remark. Silver unites readily with the greater number of metallic bodies.

One part of silver is sufficient to render twenty parts of gold considerably pale. This alloy, or mixture of gold and silver, is used for various purposes, and also for coin. As gold and silver have different solvents, their separation may be readily accomplished. See Gold.

Besides the use of nitro-muriatic acid for the separation of gold, and of nitric acid for the solution of silver, there is another mode of separating silver by a process called cementation. For this purpose the alloy of silver and gold is made into leaves, which are placed *stratum superstratum* with a cementing powder, composed of such ingredients as would disengage either muriatic or nitric acid vapours by the action of a moderate red heat. Of the first kind is a composition of equal parts of muriate of soda and sulphate of iron, calcined to redness, with four parts of brick dust; of the second, a mass of nitrate of potash and calcined sulphate of iron, blended with brick dust in the same proportions. Neither of these neutral salts should be contaminated with the other. The acid vapours disengaged in either cementing powder, corrode the silver, leaving the gold untouched. After the cement has been diligently separated from the plates, they are washed. As the cementing powder contains the silver, its separation is accomplished by melting the mass with litharge and charcoal dust, and by subsequent cupellation or scorification.

There is another process for separating silver from gold, founded on the affinity of silver with sulphur. It is called *dry parting*, or separation by casting and fusion. The alloy, being finely granulated, and mixed with a sixth or eighth part of sulphur, is fused in a black lead crucible, and then poured into a hollow metallic cone. The sulphur combines with the silver into a sulphuret, and after cooling the gold is found among the scoria of the sulphuret. In order to separate all the silver, the process is repeated. If the sulphuret of silver be roasted under the muffle, the silver is disengaged.

Silvering. This is an art which consists in giving a covering of silver to the surface of bodies, in the following manner:

Experiment 49. If two drachms of super-tartrate of potash, the same quantity of muriate of soda, and half a drachm of sulphate of alumina, mixed with fifteen or twenty grains of silver, precipitated from nitrate of silver by copper, be applied to the surface of copper, by rubbing it with this powder, it will acquire a coat of silver. It may be afterwards polished with leather. For the purpose of covering the wares of saddlers and harness makers, the following cheap silvering is generally used:

Experiment 50. Half an ounce of silver that has been precipitated from nitrate of silver by the addition of copper, muriate of soda, and muriate of ammonia, of each two ounces, and one drachm of muriate of mercury, are triturated together and made into a paste with water.

Remark. Mr. Accum observes, that with this, copper utensils of every kind, that have been previously boiled with acidulous tartrate of potash, and sulphate of alumina, are rubbed; after which they are made hot, and then polished The intention of this process appears to be little more than to apply the silver in a state of minute division to the clean surface of the copper, and afterwards to fix it there by fusion; and accordingly this silvering may be effected by using the argentine precipitate here mentioned with supersaturated borate of soda, or mercury, and causing it to adhere by fusion. Various instruments, as well as dial plates, the scales of barometers, &c. may be silvered by rubbing them with the following mixture, viz. muriate of silver, muriate of soda, and super-tartrate of potash, and washing off the saline matter with water. The coating given by this mixture is not durable, but may be improved by heating the article, and continuing the operation until the covering becomes sufficiently thick.

Experiment 51. If silver leaf be triturated in a mortar with honey or mucilage of gum arabic, and afterwards the honey or gum washed off, and the silver put in shells, the *shell-silver* for the use of painters will be formed.

Plating, or the art of covering the surface of copper with silver, is performed in the following manner: plates of silver are bound with iron wire, on small ingots of copper, in the proportion of about one ounce of silver to twelve ounces of copper. Upon the edges of the copper, not covered with the silver, a little borax is put. When heat is applied, the borax melts, and contributes to fuse that part of the silver in contact with it. The ingot, in this situation is rolled under steel rollers, till it acquires a certain thickness.

In the manufacture of French plate, the copper is heated, silver leaf is then applied, and the burnisher is used to finish it.

SECTION IV.

OF MERCURY.

Experiment 1. If two parts of red sulphuret of mercury (cinnabar) reduced to powder and mixed with one of iron filings, be put into a stone retort, the neck of which is then introduced into a receiver filled with water, and heat applied until the retort is of a red colour, mercury will come over.

Rationale. The sulphuret of mercury is decomposed by the iron filings; the sulphur combines with the iron, forming a sulphuret of iron, and the mercury is disengaged, which is then volatilized, and condensed in the receiver.

Experiment 2. If to a solution of corrosive muriate of mercury, ammonia be added, and the precipitate thus obtained heated in a retort by itself, or mixed with oil, mercury will be obtained.

Rationale. The ammonia unites with the muriatic acid of the muriate, forming muriate of ammonia, at the same time an oxyd of mercury is precipitated. The oxyd when exposed to heat is decomposed, and the mercury is obtained pure.

Remark. Mercurial ores, if they be sulphurets, are best analyzed by distilling a mixture of three parts of the ore and one of lime, or iron filings, in a strong red heat, in the manner stated in Experiment 1. For the different modes of examining mercurial ores, consult Klaproth's Analytical Essays. The different ores of this metal are enumerated in the table of the classification of ores. The colour of mercury is similar to that of silver. It is also known by the names of *hydragyrum*, *argentum vivum* and *quicksilver*. Its specific gravity is 13.568. In a solid state, which is effected by artificial means, its density is increased; its specific gravity being about 14.4. Mercury may be rendered solid, according to

Mr. Pepys, who froze 56lbs. of it, in the following manner:

Experiment 3. Into a mixture consisting of muriate of lime, 2lbs. at + 33°, and the same weight of snow at + 32°, which will produce a cold equal to — 42°, introduce a bladder containing the mercury. When the mixture has robbed the mercury of so much of its heat, as to have its own temperature thereby raised from — 42° to + 5°, another mixture of the same kind and quantity is to be made, which will give with a spirit thermometer — 43°. If a cloth be used, in order to suspend the bladder containing the mercury, the mercury may be received into it, and put gently into this new mixture, where it will be cooled still lower than before. Five pounds of muriate of lime, placed in a large pail made of tinned iron, is now to be placed in a cooling mixture in an earthen ware pan. The mixture in the pan, in Mr. Pepy's experiment, which consisted of 4lb. of muriate of lime, and a like quantity of snow of the same temperature as the former, in one hour reduced the 5lbs. of muriate in the pail to — 15°. The mixture was then emptied out of the earthen pan, and four large corks at proper distances, placed on its bottom to serve as rests for the japanned pail ,which is now put into the pan. The corks answer the purpose of insulating the inner vessel, while the external one kept off the surrounding atmosphere, and preserved the air between the two at a low temperature.

In the experiment of Mr. Pepys, to the five pounds of muriate of lime which had been cooled, as already noticed to — 15°, and which still remained in the metallic vessel, was now added snow, uncompressed and free from moisture, at the temperature of 32°. In less than three minutes it gave a temperature of — 62°, a degree of cold which was never produced before, being 94° below the freezing point of water.

The mercury by immersion in the second cooling mixture, will be reduced to about — 30°, and is to be cautiously put into the last made mixture of — 62°; the bladder containing the mercury, is now to be suspended from net-work into the mixture, but prevented from touching the vessel: in the course of an hour and a half the mercury will be completely frozen, and the temperature of the mixture will indicate about — 46°.

Remark. Large pieces of mercury, thus frozen, may be kept some time in a solid state. In conducting the experiment, vessels, which are bad conductors of heat, should be used.

The temperature necessary for freezing mercury is — 39°. This effect of the congelation of mercury is owing to the abstraction of caloric from that metal, which is accomplished by the freezing mixture. That mercury might be rendered cold was accidentally discovered by professor Braun at Petersburg in 1759. The experiment was afterwards repeated in England and France, and in the United States. Solid mercury may be subjected to the blows of a hammer, and may be extended without breaking. It is therefore malleable. Mercury as it occurs is always in a fluid form, because its fusibility is so great, that the ordinary temperature of the atmosphere is sufficient to preserve it in that state. At the poles, however, mercury in all probability would remain solid.

Experiment 4. If a lump of frozen mercury be dropped into a cup of warm water, it will become fluid, and the fluid water in the same instant will become solid.

Rationale. The temperature of the water is reduced by the solid mercury to 32 or below 32°, which therefore freezes, whilst the frozen mercury absorbs the caloric of the water, and becomes fluid.

Experiment 5. If mercury be exposed to the temperature of 65-6°, it boils, and is converted into vapour.

Remark. Mercury may, therefore, be evaporated and distilled; the vapour of which is invisible and elastic like common air. By the distillation of mercury it is purified; if it be entirely pure, no residuum is left. Mercury is not altered by water. As that fluid has the property of oxydizing some metals, with which mercury is sometimes contaminated, its purification has been proposed by Dr. Priestley in the following manner:

Experiment 6. Put mercury into a vial with water; shake the vial occasionally; and let the whole remain for some time. Pour off the fluid, which contains those metals in an oxydized state, and the quicksilver will remain pure.

Rationale. Water has the property of oxydizing some metals, whereas on others it has no effect. Hence, when they are thus converted into oxyds, they separate from the mercury. I have tried this method, and found it to answer; if the mercury, however, contains gold or silver, it is then only purified by distillation. Some chemists, as Wasserburg, are of opinion that the oxyd formed by the agency of water on mercury, is nothing more than the black oxyd of mercury.

Experiment 7. If mercury be agitated for some time in oxygen gas, or in common air, it is converted into the black oxyd.

Remark. This oxyd, the prot oxyd, contains about 7.5 per cent. of oxygen. The black oxyd of mercury may be obtained, according to Saunders, in the following manner:

Experiment 8. Triturate submuriate of mercury with lime water, till the former is completely decomposed, and a black powder will remain.

Rationale. The muriatic acid of the muriate unites with the lime, whilst the oxyd of mercury is separated in the form of a black powder.

Remark. What is called the ash coloured oxyd of mercury in the Dispensatories, appears to be a subnitrate of mercury and ammonia. See salts of mercury.

The preparation called *hydragyrum cum creta*, formed by triturating quicksilver with chalk, contains mercury, according to Fourcroy, with 0.04 of oxygen. When mercury is triturated with viscid substances, as fats, honey, syrups, &c. or with pulverent substances, for the purposes of medicine, it appears to be oxydized to the *minimum*. The solution of mercury in nitric acid, prepared without the assistance of heat, contains an oxyd, according to Chenevix, composed of 89.3 mercury, and 10.7 oxygen.

Experiment 9. If mercury, or its prot-oxyd, be exposed to the heat of about 600° it assumes a red colour. This oxyd is called the per oxyd ; or,

Experiment 10. If mercury be introduced into a mattrass with a long neck, and placed in a sand bath heated constantly to the boiling point, its surface will become black, then red, and at last the whole will be converted into the *precipitate per se.*

Rationale. The mercury gradually absorbs oxygen, and forms the red oxyd. This oxyd, contains seven per cent. of oxygen.* The precipitate per se, known also by the name of calcined mercury, has been administered as a medicine.

Experiment 11. If mercury be dissolved in nitric acid, the solution evaporated to dryness, and exposed to a strong heat, it assumes a red colour.

Rationale. The oxydizement of the mercury is effected, in this instance, by the decomposition of nitric acid; nitric oxyd gas is disengaged, and the mercury combines with oxygen. This preparation, however, as it is considered a variety sub-nitrate of mercury, will be noticed under the salts of that metal.

Experiment 12. If one part of mercury and three of sulphur, be triturated in a mortar, and the mixture moistened with water until all the mercury disappears, a black powder will be obtained.

Rationale. The sulphur unites with the mercury, at the same time some moisture is decomposed, and a black hydrosulphuret of mercury, or Ethiop's mineral, is formed ; or,

Experiment 13. If mercury be heated and poured upon sulphur in the state of fusion, and the mixture then stirred, a combination will be formed similar to the last experiment.

Remark. The black sulphuret prepared according to this mode, differs from the former in some of its properties.

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* Fourcroy.

Experiment 14. If mercury be agitated with sulphuretted hydroguret of ammonia, according to Berthollet, a black sulphuret of mercury is formed; but,

Experiment 15. If hydro-sulphuret of ammonia be used, the black precipitate formed gradually assumes a red colour, and the solution will contain sulphuretted hydroguret of ammonia.

Experiment 16. If sulphuret of potash, dissolved in water, be added to a solution of mercury, the latter will be precipitated in the form of an hydrosulphuret.

Remark. It is supposed by some chemists, as Fourcroy, that in this preparation the mercury is always oxydized; hence it is sometimes called the black sulphuretted oxyd of mercury. Proust, however, has asserted the contrary. Ethiop's mineral, again, is considered merely a sulphuret of mercury.

Experiment 17. If the black sulphuret be sublimed, a product will be obtained called the red sulphuret of mercury, or cinnabar, known also by the name of vermillion; or,

Experiment 18. According to Mr. Kirchoff, let 300 grains of mercury, and 68 of sulphur, with a few drops of a solution of potash to moisten them, be triturated in a Wedgwood's, or glass mortar, until it be converted into a black powder. Add to this 160 grains of potash, dissolved in as much water. Heat the vessel containing the ingredients over the flame of a candle, and continue the trituration without interruption during the heating. As the liquor evaporates, add water from time to time, so that the black oxyd may be constantly covered, to the depth of an inch. The trituration must be continued until the mixture begins to change from its original black colour to a brown, which usually happens when a large part of the fluid is evaporated; it then passes very rapidly to a red. No more water is now to be added, but the trituration is to be continued. When the mass has acquired the consistence of a jelly, the colour increases in brightness, with an incredible degree of quickness. The instant it has acquired its utmost beauty the heat must be withdrawn, otherwise its brilliancy will be impaired, and the red will pass to a brown colour. This red powder is also sulphuret of mercury or cinnabar.

Count de Moussin Pouschin has discovered that its passing to a brown colour may be prevented by taking it from the fire as soon as it has acquired a red colour, and placing it for two or three days in a gentle heat, taking care to add a few drops of water, and to agitate the mixture from time to time. During this exposure the red colour gradually improves, and at last becomes excellent. He discovered also, that when the sulphuret is exposed to a strong heat, it becomes instantly brown, and then passes to a dark violet; when taken from the fire it acquires a beautiful carmine red.[*]

Remark. The changes which sulphur and mercury undergo when exposed to heat, is shewn in the following experiments of Parke.[†]

Experiment 19. Take equal parts of mercury and flowers of sulphur, add a drop or two of water and grind the whole together in a glass mortar. Presently the mercurial globules will totally disappear and the mass assume a black colour. It thus becomes a black sulphuret of mercury, or the true *Ethiops mineral.*

Experiment 20. If the black sulphuret of mercury formed in the last experiment be heated in an open vessel, part of the sulphur will pass off, sulphurous acid gas will be emitted, and the mass remaining in the vessel will have acquired the colour of the *violet.*

Experiment 21. If the violet residuum of the last experiment be removed to a glass mattrass or flask, and heat gradually applied, the whole will sublime into a dark shining mass, which, by being reduced into powder, furnishes a most *brilliant scarlet.*

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[*] Nicholson's Journal, ii. 1.

[†] Parke's Rudiments of Chemistry, p. 191.

Experiment 22. If mercury and flowers of sulphur, according to the count Apollos de Moussin Pouschin, be triturated with a solution of caustic potash, keeping it at a proper temperature, and afterwards washing it repeatedly with boiling water, which carries off Ethiops, not surcomposed, the red sulphuret of mercury will be produced.*

Remark. The alkali appears to act by dissolving, or otherwise disengaging the sulphuretted hydrogen and superfluous sulphur.

Experiment 23. If sub-muriate or sub-sulphate of mercury be sublimed with sulphur, the red sulphuret of mercury, and muriate or sulphate of mercury will be formed.

Rationale. The excess of base in the mercurial salt unites with the sulphur, whilst the sub is reduced to the state of a neutral salt.

Remark. Cinnabar, according to Proust, is composed of 85 parts of mercury, and 15 of sulphur. The specific gravity of this sulphuret is about 10. It has neither smell nor taste, and is insoluble in water and in alcohol. In close vessels it sublimes entirely unchanged, but requires for this purpose a pretty great degree of heat. It is not soluble in any acid, and is only decomposed by the nitro-muriatic which dissolves the quicksilver, and separates the sulphur. It is not decomposed by boiling it with solutions of the alkalies, but is decomposed by melting it with potass, soda, lime, iron, lead, copper, antimony, and several other metals.

Experiment 24. If equal parts of red oxyd of mercury and phosphorus, with one part of water, be put into a flask, and exposed on a sand bath to heat, a blackish compound, or phosphuret of mercury will be formed.

Rationale. The oxygen of the oxyd of mercury unites with a part of the phosphorus, forming phosphoric acid, which is dissolved by the water, and the

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* Nicholson's Journal.

mercury combines with the other portion of phosphorus.

Remark. As phosphorous combines readily with the black oxyd of mercury, and as Pelletier could not succeed in combining mercury with phosphorus, without the presence of oxygen, it is inferred, that it is not a phosphuret of mercury, but a black phosphuretted oxyd of mercury.

Experiment 25. The preparation of *Howard's fulminating mercury* is made in the following manner:

One hundred grains (or a greater proportional quantity, not exceeding 500) are to be dissolved, with heat, in a measured ounce and a half of nitric acid. This solution being poured *cold* upon two measured ounces of alcohol, previously introduced into any convenient glass vessel, a moderate heat is to be applied till effervescence is excited. A white fume then begins to undulate on the surface of the liquor, and the powder will be gradually precipitated on the cessation of action and re-union. The precipitate is to be immediately collected on a filter, well washed with distilled water, and cautiously dried in a heat not exceeding that of a water-bath. The immediate washing of the powder is material, because it is liable to the re-action of the nitric acid; and while any of the acid adheres to it, it is very subject to the action of light. From 100 grains of mercury about 120 or 130 of the powder are obtained.*

Rationale. As this powder is composed of oxyd of mercury, oxalic acid, and nitrous etherized gas, it would appear, that the nitrate of mercury in its decomposition by the alcohol is resolved into oxyd of mercury; that its nitric acid, by imparting oxygen, converts the alcohol into oxalic acid, during which nitrous ether is formed; and that the oxalic acid then combines with the oxyd of mercury, together with a portion of ether, and forms the fulminating mercury.

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*Phil. Trans. 1800, p. 214.

Remark. Three or five grains of this powder produce a great explosion, when struck on an anvil or hammer. It takes fire at 368° Fahrenheit. It explodes not only by friction, but by electricity, galvanism, by the flint and steel, and by being thrown into concentrated sulphuric acid. Its detonation is thus explained: the oxygen unites with the hydrogen and carbon, forming water and carbonic acid, and a considerable quantity of caloric is liberated, which not only gives elasticity to these bodies, but also converts the mercury, which is revived, into vapour.

Experiment 26. If to a solution of mercury in nitric acid, oxalate of potash be added, a precipitate will be formed, which, if collected, washed, and dried, will fulminate; or,

Experiment 27. If red oxyd of mercury, be digested in a solution of super-oxalate of potash, or in oxalic acid, the same combination will be produced.*

Rationale. In the first process, the nitric acid of the nitrate of mercury unites with the potash, forming nitrate of potash, which remains in solution, whilst the oxalic acid of the oxalate of potash combines with the oxyd of mercury, thus separated, into an oxalate of mercury. In the second process a direct combination of the constituent parts takes place. This powder is of a gray colour, and produces a considerable detonation when struck.

Experiment 28. If a little mercury be rubbed on gold, it will give it a silvery appearance. If the gold be ignited, and conveyed into hot mercury, the combination will be facilitated.

Experiment 29. If the gold thus covered with mercury, be exposed to a red heat, the mercury will be disengaged.

Experiment 30. If silver be brought into contact with mercury, a union will take place as in experiment 27. And,

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* See a memoir of the author, on Fulminating Mercury, in Coxe's Medical Museum.

Experiment 31. If the amalgam thus found be heated, the mercury will be volatilized.

Experiment 32. If a solid amalgam of silver be melted, and suffered to cool undisturbed, it crystallizes in octahedral crystals, or else in four sided columns, with tetrahedral terminations.

Experiment 33. If copper be presented to mercury, a union will ensue, as in a former experiment.

Experiment 34. If to a solution of gold in nitro-muriatic acid, mercury be added, the gold will be precipitated in the form of a brown powder.

Rationale. The mercury takes the oxygen from the oxyd of gold held in solution, and, while the gold is precipitated, it unites with the muriatic acid, forming sub-muriate of mercury, which, being insoluble, also precipitates.

Remark. It is on account of the considerable affinity of mercury for oxygen, that the *Arbor Dianæ* is produced by mercury and silver. See Silver. Since mercury precipitates silver, but not copper from its solution in nitric acid, it furnishes an easy method to part the silver from its alloyed copper. Mercury, if assisted by ammonia, is likewise a means of reviving the silver from its muriate. For this purpose, the muriate is triturated with carbonate of ammonia ; mercury is then added, and the trituration continued. An amalgam of silver is produced, from which the mercury is separated by heat. As silver has a greater affinity for sulphur than mercury, if the sulphuret of mercury be distilled with the filings of silver, the sulphur will unite with the silver, and the mercury be reduced.

For the combinations of mercury with the different acids, see Salts of Mercury.

SECTION V.

OF PALLADIUM.

Experiment 1. If crude platinum be dissolved in nitro-muriatic acid, and the solution, previously freed from any excess of acid, mixed with prussiate of mercury, the solution will become turbid, and a pale yellowish white matter will fall. If this be collected, washed, dried, and exposed to a strong heat, a white matter will be left, which is palladium.

Experiment 2. To the product of the last Experiment add sulphur and borax, and fuse the mixture in a crucible; a metallic button of palladium will be obtained.*

Rationale. The solution of platinum is decomposed by prussiate of mercury, which according to Dr. Wollaston, precipitates palladium, exclusively of all other metals. This property, which the mercurial prussiate possesses, of precipitating palladium only, is accounted for on the great affinity of mercury for the prussic acid, which prevents the precipitation of iron or copper. In the opinion of Dr. Wollaston, the muriate of palladium in the solution is not decomposed solely by the superior affinity of mercury for muriatic acid, but is assisted also by the greater affinity of prussic acid for palladium.

Remark. This metal, which has received the name of *palladium*, or *new silver*, was discovered by Dr. Wollaston, who found it in the ore of platinum. It was called palladium from the planet that had been discovered, about the same period, by Dr. Olbers. This metal has given birth to a very extraordinary controversy, and several sets of experiments have

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* See Wollaston on Palladium. Phil. Trans. 1805.

been made on it. Mr. Cloud, of the mint of the United States, has improved the process for obtaining palladium from crude platinum.

Palladium is a white metal, rather harder than wrought iron, as malleable as platinum, and about 11.8 specific gravity. It requires a violent heat for fusion, and is not altered by exposure to the air. When heated it acquires a blue colour, which is the commencement of oxydizement.

Sulphuric acid boiled upon palladium, dissolves a portion, and acquires a red colour. Nitric acid acts more powerfully. Muriatic acid, assisted by heat, also dissolves it; but the nitro-muriatic acid dissolves with facility. The solution is decomposed by potash or lime water, which precipitates the metal of a fine orange colour, not however pure, but in combination with a portion of the acid and precipitant. With sulphur, it readily unites into a sulphuret. With phosphorus it also combines, forming a phosphuret. Liquid ammonia dissolves a portion of it, and assumes a bluish hue.

Muriate of tin precipitates palladium of a brown colour, and is considered a very delicate test for this metal; but as prussiate of mercury separates palladium from all its solutions, it is therefore the best test for the discovery of it.

Green sulphate of iron, it is said, will precipitate palladium in a metallic state. The prussiate of palladium, separated by a neutral solution of prussiate of mercury, has the property, when heated to about 500° of Fahrenheit, of detonating, with a noise similar to that occasioned by firing an equal quantity of gun powder. Hydrosulphurets, and water impregnated with sulphuretted hydrogen gas occasion a dark brown sediment from solutions of palladium. See Hydrosulphurets.

Palladium unites with various metals, an account of which may be seen in the papers of Chenevix, and Wollaston in the Philosophical Transaction of 1803, 4, and 5. For the combination of this metal with acids, see Salts of Palladium.

SECTION VI.

OF RHODIUM.

Experiment 1. Into a solution of the ore of platinum, which has been previously precipitated by the admixture of muriate of ammonia, and from which the ammoniacal muriate of platinum has been separated, suspend a cylinder, or thin slips of zinc, or iron. All the metals which are left in the solution are thus thrown down in the form of a black powder. This being done, transfer the precipitate, *without drying it*, into a flask containing very dilute nitric acid, and assist the action by a gentle heat; by this means the copper and lead become dissolved. Then transfer the residue into dilute nitro-muriatic acid, and when the solution is effected, add to it a portion of muriate of soda, equal in weight to about $\frac{1}{50}$th of the ore of platinum employed for obtaining the first solution: evaporate the whole by a gentle heat. The dry mass obtained contains the muriate of soda and platinum, palladium, and rhodium. On washing this precipitate repeatedly in small quantities of alcohol, the muriate of platinum and soda, as well as the palladium, become separated, and the salt of rhodium remains behind in a state of purity; from this the rhodium may be obtained, by merely dissolving it in water, and precipitating the solution by suspending in it a cylinder of zinc. The black powder which is obtained is rhodium. The rhodium thus prepared acquires a white metallic lustre with borax, but it appears infusible by any degree of heat. It may be rendered fusible by arsenic, and also by sulphur, both of which may again be separated by a continued heat. The metallic button thus obtained is not malleable.*

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* See Phil. Trans, 1804. p. 428.

Remark. Rhodium is of a white colour. Its specific gravity is more than 11. It is extremely infusible. It is said that no degree of heat hitherto applied is capable of melting it. It is not oxydized by exposure to heat and air, neither is it much acted upon by acids.

Rhodium readily combines with sulphur, and, like palladium, is rendered fusible by it. With arsenic also it unites, but the arsenic or sulphur may be expelled by means of heat. It forms alloys with the greater number of the metals. It does not, like platinum and palladium, destroy the colour of gold when alloyed with it.*

It may be made to unite with oxygen; the only oxyd known of a yellow colour. This oxyd may be obtained in the following manner:

Experiment 2. If the salt of rhodium mentioned in Experiment 1, be dissolved, and a solution of potash added, the rhodium will be precipitated in the form of a yellow powder, being the oxyd of this metal.

Rationale. The potash unites with the acid, and the metal is separated in the form of a yellow oxyd.

Experiment 3. If to a solution of rhodium, prussiate of potash be added, no decomposition will ensue.

Experiment 4. If to a portion of the same solution, muriate of ammonia be poured in, no precipitation will ensue.

Experiment 5. If hydrosulphuret of ammonia be used in the same manner, no effect will take place.

Experiment 6. If the carborated alkalies be added, no change will ensue; but,

Experiment 7. If the pure alkalies be employed, a precipitate of the yellow oxyd will be formed.

Remark. Hence it is, that this metal differs from others in its chemical properties.

Experiment 8. If an alloy of silver or gold with rhodium, be digested in nitric or nitro-muriatic acid, the rhodium will remain untouched; but,

Experiment 9. If it be alloyed with three times its weight of bismuth, copper or lead, each of these alloys

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* See Dr. Wollaston's paper in the Phil. Trans.

may be dissolved completely, in a mixture, by measure, of two parts muriatic acid with one of nitric.

The lead appears preferable, as it is reduced, by evaporation, to an insoluble muriate. The muriate of rhodium then exhibits the rose colour, from which the name of the metal was given.

SECTION VII.

OF IRIDIUM.

Experiment 1. Mr. Tennant obtained iridium in the following manner: introduce a quantity of the black powder, remaining after the solution of the ore of platinum in nitro muriatic acid, into a silver crucible, with a large portion of soda, and fuse the mixture for some time. The alkaline mass, according to Mr. Tennant, will acquire, when dissolved in water, a deep orange, or brownish yellow colour, but much of the powder remains undissolved. This powder, on being digested in muriatic acid, afforded Mr. Tennant a dark blue solution, which afterwards became of a dusky olive green, and finally, by continuing the heat, of a deep red colour Part of the powder being yet left undissolved by the muriatic acid, was again heated with alkali, and by the alternate application of the alkali and acid a complete solution was at last obtained. The alkaline fluid, containing the oxyd of a volatile metal (osmium) not yet noticed, but which shall be described presently, was put aside. The acid solution contained the metal iridium, (and also a small portion of osmium.) To obtain the muriate of iridium, free from the other metal, the solution was evaporated to dryness; the dry mass was again dissolved in water, and suffered to crystallize. It yielded distinct octahedral crystals. These crystals, on being dissolved in water, gave a deep red coloured solution, inclining to orange. With an infusion of galls, no precipitate was formed, but the colour was instantly and almost entirely taken away. Muriate of tin, carbonate of soda, and prussiate of potash, produced nearly the same effect. Ammonia precipitated the oxyd, but retained a part, and acquired a purple colour. The alkalies also precipitated the greater part of the oxyd, and if added in excess, a portion of the oxyd became again dissolved, which imparted to the solution a yellow colour. All the metals, except gold and platina, produced a dark or black precipitate, when mingled with the muriatic solution of iridium, and rendered it at the same time colourless. To obtain the iridium in a pure state the octahedral crystals of muriate of iridium need merely be exposed to heat; both the muriatic acid as well as the oxygen are driven off, and the metal is obtained pure.*

Mr. Smithson Tennant discovered this metal in 1803; Descotils, Vauquelin and Fourcroy afterwards investigated it. Iridium has the appearance of platinum. It resists the action of all acids, even the nitro muriatic almost completely; much more than three hundred parts being necessary to dissolve one of iridium.† The affinity between this metal and oxygen is very weak; but, like other metals, it unites with it. It combines with two doses of oxygen, and forms two oxyds. This is inferred from the phenomena of its solution in muriatic acid.‡

Iridium does not combine with arsenic; but it readily unites with lead. The latter is separated by cupellation, leaving the iridium upon the cupel, as a coarse black powder.§

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* See Tennant's paper in the Phil Trans. for 1804, or Nicholson's Journal, No. 37, 1805, p. 24.

† Fourcroy and Vauquelin. Ann. de Chim.

‡ Thomson, i. 199.

§ For the experiments on this subject, consult Tennant's paper already quoted.

SECTION VIII.

OF OSMIUM.

Experiment 1. Osmium may be obtained by fusing any quantity of the black powder which is mixt with the ore of platinum, or which remains after dissolving the ore in nitro-muriatic acid, with at least four or six times its quantity of soda, or potash, dissolving the alkaline mass in water, and simply distilling the solution previously mingled with an acid.* The oxyd of osmium is thus taken up by the water, and passes over in the receiver. The sulphuric acid being the least volatile, is the most proper for this purpose. But as even of this acid a little is liable to pass over, a second slow distillation should be had recourse to, to obtain the oxyd of osmium in a pure state. The solution of the oxyd of osmium thus procured is colourless; it has a sweetish taste, and strong odour.

Another mode of obtaining the oxyd of osmium consists in distilling the black powder procured from the ore of platinum with nitrate of potash. By this means the oxyd of osmium is obtained in a more concentrated state. See Tennant's paper, on two new metals found in the black powder after the solution of platina. Philos. Trans. 1804; and Nicholson's Journal, No. 37, 1805, p. 24.

Remark. This metal was discovered by Mr. Tennant. Messrs. Fourcroy and Vauquelin discovered

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* Mr. Tennant noticed that the oxyd of osmium even escapes in part by the mere affusion of water upon the dry alkaline mass, as is manifested by the pungent peculiar colour, from which property its name has been derived.

some of its properties. Its colour is of a dark gray, or blue. When heated in the open air it evaporates with a peculiar smell; but in close vessels, when the oxydizement is prevented, it does not appear in the least volatile. It is not acted upon by any acid, not even the nitro-muriatic, after exposure to heat; but with potash, as before noticed, it unites, and forms with it an orange yellow solution. One of the most singular characters of this metal, is the facility with which it unites with oxygen, and becoming oxydized, when heated in the open air, or when fused with potash, though it resists the action of acids. Considering the great volatility of this oxyd, its smell, taste, solubility in water, and the peculiar colour which it assumes with potash, is sufficient to distinguish it from every other metal.

The solution of osmium stains the skin of a dark colour, which cannot be effaced. With the infusion of galls it produces a purple colour, which gradually assumes a vivid blue. A mixture of iridium and osmium may be easily detected. On adding the infusion the red colour of the iridium is instantly taken away, and soon after the purple or blue colour of the osmium appears. Alcohol or ether mixed with the solution of oxyd of osmium in water, becomes black, the oxyd is reduced, and the osmium appears in black films. This oxyd is decomposed by all the metals, except gold and platinum. Silver immersed into the solution acquires a black colour. Copper, zinc, tin, and phosphorus produce a black or gray powder, and deprive the solution of its smell, and the power of giving a blue colour with galls. This black powder contains osmium in a metallic state, and the oxyd of the metal employed to precipitate it. It is soluble in nitro-muriatic acid, and then becomes blue with infusion of galls.

Osmium unites with some of the metals. As this metal, like the preceding, is but little known, for further information on it, the reader is referred to Mr. Tennant's paper in the Philosophical Transactions.

SECTION IX.

OF COPPER.

Experiment 1. In order to obtain copper from its ores, if they contain much sulphur, after being pounded and washed, they are roasted in the open air. After the roasting has been continued, the ore is melted in the open fire into a mass, called a mat of copper. After roasting it again, the metal acquires a certain degree of purity, and is called black copper. In order to get rid of some impurities, the copper is hastily fused with three times its weight of lead. As the black copper contains sulphur, iron, and some other foreign bodies, the lead acts by uniting with the copper, and expelling the iron or other impurity. By keeping the copper heated in crucibles, it is further purified, as the foreign bodies are disengaged in the form of scoriæ. Its purity is judged by immersing iron rods from time to time, into the melted metal. As these rods become coloured with a small quantity of copper, the brilliancy of which indicates the goodness of the copper.

Rationale. The roasting separates the sulphur in part, and, by fusion with lead, iron, if it be present, is disengaged; the copper is afterwards separated by fusion, and the other metals are thrown up in the form of scoriæ. If the ore of copper should contain oxygen, as in the calciform ores, the ore, for obtaining the metal, must be fluxed with some carbonaceous matter. An enumeration of the ores of copper, may be seen in the classification of ores.

Experiment 2. If copper be dissolved in muriatic acid, and precipitated by a polished plate of iron; or the black oxyd of copper obtained by decomposing cuprated ammonia, melted with its own weight of pounded glass and pitch, will afford pure copper.*

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* Thomson.

Experiment 3. If copper ore be boiled in five times its weight of concentrated sulphuric acid, till a dry mass is obtained, and if to this mass water be added, and afterwards a polished plate of iron immersed, the copper will be precipitated in its metallic state. It may be scraped off and weighed. If silver should occur with the copper, the following process may be employed:

Experiment 4. Add to the ore nitric acid, as long as it continues to extract any metal; and, should silver be present, it may be detected and separated by a plate of copper.*

Remark. Copper is of a fine red colour, and possesses considerable brilliancy. Its taste is nauseous and styptic. Its hardness is 7.5, and its specific gravity varies according to its purity. According to Lewis it is 8.830. Its malleability is so great, that it may be hammered out into leaves of extreme thinness. In this state it is known by the name of *Dutch metal*. It possesses considerable ductility and tenacity. A wire 0.078 inch in diameter is capable of supporting 302.26lbs. avoirdupois without breaking. At 27° Wedgwood, or, according to Mortimer, at 1450° Fahrenheit, copper melts; and if the heat be continued, it may be dissipated in visible fumes. If allowed to cool slowly, it exhibits a kind of crystallization. The abbe Mongez obtained it in crystals of quadrangular pyramids.

Except gold and silver, copper seems to have been known at an earlier period than any other metal. Before the working of iron was known, it was employed as a principal ingredient in all domestic utensils and instruments of war. In mixture with tin, it formed the bronze for the armour worn by the Trojans, as related by Homer.

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* On the analysis of copper ores see Klaproth's Essays, vol. i. 54. 541. &c. Chenevix on the analysis of arseniates of copper and iron. Phil. Trans. 1801, &c.

The word copper, it is said, is derived from the island of Cyprus, where it was first discovered, or wrought, by the Greeks. Professor Kidd, however, is of opinion, that the word copper, *cuprum*, is derived from the name of an artificial alloy of this metal, called *æs cyprium;* which was a compound of copper and tin. In the early natural historians *æs*, when used simply, very often signifies copper.

Besides the ores of this metal enumerated in the general classification, copper in its native state has been known from time immemorial.

Native copper, which is as easily recognized as most substances by its external characters, is met with in many parts of the world: sometimes distinctly crystallized; more frequently ramifying in various forms through the substance containing it.

Some of the most beautiful specimens of native copper are met with in Siberia, in the eastern extremity of the Oural mountains, in about the sixtieth degree of latitude: the matrix of copper is a granular white carbonate of lime.

Native copper is also met with in quartz, through which it often penetrates in the form of irregularly prismatic bars; in serpentine; in varieties of basalt and porphyry; and in granite.

According to Mr. Jameson it is frequently found in great masses dispersed over the surface of the earth, in uncultivated countries; hence Werner conjectures that it was the first metal worked by man. From its obvious metallic characters the opinion may be considered as very probable, especially when supported by the account which is given of some of the savage tribes in the north western parts of America; who though little civilized in most respects, have applied to domestic purposes the native copper with which their country abounds; and, from one of the uses to which they have applied it, are commonly denominated copper-knived Indians.

Lucretius alludes to the early use of copper in these words:

> Prior *æris* erat, quam ferri cognitus usus.[*]

When native copper is met with in the body of primitive limestone, and other rocks which appear to have undergone a state of fusion, it is presumed that it originally crystallized in the situation where it is now found. In particular situations it appears to be the result of a secondary formation; and is conjectured by some to have been derived from the saline form of this metal, called blue vitriol; which is a combination of copper and sulphuric acid. In these instances it is supposed that some substance, having a stronger attraction for sulphuric acid than copper, has decomposed the salt; and that the copper has been precipitated in consequence. Thus into the water of some mines, holding blue vitriol in solution, it is customary to throw pieces of iron in order to decompose that metallic salt: and the copper is precipitated on the iron in proportion as the decomposition proceeds. This method of separating copper was first practised at Herengrund, near Neusol, in Hungary. The copper so obtained is called copper of *cementation*, or *cement* copper: but Mr. Price, in his "Mineralogia Cornubiensis," says, that the word cement is a corruption of "Ziment," which is the name of a place near Herengrund. From observing what happens in this artificial process, and comparing the effect with the occasional stalagmitic appearance of native copper, some mineralogists are inclined to attribute this appearance to a similar origin.[*]

Mr. Jameson mentions a mass of native copper, on the authority of Professor Vandilli, weighing 2600 Portuguese pounds. It is said to have been found in a valley near Cachoeira, in Brasil.

Native copper has been discovered, sometimes in large quantities in many places in the United States.

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[*] Lib. v.

[†] Kidd ii. 100.

Experiment 5. If copper filings be put into water, and excluded from the air, the metal will remain unaltered; or,

Experiment 6. If the vapour of water be passed through an ignited copper tube, the water will pass unchanged; but,

Experiment 7. If copper filings be exposed, when moistened with water, to the free access of air, they will corrode, and assume a green colour

Remark. Copper exposed to the air gradually absorbs oxygen, more especially if moistened with water, becoming tarnished, then brown, and at last green. The latter consists of oxyd of copper and carbonic acid. The oxydizement of copper is facilitated, if,

Experiment 8. The metal be heated red hot, and plunged alternately after each heating into water: the scales thus produced fall to the bottom of the vessel. The gradual oxydizement of copper is shewn in the following manner:

Experiment 9. Expose a piece of copper to a low red heat, its surface will gradually assume various shades of orange, yellow, and blue. Childrens toys are ornamented with thin plates of copper, thus tinged of different colours.

Experiment 10. If copper be exposed to a violent heat, it will take fire and burn with great brilliancy; or,

Experiment 11. If it be treated with a stream of hydrogen and oxygen gas, in the state of inflammation, the same effect will take place, and the product will be, in both cases, an oxyd of copper.

Experiment 12. If 57.5 parts of black oxyd of copper and 50 parts of metallic copper, obtained by precipitating it from its solution by a plate of iron, be mixed together, and dissolved in muriatic acid; and the solution decomposed by the addition of potash, the *prot-oxyd of copper* will be precipitated of an orange colour; or,

Experiment 13. If copper be dissolved in muriatic acid, and pieces of metallic copper afterwards immersed into this solution, and potash then added, the prot-oxyd will be precipitated as before.

Rationale. When the black oxyd and metallic copper are dissolved together in muriatic acid, the whole being oxydized to the minimum, is dissolved; and the muriate of copper then decomposed by the vegetable alkali, the muriatic acid unites with the latter, and the prot-oxyd of copper is precipitated. But when copper is dissolved in muriatic acid, and the solution exposed to plates of metallic copper, the latter abstracts oxygen to a certain degree from the oxyd of copper held in solution, so that on the addition of potash, the prot-oxyd of that metal is precipitated.

Remark. Mr. Chenevix, to whom we are indebted for the most accurate information respecting this oxyd, although it was first observed by Mr. Proust, says, that it is composed of 88.5 parts of copper and 11.5 oxygen.* It absorbs oxygen when moist with avidity, changing to a blueish green.

Experiment 14. If the scales of copper, obtained by immersing red hot copper into water, be exposed to a red heat in an open vessel, they become black, forming the per-oxyd of copper.

Rationale, The copper is further oxydized by exposure to air, assisted by an increased temperature; hence it becomes oxydized to the maximum, forming the per-oxyd; or,

Experiment 15. If the sulphate or nitrate of copper be decomposed by means of potash; and the precipitate afterwards heated to drive off any moisture which it may retain, the per-oxyd of copper will be produced.

Rationale. The copper in the sulphate or nitrate is oxydized to the maximum; hence on the addition of potash, a sulphate or nitrate of potash is formed, and the per-oxyd of copper is precipitated.

Remark. The per-oxyd contains 20 per cent. of oxygen. The oxyds of copper may be reduced in several ways; as,

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* Chenevix. Phil. Trans. 1801.

Experiment 16. If a mixture of oxyd of copper, and charcoal, or oil, be exposed in a crucible to heat, metallic copper will be obtained.

Rationale. The oxyd is decomposed; if charcoal be used, carbonic acid is disengaged; if oil, carbonic acid and water; the metal being revived; or,

Experiment 17. If the oxyd be mixed with zinc filings, and exposed to heat, the copper will be obtained in a metallic state.

Rationale. The oxygen having a greater affinity for the zinc, unites with it, forming an oxyd of zinc, whilst the copper is revived.

Experiment 18. If equal parts of sulphur and copper, are stratified alternately in a crucible, they melt and combine in a red heat.

Remark. Sulphuret of copper, thus obtained, is of a black, or of the colour of iron, and composed, according to Proust, of 78 parts copper and 22 of sulphur; or,

Experiment 19. If copper filings and sulphur be mixed, and formed into a paste with water, and allowed to remain for some short time, a compound of sulphur and copper will be formed; and,

Experiment 20. If this be exposed a longer time, and in contact with air, and afterwards lixivated, sulphate of copper may be obtained by evaporation and crystallization.

Rationale. The sulphur unites with the copper into a sulphuret: in the second case, the sulphuret is decomposed, oxygen is absorbed, and sulphate of copper formed.

Experiment 21. If a mixture of three parts of copper filings and one of sulphur, be melted in a glass tube, at the moment of combination, a brilliant inflammation ensues, and a sulphuret of copper is formed.

Remark. This experiment was first made by the associated Dutch chemists, Dieman, Troostwyk, Nieuwland, Bondt, and Laurenburg, in 1793. This experiment has excited much attention, as it appears to contradict the Lavoiserian theory of the necessity of oxygen in every instance of combustion.

The *copper-matt*, as the workmen call it, seems to contain sulphuret of copper.

Experiment 22. If a polished plate of copper be immersed into water containing sulphuretted hydrogen, or into an alkaline hydrosulphuret, it will become tarnished, and covered with a blackish brown crust.

Remark. Hence this metal may be used as a test for hepatic water. See Hydrosulphurets.

Experiment 23. If the sulphuret of copper, formed as before mentioned, be melted with sulphur; a compound will be formed, called super-sulphuret of copper.

Remark. The ore known by the name of copper pyrites, is a super-sulphuret of this metal.

Experiment 24. If 16 parts of copper, the same quantity of phosphoric glass, and one part of charcoal be fused in a crucible, the phosphuret of copper will be formed.

Rationale. The charcoal decomposes the phosphoric acid; carbonic acid is disengaged; and the phosphorus at the instant unites with the copper into a phosphuret; or,

Experiment 25. According to Margraf, if phosphorus and oxyd of copper be distilled, the same compound will result; or,

Experiment 26. If phosphorus be projected into red hot copper, a union will ensue, and the same product will be formed.

Remark. According to Pelletier, the phosphuret of copper is composed of 26 parts of phosphorus, and 80 of copper. Several experiments have been made on this compound.

Experiment 27. If to a diluted solution of sulphate of copper, caustic ammonia be added, the copper will be precipitated in the state of an oxyd; if more ammonia be now added, the precipitate will become dissolved, forming an ammoniaret of copper, or *aqua celestis*.

Rationale. The ammonia at first unites with the sulphuric acid of the sulphate of copper, forming sulphate of ammonia, which remains in solution, whilst the oxyd of copper is precipitated; another portion of the ammonia then dissolves the oxyd, forming a beautiful blue liquid, or ammoniaret of copper.

Experiment 29. If eight ounces of lime water, two scruples of sal ammoniac, and four grains of verdigrise be mixed and digested for a short time, the *aqua sapphirina*, or liquor of ammoniated copper of the Dublin Dispensatory will be formed; or,

Experiment 30. If one dram of sal ammoniac and one pint of lime water be suffered to stand together in a copper vessel, the same preparation will be produced.

Rationale. The lime water decomposes the muriate of ammonia; muriate of lime is formed, and ammonia is disengaged, which dissolves the oxyd of copper in the verdigrise. In the latter process, the copper is oxydized, and the oxyd of copper afterwards dissolved. The quantity of lime is not sufficient to decompose all the muriate of ammonia, hence it is, that this preparation contains muriate of ammonia, muriate of lime, and ammoniaret of copper. The *cuprum ammoniacum* of the shops, is prepared in the following manner:

Experiment 31. Take of sulphate of copper, two parts; and carbonate of ammonia, three parts. Rub them carefully together in a glass mortar, until after the effervescence has entirely ceased, they unite into a violet coloured mass, which must be wrapt up in blotting paper, and first dried on a chalk stone, and afterwards by a gentle heat.

Rationale. As soon as the ingredients begin to act upon each other, a quantity of water is set at liberty, which renders the mass soft; during the action, the sulphuric acid of the sulphate of copper passes to the ammonia, whilst the ammonia of the carbonate of ammonia combines with oxyd of copper into an ammoniaret of copper. Prepared according to the above formula, *cuprum ammoniacum* evidently contains oxyd of copper, ammonia, and sulphuric acid. The following process has been recommended in preference.

Experiment 32. Decompose a solution of sulphate of copper by ammonia as before stated; concentrate the solution of copper in the ammonia by evaporation, and mix it with about an equal quantity of alcohol, and the whole of the salt will be precipitated in silky blue crystals, which are to be collected by filtration, dried, and kept in a vial, with a ground glass stopper.

Rationale. The theory of the formation of *cuprum ammoniacum* has already been noticed. When alcohol is added, the water of the solution is abstracted, and the whole of the saline matter is precipitated.

Experiment 33. If copper filings be put into a vial with ammonia, and the air excluded, no solution will take place; but,

Experiment 34. If air be admitted into the same vial, the liquor will gradually become blue.

Rationale. Metallic copper is not soluble in ammonia; but when air is admitted, the metal is oxydized, and the oxyd is taken up by the ammonia.

Experiment 35. If cuprum ammoniacum be exposed to the air, it will change from a blue to a green colour.

Rationale. The ammonia, on exposure, is disengaged from the oxyd of copper, and the latter, by absorbing carbonic acid, becomes green, forming the carbonate of copper.

Experiment 36. If copper filings be boiled with a solution of sal ammoniac, a solution will be formed, which, when evaporated, produces the *Brunswick green.*

Remark. This preparation appears to be a triple compound; and, according to Goetling, is the Brunswick green. This pigment, however, is considered by some as a triple tartrate of potash and copper. See Salts of Copper.

Experiment 37. If a small quantity of copper, or its oxyd, be mingled by triturating it with muriate of ammonia, and sublimed, some ammonia is at first disengaged, but after it the remaining muriate of ammonia rises, tinged of a greenish yellow by the muriate of copper which also sublimes. This last product has been called cupreous flowers of sal ammoniac (ens veneris). See Salts of Copper.

Experiment 38. Prepare two glasses of very diluted nitrate of copper; into one drop a little ammonia, and into the other some diluted arseniate of potass. The addition of these two *colourless* solutions will produce very different effects, for the one glass will have an abundant precipitate of a beautiful grass green, and the other precipitate of a brilliant sapphire blue.

Rationale. With the arseniate of potash, an arseniate of copper is formed, which is of a green colour; with ammonia, ammoniaret of copper is produced.

Experiment 39. If paper be written on with a diluted solution of muriate of copper, the writing will not be visible, but on being warmed before the fire, it will become of a beautiful yellow, forming a *sympathetic ink*.

Experiment 40. Write with a solution of sulphate of copper, wash the paper with prussiate of potass, and the writing will be revived of a reddish brown colour. In this experiment the sulphate is converted to a true prussiate of copper.

Experiment 41. If a piece of bright silver be dipped in a solution of sulphate of copper. it will come out unchanged: but if the blade of a clean penknife, or any piece of *polished* iron, be dipped in the same solution, the iron will instantly put on the appearance of copper.

Experiment 42. Take the piece of silver employed in the last experiment, hold it so that the silver and the polished steel may be *in contact;* then in this situation plunge them into the same solution, and in a moment BOTH will be covered with copper.*

Rationale. Silver will not precipitate copper from its solution; but iron has this property. The copper, thus precipitated by iron, is called *copper of cementation*. But when silver and polished steel are immersed together in contact, the property which they both possess in this state of precipitating copper from its solution, appears to depend on the galvanic influence.

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* Parke's Rudiments.

Experiment 43. If to a solution of nitrate of copper pulverised lime be added, and the mixture shaken, a precipitate will be produced, which, when collected, washed and dried, will form a *green pigment.*

Rationale. The nitric acid of the nitrate of copper unites with the lime, forming nitrate of lime, whilst the copper is precipitated in the state of an oxyd.

Experiment 44. If the green precipitate of the last experiment be mixed on a slab with a little quicklime, it will acquire a lively blue colour, forming the *blue verditer.*

Remark. Sulphate of copper is generally used instead of the nitrate; but in that case, besides being contaminated with sulphate of lime, some oxyd of iron is always present. The combination of copper and arsenic acid, forming arseniate of copper, or *Scheele's green*, is effected in the following manner:

Experiment 45. Dissolve potash in water with heat; add white oxyd of arsenic or arsenic acid to the point of saturation, and filter the liquor. Then take a warm solution of sulphate of copper, and pour it into the arseniate of potash: a little only must be added at a time, and it must be continually stirred with a glass rod. Leave the mixture at rest till a precipitate is formed; then decant the liquor, and having washed the residuum repeatedly in warm water, filter it and leave it to dry. By this process a beautiful green colour is obtained.

As this colour is not alterable by air, it is employed in painting.

Experiment 46. If prussiate of potash be added to a solution of sulphate of copper, a brown precipitate will be formed, which has been used as a paint under the name of *Hume's pigment.*

Rationale. The sulphuric acid of the sulphate of copper, unites with the potash, forming sulphate of potash, whilst the prussic acid of the prussiate of potash, combines with the copper, thus separated, in the state of prussiate of copper.

Experiment 47. If plates of copper be moistened with vinegar, they will be corroded, and form a green oxyd or sub-acetate of copper, known by the name of *verdigrise;* or,

Experiment 48. If copper plates be stratified with the husks of grapes, yet under the vinous fermentation, which soon grow acid, they become corroded, forming *verdigrise.*

Copper is acted upon by the acids, forming peculiar salts. See Salts of Copper.

Copper is capable of combining with the most of the metals. With gold it combines in any preparation. If only a little copper be added, the ductility of gold is not much impaired, though its hardness is considerably increased. Gold coin, sterling or standard gold, consists of pure gold alloyed with $\frac{1}{12}$th of some other metal.* The metal used is always either copper or silver, or a mixture of both. The mixture of gold with copper is called *red carating*, to distinguish it from the less usual one, made with silver, and which is termed *white carating*.† To ascertain the quantity of fine gold contained in the alloy, the *touch-needles*, as they are called, are of service. These needles are small bars composed of different proportions of copper.‡

With platinum, copper unites by fusion, forming a ductile alloy, which has been employed with advantage for composing the mirrors of reflecting telescopes.

A method has lately been proposed for coating copper vessels with platinum instead of tin; it consists in rubbing an amalgam of platinum over the copper, and then exposing it to the proper heat. Silver is easily alloyed with copper by fusion; these two metals are combined to form solder. The compound is harder and more sonorous than silver. In the silver coin, copper always constitutes a part. In Great Britain, the standard silver is a compound of 23½ silver

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* Hatchet on the Alloys of Gold, p. 66.

† Gren, ii. 280.

‡ Ibid. 281.

and one copper. Its specific gravity, after simple fusion, is about 10.200. The old French silver coin was composed of 261 parts of silver and 27 of copper, or one part of copper alloyed with $9\frac{2}{3}$ of silver. The Austrian silver coin contains $\frac{13}{288}$ of copper. The silver coin of the ancients was nearly pure. Dr. Thomson analyzed an East Indian rupee, and found it to contain $\frac{1}{32}$ part of copper. The Dr. also examined other coin; the result of his experiments are to be seen in his System of Chemistry, vol. i. p. 214. Silver is not only combined with copper for the purpose of coin, but it is always mixed with this metal before it is wrought into plate, trinkets and the like. The alloy of silver and copper is specifically denominated by the number of *loths* (half ounces) of pure silver contained in one mark of the silver. The *touch needles* for silver are made upon the same principles as those for gold; but they are required only for one kind of alloy, namely, with copper.* Besides the separation of silver from copper, by cupellation, and precipitation, Mr. Engenstrom has proposed the following method with liver of sulphur:

Experiment 49. If silver alloyed with copper be fused with sulphuret of potash, the silver will be separated.

Rationale. During the fusion, the copper unites with the sulphuret, forming a scoriæ, which floats on the silver.

Experiment 50. If melted copper be cautiously poured into mercury heated nearly to the boiling point, the two metals combine and form a soft white amalgam; or,

Experiment 51. According to Boyle: triturate together two parts of mercury, two and an half parts of

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* For a particular account of the mode of separating silver, or gold, from its alloys, as effected by cupellation, &c. consult Schluter's and Cramer's Metallurgy.

verdigrease, and one part of common salt, with some acetous acid, and keep them for some time, over a moderate fire, stirring them constantly, and supplying acid as it evaporates; then wash the amalgam and pour it into a mould; it is at first nearly fluid, but in a few hours it crystallizes and becomes quite solid:* or, this amalgam may be formed in the following manner:

Experiment 51. Put a plate of copper into a solution of mercury in nitric acid; the plate will soon become impregnated with mercury.

Remark. The amalgam of copper is of a white colour, and may be readily decomposed by heat; the mercury evaporates and leaves the copper. Lead and copper unite by fusion, but the compound is not lasting. With bismuth copper also combines, rendering the former paler.

Respecting the combinations of copper with palladium, rhodium, iridium, and osmium, all that is known on the subject is mentioned in the preceding section. The union of copper and zinc constitutes *brass*, which may be made in the following manner:

Experiment 52. Put into a crucible four parts of granulated copper and six or eight of zinc, and nearly fill the crucible with charcoal-powder, cover it and bring it briskly to a red heat; the copper will unite with the zinc, and form brass.

Experiment 53. If plates of copper be cemented with native oxyd of zinc reduced to powder, and mixt with charcoal also in powder; by bringing the mixture to a red heat in a covered crucible, the copper and zinc will unite, and likewise form brass.

Brass is made in the large way by a process similar to this. *Similor* or Manhein gold, is also formed of zinc and copper.

Experiment 55. If twelve parts of copper and three of zinc be melted together in a crucible, the mixed

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* Shaw's Boyle, i. 343.

metal, called *tombac* will be formed. Arsenic is sometimes added.

Experiment 54. If copper be melted with one tenth part of tin, *gun metal* will be produced.

Experiment 55. If copper be alloyed by melting it with one sixth part of tin, the result is *bell-metal*. The proportion of the ingredients of this metal, varies according to the uses to which the bells are to be applied. A similar mixture constitutes *bronze*.

Copper and tin, it appears, formed the ancient metallic arms. Dr. Pearson examined some of them, and found them to contain these two metals, in the proportion of from six to twelve parts of copper to one of tin, according to the uses to which they were intended.

The union of copper with the other metals, not here enumerated, will be considered hereafter.

SECTION X.

OF IRON.

Experiment 1. If iron ore be roasted in a strong heat, afterwards reduced to small pieces, then mixed with charcoal, or coke, and exposed to an intense heat in a close furnace excited by bellows, iron will be obtained in its metallic state.

Rationale. The roasting dissipates the sulphur, carbonic acid, or other volatile matter if it be present, whilst the charcoal in the subsequent operation carries off the oxygen from the metal, which is generally present in the form of carbonic acid. The iron, therefore, appears in the state of metal.

Remark. In the reduction of some iron ores, different fluxes are sometimes used. The ores of iron very often occur in a matrix of argillaceous, or calcareous earth, and occasionally with silicious earth;

hence, in the reduction of ores containing any of these, the addition of one or other of these earths makes a proper flux.

The metal obtained at first is not pure, but contains carbon, &c. In this state it is called smelted, pig, or cast iron. According to the nature and proportion of the foreign matter, the iron appears either light gray, dark gray, blue, or black.

There is one kind of forged iron, which, when cold, possesses ductility; but when heated is extremely brittle. This is called *hot short iron*. Another variety of forged iron, whose characters are opposite, is called the *cold short iron*. It is ductile while hot, but when cold is extremely brittle. The cause of that property of cold short iron, depends on the presence of a substance termed *siderite*, which is a compound of phosphoric acid and iron. On the contrary, that of hot short iron, to the presence of arsenic or sulphur; but the real cause is not known

In order to ascertain the quantity of iron in an ore, Rinman has proposed the following method: Take its specific gravity, and state it in integral numbers, then divide it by 80.

An ore, for instance, whose specific gravity was 31.893 gave $\frac{3893}{80}$ — 48.6, and contained on trial 50 per cent. of iron. The error was only 1.5 per cent. Ores, whose specific gravity are less than 3.6 should be divided by 150; a small difference, however, will exist. Iron may always be detected by adding to a solution supposed to contain it, either tincture of galls, prussiate of potash, or succinate of ammonia. The first will produce a black, the second a blue, and the third a brown precipitate.

For the analysis of the different ores of iron, see Klaproth's Essays, Kirwan's Mineralogy, and Accum's Analysis.

Iron is one of the most useful metals. It was known to the nations of the east at a very early period. Moses, who was born about 1635 years before Christ, gives ample proof of the knowledge, which the Egyptians at

Phœnicians had of this metal. Moses not only tells us, in his writings, that furnaces were constructed for the working of iron, but also, that the metal itself was made use of in the manufacture of swords, knives, axes, and tools for cutting stone.* Iron must have been known, in all probability, long before the days of Moses, as Hesiod (quoted by Pliny, lib. vii. c. 57.) observes, that the knowledge of iron was brought over from Phrygia to Greece by the Dactyli. This person settled in Crete during the reign of Minos I, about 1431 years before Christ. We find also, that 200 years after, iron was held in such high estimation, that during the Trojan war Achilles proposed a ball of it as one of his prizes, during the games which he celebrated in honor of Patroclus.

The specific gravity of iron varies from 7.6 to 7.8. It is of a bluish white colour. It is attracted by the load stone, and is itself the substance which constitutes the load stone. It is very malleable, and its malleability increases in proportion as the temperature is increased. It is extremely ductile. It possesses considerable tenacity. An iron wire, for instance, 0.378 of an inch in diameter will support a weight of 549.25lbs. avoirdupois, without breaking. At 158° Wedgwood it melts. When broken it appears to be composed of a number of fibres or strings bundled together.

Experiment 2. If iron be exposed to the air, its surface becomes tarnished, and is gradually converted into rust.

Rationale. As iron is one of the metals that is oxydized by the atmosphere, in this experiment it unites with oxygen, and becomes converted into rust or oxyd.

Experiment 3. If iron filings be moistened with water, and exposed to the atmosphere, they are rapidly converted into rust, which, when ground into an impalpable powder, and made into conical lumps, forms the *rubigo ferri* or rust of iron of the Dispensatories.

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* See the books of Deuteronomy and Leviticus.

Rationale. Iron, by exposure at the same time to air and moisture, is very quickly oxydized. The oxyd thus formed, is said to absorb carbonic acid ; hence it has been called carbonate of iron. The proportion of carbonic acid, however, is small. See Salts of Iron.

Experiment 4. If iron filings be introduced into water, not under the temperature of 70°, they are gradually converted into a black powder, and hydrogen gas is emitted ;[*] or,

Experiment 5. If iron filings be put into a retort containing water, the beak of which is to be plunged into a vessel of water, and the heat of a lamp applied, so that the water may be made to boil, hydrogen gas will come over ;[†] or,

Experiment 6. If the steam of water be made to pass through a red hot iron tube, the same product will be obtained. See Hydrogen Gas.

Rationale. In all these experiments water is decomposed ; its oxygen unites with the metal, and its hydrogen is disengaged in the form of gas.

Experiment 7. If iron wire, in a white heat, be immersed in a jar of oxygen gas, vivid combustion will ensue ; and the metal will be converted into an oxyd. See Oxygen Gas.

Remark. Iron, by uniting with oxygen, is converted into oxyds of different colours. There are two oxyds sufficiently characterized, namely, the black and red oxyd ; but Thenard is of opinion, that there are three oxyds, viz. the white, green, and red. The green oxyd of this chemist is supposed by Darso, to owe its colour to the presence of hydrogen, and that the white oxyd is a sub-salt, having always a portion of acid in its composition. Mr. Chenevix, in his paper on Arseniate of Copper, has asserted, that iron is capable of furnishing four distinct oxyds. The first oxyd is white, the

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[*] Thomson, i. 218. Bergman *Opusc* iii. 95. Scheele on Fire, i. 180.

[†] Thomson, i. 219.

second green, the third black, and the fourth red; but in confirmation of this opinion he does not appear to have adduced any particular experiments. In combination with alumina, clay, &c. iron, in the state of oxyd constitutes with the first the potter's clay, and with the second, some of the ores of iron. In the hematite, the iron is oxydized, forming a calciform iron ore. If lime water be added to a water holding iron in solution as in the aerated chalybeate waters, the iron will be precipitated in the form of a brown oxyd or ochre. Besides giving colour to a great variety of natural substances, as before stated, its oxyd communicates it to the cornelion, the oriental ruby, the garnet, and other precious stones. With different proportions of oxygen it imparts other colours, as the blue to the lapis lazuli, and the yellow to the topaz.

The black oxyd of iron may be obtained in the manner before stated, namely, by wetting iron filings with water at the temperature of 70°. This preparation was known by the name of *Martial ethiops*. When steam is made to pass through an iron tube, the metal is also converted into the black oxyd; and when iron is burnt in oxygen gas, an oxyd is obtained, which answers to the characters of the black.

If sulphate of iron be decomposed by adding potash, a green powder will precipitate, which, when collected, washed, and dried quickly in close vessels, forms the black oxyd, or martial ethiops. According to Lavoisier and Proust, this oxyd is always composed of 73 parts of iron, and 27 of oxygen. This oxyd is attracted by the magnet. The per oxyd of iron, in which the metal is oxydized to the maximum, may be formed by exposing iron filings, red hot, in an open vessel, to the atmosphere, and agitating them till they are converted into a dark red powder. This oxyd is the same as the saffron of mars of the older dispensatories. The common rust, before noticed, is said to be composed of this oxyd and carbonic acid. The same preparation may be formed by exposing a diluted solution of iron in sulphuric acid to the atmosphere, and then decomposing it by the addition of an alkali; the oxyd being precipitated.

The per oxyd, according to Proust, contains 48 per cent. of oxygen.

When the per oxyd is heated with its own weight of iron filings, it is converted into the black oxyd. It is also converted into the black oxyd by sulphuretted hydrogen gas and many other substances.

Iron is attracted by most acids, with which it forms salts. See Salts of Iron.

Experiment 8. If sulphate of iron be distilled in an earthen retort, a brown coloured matter will remain, and the greater part of the sulphuric acid will pass over.

Rationale. Heat decomposes the sulphate; sulphuric acid distils, and the iron is left in the retort partly in the state of oxyd, and partly combined with a portion of the acid, in the form of sub-sulphate of iron. It was from the distillation of vitriol, to obtain the acid, that the term *oil of vitriol* took its rise.

Remark. After the distillation of sulphate of iron, commonly called green vitriol, or copperas, the residue has been called *colcothar:* if this be well lixiviated, it forms the pigment, sold under the name of English brown-red.

The red oxyd of iron of the Edinburgh Dispensatory, is formed by exposing the sulphate to the action of a strong heat.

Experiment 9. If sulphate of iron be dissolved in water, and prussiate of potash added; a blue precipitate will be obtained.

Rationale. The sulphuric acid of the sulphate of iron unites with the potash, whilst the prussic acid of the prussiate of potash, combines with the oxyd of iron, thus separated in the form of a blue precipitate, prussiate of iron, or prussian blue. The preparation of prussian blue, particularly, will be noticed hereafter.

Remark. It is with the per oxyd of iron, that a blue colour is formed with prussiate of potash; with the prot-oxyd, on the contrary, a white precipitate is produced; as, *Experiment* 10. Into a solution of sulphate of iron, introduce some iron filings; let the whole remain for a few hours; then decant the fluid and add to it prussiate of potash; a white precipitate will be obtained.

Rationale. The iron added to the sulphate, abstracts a portion of oxygen from the oxyd of iron, previously combined with the sulphuric acid, so that when prussiate of potash is mixed with it, a white prussiate of iron is precipitated. Hence iron, at the minimum of oxydizement, forms with prussic acid, a white prussiate.

Experiment 11. Write on paper with a weak solution of sulphate of iron, let it dry and the writing will be invisible. By dipping a feather in a solution of prussiate of potash, and drawing it wet over the letters, the writing will be restored and the letters will be of a bright blue.

In this experiment, prussiate of iron is formed. Hence the formation of a sympathetic ink.

Experiment 12. If paper be written on with an infusion of galls, the characters will not be legible till a solution of sulphate of iron is applied; they then appear black.

Rationale. When sulphate of iron is applied, the gallic acid of the infusion, it is generally considered, unites with the iron into a gallate of iron, and is thus rendered visible.

Experiment 13. If half an ounce of sulphate of iron, one ounce of powdered galls, and a quarter of an ounce of gum arabic be mixed together, the ink powder for forming ink will be prepared; and,

Experiment 14. If sixteen ounces of rain water be added to this powder, writing ink will be formed.

Rationale. Although in a dry state the materials, of which the ink powder is composed, do not act upon each other, yet when water is added, the sulphate of iron and gallic acid of the galls are taken up, and produce gallate of iron. The gum is intended to suspend the precipitate or gallate of iron. For further particulars, see Salts of Iron.

Experiment 15. If to the black liquid, formed by adding infusion of galls to the sulphate of iron, a few drops of muriatic acid be added, the whole will become limpid; and,

Experiment 16. If to this limpid fluid the addition of a solution of potash be made, the black colour will be restored.

Rationale. The gallate of iron is decomposed by the muriatic acid, and muriate of iron is formed. The addition of potash then unites with the muriatic acid, and the oxyd of iron is set free, which combines with the gallic acid into a gallate of iron. Some caution is necessary in adding the alkali, in order to produce the desired effect.

Experiment 17. If a piece of calico be immersed in a colourless solution of sulphate of iron, and, when dry, washed in a weak solution of carbonate of potash, a permanent colour will be produced, viz. the buff of the calico printers.*

Rationale. The sulphuric acid of the sulphate of iron, combines with the potash, forming sulphate of potash, whilst the carbonic acid of the carbonate of potash passes to the iron, and is fixed on the stuff in the state of carbonate of iron.

Experiment 18. If ether be added to a solution of iron in muriatic acid, the preparation known formerly under the name of *Lamotte's gold-drops* will be produced.

Experiment 19. If muriate of ammonia be sublimed in contact with iron filings, or its oxyd, the *martial flowers of sal ammoniac* will be prepared.

Rationale. Part of the muriate is decomposed, muriated iron is formed, which sublimes with the undecomposed muriate of ammonia. See Salts of Iron.

Experiment 20. If hydrogen gas, obtained by adding diluted sulphuric acid to iron filings, be suffered to stand undisturbed, a brown powder will be deposited on the sides of the jar. This powder has been found to be iron.†

Remark. Although hydrogen has never been united to iron in its solid state, yet this first furnishes a proof that they may be combined.

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* Parke.

† Thomson, i. 225.

Experiment 21. If equal parts of glacial acid of phosphorus and iron filings, be fused together, a phosphuret of iron will be formed; or,

Experiment 22. If equal parts of the glacial acid of phosphorus and iron filings, mixed with half a part of charcoal powder, be melted in a covered crucible, the same compound will result.

Rationale. In the first experiment part of the iron unites with the oxygen of the phosphoric acid, and the other part combines with the phosphorus into a phosphuret, which sinks to the bottom of the crucible. In the second experiment the charcoal decomposes the phosphoric acid; carbonic acid is disengaged, and the phosphorus unites with the iron. The phosphuret of iron may also be formed in the following manner:

Experiment 23. Heat iron filings red hot in a crucible, drop in phosphorus, and cover the vessel.

Remark. It was this compound, which Bergman took for a new metal, and gave it the name of *siderum.* Both Bergman and Meyer supposed, that it was this compound, which they then considered a peculiar metal, that gave to that particular kind of iron, known by the name of *cold short*, the property of being brittle when cold. The subject was afterwards investigated by Klaproth, who proved, that the white powder obtained from cold short iron, contained phosphoric acid and iron. Scheele decomposed this powder, and formed the same conclusions. The siderum of Bergman, however, is composed of phosphorus and iron, the phosphoric acid being deprived of its oxygen during the reduction.

Experiment 24. If two parts of sulphur and one of iron filings be melted together in a crucible, a compound will be formed called sulphuret of iron, which is of a black or very deep gray colour; or,

Experiment 25. If iron be ignited, and in this state applied to a roll of sulphur; both of them will be fused, and the sulphuret will fall down in drops.

Experiment 26. If a mixture of one part of iron filings and three of sulphur, be melted in a glass tube, at the moment of union a brilliant combustion will ensue.

Experiment 27. If equal parts of iron filings and flowers of sulphur, worked with water to a paste, be exposed to the air, the mass becomes hot, falls to pieces, and is converted into sulphate of iron.

Rationale. The sulphur unites with the iron into a sulphuret, which decomposes the water in part, and in part absorbs oxygen from the air. The sulphur is therefore acidified, and in union with the iron, forms the sulphate of iron.

Remark. A hundred pounds of iron filings were mixed by Baume, with an equal quantity of sulphur, which was moistened with water, and rammed into an iron pot. After ten hours the mass swelled up and grew warm, aqueous vapours arose, and the mass burst. Ten hours afterwards, the heat, vapours, and odour, greatly increased, and a flame issued forth, lasting only from 2 to 3 minutes. Finally, the mass became red hot, and the burning and heat continued 40 hours longer; but without flame. A similar mixture forms Lemery's volcano, the mass being laid under the ground.

Sulphuret of iron, according to Proust, is composed of 62.5 iron and 37.5 sulphur in the hundred. Iron pyrites are composed of iron and sulphur. If sulphuret of iron be added to sulphuric or muriatic acid, a solution readily ensues, emitting abundance of sulphuretted hydrogen. When heated with nitric acid, much sulphur is separated.

Experiment 28. If iron filings be added to a solution of sulphuret of potash, they will be in part dissolved; and,

Experiment 29. If an acid be poured into this solution, a precipitate of hydrosulphuret of iron will be produced; or,

Experiment 30. If a solution of sulphuret of potash be added to another of iron in any acid, the same compound will be formed; or,

Experiment 31. If a polished plate of iron be immersed into an hepatic water, or water holding sulphuretted hydrogen gas in solution, it will become blackened. See Hydrosulphurets.

Experiment 32. If iron filings be mixed with sulphuret of copper, and exposed to heat, sulphuret of iron will be formed, and the copper separated. In this way copper may be separated from sulphur.

Experiment 33. If five parts of iron filings be heated to redness in a crucible, and sixteen parts of powdered sulphuret of antimony introduced into it, and the whole exposed to a sudden and strong heat, the sulphur will leave the antimony and pass to the iron. When the mixture is thoroughly fused, a little nitre added will facilitate the separation of the scoriæ from the antimony.

Experiment 34. If one part of iron be melted with two of sulphuret of antimony, a little iron will remain united with the antimony, forming the *martial regulus*.

Remark. The combination of carbon and iron, forming what is called carburet of iron, plumbago, and black lead, which is found native, appears to be composed of 90 carbon, and 10 iron in the hundred.

Iron, in order to distinguish the different varieties, is known to artists by the names of *cast or pig iron*, *wrought or soft iron*, &c.

Cast iron, or pig iron, is the name of the metal when first extracted from its ores; the process made use of has already been noticed. There are several varieties of cast iron, distinguished from its colour and other qualities viz. *white cast iron*, *gray* or *mottled cast iron*, *black cast iron*, &c. Cast iron melts when heated to about 130° Wedgwood. Its specific gravity is about 7. It is converted into soft or malleable iron by a process called refinement. This is generally accomplished by keeping the iron for a considerable time in a bed of charcoal and ashes, and then forging it repeatedly till it becomes compact and malleable. The process of refinement, however, varies in different countries, according to the nature of the ore and the fuel employed. Mr. Cort's process consists in melting the cast iron in a reverberatory furnace by means of the flame of the combustibles, which is made to play upon its surface

After some hours, during which it swells and emits a lambent blue flame, with an extrication of air, the iron acquires consistency; and, at last, it congeals altogether. It is now removed, while hot, and hammered by means of the tilt hammer. Cast iron thus converted into malleable iron, is always mixed with some foreign substances. They are generally either some of the other metals, or oxygen, carbon, or phosphorus. Besides containing a portion of oxygen, crude iron always holds a considerable quantity of carbon in combination, the gray containing a greater quantity than the white crude iron. The names forge iron, plate or bar iron are given to malleable iron. Steel, a combination of iron and carbon in certain proportions, may be made as follows:

Experiment 35. Stratify small pieces of iron with charcoal powder in a close crucible, and keep the whole in a strong red heat for eight or ten hours.

Steel may be made either by fusion, or cementation, and as it is commonly *blistered*, it is refined or rendered more uniform in its whole mass, by repeated ignition between red hot coals and forging. Natural steel or steel made by fusion, is formed by fusing the iron in a violent heat, converting it first into cast iron, and afterwards into steel, which takes place when the mass of melted scoriæ is five or six inches deep.

Part of the carbon is disengaged with the oxygen in the form of carbonic acid, whilst the other part in union with the pure iron forms steel. This steel is inferior to that made by cementation. When bars of pure iron and charcoal powder are stratified alternately in large earthen troughs or crucibles, the mouths of which are carefully closed up with clay, and in this state kept sufficiently hot for eight or ten days, the bars of iron are converted into steel. In this state they are generally blistered, hence the term *blistered steel.* When drawn out into small bars, they receive the name of tilted steel. When broken to pieces and welded repeatedly in a furnace, and then drawn into bars, it is called *German* or sheer steel.

A new method of preparing cast steel has been lately announced in France by Clouet. His process is the following: take small pieces of iron and place them in a crucible, with a mixture of the carbonate of lime and the earth of Hessian crucibles; six parts of the carbonate of lime and six of this earth must be employed for twenty parts of the iron. The matters are to be so disposed, that after fusion the iron must be completely covered by them, to prevent it from coming into contact with the external air. The mixture is then to be gradually heated, and at last exposed to a heat capable of melting iron. If the fire be well kept up, an hour will generally be sufficient to convert two pounds of iron into excellent and exceedingly hard steel, capable of being forged; an advantage not possessed by steel made in the common manner.*

Carburetted iron, or steel, possesses properties different from that of wrought iron. In the operation of converting iron into steel, an increase of weight from $\frac{1}{180}$ to $\frac{1}{140}$ is gained. The proportion of carbon, however, necessary for convertion has not accurately been ascertained, notwithstanding the investigations of Vauquelin, Morveau, Clouet and other chemists. That carbon is essential in this process, is obvious from the following experiment of Morveau:

A diamond was enclosed in a small crucible of pure iron, and exposed, when completely covered, to the action of a sufficient heat. The diamond disappeared, and the iron was converted into steel. The diamond weighed 907 parts, the iron 57.800, and the steel obtained 56.384. It was inferred, therefore, that steel contains about $\frac{1}{60}$th of its weight of carbon. This experiment was objected to by Mr. Mushet, and partly confirmed by sir George M‘Kenzie.

In whatever manner steel is formed, cast steel has the preference, as its texture is more compact, and it

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* Phil. Mag. ii. p. 219.

admits of the finest polish. With it are made razors, surgeon's instruments, and the like. It is more fusible than common steel, and therefore cannot be welded to it. The method of making it was discovered by Mr. Huntsman about the year 1750. It is formed by fusing blistered steel in a close crucible, mixed with pounded glass and charcoal powder. According to Clouet, it may be formed by melting together 30 parts of iron, one part of charcoal, and one part of glass.

If iron be surrounded in a crucible with a mixture of equal parts of chalk and clay, and kept in a white heat, cast steel will be formed.

Mr. Mushet, to whom we are indebted for a number of facts on this subject, made the following table of the proportion of charcoal, which disappears during the conversion of iron to the different varieties of subcarburet known in commerce.*

$\frac{1}{120}$	Soft cast steel.
$\frac{1}{100}$	Common cast steel.
$\frac{1}{90}$	The same, but harder.
$\frac{1}{50}$	The same, too hard for drawing
$\frac{1}{25}$	White cast iron.
$\frac{1}{20}$	Mottled cast iron.
$\frac{1}{15}$	Black cast iron.

It was the opinion of Pliny, that steel owes its peculiar properties to water;† of Beccher that fire was the only agent in the conversion of iron into steel; and of Reaumur, that it contains saline and sulphurous particles. But these opinions have been exploded.

Experiment 36. If a slender rod of wrought iron be immersed into cast iron in fusion, it will absorb part of the carbon and become steel.

According to Rinman, steel may be distinguished from iron in the following manner:

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* Phil. Mag. xiii. 142.

† Lib. xxiv. 14.

Experiment 37. If a little diluted nitric acid be dropt upon a plate of steel, and allowed to remain a few minutes, and then washed off, black spots will remain; but,

Experiment 38. If iron be treated in the same way, it will leave only a whitish spot.

The former effect is attributed to the separation of carbon, which of course remains undissolved. It is said, however, that the blackness is owing to the carbon being oxydized by the acid, and converted into charcoal. Mr. Mushet is of opinion, that carbon exists in steel, in a concrete state, though not in crude; in chemical union, however, and not in mere mixture as in crude iron.

Dr. Pearson, by an ingenious investigation of the nature of a kind of steel, called wootz, which is brought from Bombay, discovered that it contains oxygen, and concluded from all the properties it possesses, that oxygen is the ingredient which distinguishes wootz from steel.

What is called *case hardening* is the conversion of the surface of iron into steel. What is termed *tempering* of steel is nothing more than plunging the metal red hot into water. It then acquires more hardness, and may be employed with advantage for some other purposes. It may have its softness and ductility restored by again heating it, and suffering it to cool slowly. On heating steel in contact with air, it acquires different colours. It passes from a yellow, purple, violet, and red to blue. At this period it becomes red hot, the colours disappear, and a number of scales are formed. These different colours indicate the different tempers of the metal.

The tempering of iron or steel, which is effected by suddenly cooling it after it is heated, seems to produce its hardness, brilliancy, and brittleness, by the integrant parts, separated by heat, being kept and left at a certain distance from each other; the sudden cold checking their approximation by the affinity of aggregation

Welding is a process of joining two ignited pieces of the same metal; the degree of heat requisite to that effect, is called the *welding heat*. Iron combines with most metals, as, 1, with gold. An alloy composed of one part iron and eleven gold, is much harder than gold, and has been recommended by Dr. Lewis for making edge-tools. Gold answers well as a solder for iron. The iron cannot be separated from its alloy with gold by cupellation with lead, except it be previously oxydized, which may be effected by repeated fusion with borax or nitre. If gold alloyed with iron be melted with sulphuret of lead, sulphuret of iron is then formed and separated. The gold is afterwards purified by cupellation. If an alloy of gold and iron be dissolved in nitro-muriatic acid, the addition of metallic iron will precipitate the gold; hence iron has a greater affinity than gold with oxygen. Sulphate of iron will also separate gold from its solution. See Gold.

2. Iron is generally found with platinum in the state of alloy; but Dr. Lewis did not succeed in his attempt to unite these metals by fusion. The platinum may be separated from the iron, by dissolving the alloy in nitro-muriatic acid, and adding muriate of ammonia. See Platinum.

3. With silver, iron readily unites by fusion. Cupellation with lead will not separate them, except the iron be oxydized and converted into scoriæ by fusing the compound with borax or nitre. In the humid way silver may be separated from iron by precipitation. See Silver. Silver may be separated from iron by sulphuret of lead, or by sulphur.

4. Mercury has been combined with iron indirectly, by triturating iron filings, and the amalgam of zinc, adding to the mixture a solution of iron in muriatic acid. By kneading this mixture, and heating it, the iron and mercury, which combine together gradually, will assume the metallic lustre.

5. Iron may be combined with copper by fusion, but not without difficulty. This alloy is of a gray colour. Copper has been employed in the soldering of iron.

M. Descotils has shewn, that when iron and charcoal are strongly ignited with boracic acid, the iron produces, during its solution, boracic acid.

It has therefore been supposed, that iron is capable of combining with boron. With potassium and sodium, iron is susceptible of union, forming alloys more fusible and white than iron.

It may be proper to mention, that the formation of tin plate depends upon the chemical affinity between iron and tin. See Tin.

SECTION XI.

OF NICKEL.

Experiment 1. To obtain nickel, the ore is first roasted, in order to free it from sulphur and arsenic; it then is changed into a greenish oxyd. This oxyd is mixed with two or three parts of black flux. The mixture is put into a crucible, and being covered with decrepitated muriate of soda, it is brought to the state of fusion, by the strongest heat of a smith's forge.

When the crucible is broken, there is found at the bottom, under brown, blackish, and sometimes blue scoriæ, a button of a yellowish white colour, equal in weight to a tenth, a fifth, and even a half of the ore employed. This metal, however, is still far from being pure.

In order to purify it, the button obtained is again broken into small pieces, strongly heated, and then digested with its own weight of concentrated sulphuric acid, and distilled to dryness. The dry mass is dissolved in water and filtered. This solution, in general, deposits crystals of arsenic, and finally affords dark green crystals of sulphate of nickel. This sulphate is re-dissolved in water, and decomposed by carbonate of potash. The precipitate is dissolved in liquid ammonia; the blue solution leaves a residuum which is filtered off, and the filtered solution saturated with nitric acid. The nickel is then precipitated in the form of a grayish green powder, by carbonate of potash. From this oxyd the metallic nickel is obtainable by exposing it to heat, when made into a mass with oil and a little charcoal powder.

The nickel obtained in this manner was, until lately, considered as perfectly pure. It possesses, however, magnetic properties. It is therefore contaminated with iron.

Chenevix has proposed the following process, in order to obtain this metal in a state of absolute purity:

Experiment 2. Take the native sulphuret of nickel, reduce it to a powder, and roast it in contact with charcoal powder over a gentle fire. When no more fumes arise, then pour nitric acid over it, and dissolve it by heat in a Florence flask. Decant the solution, filter it through bibulous paper, and evaporate it to dryness in a glass basin. Dissolve the nitrate of nickel in a sufficient quantity of distilled water, and decompose it by the addition of the strongest liquid ammonia, taking care to add it in excess. The oxyd of nickel and cobalt will thus be re-dissolved; then let the solution stand undisturbed till a precipitate again ensues. The solution must then be evaporated; it becomes blue during this process, by the precipitation of the cobalt, which should be separated, and the evaporation be then continued to dryness: the residue will be pure oxyd of nickel.

In order to reduce this oxyd to the metallic state, let it be made into a paste with oil, mix it with about three parts of black flux, and put it into a crucible, covering it with borax and muriate of soda, and heat the crucible violently for an hour and a half in a forge; a button will be obtained, which is *pure nickel.*

Several processes have been recommended to obtain nickel in a state of purity. The substance from which nickel is procured, was first supposed to be an ore of copper. It is found in different parts of Germany, and was called by miners *Kufernickel*, or "false copper." It was afterwards investigated by Constedt in 1751, and found to contain a new metal. Nickel is of a white colour, resembling silver. Its specific gravity rather exceeds 8.00. It is malleable both cold and hot. It is attracted by the magnet, and, like that metal, may be converted into a magnet. It is fusible at 160° Wedgwood. Nickel on exposure to heat is soon tarnished, and, if in powder, it is converted into oxyd. If the oxyd be exposed to a strong heat, it is reduced to a metallic state. There are two oxyds of this metal, the green and the black, the former is the prot-oxyd and the latter the per-oxyd. If the solution of nickel in nitric acid be decomposed by carbonate of potash, and the precipitate exposed to a faint red heat, the prot-oxyd of nickel will be formed.

This oxyd contains about 22 per cent. of oxygen, is soluble in ammonia, and forms with it a blue solution. The per oxyd of nickel is formed by causing a current of oxymuriatic acid to pass through water holding prot-oxyd of nickel suspended in it; a portion is dissolved, and the rest acquires a black colour. The oxyd is likewise soluble in ammonia.

Sulphur combines with nickel by fusion, and forms a bright gray sulphuret. According to Mr. E. Davy, that besides this sulphuret, which contains about 34 per cent. of sulphur, there is a super-sulphuret, which may be formed by heating the gray oxyd with sulphur, and which contains about 56.5 of nickel to 43.5 of sulphur.

Phosphorus and nickel unites into a phosphuret, which may be formed either by fusing nickel along with phosphoric glass, or by dropping phosphorus into it while red hot. The alloys, which this metal forms, are imperfectly known. In all the meteoric stones that have been examined, it is remarkable that the iron is alloyed, by from 1.5 to 1.7 per cent. of nickel. The alloy of iron and nickel is much less liable to rust than common iron. The oxyd of nickel will impart colours to enamels and porcelain.

SECTION XII.

OF NICOLANUM.

Dr. J. B. Richter has announced the existence of a new metal, to which he has given the name of *nicolanum*, because it always accompanies nickel in the ores of that metal. This metal has not hitherto been examined, nor recognized by other chemists. Its existence, however, is rather doubtful. Dr. Richter observes, that he was surprised to find, that nickel, after being purified from cobalt, iron, and arsenic, and after that reduced without the addition of a combustible body, never formed a mass, but was always found dispersed in small particles in a hard heavy substance, which had the appearance of the remains of vitrified copper.

The following additional remarks, are taken chiefly from the Annales de Chimie, lxiv. and Nicholson's Journal, No. 48, p. 261.

It resembles cobalt—

1. By its property of super-saturating itself with oxygen, at the expense of the nitric acid, and thus forming a body which resembles the black oxyd of manganese with regard to its solubility in the acids: 2. By its property of not being reducible but by the intervention of a combustible body.

It differs from cobalt—

1. By the blackish-green colour of its solution, even when they are entirely neutralized. It is known that the neutral solutions of cobalt in the sulphuric, nitric, and muriatic acids, are of a crimson-red colour; and that the muriate of cobalt alone becomes of a greenish-blue on being deprived of its water: from whence it happens that an excess of acid produces this colour, because it combines with the water. With the muriate of nicolanum precisely the reverse takes place; when water it is green (although of a less beau-

tiful colour than the cobalt without water) and when deprived of its water it becomes reddish. 2. By the colour of its carbonate: that of cobalt is of a beautiful poppy blue, but the carbonate of nicolanum is a bluish green inclining to a pale gray. 3 By the colour of its oxyd precipitated without carbonic acid: that of cobalt is of a deep blue, and changes on washing to a blackish brown; but this oxyd of nicolanum is of a greenish blue, and its colour does not change.

Nicolanum resembles nickel—

1. By its strong magnetic quality; although this is not so great as that of nickel. 2. By its malleability, which however is less than that of nickel. 2. By the deep green of its solutions; although this colour is not so beautiful as that of the solutions of nickel.— 4. By the loss of this green colour when its neutral combinations are deprived of water. 5. By the colour of the acid solution with an excess of ammonia, which cannot be well perceived by candle-light.

Nicolanum differs very distinctly from nickel—

1. Because it cannot be reduced without a combustible body added to it. 2. Because nitric acid attacks and oxydates it more easily. Nickel is not near so readily acted on by the nitric acid if it is not mixed with the nicolanum, which almost always happens with the magnetic nickel which is considered to be in a state of purity, and which has not been reduced *per se* before the discovery. 3. It also differs from nickel by the property first mentioned of those in which it resembles cobalt 4. By the colour of its combinations with the acids, when deprived of water: this colour in nickel is almost a buff (*chamois*) and in nicolanum a reddish, except in the nitrate of nicolanum, which cannot be deprived of water without decomposing it. 5. By the colour of precipitates, mentioned in the second and third articles concerning the properties wherein this new metal differs from cobalt, which are in those of nickel of a green colour, entirely different from those of nicolanum, which latter are of a much more agreeable green, especially those of the carbonate.

Richter obtained this metal in the following manner: he exposed the oxyd of nickel to a sufficiently strong heat, and obtained one ounce of nickel; the rest was converted to a kind of scoriæ. This matter was reduced to powder, mixed with charcoal, and exposed for 18 hours to the strongest heat of a porcelain furnace. Under a blackish brown scoriæ, he obtained a metallic button, which weighed $2\frac{3}{4}$ ounces, to which he gave the name of nicolanum. The general properties of this metal are: Its colour is steel gray with a shade of red. It is slightly malleable while cold. It is attracted by the magnet. Its specific gravity after fusion is 8.55; when hammered 8.60. It is soluble in nitric acid, the solution has a blackish green colour, which galatinizes when concentrated. When the solution is evaporated, a black powder, or oxyd of nicolanum, remains. This oxyd is insoluble in nitric acid, unless some sugar or alcohol be added to the mixture. It dissolves in muriatic acid, while oxymuriatic acid exhales. The solution is green. The sulphate of nicolanum exhibits the same phenomena. Carbonate of potash precipitates nicolanum from its solution of a pale blue colour. Ammonia renders the solution red, but occasions no precipitate. There are two oxyds of nicolanum; the first is greenish blue, the second black.

For further particulars, see Gehlen's Journal, iv. 392. and v. 394.

SECTION XIII.

OF TIN.

Experiment 1. If tin ore be pulverised, mixed with charcoal, and exposed to a sufficient heat, the metal will be obtained; or,

Experiment 2. If the ore be roasted, and afterwards mixed with equal parts of potash, one half of common rosin, and two parts of black flux, and the mixture fused in a crucible covered with charcoal, a button of metallic tin will be formed.

Rationale. The roasting dissipates the sulphur, and the subsequent process disengages the oxygen, if it be present, leaving the metal in the crucible. Pure tin may be obtained in the following manner:

Experiment 3. Let the tin obtained before be rapidly dissolved in strong nitric acid with heat. Thus some of the metals it may contain will be held in solution, and others become oxydated; but muriatic, or nitro-muriatic acid will, on digestion, take up these oxyds, and after sufficient ablution leave that of tin, which may afterwards be reduced by mixing it when pulverised with double its weight of a flux formed of equal parts of pitch and borax, or resin and borax, and putting it into a covered crucible, lined with charcoal, which must be placed in a forge, and strongly heated for a quarter of an hour.

The analysis of ores of tin may be accomplished in the following manner, for which we are indebted to Klaproth:

Experiment 4. Boil 100 grains, in a silver vessel, with a solution of 600 grains of pure potash. Evaporate to dryness, and then ignite, moderately, for half an hour. Add boiling water, and, if any remain undissolved, let it undergo a similar treatment.

Saturate the alkaline solution with muriatic acid, which will throw down an oxyd of tin. Let this be re-dissolved by an excess of muriatic acid; again precipitated by carbonate of soda; and being dried and weighed, let it, after lixiviation, be once more dissolved in muriatic acid. The insoluble part consists of silex. Into the colourless solution, diluted with two or three parts of water, put a stick of zinc, round which the reduced tin will collect. Scrape off the deposit, wash, dry, and fuse it under a cover of tallow in a capsule placed on charcoal. A button of pure metallic tin will remain at the bottom, the weight of which, deducted from that of the ore, indicates the proportion of oxygen.

The presence of tin in an ore is indicated by a purple precipitate, on mixing its solution in muriatic acid with one of gold in nitro-muriatic acid.

Remark. The ores of tin, which are either oxyds or sulphurets, are enumerated in the general classification of ores. Tin, in its native state, is said to have been discovered in Cornwall, but its existence is rather questionable.

M. Klaproth analysed six varieties of the native oxyd of tin, from which the following comparative view of the proportion of metallic tin contained in them, is deduced.

Grs.		*Grs.*
100	of stream tin, from Alternon in Cornwall, sp. gr. 6.97, gave of metallic tin	76
100	of brown crystallized tin stone from Schlackenwalde in Bohemia, sp. gr. 6.76, gave .	72.5
100	of wood-tin from Cornwall, sp. gr. 6.45, gave	73
100	of crystallized gray tin stone, having some white transparent spots, from St. Agnes in Cornwall, sp. gr. 6.84, gave	74
100	of black stream tin from Ladock in Cornwall, sp. gr. 6.96, gave	76
100	of light brown acicularly crystallized tin stone from Polgooth in Cornwall, sp. gr. 6.75, gave	77

Tin has been known from the earliest ages. It was in common use in the time of Moses.* It is mentioned by Homer. It was brought from Cornwall to England, by the Phœnicians and Greeks, some centuries before the Christian era.† It is mentioned by Aristotle under the Greek name of Celtic tin.

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* Numbers, xxxi. 22.

† Pliny states (lib. iv. cap. 54. and lib. xxxiv. cap. 47.) that the Phœnicians procured it from Spain as well as from England.

This metal is of a white colour. Its hardness is 6. Its specific gravity is 7.291. It is very malleable. Tin leaf, or *tin foil*, is about $\frac{1}{1000}$ part of an inch thick. A tin wire $\frac{1}{12.6}$ inch in diameter is capable of supporting a weight of 31 pounds without breaking. At the temperature of 442° it melts. At a violent heat it evaporates. When cooled slowly, it may be obtained crystallized in the form of a rhomboidal prism.

It loses its lustre when exposed to the air, and assumes a greyish white colour, but when the vapour of water is made to pass over it in the state of ignition, the water is decomposed, the tin is oxydized, and hydrogen gas is disengaged. When tin is melted in an open vessel, its surface becomes very soon covered with a grey powder, or oxyd of the metal. When heated violently it takes fire, and is converted into a fine white oxyd. Tin is capable of combining with three different proportions of oxygen, and of forming three distinct oxyds. Two of them have been named the *yellow* and the *white oxyd*. The gray oxyd may be obtained in the following manner:

Experiment 5. Dissolve tin in muriatic acid, either by means of heat, or by adding a little nitric acid occasionally. When the solution is formed decompose it by adding an excess of potash; a white powder will precipitate, which, in part will be taken up. But the remainder on standing, will assume a dark grey colour, which is the grey oxyd of tin. According to Proust, this oxyd contains 20 per cent. of oxygen.

Experiment 6. If tin be dissolved in concentrated nitric acid, a violent action will take place, and the metal be converted into a white powder, which is deposited at the bottom of the vessel.

Rationale. The nitric acid is decomposed; nitric oxyd gas is disengaged; and the tin is oxydized to the maximum, forming the per oxyd. This oxyd is composed of about 28 parts of oxygen and 72 of tin.

Experiment 7. If granulated tin be dissolved in dilute nitric acid, and the solution decomposed by the addition of potash, a yellow oxyd of tin will be precipitated.

Rationale. The nitric acid unites with the metal, forming a nitrate which is decomposed by the potash; nitrate of potash is produced and the metal is precipitated in the form of a yellow oxyd.

Experiment 8. If five parts of concentrated sulphuric acid, and one part of granulated tin, be introduced into a flask and digested, a solution of the metal will take place.

Rationale. The metal is oxydized at the expense of the acid; sulphurous acid gas is disengaged, and the metal is dissolved.

Experiment 9. If the solution of tin, of the last experiment, be evaporated, crystals of sulphate of tin will be produced.

Experiment 10. If one part of tin, be added to two parts of muriatic acid, it will be dissolved, forming muriate of tin.

Rationale. The metal is oxydized by the water contained in the acid; hydrogen gas is evolved; and the oxyd of tin, thus produced, is then dissolved.

Experiment 11. If the solution of the last experiment be evaporated, crystals of muriate of tin will be formed.

Experiment 12. If two parts of nitro-muriatic acid be introduced into a flask, and one part of tin gradually added, a solution of the metal will take place.

Experiment 13. If equal parts of grained tin and muriate of ammonia be mixed, and introduced into a retort, and heat applied; ammonia will come over, leaving a residuum of solid muriate of tin.

Rationale. The muriate of ammonia is decomposed; the tin is oxydized, and the oxyd combines with the muriatic acid, forming muriate of tin, whilst the ammonia is disengaged in the form of gas.

Experiment 14. If five parts of tin and one of mercury be fused together, the mixture then triturated with an equal quantity of corrosive muriate of mercury, and the whole introduced into a retort and distilled, the oxymuriate of tin, or the *smoking liquor of Libavius* will be obtained.

Remark. Adet has published a very interesting memoir on this production. From the observations of this chemist it appears, 1st, that the oxygenated muriate of tin is a saline substance, formed by the combination of tin with oxygenated muriatic acid deprived of water. 2d. That if it be mixed with water in the proportion of seven to twenty-two, a concrete saline substance will be obtained. 3d. That when diluted with water, it can dissolve a new quantity of tin without a disengagement of hydrogen gas. According to these facts, it is a true *oxygenated muriate of tin.*

Experiment 15. Having found a piece of blue linen cloth, that will bleach in oxygenized muriatic acid, dip the tip of the finger in a solution of *muriate of tin*, and press it while wet with the solution, upon a strip of this cloth. After an interval of a few minutes immerse the cloth in the vial of liquid oxygenized muriatic acid, and when it has remained in it the usual time, it will be found that the spot which was previously wet with muriate of tin has preserved its original colour, while the rest of the cloth has become white.

Experiment 16. Dip a piece of white calico in a strong solution of acetate of iron; dry it by the fire, and lay it aside for three or four days. After this, wash it well in hot water, and then dye it black, by boiling it for ten minutes in a strong decoction of Brazil wood. If the cloth be now dried, any figures printed upon it with a *colourless* solution of muriate of tin will appear of a beautiful scarlet, although the ground will remain a permanent black.

Experiment 17. Take a piece of very dark olive coloured linen that has been dyed with iron and quercitron bark, or weld, and spot it in several places with a *colourless* solution of muriate of tin. Wherever the cloth has been touched with this solution, the original colour will be discharged, and spots of a bright yellow will appear in its stead.

Experiment 18. Boil a little cochineal in water with a grain or two of cream of tartar (supertartrate of potass) and a dull kind of crimson solution will be formed. By the addition of a few drops of nitro-muriate of tin, the colouring matter will be precipitated of a beautiful scarlet. This, and some of the former instances, will give the student a tolerably correct idea of the general processes of dyeing woollen cloths. See light.*

The union of white oxyd of tin with sulphur by fusion, forms yellow sulphuretted oxyd of tin (aurum musivum.)

Experiment 19. The process generally adhered to in this preparation is as follows: twelve parts of tin are melted in a crucible by a brisk fire, and three of mercury added to it. This mass is to be reduced to powder in a stone mortar, and then intimately mixed by trituration with seven parts of sulphur, and three of muriate of ammonia: the mixture is exposed to heat as long as any white vapours are disengaged; the heat is then moderately increased; a little sulphuret of mercury and some oxygenated muriate of tin sublime, and the *aurum musivum* remains at the bottom of the mattrass.

A variation in the proportion of the ingredients produces no very essential change in the result. Pelletier obtained a very beautiful musive gold by distilling together equal parts of mercury, muriate of ammonia, tin, and sulphur. The main point is the proper regulation of the heat; if this be too strong the operation does not succeed, and instead of a beautiful *aurum musivum*, common sulphuret of tin, of a very dark colour, is obtained.

Rationale. The theory of the formation of this compound is one of the most intricate in chemistry, but it appears to have been sufficiently ascertained by the researches of Pelletier. In the first amalgamation and trituration of the mercury and tin, the latter is divided,

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* Parke.

and in some degree oxydated; when the mixture of this amalgam with the sulphur and muriate of ammonia is heated, the muriatic acid, by a disposing affinity, enables the tin to be oxydated by decomposing the water, and this oxyd combines with the muriatic acid; the hydrogen of the water is disengaged with the ammonia of the muriate of ammonia; this ammonia unites with a portion of the sulphur, and forms sulphuret of ammonia, which being disengaged, causes the white fumes. The heat being now augmented, the muriate of tin is again decomposed, the oxyd of the metal attracting a portion of the sulphur, and forming the *aurum musivum*. Such is the aetiology of that complicated process given by Pelletier.

Aurum musivum is employed to give a beautiful colour to bronze, and to excite the strength of electrical machines. It is used by japanners, and for many articles intended to have the appearance of metallic gold.*

Tin combines very readily with sulphur; as,

Experiment 20. By fusing together, in a covered crucible, one part of tin with four or five of sulphur. The compound is heavier than tin, and not so fusible.

Tin combines also with phosphorus; as follows:

Experiment 21. Take equal parts of tin filings and glacial acid of phosphorus, and one eighth part of charcoal powder: mix these three substances intimately, and fuse them in a crucible; a few grains of a metallic appearance, and of a pretty large size, will be obtained. These do not differ in appearance from tin, but when melted by the blow-pipe, the phosphorous abandons the metal and burns on its surface.

Remark. In fusing tin with charcoal powder and glacial acid of phosphorus, care must be taken to regu-

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* Accum.

late the fire properly, for the phosphorous easily abandons the metal.

The accension of tin-foil by nitrate of copper, mentioned under affinity, the decomposition of nitrate and oxymuriate of potash by tin, causing detonation, shews that this metal, like the others, is inflammable and capable of combining with oxygen.

With the metals, tin is capable of combining, and forming alloys of a peculiar nature. Thus we have alloys of tin with gold, platinum, silver, mercury, copper, iron, &c.

Tinning copper vessels.

Vessels of copper, especially when used as kitchen utensils, are usually covered with a thin coat of tin, to prevent the copper from oxydating, and to preserve the food which is prepared in them from being mixed with any of that poisonous metal. These vessels are then said to be *tinned.* Their interior surface is scraped very clean with an iron instrument, and rubbed over with muriate of ammonia. The vessel is then heated, and a little pitch thrown into it, and allowed to spread on the surface. Then a bit of tin is applied all over the hot copper, which instantly assumes a silvery whiteness. The intention of the previous steps of the process is to have the surface of the copper perfectly pure and metallic; for tin will not combine with the oxyd of copper. The coat of tin thus applied is exceedingly thin. Bayen ascertained, that a pan nine inches in diameter, and three inches three lines in depth, when tinned, only acquired an additional weight of 21 grains. Nor is there any method of making the coat thicker. More tin indeed may be applied; but a moderate heat melts it, and causes it to run off.

The alloy or amalgam of mercury and tin is used in *silvering* the backs of looking glasses A sheet of tin foil is spread upon a table, and mercury rubbed upon it by a hare's foot, till the two metals incorporate;

then a plate of glass is slid over it, and kept down with weights. The excess of mercury is driven off, and in a short time the tin foil adheres to the glass and converts it into a mirror. Two ounces of mercury are requisite for covering three square feet of glass.

Iron is tinned in the following manner: plates of iron, after being reduced to a proper thickness, are immersed in water acidulated with sulphuric or muriatic acid, in order to clean them completely from rust; they are then scoured quite bright, and placed in a pot, or other convenient vessel, filled with melted tin, whose surface is covered with suet, pitch, or rosin, to prevent the surface of the tin being oxydated. The plates of iron being then suffered to pass through it, the tin will unite with them so as to cover each side of the plate with a thin white coat. They are then what are called tin plates.

In the same way stirrups, buckles, bridle bits, &c. are covered with coats of tin.

Tin plate is known in Scotland by the name of *white iron.*

The alloys of copper and tin have already been noticed. See Copper.

Besides the union of copper and tin, for the formation of gun metal, bell metal, bronze, &c. it is asserted that the *conch* of the East Indians is composed of the same metals.

Three parts of tin, five of bismuth, and two of lead, forms the alloy, or soft solder of Lichtenburg. According to Wallerius, two parts of tin with one of bismuth forms the Tutenag of the Chinese. Equal parts of tin and zinc, with two parts of mercury, melted together, forms the amalgam for exciting electrical machines. Tin enters into the composition of pewter, enamel, &c.

SECTION XIV.

OF LEAD.

Experiment 1. In order to obtain lead in the large way, the ore is picked from among the extraneous matter with which it was combined by nature. It is then pulverised and washed. It is next roasted in a reverberatory furnace in which it is to be agitated, in order to bring all its surfaces in contact with the air. When the external parts begin to soften, or assume the form of a paste, it is covered with charcoal, the mixture is stirred, and the heat increased gradually; the lead then runs on all sides, and is collected at the bottom of the furnace, which is perforated so as to permit the metal to flow in a receptacle defended by a lining of charcoal dust.

The scoria remaining above in the furnace still retain a considerable portion of lead; in order to extract it they are fused in a blast furnace. The lead is by that means separated, and cast into iron moulds, each of which contains a portion called *a pig of lead.* These pigs are sold under the name of *ore lead.*

Experiment 2. To disengage the silver from lead thus obtained, the metal is subjected to the action of the refining furnace. The continual application of a quantity of fresh air which is thrown by means of large bellows upon the fused lead, which is at the same time heated as intensely as possible, oxydizes the lead, and converts it into the yellow scaly oxyd, known by the name of *litharge*, or vitreous oxyd of lead.

This oxyd being driven off from the surface of the fused metal, as it is formed, leaves the silver alone unaltered at the bottom in a metallic state.

The litharge is then to be fused in contact with charcoal, in order to reduce it again to the state of metallic lead.

Experiment 3. To obtain perfectly pure lead, the lead of commerce may be dissolved in nitric acid, and the solution be decomposed by adding to it, gradually, a solution of sulphate of soda, or sulphuric acid, so long as a precipitate ensues. This precipitate must be collected on a filter, washed repeatedly in distilled water, and then dried. In order to reduce it to the metallic state, let it be mixed with two or three times its weight of black flux, introduce the mixture into a crucible, and expose it briskly to a red heat.*

Lead ores may be analyzed by solution in nitric acid, diluted with an equal weight of water. The sulphur, if any, will remain undissolved. Let the solution be precipitated by muriate of soda. If any silver be present, it will be taken up by pure liquid ammonia. Wash off the excess of ammonia by distilled water; and add concentrated sulphuric acid, applying heat, so that the muriatic acid may be wholly expelled. Weigh the sulphate of lead, and, after deducting 70 per cent. the remainder shows the quantity of lead.

Muriate of lead may also be separated from muriate of silver by its greater solubility in warm water. From the solution, iron may be separated by prussiate of potash, and the solution decomposed by sulphuric acid.† Lead has been known at an early period. It is mentioned by Moses, but the ancients confounded it very often with tin, or considered that it had a close resemblance to that metal.

Lead is of a bluish white colour; its specific gravity, according to Brisson, is 11.3523. It is very malleable, and may therefore be hammered into leaves of extreme thinness. Its tenacity is such, that a lead wire $\frac{1}{12.8}$ inch in diameter is capable of supporting only 18.4 pounds without breaking. It melts at about 612°. At a considerable temperature it boils and evaporates. If it be cooled slowly, it crystallizes. The abbe Mongez obtained it in quadrangular pyramids, lying on one

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* Accum, ii. 70. † Henry.

of their sides. It has been obtained, however, in the form of a polyhedron with 32 sides, formed by the concourse of six quadrangular pyramids. When exposed to the air, lead loses its lustre, and acquires a dirty gray colour, and at last becomes almost white. When melted and exposed in the same manner, its surface is converted into scoriæ, or oxyd. Lead is capable of combining with four doses of oxygen, and of forming four different oxyds. The yellow oxyd of lead may be prepared in the following manner.

Experiment 4. Dissolve lead in a sufficient quantity of nitric acid, so as to form a colourless solution; then supersaturate it with carbonate of potash; collect the precipitate, which is white, wash it, and heat it nearly to redness. It will assume a yellow colour.

Rationale. The lead is oxydized by the acid; the oxyd is taken up, and again separated by the addition of carbonate of potash; nitrate of potash is formed, and the carbonate of lead precipitated. On exposing this to heat the carbonic acid is disengaged, leaving the yellow oxyd of lead behind. According to Thomson, this oxyd contains 9.5 per cent. of oxygen.

Experiment 5. If lead be melted in an open vessel, its surface will become covered with a gray powder; if this be removed another will proceed; and, finally, the whole will be converted into an ash coloured powder; and,

Experiment 6. If the product of the last experiment be heated, and agitated for a short time in an open vessel, it will assume the appearance of a grayish yellow powder.

This powder is a mixture of the yellow oxyd and metallic lead; but,

Experiment 7. If this powder be exposed to heat for some time longer in an open vessel, it will assume a yellow colour, forming the *massicot* of commerce.

Experiment 8. If thin plates of lead be exposed to the vapour of vinegar, they will gradually be corroded, and converted into a heavy white powder, used as a paint, and called *white lead.* This preparation, though formerly considered a white oxyd, is considered a compound of the yellow oxyd and carbonic acid. See Salts of Lead.

Lead may be combined with a minimum of oxygen, forming the prot oxyd, in the following manner:

Experiment 9. Dissolve lead in nitric acid, and boil the crystals which that solution yields along with pieces of metallic lead. Small scaly crystals of a yellow colour may be obtained from this solution. These crystals are composed of the prot oxyd of lead and nitric acid.

Experiment 10. If the crystals of the last experiment be decomposed by potash, a yellow oxyd will be obtained, which is the prot oxyd of lead, and according to Proust, contains 8½ per cent. of oxygen.

Experiment 11. If massicot, ground to powder, be put into a furnace, and constantly stirred while the flame of the burning coals plays against its surface, it is in about 48 hours converted into a beautiful red powder, known by the name of *minium* or *red lead.*

This powder is considered the trit oxyd of lead, and contains about 12 per cent of oxygen.

Experiment 12. If nitric acid, of the specific gravity 1.260, be poured upon red lead, 185 parts of the oxyd will be dissolved, leaving 15 parts in the state of a deep brown powder, being the per oxyd, or brown oxyd of lead of Scheele; or,

Experiment 13. Put a quantity of red oxyd of lead into a vessel partly filled with water, and make oxymuriatic acid gas pass into it. Into the solution, which will thus be formed, pour a solution of potash, and the brown oxyd of lead will precipitate.

This oxyd contains 20 per cent. of oxygen.

Experiment 14. If the red oxyd of lead be exposed to a heat sufficient to reduce it to a semi vitrified state, its parts become agglutinated into small thin scales, which always preserve their red colour, but have less brightness. This oxyd is now called *litharge.*

Experiment 15. If the product of the last experiment be exposed to a violent heat in a crucible, it will fuse and be converted into the *glass of lead.* This vitreous oxyd of lead constitutes the basis of the glazing for common pottery.

All the oxyds of lead are very easily converted into glass; and in that state they oxydize and combine with almost all the metals except gold, platinum, silver, and the metals recently discovered in crude platinum. Hence lead is used in *cupellation*. In the process of refining, *litharge* is also formed. The following experiment will give some idea of the process:

Experiment 16. Alloy a piece of silver with a portion of lead, place the alloy upon a piece of charcoal, attach a blow-pipe to a gasometer charged with oxygen gas, light the charcoal first with a bit of paper, and keep up the heat by pressing upon the machine. When the metals get into complete fusion, the lead will begin to burn, and very soon will be all dissipated in a white smoke, leaving the silver in a state of purity.

The oxyds of lead may be reduced in the following manner:

Experiment 17. Take one ounce of red lead, and half a dram of charcoal in powder, incorporate them well in a mortar, and then fill the bowl of a tobacco pipe with the mixture. Place this in the middle of a common fire, and presently the lead will be reduced, when it may be poured out as metallic lead.

Experiment 18. If the red oxyd of lead be put into a receiver of hydrogen gas, and the oxyd be heated by means of a glass lens, the oxygen of the metal will combine with the hydrogen to form water, and the metal will be completely revived.

Experiment 19. Dip a piece of white calico in an aqueous solution of acetate of lead, and then drop a little solution of sulphuret of potass upon it. If this be now placed in the palm of the hand, the lead will be observed gradually to revive, and will soon be reduced to its metallic state.

Experiment 20. Write with a solution of nitrate or acetate of lead. When the writing is dry it will be invisible. Then having prepared a glass decanter with a little sulphuret of iron strewed over the bottom of it, pour a little very dilute sulphuric acid upon the sulphuret, so as not to wet the mouth of the decanter, and suspend the writing by means of the glass stopper, within the decanter. By an attention to the paper, the writing will become visible by degrees, as the sulphuretted hydrogen gas rises from the bottom of the vessel.

Experiment 21. In like manner add sulphuretted hydrogen to a solution of lead, and a deep brown precipitate will be occasioned. This is an effectual mode of detecting this and some other pernicious metals.

Experiment 22. If phosphorus be dropped into melted lead, they will unite, and form phosphuret of lead; or,

Experiment 23. If a mixture of equal parts of filings of lead and glacial acid of phosphorus be fused in a crucible, with one-eighth part of powdered charcoal, a button of phosphuret of lead will be formed. This phosphuret is composed of about 12 parts of phosphorus and 88 of lead.

Experiment 24. If three parts of lead be melted in an iron ladle, and one part of sulphur added, the two will unite into a sulphuret of lead, or artificial *galena.* We have the common sulphuret of lead, which contains about 14 per cent. of sulphur, and the super sulphuret composed of 25 per cent. of sulphur.

With respect to the uses made of lead in former times, the Romans sheathed the bottoms of their ships with this metal, fastened with nails made with bronze. During the first century, lead at Rome was twenty-four times as dear as it is now; whereas tin was only eight times its present price. Ceruse, or white lead, was in great use by the Roman ladies as a cosmetic. According to Bishop Watson, Plautus introduced a waiting woman who refused to give her mistress either ceruse, or rouge, because, forsooth, in the true spirit of a flattering Abigail, she thought her quite handsome enough without them. The use of lead, in imparting a saccharine taste to acid wines, was known to the ancients. Pliny mentions, that the Greeks and Romans proved the quality of their wines by dipping a plate of lead in them.* The practice of hiding the defects of wines by the use of lead, is happily abolished; its presence may be known in several ways.†

Lead has also been used to take off the rancidity of oils. Vats of lead have been used in some cyder countries, which have produced incalculable mischief.

The manufacture of lead into sheets is performed by suffering the melted metal to run out of a box through a long horizontal slip upon a table prepared for the purpose, while the box is drawn by appropriate ropes and pulleys along the table, leaving the melted lead behind it in the desired form to congeal. There is also a large consumption of lead in making shot.‡

Lead is capable of combining with most of the metals, by different processes; as, with gold, platinum, silver, mercury, copper, iron and tin. The *ley pewter*, as well as the *tin foil*, of the English, is often nothing more than the alloy of tin and lead. Of the other alloys, but little is known.

Experiment 25. Mix two parts of fine powdered red oxyd of lead with one of common salt in a stone mortar, and form the two substances into a paste, with a little water, adding more occasionally as the mixture becomes dry.

The soda of the common salt becomes disengaged, and the muriatic acid unites with the oxyd of lead. Wash off the soda, dry the white mass, and fuse it in a crucible, it will form the beautiful and durable pigment called *patent* or *mineral yellow*.

The decomposition of muriate of ammonia by oxyd of lead may be effected in a similar manner when assisted by caloric.

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* See Beckman's History of Inventions, i. 398. 400.

† Lambe on the Nature of Spring Water. Johnstone on Poisons, 113.

‡ For a description of the process, see Black's Chemistry, ii. 604.

Experiment 26. Lead and tin form an alloy, which is more fusible than either of the metals separate, in the following manner: This alloy, which is known by the name of plumbers solder, is made by fusing together in an iron ladle, two parts of lead and one of tin.

Experiment 27. That lead precipitates silver or mercury, is obvious from the following experiment. Suspend a piece of lead, scraped bright, in a concentrated solution of nitrate of silver, or nitrate of mercury. The lead, by its greater affinity for oxygen, will first become black, and then separate the silver or mercury from the solution.

A similar effect will take place by distilling muriate of mercury with granulated lead. Mercury will pass over into the receiver, and muriate of lead remain in the retort.

Experiment 28. That zinc precipitates lead in a metallic state forming the *lead tree*, is shown in the following manner: Dissolve one part of acetite of lead in 36 or 40 parts of distilled water; put this solution into a glass bottle, suspend a cylinder or ball of zinc in it, and then leave the vessel containing it undisturbed. The zinc will soon become covered with a moss-like substance, which increases gradually, shooting out symmetrical leaves of a metallic splendour, which arrange themselves into a kind of tree.

Rationale. The explanation of this experiment is obvious; the zinc has a greater affinity for oxygen than the lead has, it therefore deprives the latter of it, which being thus reduced to the metallic state, arranges itself by virtue of its molecular attraction into a symmetrical form.

SECTION XV.

OF ZINC.

Experiment 1. In order to obtain zinc from its ores, they must first be torrified, and then mixt with half their weight of charcoal powder, and distilled in an earthen retort three quarters full (to which a receiver is luted) in a strong heat gradually increased for some hours. The zinc in its metallic form, is then found in the neck of the retort. In order to obtain the metal in a pure state, dissolve it in diluted sulphuric acid, and boil the concentrated solution for a few minutes upon granulated zinc. Then filter it, and precipitate, wash the precipitate, and when dry mix it with half its weight of charcoal-powder, and submit it to a red heat in an earthen retort. Pure zinc will then be found in the neck of the retort.

The ores of zinc are analyzed in the following manner:

Experiment 2. Let one part of the powdered ore be gently boiled in six of diluted nitric acid in a flask to dryness, and repeat this operation with the same ore two or three times. Then dissolve the dry mass in a sufficient quantity of water in which about one-fourth of nitric acid has been added, and precipitate the fluid by a solution of soda. Collect the precipitate on a filter, wash it by passing water over it, and re-dissolve it in muriatic acid. Then decompose this solution by liquid ammonia in excess, in order to separate the iron, lead, and alumina which may have been dissolved. If this precipitate be boiled in four times its quantity of potash, the alumina will be separated.

From the before-going solution the zinc may be separated by the addition of an acid. It may be reduced to the metallic state by strongly igniting it with half its weight of charcoal in a closed crucible.

Experiment 3. In order to analyze *calamine*, let it be digested repeatedly in diluted nitric acid, and the insoluble residue boiled in concentrated muriatic acid three times. What remains after ablution with boiling water is silex.

The nitric solution obtained before contains the zinc, and also iron and alumina, if they were present in the ore. Let the solution therefore be evaporated to dryness; re-dissolve it in nitric acid, and evaporate it again as before, in order to render the iron as insoluble as possible. Then dissolve the mass in water.

A tolerably exact assay of the ore called calamine, may be made in the following manner.

Experiment 4. Mix any quantity of the pulverised ore, previously freed from sulphur by roasting, with one-eighth part of charcoal powder. Put this mixture into a crucible capable of containing thrice the quantity. Diffuse equally amongst this mixture a quantity of small grains or thin plates of copper equal to that of the calamine or ore employed, and upon the whole lay another equal quantity of grains or plates of copper, and lastly, cover this latter portion with charcoal powder. Lute a cover upon the crucible, and apply a red heat during one or two hours. The volatilized zinc will thus combine with the copper, and convert it into brass. By comparing the weight of the metal after the operation with the weight of the copper employed, the quantity of zinc united with the copper will be known.

More copper with fresh charcoal powder, may be again added in the same manner to the remaining ore, and the operation repeated with a heat somewhat more intense, in order that any zinc remaining in the ore may be thus extracted. A curious circumstance is, that a much greater heat is required to obtain zinc from its ore without the interposition of copper, than in the process now described of making brass; in which the separation of the zinc from its ore is certainly facilitated by the interposition of the copper.

Although we have no positive proof that the ancients were acquainted with zinc as a metal, yet they knew a mineral called Cadmia (from Cadmus, who first taught the Greeks to use it) which when melted with copper formed brass. Besides being mentioned by Pliny, it also occurs in the writings of Albertus Magnus, who died in 1280. The word zinc also occurs in the writings of Paracelsus, who died in 1541. Zinc is also known by the name of spelter. Henkel, Von Swab and Margraff, pointed out the means of obtaining it from its ore. It has been obtained in the United States from the sulphuret of zinc, which is found at Perkiomen, and in some other places in this country.

Zinc is a white metal, whose hardness is 6½, and whose specific gravity varies from 6.8 to 7.1. Its malleability is by no means to be compared to some of the other metals. When heated somewhat above 212° it becomes very malleable. When carefully annealed it may be made into thin plates. At 400° it becomes extremely brittle, and may be reduced to powder in a mortar. It possesses some degree of ductility. Its tenacity is such, that a wire whose diameter is $\frac{1}{10}$th of an inch, is capable of supporting a weight of 26 pounds.

Experiment 5. If zinc be heated to the temperature of about 680°, fusion will take place ; and,

Experiment 6. If the heat be increased, the metal evaporates, and may be collected in close vessels.

Experiment 7. If melted zinc be allowed to cool slowly, quadrangular prismatic crystals will be obtained.

Experiment 8. If the vapour of water be made to pass over zinc at a very high temperature, the metal will become oxydized, and hydrogen gas emitted.

Rationale. The water is decomposed ; its oxygen unites with the zinc, and its hydrogen is disengaged in the form of gas.

Experiment 9. If zinc be melted in an open vessel, exposed to the air, its surface will become covered with a gray coloured pellicle, and the whole is gradually changed to a gray powder, being the *gray oxyd of zinc.*

Experiment 10. If zinc be exposed to a strong heat in an open vessel, it will take fire and burn with a brilliant white flame, emitting a quantity of white flakes, known by the names of *pompholyx*, *nihil album*, *lana philosophica*, and *flowers of zinc*.

Rationale. In combustion, zinc combines with oxygen, forming a white oxyd, and the gas gives out caloric and light.

Experiment 11. If sulphate of zinc be decomposed by the addition of potash, a white precipitate will be obtained, which, when washed and dried, forms the per oxyd, or white oxyd of zinc.

Rationale. Zinc combined with sulphuric acid in the sulphate, is oxydized to the maximum; if this compound be decomposod by potash, the sulphate of that alkali is formed, and the per oxyd of zinc is precipitated. The per oxyd contains 20 per cent. of oxygen.

Experiment 12. If the per oxyd of zinc be exposed to a strong heat in an earthen-ware retort, or covered crucible, it assumes a yellow colour, and is reduced to the state of prot oxyd.

Rationale. The exposure to heat expels a portion of oxygen from the per oxyd, forming thereby the prot oxyd.

Experiment 13. Take a phial with a solution of sulphate of zinc, and another containing a little liquid ammonia, both transparent fluids. By mixing them, a curious phenomenon may be perceived: the zinc will be immediately precipitated in a white mass, and, if then shaken, almost as instantly re-dissolved.

Rationale. The ammonia precipitates the zinc in the form of oxyd, and produces sulphate of ammonia; the oxyd is then dissolved by another portion of the ammonia, forming the ammoniaret of zinc.

Experiment 14. Mix equal parts of nitrate of potash and filings of zinc, and project the mixture by spoonfuls into a crucible which has been brought to a state of ignition. When the powder has acquired a certain degree of heat, a strong detonation suddenly takes place; as soon as it ceases throw another spoonful of the mixture into the vessel, and repeat the operation till the whole quantity is consumed. The residuum will be an oxyd of zinc.

Remark. This experiment requires caution, to prevent accidents.

Experiment 15. When a few grains of fine zinc filings and oxygenated muriate of potash are struck on an anvil, a violent detonation takes place, with a white flame.

Experiment 16. Distil two parts of muriate of mercury and one of zinc, in a glass retort; a salt which crystallizes in small needles united together will be sublimed, and the mercury will remain fluid in the retort. This salt is muriate of zinc.

Experiment 17. If zinc be melted, and small pieces of phosphorus dropped into it while in fusion, a compound called phosphuret of zinc will be formed.

Experiment 18. If 12 parts of oxyd of zinc, 12 parts of phosphoric glass, and 2 parts of charcoal powder, be mixed and distilled in an earthen retort in a strong heat, a phosphuretted oxyd of zinc will be the result.

Experiment 19. If sulphur be melted with oxyd of zinc, a combination is formed, called the sulphuretted oxyd of zinc.

The alloys of zinc have already been mentioned.

1. With gold: it has been proposed by Mr. Hellot as very proper for the specula of telescopes. See Gold.

2. With platinum it forms a brittle alloy. See Platinum.

3. With silver it forms an alloy of a bluish white colour. See Silver.

4. With mercury it forms amalgams of different degrees of hardness. See Mercury.

SECTION XVI.

OF BISMUTH.

Experiment 1. If the ore of bismuth be fused with an eighth part of white flux in a well closed vessel, the metal will be obtained.

Remark. Bismuth thus obtained is not pure, but constitutes the metal of commerce. In order to purify it, the following process is necessary.

Experiment 2. Powder the product of Experiment 1, and dissolve it in pure nitric acid, and precipitate by adding water to the solution, collect the precipitate, form it into a paste with oil, and rapidly fuse it with black flux in a closed crucible.

Rationale. The solution of the bismuth of commerce in nitric acid not only dissolves that metal, but others, with which it may be mixed, and the oxyd thrown down by water on being treated with a carbonaceous flux is reduced to the state of metal.

Remark. The German miners appear to have discovered this metal, and to have given it the name of bismuth; they also called it *tectum argenti.* A number of Essays were written on it at different times. The metal is of a reddish white colour, extremely brittle, and can not be drawn out into wire. Muschenbroeck says, that a rod $\frac{1}{10}$th of an inch in diameter will sustain a weight of 29 pounds. It melts at 476° and may be volatilized by continuing the heat. On exposure to the air, it loses its lustre. The *yellow oxyd* may be obtained in the following manner:

Experiment 3. If bismuth be raised to a strong red heat it takes fire, and emits a yellow smoke, which, when collected, condenses into a yellow powder.

Rationale. During combustion it unites with oxygen, forming an oxyd, which is disengaged in the form of smoke.

Experiment 4. If the powder of bismuth be thrown into oxymuriatic acid gas, it will take fire, and exhibit a beautiful phenomena. See the Properties of Oxymuriatic acid gas.

The compound thus formed consists of the metal oxydized to the maximum, and muriatic acid, and is called *butter of bismuth*, but Mr. Davy calls it *bismuthane*.

Experiment 5. If bismuth be dissolved in nitric acid, and water poured into the solution, a white powder will fall, which, when collected, and washed in the usual manner, forms the *white oxyd* used in medicine, or the magistery of bismuth, known also by the name of *pearl or flake white*.

Rationale. See Experiment 2. This oxyd is the per oxyd; but some consider it a sub nitrate, and others a hydrate of bismuth.

Experiment 6. If the white oxyd of bismuth be placed in an atmosphere of sulphuretted hydrogen gas, it will become tarnished, forming a *sulphuretted oxyd*. Hence the impropriety of using this oxyd as a cosmetic. Ladies, in the habit of using it, on going into waters containing that gas, have become dark tawnies. Some idea may be had of this fact from the following experiment.

Experiment 7. A letter written with a diluted solution of bismuth, becomes, when dry, illegible, but a feather dipped into a solution of sulphuret of potash, will instantly blacken the oxyd, and revive the writing.

Rationale. The acid of the solution of bismuth first unites with the potash of the sulphuret, and the sulphur then combines with the oxyd, forming a black sulphuretted oxyd.

Experiment 8. Write on paper with a solution of nitrate of bismuth; when this is dry the writing will be invisible; but if the paper be immersed in water, it will be distinctly legible.

Rationale. The nitrate of bismuth being insoluble in water, on coming in contact with that fluid is decomposed; the oxyd of bismuth is therefore separated.

Experiment 9. If one part of oxyd of bismuth and two of muriate of ammonia be distilled, the residue in the retort will be muriate of bismuth.

Rationale. The muriate of ammonia is decomposed; ammoniacal gas is disengaged, which may be absorbed by water; the muriatic acid combines with the bismuth into a muriate.

Experiment 10. If bismuth be fused in a crucible, and small pieces of phosphorus dropped into it, a phosphuret of bismuth will be formed.

Experiment 11. If sulphur and bismuth be mixed, and melted, a compound will be produced called the sulphuret of bismuth.

Remark. Bismuth unites with the metals:

The common mixture for *pewter* is 112 pounds of tin, 15 pounds of lead, and six pounds of brass; but many manufacturers use also bismuth and antimony to compose this metal. Bismuth is likewise generally mixed with tin for vessels of capacity, &c. as it gives to that metal a greater degree of brilliancy and hardness.

Experiment 12. Melt together 8 parts of bismuth, 5 of lead, and 3 of tin, the mixed metal will fuse at a heat no greater than 212.° Tea-spoons made with this alloy, surprise those who are unacquainted with their nature. They have the appearance of common tea-spoons, but melt as soon as they are put into hot tea.

Experiment 13. If lead, zinc and bismuth be taken in equal parts, the resulting alloy will melt with so small a portion of caloric, that it may even be kept in fusion upon paper over a lamp.

SECTION XVII.

OF ANTIMONY.

Experiment 1. To obtain antimony, heat 32 parts of filings of iron to redness, and project on them, by degrees, 100 parts of antimony; when the whole is in fusion, throw on it, by degrees, 20 parts of nitrate of potash, and after a few minutes quiet fusion, pour it into an iron melting cone, previously heated and greased.

Experiment 2. It may also be obtained by melting eight parts of the ore mixed with six of nitrate of potash, and three of acidulous tartrite of potash, gradually projected into a red-hot crucible, and fused.

Experiment 3. To obtain perfectly pure antimony, Margraff melted some pounds of the sulphurated ore in a luted crucible, and thus scorified any metals it might contain. Of the antimony thus purified, which lay at the bottom, he took sixteen ounces, which he oxydated cautiously, first with a slow, and afterwards with a strong heat, until it ceased to smell of sulphur, and acquired a grayish white colour. Of this gray powder he took four ounces, mixed them with six drams of acidulous tartrite of potash, and three of charcoal, and kept them in fusion in a well covered and luted crucible, for one hour, and thus obtained a metallic button that weighed one ounce, seven drams, and twenty grains.

The metal, thus obtained, he mixed with half its weight of desiccated carbonate of soda, and covered the mixture with the same quantity of the carbonate. He then melted it in a wet covered and luted crucible, in a very strong heat for half an hour, and thus obtained a button which weighed one ounce, six drams, and seven grains, much whiter and more beautiful than the former. This he again treated with one and a half ounce of carbonate of soda, and obtained a button, weighing one ounce, five drams, and six grains. This button was still purer than the foregoing. Repeating these fusions with equal weights of carbonate of soda three times more, and an hour and a half each time, he at last obtained a button so pure as to amalgamate with mercury with ease, very hard, and in some degree malleable; the scoriæ formed in the last fusion were transparent, which indicated that they contained no sulphur, and hence it is the obstinate adherence of the sulphur that renders the purification of this metal so difficult.

It melts at 810°, and evaporates when the heat is raised. It is tarnished by exposure, and it readily decomposes water, as follows:

Experiment 4. If the vapour of water be made to pass over red hot antimony, a detonation will take place.

Rationale. The oxygen of the water unites with the antimony; its hydrogen is disengaged, and at this instant is inflamed.

Experiment 5. When antimony is heated to whiteness in a crucible, and in this state agitated, in contact with the air, it inflames with a sort of explosion, and presents while burning a very singular kind of white flame, forming what have been formerly called *argentine flowers.*

Rationale. By the combustion of antimony, it unites with oxygen, forming the white or per oxyd, or flowers of antimony. According to Thenard, antimony is capable of combining with six different doses of oxygen. The prot oxyd may be procured thus:

Experiment 6. The solution of antimony in muriatic acid being decomposed by the addition of water, and the white precipitate thus obtained being boiled for some time in a solution of potash, will afford a dirty white powder or prot oxyd of antimony.

Rationale. The addition of water precipitates the prot oxyd of antimony, but containing a portion of the acid, from which it is separated by the use of potash.

Experiment 7. If sulphur and antimony be fused together in a crucible, a compound will be formed called sulphuret of antimony, or artificial crude antimony.

Experiment 8. If equal parts of dry phosphoric acid and antimony, with one eighth of powdered charcoal, be fused together in a crucible, a substance will be formed called phosphuret of antimony.

Rationale. The charcoal decomposes the phosphoric acid, carbonic acid is disengaged, and the phosphorus combines with the antimony.

Experiment 9. If crude antimony and nitrate of potash be deflagated in a crucible, a compound of sulphuret of potash, sulphate of potash, and oxyd of antimony with sulphur will be formed.

Experiment 10. If the scoria be separated from the product of the last experiment, the remaining substance being of a *liver* colour, has received the name of liver of antimony, or crocus of antimony.

Experiment 11. By a similar process, but varying the proportion of the ingredients, a compound is formed, called the white calx or unwashed diaphoretic antimony.

Experiment 12. If water be added to the last mentioned compound, a preparation will be formed, called the washed diaphoretic antimony.

Rationale. The object of washing it, is to separate the saline matter.

Experiment 13. If the gray sulphuretted oxyd of antimony be fused in a crucible, we procure a beautiful transparent glass, which is called the *glass of antimony*. This takes the colour of the hyacinth.

Experiment 14. If antimony be ground fine, and thrown into a dry glass jar filled with oxygenized muriatic acid, it will inflame immediately, and continue to burn with great rapidity and with a brilliant white flame. The combustion affords a beautiful spectacle. See the Properties of Oxymuriatic Acid Gas.

Experiment 15. When antimony is well fused upon charcoal, and if, at the moment when its surface is not covered with any particle of oxyd, we throw it suddenly upon the ground, the globules, into which it divides in its fall, burn with a very lively flame, throwing out on all sides brilliant sparks, different from that of any other metal.

Experiment 16. Mix five or six grains of sulphuret of antimony with half its weight of oxygenized muriate of potass, and then, if a sudden stroke be given to the mixture, upon a steel anvil, it fulminates with a loud report, emitting, according to Fourcroy, a flame as brilliant and rapid as lightning.

Experiment 17. Into a boiling ley of pure potash dissolved in about three or four times its weight of water, throw sulphuret of antimony equal to a sixteenth of the alkali employed. Stir the mixture well, and after it has boiled a little, filter it. On cooling, this liquor will deposit an abundant precipitate, which must be washed, first with cold, and afterwards with boiling water, until it becomes insipid: when dry, pulverise it and sift it through a silk sieve.

Rationale. The sulphuret of antimony is dissolved in the solution of potash; and the water at a high temperature holding more of the compound in solution than it is capable at a low one, is the cause of the subsequent precipitation as the liquor cools. This precipitate is *Kermes' mineral*, or the brown *antimoniated sulphur*. It is said, that the compound of sulphuret of antimony and potash on being boiled in water, decomposes that fluid; the metal is oxydized and hydrogen is evolved, which combines with the sulphur; that the sulphuretted hydrogen thus formed, combines partly with the potash, and partly with the oxyd of antimony, and that the sulphuretted hydroguret of brown oxyd of antimony (Kermes' mineral) is soluble in a solution of sulphuretted hydroguret of potash at 212°, but not at ordinary temperatures. Therefore, on cooling, it separates and falls to the bottom. There are other processes for preparing Kermes, which may be found in Duncan's Pharmacopea. The *golden sulphur of antimony*, which is similar in some respects to the Kermes, may be prepared in the following manner:

Experiment 18. Drop into the fluid in which the Kermes has been formed, either nitric, sulphuric, or muriatic acid until the precipitate ceases to appear. Or,

Experiment 19. Boil together about 2 parts of potash, two parts of sulphuret of antimony, and three parts of water; strain the liquor while warm through a double cloth, and add to it when filtered as much diluted sulphuric acid as is necessary to precipitate the sulphuret, which must be well washed with warm water.

Rationale. On boiling the sulphuret of antimony with a solution of potash, the water is decomposed in the same manner as before stated, and the sulphuretted hydroguret of antimony thus formed, is separated by the addition of acid, which unites with the alkali.

Remark. Other preparations of antimony as the muriate, supertartrite of potash and antimony, &c. will be noticed under the Salts of Antimony. The following, however, may be noticed here. To prepare cinnabar of antimony:

Experiment 20. Pulverise one part of sulphuret of antimony and three of oxygenated muriate of mercury, according to Baume; but according to Fourcroy, one part of the former to two of the latter: mix these substances, and proceed in other respects as in the preceding operation. When the distillation is finished, adapt another receiver to the retort, and sublime the residuum with a strong heat. A substance will be obtained in the form of red needles, called cinnabar of antimony.

This is the effect of a double affinity. The sulphuret of antimony exchanges its sulphur for the acid given up by the oxygenated muriate of mercury.

The combination of antimony with other metals is not attended with any difficulty.

Antimony combines with most of the metals; but the alloys so formed, are of little or no importance, if we except one or two, such as that of type metal and of music plates.

SECTION XVIII.

OF TELLURIUM.

Experiment 1. Tellurium is obtained, according to Klaproth, by forming oxyd of tellurium into a paste, with a few drops of linseed oil, and then putting it into a small glass retort, or crucible. As the oil becomes decomposed, brilliant and metallic drops are observed on the upper part of the vessel, which increase in number until the oxyd is revived.

The process for obtaining oxyd of tellurium may be seen in the following analysis of tellurium.

Experiment 2. Let the white gold ore be gently heated with six parts of muriatic acid; three parts of the nitric being then added, the mixture is boiled, upon which there arises a considerable effervescence, and a complete solution is obtained. The filtered solution must be diluted with as much water as it can bear without becoming turbid, which is a very small quantity; and a solution of potash is then to be added to the liquor, until the white precipitate, which is at first formed, disappears, and nothing remains but a brown flaky sediment, which is the oxyd of gold mixed with the oxyd of iron contained in the ore. This may be dissolved in nitro-muriatic acid; and the gold be precipitated by a solution of nitrate of mercury, and then the iron by potash. Muriatic acid is then added to the before obtained alkaline solution, in sufficient quantity to saturate the potash. An excess of the acid must be avoided. A white precipitate is thus produced in great abundance. This, when washed, is the oxyd of tellurium.

Remark. Tellurium is a new metal discovered by Klaproth, in the year 1797. It is found in three different ores; namely, 1. In the *white gold ore of Fatzebay*, formerly named *aurum paradoxum*, found in the mine called Maria-hilf, in the mountains of Fatzebay, in Transylvania. In this ore tellurium exists alloyed with gold and iron. Its colour is between tin-white and lead-gray. It is in general found massive. The texture of this ore is granular, and its lustre considerably metallic. 2. In the *graphic gold ore*, (*aurum graphicum*) of Offenbanya, it is alloyed with gold and silver. This ore is composed of flat prismatic crystals, the arrangement of which has some resemblance to Turkish letters; hence the name of the ore. It has a metallic lustre, and a tin-white colour, with a tinge of brass-yellow. 3. It exists also in the ore known under the name of the *yellow foliated gold ore of Nagzag*; alloyed with gold, lead, silver, copper, and sulphur. This ore is found in plates of different degrees of thickness. Its colour is of a deep lead-gray, passing to iron-black. It has a considerable metallic lustre, and stains the fingers.*

Tellurium is a bluish white metal, very brittle, and of the specific gravity 6.115. It is very rare.

SECTION XIX.

OF ARSENIC.

Experiment 1. If two parts of white arsenic and one of black flux be mixed, and put into a crucible, and over this another crucible, inverted, being luted together with sand and clay, and heat applied; the oxyd will be reduced and found lining the upper crucible in small crystals of a metallic brilliancy.

Rationale. The arsenic being first united with oxygen, is reduced by the flux, the oxygen is carried off, and the metal in its pure state is obtained.

Experiment 2. If the metal thus obtained be dissolved in nitro muriatic acid, and then precipitated by immersing into the solution a plate of zinc, the arsenic will be precipitated in a fine powder, which, treated as before in a crucible, will yield the metal in greater purity.

Rationale. The solution of arsenic in nitro muriatic acid is intended as a medium, in which the zinc may precipitate the metal, which is then partly metallic, and, subsequently, the reduction consists in the separation of any oxygen as before.

Remark. Arsenic has been known for a long time; and its different compounds have engaged the attention of chemists. The white oxyd of arsenic was known to Avicenna and Paracelsus. The metal has a bluish

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* Accum.

white colour, possesses brilliancy, and tarnishes in the air. It may be kept, however, by immersion in alcohol. Its specific gravity is about 8. It is extremely brittle. At a temperature of 356° it sublimes.

Experiment 3. If metallic arsenic be previously inflamed in oxygen gas, it will burn till the whole is consumed. The combustion is very brilliant, and forms a striking experiment.

Remark. The result of the combustion is the white oxyd, or otherwise the arsenious acid.

Experiment 4. If metallic arsenic be introduced into oxymuriatic acid gas, spontaneous accension will ensue. See the Properties of Oxymuriatic Acid Gas.

Rationale. During the combustion in oxymuriatic acid gas, which takes place at ordinary temperatures, the metal is oxydized, and the oxyd combines with the remaining acid, forming what Mr. Davy calls the *arsenicane.* See Salts of Arsenic. A somewhat similar compound is formed in the following Experiment.

Experiment 5. Put a few grains of arsenic in contact with hyper-oxygenated muriate of potash, on an anvil or any smooth solid surface, and give it a smart blow with a hammer. The mixture will explode with a loud report.

Experiment 6. If arsenic be sublimed in contact with air, a white powder will be obtained, being the *prot oxyd* of arsenic or *white arsenic* of the shops, or the arsenious acid of some chemists, which contains about 24 per cent. of oxygen.

Experiment 7. If 80 parts of water, at the temperature of 60° be added to 1 part of white arsenic, the solution of arsenic for the purposes of experiment will be formed.

Experiment 8. If sulphuretted hydrogen be added to any of the oxydes of arsenic in solution, a yellow-coloured precipitate will be produced. This precipitate is the same as that beautiful ore called orpiment (sulphuret of arsenic.)

Experiment 9. If three parts of the white oxyd be dissolved in seven parts of muriatic acid, and five parts of nitric acid added, and distilled to dryness, a residue will be left, which is the per oxyd or arsenic acid. See Arsenic Acid.

Experiment 10. If one part of arsenic and four or five of sulphur be hastily melted together in a well closed crucible, a compound of a yellow colour, called sulphuret of arsenic will be formed.

Experiment 11. Put equal quantities of arsenic, reduced to powder, and phosphorus, into a Florence flask; pour water upon them, so as to cover them an inch, and apply the gentle heat of a lamp. The arsenic and phosphorus will unite, and form a phosphuret of that metal.

This combination may likewise be conveniently effected by gently heating, in a close phial, equal parts of phosphorus and pulverised arsenic.

Experiment 12. If zinc and arsenic be put into a flask, and diluted sulphuric acid added, the arseniuretted hydrogen gas will be formed. See the Preparation of Arseniuretted Hydrogen Gas.

Arsenic unites with most metals, and its presence is detected by the appearance it gives to copper, in the following manner:

Experiment 13. Insert a little arsenic, reduced to fine powder, between two polished plates of copper; bind them closely together with iron wire, and heat them. The inner surfaces of the copper plates will be rendered white by the arsenic.

The union of arsenic with copper may likewise be effected by fusing one part of arsenic and four of copper, in a common crucible. This alloy has received the name of *white copper* or *white tombac.* The alloy of tin and arsenic may be made in the following manner:

Experiment 14. Put into a crucible placed in a fire seven parts of tin, and one of arsenic; melt the mixture, and when completely united pour it out into an ingot. The alloy obtained will be found to be of a white colour; it is much harder, more sonorous, and less fusible than tin.

SECTION XX.

OF COBALT.

Experiment 1. The process made use of by chemists for obtaining cobalt, is to torrify the cobalt ore in an open fire, in order to separate from it the arsenic or sulphur. The cobalt is then obtained in the state of a black oxyd more or less dark. This oxyd must be mixed with three parts of black flux, and one of decrepitated muriate of soda; some add also half a part of resin. The whole is put into a crucible of such a capacity that at least one-third of it may remain empty, and placed in a furnace exposed to a gentle heat until the resin ceases to burn; the fire must then be raised gradually, in order to bring the crucible to a white heat, and in that state it must be kept until the matters are completely fused. It is then suffered to cool, and having broken the crucible, the cobalt must be separated from the scoriæ, which are of a blue colour.

As cobalt thus obtained is always more or less impure (generally contaminated with iron) in order to get rid of the impurities, and particularly the iron, the following process is employed:

Experiment 2. The cobalt previously oxydated is to be dissolved in nitric acid. The solution must then be evaporated to dryness, and the remainder exposed for some time to a red-heat, whereby the nitrated iron becomes decomposed: or the solution of cobalt in nitric acid may be precipitated by pure potash. The precipitate after being washed is dissolved in nitric acid. This solution must be evaporated to dryness, and redissolved in as little distilled water as possible, and then precipitated by liquid ammonia. More ammonia is then to be added, in order to re-dissolve the precipitate. This ammoniacal solution must be evaporated to dryness, and then mixed with two parts of black flux into a paste with a sufficient quantity of oil, and exposed to a white heat in a forge for at least two hours. A button will thus be obtained which is pure cobalt.

If the ore of cobalt can not be had, the metal may be obtained from smalt (which is glass coloured with that metal) in the following manner:

Experiment 3. Take an ounce of best smalt, and fuse it in a crucible with 8 ounces of dried soda, and the cobalt will be set at liberty. The alkali or rather silicated alkali which is formed, may be washed off.

Remark. Cobalt is of a gray colour, brittle, easily pulverisable, and melts at 130° Wedgwood. Its specific gravity is about 7.7.

Experiment 4. If cobalt be kept red hot in an open vessel, it is gradually converted into a powder at first blue, and at last becomes very dark.

Remark. It is hardly necessary to add, that this effect is owing to the absorption of oxygen. Cobalt is capable of combining with three doses of oxygen.

Experiment 5. If cobalt be dissolved in nitric acid and precipitated by potash, the prot oxyd will be formed.

Experiment 6. If this oxyd be exposed to the air it gradually absorbs oxygen, and is converted into the deut oxyd.

Experiment 7. If this be heated in the open air, it is further changed, gradually becoming black, and is then the per oxyd.

Experiment 8. If oxyd of cobalt and sulphur be heated together, the sulphuret of cobalt will be formed.

Experiment 9. If cobalt be heated red hot in a crucible, and small pieces of phosphorus gradually dropt in, the phosphuret of cobalt will be the result.

The solution of cobalt in acids forms sympathetic inks. The muriate of cobalt, or green sympathetic ink, is made in the following way:

Experiment 10. Put into a mattrass one part of cobalt and four of nitric acid. Digest the mixture on a sand-bath for three or four hours, or until the solution be almost completed; then add muriate of soda equal in quantity to the cobalt employed, and four times as much water as nitric acid; filter the liquor through paper, and nitro-muriate of cobalt, or more properly muriate of cobalt, will be obtained.

If letters be traced on clean paper with this solution they will be invisible; but by exposing the paper to a gentle heat, they will appear of a beautiful green: this colour will disappear as the paper cools, and may be made to appear and disappear successively.

The blue sympathetic ink is formed as follows:

Experiment 11. Take one ounce of cobalt reduced to powder, put it into a Florence flask, and pour over it two ounces of pure nitric acid. Expose the mixture to a gentle heat, and when the cobalt is dissolved, add, by small quantities, a solution of potash, until no more precipitate ensues. Let this precipitate subside, decant the super-natant fluid, and wash the residuum repeatedly in distilled water until it passes tasteless. Then dissolve it in a sufficient quantity of pure distilled vinegar, by the assistance of a gentle heat; taking care to have a saturated solution, which will be known by part of the precipitate remaining undissolved after the vinegar has been digested on it for some time. This fluid is a solution of oxyd of cobalt in acetic acid, and forms a beautiful blue sympathetic ink, by the addition of about one-eighth part of muriate of soda. This ink, like that made with the nitro-muriatic acid, is not visible without heat, and disappears when the paper grows cold.

Remark. The cause of this singular change of the solutions of cobalt, Mr. Accum observes (vol. ii. p. 152) has not hitherto been explained in a satisfactory manner. It takes place equally in close vessels, so that it can scarcely be ascribed to the action of the air or of moisture. At present it is supposed (but without any direct proof) to be owing to the partial de-oxydation of the oxyd of cobalt by heat, and its re-absorption of oxygen when cold.

These phenomena arrested particularly the attention of former chemists, and accordingly to their fanciful way they gave them the name of *sympathetic inks*; an appellation appropriated to all liquids; the characters of which are colourless and invisible when written on paper, but become visible and coloured by undergoing certain processes, and likewise to those which form characters upon paper susceptible of changing their colour by artificial methods.

The following miscellaneous experiments with these inks are given by Parke.

Experiment 12. Write with a solution of muriate of cobalt, and the writing while dry will not be perceptible; but if held towards the fire, it will then gradually become visible; and if the muriate of cobalt be made in the usual way, the letters will appear of an elegant green colour.

Experiment 13. Write with acetate of cobalt, or with a muriate of cobalt, previously purified from the iron which it generally contains. When the writing is become dry, these letters will also be invisible. Warm the paper a little, and the writing will be restored to a beautiful blue.

Experiment 14. Draw a landscape with Indian ink, and paint the foliage of the vegetables with muriate of cobalt, the same as that used in Experiment 12, and some of the flowers with acetate of cobalt, and others with muriate of copper. While this picture is cold it will appear to be merely an outline of a landscape or winter scene, but on holding it near the fire it will be transformed to a beautiful summer landscape: this again will appear gradually to lose its verdure, and resume its winter dress, on being removed to a cold situation.

Experiment 15. If oxyd of cobalt be dissolved in ammonia, a red solution will be produced, different in colour from that of all other metallic oxyds.

Experiment 16. Cobalt ores may be analyzed thus: take 100 grains of the ore, dissolve them in nitrous acid, precipitate the iron by the addition of ammonia, and separate it from the solution by a filter. The nickel, which is always found in these ores, may afterwards be precipitated by the addition of a solution of potash, and separated in the same manner as the iron. The remaining solution may be evaporated to dryness, and the oxyd reduced by the usual fluxes. A smal quantity of cobalt for experiment may be readily procured from smalt.

The oxyd of cobalt forms the most permanent blue colour that we are acquainted with; the oil painters use this oxyd mixed with oil in their paintings, which is the reason why the sky and drapery in some old pictures are of so durable a blue.

Zaffre, which we have long imported from Saxony, is an oxyd of cobalt, mixed with three times its weight of ground silex. There are the black, the brown, and the yellow cobalt ores, all which are oxyds of this metal. The white cobalt ore is a sulphuret of cobalt.

Cobalt seems capable of combining with most of the metals.

SECTION XXI.

OF MANGANESE.

Experiment 1. If the black oxyd of manganese (manganese of the shop) finely pulverised, be mixed with pitch and made into a ball, and introduced into a crucible with powdered charcoal, $\frac{1}{10}$th of an inch thick at the sides, and $\frac{1}{4}$th of an inch thick at the bottom (filling the empty space with powdered charcoal, and then luting on a cover) and the strongest heat that can be raised applied for one hour, manganese in its metallic state will be produced.

Rationale. As the object is in the reduction of metals to dissipate the mineralising substance, in this case the pitch answers as a flux, and carries off the oxygen from the metal. The metal may also be obtained in the following manner:

Experiment 2. Digest the black oxyd repeatedly, with the addition of $\frac{1}{16}$th of sugar, in nitric acid; dilute the mixture with three times its bulk of water, filter it, and decompose it by the addition of potash; collect the precipitate, form it into a paste with oil, and put it into a crucible well lined with charcoal. Expose the crucible for at least an hour to the strongest heat of a forge.

Rationale. The object in using the sugar is to disoxygenise the manganese, so as to render it soluble in the acid; after the solution is formed, the addition of potash precipitates the manganese, not however in a metallic form; but in the subsequent part of the process, the oil disengages the oxygen and leaves the metal behind. Or the following process may be used:

Experiment 3. Prepare a saturated solution of sulphate of manganese, bring it to a boiling heat, and add to it, gradually, a solution of tartrite of potash, until no further precipitate ensues; then filter the solution, and wash the precipitate in water, and, when dry, make it into a paste with oil, and proceed as before.

Rationale. The sulphuric acid unites to the potash, and forms sulphate of potash; and the tartarous acid joins to the manganese, and forms a tartrite of manganese, which is decomposable by heat.

In order to preserve specimens of manganese in a metallic state, it is necessary to varnish them, or to keep them immersed in oil, or ardent spirits.

Remark. Manganese has been in use for many years in the manufacture of glass. A number of experiments were made on it, the result of which proved, that the black manganese contains a peculiar metal; hence the metal received the name of manganese, and the other the oxyd.

In its metallic state, it is of a grayish white colour, and has a good deal of brilliancy. Its hardness is equal to that of iron. Its specific gravity is about 6.8. It is extremely brittle. It melts at 160° Wedgwood.

The metal becomes tarnished on exposure to the air, which takes place by the absorption of oxygen.

We are furnished with three oxyds of this metal, the white, the red, and the black.

Experiment 4. If the black oxyd be put into nitric acid, with a small quantity of white sugar, a solution of the manganese will take place; and if potash be added, the metal will be precipitated in the form of the white or prot oxyd. This oxyd may also be formed thus:

Experiment 5. Take the residuum left in the retort after the disengagement of oxygenated muriatic acid gas, dilute it with distilled water, and filter it. Then decompose it by gradually adding a solution of potash, wash the precipitate, and dry it.

Remark. In every case in which manganese is oxydized to the minimum, the prot oxyd is formed; hence all these processes have, for their object, the disengagement of superfluous oxygen.

Experiment 6. If the black oxyd be made to unite with sulphuric acid, as we shall presently notice, and the metal afterwards precipitated by the addition of potash, the red or deut oxyd of manganese will be formed.

Experiment 7. If the product of Experiment 4, 5, or 6th be exposed to the air, the black or per oxyd of manganese will result.

Remark. This takes place by the absorption of oxygen: the black manganese is the same substance as afforded by nature.

Experiment 8. Let six parts of concentrated sulphuric acid be poured upon one of pulverised black oxyd of manganese, and the mixture heated in a glass retort. A vast quantity of oxygen gas will be disengaged, and the residuum will be a hard white mass, which must be powdered and boiled in water. The fluid, when filtered, affords, on adding a little sugar, a colourless solution, which, by evaporation, yields large, transparent, quadrangular crystals, called *sulphate of manganese.*

Experiment 9. If the coloured solution of sulphate of manganese be exposed to the rays of the sun, it loses its colour, and regains it when removed into darkness. See Light.

Experiment 10. If one part of the black oxyd of manganese and three parts of nitrate of potass, be melted in a crucible till no more oxygen gas is disengaged, a greenish friable powder is obtained, called *mineral cameleon*, from its property of changing colour during its solution in water.

Experiment 11. Put into a wine-glass about a scruple of the oxydized manganese and potass, prepared as above, and an equal quantity of the same compound into another glass. On one pour hot, and on the other cold water. The hot solution will exhibit a beautiful *green* colour; the cold one, a deep *purple*.

Experiment 12. If a small portion of the same compound be put into several glasses, and water at different temperatures be poured upon each, the contents of each glass will exhibit a different shade of colour.

Rationale. In the preparation the nitrate of potash is decomposed, and the black oxyd of manganese is brought to the state of a more imperfect oxyd by the ignition: it then becomes partly soluble in the potash. This solution would appear blue; but as some portion of oxyd of iron is always contained in the black oxyd of manganese, its colour is changed to green by the yellow tint of the oxyded iron. This oxyd gradually subsides, and the blue colour appears. The oxyd of manganese now attracts more oxygen from the air, and assumes a reddish brown tinge, which increases more and more, and at last becomes black. It is then precipitated, and the solution becomes limpid.

Remark. Manganese, treated in a particular manner, will unite with sulphur and phosphorus; the former combination has been effected by Bergman, and the latter by Pelletier. It unites with many of the metals; these combinations are but little known. The black oxyd sold in the shops, contains from 30 to 40 per cent. of oxygen. The oxyds of this metal are used in bleaching, in purifying glass, and in glazing black earthen ware.

SECTION XXII.

OF CHROMIUM.

Chrome is obtained from its native combinations by decomposing them by the alkaline carbonates, precipitating the chromic acid, and heating it strongly in a crucible.

Experiment 1. The following method is recommended by Vauquelin. Seventy-two parts of chromic acid are to be introduced into a charcoal crucible placed within another of porcelain filled with charcoal dust. The apparatus is then to be put into a furnace, and subjected to a very strong heat. Metallic chromium will then be found in the charcoal crucible. From seventy-two parts, Vauquelin obtained forty-three of metal.

Remark. This metal, which exists only in the state of a metallic oxyd, was discovered by Vauquelin. He found it in an ore called red lead ore of Siberia, or *chromate of lead.* The colour of this ore is red with a shade of yellow; when reduced to powder it is of a bright orange. Chromium has likewise been found in combination with iron, alumina, and silica (*chromate of iron and alumina*) in the department of Var in France.

Chromate of iron has been discovered in quantities in the United States, from which the paint called chromic yellow (chromate of lead) has been prepared.

This pigment has been made in this country by several chemists.

Experiment 2. If chromate of iron be boiled in a solution of potash, the liquor then added to nitric acid, and a solution of nitrate of lead poured in, the chromic yellow, or chromate of lead, will be formed.

Experiment 3. If nitrate of mercury be used in the same manner, a chromate of mercury of the colour of vermillion will be produced.

Experiment 4. If nitrate of silver be employed the product will be a chromate of silver of a carmine colour.

Experiment 5. If nitrate of zinc or bismuth be used, a chromate of zinc, or bismuth, of a bright yellow will be formed.

Remark. In all these experiments a double decomposition ensues, by which the peculiar chromates are formed.

Chromium in its metallic state is white. Its specific gravity is 5.9. It is capable of combining with three different proportions of oxygen, and of forming three oxyds, the green, the brown, and the yellow, or chromic acid.

The prot oxyd is the first, obtained by exposing chromic acid to heat in close vessels; the deut oxyd is the second; and the per oxyd, or chromic acid, is the third, and contains 67 per cent. of oxygen.

SECTION XXIII.

OF URANIUM.

Experiment 1. In order to obtain uranium, the *pechblende* is first freed from sulphur by heat, and cleared from the adhering impurities as carefully as possible. It is then digested in nitric acid; the metallic matter that it contains is thus completely dissolved, while part of the sulphur remains undissolved, and part of it is dissipated under the form of sulphurated hydrogen gas. The solution is then precipitated by a carbonated alkali. The precipitate has a lemon-yellow colour when it is pure. This yellow carbonate is made into a paste with oil, and exposed to a violent heat, bedded in a crucible containing and lined with charcoal.

Klaproth obtained a metallic globule 28 grains in weight, by forming a ball of 50 grains of the yellow carbonate with a little wax, and by exposing this ball in a crucible lined with charcoal to a heat equal to 170° of Wedgwood's pyrometer.

Richter obtained in a single experiment 100 grains of this metal, which seemed to be free from all admixture.

Remark. This metal was discovered by Klaproth in the year 1789. It exists combined with sulphur and a portion of iron, lead, and silica, in the mineral termed *Pechblende*, or *oxyd of uranium*. Combined with carbonic acid, it forms the *chalcolite*, or *green mica*: and mixt with oxyd of iron, it constitutes the *uranilic ochre*. It is always found in the state of an oxyd with a greater or smaller portion of iron, or mineralized with sulphur and copper.

The colour of uranium is iron gray; it has considerable lustre. Its specific gravity according to Klaproth is 8.1. According to Bucholz there are several oxyds of this metal. As this metal is not much known, the reader may find some further account in Thomson's Chemistry.

SECTION XXIV.

OF MOLYBDENUM.

Molybdenum may be obtained in a state of purity in the following manner:

Experiment 1. Expose molybdena (sulphuret of molybdenum) to a moderate red heat, till the whole is reduced to the state of a fine powder, and passes through a seive. Dissolve the powder in ammonia, filter the solution, and evaporate to dryness. Heat the residuum, add a little nitric acid, and a white powder will be left, which is the oxyd of molybdenum. Mix this with oil, and expose the mixture to a violent heat. Or,

Experiment 2. Molybdic acid is to be formed into a paste with oil, dried at the fire, and then exposed to a violent heat in a crucible lined with charcoal. By this means the oxyd becomes decomposed, a black agglutinated substance is obtained, very brittle under the finger, and having a metallic brilliancy.

Remark. Molybdenum exists mineralized by sulphur in the ore called *sulphuret of molybdenum*. This ore, which is likewise scarce, is so similar in several of its properties to plumbago, that they were long considered as varieties of the same substance. It is of a light lead gray colour; its surface is smooth, and feels unctuous; its texture is lamellated; it soils the fingers, and marks paper bluish black, or silver gray. It may be cut with a knife. It is generally found in compact masses; seldom in particles, or crystallized. It is met with in this country, Sweden, Spain, Saxony, Siberia, and Iceland. Scheele proved that a peculiar metallic acid might be obtained from it; and later chemists have succeeded in reducing this acid to the metallic state.

The native *sulphuret of molybdenum* is the only ore hitherto known, which contains this metal.

Molybdenum is either in an agglutinated blackish friable mass, having little metallic brilliancy, or in black powder. The mass slightly united shows by a magnifying glass small round brilliant grains. Its weight is from 6.600 to 7.500. It is one of the most infusible of the metals. It is capable of combining with a number of metals by fusion. It forms with sulphur an artificial sulphuret of molybdenum analogous to its ore. It unites also to phosphorus. The affinity of molybdenum for oxygen, according to Mr. Hatchett is very feeble.

For other facts respecting this metal, see Thomson, i, p. 361.

SECTION XXV.

OF TUNGSTEN.

Tungsten is obtained from a mineral called *wolfram*, which contains the oxyds of tungsten, manganese, and iron, with earthy matter. Mineralogists call tungsten a mineral, which contains the oxyd or acid combined with lime. Although several attempts have been made by different chemists to obtain this metal, yet very few have succeeded. It may be produced in the following manner, according to Richter.

Experiment 1. Let equal parts of tungstic acid and dried blood be exposed for some time to a red heat in a crucible; press the black powder which is formed into another smaller crucible, and expose it again to a violent heat in a forge for at least an hour. Tungsten will then be found, according to this chemist, in its metallic state in the crucible.

To produce the metal pure, the following process has been recommended.

Experiment 2. Boil finely pulverised wolfram in strong muriatic acid for some time; separate the solution; the residuum contains a yellow powder; it is to be washed, dissolved in ammonia, evaporated to dryness, and mixed with a little fine charcoal powder, and exposed to a very intense heat for about 20 minutes in a covered Hessian crucible. Small grains of pure tungsten will be found at the bottom of the crucible.

Tungsten in its metallic form was first procured by Messrs. D'Ethuryars in 1782.

Remark. Tungsten or *Scheelium* of the Germans, is of a grayish white colour. Its specific gravity is 17.3. It requires for fusion about 170° Wedgwood. It combines with oxygen, forming a blue and yellow oxyd The prot oxyd is blue, and the per oxyd is yellow, known by the name of tungstic acid. The former may be obtained by heating the yellow oxyd for some hours in a covered crucible, and the latter, or tungstic acid, in the following way:

Experiment 3. Boil three parts of muriatic acid on one part of *wolfram*. Decant the acid, and allow it to settle. A yellow powder gradually precipitates. This powder is to be dissolved in ammonia, the solution to be evaporated to dryness, and the dry mass kept for some time in a red heat. It is then yellow oxyd, or acid in the state of purity.

Sulphur and phosphorus will both unite with tungsten. Silver, copper, iron, lead, tin, antimony, and bismuth will combine with it; but it does not unite with gold and platina. It is not attacked by the sulphuric, nitric, or muriatic acids; nitro-muriatic acid acts upon it very slightly. It is oxydable and acidifiable by the nitrates and super-oxygenated muriates. It colours the vitrefied earth, or the vitreous fluxes, of a blue or brown colour. It is not known what its action will be on water and different oxyds. Its action on the alkalies is likewise unknown. It is not employed yet, but promises real utility, on account of its colouring property, as a basis for pigment, since the compounds it is said to form with vegetable colouring matters afford colours so permanent as not to be acted on by the most concentrated oxygenated muriatic acid, the great enemy of vegetable colours. See Thomson, Murray, Fourcroy, &c.

SECTION XXVI.

OF TITANIUM.

This newly discovered metal was first noticed by Mr. Gregor as existing in the state of an oxyd, mixed with iron, manganese, and silica, in a grayish black sand found in the vale of Manachan in Cornwall, and thence named *Menachanite, or oxyd of Titanium, combined with iron.* It has since been discovered by Klaproth, in an ore named *Titanite,* or *oxyd of Titanium, combined with* *lime and silex.* It exists also in an ore called *Red schorl of Hungary*, or *red oxyd of Titanium.*

It is extremely difficult to reduce the oxyd of titanium to the metallic state. However, the experiments of Klaproth, Hecht, and Vauquelin, have proved its reducibility.

Experiment 1. According to the two latter, one part of the oxyd of titanium is to be melted with six of potash; the mass when cold is to be dissolved in water. A white precipitate will be formed, which is carbonate of titanium. This carbonate is then made into a paste with oil, and the mixture is put into a crucible filled with charcoal powder and a little alumina. The whole is then exposed for a few hours to the action of a strong heat. The metallic titanium will be found in a blackish puffed up substance, possessing a metallic appearance.

Remark. Titanium has only been obtained in very small agglutinated grains. It is of a red yellow and crystalline texture, brittle, and extremely refractory. Its specific gravity is about 4.2; when broken with a hammer while yet hot from its recent reduction, it shows a change of colours of purple, violet, and blue. In very intense heat it is volatilized. Most of the acids have a striking action on this metal. Nitric acid has little effect upon it. It is very oxydable by the muriatic acid. It is not attacked by the alkalies. Nitro-muriatic acid converts it into a white powder. Sulphuric acid when boiled upon it is partly decomposed. It is one of the most infusible metals. It does not combine with sulphur, but it may be united to phosphorus. It does not alloy with copper, lead, or arsenic; but combines with iron. See Chenevix's paper in Nicholson's Journal, v. 134, and Accum.

SECTION XXVII.

OF COLUMBIUM.

To the acidifiable metals, which have been some time known to the chemical world, we have to add one, of a more recent discovery, called Columbium, for which we are indebted to Mr. Hatchett, who discovered it in the year 1802. This accurate analyst, being engaged in examining and arranging some minerals in the British Museum, observed a specimen of ore which greatly resembled the Siberian chromate of iron. It appeared that the mineral in question was sent from the mines of Massachusetts in North America.

A very few facts respecting this metal have been ascertained. It is found to combine with oxygen, and of forming oxyds of different colours.

SECTION XXVIII.

OF CERIUM.

This metal has been lately discovered by Messrs. Bergelius and Heisinger of Stockholm, in a mineral from Bastnas, in Sweden, which had been supposed to be an ore of tungsten. This discovery has been since confirmed by the unquestionable testimony of Vauquelin, who, after a careful examination of the mineral, concurs in opinion that it contains the oxyd of an unknown metal. From the planet Ceres, discovered about the same period, it has been called cerium, and the mineral that contains it is termed cerite.

The tungsten of Bastnas, which is now called *cerite*, was found in the year 1750, in a copper-mine called Bastnas, or Saint-Gorans Koppargrufva, at Riddare-Hyltan, in Westmania, of which, with asbestos, it formed the matrix: but after this time it was imbedded in quartz and mica, to the depth of seventeen toises.

Cerium appears to be susceptible of two degrees of oxydation. The alkalies precipitate a white oxyd from its solution, which is of a yellowish colour in the air, but, when perfectly dried, becomes dark. Exposed to a brisk and long continued fire, it takes a deep brick-colour. The oxalate and acetate of cerium, calcined in vessels not completely closed, yield a white oxyd, which, in an open fire, becomes of the colour of brick. It does not melt by itself.

Treated with borax by the blow-pipe, it melts readily and swells. The globule heated by the exterior flame assumes the colour of blood; which, by cooling, passes to a yellowish green, and at length becomes colourless, and perfectly transparent. Melted by the interior flame, these changes do not take place; it is then reduced into a colourless glass; but exposed for a short time in the exterior flame, the same phenomena are produced. If too much oxyd of cerium is made use of, the glass resembles an opaque yellowish enamel. These changes are more easily manifested with the phosphate of soda and ammonia. If two clear and colourless globules are melted together, one of which is prepared with borax, and the other with the phosphate, they form a transparent glass, which, on cooling, becomes opaque and pearl coloured.

These characters, taken together, sufficiently distinguish the oxyd of cerium from the oxyd of iron. The latter also affords the same changes of colour; but its glass, on cooling, has a deep green colour, *which fades*. The globules made with borax and the phosphate melted together yield an opaque glass, the colour of which is a little deeper.

When oxyd of cerium is digested with sulphuric acid, these two substances unite, and the result is a red insoluble salt, which is sulphate of cerium at a *maximum of oxydation*. If the acid is concentrated, it scarcely dissolves any of it.

Treated with muriatic acid, the yellow acidulous sulphate of cerium yields part of its oxygen to the acid, which is volatilized in oxygenated muriatic acid gas. The salt remains colourless. An augmentation of temperature alone is sufficient for the yellow acidulous sulphate of cerium to lose its colour, by losing the excess of its oxygen. If the heat is increased still more, the surplus of the acid is carried off, and a saturated sulphate of cerium remains. By a continued calcination, it regains oxygen, becomes red, and yields a sulphate of cerium at a *maximum*. The sulphate of cerium, disoxygenated by the muriatic acid, is more difficult to re-oxydate by calcination.

In the humid way, the alkalies only decompose the sulphate of cerium incompletely.

If a solution of acidulous sulphate of cerium is precipitated by potash, a triple combination of cerium, sulphuric acid, and potash, is separated, before the acid is saturated. If too much potash is added, the combination is partly destroyed. The sulphate of cerium and potash, at a *maximum*, is of an orange colour; that which is at a *minimum* is white.

These characters offer a ready method of separating the sulphate of cerium from iron. It must, however, be observed, that when the solutions are saturated, a little iron is also deposited, which gives a yellow colour to the precipitate; but by adding a little sulphuric acid in excess, the iron is re-dissolved, and leaves the precipitate entirely white. This combination is only dissolved in part by dilute sulphuric acid, and the greatest quantity of that separates afterwards.

SECTION XXIX.

OF TANTALIUM.

As the existence of this metal is questionable, although announced as such by Ekeberg, and supposed to be an oxyd of tin, we shall not trouble the reader with its history or properties.

PART XVI.

OF ACIDS.

Acids are a class of bodies, which possess a sour taste, and certain determinate properties. Substances partaking of the following characters, are considered under this head.

1. When applied to the tongue, they excite that sensation, which is called *acid* or *sour*.

2. They change the blue colour of vegetables, as the infusion of litmus and syrup of violets, to a red. If these colours have been previously converted to a green by alkalies, the acids restore them again. This effect is apparent in the following experiments.

Experiment 1. Make an infusion of red roses, violets, or mallow flowers; treat it with solution of potash, and it will become *green*; the addition of diluted muriatic acid will convert it immediately to a *red*.

Experiment 2. Pour a little tincture of litmus into a wine glass, and into another some diluted sulphate of indigo; pour these two blue fluids together, and the mixture will become perfectly red.

Experiment 3. Take a slip of blue litmus paper, dip it into acetous acid, and it will immediately become red.

Experiment 4. Take some water impregnated with carbonic acid, and add to it a little blue tincture of litmus, the whole will be changed to a red.

3. They unite with water in indefinite proportions.

4. They combine with alkalies, earths, and metallic oxyds, and form with them a class of bodies called *salts*.

Experiment 5. Take some of the same carbonated water, and boil it. Then add a little tincture of litmus, and the blue colour will experience no change.

Not to state the opinions, or the different hypotheses which have been advanced, we shall observe, that, according to the theory of Lavoisier, all acids consist of a certain base united to oxygen, which is considered to be the cause of acidity. We are acquainted with the bases of the sulphuric, nitric, &c. acids: we know that hydrogen, carbon, and oxygen, form the bases of the citric, malic, and all the rest of the acids called *vegetable*; and that the same substances, in combination with nitrogen, constitute those called *animal* acids, such as prussic, &c. But we are totally unacquainted with the radicals of some acids; they must therefore be analogically considered as simple bodies in the present state of our knowledge.

The bases which become acid by the union of oxygen are capable of being united to it in various degrees. When the oxygenation is complete they are called *perfect acids.* But if they are not saturated with oxygen, they mostly appear in a state of less acidity. In the new nomenclature the termination IC is given to the complete oxygenation of these bodies, and the termination OUS when they present themselves in an imperfect state of combination with oxygen. Hence by the name of sulphuric acid, we mean sulphur completely saturated with oxygen; and by the name sulphurous acid, we understand sulphur not saturated with oxygen.

All acids are either products of combustion, or supports of combustion, or combustible. We shall not, however, confine ourselves to the division.

SECTION I.

OF SULPHURIC ACID.

Experiment 1. If sulphur be burnt in a close vessel in contact with nitre, and the vapour collected in water, the product will be diluted sulphuric acid; and, *Experiment* 2. If this be concentrated by evaporation, the residue will be strong sulphuric acid.

Remark. Sulphur we observed is capable of combining with oxygen, so as to form either an oxyd, or the sulphurous or sulphuric acid. In the two last the proportion of oxygen varies. In using nitre, the object is to furnish oxygen from that salt, and to oxygenate, or in other words to acidify the sulphur completely: this is effected in the large way as follows:

Peculiar buildings or apartments, with their insides lined with lead, are constructed. In these apartments sulphur is burnt, in order to absorb oxygen from the air during its combustion. But as the sulphur would not burn or become fully acidified in a confined quantity of air, $\frac{1}{8}$th to $\frac{1}{12}$th of nitrate of potash is previously mixed with it. The sulphuric acid which is formed is absorbed by a *stratum* of water at the bottom of the chamber. The water, after being sufficiently impregnated, is exposed to heat in large glass retorts, so as to deprive the acid of the superfluous water, the sulphurous acid, and nitrous gas, with which it is mixed.

This acid has been obtained from vitriol by distillation; hence it was called *oil of vitriol*, and afterwards *vitriolic acid.* The method of obtaining it, by burning sulphur under a glass bell gave rise to the name of *spiritus or oleum sulphurus per campanum.*

Sulphuric acid, when fully concentrated, is said to be 2.000 specific gravity; but it seldom exceeds 1.8. It changes all vegetable blues except indigo. It boils at 546°. When exposed to a sufficient degree of cold, it crystallizes. It has a considerable attraction for water, and in its union with it, it emits a large quantity of free caloric, as is shown by the following experiment:

Experiment 3. Weigh one pound of water into a vessel capable of bearing a sudden heat. Pour gradually four pounds of sulphuric acid upon the water, and stir the mixture. So great will be the condensation of the water by this mixture, that the temperature of the whole will instantly rise to 300°

Sulphuric acid is not altered by oxygen, azote, or hydrogen. It combines with nitric acid, and forms a compound which dissolves silver, but scarcely any other metal. Boiled with sulphur, phosphorus, or charcoal, it is partly disoxygenized, and converted into sulphurous acid. See the Preparation of Sulphurous Acid Gas. Its action on zinc or iron, in a diluted state, is manifest in the production of hydrogen gas. See the Preparation of Hydrogen Gas. Its union with different bases, constitutes sulphates. Its composition is 42.3 sulphur, and 57.7 oxygen in the hundred.

Sulphuric acid is detected by muriate of barytes. See Salts of Barytes.

SECTION II.

OF SULPHUROUS ACID.

Experiment 1. To prepare sulphurous acid, take one part of mercury and four of concentrated sulphuric acid, put them into a retort, furnished with a receiver, and connected with Pepy's apparatus. The sulphurous acid gas which is disengaged is absorbed by the water in the vessel, and constitutes sulphurous acid.

Experiment 2. Sulphurous acid is likewise formed during the slow combustion of sulphur. See Sulphur.

Remark. Stahl gave to this acid the name of *phlogisticated sulphurous acid*. Scheele obtained it by decomposing sulphite of potash by tartaric acid.

The acid properties of sulphurous acid are not considerable. It does not redden blue vegetable colours, but, on the contrary, renders them white. It exerts little action on metallic substances, and has a feeble attraction for the alkalies and earths. It is exceedingly volatile, and assumes the state of gas, if moisture be excluded.

Sulphurous acid unites with certain bases, and forms sulphites.

See Sulphurous Acid Gas.

SECTION III.

OF PHOSPHORIC ACID.

Experiment 1. If phosphorus be burnt in oxygen gas, a product will be obtained, which appears first in white fumes, called dry phosphoric acid. Or,

Experiment 2. If nitric acid be added to phosphorus from time to time, until the effervescence ceases, the same acid will be produced.

Rationale. Phosphorus by combining with oxygen forms either an oxyd or an acid: in the first experiment it unites with oxygen by combustion; in the latter by the decomposition of nitric acid, nitric oxyd being formed. Phosphoric acid, for the purpose of making phosphorus, is prepared in the following way:

Experiment 3. Dilute in a spacious glass jar one pound of sulphuric acid with six or eight pounds of water; then add gradually, and with constant stirring, one pound and a half of finely pulverised bones burnt to whiteness. An effervescence will take place. When this has ceased, leave the whole on a gentle sand-bath for a few hours, taking care to stir it frequently, and to supply the loss of water which happens by evaporation. After it has been suffered to remain undisturbed, strain the whole through a cloth, and wash the residual matter repeatedly in water till it passes tasteless. The fluid thus obtained contains the phosphoric acid, contaminated with lime, and may be evaporated in a Wedgwood's, or glass basin, to any wished for consistence. See Phosphorus.

Remark. The acid produced in this way is not pure; to obtain it so, carbonate of ammonia must be added until no more precipitate falls down; the precipitate is carbonate of lime, which must be separated by filtration: the fluid being then evaporated to dryness leaves phosphate of ammonia. This is exposed to heat in a china cup, till all the ammonia is disengaged, which may be known by the mass frothing no longer, but flowing quietly. On cooling, it congeals into a transparent vitreous substance, called glacial acid of phosphorus, which attracts moisture, and is soluble in water.

Experiment 4. If solid phosphoric acid be exposed to the air, it will deliquesce.

Rationale. This takes place by the absorption of moisture from the air.

Experiment 5. If liquid phosphoric acid be put into a platinum crucible, and exposed to the heat, a transparent gelatinous mass will be formed; but,

Experiment 6. If the heat be increased, it will take the appearance of melted glass, which, when cold, is called phosphoric glass.

Rationale. The exposure to heat disengages the watery portion, leaving the phosphoric acid in a dry state.

Experiment 7. If this acid be mixed with charcoal powder and distilled, phosphorus will be obtained. See Phosphorus.

Phosphoric acid acts only on a small number of metallic substances. Its union with alkalies, earths, and metallic oxyds forms a class of salts called phosphates. Phosphoric acid is composed of 46.5 phosphorus, and 53.5 oxygen in the hundred.

SECTION IV.

OF PHOSPHOROUS ACID.

Experiment 1. If a few sticks of phosphorus be exposed to the action of atmospheric air, in a glass funnel, phosphorus acid will be formed, and may be collected in a bottle placed underneath. Two or three pieces of broken glass fixed in the neck of the funnel to support the phosphorus, and a small quantity of distilled water put into the receiving bottle, complete this simple apparatus. The pieces of phosphorus should be placed so as not to touch each other.

Remark. When phosphorus is burnt slowly, as in the above experiment, it forms an acid different from the phosphoric. It was called *phlogisticated phosphoric acid* by Morveau.

Phosphorous acid is liquid, has an unpleasant taste, and emits an alliaceous and disagreeable odour when rubbed, and especially if warmed. When heated more strongly, part of it is volatilized in the form of a white vapour.

Exposed to the air, or to oxygen gas, the phosphorus acid is converted into the phosphoric acid.

Its union with different bases, forms *phosphites.*

SECTION V.

OF CARBONIC ACID.

Experiment 1. If diluted sulphuric acid be added to marble, carbonic acid will be disengaged in the state of gas.

Experiment 2. If water be impregnated with carbonic acid gas, which may be effected by means of a Nooth's apparatus, or by employing artificial pressure, the liquid carbonic acid, or ærated water will be formed.

Remark. Carbonic acid is composed of 18 parts carbon and 82 oxygen; which has been ascertained by analysis as well as synthesis.

Experiment 3. Put a small piece of phosphorus into a crucible, cover it closely with common chalk, so as to fill the crucible. Let another crucible be inverted upon it, and both subjected to the fire. When the whole has become perfectly red hot remove them from the fire, and when cold, the carbonic acid of the chalk will have been decomposed, and the *black charcoal,* the basis of the acid, may be easily perceived amongst the materials.

Remark. Carbonic acid gas is found in abundance in many natural waters. Those of Pyrmont, Spa, and Seltzer, are instances; the last particularly is highly impregnated with this acid.

Experiment 4. To a glass of water, suspected to contain carbonic acid, add a small quantity of any of the other acids. If carbonic acid be present, it will become visible by a sparkling appearance on the sides of the glass and surface of the fluid.

SECTION VI.

OF FLUORIC ACID.

Experiment 1. Put one part of fluate of lime in coarse powder into a leaden or tin retort, and pour upon it two parts of sulphuric acid. Lute the retort to a receiver of the same metal, containing one part of water, and apply a gentle heat. The fluoric acid gas disengaged will be absorbed by the water and form liquid fluoric acid, which must be kept in well-closed leaden or tin bottles, or phials coated within with wax or varnish.

Rationale. The sulphuric acid, by virtue of a superior affinity, unites with the lime of the fluate, forming sulphate of lime, and the fluoric acid gas is disengaged. United to water, it forms liquid fluoric acid.

Remark. Fluoric acid combined with different bases forms saline compounds, called fluates.

The distinguishing property of fluoric acid is, its power of dissolving and volatilizing silica. Its odour resembles muriatic acid.

To preserve the liquid acid it must be kept in bottles lined on the inside with wax dissolved in oil, or in vessels of lead or platina.

See Fluoric Acid Gas.

SECTION VII.

OF BORACIC ACID.

Experiment 1. If to a concentrated solution of borax in hot water, sulphuric acid be added, small crystals will gradually form, and fall to the bottom as the liquor cools, which is *boracic acid.* Or,

Experiment 2. Dissolve any quantity of sub-borate of soda, or borax in boiling water, and add to this solution sulphuric acid, by a little at a time, till the solution be rather more than saturated. Then evaporate it slowly to one-third, and set it aside to cool; white scales will be deposited, which are boracic acid. After all the acid has been crystallized out of the solution, the salt must be re-dissolved, re-crystallized, and lastly washed in distilled water, drained on filtering paper, and then dried.

Rationale. In both these experiments, the sulphuric acid unites with the soda, forming sulphate of soda, which remains in solution, and the boracic acid is separated.

Remark. Boracic acid may likewise be obtained by sublimation, from two parts of sur-saturated borate of soda, one of sulphuric acid, and one of water.

The union of boracic acid with different bases forms salts, called borates.

This acid exists united to soda in the salt called borax, or sub-borate of soda. United to lime and magnesia, it forms the mineral called borate of lime.

Boracic acid appears in brilliant, glittering, white, hexahedral scales, soft and unctuous to the touch. Its taste is bitterish, with a slight degree of acidity. It is soluble in alcohol, which it causes to burn, when set on fire, with a green flame, surrounded with a white one.

Experiment 3. If a spoonful of good alcohol and a little boracic acid be stirred together in a tea-cup, and then set on fire, they will produce a very beautiful green flame.

Experiment 4. If a paper be dipped in alcohol and then sprinkled with this acid, they will burn with a green flame.

The composition of this acid is unknown, if we except however the opinion of Mr. Davy, that it contains oxygen.

SECTION VIII.

OF NITRIC ACID.

Experiment 1. If electric explosions be passed through a mixture of three measures of oxygen gas and one measure and a quarter of azotic gas, a union will take place, and nitric acid be formed. Or,

Experiment 2. If equal parts of nitrate of potash and sulphate of iron be mixed, and introduced into a retort, to which two bottles, according to the plan of Woulf's apparatus, is afterwards affixed, and the heat of a lamp applied, nitric acid with nitrous gas will be obtained. Or,

Experiment 3. If two ounces of nitrate of potash be introduced into a retort, and one ounce of sulphuric acid added, and the whole exposed to heat, the same product will come over.

Remark. The following is a more particular account of the method of obtaining nitric acid by chemists:

Take two parts of dry nitrate of potash in coarse powder, put it into a tubulated glass retort, of which it occupies no more than one third, or one-fourth, and to which a large receiver has been luted containing a little water; then pour on it, in small quantities at a time, one part of concentrated sulphuric acid. As soon as the last quantity of the acid is introduced into the retort apply a very gentle heat, and distil slowly till no more drops issue from the neck of the retort. The acid collected in the receiver is fuming, and of a reddish or yellow colour: on being brought into contact with atmospheric air, it sends forth reddish yellow fumes, which likewise always fill the empty space of the receiver or bottle. In order to deprive it of these fumes, the acid must be re-distilled, or at least heated for some time in a glass retort, with a very gentle heat; the fuming part will rise first, and the remainder will be deprived of all its colour and fuming property.

Rationale. Nitric acid, being a compound of 29.77 azote, and 70.23 oxygen, is formed in every case in which these elements unite in proper proportions. In the first experiment, a direct combination takes place. In the second and third, it is merely the disengagement of the acid from the base, with which it was previously united. When sulphate of iron is used, the heat disengages the greater part of the acid from that salt, which then decomposes the nitrate of potash, forming sulphate of potash, which remains behind, and disengages the nitric acid. When sulphuric acid itself is used, the application of heat causes it to act directly on the nitrate, by which the nitric acid is evolved.

Remark. Nitric acid appears to have been known in the time of Raymond Lully. Basil Valentine describes the process, and calls the product *water of nitre*. It has since been called spirit of nitre, and nitric acid. In large manufactories, it is generally obtained by distilling a mixture of nitre and clay.

Nitric acid is liquid, colourless, and transparent, possessing in a very eminent degree all the properties of acids. Its specific gravity varies; the strongest kind is about 1.5. It tinges the skin yellow, which does not disappear till the *epidermis* wears off. It has a strong affinity for water, and has never yet been found in nature except in combination. It produces heat when added to water. When concentrated, exhales white acrid fumes on being exposed to the air, which are nitric acid in a gazeous state. When poured on oils, charcoal, &c. it sets them on fire. See Caloric. It causes the sulphurous and phosphorous acids to pass to the state of sulphuric and phosphoric acids, by yielding to them part of its oxygen. It is capable of oxydating all the metals except gold, platinum, titanium, and tantalium.

The changes which take place on the addition of water to strong nitrous acid exhibit very curious phenomena. Different portions change its colour to a blue, a green, a yellow, &c. while the vapours which rise from it preserve their original flame-coloured red.

Experiment 4. If 4 parts of water, by measure, be added to 12 parts of strong fuming nitrous acid, the colour will be changed from a deep *orange* to a *green.*

Experiment 5. Mix 4 measures more of water with the diluted acid produced in the last experiment, and the colour will thereby be changed to a *paler green*, mixed with *yellow*.

Experiment 6. Add 4 measures more of water to the above, and the green will disappear and a *pale yellow* acid will be produced.

Experiment 7. If 40 measures of water be now added to the yellow acid produced in the last experiment, you will have an acid as colourless as pure water.

SECTION IX.

OF NITROUS ACID.

Experiment 1. If colourless nitric acid be exposed to the rays of the sun, it will acquire a *smoking* appearance, and a yellow or brown colour, forming the nitrous acid. Or,

Experiment 2. If nitric acid be exposed to nitrous gas, the latter will be absorbed. Or,

Experiment 3. If nitre be subjected to a strong heat in an iron mattrass, in order to obtain oxygen gas, after this has passed off for some time, the residue is a salt composed of nitrous acid and potash. Consequently nitrous acid is formed.

Remark. As it is now generally admitted that nitrous acid is nitric holding nitrous gas in solution, and that the proportion of oxygen is probably less in the nitrous, we can readily account for the changes which take place when nitric acid is exposed to the sun's rays, or when nitric acid is saturated with nitrous gas; the former showing that light separates a portion of oxygen, and the latter, that nitrous gas by combining with the nitric acid, changes its colour and some of its properties. In the same manner also, the action of heat robs the nitrate of a part of its oxygen, and converts it into nitrite of potash. See Nitric Oxyd Gas.

Nitrous acid exists in the state of gas, in the form of a red vapour, slightly coercible. When combined with water it is of a yellow or orange colour. It emits copious orange-coloured or red fumes.

SECTION X.

OF OXYMURIATIC ACID.

Experiment 1. Put into a tubulated retort, supported over a lamp, one part of black oxyd of manganese reduced to a gross powder, and pour over it three parts of concentrated muriatic acid; recline the retort in such a manner that the fluid which rises up into its neck may easily run back again into the body, and apply a receiver with a little distilled water in it; the receiver must be luted to the retort by a fillet of paper. When the effervescence, which instantly takes place on the affusion of the acid, ceases, apply a gentle heat. Oxygenized muriatic acid gas will be evolved, and the receiver become filled with yellow vapours, which are absorbed by the water. When the water has acquired a yellowish green colour, the receiver may be removed, and another one applied till no more gas is extricated.

Remark. The process may be more elegantly conducted by employing the distillatory apparatus of Mr. Hembel, noticed in the Memoirs of the Columbian Chemical Society. See the Preparation of Oxymuriatic Acid Gas.

The oxymuriatic acid is composed of 77.5 muriatic acid, and 22.5 oxygen in the hundred. That the acid, or water saturated with oxymuriatic acid gas has the same properties as the gas in discharging vegetable colours, is obvious in the following experiment:

Experiment 2. If a few strips of dyed linen cloth, of different colours, be dipped into a phial of oxygenized muriatic acid, the colours will be quickly discharged; for there are few colours that can resist the energetic effect of this acid. This experiment may be considered as a complete example of the process of bleaching coloured goods.

SECTION XI.

OF HYPER OXYMURIATIC ACID.

Although this acid was supposed to be the same as the oxymuriatic, yet Mr. Chenevix has determined beyond a doubt that it is a separate acid. When potash is saturated with oxymuriatic acid crystals are deposited, which have received the name of *hyper oxymuriate of potash*; and when the liquor, which remains, is evaporated, a salt will be obtained, composed of muriatic acid and potash. From these circumstances, it was inferred, that oxymuriatic acid is decomposed; that one portion of it lost the whole of its oxygen, and was reduced to the state of muriatic acid, while another portion combined with an additional dose of oxygen, and was converted into hyper oxymuriatic acid. This subject, however, is still obscure.

SECTION XII.

OF NITRO MURIATIC ACID.

Experiment 1. If two parts of nitric acid be added to one part of muriatic acid, a compound will be formed called nitro muriatic acid or *aqua regia*; or according to the older method,

Experiment 2. Put common salt into a retort, add nitric acid, and apply heat; or,

Experiment 3. To nitric acid, add sal ammoniac or common salt.

Remark. The formation of nitro muriatic acid is nothing more than a partial decomposition of the nitric acid, and the change of the muriatic into the oxymuriatic acid. That nitro muriatic acid is in reality a mixture of nitrous acid and oxymuriatic acid, is evident from the following experiment:

Experiment 4. Mix together in a capacious jar oxymuriatic acid gas and nitric oxyd gas; they will combine and form nitro muriatic acid.

Remark. This acid is first mentioned by Isaac Hollandus. It has the property of dissolving gold and platinum. The salts formerly called nitro muriates cannot be considered as such.

SECTION XIII.

OF MURIATIC ACID.

Experiment 1. If two parts of dried muriate of soda be put into a gas bottle, and one part of sulphuric acid added, muriatic acid gas will come over; and if this gas be suffered to come in contact with water, it will be absorbed, and, if the water be saturated, will form the liquid muriatic acid. Or, *Experiment* 2. If the same quantity of salt and acid be introduced into a retort, with 5 or 6 parts of water, and distilled, liquid muriatic acid will pass over. Or,

Experiment 3. Put into a tubulated retort, lodged in a sand-heat, or supported over a lamp, and connected with Pepys's distillatory vessel, or Woulf's bottles, every one containing a small quantity of distilled water, three parts of muriate of soda, and pour on it one of sulphuric acid very gradually, or rather let it be suffered to drop into the retort, by means of a hydrostatic funnel fastened into its tubulure. Muriatic acid gas will be plentifully disengaged, which passes through the neck of the retort, and becomes absorbed by the water. When the water in the first bottle is fully saturated it absorbs no more, and becomes cold, being considerably heated by the absorption of the gas; but the gas continues to pass into the next bottles, and heats the water they contain. The water thus impregnated with muriatic acid gas is called muriatic acid.

Remark. If sulphuric acid diluted with an equal quantity, by weight, of water, be made use of in this process, the apparatus of Pepys or Woulf may be dispensed with, and a common receiver may be used with safety.

In all these experiments the muriatic acid is disengaged from the muriate of soda, by the sulphuric acid. The acid is nothing more than water saturated with the gas.

Liquid muriatic acid, or water saturated with this gas is about 1.196 specific gravity. The muriatic acid, or *spirit of salt* of commerce varies from about 1.120 to about 1.164.

Sulphuric, phosphoric, nitric, and other acids may be decomposed by charcoal; but muriatic acid is unalterable by any of the combustibles with which we are acquainted.

With various bases it forms the salts called *muriates.*

SECTION XIV.

OF ARSENIC ACID.

Experiment 1. Take two ounces of arsenious acid in powder, put it into a tubulated retort, pour on it six or seven ounces of muriatic acid, and apply the heat of a lamp until the arsenious acid is dissolved. Then add three or four ounces of nitric acid, and heat it again gradually. An intestine motion now takes place, and much red vapour or nitrous gas is extricated. As soon as, in the progress of the operation, the red vapours have ceased, an ounce of finely powdered arsenious acid is to be again added, and the solution effected as before, by a gentle ebullition; to this two ounces of nitric acid must be added, which will produce a second effervescence and discharge of red vapours; the distillation must now be continued to dryness, and the fire must be urged towards the end, to such a degree, as to make the residual mass thoroughly red-hot. This mass is arsenic acid, which may either be preserved in that form, or be dissolved in boiling distilled water.

Remark. All the preparations of arsenic are deadly poison. The hydro-sulphurets are the best antidotes. A diluted solution of hydro-sulphuret of potash, soda, or lime, is therefore administered with success to persons who have been poisoned by arsenic. For the same reason sulphurous mineral waters may be given in such cases; oil, milk, butter, &c. which are too often resorted to, should never be employed, if a sulphuret or hydro-sulphuret can possibly be procured.

Arsenic is capable of combining with two doses of oxygen, and of forming two acids, namely, the arsenious, commonly called the white oxyd of arsenic, and the arsenic, which was discovered by Scheele. Arsenic acid is composed of about 65 arsenic and 35 oxygen in the hundred.*

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* Thomson.

Arsenic acid is capable of existing in the solid state, but it is not crystallizable. It appears in the form of a white pulverulent matter. It attracts humidity from the air. It has an acid caustic taste. It is soluble in six parts of its weight of water. This solution possesses a considerable acid taste. It is not volatile, but may be evaporated to dryness and even converted into glass. It is decomposable by all combustible bodies and by many oxyds. It is soluble in some acids, but without change or intimate combination. Its specific gravity is 3.391. See Arsenic.

SECTION XV.

OF TUNGSTIC ACID.

Experiment 1. Let one part of powdered tungstate of lime be digested in three of nitric acid, till it acquires a yellow colour. Decant the acid, and let the remaining yellow powder, after being washed in distilled water, be digested in liquid ammonia till it is rendered considerably whiter. This ammoniacal solution is then poured off, and the residual undecomposed part of the tungstate is once more treated with nitric acid as before. The acid being again separated, it is again digested with liquid ammonia, and so on alternately till it is totally decomposed.

The ammoniacal solution is then decomposed by the addition of nitric acid; the tungstic acid becomes precipitated in the form of a white powder, which, after being washed, dried, and exposed to heat, assumes a yellow colour.

Rationale. On adding nitric acid to the ammoniacal solution, nitrate of ammonia is formed, and the tungstic acid becomes separated; but this last is not perfectly free from ammonia, it is therefore necessary to heat it, or to wash it in diluted nitric acid, by which means the adhering ammonia is either volatilized or neutralized, which then may be washed away by means of distilled water.

Remark. The tungstic acid may also be obtained from the mineral called wolfram, in which it is combined with iron and manganese, and frequently with silica, in the state of a yellow oxyd, as directed before.

Tungstic acid does not exist in nature in an uncombined state, but always united to lime (*tungstate of lime*) or with iron and manganese (*wolfram.*) See Tungsten.

SECTION XVI.

OF MOLYBDIC ACID.

Experiment 1. If sulphuret of molybdenum, reduced to powder, be introduced into a retort with a mixture of nitric and muriatic acids, and heat applied, it will be converted into molybdic acid, which appears in the form of a white powder: if this be washed with water, the remainder will be pure molybdic acid.

Rationale. As in other cases, the nitric acid acidifies the metal, as well as a portion of the sulphur, forming the molybdic and sulphuric acids; the latter, together with the muriatic acid, is washed off, leaving the molybdic acid in a state of purity.

Remark. This acid was discovered by Scheele, and more accurately investigated by Bucholz. It exists in the form of a white powder, whose specific gravity is 3.46. It melts and crystallizes in close vessels; but, in the open air, it sublimes, and may be collected. It is soluble in water. The solution reddens litmus. It is decomposed by sulphur and charcoal, and several of the metals. It is soluble in sulphuric and muriatic acid. It unites with salifiable bases, forming a class of salts called molybdates. It contains 33 per cent. of oxygen.

SECTION XVII.

OF CHROMIC ACID.

Experiment 1. If chromate of lead (*red lead ore of Siberia*) be introduced into a vessel with a solution of carbonate of soda, and the whole boiled for a short time; the solution then filtered, and sulphuric acid added to saturation, a red precipitate will be obtained, which is chromic acid.

Rationale. The carbonate of soda decomposes the chromate of lead; chromate of soda remains in solution, and carbonate of lead is precipitated. From the former, the chromic acid is separated by the sulphuric acid; sulphate of soda being formed, whilst the chromic acid is precipitated.

Remark. This acid was discovered by Vauquelin. It is of a red or orange yellow colour, and has an acrid and metallic taste. It is soluble in water, and susceptible of crystallization. Added to filings of tin and muriatic acid, it becomes at first yellowish brown, and afterwards a beautiful green colour.

If paper be dipped in chromic acid, and exposed for some days to the rays of the sun, it assumes a green colour, which does not change in the dark. Muriatic acid, heated in a retort with this acid, produces a strong effervescence, and oxygenated muriatic acid gas is evolved.

Chromic acid, mixed with a solution of the hydrosulphuret of potash, is precipitated in the form of greenish brown flakes. *Tannin* precipitates it in flakes of a fawn colour. Heated by the blow pipe on charcoal, it boils up, and leaves an infusible green matter. Fused with phosphoric acid, or with borax, a vitreous globule is obtained, of an emerald-green colour. Sulphuric acid, while cold, produces no effect upon it; but when heated it makes it assume a bluish green colour. With a solution of nitrate of mercury, it gives a precipitate of a dark cinnabar red. With a solution of nitrate of silver, it gives a precipitate, which, the moment it is formed, appears of a beautiful carmine red, but becomes purple by exposure to light. It unites with the alkalies, and forms crystallizable salts of a beautiful orange colour.

SECTION XVIII.

OF COLUMBIC ACID.

This acid was discovered by Hatchett in an ore brought from the United States. Its existence, however, has been questioned. It was obtained by fusing the ore with potash, dissolving the potash in water, and adding nitric acid to the solution. The columbic acid precipitates in flakes.

A summary of its general properties, may be found in Thomson's Chemistry.

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COMBUSTIBLE ACIDS.

The acids considered under this head, comprehending the vegetable and animal are combustible; hence some chemists have treated them as such. The following properties will serve to characterize them:

1. If combined with potash and distilled, they are decomposed; charcoal is formed, and carburetted hydrogen gas is disengaged.

2. They contain, as a base, at least two simple combustibles, viz. hydrogen and carbon. Azote, sometimes enters into their composition. Oxygen is a constituent part of them, though perhaps not always.

3. They are not susceptible of union with different doses of oxygen, without changing the other constituent parts.

4. The more powerful acid supporters decompose them, converting them into other combustible acids or oxyds.

5. They may be divided into four orders, as, 1, Crystallizable and volatilizable, such as the acetic, benzoic, sebacic, succinic, moroxylic, camphoric, and oxalic acids, composed of hydrogen, carbon, and oxygen; 2, Crystallizable and not volatilizable, as the mellitic, tartaric, citric, kinic, and saclactic acids, composed of carbon, hydrogen, and oxygen, to which may be added the uric and laccic acids, the former of which contains also azote; 3, Not crystallizable, as the malic, suberic, and formic acids, containing carbon, hydrogen and oxygen; and 4, Colorific, as the gallic, and prussic acids, the former of which is composed of carbon, hydrogen and oxygen, and the latter of carbon, hydrogen and azote: to which some add sulphuretted hydrogen or hydrothionic acid of the Germans, composed of sulphur and hydrogen.

SECTION XIX.

OF ACETIC ACID.

Experiment 1. Mix in a glass retort two ounces of very strong vinegar with four ounces of dried muriate of lime, and draw off a portion of the acid by distillation. Mix this with the like quantity of muriate of lime, and distil again. The first products now will be *acetic* acid.

Rationale. The muriate of lime attracts the water, with which the acetic acid is diluted, in the form of vinegar, and the distillation separates the colouring or other fixed ingredient of the vinegar. Or,

Experiment 2. Take one part of acetate of potash, put it into a tubulated retort, lodged in a sand-heat, and pour gradually upon it half its weight of sulphuric acid. A violent action takes place, and part of the acetic acid becomes liberated in the form of white vapours. After the spontaneous action has ceased, distil with a gentle heat, and acetic acid will be obtained in a considerable quantity.

Rationale. In the acetate of potash the acetic acid is already combined; the object, therefore, is to separate it in a distinct state. This is accomplished by using sulphuric acid, which unites with the alkali, forming sulphate of potash, whilst the acetic acid distils. Or,

Experiment 3. Put acetate of copper into a retort, and distil; acetic acid will come over.

Rationale. In this salt the acid is combined with the oxyd of copper: by distillation this salt is decomposed; for the caloric applied separates the acid, leaving an oxyd of copper in the retort.

Experiment 4. If vinegar be introduced into a retort and distilled, a product will be obtained called acetous acid.

Rationale. The object of distillation is only to separate the colouring matter; the liquor obtained is not therefore the acetic or radical vinegar (as it is sometimes called) but the acetous acid, being nothing more than the acetic acid diluted.

Remark. Acetous acid is formed by the fermentation of wine, on which account it is called vinegar. However, wine is not indispensably necessary for its production, as it is found in the urine of animals, &c. The vinegar produced during fermentation is far from being pure acetous acid, but may be obtained so by distillation.

The acid principle in all these acids is the same. They differ merely in the concentration of that acid. The specific gravity of vinegar varies from 1.0135 to 1,0251. Vinegar may be preserved for a long time by previously boiling it. Besides acetic acid and water, vinegar contains several other ingredients, such as mucilage, tartar, or colouring matter, and often two or more vegetable acids. Acetous acid, or distilled vinegar, exposed to the action of cold, is considerably concentrated, provided the cold be sufficient to freeze it. The process mentioned above for obtaining acetic acid by the distillation of acetate of copper, was known to the alchemists, who called the product *vinegar of ve-*

nus. This acid is transparent and colourless, and has a peculiar aromatic flavour. That it is considerably stronger than the acetous acid is evident for its specific gravity; that of the acetous is 1.007 and the acetic 1.080. It is extremely pungent and acid. It is very volatile, and is inflammable. It may be obtained in a crystallized state, according to Lowitz, in the following manner:

Experiment 5. Mix distilled vinegar with well burnt charcoal, so as to form it into a paste, and expose the mixture to a heat not above 212°. By applying a stronger heat, having the mixture in a retort, very strong acid is obtained. This will readily crystallize.

SECTION XX.

OF BENZOIC ACID.

Experiment 1. If gum benzoin be pulverised, and put into an earthen pan, after which a paper cover attached; the whole then exposed to a sufficient heat in a sand bath, the *flowers of benzoin*, or benzoic acid, will be obtained; and,

Experiment 2. If the flowers, thus produced, be dissolved in water, the solution evaporated and crystallized, the *purified salt of benzoin* of the dispensatories will be prepared.

Experiment 3. If storax, tolu, or any other balsam be treated as in Experiment 1, the same product will be formed.

Remark. As benzoic acid exists ready formed in the natural balsams, some of which contains more than others, in which it is always combined with resin, it may be separated either by sublimation, or by combining it with a salifiable base. The following beautiful experiment may be made with benzoin by sublimation:

Experiment 4. Into a large glass jar, inverted upon a flat brick tile, and containing near its top a branch of fresh rosemary, or any other such shrub, moistened with water, introduce a flat thick piece of heated iron on which place some gum benzoin in gross powder. The benzoic acid, in consequence of the heat, will be separated, and ascend in white fumes, which will at length condense, and form a most beautiful appearance upon the leaves of the vegetable.

Experiment 5. If benzoin be boiled with a solution of carbonate of soda, the solution filtered, then suffered to cool, and sulphuric acid dropped into it as long as any precipitate is produced, benzoic acid will be formed.

Rationale. The benzoic acid, of the gum benzoin, first unites with the soda of the carbonate, forming benzoate of soda, and the sulphuric acid then combines with the soda into a sulphate of soda, whilst the benzoic acid is precipitated.

Remark. Benzoic acid prepared in either of the above modes, is a fine light matter, possessing an acrid, hot and bitter taste. Its odour is aromatic.

Its specific gravity is 0.667. It is easily volatilized by heat. It is soluble in hot water; also in alcohol and the stronger acids. It is not acted upon by oxygen gas, or by any of the simple combustibles or incombustibles.

SECTION XXI.

OF SEBACIC ACID.

Experiment 1. Distil hog's lard, wash the product with hot water, and drop into it a solution of acetate of lead, till it occasions no further precipitate. Collect this precipitate, wash it, and dry it. Having done this, pour over it sulphuric acid and heat it; a substance resembling fat will then appear on the surface. This being collected, dissolved in boiling water, and suffered to cool, crystallizes, and is sebacic acid.

Rationale. Distillation separates the sebacic acid, which is precipitated by acetate of lead; the sebate of lead is then decomposed by sulphuric acid, which unites with the lead, and the sebacic acid is disengaged.

Remark. Sebacic acid exists in a concrete form. It crystallizes in needles. It is void of odour. Its taste is slightly acid. When heated it liquefies like tallow, and is not volatile. It is soluble in cold water. Boiling water dissolves it very readily. It is also soluble in alcohol. It precipitates the acetates and nitrates of silver, mercury, and lead, and the acetates of lead and mercury. It does not precipitate lime-water.

Berzelius asserts, that this acid, in most of its properties, coincides with benzoic acid.

SECTION XXII.

OF SUCCINIC ACID.

Experiment 1. Fill a matrass half full of amber, lute to it an alembic, and distil with a gradual heat, till drops of oil fall from the beak of the alembic. Then separate the solid acid which has sublimed, dissolve it in water, filter the solution, and suffer it to crystallize. Repeat these latter operations till the salt is nearly colourless; or this trouble may be saved by abstracting from it a small quantity of nitric acid, which renders it a beautiful white: one dram of nitric acid is sufficient to one ounce of succinic acid of commerce.

Remark. As succinic acid exists ready formed in amber, mere distillation will separate it.

Succinic acid exists in a solid form. Its crystals are colourless, four-sided, oblique plates, which are permanent in the air. It has a strong acid taste. It is soluble in 24 parts of cold, and in two of boiling, water. It is soluble in hot alcohol. It may be volatilized by heat, but suffers a partial decomposition.

When combined with ammonia this acid becomes a valuable re-agent, by the property of separating iron from its solutions, and not operating upon other metals.

Experiment 2. Pour a little of this succinate of ammonia to a solution of sulphate of iron, and a succinate of the metal will be precipitated. It may be calculated that every 100 grains of the precipitate contain 68 grains of iron.

SECTION XXIII.

OF MOROXYLIC ACID.

Experiment 1. If the saline exudation, which incrusts the bark of the white mulberry tree, be dissolved in water, and precipitated by means of acetate of lead, the precipitate afterwards digested with sulphuric acid, moroxylic acid will be disengaged.

Rationale. The saline exudation consists of the acid in question united with lime; the addition of acetate of lead, therefore, by double affinity, takes the moroxylic acid from the lime, forming a precipitate of moroxylate of lead, whilst the lime unites with the acetic acid. Sulphuric acid then decomposes the precipitate; sulphate of lead is formed, and moroxylic acid is disengaged.

Remark. This acid was discovered by Klaproth. It crystallizes in needles. It is soluble in water and in alcohol. It is volatile, and may be sublimed.

SECTION XXIV.

OF CAMPHORIC ACID.

Experiment 1. Put into a retort one part of camphor and eight of nitric acid, distil the mixture, and repeat it three times on the same residue with a like quantity of acid; after the last distillation is accomplished, crystals will be found in the retort, which are camphoric acid; re-dissolve them in boiling water, and suffer the fluid to crystallize.

Rationale. The nitric acid is decomposed; a part of its oxygen goes to acidify the camphor, whilst the other part is disengaged in union with azote in the form of nitrous gas.

Remark. Camphoric acid exists in the form of white parallelopipedes which effloresce in the air. Its state is acid, slightly, and somewhat bitter. It strongly reddens vegetable blues. It is very volatile; it is sparingly cold; soluble in water, more soluble in alcohol, in sulphuric, nitric, and muriatic acid, and in volatile and fat oils. It is fusible, and sublimes by heat.

This acid was first accurately described by La Grange.

SECTION XXV.

OF OXALIC ACID.

Experiment 1. Put one part of white sugar into a retort, and pour over it four parts of nitric acid, of about 1.567 specific gravity, adapt a receiver, and make the solution boil. When the fluid in the retort acquires a brown colour, add three parts of acid more, and continue the boiling till it again becomes brown; then add two parts more of acid, and continue the heat till the red fume almost disappears. Having done this, suffer the mixture to crystallize. After having removed the obtained crystallized acid, the residue may again be treated in a similar manner as before, until no more crystals are obtained. It may then be purified by dissolving it in water, and re-crystallizing it repeatedly.

Rationale. The sugar is converted into an acid by the nitric, which, by decomposition, imparts oxygen to it, forming therewith the oxalic or saccharinc acid.

Remark. Oxalic acid is always concrete; its crystals are colourless quadrilateral prisms, having their sides alternately broad and narrow, and terminating in two-sided summits, of a very acid taste. It is particularly distinguished by its strong attraction to lime, which is superior to that of any other acid. It is not altered on exposure to air. It acts on most of the metals. Exposed to heat it becomes decomposed into carbonic acid, and carburetted hydrogen gas. It contains more oxygen than any other vegetable acid. Oxalic acid is soluble in its own weight of water at 212, and in about two parts of water at 65°. It reddens vegetable blues readily. Boiling alcohol dissolves somewhat more than half its weight. It is composed of 64 oxygen, 32 carbon, and 4 hydrogen. This acid exists ready formed in many vegetable substances, as in the salt of sorrel.

Sal-acetosellæ, or the salt of sorrel of commerce, has usually been imported from Switzerland and the neighbouring countries, where it is prepared in large quantities from the juice of sorrel.

The oxalic radical appears to exist still more abundantly in insipid matters. Berthollet has obtained from wool more than half its weight of oxalic acid.

Two of its most striking applications may be exhibited in the following manner:

Experiment 2. Pour a few drops of the solution of oxalic acid into a neutral solution of muriate of lime, and an abundant precipitate of insoluble oxalate of lime will immediately appear. If there be any excess of muriatic acid in the solution, the lime will be re-dissolved. Hence the superiority of oxalate of ammonia, to simple oxalic acid, as a test.

Experiment 3. Spot a piece of linen with common ink, and, when the spots are dry, rub them over with a solution of super oxalate of potash. This will dissolve the iron in the ink, and the stains will consequently disappear.

SECTION XXVI.

OF MELLITIC ACID.

Experiment 1. If the stone called *mellite* or honey stone be pulverised and boiled in seventy-two times its weight of water, the solution then filtered and evaporated, crystals of mellitic acid will be formed.

Remark. This acid was discovered by Klaproth. Few of its properties have been investigated.

SECTION XXVII.

OF TARTARIC ACID.

Experiment 1. To obtain tartaric acid dissolve thirty-two parts of acidulous tartrate of potash in water, and throw chalk into it gradually till it is completely saturated, a precipitate will be formed; decant the fluid, and put the precipitate into a matrass, pour over it nine parts of sulphuric acid and five of water; digest the whole for six hours, taking care to stir it from time to time; the tartaric acid will then remain free, and may be separated, by means of cold water, from the sulphate of lime which has been formed, and crystallized by suffering it to evaporate slowly.

Remark. To ascertain whether the tartaric acid contains sulphuric acid, let fall into it a few drops of acetite of lead: if the precipitate, which is formed, be entirely soluble in acetous acid, the fluid contains no sulphuric acid; if it is not soluble, sulphuric acid is present: to free it from this fluid it must again be digested over another quantity of the tartrate of lime.

Rationale. The carbonate of lime is decomposed; the tartaric acid in excess in the supertartrate, unites with the lime into a tartrate of lime. Sulphuric acid then decomposes the precipitate; sulphate of lime is formed, and tartaric acid is disengaged.

Remark. Tartaric acid exists in the juices of many vegetables, generally combined with lime.

It appears in the form of tabular crystals. Its specific gravity is 1.5962. Its taste is exceedingly sour. It is permanent in the air. It readily dissolves in water. The solution is not decomposed by evaporation nor on exposure to air, unless very diluted. It takes lime from the nitric, muriatic, phosphoric, and acetous acids. It has a strong tendency to unite to potash. In one proportion it forms a soluble salt (tartrate of potash) but when the acid is in excess it forms a salt of difficult solubility (acidulous tartrate of potash.) It is on this account that the presence of tartaric acid in any solution may easily be detected. It is decomposable by heat. It may be changed into oxalic acid, by the repeated use of nitric acid. Tartaric acid is composed, according to Fourcroy, of 10.5 oxygen, 19.0 carbon, 15.5 hydrogen.

SECTION XXVIII.

OF CITRIC ACID.

Experiment 1. Saturate any quantity of boiling lemon juice, by adding to it, gradually, chalk, in small quantities, until the effervescence ceases, on adding to it a new portion of chalk. During this process a white precipitate will be formed, and fall down to the bottom, consisting of citric acid and lime (citrate of lime.) Separate this precipitate by transferring the whole on a strainer, and pour water over it till this fluid passes tasteless. Transfer the washed precipitate into a matrass, or other convenient vessel, and pour over it as much sulphuric acid as will neutralize the chalk employed, having previously diluted the acid with six times its weight of water. Boil the whole about half an hour, agitating it with a wooden spatula during the whole time, and then pour it on a filter, taking care to return the fluid, which passes through, back upon the filter until it becomes perfectly clear. Having done this, evaporate it in a shallow vessel to the consistence of a thin syrup, and leave it to crystallize undisturbed. The crystals obtained are citric acid; in order to obtain them in a state of purity they must be re-dissolved, the solution filtered, and re-crystallized repeatedly.* Four parts of chalk require in general, for saturation, 94 parts of lemon juice. The citrate of lime produced amounts to about 7½ parts. To decompose this, nearly 20 parts of sulphuric acid are necessary.*

Rationale. The citric acid combines with the lime into a citrate of lime, which is decomposed by sulphuric acid; sulphate of lime is formed, and citric acid is disengaged.

Remark. Citric acid exists in the juice of lemons and oranges; in unripe grapes, cranberries, bilberries, and a variety of other sour fruits.

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* Accum.

Citric acid crystallizes in the form of rhomboidal prisms, which suffer no alteration from exposure to air. They are easily dissolved by water, and excite a very sour taste, which, when diluted, is exceedingly pleasant. One part of boiling water dissolves two of citric acid. It acts upon iron, zinc, tin, lead, and various other metals. Sulphuric acid chars it, and forms vinegar. Treated with nitric acid it becomes converted into oxalic and acetic acid. Exposed to a red heat it becomes decomposed into carbonic acid, and carbonated hydrogen gas, and a little charcoal remains behind.

This elegant acid is very useful to manufacturers on account of its solubility. One ounce of cold water will dissolve $\frac{1}{4}$th of an ounce of it, and boiling water will dissolve double its weight.

Experiment 2. This acid may be kept ready mixed with either of the dry carbonates of potash or soda; and, as no effervescence ensues till the mixed powder is put into water, we have a ready mode of making a pleasant saline draught.

Experiment 3. Dip a piece of white calico in a cold solution of sulphate of iron, and suffer it to become entirely dry. Then imprint any figures upon it with a strong solution of colourless citric acid, and allow this to dry also. If the piece be then well washed in pure warm water, and afterwards boiled in a decoction of logwood, the ground will be dyed either of a slate or black colour, according to the strength of the metallic solution, while the printed figures will remain beautifully white. This experiment is designed to show the effect of acids in discharging vegetable colours.

Experiment 4. If lemon juice be dropped upon any kind of buff colour, the dye will be instantly discharged. The application of this acid by means of the block, is another method by which calico-printers give the white spots or figures to piece goods. The crystallized acid in a state of solution is generally used for this purpose.

SECTION XXIX.

OF KINIC ACID.

Experiment 1. Dissolve the salt of Peruvian bark in water; add oxalic acid till no further precipitate is formed; separate the precipitate, and evaporate the liquor: crystals of kinic acid will be produced.

Rationale. The salt of bark contains lime united with kinic acid; the former is separated by oxalic acid in the form of oxalate of lime; and the latter is obtained by evaporating the fluid.

Remark. This acid was discovered by Vauquelin. Its colour is brown. Its taste is acrid. It is very soluble in water. It is decomposed by fire, charcoal remaining behind.

SECTION XXX.

OF MUCOUS OR SACCHOLACTIC ACID.

Experiment 1. Take one part of gum arabic reduced to powder, put it into a retort, and pour over it two parts of nitric acid; heat the mixture gradually, keep it boiling for about a quarter of an hour, and then suffer it to cool; a white powder will separate, which, after being washed, is mucous acid.

Experiment 2. Mucous acid may be obtained, by treating sugar of milk with nitric acid, in a similar manner.

Remark. This acid was discovered by Scheele, who obtained it by treating sugar of milk with nitric acid. Hence he called it saccho-lactic acid.

Mucous acid exists in the form of a white gritty powder. It is soluble in eighty times its weight of boiling water, but more soluble in alcohol. Its taste is slightly acid, but it sensibly reddens tincture of cabbage. It scarcely acts upon any of the metals. It forms soluble salts with potash, soda, or ammonia: but insoluble compounds with most of the rest of the alkalies and earths.

SECTION XXXI.

OF URIC ACID.

This acid was discovered by Scheele in the urinary calculi; it exists also in human urine. That species of calculus which resembles wood in its colour and appearance, consists almost entirely of uric acid. It was formerly called lithic acid, a name now superseded by the judicious remarks of Dr. Pearson, to whom we are indebted for a thorough knowledge of it. It may be found by boiling calculi in a solution of potash, and precipitating by means of muriatic or acetic acid. The white powder which falls is uric acid.

Uric acid crystallizes in thin acicular and brilliant crystals, of a pale yellow colour. It has very little taste or odour. It is almost insoluble in cold, and sparingly soluble in 300 parts of boiling water; it then reddens delicate vegetable blues, but it becomes very soluble when combined with an excess of potash or soda. It is not acted upon by muriatic acid. Sulphuric acid, assisted by heat, decomposes it. It is soluble in nitric acid, and communicates to it a pink colour. The solution tinges animal matter of the same colour. It combines readily with alkalies and earths, and forms salts, which are decomposable by most of the other acids. Uric acid combined with soda is found crystallized in the human body, forming the gouty concretions of those afflicted with the gout. Uric acid is decomposable at high temperatures, and furnishes carbonate of ammonia, and carbonic acid, with very little oil or water. It is also decomposed by the nitric and oxygenized muriatic acids.

SECTION XXXII.

OF MALIC ACID.

Experiment 1. Take the juice of apples, saturate it with potash, and then add a solution of acetate of lead till it no longer occasions a precipitate; wash this precipitate, which is malate of lead; pour over it sulphuric acid till the liquor acquires an acid taste without any mixture of sweetness, and filter the whole, in order to separate the malic acid from the sulphate of lead which is formed.

Experiment 2. Malic acid is also obtained by adding to the expressed juice of house-leek, a solution of acetate of lead, till no further precipitate ensues. The precipitate, after being washed, may be decomposed by sulphuric acid as before.

Experiment 3. Malic acid may likewise be produced by distilling equal quantities of nitric acid and sugar, till the solution acquires a brown colour. The sugar is thus partly converted into oxalic, and partly into malic, acid. The oxalic acid may be separated by mingling the solution with lime-water, until no further precipitate ensues; the malic acid is then left behind. In order to obtain it in a pure state neutralize it with lime, filter the solution, and mix it with alcohol. A coagulation now takes place; for the water separates, and the malic acid, united to the lime, may be obtained by filtration. Having done this, let it be dissolved in water, and add to it a solution of acetate of lead until no further precipitate ensues. This precipitate, which is malate of lead, may be decomposed by sulphuric acid, as before directed.

Malic acid has been lately detected in the acid liquid obtained from ants. When this acid liquid is saturated with lime, and mingled with acetate of lead, a precipitate is obtained which is malate of lead, which may be decomposed by the affusion of sulphuric acid.

Rationale. In Experiment 1, the malate of potash, which is formed, is decomposed by acetate of lead; malate of lead is precipitated, and acetate of potash remains in solution. The former is treated with sulphuric acid, which disengages the malic acid. In Experiment 2, the acetate of lead acts nearly in the same manner; in Experiment 3, malic acid is obtained by the decomposition of nitric acid.

Remark. This acid is found ready formed in the juice of unripe apples, and in those of barberries, elderberries, gooseberries, plums, and the common house-leek.

Malic acid is incapable of crystallizing, but appears always in the liquid state, of a reddish brown colour. Its taste is an unpleasant sour. If left exposed to the air, it gradually undergoes a spontaneous decomposition. Nitric acid converts it into oxalic acid. It forms precipitates in the solution of nitrate of mercury, lead, and silver.

SECTION XXXIII.

OF SUBERIC ACID.

Experiment 1. Introduce one part of cork cut into small pieces into a retort, and pour upon it six of nitric acid, distil the mixture with a gentle heat till no more nitrous gas appears. Then pour the contents into a basin, and evaporate it till it acquires the consistence of honey, and a pungent suffocating vapour arises; then add to it twice its bulk of boiling water, heat it gently, and pour it on a filter. The fluid which passes, when cooling, deposits a precipitate, which must be separated; the fluid is then evaporated to dryness, and the product obtained is suberic acid.

Rationale. The nitric acid is decomposed; its oxygen unites with the cork, converting it into an acid, whilst nitrous gas is liberated.

Remark. Suberic acid is not crystallizable, but it may be produced in the solid form of a powder, or thin pellicles. It is volatilized by heat. Suberic acid has a sharp, acid, bitterish taste. It acts strongly upon the throat, and excites coughing. It strongly reddens vegetable blues, and has the peculiar property of turning the blue colour of a solution of indigo in sulphuric acid, of the nitrate of copper, and of the sulphate of copper to green, and gives a yellow colour to the solution of green sulphate of iron, and to the solution of sulphate of zinc. It is difficultly soluble in cold but easily soluble in boiling water. When heated it first fuses, then becomes dry, and at last sublimes entirely.

This acid was discovered by Brugnatelli, and its properties were afterwards more investigated by Lagrange.

SECTION XXXIV.

OF FORMIC ACID.

Experiment 1. If ants be infused in water, the water distilled off as long as it comes over without any burnt smell; the liquor saturated with potash, and evaporated to dryness; the dry mass saturated with sulphuric acid, and again distilled, formic acid will be obtained.

Rationale. The acid of the ant is taken up by the water, and afterwards continued with potash; the bombate of potash, thus formed, is then distilled with sulphuric acid, and the bombic acid is disengaged.

Remark. This acid was found to exist many years ago in the *formica rufa*, or red ant, and many of its properties were investigated by Margraff; and although Fourcroy and Vauquelin endeavoured to prove that it was only a mixture of acetic and malic acids, yet from subsequent experiments it is found to be a distinct acid. This acid is colourless, has a peculiar smell, and unites with different bases.

SECTION XXXV.

OF PRUSSIC ACID.

Experiment 1. Put into a glass matrass two parts of pulverized Prussian blue, one part of red oxyd of mercury, and six parts of water; boil this mixture for half an hour, agitating it frequently, then filter it, and pour over the residuum two parts more of boiling water, having united the liquors, evaporate the whole to obtain crystals, and prussic acid will be formed.

Rationale. The prussic acid quits the oxyd of iron to unite to the oxyd of mercury, with which it forms prussiate of mercury, which can neither be decomposed by acids nor alkalies. In order to disengage from it the prussic acid, dissolve it in water, or take the liquor above mentioned, not concentrated: pour the quantity obtained in the preceding experiment into a bottle containing about an ounce of iron filings, add nearly three ounces of concentrated sulphuric or muriatic acid, and shake it well for some minutes: the mixture now becomes black, for the iron unites to the oxygen of the mercury, and combines with the acid. Leave the fluid at rest, and then decant it, and put it into a retort placed on a sand bath; adapt to the retort a receiver, containing a little distilled water, to absorb the acid, and carefully lute all the joinings. By the help of a gentle heat, the prussic acid, being more volatile than water, will pass over first; and when about a fourth of the liquor has passed, stop the operation.

The liquor which passes contains a little sulphuric acid: to free it from this acid, distil it again with a very gentle heat from pulverized chalk, and prussic acid will be obtained in the greatest purity.

Experiment 2. If a mixture of two parts of prussian blue, one of sulphuric acid, and one of water be distilled, prussic acid will come over.

Experiment 3. Prussic acid may be obtained by distilling two parts of prussiate of potash with one of sulphuric acid, previously diluted with an equal quantity of water; the prussic acid becomes disengaged, and is absorbed by the water previously put into the receiver; or by distilling bitter almonds, the kernels of peach-stones, or the leaves of the cherry-laurel (lauro cerasus, Lin.) with water.

Remark. Scheele succeeded in forming prussic acid by causing a current of ammoniacal gas to pass through red hot charcoal. Oxy-prussic acid, of Berthollet, is formed by treating prussic acid with oxymuriatic acid.

This acid derives its name from the pigment called Prussian blue, of which it forms a component part.

It was first obtained in a separate state by Scheele.

Prussic acid exists in the form of a colourless fluid. It has a strong odour, greatly resembling that of peach tree flowers, or of bruised bitter almonds. Its taste is sweetish, pungent, and somewhat acrid. It is very volatile, and inflammable when in the state of vapour or gas. It does not redden the most delicate vegetable blues, and unites difficultly with alkalies and earths in the direct way. It is easily decomposable by light, heat, or oxygenized muriatic acid at high temperatures; it becomes converted into ammonia, carbonic acid, and carburetted hydrogen gas. It does not act upon any of the metals, but readily unites with most of their oxyds, with which it forms highly insoluble compounds. It has a great tendency to form triple compounds with alkalies and metallic oxyds, and in that state it decomposes all metallic salts, and hence it is one of the most important re-agents of the chemist. It is composed of hydrogen, carbon, and azote.

Prussic acid united with potash is employed as a re-agent; its use may be seen in the following experiments:

Experiment 4. Into a wine glass of water put a few drops of prussiate of potash, and a littl edilute solution of sulphate of iron into another glass: by pouring these two *colourless* fluids together, a bright deep blue colour will be immediately produced, which is the true prussian blue.

Experiment 5. Put some prussiate of potash into one glass; into another a little nitrate of bismuth. On mixing these colourless fluids, a yellow will be the product.

Experiment 6. Pour a little prussiate of potass into a glass containing a *colourless* solution of sulphate of copper, and a reddish brown will be produced, being a true prussiate of copper.

Experiment 7. Take water holding carbonate of iron in solution, and add some diluted prussiate of potass; prussian blue will be formed by the mixture.

Experiment 8. Take some of the same water as that used in the last experiment; boil it, and now add prussiate of potash. In this case no colour will be produced.

SECTION XXXVI.

OF GALLIC ACID.

For the following method of obtaining gallic acid we are indebted to Mr. Fiedler:

Experiment 1. Dissolve two ounces of alum of commerce in water, and precipitate the solution, by letting fall into it a solution of potash; wash the precipitate well, and transfer it into an aqueous infusion of gall-nuts (obtained by infusing 1 ounce of galls into 16 of water, and evaporating the infusion to one half) agitate the mixture frequently during the course of 24 hours, and transfer it on a filter. The fluid which passes through the filter is gallic acid; it may be obtained in the form of needle-shaped crystals by evaporating it slowly, till a pellicle appears, and then letting it stand undisturbed.

Experiment 2. Gallic acid may also be obtained, according to Scheele, in the following manner: reduce a pound of nut-galls to powder, and pour upon it six pounds of distilled water: leave this mixture to macerate for the space of 15 days at a temperature of 68° 77°. Then filter this liquor; and after the filtration, expose it in a vessel of glass or stone-ware, to evaporate slowly in the air. During this evaporation, which may be continued during two or three months, the gallic acid will be deposited in crystals, on the sides and bottom of the vessel, and on the inferior surface of a pellice which will have formed over the mixture. At the end of this period, pour off the liquor. Then dissolve whatever remains in the vessel in alcohol. This last solution, evaporated, will afford the gallic acid in crystals.

Experiment 3. Gallic acid may likewise be obtained by exposing powdered nut-galls in a retort to a moderate heat. The acid by this means sublimes; part condenses in small white crystals, and part is obtained in a fluid form, from its combination with a portion of water contained in the galls.

Remark. Gallic acid exists in the gall-nut, an excrescence growing on some species of oaks, in the husk of nuts, in oak bark, and in all those vegetables commonly called astringents.

Gallic acid appears in the form of minute, brilliant, colourless plates. Its taste is sour, and austere or astringent. It strongly reddens blue vegetable colours. It is soluble in about 10 parts of cold, and in three of boiling, water. It is likewise soluble in alcohol. It has a peculiar disagreeable odour when heated. It is not altered by exposure to air. Exposed gradually to a gentle heat, it sublimes without alteration; but if exposed to a strong heat, quickly applied, it becomes decomposed into carbonic acid, and carburetted hydrogen gas. It has a strong tendency to unite with metallic oxyds. With the red oxyd of iron it produces a deep black precipitate. This combination is the basis of ink and black dyes. It precipitates gold, copper, and silver, brown; mercury, orange; bismuth, yellow; and lead, white. It has no action on the oxyds of platinum, tin, zinc, cobalt, manganese, and arsenic.

The use of the tincture of galls as a re-agent for the discovery of iron, is exhibited in the following experiments:

Experiment 4. Prepare a phial with pure water and a little tincture of galls; and another with a weak solution of sulphate of iron; then mix these transparent colourless fluids together, and they will instantly become black.

Experiment 5. Write with a weak solution of sulphate of iron; let it dry, and it will be invisible. By dipping a feather in tincture of galls and drawing the wet feather over the letters, the writing will be restored and appear black.

SECTION XXXVII.

OF LACTIC ACID.

Experiment 1. Take any quantity of whey, evaporate it very slowly to one eighth, filter it, and then add to it lime-water till no farther turbidness appears. Filter the mixture again, and let fall into the fluid, diluted with water, a solution of oxalic acid, till it produces no further cloudiness. Then filter it and evaporate the fluid to the consistence of syrup, and mingle with it alcohol. Having done this, separate the fluid again by filtration, add to it a small quantity of water, put it into a retort, and distil off the spirit; the remaining water then contains the lactic acid in a pure state.

Remark. This acid exists in the whey of milk; and, when separated, is capable of being changed into a solid form. It attracts moisture, and unites with salifiable bases.

SECTION XXXVIII.

OF LACCIC ACID.

This acid has been discovered by Dr. Pearson, in a wax-like substance called *white lac*, of Madras, formed by certain insects of the coccus tribe.

Laccic acid naturally exists in the fluid state. It rises in distillation. It decomposes the carbonates of lime and soda. It renders the nitrate and muriate of barytes turbid. It assumes a green colour with lime water, and a purplish colour with sulphate of iron; and precipitates sulphuret of lime, white; tincture of galls, green; acetate of lead, reddish; nitrate of mercury, whitish, &c.

SECTION XXXIX.

OF BOMBIC ACID.

The phalæna, or moth of the silk-worm, particularly when in the state of a crysalis, contains in a reservoir situated near the anus, an acid liquor, said to be of a peculiar nature.

Experiment 1. This acid is obtained by squeezing the juice of the crysalis through a cloth, and precipitating the mucilage by the admixture of alcohol.

Experiment 2. Or, it may be obtained by digesting the crysalis in alcohol, mixing the infusion with a little water, and subtracting the alcohol by a gentle heat. The acid thus obtained is of an amber colour. It affords prussic acid when distilled with nitric acid. Its other properties and combinations are hitherto little known. An acid analogous exists in several caterpillars, in that of the willow, and in other insects.

SECTION XL.

OF AMNIOTIC ACID.

Vauquelin and Buniva have discovered a peculiar acid in the liquor of the amnios of the cow, to which they have given the name of amniotic acid.

Experiment 1. To obtain amniotic acid in a state of purity, evaporate the liquor of the amnios of the cow, to a syrupus consistence, which collects on the surface of the fluid. Transfer the concentrated fluid into alcohol, digest it by heat, decant the alcohol, and repeat this operation for several times. Having done this, mingle the alcohol solution with one quarter of water, and abstract the alcohol by heat. Crystals of amniotic acid will be deposited upon cooling. In this case the acid is not pure. It is necessary to re-dissolve it in boiling water or alcohol, or re-crystallize it repeatedly.

Whether this acid exists in the liquor of the amnios of other animals is not yet known.

Amniotic acid exists in the form of a white pulverulent powder. It is slightly acid, but sensibly reddens vegetable blues. It is difficultly soluble in cold, but readily soluble in boiling water, and in alcohol. When exposed to a strong heat it exhales an odour of ammonia and of prussic acid.

Amniotic acid does not decompose the alkaline carbonates at the usual temperature, but it does so when assisted by heat. These properties are sufficient to shew that it is different from every other acid. It approaches nearest to the mucous acid and the uric acid; but the first does not yield ammonia by heat, and the latter is not so soluble in hot water, does not crystallize in needles, and is insoluble in alcohol.

PART XVII.

OF SALTS.

Although the word salt was originally confined to muriate of soda or *common salt*, yet chemists have generalized the term, and applied it to all bodies which are sapid, easily melted, and soluble in water. The term was afterwards extended to all the compounds, which the acids form with alkalies, earths and metallic oxyds; these compounds have been called alkaline, earthy, and metallic salts.

The following facts respecting saline bodies, may be proper to premise:

1. The salts are denominated from the acids they contain.
2. The alkali, earth, or metallic oxyd constitutes the *base* of the salt.
3. An acid combined with two bases, forms a triple salt.
4. A salt formed with an excess, or an additional dose of acid, is called a supersalt.
5. A salt containing an excess of base is a subsalt.
6. If the acid, in the salt, contains a maximum of oxygen, the termination is *ate*, as sulphate, nitrate &c.
7. Those which do not contain a maximum, end in *ite*, as sulphite.
8. Every particular species is distinguished by subjoining to its generic term the name of its base.

All salts, we have observed, are either alkaline, earthy, or metallic, or they possess either an alkali, earth, or metal for their base, which is combined with an acid. The base may be in excess, which constitutes a subsalt, or the acid may be in excess which forms a supersalt. Thus for instance, sulphuric acid united with soda forms sulphate of soda, or *Glouber's salt*, which is an alkaline salt, with lime it forms sulphate of lime or *gypsum*, an earthy salt; and with iron, it forms sulphate of iron or copperas, which constitutes a metallic salt. In order to show the difference between alkaline, earthy, and metallic salts, the following experiments may be useful:

Experiment 1. If into a fluid, prussiate of potash, tincture of galls, or a solution of potash be dropped, which is followed by a *dark coloured* precipitate, the presence of metallic matter may be inferred, indicating a *metallic salt.*

Rationale. If metal be present, prussiate of potash will cause a peculiar coloured precipitate, as blue with iron, forming a metallic prussiate; tincture of galls will also strike a particular colour; and potash precipitates the metal in the form of oxyd.

Experiment 2. If a solution of salt in which prussiate of potash occasions no precipitate, affords a copious white precipitate by the addition of carbonate of potash, the salt has an earth for its base, and therefore belongs to the class of *earthy salts.*

Rationale. The acid which holds the earth in solution, unites with the alkali of the carbonate, and the carbonic acid passes to the earth, forming a carbonated earth.

Experiment 3. If carbonate of potash be added to a fluid known to contain a salt in solution, and no precipitation takes place, the presence of an *alkaline salt* is inferred.

Rationale. As the acid is already combined with an alkali, it is obvious, that as no decomposition can take place by the addition of potash, and that the alkali itself is not precipitated, no effect will ensue.

Mr. Parke has given the following beautiful experiments in illustration of the nature of saline bodies:

Experiment 4. Pour a little sulphuric acid into a solution of soda in water, evaporate the superfluous water, and then notice the crystallization of the new-formed salt. If the liquor be allowed to stand quietly for a few hours in a cool place, the salt will be seen to shoot into beautiful crystals of sulphate of soda.

Experiment 5. Dissolve some magnesia in diluted sulphuric acid, so as to saturate the acid. Pour off the clear liquid, and evaporate a portion of the superfluous water. If the remainder be suffered to cool, a crystallized salt will be formed, similar in every respect to Epsom salt.

Experiment 6. Put about half an ounce of quicksilver into an oil flask, and pour about an ounce of diluted nitrous acid upon it. The nitrous acid will be decomposed by the metal with astonishing rapidity; the bulk of the acid will be quickly changed to a beautiful green, while its surface exhibits a dark crimson; and an effervescence indescribably vivid and pleasing will go on during the whole time the acid operates upon the quicksilver. When a part only of the metal is dissolved, a change of colour will again take place, and the acid by degrees will become paler, till it is as pellucid as pure water. This is one instance of a metallic solution by means of an acid; in which the opacity of a metallic body is completely overcome, and the whole rendered perfectly transparent.

Experiment 7. Take the metallic solution formed in the last experiment, add a little more quicksilver to saturate the acid; then place it at some distance, over the flame of a lamp, so as gently to evaporate a part of the water. The new formed salt will soon be seen to begin to shoot into needle-like prismatic crystals, crossing each other in every possible direction; affording an instance of the formation of a metallic salt.

We shall first notice the alkaline salts, then the earthy salts, and lastly the metallic salts. With respect to the number of these saline combinations, it would appear, that having 32 acids and 57 bases, there must be 1824 salts: but there are several of the metallic oxyds which cannot combine with many of the acids; which is also the case with silica, one of the earths. However, to compensate for this deficiency, there are several acids capable of combining with two bases at once. These, we have said, are called *triple-salts*. Besides these there are also super-salts and sub-salts.

DIVISON I.

ALKALINE SALTS.

SECTION I.

SALTS OF POTASH.

MURIATE OF POTASH.

Experiment 1. If muriatic acid be saturated with potash, and the fluid evaporated, muriate of potash will form and crystallize in irregular cubes.

Remark. This salt is soluble in three times its weight of cold water. It melts in a red heat, and loses about three per cent. of its weight. It is the same as the *febrifuge salt of sylvius.* It contains near 30 per cent. of acid. It is found in sea water, in old plaster, and in vegetable and animal fluids. It constitutes the greater part of the soap-boilers liquor, after the formation of hard soap. See Soap.

Experiment 2. If sulphuric acid be added to muriate of potash, white acrid fumes, or muriatic acid gas, will be disengaged.

Rationale. The sulphuric acid unites with the potash, forming sulphate of potash, and the muriatic acid is evolved.

FLUATE OF POTASH.

Experiment 1. If fluoric acid be saturated with potash fluate of potash will result.

Remark. This salt is hardly known. It is a gelatinous substance, which is deliquescent, and readily soluble in water. It combines with silica, into a white powder.

Experiment 2. If lime water be added to fluate of potash, a precipitate will be formed analogous in composition to the native *fluor spar*.

Rationale. The fluoric acid in part quits the potash, and unites with the lime, forming fluate of lime.

Experiment 3. If sulphuric acid be poured on fluate of potash, fluoric acid gas will be disengaged.

Rationale. The sulphuric acid unites with the potash into a sulphate of potash, and the fluoric acid is separated.

BORATE OF POTASH.

Experiment 1. If boracic acid be saturated with potash, a compound will be formed called borate of potash, a salt not much known.

Experiment 2. If this salt, dissolved in water to saturation, be mingled with a small quantity of sulphuric acid, boracic acid will separate as the liquor cools.

Rationale. The sulphuric acid unites with the potash, and the boracic acid is disengaged.

PHOSPHATE OF POTASH.

Experiment 1. If carbonate of potash be added to phosphoric acid till all the effervescence cease, and the solution then evaporated, crystals of superphosphate of potash will form in striated prisms ; and,

Experiment 2. If the superphosphate be saturated with potash, and the mixture exposed to heat in a platinum crucible, the phosphate of potash will be prepared.

Experiment 3. If the salt thus formed, be dissolved in nitric acid, and the solution decomposed by lime water or ammonia, the phosphate will be precipitated.

Rationale. The lime or alkali added, unites with the nitric acid, by which the phosphate is disengaged. The solution, in order to decompose it, must sometimes be heated. The phosphate contains 100 acid, and 164 base.

PHOSPHITE OF POTASH.

Experiment 1. If phosphorous acid be combined with potash, a phosphite of potash will result.

Remark. This salt crystallizes in four sided prisms, and possesses a sharp, saline taste.

CARBONATE OF POTASH.

Experiment 1. If carbonic acid gas be passed through a solution of potash, till the salt crystallizes, carbonate of potash, or the super carbonate of some, will be formed.

Remark. The union of potash with carbonic acid to a maximum forms, therefore, a salt, which crystallizes in rhomboidal prisms, with dihedral summits, having an alkaline taste, and still gives a green colour to vegetable blues. This preparation is known also by the name of *ærated potash*, or *ærated vegetable alkali*. It contains 100 acid, 95 base, and 37 water.

Experiment 2. If 120 grains of potash be dissolved in 20 ounces of water, and combined with carbonic acid to the quantity of 6 times the volume of the water, the *ærated potash water* of the French will be formed.

Experiment. 3. If one ounce of pearl-ash be dissolved in ten pounds of water, and the solution saturated with carbonic acid, either in a Nooth's or Woulf's apparatus, or more conveniently in the apparatus lately invented by Mr. Hembel of this city, the *solution of super carbonate of potash* of the Edinburgh college will be formed.

Remark. It may be proper to notice, that the *mineral waters* sold in our city are either simple water saturated with carbonic acid, and occasionally mixed with saline substances, or potash or soda in solution, supersaturated with that acid. The quantity of the ingredients is variable. It is a salutary beverage, and answers as a substitute in warm weather for spirituous liquors.

Experiment 4. If the carbonate of potash formed as in Experiment 1, be exposed to a strong red heat, it will be converted into the sub carbonate.

Remark. This salt contains exactly one half of the acid contained in the carbonate. It is more soluble in water; its taste is acrid; it deliquesces in the air; and is decidedly different in many other properties from the carbonate. The *potash* of commerce, the *kali preparatum* the *alkali vegetabile mite*, the *sal absynthii*, and the *sal tartari* are sub carbonates of potash. The salt of tartar is prepared, according to the Edinburgh college, in the following manner:

Experiment 5. Take super tartrate of potash or cream of tartar, and burn it among live coals; reduce the mass to powder, and expose it in an open crucible to the action of a moderate fire, till it becomes white; dissolve it in warm water; strain the liquor, and evaporate it to dryness, stirring it towards the end of the process, and a white substance will remain.

Rationale. By the action of heat the acid of the tartar is decomposed; water, carburetted hydrogen gas, and carbonic acid are disengaged, leaving the potash combined with carbon, and afterwards (when the carbon is burnt) with carbonic acid.

SULPHATE OF POTASH.

Experiment 1. If diluted sulphuric acid be saturated with potash, and the solution evaporated, crystals of sulphate of potash will be formed.

Experiment 2. If the residue which remains after the distillation of nitric acid from nitre by sulphuric acid, be dissolved in water, and if necessary the superphuous acid saturated with potash, and the solution evaporated, sulphate of potash will likewise be formed.

Remark. The greatest part of the sulphate of potash of commerce is obtained from the residuum of the distillation of sulphate of iron with nitrate of potash, by lixivating it, supersaturating the solution with carbonate of potash, filtering it boiling hot, and allowing it to crystallize. The crystals of sulphate of potash are six sided prisms, which are generally aggregated in crusts.

It contains 100 acid, 130 base, and 20 water. This salt has been long known under the name of *arcanum duplicatum, sal de duobus, vitriolated tartar, and vitriol of potash.*

Experiment 3. If sulphate of potash be dissolved in sulphuric acid, and the solution evaporated, small slender six sided prisms will be formed, of supersulphate of potash.

Remark. This salt is acid; readily fusible, and when exposed to heat changes into sulphate of potash.

Experiment 4. If sulphate of potash be dissolved in water and muriate of barytes added, a white insoluble precipitate will be formed.

Remark. Hence sulphuric acid in sulphate of potash may be known by this re-agent; the precipitate is sulphate of barytes, and muriate of potash remains in solution:

Experiment 5. If sulphate of potash in solution be mixed with alcohol, a precipitate will take place.

Remark. Hence the sulphate is insoluble in alcohol; for the alkali unites with the water, and precipitates the salt.

Experiment 6. If a mixture of charcoal powder and sulphate of potash, be heated in a crucible, sulphuret of potash will result.

Remark. As charcoal decomposes sulphuric acid, in this instance it decomposes the sulphate; carbonic acid is disengaged and the sulphur remains united with the alkali in the state of sulphuret of potash or *hepar sulphuris.*

Experiment 7. If a mixture of equal parts of nitrate of potash and sulphur, be deflagated in a crucible, a compound will be formed called sulphate of potash with sulphur or *sal polychrestum.*

Rationale. The nitric acid of the nitrate of potash is decomposed by the sulphur, which is in part acidified by combining with its oxygen. The whole of the sulphur not being acidified, although united with the potash, forms the sulphate combined with sulphur.

SULPHITE OF POTASH.

Experiment 1. If sulphurous acid gas be passed through a solution of potash, sulphite of potash will result, which when evaporated will yield crystals in rhomboidal plates.

Experiment 2. If nitric acid be added to this salt, it will be converted into sulphate of potash.

Rationale. The sulphurous acid in the first unites directly with the alkali, and in the second experiment, the sulphurous is converted into the sulphuric by the oxygen of the nitric acid; nitric oxyd being evolved.

Experiment 3. If sulphite of potash be heated, sulphurous acid and water will be disengaged.

Remark. In this manner sulphurous acid was obtained by Scheele.

This salt contains 100 acid, 125 base, and 4.6 water.

NITRATE OF POTASH.

Experiment 1. If calcareous nitre, or nitrate of lime (which is the nitre of *salt petre caves*) be dissolved in water, the solution filtered, and potash added until no more precipitate is formed; the liquor then evaporated and crystallized, nitrate of potash will be formed.

Rationale. As nitric acid is combined with lime, the addition of potash precipitates the latter, and unites with the former into nitrate of potash.

Remark. In the Western United States, the manufacturers of salt petre use wood ashes, which they dispose either in tubs sometimes mixed with the salt petre earth, or lixivate into ley which they afterwards mix with the nitre earth. The nitric acid quits the lime, and unites with the potash. Immense quantities of this salt are made from the different caves. Nitre is produced spontaneously in various situations, sometimes efflorescing on the surface of the earth and on the walls of old buildings; it is also found in some vegetables, in mineral waters, dung-hills, &c. It may be artificially produced by the concurrent corruption, not strictly putrefaction, of animal and vegetable substances. Light earths, such as lime and marle, the refuse of soap factories, ashes, &c. being stratified for this purpose with straw, dung, and animal and vegetable substances; wetted with wine, blood, dung-hill water, and the mother water of salt-petre; and turned and exposed to the current of air.

In putrefaction the azote first unites with hydrogen and forms ammonia, after which the azote, in the next stage of corruption, unites with oxygen and forms nitric acid, which attaching itself to alkaline or earthy bodies, is afterwards converted into nitre by solution, filtration, evaporation, and crystallization. As nitre occurs in commerce it often contains a little muriate of potash and muriate of soda, from which it is easily purified by dissolving it in boiling water and filtering it: on cooling, the nitrate of potash crystallizes, and the other salts remain dissolved. This salt, when purified, is characterized by the following properties: It has a sharp bitterish, cooling taste. It shoots in pretty large crystals, which are generally six sided prisms, terminated by six sided pyramids; very brittle and permanent in the atmosphere; soluble in seven times their weight of water at 60°, and in an equal weight at 212°; melting when exposed to a strong heat, giving out at first oxygen, and afterwards nitrogen gas, until the whole acid be decomposed, and the potash alone remain behind. It deflagrates more or less violently with all oxygenizable substances, oxydizing or acidifying them. When dried in the temperature of 70°, it consists acccording to Kirwan of 44 nitric acid, 51.8 potash and 4.2 water. It is decomposed by the sulphuric acid and baryta, and the sulphates of soda, ammonia, magnesia, and alumina.

Experiment 2. If nitre be fused in a crucible and cast into moulds, it forms *crystal mineral* or *sal prunel.*

Remark. The only change which nitre undergoes in this process, is the separation of the water of crystallization.

Experiment 3. If 2 parts of nitre be introduced into a retort with one of sulphuric acid, and distilled, nitric acid will be obtained. See Nitric Acid.

Experiment 4. If three parts of nitre, two of potash, and one of sulphur be mixed together, *fulminating powder* will be prepared. See Sulphur.

Experiment 5. If one part of nitre and two of cream of tartar (or common flour) be detonated, the residue will form *black flux*.

Rationale. The vegetable acid, if tartar be employed, or the vegetable substance, if flour be used, is decomposed as well as the nitrate of potash; carbonic acid and water are disengaged, and the superfluous carbon remains mixed with the potash, forming the black flux for the fusion and reduction of metals.

Experiment 6. *White flux* is produced by detonating equal parts of nitrate of potash and acidulous tartrate of potash, or flour, in a similar manner.

Rationale. In this case, the oxygen of the nitric acid is sufficient to carry off all the carbon in the state of carbonic acid.

Experiment 7. Mix eight grains of nitrate of potash with four grains of phosphorus; place the mixture on a warm anvil, and strike it smartly with a hot hammer. This will produce a violent detonation. See Phosphorus.

Experiment 8. If ten grains of nitrate of potash be mixed well with three grains of pulverized charcoal, and the mixture thrown on a red hot fire shovel, a very brilliant combustion, accompanied with a loud detonation, will be the consequence. See Charcoal.

Experiment 9. Fuse a small quantity of nitre in a crucible, and, when in complete fusion, throw pulverized coal into it by small quantities at a time. The carbonaceous matter will decompose the nitre, and the bituminous part will burn away without acting upon it. This experiment will exhibit a mode of analysing coal; for every 100 grains of nitre that are decomposed in this way, denote ten grains of carbon.

Experiment 10. If 75 parts of nitre, 16 of charcoal, and 9 or 10 of sulphur be mixed together in a wooden mortar, the powder duly moistened, and afterwards passed through seives and dried, *gun powder* will be formed.

Remark. The mixture of these ingredients is performed in mills, called *gun powder mills*. The *powder paste* is afterwards *grained*, and for nice purposes glazed.

The excessive power of gun powder is owing to the formation, and sudden expansion, of several gases, such as carbonic, hydrogen, carburetted hydrogen, sulphuretted hydrogen, and azote; these gases being formed by the decomposition of the powder, and the union of the different elements agreeably to the laws of affinity.

NITRITE OF POTASH.

Experiment 1. If nitrate of potash be exposed to heat, in order to obtain oxygen gas, and the process stopped in time, the residue is a salt called nitrite of potash.

Rationale. The disengagement of oxygen from nitrate of potash, converts the nitric into the nitrous acid, which being already combined with the alkali forms nitrite of potash, a salt which deliquesces when exposed to the air, and gives out nitrous fumes.

OXYMURIATE OF POTASH.

Experiment 1. If potash in a dry state, be made to come in contact with oxymuriatic acid gas, so that saturation may take place, the oxymuriate of potash will be formed.

Rationale. The oxymuriatic acid quits its gaseous state, and unites with the potash.

HYPER-OXYMURIATE OF POTASH.

Experiment 1. If potash be dissolved in water and oxymuriatic acid gas passed through it, by means of Woulf's apparatus, hyper oxymuriate of potash will result.

Rationale. When potash is dissolved in water, and in this state comes in contact with oxymuriatic acid gas, the latter is decomposed, and converted into hyper oxymuriatic and common muriatic acid. The former, as well as the latter combine with the alkali, and constitute the hyper-oxymuriate, and muriate of potash. The hyper-oxymuriate crystallizes in flat rhomboidal prisms of a silvery whiteness. Its taste is cooling, austere, and disagreeable, somewhat analogous to that of nitre; it dissolves in 16 parts of cold and 2-12 of boiling water; it is not sensibly altered by exposure to the air. When heated nearly to redness, it gives out more than a third of its weight of oxygen gas. It detonates with sulphur or phosphorus.

Mr. Parke has given a collection of some experiments with this salt, which may be interesting to the student. We shall here insert them.

Experiment 2. By gently triturating 3 grains of hyper-oxymuriate of potash, and one of sulphur in a mortar with a metallic pestle, a series of detonations takes place resembling the cracks of a whip.

Experiment 3. Take about six grains of hyper-oxygenized muriate of potash, and three grains of flour sulphur; rub them together in a mortar, and a smart detonating noise will be produced. Continue to rub the mixture hard, and the reports will be frequently accompanied with vivid flashes of light. If the same mixture be wrapped in paper, laid on an anvil, and smartly struck with a hammer, the report will be as loud as what is usually produced by a pistol.

Experiment 4. Take ten grains of the salt, and one grain of phosphorus. Treat this mixture as in the last experiment, and very violent detonations will be produced. It is advisable never to exceed the quantity of phosphorus that is prescribed here, and in other similar experiments.

Experiment 5. Take a similar quantity of hyper-oxygenized muriate of potash with three or four grains of flour sulphur, and mix the ingredients very well on paper. If a little of this mixture be taken up on the point of a knife, and dropped into a wine glass containing some sulphuric acid, a beautiful column of flame will be perceived, the moment the powder comes in contact with the acid.

Experiment 6. Put a little hyper-oxygenized muriate of potash and a piece of phosphorus into an ale-glass, pour some cold water upon them cautiously, so as not to displace the salt. Now take a small glass tube, and plunge it into some sulphuric acid: then place the thumb upon the upper orifice, and in this state withdraw the tube, which must be instantly immersed in the glass, so that, on removing the thumb, the acid may be immediately conveyed upon the ingredients. This experiment is an example of a very singular phænomenon, combustion under water.

Experiment 7. Proceed in all respects as in the last experiment, and add a morsel of phosphuret of lime. Here, besides the former appearance, we shall have combustion also on the surface of the water.

Experiment 8. Prepare a mixture of equal parts of lump sugar and hyper-oxygenized muriate of potash; put a small quantity of this mixture upon a plate or a tile; then dip a piece of sewing thread into a phial of sulphuric acid, so as to convey the smallest quantity of the acid: with this touch the powder, and an immediate burst of flame will be the consequence.

Experiment 9. Mix, without much friction, ten grains of hyper-oxygenized muriate of potass with one grain of phosphorus, and drop the mixture into concentrated sulphuric acid. This is an instance of detonation and flame being produced, by the mixture of a powder with a cold liquid.

Experiment 10. If strong nitrous acid be poured upon a small quantity of a mixture of hyper-oxygenized muriate of potash and phosphorus, flashes of fire will be emitted at intervals for a considerable time.

Experiment 11. Add a few grains of hyper-oxygenized muriate of potass to a tea-spoonful or two of alcohol, drop one or two drops of sulphuric acid upon the mixture and the whole will burst into flame, forming a very beautiful appearance.

Experiment 12. A mixture of hyper-oxygenized muriate of potash and arsenic furnishes a detonating compound, which takes fire with the utmost rapidity. The salt and metal first separately powdered, may be mixed by the gentlest possible triture, or rather by stirring them together on paper with the point of a knife. If two long trains be laid on a table, the one of gunpowder and the other of this mixture, and they be 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 other burns with comparatively extreme slowness.

ARSENIATE OF POTASH.

Experiment 1. If arsenic acid be saturated with potash, a salt will be formed called arseniate of potash.

Remark. This salt does not crystallize. It deliquesces, and changes vegetable blues to green.

Experiment 2. If the arsenic acid exists in excess, the super arseniate of potash is formed.

Remark. This is a transparent white salt, which crystallizes in four sided prisms, terminated by four sided pyramids.

Experiment 3. If a mixture of nitrate of potash and arsenious acid be detonated in a crucible, the residue will be arseniate of potash.

Remark. The arsenious acid being converted into the arsenic acid by the oxygen of the nitric acid, by combining with potash, the base of the nitre forms arseniate of potash.

ARSENITE OF POTASH.

Experiment 1. If white arsenite, or arsenious acid, be boiled in a solution of potash, a compound will be formed called arsenite of potash. See Arsenic.

Remark. The alkaline arsenites were formerly called *livers of arsenic*.

MOLYBDATE OF POTASH.

Experiment 1. If molybdic acid be saturated with potash, molybdate of potash will result. Or,

Experiment 2. If one part of molybdenum be detonated with four of nitrate of potash, a residue will be left, which contains the molybdate of potash.

Rationale. The oxygen of the nitric acid acidifies the metal, and the molybdic acid, thus formed, unites with the potash of the nitre.

TUNGSTATE OF POTASH.

Experiment 1. If tungstic acid be united with potash, tungstate of potash will be produced. See Tungsten.

CHROMATE OF POTASH.

Experiment 1. Chromic acid combined with potash, forms chromate of potash. See Chromium.

COLUMBATE OF POTASH.

Experiment 1. If columbic acid be united with potash, columbate of potash will result. See Columbium.

ACETATE OF POTASH.

Experiment 1. If acetic acid be saturated with potash and evaporated, acetate of potash will crystallize in prisms.

Remark. This is the *acetated kali*, or *diuretic salt*, of the Dispensatories. This salt may be prepared thus:

Experiment 2. If acetate of lead be decomposed by sulphate of potash, the liquor then filtered, and evaporated, acetate of potash will be formed.

Remark. This is effected by double affinity; sulphate of lead falls to the bottom, and acetate of potash remains in solution. This salt has a strong pungent taste; is deliquescent, soluble in alcohol, and decomposable by the stronger acids; by a decoction of tamarinds; by the sulphate of soda and magnesia; by muriate of ammonia; by the tartrate of potash and soda; and by some metalline salts. It contains 100 acid and 103.45 base.

BENZOATE OF POTASH.

Experiment 1. Potash added to benzoic acid in solution, till it is saturated, forms benzoate of potash.

SUCCINATE OF POTASH.

Experiment 1. If succinic acid or volatile salt of amber, be saturated with potash, succinate of potash will result.

Remark. This salt has been recommended as a reagent, to discover the presence and quantity of iron in any solution.

MOROXYLATE OF POTASH.

Experiment 1. The combination of potash and moroxylic acid, forms moroxylate of potash.

CAMPHORATE OF POTASH.

Experiment 1. Camphoric acid saturated with potash, constitutes camphorate of potash, which crystallizes in hexagons.

Remark. This salt is soluble in cold and hot water; decomposable by heat; and burns with a deep blue flame.

OXALATE OF POTASH.

Experiment 1. If oxalic acid, or saccharine acid, be saturated with potash, oxalate of potash will result.

Remark. This salt crystallizes in flat rhomboids.

Experiment 2. If an excess of acid be added to the product of the last experiment, super-oxalate of potash will result.

Remark. This salt known also by the name of *salt of sorrel*, because it is extracted from that plant, crystallizes in small opaque parallelopipedes. It has an acid, pungent, bitterish taste. It contains exactly double the quantity of acid which the oxalate of potash contains. Oxalate as well as the superoxalate of potash has been used as a test for lime, with which it forms an insoluble compound of oxalate of lime.

Experiment 3. If super-oxalate of potash be digested in nitric or muriatic acid, the quadroxalate of potash of Dr. Wollasten will be formed.

Remark. One half of the alkali is separated, leaving a salt, which contains four times the proportion of acid that exists in oxalate of potash. The oxalates already noticed are easily decomposed in a red heat; water, carbonic acid, carbonic oxyd, carburetted hydrogen and charcoal are evolved, and the acid destroyed.

MELLATE OF POTASH.

Experiment 1. If the mellitic acid be combined with potash, mellate of potash will result.

TARTRATE OF POTASH.

Experiment 1. If the supertartrate of potash be saturated with potash, tartrate of potash, or *soluble tartar* will be formed.

Remark. This salt crystallizes in four sided rectangular prisms, terminated by dihedral summits. This salt contains 100 acid and 72.41 base.

Experiment 2. If the red or crude tartar of the shops be boiled in water, the solution filtered and evaporated, crystals of supertartrate of potash may be formed.

Remark. This salt in its crude state is coloured; it deposits itself on the sides of casks in which wine is kept, and is considerably acid. When distilled it gives out a great deal of inflammable air, and carbonic acid gas; and an acid liquor is obtained, formerly called pyrotartaric, but now known to be merely acetic contaminated with a little empyreumatic oil. The tartar of commerce contains about 5 per cent. of tartrate of lime.

TARTRATE OF POTASH AND SODA.

Experiment 1. When supertartrate of potash or cream of tartar, in solution, is saturated with carbonate of soda, a triple salt is formed, which crystallizes in large irregular prisms, called tartrate of potash and soda, and also *Rochelle salt*, *salt of Seignette*, and *tartarized natron*.

Remark. This salt is soluble in about five parts of water, and effloresces in the air. It is decomposed by the stronger acids, which combine with the soda and separate supertartrate of potash.

It consists of 54 tartrate of potash, and 46 tartrate of soda.

PRUSSIATE OF POTASH.

Experiment 1. If a solution of potash be digested on Prussian blue, a salt will be formed called prussiate of potash.

Rationale. The prussic acid quits the iron, and unites with the alkali. This salt crystallizes in cubes or parallelopipedes. It is not pure prussiate of potash, but rather a triple prussiate, of potash and iron. The best mode of preparing this salt, for the purposes of experiment, may be seen in Henry's Chemistry, octavo. The remaining salts of potash are not much known; such as the citrate, kinate, saccolate, sebate, urate, malate, formiate, suberate, and gallate of potash.

SECTION II.

SALTS OF SODA.

MURIATE OF SODA.

Experiment 1. If muriatic acid be saturated with soda, or natron, and the compound evaporated and crystallized, muriate of soda will form in cubes.

Remark. This salt has been known from the earliest ages. It has received the name of *marine salt*, *common salt*, *rock salt*, *bay salt*, *sal gem*, &c. It is found native in mines, in many places, but particularly in Poland and Hungary. It is also obtained from sea water, salt licks or springs, by evaporation. Its taste is universally known. It dissolves in rather less than thrice its weight of water. It is insoluble in pure alcohol. It is somewhat deliquescent. It evaporates in a violent heat; and, as it promotes the vitrification of siliceous earth, is used in the glazing of stone ware. It contains 100 acid, 114 base, and 14 water.

Experiment 2. If sulphuric acid be added to muriate of soda, muriatic acid gas will be disengaged; and,

Experiment 3. If the residue be dissolved in water, and crystallized, sulphate of soda is formed.

Rationale. In Experiment 2, the muriatic acid is disengaged from the soda, and in Experiment 3, the sulphuric acid, by uniting with that alkali, forms sulphate of soda, or Glauber's salt. See Muriatic Acid, and Muriatic Acid Gas.

Experiment 4. If litharge and muriate of soda be mixed with water, and digested, the soda will be disengaged, and a white compound or muriate of lead formed.

Rationale. The oxyd of lead decomposes the salt; the muriatic acid unites with the lead, and the soda is disengaged.

Experiment 5. If the product of the last Experiment be washed, and then fused in a crucible, *patent yellow* will be produced. See Lead, and Soda.

Experiment 6. If acetate of lead and muriate of soda be added together in solution, in proper proportion, muriate of lead will be precipitated; and,

Experiment 7. If the liquor be now filtered, and the filtered fluid evaporated and exposed to a strong heat, soda will remain behind.

Rationale. In the first experiment, the muriatic acid unites with the lead of the acetate, and the acetic acid combines with the soda; in the second experiment, the acetic acid is expelled, and the soda remains in the crucible.

FLUATE OF SODA.

Experiment 1. If fluoric acid be saturated with soda, the compound evaporated and crystallized, fluate of soda will form in cubes.

Experiment 2. If this salt be treated with sulphuric acid, fluoric acid will be disengaged, and sulphate of soda formed.

BORATE OF SODA.

Experiment 1. If sub borate of soda be saturated with boracic acid, a compound will be formed, called borate of soda.

Experiment 2. If boracic acid be united with soda, at a minimum, a salt will be formed called sub borate of soda or borax.

Remark. Borax has been long known. It is brought from the East Indies. It is found in a crystallized state at the bottom of certain salt lakes in a barren volcanic district of the kingdom of Thibet, incrusted in a greasy covering, and is called *brute borax*, *tincall*, or *chrysocolla*. It is purified by long boiling; the crystals this affords, being again purified by a second filtration and crystallization. When purified, it is white and transparent. Its crystals are hexangular prisms, but is usually in roundish semi-transparent lumps. Specific gravity 1.7. Converts vegetable blues to green. Soluble in about twenty times its weight in water. It melts when exposed to heat, and loses its water of crystallization; it is then called *calcined borax*. It is employed in forming reducing fluxes; in soldering metals, &c. It is said to be composed of 39 acid, 17 base, and 44 water.

Experiment 3. If borax be dissolved in boiling water, and sulphuric acid added; as the liquor cools boracic acid will be precipitated. See Boracic acid.

PHOSPHATE OF SODA.

Experiment 1. If phosphoric acid be saturated with soda, the liquor evaporated and crystallized, phosphate of soda will be formed; or,

Experiment 2. If super phosphate of lime, prepared in the same manner as for making phosphorus, be decomposed by carbonate of soda; the precipitate separated, and the fluid evaporated and crystallized, phosphate of soda will be the result.

Rationale. The carbonic acid of the carbonate of soda, unites with the lime, forming carbonate of lime, whilst the phosphoric acid combines with the soda and forms phosphate of soda.

Remark. This salt is the *soda phosphorata* of the apothecaries. As it occurs in the shops, it is always adulterated with sulphate of soda. It contains 100 acid and 87.7 base. This salt crystallizes in rhomboidal prisms. It dissolves in four times its weight of cold water. When heated it undergoes the watery fusion. This salt has been recommended as a test, which will be noticed hereafter.

Experiment 3. If this salt be dissolved in nitric acid, and precipitated by ammonia, it will be separated as the phosphate of potash, which see.

Experiment 4. If phosphoric acid be saturated with an equal quantity of soda and ammonia, and the fluid evaporated, the phosphate of soda and ammonia will be the result; or,

Experiment. 5. If urine be evaporated and crystallized, the same compound will be formed.

Remark. This salt composed of phosphoric acid and two bases, having originally been obtained from urine, received the name of *salt of urine* and *microcosmic salt*. It is generally used as flux for the blow pipe.

PHOSPHITE OF SODA.

Experiment 1. Phosphorous acid saturated with soda, constitutes this salt.

Remark. This salt crystallizes in rhomboids, and when heated gives out a little phosphorus and is converted into phosphate of soda.

CARBONATE OF SODA.

Experiment 1. If a current of carbonic acid be made to pass through a solution of soda, till it ceass to absorb any more, carbonate of soda will be produ- ed.

Remark. This salt runs into a hard mass, which is ot altered by exposure to the air.

Experiment 2. If carbonic acid be combined with oda to the minimum, a salt will be formed called ubcarbonate of soda.

Remark. The soda or natron of commerce is a ub carbonate of soda. The properties of this salt nay be seen under the head of Soda, Vol. 1.

SULPHATE OF SODA.

Experiment 1. If diluted sulphuric acid be satura- ed with soda, and the compound evaporated and crys- allized, sulphate of soda will be the result.

Remark. This salt, called also *Glauber's salt, sal nirabile*, &c. is prepared in different ways, and is found in many mineral waters, brine springs, &c. from which it is obtained by evaporation. It is sometimes prepared by dissolving, filtering, and evaporating the residuum left after the formation of muriatic acid, as the residue consists of sulphuric acid and soda. It forms the *caput mortum* of other distillations, and is formed in abundance in the preparation of muriate of ammonia and oxygenized muriatic acid.

Glauber's salt crystallizes in six sided transparent prisms, terminated by dihedral summits. The sides of the prisms are usually channeled. It dissolves in less than three times its weight of cold water, and in less than its weight of boiling water. When exposed to the air, it loses its water, and falls into powder or effloresces. The loss of weight is about 56 parts. It contains 100 acid, 78.32 base, 246.6 water.

Glauber's salt is obtained in the United States from the mother water, or fluid remaining after the separation of common salt from sea water and brine springs.

Experiment 2. If sulphate of soda be dissolved in sulphuric acid, and the compound evaporated, a salt will be formed called super-sulphate of soda.

SULPHITE OF SODA.

Experiment 1. If sulphureous acid be saturated with soda, and the compound evaporated, sulphite of soda will be the result.

Remark. This salt crystallizes in flat four sided prisms. When heated it emits sulphurous acid and water. It contains 100 acid, 58 base, and 164 water.

NITRATE OF SODA.

Experiment 1. If nitric acid be saturated with soda and evaporated, cubic crystals of nitrate of soda will be formed.

Remark. Nitrate of soda remains in solution after the precipitation of calomel from a solution of mercury in nitric acid by muriate of soda.

This salt, from the form of its crystal, has been called cubic or rhomboidal nitre. Its properties in many respects resembles nitre. It contains 100 acid, and 73.43 base. Sulphuric acid decomposes it.

NITRITE OF SODA.

Experiment 1. If the crystallized nitrate of soda be exposed to heat, sufficient to disengage oxygen, the residue will be nitrite of soda.

OXYMURIATE OF SODA.

Experiment 1. If oxymuriatic acid be made to pass through soda in a dry state, a union will take place, and produce oxymuriate of soda.

HYPER-OXYMURIATE OF SODA.

Experiment 1. If oxymuriatic acid gas, be passed through a solution of soda till it is saturated, in the same manner as the hyper-oxymuriate of potash, the hyper-oxymuriate of soda will be formed.

Remark. This salt is not easily obtained pure, because it is as soluble as muriate of soda, with which it is always contaminated. It crystallizes in cubes. It dissolves in about three parts of cold water. Its general properties resemble the hyper-oxymuriate of potash. It contains 100 acid, 44.78 base, and 6.35 water.

ARSENIATE OF SODA.

Experiment 1. Arsenic acid combined with soda and the compound evaporated, yields arseniate of soda, which crystallizes in six sided prisms.

Experiment 2. If the former be dissolved in arsenic acid, the super-arseniate of soda will be produced.

ARSENITE OF SODA.

Experiment 1. If arsenious acid or white arsenic of the shops, be dissolved in water, and saturated with soda, arsenite of soda will be formed.

MOLYBDATE OF SODA.

Experiment 1. When molybdic acid is saturated with soda, molybdate of soda is the result.

Experiment 2. If into the molybdate of soda, a cylinder of tin with some muriatic acid be put, the liquid will gradually assume a deep blue colour.

TUNGSTATE OF SODA.

Experiment 1. If the yellow oxyd, or otherwise acid, of tungsten, be combined with soda, the tungstate of soda will result.

Remark. This salt crystallizes in elongated hexahedral plates.

CHROMATE OF SODA.

Experiment 1. Chromic acid united with soda, constitutes the chromate of soda.

Remark. The properties of this salt are similar to the chromate of potash.

COLUMBATE OF SODA.

Experiment 1. If columbic acid be combined with soda, the columbate of soda will result.

Remark. Besides the salts already enumerated, some of which are rare and hardly known, we have other compounds of soda with other acids, such as the acetate, benzoate, succinate, moroxylate, camphorate, oxalate, mellate, tartrate, citrate, saccolate, sebate, urate, mallate, formiate, suberate, gallate, and prussiate of soda, produced by the combination of the several acids with soda.

SECTION III.

SALTS OF AMMONIA.

MURIATE OF AMMONIA.

Experiment 1. If muriatic acid be saturated with ammonia or volatile alkali, and evaporated, muriate of ammonia will be produced.

Remark. This salt, known in commerce by the name of *sal ammoniac*, occurs native; but is prepared for various purposes either by combining directly ammonia with muriatic acid, or by decomposing the sulphate of ammonia by means of muriate of soda, or the muriates of lime and magnesia by means of ammonia. It was first prepared in Egypt from the soot of camel dung by sublimation. This salt was originally found native near the temple of *Jupiter Ammon* in *Africa*, from which its name is derived.

It is usually in large cakes, but by solution and evaporation it may be obtained crystallized in long four sided pyramids. It is soluble in thrice its weight of cold water, and in about seventy-five parts of alcohol. It sublimes without decomposition. It contains 100 acid, 58.4 base, and 75.4 water. It is decomposed by lime, potash, &c. as is shown in the preparation of liquid ammonia. See Ammonia.

Mixed with carbonate of lime and sublimed, it yields carbonate of ammonia, or *sal volatile ammonia*.

Experiment 2. If a mixture of quicklime and muriate of ammonia be exposed to heat in a gas bottle, ammoniacal gas will be obtained. See Ammoniacal Gas.

Experiment 3. If two parts of muriate of ammonia, one of quicklime, and three or four of water be distilled, the *water of pure ammonia* will come over. See Ammonia.

Experiment 4. If potash be used with sal ammoniac in the same manner, the result will be the *spirit of sal.*

ammoniac, or the *common water of ammonia* of the shops. See Ammonia.

Experiment 5. If sulphuric acid be added to muriate of ammonia, muriatic acid will be disengaged, and the remaining compound forms sulphate of ammonia, or *Glauber's secret sal ammoniac.*

Experiment 6. If the muriates of ammonia and magnesia be mixed and evaporatd, the result is a triple salt, called muriate of ammonia and magnesia.

FLUATE OF AMMONIA.

Experiment 1. Ammonia combined with fluoric acid, forms fluate of ammonia, a salt readily crystallizable, and may be sublimed without decomposition.

Remark. Fluate of ammonia is a very delicate test of lime. This was first recommended by Scheele.

Experiment 2. Into a glass of transparent lime water drop a single drop of fluate of ammonia, and an immediate precipitate will be occasioned.

Rationale. The fluoric acid quits the ammonia, and unites with the lime, forming a fluate of lime.

BORATE OF AMMONIA.

Experiment 1. If boracic acid be saturated with ammonia, and evaporated, borate of ammonia will be the result.

Remark. This salt forms permanent crystals, which resemble those of borax.

Experiment 2. If to the product of Experiment 1, dissolved in boiling water, sulphuric acid be added, as the liquor cools boracic acid will precipitate.

Rationale. The sulphuric acid unites with the ammonia, forming sulphate of ammonia, and boracic acid is separated.

PHOSPHATE OF AMMONIA.

Experiment 1. If phosphoric acid be saturated with ammonia, phosphate of ammonia will be formed. Or,

Experiment 2. If super-phosphate of lime be saturated with ammonia, or carbonate of ammonia, until no further precipitation takes place, and the liquor filtered, evaporated and crystallized, the same product will be the result.

Rationale. In Experiment 1, the ammonia unites with the acid by simple affinity, in Experiment 2, it combines with the acid by compound affinity; the phosphoric acid uniting with the ammonia, whilst the carbonic acid combines with the lime forming carbonate of lime.

Experiment 3. If the phosphates of ammonia and magnesia be mixed, and evaporated, a triple salt is formed called phosphate of ammonia and magnesia.

Remark. This salt crystallizes in four sided transparent prisms, terminated by four sided pyramids. In a strong heat, it loses its ammonia. The phosphate of ammonia contains 100 acid, and 68.6 base.

PHOSPHITE OF AMMONIA.

Experiment 1. If phosphorous acid be saturated with ammonia, the result is phosphite of ammonia.

Remark. This salt crystallizes in four sided prisms.

Experiment 2. If phosphite of ammonia be heated on charcoal by means of a blow-pipe, it boils, and loses its water of crystallization: it then becomes surrounded with a phosphorescent light, and bubbles of phosphuretted hydrogen gas are emitted, which burn in the air with a lively flame, and form a fine coronet of phosphoric acid vapour.

Rationale. When heat is applied, the salt is decomposed; the hydrogen of the ammonia combines with a portion of phosphorus, and forms phosphuretted hydrogen gas, which, by combustion, constitutes phosphoric acid and water.

CARBONATE OF AMMONIA.

Experiment 1. If a current of carbonic acid gas be passed through a solution of sub-carbonate of ammonia, until saturation is complete, carbonate of ammonia will be formed.

Remark. This salt crystallizes in six sided prisms. When heated it sublimes, and is decomposed.

Experiment 2. If one part of muriate of ammonia and two parts of carbonate of lime be mixed together and sublimed, a salt will be formed called sub-carbonate of ammonia.

Remark. This salt, called also *prepared ammonia*, *sal volat ammonia*, *mild volatile alkali*, &c. is the result of a double decomposition. The muriatic acid of the muriate, first unites with the lime, which remains behind, and the carbonic acid of the carbonate combines with the ammonia into a carbonate of ammonia. There are different varieties of this salt, containing different proportions of acid and base. It usually contains from 30 to 40 per cent. of alkali. It is decomposed by most of the acids, and all the alkaline and some of the earthy bases; by the earthy sulphates except those of barytes and strontian; by the earthy sulphates, muriates and fluates; by the nitrates of barytes, and super-phosphate of lime. It is very volatile in the fire, and changes in its composition with every change of its temperature, giving out carbonic acid when heated, and absorbing it again as it cools: when passed through a tube heated red, it is decompounded into water, charcoal, nitrogen, and hydro-carbonate.

Experiment 3. If the solutions of carbonate of ammonia and carbonate of magnesia be mixed, a triple salt will be produced, called carbonate of ammonia and magnesia.

Experiment 4. If any of the stronger acids be poured on carbonate of ammonia, an effervescence will be produced, and carbonic acid gas disengaged.

Rationale. The acid added unites with the ammonia, owing to a superior affinity, and a new product is formed, at the same time the carbonic acid is expelled.

Experiment 5. If lime water be added to a solution of carbonate of ammonia, carbonate of lime will be produced. See Lime.

SULPHATE OF AMMONIA.

Experiment 1. If sulphuric acid be saturated with ammonia, a salt will be formed called sulphate of ammonia, or *Glauber's secret sal ammoniac.*

Remark. This salt crystallizes in small six sided prisms. It has a sharp bitter taste; is soluble in twice its weight of cold water, and in its weight of boiling water. When exposed to the air, it slowly attracts moisture. When heated it decripitates, then melts and sublimes with some loss of its alkali. When heated nearly to redness, the greatest part of it is decomposed. This salt is made by adding sulphate of iron to liquid ammonia, obtained from bones. The sulphate of ammonia thus obtained, is decomposed by muriate of soda, in the formation of sal ammoniac.

Experiment 2. If muriate of soda and sulphate of ammonia be mixed and sublimed, muriate of ammonia and sulphate of soda will be the result. See Muriate of Ammonia.

Experiment 3. If the sulphates of potash and ammonia in solution be mixed, the triple sulphate of potash and ammonia will be formed.

Experiment 4. If the sulphates of magnesia and ammonia be combined, the triple sulphate of magnesia and ammonia will be produced.

Experiment 5. If sulphuric acid be saturated with alumina and ammonia, the triple sulphate of alumina and ammonia will be the product: but,

Experiment 6. If the same substances be added to sulphuric acid, so that the latter may exist in excess, the super sulphate of alumina and ammonia will be formed. See Alum.

SULPHITE OF AMMONIA.

Experiment 1. If liquid ammonia be put into Woulfe's bottles, and a current of sulphurous acid gas passed through it until saturation is complete, the solution then evaporated, crystals of sulphite of ammonia in flat four sided prisms will be formed.

Experiment 2. If on this salt nitric acid be poured, it will be converted into sulphate of ammonia.

Rationale. The nitric acid imparts oxygen to the sulphurous acid, by which the sulphite is changed into the sulphate of ammonia.

Experiment 3. If liquid ammonia and magnesia be saturated with sulphureous acid, as in Experiment 1, the triple sulphate of ammonia and magnesia will be produced.

Remark. Sulphate of ammonia contains 100 acid, 26.5 base, and 57 water; and the sulphite 100 acid, 48.3 base, and 18.3 water.

NITRATE OF AMMONIA.

Experiment 1. If nitric acid be saturated with ammonia, by using the carbonate of that alkali, and the solution evaporated, crystals of nitrate of ammonia, in six sided prisms terminated by six sided pyramids will be formed; or,

Experiment 2. If nitrous gas and ammoniacal gas with a portion of oxygen gas in due proportion, be mixed, the result will be nitrate of ammonia. Or,

Experiment 3. If nitrate of potash be added to a saturated solution of sulphate of ammonia, the mixture then evaporated twice at 250°, and, after the crystals thus formed is separated, the remaining liquor evaporated at 212°, nitrate of ammonia will crystallize.

Rationale. The first experiment is a direct combination of the constituent parts of this salt, and is the mode generally used; the second is a union of the same substances in a gaseous state, the oxygen intended to convert the nitrous gas into the nitrous acid; and the third, is the effect of double decomposition, forming sulphate of potash, and nitrate of ammonia.

Remark. This salt when heated nearly to redness, burns with a kind of explosion; hence it was formerly called *nitrum flammans.* It is readily soluble, and very deliquescent. At a temperature of 400 degrees, it is decomposed and converted into *water* and *nitrous oxyd gas.* It contains 100 acid, 43.38 base, and 35.1 water. See the Preparation of Nitrous Oxyd Gas.

Experiment 4. If the nitrates of ammonia and magnesia be mixed, a triple salt will result, called nitrate of ammonia and magnesia.

HYPER OXYMURIATE OF AMMONIA.

Experiment 1. If carbonate of ammonia be mixed with an earthy hyper oxymuriate, the hyper oxymuriate of ammonia will result.

Rationale. The ammonia unites with the acid, and the earth of the original salt is separated.

ARSENATE OF AMMONIA.

Experiment 1. When arsenic acid is saturated with ammonia, the result is arseniate of ammonia.

Remark. This salt crystallizes in rhomboidal prisms.

ARSENITE OF AMMONIA.

Experiment 1. If arsenious acid be combined with ammonia to saturation, arsenite of ammonia will be formed.

Experiment 2. If this salt be added to sulphate of copper, *Scheele's green* will result. See Arsenic.

MOLYBDATE OF AMMONIA.

Experiment 1. Molybdic acid combined with ammonia, forms molybdate of ammonia, a salt very soluble in water, and not crystallizable.

Experiment 2. If into a solution of molybdate of ammonia, a cylinder of tin with some muriatic acid be put, the same effect will take place as in molybdate of potash.

TUNGSTATE OF AMMONIA.

Experiment 1. If the yellow oxyd or otherwise tungstic acid, be united with ammonia, the result is a salt which crystallizes in needles or small plates, called tungstate of ammonia.

CHROMATE OF AMMONIA.

Experiment 1. When chromic acid is combined with ammonia, chromate of ammonia is the result.

ACETATE OF AMMONIA.

Experiment 1. If distilled vinegar be saturated with ammonia, the result is acetate of ammonia, or the *spirit of mindereus* of the shops.

Remark. When common vinegar is used, the compound is always more or less brown, owing perhaps, to the separation of carbon or mucilaginous matter. The colleges, therefore, recommend the use of distilled vinegar. This salt does not crystallize by evaporation, but it may be obtained in needles by sublimation. It melts at 170°, and sublimes at 250°. It contains 100 acid, and 45.40 base. It is decomposed by the stronger acids.

BENZOATE OF AMMONIA

Experiment 1. Benzoic acid saturated with ammonia, constitutes benzoate of ammonia, a salt not much known.

SUCCINATE OF AMMONIA.

Experiment 1. If to a solution of succinic acid, or salt of amber of the shops, ammonia be added to saturation, the benzoate of ammonia will be formed.

Experiment 2. If to a solution of iron, succinate of ammonia be added, the metal will be precipitated in the form of succinate of iron.

Rationale. The acid, the solvent of the iron, unites with the ammonia, and remains in solution, whilst the succinic acid combines with the iron into a succinate of iron. The succinate of ammonia is used as a test for iron.

The remaining salts of ammonia are but little known. They are formed by the union of the other acids, not heretofore mentioned, viz, the moroxylic, camphoric, oxalic, tartaric, citric, kinic, &c.

DIVISON II.

EARTHY SALTS.

SECTION I.

SALTS OF MAGNESIA·

MURIATE OF MAGNESIA.

Experiment 1. If muriatic acid be saturated with magnesia, a salt will be formed called muriate of magnesia.

Remark. This salt exists in sea water. It is not easily crystallized; it may be obtained in small needles, if concentrated and exposed to a sudden cold. It is very bitter. It is soluble in water. In a dry state it deliquesces. It contains 100 acid and 86.8 base.

Experiment 2. If sulphuric acid be added to muriate of magnesia, sulphate of magnesia will result.

Rationale. The sulphuric acid unites with the magnesia, and the muriatic acid is expelled.

FLUATE OF MAGNESIA.

Experiment 1. Fluoric acid combined with magnesia, forms fluate of magnesia; and,

Experiment 2. If the acid be made to unite with the earth in excess; crystals may be obtained in dodecahedrons.

Experiment 3. If sulphuric acid be added to either of these salts, the fluoric acid will be expelled in the form of gas, leaving sulphate of magnesia

BORATE OF MAGNESIA.

Experiment 1. If boracic acid be saturated with magnesia, borate of magnesia will be formed, which will form on evaporation into small irregular crystals.

Remark. This salt is soluble in acetic acid. It is decomposed by sulphuric acid, and boracic acid is separated.

PHOSPHATE OF MAGNESIA.

Experiment 1. Phosphoric acid saturated with magnesia, forms phosphate of magnesia. Or,

Experiment 2. If a concentrated solution of phosphate of soda be added to another of sulphate of magnesia; in a few hours crystals of phosphate of magnesia are deposited.

Rationale. The sulphuric acid of the sulphate of magnesia combines with the soda, and the phosphoric acid of the phosphate of soda unites with the magnesia.

Remark. This salt crystallizes in six sided prisms with unequal sides.

PHOSPHATE OF AMMONIA AND MAGNESIA.

Experiment 1. This salt is formed by the union of the two phosphates. Or,

Experiment 2. If urine be evaporated, crystals of this salt will form in four sided transparent prisms, terminated by four sided pyramids.

Experiment 3. If this salt be exposed to a strong heat, it is converted into phosphate of magnesia, the ammonia being evolved.

PHOSPHITE OF MAGNESIA.

Experiment 1. If Phosphorus acid be combined with magnesia, phosphite of magnesia will result.

Experiment 2. If magnesia and ammonia be combined with phosphorus acid, a triple salt of magnesia and ammonia will be formed.

Remark. Phosphate of magnesia contains 100 acid, and 62 8 base; the phosphite contains about the same proportions.

CARBONATE OF MAGNESIA.

Experiment 1. If Magnesia be diffused in water, and a stream of carbonic acid passed through it, the carbonate of magnesia will be formed. Or,

Experiment 2. If sulphate of magnesia be decomposed by a fully saturated carbonate of potash, without the application of heat, carbonate of magnesia will be deposited in crystals.

Remark. Crystallized carbonate of magnesia, which is in six sided transparent prisms, consists of 50 acid, 25 magnesia, and 25 water. It is soluble in 480 parts of water. This salt is decomposed by acids, and by various other bodies.

Experiment 2. If sulphate of magnesia be decomposed by sub carbonate of potash, the sub carbonate of magnesia, or *magnesia of the shops*, will be formed.

Rationale. In both experiments a mutual decomposition ensues; in the former, carbonate of magnesia fully saturated, in the latter carbonate of magnesia containing an excess of base, with sulphate of potash, is produced. See Magnesia.

SULPHATE OF MAGNESIA.

Experiment 1. If diluted sulphuric acid be saturated with magnesia, and the compound evaporated, sulphate of magnesia will be formed.

Remark. This salt called also *Epsom salt*, because it is obtained from a spring near London, crystallizes in regular four sided prisms or dihedral summits. The crystals of this salt refract doubly. It is intensely bitter. It contains 100 acid, 57.92 base, and 182.8

water. It is decomposed by alkalies; from it magnesia is procured. See Magnesia.

This salt besides being found in the springs of Epsom, exists in sea water, and occurs native. When sulphuric acid is poured on magnesia in the dark, considerable light is produced.

SULPHITE OF MAGNESIA.

Experiment 1. If magnesia be suspended in water, and sulphurous acid gas passed through, a salt will be formed which crystallizes in tetrahedrons, called sulphite of magnesia.

Remark. This salt contains 100 acid, 41 base, and 115 water. On exposure to the air it gradually absorbs oxygen, and is converted into sulphate of magnesia.

NITRATE OF MAGNESIA.

Experiment 1. If nitric acid be combined with magnesia, and the compound evaporated, rhomboidal prismatic crystals of nitrate of magnesia will be the result.

Remark. This salt is found in decayed walls. It is very bitter and deliquescent. It is decomposed by sulphuric acid, and nitric acid is disengaged. It contains 100 acid and 47.64 base.

NITRITE OF MAGNESIA.

Rationale. If nitrate of magnesia be exposed to a sufficient heat, the nitrate is converted into the nitrite of magnesia.

OXYMURIATE OF MAGNESIA.

Experiment 1. When oxymuriatic acid gas is passed through magnesia in a dry state, the oxymuriate of magnesia is formed.

HYPER-OXYMURIATE OE MAGNESIA.

Experiment 1. If magnesia diffused in water, be made to come in contact with oxymuriatic acid gas, in the manner before stated, until saturation is completed, the hyper-oxymuriate of magnesia will be formed.

Rationale. The oxymuriatic acid is converted into hyper-oxymuriatic and common muriatic acid, which unite with the magnesia, forming the hyper-oxymuriate and common muriate of magnesia. This salt resembles the hyper-oxymuriate of lime in its properties, and has been recommended for bleaching. It contains 100 acid, 42.80 base and 23.83 water.

ARSENIATE OF MAGNESIA.

Experiment 1. When arsenic acid is combined with magnesia, to saturation, arseniate of magnesia will be formed.

Remark. This salt does not crystallize, but may be obtained in a gummy mass. If charcoal powder be mixed with this salt and exposed to heat, carbonic acid is formed, and arsenic re-produced.

ARSENITE OF MAGNESIA.

Experiment 1. When arsenious acid is united with magnesia, the arsenite of magnesia is formed.

Remark. The remainder of the salts of this earth are but little known. They are formed by the union of molybdic, chromic, acetic, benzoic, succinic, camphoric, &c. acids with magnesia, in the manner already noticed.

SECTION II.

SALTS OF LIME.

Experiment 1. If muriatic acid be saturated with lime, muriate of lime will be formed. Or,

Experiment 2. If muriate of ammonia be decomposed by quicklime, by distillation, muriate of lime and ammonia will be formed. See Ammonia.

Remark. On account of the ready solubility of this salt, it is very difficult of crystallization. Its crystals are six sided prisms, terminated by pyramids. It is known by the names of *muriated calx*, *calcareous marine salt*, and *Glauber's fixed sal ammoniac*.

Its taste is very bitter and pungent. At the temperature of 60 degrees water dissolves four times its weight of this salt, and it dissolves any quantity whatever, at the temperature of 100 degrees. Alcohol seems capable of dissolving more than its own weight of this salt.

This salt is deliquescent in the air, is found in mineral waters, but particularly the waters of the sea, to which it contributes to give their bitter taste, and contains 100 acid, 89.8 base, and 99.3 water. It has been used as a re-agent for alkalies, as follows:

Experiment 3. If to muriate of lime carbonate of potash be added, a white precipitate of carbonate of lime is produced.

Experiment 4. If a concentrated solution of muriate of lime be mixed with sulphuric acid, a solid precipitate will be formed.

Rationale. The sulphuric acid unites with the lime into a sulphate of lime, or artificial gypsum, and the muriatic acid is disengaged.

Experiment 5. If muriate of lime be dissolved in alcohol, and the solution inflamed, it will burn of a lively red.

Experiment 6. If muriate of lime be fused, the *phosphorus of Homberg* will be prepared. See Light.

FLUATE OF LIME.

Experiment 1. When fluoric acid is combined with lime, fluate of lime will be the result.

Experiment 2. If sulphuric acid be added to this artificial fluate, fluoric acid will be disengaged as with the natural fluate.

Remark. Fluate of lime, as it occurs native, is known by the names of *fluor spar* and *Derbyshire spar.* It is found crystallized in cubes, sometimes in octahedrons. Its specific gravity is 3.15. When heated it decrepitates, and becomes phosphorescent. It melts in a strong heat, into a transparent glass. It contains 32 2-3 acid, and 67 1-3 lime.

BORATE OF LIME.

Experiment 1. If boracic acid be combined with lime, a compound, called borate of lime, will be produced.

Remark. This salt is a white powder. It is found native, and known to mineralogists by the name of *boracite.* The boracite of Luneberg is crystallized. It cuts glass, and strikes fire with steel.

PHOSPHATE OF LIME.

Experiment 1. If bones be calcined, dissolved in muriatic acid, and precipitated by ammonia, phosphate of lime will be obtained.

Rationale. The impure phosphate of lime is dissolved in the muriatic acid, and the phosphate is separated in a pure state by the addition of ammonia.

Remark. This salt constitutes the bases of bones. It occurs native, crystallized in six sided prisms, and is known by the name of *apatite.*

Prepared as above mentioned, it is in the state of a white powder, having no taste. It contains 100 acid, and 81 base.

Experiment 2. If sulphuric acid be added to phosphate of lime, the super-phosphate of lime will be formed.

Rationale. The sulphuric acid unites with a portion of the lime, forming sulphate of lime, and disengages a part of the phosphoric acid, which, by combining with the remaining phosphate, forms the super-phosphate of lime.

PHOSPHITE OF MAGNESIA.

Experiment 1. If phosphorus acid be saturated with lime, phosphite of lime will result; and,

Experiment 2. If this compound be dissolved in phosphorus acid, a salt with an excess of base, called the super-phosphite of lime, which crystallizes in prisms, will be formed.

CARBONATE OF LIME.

Experiment 1. If lime be suffered to come in contact with carbonic acid, whether in solution, or in the state of gas, carbonate of lime will be formed.

Remark. The different *marbles*, *chalks*, *limestone*, *calcareous spar*, &c. are combinations of lime and carbonic acid. Carbonate of lime crystallizes in rhomboidal prisms, with angles of 101½ degrees and 78½ degrees; and no less than six hundred and sixteen different varieties of form have been observed and described.

Carbonate of lime is insoluble in water, but soluble in small proportion by means of carbonic acid. It contains about 100 acid, and 122 base.

Experiment 2. If carbonate of lime be exposed to a strong heat, carbonic acid will be disengaged, and quicklime produced. See Lime.

Experiment 3. If sulphuric, nitric, or muriatic acid be poured on carbonate of lime, carbonic acid gas will be disengaged. See Carbonic Acid Gas.

SULPHATE OF LIME.

Experiment 1. If sulphuric acid diluted with water, be added to lime, a compound called sulphate of lime, will be formed.

Remark. This salt is found native, and occurs crystallized in octahedrons, six sided prisms, and in lenses. It is usually amorphous, and constitutes the plaster of Paris, gypsum, or selenite. Sulphate of lime dissolves in 460 parts of cold water. It also dissolves in sulphuric acid.

Experiment 2. If gypsum be exposed to fire, it is reduced to a white powder, called *burnt gypsum* or calcined plaster of Paris.

Rationale. The action of heat separates the water contained in gypsum: in this state it speedily combines with that fluid, forming a paste, which soon hardens, and is therefore employed as a mortar, and for stucco work. Sulphate of lime consists of 100 acid, 76.70 base, and 55.8 water.

SULPHITE OF LIME.

Experiment 1. If sulphurous acid be saturated with lime, sulphite of lime will be produced.

Remark. As a neutral sulphate, this salt is in the form of a white powder; if an excess of acid be added it crystallizes in six sided prisms, terminated by six sided pyramids. It contains 100 acid, 97.9 base, and 10.5 water.

NITRATE OF LIME.

Experiment 1. When nitric acid is combined with lime, nitrate of lime is the result, which, when evaporated, yields crystals in six sided prisms terminated by long pyramids.

Remark. This salt is soluble in water and in alcohol. It is very deliquescent. It contains 100 acid, 55.70 base, and 18.7 water. This salt, called also *nitrous selenite* and *calcareous nitre*, is found in calcareous stones, caves, and dissolved in water. It is formed near inhabited places, and is yielded by the lixivation of old plaster, and by the mother waters of salt petre, as they are termed by the manufacturers. It is this salt, principally, which occurs in abundance in the nitre caves of the Western United States, that afford saltpetre.

Experiment 2. If to a solution of nitrate of lime, potash be addded, nitrate of potash will be formed, and remain in solution.

Rationale. The nitric acid unites with the potash, forming nitrate of potash, and the lime is precipitated. See Nitrate of Potash.

Experiment 3. If nitrate of lime be fused in a crucible, and then exposed for some time to heat, it becomes phosphorescent, forming *Baldwin's phosphorus.* See Light.

Experiment 4. Nitrate of lime dissolved in alcohol, imparts to its flame a red colour.

Experiment 5. When sulphuric acid is added to this salt, the nitric acid is disengaged as in nitrate of potash, leaving a sulphate of lime.

ARSENIATE OF LIME.

Experiment 1. If arsenic acid be united with lime, the arseniate of lime will be the result.

ARSENITE OF LIME.

Experiment 1. If arsenious acid and lime be united by digesting them together, the result is arsenite of lime.

MOLYBDATE OF LIME.

Experiment 1. When molybdic acid is added to lime, a compound is formed called molybdate of lime, which exists in the form of a white powder.

OXALATE OF LIME.

Experiment 1. If oxalic acid or oxalate of potash be dropped into lime water, the oxalate of lime will be precipitated. See Oxalic Acid. This salt contains 100 acid and 60 base.

KINATE OF LIME.

Experiment 1. If yellow Peruvian bark be macerated in water, and the solution evaporated, kinate of lime will be formed.

Remark. This salt is white, crystallizes in rhomboidal plates, and is soluble in water and alcohol.

MALATE OF LIME.

Experiment 1. If malic acid be saturated with lime, malate of lime, which is almost insoluble, will be produced: but,

Experiment 2. If an excess of acid be used, the result is a super-salt, which is soluble in water, and is common in the vegetable kingdom.

Remark. The remainder of the salts of lime, such as the citrate, camphorate, &c. are but imperfectly known.

SECTION III.

SALTS OF BARYTES.

MURIATE OF BARYTES.

Experiment 1. If muriatic acid be saturated with barytes, the muriate of this earth will be formed. Or,

Experiment 2. If sulphate of barytes and charcoal be exposed in a crucible to the action of heat for five or six hours, the residue then dissolved in muriatic acid, and the solution filtered and evaporated, muriate of barytes will be produced. Or,

Experiment 3. If sulphate of barytes and carbonate of potash be mixed, and boiled with water, carbonate of barytes will result; decant the supernatent fluid, and dissolve the residue in muriatic acid, and muriate of barytes will be formed.

Rationale. In Experiment 1, a direct union of muriatic acid and barytes takes place; in Experiment 2, the sulphate of barytes is converted into a sulphuret, the charcoal disengaging the oxygen from the sulphuric acid, and the sulphuret is decomposed by the muriatic acid, sulphuretted hydrogen gas being evolved; in Experiment 3, the sulphate is decomposed by the carbonate of potash, and the carbonate of barytes thus formed being treated with muriatic acid, is converted into muriate of barytes.

Remark. This salt crystallizes in four sided prisms, whose bases are squares; but it is obtained more commonly in tables.

Experiment 4. If muriate of barytes be dissolved in alcohol, the solution will burn of a red colour.

Experiment 5. If sulphate of soda, or any of the soluble sulphates, be added to muriate of barytes, a white precipitate will be obtained. Or,

Experiment 6. If sulphuric acid be poured into muriate of barytes, the same effect will take place.

Rationale. The sulphuric acid of the sulphate, or the sulphuric acid uncombined causes a precipitate in consequence of the strong affinity which it has for barytes, with which it forms sulphate of barytes. This salt has therefore been employed as a test for sulphuric acid. Muriate of barytes contains 100 acid, 314.5 base, and 87 water. Every hundred grains of sulphate of barytes, formed in the above experiments, indicate 24 of sulphuric acid.

FLUATE OF BARYTES.

Experiment 1. If barytes be added to fluoric acid, fluate of barytes will result. Or,

Experiment 2. If fluate of potash be added to muriate of barytes, the same compound will be formed.

Rationale. The fluoric acid of the fluate of potash unites with the barytes, whilst the muriatic acid of the muriate of barytes combines with the potash; the former is precipitated, and the latter remains in solution.

BORATE OF BARYTES.

Experiment 1. When boracic acid is united with barytes, a compound is formed called borate of barytes, a salt but little known.

PHOSPHATE OF BARYTES.

Experiment 1. If muriate of barytes be added to phosphate of soda, the phosphate of barytes will be precipitated.

Rationale. The muriate of barytes is decomposed by the phosphate of soda by double affinity; phosphate of barytes is gradually precipitated, and muriate of soda remains in solution. Or,

Experiment 2. If barytes be dissolved in phosphoric acid, the result will be phosphate of barytes.

Remark. This salt contains 100 acid, and 222 base.

PHOSPHITE OF BARYTES.

Experiment 1. If barytes be added to phosphorous acid, the result is a salt called phosphite of barytes.

Experiment 2. If the product of Experiment 1, be supersaturated with phosphorous acid, a compound readily soluble in water will be formed.

CARBONATE OF BARYTES.

Experiment 1. If to barytic water, water holding carbonic acid in solution be added, a white precipitate will be formed, called carbonate of barytes.

Rationale. The carbonic acid unites with the barytes, forming a carbonate, which contains about 100 acid and 354.5 base.

Experiment 2. If a mixture of sulphate of barytes and carbonate of potash be boiled in water, the same product will be obtained.

Rationale. The sulphuric acid of the sulphate unites with the potash into a sulphate of potash, and the carbonic acid of the carbonate combines with the barytes, forming carbonate of barytes.

Remark. The combination of barytes with carbonic acid is tasteless, almost insoluble in water, but is decomposed by heat and by all the acids. It is found native, and is known by the names of barolite, witherite, &c. It crystallizes in double six sided and four sided pyramids. It is a deadly poison. Specific gravity 4.3 to 4.33. See Barytes.

SULPHATE OF BARYTES.

Experiment 1. If sulphuric acid be added to muriate of barytes, a white precipitate will be produced, which is sulphate of byrytes. See Muriate of Barytes.

Remark. This compound occurs native, and is known by the names of *ponderous spar*, *heavy spar*, *baroselenite*, *cawk*, &c. It is found crystallized in tables with bevilled edges, in four sided prisms, &c. It is tasteless, insoluble in water, but soluble in hot sulphuric acid, and is decomposed by charcoal in a red heat. In a violent heat it vitrifies. The *Bolognian phosphorus* is prepared by calcining this stone. See Barytes.

The sulphate contains 100 acid, and 151 base.

NITRATE OF BARYTES.

Experiment 1. If barytes be dissolved in nitric acid, the nitrate of this earth will be formed, which if evaporated, will yield crystals in regular octahedrons, or in small plates.

Remark. This salt is soluble in about 12 parts of cold water. It decrepitates on burning coals. It is decomposed by sulphuric acid.

Experiment 2. If sulphuric acid be added to nitrate of barytes, sulphate of barytes will be precipitated, the same as with muriate of barytes.

Experiment 3. If the dry nitrate be exposed in a crucible to a violent heat, the nitric acid will be disengaged, leaving the barytes in a pure state. See Barytes.

Experiment 4. If the nitrate be dissolved in alcohol, it will give it the property of burning with a whitish yellow flame.

Remark. Nitrate of barytes is composed of 100 acid, 178.12 base, and 34.3 water.

OXYMURIATE OF BARYTES.

Experiment 1. If barytes, in a dry state, be combined with oxymuriatic acid, by suffering the gas to pass through it, oxymuriate of barytes will result.

HYPER OXYMURIATE OF BARYTES.

Experiment 2. If barytes be dissolved in water, and oxymuriatic acid gas passed through the solution, a salt will be formed called hyper-oxymuriate of barytes.

Rationale. The same as the other hyper-oxymuriates.

Remark. This salt is soluble in four parts of cold water, and contains 100 acid, 89.78 base and 22.98 water.

ARSENIATE OF BARYTES.

Experiment 1. If arsenic acid be combined with barytes, the result is arseniate of barytes, a compound insoluble in water.

ARSENITE OF BARYTES.

Experiment 1. If a solution of arsenious acid in water, be added to barytic water, a union of the two will take place, and arsenite of barytes in the form of a white powder will precipitate.

ACETATE OF BARYTES.

Experiment 1. If carbonate of barytes be dissolved in acetic acid, and the solution evaporated, crystals of acetate of barytes in the form of fine prismatic needles will be produced.

Remark. This salt is also used as a reagent for sulphuric acid. Its taste is bitter. It is very soluble. It contains 100 acid, and 165.72 base. It may be obtained from the muriate of barytes by double decomposition, in the following manner:

Experiment 1. Make a solution of acetate of lead, and add to it muriate of barytes till no further precipitate is formed; separate the precipitate, which is muriate of lead, and evaporate the fluid.

Remark. The remainder of the salts of barytes have been but imperfectly investigated.

SECTION IV.

SALTS OF STRONTIAN.

MURIATE OF STRONTIAN.

Experiment 1. When strontian or its carbonate is dissolved in muriatic acid, the result is muriate of strontian. Or,

Experiment 2. If sulphate of strontian, or celestine be treated with charcoal in a crucible in the same manner as sulphate of barytes, and the residue dissolved in muriatic acid, the same compound will be formed.

Remark. This salt crystallizes in long slender hexagonal prisms. It is very soluble in boiling water. It contains 100 acid, 216.2 base and 223 water.

BORATE OF STRONTIAN.

Experiment 1. When boracic acid is combined with strontian, the result is borate of strontian, which is a white powder.

PHOSPHATE OF STRONTIAN.

Experiment 1. If strontian be united with phosphoric acid, phosphate of strontian will be produced.

Remark. This is a white powder containing 100 acid, and 135.7 base. It is insoluble in water, but soluble in phosphoric acid.

CARBONATE OF STRONTIAN.

Experiment 1. If muriate of strontian be treated with an alkaline carbonate, or strontian combined with carbonic acid in any other manner, the salt called carbonate of strontian will result.

Remark. This compound occurs native, and is known by the name of *strontianite*. It is usually in semi-transparent striated masses, with a greenish tinge. When violently heated it loses its carbonic acid. See Strontian. It contains 100 acid and 231 base.

SULPHATE OF STRONTIAN.

Experiment 1. If sulphuric acid be added to a solution of strontian, a precipitate will be obtained called sulphate of strontian.

Remark. This compound occurs native, and, being generally of a blue colour, is known by the name of *celestine*. It is crystallized in rhomboidal prisms. It is soluble in hot sulphuric acid. It is composed of 100 acid, and 138 base.

NITRATE OF STRONTIAN.

Experiment 1. If strontian be dissolved in nitric acid, and the solution evaporated, octahedral crystals of nitrate of strontian may be obtained.

Remark. This salt is very soluble in hot water. It deflagates on hot coals. Sulphuric acid disengages the nitric acid from it, and converts it into sulphate of strontian. At a red heat it parts with its acid, leaving the strontian in its pure state. See Strontian. It contains 100 acid 116.86 base, and 105.3 water.

HYPER-OXYMURIATE OF STRONTIAN.

Experiment 1. If strontian be treated in the same manner as lime, by passing a current of oxymuriatic acid gas through it when diffused in water, a compound called hyper-oxymuriate of strontian will be formed.

Remark. This salt crystallizes in needles, deliquesces, and is soluble in alcohol. It contains 100 acid, 56.52 base, and 60.87 water.

ACETATE OF STRONTIAN.

Experiment 1. When strontian or its carbonate is dissolved in acetic acid, and the solution evaporated, crystals of acetate of strontian will be formed.

Remark. This salt contains 100 acid, and 89.80 base.

The remaining salts of this earth are but little known.

SECTION V.

SALTS OF ALUMINA.

MURIATE OF ALUMINA.

Experiment 1. If alumina be added to muriatic acid, a salt will be formed which exists always in the state of a super-muriate, called muriate of alumina.

Remark. Muriate of alumina hardly crystallizes, being always either gelatinous, or in the state of a white mass. It is very soluble both in water and alcohol. It is very deliquescent. It contains 100 acid, 100 base, and 135 water.

FLUATE OF ALUMINA.

Experiment 1. When alumina is added to fluoric acid, a salt called fluate of alumina is obtained, which does not crystallize, but is easily obtained in the state of a jelly.

Remark. The mineral called *cryolite* is a fluate of alumina and soda. It is composed of 40 acid and soda, 36 water, and 24 alumina.

BORATE OF ALUMINA.

Experiment 1. Boracic acid saturated with alumina, constitutes borate of alumina, which is scarcely soluble, and not crystallizable.

PHOSPHATE OF ALUMINA.

Experiment 1. Phosphoric acid added to alumina, combines with it, and forms phosphate of alumina.

Remark. This is a white powder, tasteless and insoluble in water, and contains 100 acid and 53.6 base.

PHOSPHITE OF ALUMINA.

Experiment 1. When phosphorus acid is treated with alumina, the result is phosphite of alumina.

Remark. This salt does not crystallize.

CARBONATE OF ALUMINA.

Experiment 1. When super-sulphate of alumina and potash (alum) is decomposed by carbonate of potash, a precipitate is formed, which is the carbonate or rather sub-carbonate of alumina.

Rationale. The sulphuric acid unites with the potash, forming sulphate of potash, which remains in solution, and the carbonic acid unites with the alumina, into a sub-carbonate.

Remark. According to Saussure carbonate of alumina cannot exist in a dry state.

ALUM.

Experiment 1. If alumina be dissolved in sulphuric acid, so that the acid may be in excess, and afterwards a small quantity of potash added, and the solution then evaporated, crystals of super-sulphate of alumina and potash will be formed.

Experiment 2. If pyritous clay, or pyritous schist, be calcined, and then lixivated with water to which a small quantity of ley is added, and the solution then evaporated, crystals of the same salt will result.

Rationale. Alum is a super-salt, which is formed in every case in which alumina combines with sulphuric acid. Hence it is, that in the one experiment sulphuric acid unites directly with alumina, and in the second it is formed by the decomposition of the pyrites: the conversion of the sulphur into sulphuric acid, as well as the combination of that acid with alumina (furnished by the schist or clay) and afterwards with a portion of alkali, is essential to the formation of alum.

Remark. Alum is a triple salt, of which there are several varieties, viz. sulphate of alumina and potash, sulphate of alumina and ammonia, super-sulphate of alumina and potash, and super-sulphate of alumina and ammonia. The two first have been called *alum saturated with its earth*, or aluminated alum, and the two last constitute the alum of commerce. Alum is obtained principally from schistose clays, which contain iron pyrites, by roasting, exposure, lixivation, the addition of potash ley, and crystallization. The roasting destroys the bituminous matters these clays commonly contain, which also, together with exposure to the air, acidifies the sulphur, and the other operations are employed as before noticed.

Alum crystallizes in regular octahedrons, whose sides are equilateral triangles. It has a sweetish but very astringent taste. It is soluble in 15 times its weight of water at 60; and in three fourths of its weight at 112. It reddens vegetable blues. It effloresces slightly in the air. By the action of heat it first undergoes the watery fusion, then loses its water of crystallization, and lastly great part of its acid. It is then called burnt alum. It is decomposed by barytes, potash, soda, strontian, and all salts of which these are the bases; by the nitrate, muriate, phosphate, and carbonate of magnesia, and by the nitrate, muriate, and carbonate of lime. It is also decomposed by the gallic acid, by colouring matter, and by many animal and vegetable substances, in a manner not yet sufficiently understood. It commonly consists according to Vauquelin of 49 sulphate of alumina, 7 sulphate of potash, and 44 water.

Experiment 3. If alumina be boiled in a solution of alum, the neutral sulphate of alumina will be formed.

Remark. As this sulphate contains no acid in excess, it is obvious that the addition of alumina combines with the super-abundant acid. The compound thus formed is tasteless, insoluble in water, and not altered by exposure to the air. It constitutes two of the varieties of alum before mentioned. See Alumina.

SULPHITE OF ALUMINA.

Experiment 1. If alumina be suspended in water and sulphurous acid gas passed through it, a compound called sulphite of alumina will result.

Remark. This salt is in the state of a white powder, and has an earthy and sulphurous taste. When exposed to the air it absorbs oxygen, and is converted into sulphate of alumina. It contains 100 acid, 137.5 base, and 75 water.

NITRATE OF ALUMINA.

Experiment 1. When nitric acid is combined with alumina, a salt is formed called nitrate of alumina.

Remark. This salt crystallizes with difficulty, has an acid and astringent taste, is very soluble in water, deliquesces in the air, is readily decomposable by heat, and forms, when evaporated, a gummy mass of the consistence of honey.

ARSENIATE OF ALUMINA.

Experiment 1. When arsenic acid comes in contact with alumina, a white insoluble powder, called arseniate of alumina is formed.

ACETATE OF ALUMINA.

Experiment 1. If super-sulphate of alumina and potash be dissolved in water, and a like quantity of acetate of lead, also in solution, be added, the mixture then filtered, and the clear liquor evaporated, crystals of acetate of alumina will be formed.

Rationale. The super-sulphate and the acetate mutually decompose each other; sulphate of lead is formed, which precipitates, and acetate of alumina remains in solution.

Experiment 2. If alumina be dissolved in acetic acid, the same compound will be formed.

Remark. This salt is important in the arts. See Alumina. It contains 100 acid, and 35.48 base. The remaining salts of this earth are not much known.

SECTION VI.

SALTS OF YTTRIA.

With respect to the salts of yttria, in consequence of the scarcity of this earth, we may remark, that the compounds which it forms with acids are so little known, that we deem it unnecessary to enlarge on them in this place. The facts respecting this earth, with some general remarks on its combinations, may be seen in Vol. I.

SECTION VII.

SALTS OF GLUCINA.

Owing also to the scarcity of this earth, its combinations with acids are but imperfectly known to chemists. Some observations on these compounds may be seen in Vol. I. under Glucina.

SECTION VIII.

SALTS OF ZIRCONIA.

Zirconia, like the two preceding, enters into combination with acids, forming salts; but as they have not been much attended to, for the reasons already given we defer treating of them, and refer the reader for general remarks to Vol. I. where this earth is noticed.

DIVISON III.

OF METALLIC SALTS.

SECTION I.

SALTS OF GOLD.

MURIATE OF GOLD.

Experiment 1. If gold be dissolved in nitro-muriatic acid, composed of one part of nitric and four parts muriatic acid, and the solution evaporated, crystals of muriate of gold will be produced.

Rationale. The gold is first oxydized, and the oxyd is then taken up by the muriatic acid forming muriate of gold.

Remark. The solution of gold has a yellow colour. It tinges the skin of an indelible purple. It is soluble in ether and alcohol, as well as in water. The metals generally, precipitate the gold either in the state of metal or oxyd. Hydrogen, phosphorus and sulphureous acid produce the same effect by depriving the gold of its oxygen. The muriate crystallizes in four sided prisms or turcated octahedrons. It is very deliquescent. Muriate of tin precipitates a beautiful powder, called *purple, of cassius.* According to Proust, this powder contains three parts of the oxyd of tin, and one part of gold in the metallic state. See Gold.

NITRATE OF GOLD.

Experiment 1. If nitric acid holding a large quantity of nitrous gas in solution, be digested a long time on gold, a solution of an orange colour will be formed, called nitrate of gold.

Rationale. The gold is gradually oxydized, and the oxyd is then dissolved, forming nitrate of gold.

Remark. The following appearance characterize the salts of gold:

Experiment 2. If triple prussiate of potash be added to the muriate of gold, a white precipitate will be formed.

Experiment 3. Infusion of nut galls added in like manner, strikes a green colour, and occasions a brown precipitate, which is gold reduced.

Experiment 4. A plate of tin immersed into a solution of gold, or muriate of tin added as before, produces a purple precipitate.

Experiment 5. If a solution of sulphate of iron be added, the gold will be precipitated in the metallic state. For the *rationale*, &c. see Gold.

SECTION II.

SALTS OF PLATINUM.

NITRATE OF PLATINUM.

Experiment 1. If nitric acid be poured on platinum, the metal will remain unaltered; but,

Experiment 2. If the per oxyd of platinum be used, the nitrate of platinum will be formed.

MURIATE OF PLATINUM.

Experiment 1. If platinum be digested in muriatic acid, no effect will take place; but,

Experiment 2. If platinum be added to nitro-muriatic acid, and heat applied, a solution of the metal will ensue; and,

Experiment 3. If this be evaporated, small irregular crystals of muriate of platinum will be formed.

Remark. This salt has a metallic taste, is decomposed by heat, and the oxyd is reduced to the metallic state. The other salts of this metal have been but imperfectly examined.

Experiment 3. If a solution of potash be poured into another of platinum, a precipitate will be formed-being a triple compound of muriate of platinum and potash.

Experiment 4. If ammonia be added in like manner, the same effect will ensue, forming muriate of platinum and ammonia. See Platinum.

Remark. Platinum is known by the following properties:

Experiment 5. If prussiate of potash be added, no precipitate will be formed.

Experiment 6. If infusion of nut galls be used, no effect will ensue; but,

Experiment 7. If muriate of ammonia be added, a yellow coloured precipitate will be formed. See Platinum.

SECTION III.

SALTS OF SILVER.

NITRATE OF SILVER.

Experiment 1. When silver is dissolved in nitric acid, and the solution concentrated by evaporation, crystals in the form of thin plates, of oxynitrate of silver will result.

Rationale. The silver is oxydized by the nitric acid, nitrous gas is disengaged, and oxynitrate of silver is produced.

Experiment 2. If the crystals of oxynitrate of silver be fused, and poured into moulds, so as to form small cylinders, the *lunar caustic* of the surgeons will be formed.

Experiment 3. If metallic silver be boiled in a saturated solution of the oxynitrate, a pale yellow coloured liquid is obtained, which contains the nitrate in solution.

Remark. This salt is soluble in water, and is not easily crystallized. On evaporation, it forms into a solid mass.

Experiment 4. If the nitrate be exposed to the air, it will be converted into oxynitrate; or

Experiment 5. If a little nitric acid be put on it, the same effect will take place.

Rationale. In both experiments, the change is owing to the further combination with oxygen, either by absorption from the air, or from the acids, by decomposition.

HYPER-OXYMURIATE OF SILVER.

Experiment 1. If phosphate of silver be boiled in hyper oxymuriate of alumina, a salt will be formed called hyper-oxymuriate of silver.

Rationale. The phosphoric acid passes to the alumina, forming phosphate of alumina, and the hyper-oxymuriatic acid unites with the oxyd of silver.

Remark. This salt crystallizes in small rhomboids. It is readily soluble in water as well as in alcohol.

Experiment 2. If this salt be exposed to a moderate heat, oxygen gas is given out, and muriate of silver remains.

Rationale. The hyper-oxymuriate is, therefore, decomposed; oxygen is given out, by which the hyper-oxymuriate is changed into the muriate.

Experiment 3. If this salt be mixed with sulphur, and smartly struck with a hammer upon an anvil, a loud detonation will follow.

Remark. This is explained in the same manner as the detonation of hyper-oxymuriate of potash with sulphur.

MURIATE OF SILVER.

Experiment 1. If to a solution of silver in nitric acid, muriatic acid be added, a white precipitate will be produced, which is muriate of silver. Or,

Experiment 2. If common salt be added, the same effect will take place.

Rationale. In the first experiment the muriatic acid unites with the silver by virtue of simple affinity; in the second the muriate is produced by double decomposition, nitrate of soda remains in solution, and muriate of silver is precipitated.

Remark. This precipitate is at first white, but it soon blackens when exposed to the air. It dissolves in ammonia, and is likewise soluble in muriatic acid, and by that means may be obtained in octahedral crystals. It is composed of 18 acid, and 82 per oxyd of silver. One hundred parts of dry muriate of silver contains 75.6 parts of pure silver.

Experiment 3. If muriate of silver be heated to about 500°, it melts into a gray coloured semi-transparent mass like horn, and formerly called *luna cornea.*

Experiment 4. If muriate of silver be introduced into a crucible with soda or potash, and exposed to a sufficient heat, it will be decomposed.

Rationale. The muriatic acid passes to the alkali, forming either muriate of soda or muriate of potash, and the silver is separated. See Silver.

SULPHATE OF SILVER.

Experiment 1. If silver be boiled in sulphuric acid, a white mass is obtained called sulphate of silver; or,

Experiment 2. If oxynitrate of silver be treated with sulphuric acid, the same compound will be formed. And,

Experiment 3. If the sulphate thus obtained be agitated in water, it is decomposed into sub-sulphate, which is insoluble, and oxysulphate of silver, which remains in solution.

Rationale. In the first experiment, the sulphuric acid is decomposed, sulphurous acid gas is disengaged, and the silver is oxydized, which combines with the remaining acid into a sulphate of silver. In the second experiment the oxynitrate is decomposed, nitric acid is disengaged, and sulphate of silver is formed. In the third experiment the sulphate is converted into sub-sulphate and oxysulphate, and the latter is taken up by the water.

Experiment 4. If sulphate of silver be dissolved in sulphuric acid on evaporation it will yield small prismatic crystals.

Remark. The super sulphate, as it may be called, is soluble in 87 parts of water. It is composed of about 17.4 acid, and 82.6 per oxyd of silver.

SULPHITE OF SILVER.

Experiment 1. If sulphite of ammonia be mixed with nitrate of silver, a white precipitate will be obtained called sulphite of silver.

Rationale. The nitric acid quits the silver and unites with the ammonia, and the sulphurous acid combines with silver, into a sulphite of silver.

Remark. This salt is scarcely soluble in water, and possesses an acrid metallic taste. It becomes brown when exposed to the light, and when heated it is decomposed, and the silver reduced. The following constitute the remaining salts of silver, which are but little known, viz: phosphate of silver, a white powder insoluble in water, but soluble in nitric acid; carbonate of silver, a white insoluble powder, fluate of silver, also insoluble; borate of silver possessing the same property; acetate of silver, crystallizable in small prisms and easily soluble in water; benzoate of silver, a soluble salt; succinate of silver crystallizable in thin oblong radiated prisms; and tartrate, citrate, saccolate, mallate, arseniate, chromate, and molybdate of silver; all formed by the combination of the several acids with this metal.

The salts of silver are, for the most part, characterized by the following properties:

Experiment 2. When they are exposed to the action of the blow pipe on charcoal, a globule of silver is obtained.

Experiment 3. If muriatic acid or a muriate be added to their solution, a white precipitate is obtained, which becomes black when exposed to the light

Experiment 4. If prussiate of potash be added, a white precipitate will be produced.

Experiment 5. If hydrosulphuret of potash be used, a precipitate of a black colour will result.

SECTION IV.

SALTS OF MERCURY.

NITRATE OF MERCURY.

Experiment 1. If mercury be dissolved in diluted nitric acid, without the assistance of heat, and the solution concentrated by evaporation, it will form into crystals, called nitrate of mercury

Remark. The crystals are octahedrons having their angels truncated. Sulphuretted hydrogen passed through the solution of this salt, reduces the mercury, which separates in combination with sulphur. Muriate of tin also decomposes it.

Experiment 2. If mercury be dissolved in nitric acid with the assistance of heat, provided an excess of mercury be not present, the oxy-nitrate of mercury will be formed.

Experiment 3. If to this solution or dry salt, water be added, a white or yellow powder will separate, which is a sub-oxynitrate of mercury.

Experiment 4. If the nitrate or oxynitrate of mercury be exposed to a strong heat in a crucible, for some hours, it will be changed into the sub-oxynitrate of mercury, commonly called *red precipitate*, and *oxyd of mercury*. See Mercury.

HYPER-OXYMURIATE OF MERCURY.

Experiment 1. If a current of oxymuriatic acid be passed through water, in which red oxyd of mercury is diffused, the oxyd will be dissolved, and afford on evaporation crystals of oxymuriate and hyper-oxymuriate of mercury.

MURIATE OF MERCURY.

Experiment 1. If red oxyd of mercury be dissolved in muriatic acid, the solution will yield on evaporation oxymuriate, or corrosive muriate of mercury, commonly called corrosive sublimate. Or,

Experiment 2. If equal weights of dry oxynitrate of mercury, decrepitated muriate of soda, and calcined sulphate of iron be mixed and introduced into a mattrass, to be about one third full, and heated gradually to redness, the same product forming a cake in the upper part of the vessel, will be obtained. Or,

Experiment 3. If about equal parts of dry sulphate of mercury, and decrepitated muriate of soda be mixed and sublimed, the corrosive muriate will be formed. Or,

Experiment 4. If mercury be dissolved in oxymuriatic acid, and the solution concentrated by evaporation, corrosive sublimate will be produced. Or,

Experiment 5. If a mixture of dried sulphate of iron, nitrate of potash, muriate of soda, and mercury be sublimed, the same product will result. Or,

Experiment 6. If sub-nitrate of mercury and muriate of soda be treated in the same manner, corrosive muriate will be prepared.

Rationale. In Experiment 1, we have a direct combination of mercury, oxydized partly to the maximum, with muriatic acid: in Experiment 2, the muriate is formed by double decomposition, the sulphuric acid at a red heat quits the iron, with which it was previously united, and combines with the soda of the muriate forming sulphate of soda, and the muriatic acid thus disengaged combines with the oxyd of mercury into corrosive muriate of mercury, which sublimes: in Experiment 3, a double decomposition also takes place, the sulphuric acid of the sulphate of mercury unites with the soda of the muriate, forming sulphate of soda, whilst the muriatic acid thus evolved combines with the mercury, previously oxydized, and forms muriate of mercury: in Experiment 4, the mercury is first oxydized by the oxygen of the oxymuriatic acid, and the oxyd is then taken up by the remaining acid: in Experiment 5, the sulphuric acid at a red heat decomposes the muriate of soda, as before noticed, and the muriatic acid attaches itself to the oxydized mercury: and in Experiment 6, the sub-nitrate is decomposed by the muriate, nitrate of soda and muriate of mercury being formed.

Experiment 7. If to a solution of corrosive muriate of mercury, lime water be added in sufficient quantity, a yellow coloured precipitate will be obtained, which, being suspended in the fluid, forms *phagædenic water.*

Rationale. The muriatic acid of the muriate unites with the lime, and oxyd of mercury is precipitated. The fluid, therefore, contains muriate of lime and oxyd of mercury.

Remark. Muriate of quicksilver crystallizes by sublimation in prismatic needles, forming a white semi-transparent mass. It is ponderous. Its taste is acrid, styptic, and durable. It is soluble in 20 parts of cold water, and in 2 at 212°. It is also soluble in 3.8 parts of alcohol at 70° and in almost an equal weight of boiling alcohol. It gives a green colour to syrup of violets. It is not altered by exposure to the air, and is sublimed unchanged by heat. It is not decomposed by any of the acids; but is soluble, without alteration, in sulphuric, nitric, and muriatic acids. It is precipitated by all the alkalies and earths of an orange colour, which gradually changes to a brick red, and by their carbonates of a permanent yellow colour. Ammonia forms with it an insoluble white triple salt (*white precipitate of the shops*:) it is also decomposed by several of the metals.

It consists, according to Mr. Chenevix, of

Mercury	69.7	Oxyd of mercury	82
Oxygen	12.3	Muriatic acid	18
			100

And the oxyd, therefore, consists of quicksilver	85
Oxygen	15
	100

See Mercury.

Experiment 8. If four parts of oxymuriate of mercury and three parts of mercury be triturated in a mortar, and the mixture sublimed, sub-muriate of mercury or *calomel* will be produced.

Rationale. When quicksilver is triturated with oxymuriate of mercury, it attracts from the oxydized quicksilver of the muriate a part of its oxygen, and the whole mass assumes a blackish gray colour. On exposure to a sufficient heat, the action of the different portions of quicksilver upon each other, and upon the muriatic acid is still more complete. Consequently, the whole is converted into a white mass consisting of mercury of less oxydizement, and combined with less acid than in the muriate.

Experiment 9. If twenty four ounces of sulphate of mercury, prepared by combining equal parts of sulphuric acid and mercury, be mixed with sixteen ounces of dried muriate of soda, and fourteen ounces of crude mercury, by triturating them in a mortar, and the mixture then sublimed, calomel, or sub-muriate of mercury will be the product.

Rationale. The sulphate of mercury as well as the muriate of soda is decomposed; sulphate of soda is formed, and muriate of mercury is disengaged, which, by combining with the crude mercury, imparts a portion of its oxygen, and unites with it forming sub-muriate or calomel.

Experiment 10. If calomel, thus formed, be levigated in a mortar, and washed till the water comes off tasteless, and does not occasion a yellow precipitate with lime water, the *prepared calomel* of the Dispensatories will be formed.

Remark. The *washing of calomel* is in order to free it of sublimate which, in its crude state, it is apt to contain.

Experiment 11. If six and a half ounces of mercury be dissolved in six ounces of diluted nitrous acid, with a moderate heat, and the solution then poured off from the quicksilver remaining undissolved, and mixed with ten pounds of boiling water in which four ounces of muriate of soda have been previously dissolved, a white precipitate will be obtained, which when collected, washed, and dried is the *precipitated* submuriate of mercury or calomel.

Rationale A solution of mercury in nitric acid with an excess of mercury is formed in the first part of the process, and the nitrate is then decomposed by muriate of soda; nitrate of soda is produced, which remains in solution, and sub-muriate of mercury is precipitated.

Remark. As water possesses the property of precipitating sub-nitrate of mercury, Mr. Chenevix supposes, that calomel prepared in this way is a mixture of sub-muriate and sub-nitrate of quicksilver. To remedy this defect he proposes using nitrate of mercury prepared without heat, or to add to the solution of muriate of soda a quantity of muriatic acid. It is contended, that if the solution of nitrate of mercury be poured into that of the muriate of soda, no sub-nitrate is formed.

Calomel is a dull white mass, which becomes yellowish when reduced to powder. When slowly sublimed, it crystallizes in four sided prisms terminated by pyramids. Its specific gravity is 7.1758. It is insoluble in water. It is tasteless. When rubbed in the dark it phosphoresces. It requires a higher temperature to sublime it than oxymuriate of mercury. Oxymuriatic acid, and nitric acid converts it into oxymuriate. It is composed of about eleven acid and eighty-nine prot-oxyd of mercury.

MURIATE OF MERCURY AND AMMONIA.

Experiment 1. If equal weights of muriated quicksilver, and sal ammoniac be mixed in solution, a triple salt is formed called muriate of mercury and ammonia, or sal alembroth of the alchymists.

Rationale. When to a solution of muriate of ammonia there is added muriate of mercury, about thirty times more of the latter is dissolved than the same quantity of pure water is capable of dissolving, and a change of temperature ensues; consequently a combination takes place, and a triple muriate is produced.

Experiment 2. If to the mixed solution of Experiment 1, there be added another of carbonate of potash, a precipitate of sub-muriate of mercury and ammonia, or white precipitate of the shops will be formed.

Rationale. When to a solution of sal alembroth or muriate of mercury and ammonia, carbonate of potash is added, there occurs a partial decomposition; for the alkali combines with a portion of the muriatic acid, and reduces the muriate of mercury and ammonia to the state of a sub-muriate, which being insoluble, falls to the bottom of the solution.

Remark. This combination consists of 31 oxyd of mercury, 16 muriatic acid, and three ammonia.

SULPHATE OF MERCURY.

Experiment 1. If sulphuric acid diluted with its own weight of water be boiled over mercury, and the solution evaporated, sulphate of mercury will be obtained in small prismatic crystals.

Rationale. The sulphuric acid in part is decomposed; its oxygen oxydizes the mercury, whilst the undecomposed acid combines with the mercury into a sulphate of mercury readily soluble in water.

Experiment 2. If to the solution of sulphate of mercury potash be added, a dark coloured precipitate of sub-sulphate will be obtained.

Rationale. The alkali unites with the greater part of the acid, forming sulphate of potash, and oxyd of mercury is precipitated in combination with a portion of acid in the state of sub-sulphate.

Remark. This salt contains 12 acid, 83 prot oxyd of mercury, and 5 water.

Experiment 3. When three parts of sulphuric acid are boiled on two parts of mercury, the whole, by continuing the heat, is converted into oxysulphate of mercury, which crystallizes in small prisms.

Experiment 4. If sulphuric acid in excess be present in the salt, the super-oxysulphate of mercury is formed, which deliquesces in the air.

Experiment 5. If water be poured upon the oxysulphate, it is converted into super-oxysulphate, which dissolves, and sub-oxysulphate, which remains in the state of a beautiful yellow powder, called *turpeth mineral*, which contains 15 acid, and 85 per oxyd.

PHOSPHATE OF MERCURY.

Experiment 1. If the solutions of phosphate of soda and nitrate of mercury be mixed, a white precipitate will be obtained, of phosphate of mercury, containing 28.5 acid, and 71.5 per oxyd.

Rationale. The phosphoric acid unites with the mercury, and the nitric acid combines with the soda.

ACETATE OF MERCURY.

Experiment 1. If acetate of potash be added to nitrate of mercury, acetate of mercury will be produced, which crystallizes in plates of a silvery whiteness.

Rationale. The nitric acid passes to the potash, and the acetic acid to the mercury.

Experiment 2. If red oxyd of mercury be dissolved in acetic acid, a yellow uncrystallizable mass will be obtained, which deliquesces in the air, called oxacetate of mercury.

PRUSSIATE OF MERCURY.

Experiment 1. If red oxyd of mercury and prussian blue be mixed, and boiled in water, prussiate of mercury will result, which crystallizes in four sided prisms, terminated by four sided pyramids.

OXALATE OF MERCURY.

Experiment 1. If a solution of super-oxalate of potash be digested on red oxyd of mercury, the super-oxalate of mercury will be formed.

Rationale. The excess of acid unites with the mercury, by which the oxyd is changed from a red colour, and oxalate of mercury is formed. Or,

Experiment 2. If nitrate of mercury be added to oxalate of potash, oxalate of mercury will be precipitated.

Rationale. The nitric acid unites with the potash, and the oxalic acid with the oxyd of mercury.

Remark. This compound when treated detonates. It constitutes the greater part of Howard's fulminating mercury. See an Essay of the author, on the fulminating compounds of mercury, in Coxe's Medical Museum. See also Mercury.

The remaining salts of this metal are hardly known, viz. the carbonate, fluate, borate, succinate, benzoate, mellate, tartrate, citrate, arseniate, molybdate and chromate of mercury.

The salts of mercury are characterized by the following properties:

1. They are volatilized, when strongly heated.
2. The prussiates occasion a white precipitate.
3. Hydrosulphuret of potash produces a black precipitate; and,
4. Tincture of galls occasions an orange yellow precipitate.

SECTION V.

SALTS OF PALLADIUM.

The salts of this metal are rare: they are soluble in water, and are known by the following characters:

1. Prussiate of potash occasions a dirty brown precipitate; and,
2. Hydrosulphuret of potash and the alkalies an orange yellow precipitate. See Palladium.

SECTION VI.

SALTS OF RHODIUM.

The salts of this metal, like the preceding, are not yet sufficiently known to admit of a particular description. The solution of these salts, however, are red. They are not precipitated by prussiate of potash, hydrosulphuret of potash, sal ammoniac and alkaline salts; but the pure alkalies throw down a yellow powder, soluble in an excess of alkali.

SECTION VII.

SALTS OF IRIDIUM.

The solution of these salts is at first green; but acquires a red colour when concentrated in an open vessel. Prussiate of potash and tincture of galls produce no precipitate, but they render the solutions of this metal colourless.

SECTION VIII.

SALTS OF OSMIUM.

Among the very rare salts we may include those of this metal; although this genera of salts is still unknown, yet there is no doubt but certain combinations may be effected with this metal as with others.

SECTION IX.

SALTS OF COPPER.

NITRATE OF COPPER.

Experiment 1. If copper be dissolved in nitric acid, and the solution evaporated, crystals of nitrate of copper will form in regular parallelopipedes.

Experiment 2. If this salt be exposed to heat, it will liquefy or undergo the watery fusion; and,

Experiment 3. If the heat be continued it is gradually decomposed, the acid is driven off, and the black oxyd of copper remains in a state of purity.

Experiment 4. When placed on burning coals it detonates feebly; but,

Experiment 5. If mixed with phosphorus, and struck on an anvil, a violent detonation is produced.

Experiment 6. If the nitrate be moistened, and wrapt up in tin foil, inflammation will take place. See Caloric.

Remark. The nitrate of copper contains 16 acid, 67 oxyd, and 17 water. See Copper.

HYPER-OXYMURIATE OF COPPER.

Experiment 1. If oxyd of copper be diffused in water, and oxymuriatic acid passed through it, a combination will take place, and produce hyper-oxymuriate of copper.

MURIATE OF COPPER.

Experiment 1. If copper be dissolved in nitro muriatic acid, the solution when evaporated will yield green crystals in the form of rectangular parallelopipedes, of oxymuriate of copper.

Remark. This salt is very acrid and caustic; soluble in water; very deliquescent; decomposable when exposed to heat; and contains 24 acid, 40 per oxyd, and 36 water.

Experiment 2. If copper filings be put into liquid oxymuriate of copper in a well stopped vial, the muriate of copper will result. Or,

Experiment 3. If equal weights of black oxyd of copper, and copper in powder, be dissolved in muriatic acid, in a well stopped phial, the same combination will ensue, which, on evaporation, will afford crystals in regular octahedrons. And,

Experiment 4. If water be added to muriate of copper, a white powder will precipitate, which is submuriate of copper.

Experiment 5. If this powder be exposed to the air, it is changed gradually into oxymuriate of copper.

Remark. This salt contains 24.75 acid, 70.25 prot oxyd, and 5 water. See Copper.

SULPHATE OF COPPER.

Experiment 1. If copper be dissolved in diluted sulphuric acid, the solution, on evaporation, will yield sulphate of copper, commonly called *blue vitriol*, or *blue copperas*.

Remark. Sulphate of copper may be formed in every process in which sulphuric acid is formed and combined with copper, as by the roasting and subsequent solution of sulphuret of copper, or copper pyrites. It crystallizes in oblique parallelopipedes. It is soluble in about four parts of cold water. It is decomposed by heat, leaving the oxyd of copper behind. It reddens vegetable blues, and is, indeed, a supersulphate. The real sulphate crystallizes in four sided prisms, terminated by pyramids. It contains 33 acid, 32 oxyd, and 35 water.

SULPHITE OF COPPER.

Experiment 1. When sulphite of soda, and sulphite of copper are mixed, whitish green crystals of sulphite of copper are deposited.

CARBONATE OF COPPER.

Experiment 1. If to a solution of copper, carbonate of potash be added, an apple green precipitate will be obtained, called carbonate of copper.

Remark. This compound is obtained in this experiment by double decomposition: it occurs native, and is known by the name of *malachite*.

ACETATE OF COPPER.

Experiment 1. If oxyd of copper be dissolved in acetic acid, or in distilled vinegar, the solution on evaporation will crystallize in four sided truncated pyramids, being acetate of copper, called also distilled *verdigrise*, and *crystals of venus*.

Remark. This salt is of a beautiful bluish green colour, has a metallic and nauseous taste, and, like the salts of copper, is deleterious to animal life. It is soluble in water, and in alcohol. It effloresces in the air, and when exposed to heat it yields acetic acid. It contains 61 acid and water, and 39 oxyd of copper.

Experiment 2. When copper plates are corroded by the vapour of vinegar, or by the lees of wine, a substance is obtained called sub-acetate of copper, or *verdigrise.* See Copper.

ARSENITE OF COPPER.

Experiment 1. When to a solution of copper arsenious acid, previously combined with potash, be added, a green powder will be obtained; known by the name of *Scheele's green.* See copper.

Remark. As it respects the other salts of copper, not here enumerated, they are but imperfectly known. They may be found described by Thomson.

Salts of copper are known by the following properties.

1. Ammonia, in excess, produces a deep blue colour.
2. Prussiate of potash occasions a greenish yellow, and sometimes a brownish precipitate.
3. Hydro-sulphuret of potash forms a black precipitate.
4. Gallic acid produces a brown precipitate.
5. A plate of iron or zinc precipitates the copper, in the metallic state.

SECTION X.

SALTS OF IRON.

NITRATE OF IRON.

Experiment 1. If iron filings be dissolved in nitric acid of the specific gravity 1.16, nitrate of iron will be produced.

Experiment 2. If the nitrate be exposed to heat in order to concentrate the solution, it will be converted into oxynitrate of iron, which is of a red colour, and on evaporation will afford crystals in the form of four sided prisms. Or,

Experiment 3. If nitric acid be left on black oxyd of iron, the same compound will be formed.

HYPER-OXYMURIATE OF IRON.

Experiment 1. If a current of oxy-muriatic acid gas, be passed through water, in which red oxyd of iron is suspended, a salt will be formed called hyper-oxymuriate of iron.

MURIATE OF IRON.

Experiment 1. When iron filings is dissolved in muriatic acid, without the contact of the external air, a green fluid will be obtained; which, on evaporation, will afford the same coloured crystals.

Experiment 2. If the muriate of iron, thus produced, be dissolved in alcohol, the *tincture of martis* of the Dispensatories will be produced.

Experiment 3. If a solution of muriate of iron be exposed to nitrous gas, an absorption will take place, forming the eudiometric fluid of Mr. Davy. See Nitric oxyd gas.

Experiment 4. When muriate of iron is exposed to the air, it absorbs oxygen, and is converted into oxymuriate of iron.

Experiment 5. If red oxyd of iron be dissolved in muriatic acid, the product will be oxy-muriate of iron.

Experiment 6. If this solution be exposed to heat, oxy-muriatic acid is given out, and common muriate of iron remains.

Remark. Oxy-muriate of iron has a dark brown colour. The salt does not crystallize, but evaporated to dryness, leaves a yellow coloured mass, which deliquesces, and is soluble in alcohol.

SULPHATE OF IRON.

Experiment 1. If iron be dissolved in diluted sulphuric acid, and the solution evaporated, crystals of sulphate of iron, or *copperas* will be formed.

Remark. This salt was known by the ancients, and is used in the arts. It crystallizes in rhomboidal prisms. It has a very styptic taste, and always reddens vegetable blues. It is soluble in two parts of cold, and in less than its weight of boiling water. It is insoluble in alcohol. When an alkali is poured into a solution of this salt, a white powder precipitates, which is a *sub-sulphate of iron.* When heated it melts and loses its water of crystallization. In a red heat it loses most of its acid, and is converted into a red powder, known by the name of *colcother of vitriol,* and used in polishing metallic bodies. This salt is composed of 26.7 acid, 28.3 base, and 45 water.

Experiment 2. If sulphuret of iron, or iron pyrites be exposed to the air, or roasted in an oven for a sufficient length of time, and afterward lixivated with water the solution will contain sulphate of iron, which on evaporation will leave crystals of *copperas or sal martis.*

Rationale. In every case in which sulphate of iron is formed, a combination of sulphuric acid and iron then takes place. This combination may be effected by dissolving iron in diluted sulphuric acid, as in Experiment 1.; or by treating sulphuret of iron in the manner before mentioned, by which the sulphur is acidified and combined with the iron in the state of sulphate of iron.

Remark. Proust has discovered that the common sulphate of iron contains a green and red sulphate.

Experiment 3. If the green sulphate of iron be mixed and digested with nitric acid, in the proportion of 6 parts to 1, a product will be obtained called oxy-sulphate of iron. Or,

Experiment 4. If the per-oxyd of iron be combined with sulphuric acid, the same compound will be formed.

Remark. Oxy-sulphate of iron is of a yellowish red colour, does not crystallize, and when evaporated to dryness soon attracts moisture and becomes again liquid. As it is formed with the per-oxyd, the intention in using nitric acid in the former experiment, is to furnish oxygen to the metal, by which the maximum of oxydizement is obtained; at the same time nitric oxyd is disengaged.

SULPHITE OF IRON.

Experiment 1. If iron be dissolved in sulphurous acid; the solution, or evaporation, will yield crystals of sulphite of iron.

PHOSPHATE OF IRON.

Experiment 1. If equal parts of phosphate of soda, and sulphate of iron, be mixed together in solution, a blue precipitate will be formed, called phosphate of iron.

Rationale. The sulphuric acid of the sulphate passes to the soda, and the phosphoric acid of the phosphate, unites with the iron into a phosphate of iron.

Remark. In this state, phosphate of iron is a tasteless powder, insoluble in water, but soluble in nitric acid. It occurs native, crystallized in blue coloured prisms.

Experiment 2. If oxy-sulphate of iron be decomposed by phosphate of soda, a white powder is obtained, called oxy-phosphate of iron.

Rationale. The per-oxyd of iron unites with the phosphoric acid, while the sulphuric acid combines with the soda, forming sulphate of soda.

Experiment 3. If a solution of potash be poured on oxy-phosphate of iron, it will be converted into sub-oxyphosphate, which is of a brown colour.

Rationale. The alkali unites with a part of the phosphoric acid, and of course converts the oxy-phosphate into sub-oxyphosphate of iron.

Remark. The sub-oxyphosphate is an insoluble powder; but soluble in the serum of blood, and is supposed by some to give the red colour to the blood.

CARBONATE OF IRON.

Experiment 1. If sulphate of iron be precipitated by an alkaline carbonate, a powder will be obtained, called carbonate of iron.

Rationale. The sulphuric acid unites with the alkali, and the carbonic acid combined with the oxyd of iron, forming carbonate of iron.

Remark. Carbonate of iron has been found native, crystallized in rhombs. Rust is frequently a carbonate of iron. Hence some of the colleges recommend, for the preparation of *rust of iron*, the precipitation of iron in the manner before mentioned. The carbonate contains 59.5 prot oxyd of iron, 36 acid, and 2 water. When iron is dissolved in water impregnated with carbonic acid, the *artificial ærated chalybeate water* is formed. It is this compound which is often found in those waters called chalybeate, of which the United States abound. Waters of this description, besides having a ferruginous taste, and occasioning a black or dark brown precipitate with tincture of galls, produce, on boiling, a brown coloured precipitate, or ochre. If the iron be held insolution by a fixed acid, as the sulphuric, it does not precipitate on boiling, and the usual re-agents give the same phenomena before as well as after boiling.

FLUATE OF IRON.

Experiment 1. If iron filings be introduced into fluoric acid, they will be dissolved and form fluate of iron.

BORATE OF IRON.

Experiment 1. When sulphate of iron in solution is added to sub-borate of soda, also held in solution, a precipitate will be formed, which is borate of iron.

Rationale. The sulphuric acid unites with the soda, and the boracic acid with the iron.

ACETATE OF IRON.

Experiment 1. If sulphuret of iron be dissolved in acetic acid, and the solution filtered and evaporated, crystals of acetate of iron, in the form of prisms, will be produced.

Experiment 2. If per-oxyd of iron be dissolved in acetic acid, the result is a salt, called oxacetate of iron, a liquor much in use by calico-printers.

Experiment 3. If iron be dissolved in pyroligneous acid, obtained by the distillation of wood, a fluid will be formed called iron liquor by the calico-printers, which is similar to acetate of iron.

SUCCINATE OF IRON.

Experiment 1. If succinate of ammonia be added to sulphate of iron, a brown precipitate will be produced, of succinate of iron. See Succinate of Ammonia.

BENZOATE OF IRON

Experiment 1. If iron be dissolved in benzoic acid, the result is benzoate of iron, which, on evaporation will form yellow crystals, soluble in water and in alcohol.

OXALATE OF IRON.

Experiment 1. If oxalic acid be added to the prot or per-oxyd of iron, a solution will take place, and produce oxalate of iron: with the former oxyd the simple oxalate is formed, but with the latter, the oxy-oxalate.

TARTRATE OF IRON.

Experiment 1. When prot oxyd of iron is dissolved in tartaric acid, the result is tartrate of iron, which crystallizes, and is sparingly soluble in water; but,

Experiment 2. When the per-oxyd of iron is dissolved in the same acid, the oxy-tartrate is formed, which is red and does not crystallize.

CITRATE OF IRON.

Experiment 1. If iron be dissolved in citric acid, citrate of iron will be produced, which deposits small crystals very soluble in water.

MALATE OF IRON.

Experiment 1. Malic acid when combined with iron, forms malate of iron, which is a brown solution not crystallizable.

GALLATE OF IRON.

Experiment 1. When tincture or infusion of galls is added to a solution of iron, a deep blue or black powder called gallate of iron is produced.

Remark. It has been asserted, that although this compound is formed in the making of black ink, black dye, the colouring of tanned leather, &c., yet it consists for the most part of another principle, called tannin, combined with the same metal. See iron.

PRUSSIATE OF IRON.

Experiment 1. If iron filings be digested in a solution of sulphate of iron, in order to form a sulphate with a minimum of oxygen in the oxyd, and added to prussiate of potash, a white precipitate will be formed called *prussiate of iron*; but,

Experiment 2. If the common sulphate of iron be used, or in preference the oxysulphate, the precipitate will be of a deep blue colour, forming the oxy-prussiate of iron, analogous to prussian blue. See Iron.

ARSENIATE OF IRON.

Experiment 1. If arseniate of potash be added to sulphate of iron, in which the iron is at the minimum of oxydizement, a green powder will be formed, called arseniate of iron; but,

Experiment 2. If the same salt be added to oxysulphate of iron, a brownish red powder will be formed, called oxarseniate of iron. See Arsenic.

Remark. The other salts of iron are not much known.

The salts of iron form a green, yellowish, or reddish solution, and are known by the following characters:

1. Prussiate of potash precipitates a powder either blue, or becomes so when exposed to the air.
2. Hydro-sulphuret of potash occasions a black precipitate.
3. Gallic acid, or infusion of nut-galls, throws down a black or purple precipitate.

SECTION XI.

SALTS OF TIN.

NITRATE OF TIN.

Experiment 1. If very diluted nitric acid be poured on tin, the metal will be dissolved, and form a yellow coloured solution, of nitrate of tin.

Remark. This salt contains the deut-oxyd of tin.

Experiment 2. If this solution be left to itself, or concentrated by evaporation, oxyd of tin will be precipitated.

Experiment 3. If concentrated nitric acid be digested on tin, the metal will be converted into the per oxyd.

Remark. As the per oxyd of tin is formed, in consequence of the rapid decomposition of the acid, no solution of the metal takes place. During the action of the acid ammonia is formed, and remains in a combination with the acid.

Experiment 4. If a solution of gold be added to a solution of tin in nitric acid, a beautiful purple precipitate falls. See Gold.

MURIATE OF TIN.

Experiment 1. If tin be introduced into muriatic acid, and a gentle heat applied, it will be dissolved, and form muriate of tin.

Experiment 2. If this solution be evaporated, crystals in the shape of needlès will be formed.

Remark. As this salt readily combines with oxygen, whether from the atmosphere, from oxymuriatic or nitric acid, or from various metallic oxyds and salts, the remarkable changes which it produces on many metallic solutions is accounted for.

Experiment 3. If an amalgam of tin and corrosive muriate of mercury be mixed and distilled in a retort, at first water comes over, and then a dense colourless liquid condenses, which is the *smoaking liqour of Libavius* or oxymuriate of tin.

Rationale. The muriated mercury is decomposed; the muriatic acid quits the mercury and unites with the tin, which being sufficiently oxydized in the process, constitutes oxymuriate of tin.

Experiment 4. If muriate of tin be exposed to the atmosphere, it will be converted into the oxymuriate; or,

Experiment 5. If a current of oxymuriatic acid gas be made to pass through the same solution, the same product will result.

Experiment 6. If oxymuriate of tin be combined with a sufficient quantity of water, it will yield, on evaporation, small prismatic crystals. See Tin.

SULPHATE OF TIN.

Experiment 1. If sulphuric acid be added to muriate of tin, sulphate of tin will be formed in the state of a white powder; and,

Experiment 2. If this powder be dissolved in water and the solution evaporated, crystals of sulphate of tin will be the result.

Experiment 3. If tin be oxydized to the maximum, and then combined with sulphuric acid, or the nitrate of tin decomposed by sulphuric acid, a salt will be formed called oxysulphate of tin, which assumes the form of a jelly.

SULPHITE OF TIN.

Experiment 1. When tin is kept in sulphurous acid, it is converted into oxyd and sulphuret of tin; the former is then dissolved, and forms the sulphite of tin.

PHOSPHATE OF TIN

Experiment 1. Phosphoric acid united with tin forms phosphate of tin, which is a white powder insoluble in water.

FLUATE OF TIN.

Experiment 1. Fluoric acid attacks tin, when oxydized, and forms a gelatinous solution of fluate of tin.

BORATE OF TIN.

Experiment 1. Boracic acid unites with tin into a white insoluble powder, called borate of tin.

ACETATE OF TIN.

Experiment 1. The prot oxyd of tin unites with acetic acid into acetate of tin; but,

Experiment 2. If the per-oxyd be used, it forms ox-acetate of tin, which is not crystallizable.

SUCCINATE OF TIN.

Experiment 1. Succinic acid in solution combines with tin, forming succinate of tin, which crystallizes.

BENZOATE OF TIN.

Experiment 1. If benzoic acid be united with oxyd of tin, benzoate of tin will result.

OXALATE OF TIN.

Experiment 1. Tin dissolves in oxalic acid forming oxalate of tin, which crystallizes in prisms, and is very soluble in water.

ARSENIATE OF TIN.

Experiment 1. Arsenic acid unites with tin, which is a white insoluble powder.

Remark. The salts of tin are, for the most part, soluble in water: they exhibit the following properties:

1. Prussiate of potash gives a white precipitate.
2. Hydro-sulphuret of potash occasions a brownish black, or golden yellow precipitate.
3. Muriate of mercury produces a black or a white precipitate.
4. Infusion of nut-galls occasions no precipitate in these solutions.

SECTION XII.

SALTS OF LEAD.

NITRATE OF LEAD.

Experiment 1. If lead be dissolved in diluted nitric acid, and the solution evaporated, crystals of oxy-nitrate of lead will be formed.

Remark. The crystals of this salt are sometimes tetrahedrons, having their apexes truncated; sometimes octahedrons. They are opake and white, and have a silvery lustre. Their taste is sweet and harsh. They are not altered by exposure to the air. They dissolve in less than eight parts of boiling water. When heated it decrepitates, and in a strong heat the acid is driven off, while at the same time the oxyd is partially reduced to the metallic state. This salt is composed of 66 yellow oxyd, 34 acid and water.

Experiment 2. If lead be boiled in oxy-nitrate of lead, a salt will be formed called nitrate of lead.

Remark. In this salt the lead is between a minimum and maximum of oxydizement; the solution which it forms is of a yellow colour. When evaporated the salt crystallizes in scales, and in small prisms. The oxyd in my trials appeared to be the yellow: but Buchloz affirms that it contains less oxygen. This salt is composed of 81.5 oxyd, 18.5 acid.

HYPER-OXYMURIATE OF LEAD.

Experiment 1. If oxyd of lead be diffused in water, and a current of oxy-muriatic acid gas passed through the water, hyper-oxymuriate of lead will be formed.

MURIATE OF LEAD.

Experiment 1. If muriatic acid be poured into a solution of lead, a white precipitate falls, which is muriate of lead; or,

Experiment 2. If muriate of soda be added to a solution of nitrate of lead, muriate of lead will be precipitated as before. See Lead.

Experiment 3. If this salt be fused in a crucible, it forms *plumbum corneum*; and,

Experiment 4. If the heat be urged, it is converted into sub-muriate of lead, or *patent yellow*. See Lead.

Remark. The muriate of lead is composed of about 18¼ acid, and 81¾ yellow oxyd. The crystallized salt contains 76 per cent. of metallic lead.

SULPHATE OF LEAD.

Experiment 1. If sulphuric acid be poured into a solution of lead, sulphate of lead will be precipitated; or,

Experiment 2. If sulphate of soda be added to nitrate or acetate of lead, the same compound will precipitate. See Lead.

Remark. Sulphate of lead is a white powder insoluble in water, alcohol, and nitric and acetic acid. It is found native, crystallized in octahedrons. It is composed of about twenty-five acid and seventy-five yellow oxyd. An hundred parts of it according to Kirwan, contain twenty-one of metallic lead. It may be heated to redness in a platinum crucible without alteration; but when in contact with charcoal, it melts and the lead is reduced.

SULPHITE OF LEAD.

Experiment 1. If lead or its oxyd be combined with sulphurous acid, a tasteless insoluble white powder will be formed, called sulphite of lead, which contains 74.5 per cent. of oxyd.

PHOSPHATE OF LEAD.

Experiment 1. If a solution of phosphate of soda be added to another of nitrate of lead, a precipitate of a white colour, called phosphate of lead, will be formed. See Lead.

Remark. Native phosphate of lead is found on the lead hills of Scotland, Germany, Carinthea, &c. It is of a greenish colour, and occurs in stalactites, and also in regular shapes. The artificial as well as the native phosphate is soluble in nitric acid, from which the lead is separated by ammonia, and the phosphoric acid by means of lime water. It is composed of 18 acid, and 82 yellow oxyd of lead.

CARBONATE OF LEAD.

Experiment 1. If a solution of nitrate of lead be mixed with an alkaline carbonate, a white precipitate of carbonate of lead will result. It is composed of $16\frac{1}{3}$ acid, $32\frac{2}{3}$ yellow oxyd. See Lead.

FLUATE OF LEAD.

Experiment 1. If fluoric acid be combined with oxyd of lead, the result is a white insoluble powder, called fluate of lead.

BORATE OF LEAD.

Experiment 1. If boracic acid be united with oxyd of lead, borate of lead will be formed, which is a white insoluble powder.

Experiment 2. If this compound be melted before the blow pipe, it forms a colourless glass.

ACETATE OF LEAD.

Experiment 1. If oxyd of lead be dissolved in acetic acid, or in vinegar, and the solution evaporated, crystals of super-acetate of lead will result, called also *sugar of lead* and *salt of saturn.* See Lead.

Experiment 2. If acetate of lead be dissolved in acetic acid, the compound formed will be super-acetate of lead.

Remark. The crystals of this salt are small needles. It is very soluble in water, forming the *lead water* of the shops. When distilled it is decomposed, affording acetic acid, and a yellow inflammable liquor: if the heat be continued carbonic acid and carburetted hydrogen gas are formed. It is composed of 26 acid, 58 yellow oxyd, and 16 water.

Experiment 3. If 100 parts of super-acetate of lead be boiled with 150 parts of litharge, a salt will be formed called acetate of lead, which is less soluble in water than the preceding variety, and crystallizes in plates.

Experiment 4. If litharge be dissolved in vinegar, the result is a solution of lead, called Goulard's extract, which contains acetate of lead.

SUCCINATE OF LEAD.

Experiment 1. If oxyd of lead be dissolved in succinic acid, a salt will be formed called succinate of lead, which forms in foliated crystals scarcely soluble in water, but soluble in nitric acid.

BENZOATE OF LEAD.

Experiment 1. Benzoic acid combined with lead, forms benzoate of lead which is soluble in water and alcohol, and decomposed by heat.

OXALATE OF LEAD.

Experiment 1. When oxyd of lead is combined with oxalic acid, the result is oxalate of lead.

TARTRATE OF LEAD.

Experiment 1. Tartaric acid unites with lead, forming tartrate of lead, an insoluble powder containing 37 acid, and 63 yellow oxyd.

CITRATE OF LEAD.

Experiment 1. When citric acid combines with oxyd of lead, the result is citrate of lead, which exists in the form of a white powder, and is difficultly soluble in water.

MALATE OF LEAD.

Experiment 1. If acetate of lead be added to the juice of apples, a precipitate will be obtained, which is malate of lead. See Malic Acid.

ARSENIATE OF LEAD.

Experiment 1. When arsenic acid is combined with lead, the salt called arseniate of lead is formed, which is a white powder, containing 64.3 per cent. of yellow oxyd of lead.

MOLYBDATE OF LEAD.

Experiment 1. When molybdate of potash is poured into nitrate of lead, a white precipitate is formed, which is molybdate of lead. See Molybdenum.

Remark. This salt is found native in rhomboidal plates, of a yellow colour, and is composed of 34.7 acid, and 65.3 yellow oxyd.

TUNGSTATE OF LEAD.

Experiment 1. When tungstic acid is united with lead, which may be effected by double decomposition, the result is a white powder, called tungstate of lead.

CHROMATE OF LEAD.

Experiment 1. If chromate of potash be mixed with the nitrate or acetate of lead, a yellow coloured precipitate will be formed, called chromate of lead, or chromic yellow of the painters. See Chromate of Potash.

Remark. This compound occurs native, crystallized in four sided prisms, and is composed of 34.9 acid, and 65.1 oxyd. Chromate of lead may be decomposed in a crucible by potash, in the proportion of one part of the ore, if it be native, with eight of potash ; the mass is to be dissolved in water, the excess of alkali saturated with nitric acid, and the chromate of lead may be reproduced by adding nitrate of lead.

The soluble salts of lead give the following general appearances with these re-agents, viz.

1. Prussiate of potash occasions a white precipitate.
2. Hydro-sulphuret of potash produces a black precipitate; and,
3. Infusion of nut-galls affords a white precipitate.

SECTION XIII.

SALTS OF NICKEL.

NITRATE OF NICKEL.

Experiment 1. If nitric acid be digested on nickel by means of heat, the metal will be dissolved, and form nitrate of nickel, which crystallizes in green rhomboidal prisms.

Remark. This salt when exposed to the air at first deliquesces, and afterwards falls to powder, and gradually loses the whole of its acid. It is composed of 55 acid, 25 oxyd, and 20 water.

MURIATE OF NICKEL.

Experiment 1. If nickel be dissolved in nitro-muriatic acid, the solution will yield on evaporation, crystals of muriate of nickel.

Experiment 2. If this salt be heated it loses its water, and sublimes in the state of golden yellow flowers.

Experiment 3. If these flowers be exposed to the air, they become green by absorbing moisture.

Remark. Muriate of nickel is composed of 34 oxyd, 11 acid, and 55 water.

SULPHATE OF NICKEL.

Experiment 1. If sulphuric acid be digested on nickel, a residue will be left, which, when dissolved in water, acquires a green colour, and on evaporation forms six sided prisms, composed of 35 oxyd, 19 acid, and 46 water.

CARBONATE OF NICKEL.

Experiment 1. If nitrate of nickel be decomposed by carbonate of potash, a green powder will precipitate, which is carbonate of nickel, containing 56.4 acid and water, and 43.6 oxyd.

FLUATE OF NICKEL.

Experiment 1. Fluoric acid combines with the oxyd of nickel, and forms fluate of nickel, which crystallizes of a green colour.

ACETATE OF NICKEL.

Experiment 1. If acetic acid be digested on oxyd of nickel, acetate of nickel will be formed, which forms crystals of a green colour.

OXALATE OF NICKEL.

Experiment 1. When oxalic acid is combined with oxyd of nickel, the result is oxalate of nickel, which is a green powder scarcely soluble in water.

ARSENIATE OF NICKEL.

Experiment 1. If arsenic acid be saturated with oxyd of nickel, the arseniate of nickel will be formed, which is a soluble salt, of an apple green colour.

MOLYBDATE OF NICKEL.

Experiment 1. If molybdate of potash be added to a solution of nitrate of nickel, a white precipitate will be formed, which is molybdate of nickel. See Nickel.

Remark. The salts of nickel have the following general properties:

1. Fixed alkalies precipitate the metal in an oxyd of a greenish white.
2. Ammonia produces a precipitate, but an excess re-dissolves it; the solution being blue.
3. Prussiate of potash occasions a dull green precipitate.
4. Hydro-sulphuret of potash froms a black precipitate.
5. Tincture of galls gives a grayish white precipitate.

SECTION XIV.

SALTS OF ZINC·

NITRATE OF ZINC.

Experiment 1. If nitric acid be added to zinc, a violent effervescence takes place, and the metal will be dissolved, which, on evaporation, will yield crystals of nitrate of zinc in flat four sided prisms, which deliquesces in the air, and is very soluble in water.

Experiment 2. If the nitrate thus produced be melted in a strong heat, it will part with its acid, and leave an oxyd of zinc in the crucible.

MURIATE OF ZINC.

Experiment 1. If zinc be dissolved in muriatic acid, the solution will yield on evaporation a gelatinous mass, which deliquesces in the air, called muriate of zinc.

Experiment 2. If this mass be heated, it will sublime in small needles.

SULPHATE OF ZINC.

Experiment 1. If zinc be dissolved in diluted sulphuric acid, the solution will afford, on evaporation, crystals in four flat sided prisms of sulphate of zinc, called also *white vitriol*, vitriol of zinc, and white copperas. See Zinc.

Remark. This salt was discovered in Germany about the middle of the 16th century. It is very soluble, and is decomposed in a strong heat. It contains 28.2 oxyd, 25.6 acid, and 46 water.

SULPHITE OF ZINC.

Experiment 1. If zinc be dissolved in sulphurous acid, on evaporation crystals in four sided prisms of sulphuretted sulphite of zinc, which absorb oxygen very slowly when exposed to the air, and crystals of sulphite of zinc, which speedily absorbs oxygen will result.

PHOSPHATE OF ZINC.

Experiment 1. Oxyd of zinc combined with phosphoric acid forms phosphate of zinc, which does not crystallize, but yields, when evaporated, a mass like gum arabic.

CARBONATE OF ZINC.

Experiment 1. If sulphate of zinc be decomposed by carbonate of potash, a white precipitate will be obtained called carbonate of zinc. See Zinc.

Remark. This compound occurs native, of a brown colour, and is known by the name of calamine. It is composed of one part acid, and two parts oxyd.

FLUATE OF ZINC.

Experiment 1. Fluoric acid combined with zinc, forms fluate of zinc, which does not crystallize.

BORATE OF ZINC.

Experiment 1. When boracic acid is united with zinc, the result is an insoluble compound called borate of zinc.

ACETATE OF ZINC.

Experiment 1. If zinc or its oxyd be dissolved in acetic acid, acetate of zinc will be formed; or,

Experiment 2. If sulphate of zinc be dissolved in water, and a solution of acetate of lead added until no further precipitate is formed; the mixture then filtered, and the clear fluid evaporated, the same product will be obtained. See Zinc.

Remark. This salt crystallizes in rhomboidal or hexagonal plates of a talky appearance. Its taste is bitter and metallic. It is very soluble in water. It is this salt which is formed in mixtures of acetate of lead and sulphate of zinc, and to its presence is attributed their efficacy in certain diseases.

SUCCINATE OF ZINC.

Experiment 1. If oxyd of zinc be dissolved in succinic acid, and the solution evaporated, foliated crystals of succinate of zinc will be formed.

BENZOATE OF ZINC.

Experiment 1. When benzoic acid is saturated with oxyd of zinc, the result is benzoate of zinc, which form needle shaped crystals soluble in water and alcohol.

OXALATE OF ZINC.

Experiment 1. When oxalate of potash is decomposed by sulphate of zinc, the result is sulphate of potash and oxalate of zinc; the latter being scarcely soluble in water will precipitate.

CITRATE OF ZINC.

Experiment 1. If oxyd of zinc be combined with citric acid, small brilliant crystals of citrate of zinc may be obtained.

Remark. The arseniate, tungstate, molybdate and chromate of zinc are all insoluble in water; the first three are white, the last orange red. See Zinc.

The salts of zinc possess the following properties:

1. Prussiate of potash occasions a white precipitate;
2. They are decomposed by alkalies; and,
3. Tincture of galls affords no precipitate.

SECTION XV.

SALTS OF BISMUTH.

NITRATE OF BISMUTH.

Experiment 1. If nitric acid be poured on bismuth, an effervescence will be produced, the metal will dissolve and form nitrate of bismuth, which will crystallize in four sided prisms.

Experiment 2. If nitrate of bismuth be triturated with phosphorus, a violent detonation will take place.

Experiment 3. If crystals of nitrate of bismuth be dissolved in water, oxy-nitrate of bismuth will be formed and remain in solution, and sub-nitrate of bismuth will be precipitated. See Bismuth.

MURIATE OF BISMUTH.

Experiment 1. If bismuth be dissolved in nitro-muriatic acid, and the solution evaporated, small prismatic crystals of muriate of bismuth will be formed.

Experiment 2. If this salt be distilled, a white mass will be obtained, which easily melts, and is called *butter of bismuth.*

SULPHATE OF BISMUTH.

Experiment 1. If a mixture of sulphuric acid and bismuth be heated, a white mass remains, which is sulphate of bismuth.

SULPHITE OF BISMUTH.

Experiment 1. When sulphurous acid is saturated with bismuth, a white insoluble powder is obtained called sulphite of bismuth.

PHOSPHATE OF BISMUTH.

Experiment 1. Oxyd of bismuth dissolved in liquid phosphoric acid, forms phosphate of bismuth: if a portion of the acid be abstracted, sub-phosphate of bismuth will result, which is a white powder.

ACETATE OF BISMUTH.

Experiment 1. If the solutions of acetate of potash and nitrate of bismuth be mixed and heated, small talky crystals of acetate of bismuth will gradually precipitate. See Bismuth.

SUCCINATE OF BISMUTH.

Experiment 1. If succinic acid in solution be saturated with bismuth, the result will be succinate of bismuth, which crystallizes in yellow plates, soluble in water.

BENZOATE OF BISMUTH.

Experiment 1. When benzoic acid is combined with oxyd of bismuth, benzoate of bismuth is formed, which crystallizes in needles.

OXALATE OF BISMUTH.

Experiment 1. Oxalate of potash added to nitrate of bismuth, affords a white precipitate of oxalate of bismuth.

Remark. The other salts of bismuth, viz. the tartrate, arseniate and molybdate, which are not much known, are formed by saturating the different acids with this base. The following properties are possessed by the greater part of the salts of this metal:

1. Water generally decomposes them, affording a white powder or sub-salt;
2. Prussiate of potash occasions a white precipitate;
3. Hydro-sulphuret of potash produces a black precipitate; and,
4. Tincture of galls gives an orange coloured precipitate.

SECTION XVI.

SALTS OF ANTIMOMY.

NITRATE OF ANTIMONY.

Experiment 1. When antimony is added to nitric acid, it is converted into a white oxyd, a portion of which dissolves in the remaining acid, and forms nitrate of antimony.

MURIATE OF ANTIMONY.

Experiment 1. When antimony is added to muriatic acid, and heat applied, a portion is dissolved, forming muriate of antimony. Or,

Experiment 2. If antimony be dissolved in nitro-muriatic acid, the solution will be of a yellow colour, and contain besides muriate, the oxy-muriate, of antimony, called also *butter of antimony*; or,

Experiment 3. If one part of antimony be triturated with two parts of oxy-muriate of mercury, and the mixture distilled, oxy-muriate of antimony will pass over in the state of a thick fatty mass of a grayish white, and often crystallizes in four sided prisms. And,

Experiment 4. If water be added to this salt, sub-muriate of antimony or *algorath's powder* will be precipitated. See Antimony.

SULPHATE OF ANTIMONY.

Experiment 1. When antimony is digested in sulphuric acid at a boiling heat, it will be converted into a white mass containing sulphate of antimony.

SULPHITE OF ANTIMONY.

Experiment 1. If to a solution of antimony in muriatic acid, sulphurous acid be added, sulphite of antimony will precipitate.

PHOSPHATE OF ANTIMONY.

Experiment 1. When oxyd of antimony is added to liquid phosphoric acid, the result is phosphate of antimony, which is soluble in water, but not crystallizable.

Experiment 2. When phosphate of lime, or as the colleges direct, the shavings of hartshorn and crude antimony are exposed to a strong heat in a crucible, there results a triple compound called phosphate of lime and antimony, or *James' powder*. See Antimony.

ACETATE OF ANTIMONY.

Experiment 1. If oxyd of antimony be digested in acetic acid a solution will take place, and form acetate of antimony, which, on evaporation, will crystallize.

OXALATE OF ANTIMONY.

Experiment 1. When oxy-muriate of antimony is added to oxalate of potash, oxalate of antimony will gradually precipitate.

TARTRATE OF ANTIMONY.

Experiment 1. When oxyd of antimony is dissolved in tartaric acid, a gelatinous substance will be formed called tartrate of antimony.

ARSENIATE OF ANTIMONY.

Experiment 1. When arseniate of potash is added to muriate of antimony, a white precipitate will be obtained, which is arseniate of antimony.

TARTRATE OF POTASH AND ANTIMONY.

Experiment 1. If equal parts of per oxyd of antimony and super-tartrate of potash be boiled in a sufficient quantity of water, a triple combination will be formed, which when filtered and evaporated form tartrate of potash and antimony, or *tartar emetic*. Or,

Experiment 2. If crocus of antimony, or otherwise sulphuretted oxyd of antimony, be digested in the same manner in water holding super-tartrate of potash in solution, the same product will be obtained.

Remark. This salt forms regular crystals in tetrahedrons, which effloresces when exposed to the air. It is procured in the shops in the form of powder, as a more convenient mode of administering it. It is composed of 35.4 tartaric acid, 39.6 per oxyd of antimony, 16.7 potash, and 8.3 water. See Antimony.

The salts of antimony have the following general properties:

1. They generally precipitate, or decompose by the addition of water;
2. Prussiate of potash throws down a white precipitate;
3. Tincture of galls has the same effect; and,
4. Hydro-sulphuret of potash gives an orange coloured precipitate.

SECTION XVII.

SALTS OF TELLURIUM.

NITRATE OF TELLURIUM.

Experiment 1. If nitric acid be digested on tellurium, the metal will be dissolved, and form nitrate of tellurium.

Remark. This solution of tellurium is colourless, and yields, on evaporation, small needle-form crystals.

MURIATE OF TELLURIUM

Experiment 1. When tellurium is dissolved in nitro-muriatic acid, the muriate of tellurium is formed.

Experiment 2. If water be added to this solution, a white precipitate will be obtained, which, on the addition of more water, is re-dissolved.

SULPHATE OF TELLURIUM.

Experiment 1. Sulphuric acid acts on tellurium, and forms with it sulphate of tellurium. See Tellurium.

Remark. The salts of tellurium have the following properties:

1. The fixed alkalies throw down from their solution, a white powder, which is re-dissolved by an excess of alkali;
2. Prussiate of potash occasions no precipitate;
3. Hydro-sulphuret of potash throws down a brown or blackish precipitate; and,
4. Tincture of galls produces a flaky yellow precipitate.

SECTION XVIII.

SALTS OF ARSENIC.

NITRATE OF ARSENIC.

Experiment 1. When arsenic is added to nitric acid, a violent effervescence is produced, and nitrate of arsenic is formed. See Arsenic.

MURIATE OF ARSENIC.

Experiment 1. If muriatic acid be digested on arsenic, with the assistance of heat, muriate of arsenic will be produced. Or, *Experiment* 2. If the white oxyd or arsenious acid be dissolved in muriatic acid, the same compound will result, which, on evaporation, will form small crystalline grains.

SULPHATE OF ARSENIC.

Experiment 1. When arsenic is digested in sulphuric acid, a compound will be formed called sulphate of arsenic, which is a white powder very imperfectly soluble in water.

ACETATE OF ARSENIC.

Experiment 1. When arsenious acid or white oxyd of arsenic, is digested in acetic acid, it will be dissolved and form acetate of arsenic, which will deposit regular crystals. See Arsenic.

Remark. The following are the general properties of the salts of arsenic.

1. Prussiate of potash occasions a white precipitate;
2. Hydro-sulphuret of potash forms a yellow precipitate; and,
3. Infusion of nut-galls produces no change.

SECTION XIX.

SALTS OF COBALT.

NITRATE OF COBALT.

Experiment 1. When cobalt is dissolved in nitric acid, and the solution evaporated, red prismatic crystals of nitrate of cobalt will be the result.

Experiment 2. If one part of cobalt be dissolved in three of diluted nitric acid, and diluted with 24 of water, and one part of muriate of ammonia added, *Hellot's sympathetic ink* will be prepared.

Remark. Letters traced by this solution are invisible while cold, but when very moderately heated they become green, if the cobalt contains much iron, but blue, if free from iron.

MURIATE OF COBALT.

Experiment 1. When oxyd of cobalt is dissolved in muriatic acid, muriate of cobalt will be found; or,

Experiment 2. If nitro-muriatic acid be used, the same salt will be produced.

Remark. The solution of cobalt in muriatic acid is blue, if it be neutral; if there be an excess of acid, the solution is green. See Cobalt.

Experiment 2. If characters be written with this solution, they will be invisible; but if heat be applied they will become green, forming a *sympathetic ink.* See Cobalt.

SULPHATE OF COBALT.

Experiment 1. If oxyd of cobalt be dissolved in sulphuric acid, and the solution evaporated, crystals of sulphate of cobalt will be obtained, which will form in rhomboidal prisms, terminated by dihedral summits.

Remark. This salt contains 26 acid, 30 oxyd, and 34 water. It readily combines with potash and ammonia, and forms triple salts with each.

ACETATE OF COBALT.

Experiment 1. If one part of oxyd of cobalt be dissolved in 16 parts of distilled vinegar, and the solution evaporated to one fourth, and one fourth, of the cobalt, of muriate of soda be then added, the *blue sympathetic* ink of Ilseman will be formed.

Remark. The remaining salts of cobalt are not much known.

The salts of this metal exhibit the following properties:

1. Alkalies precipitate a blue powder.
2. Hydro-sulphuret of potash affords a black precipitate; and,
3. Infusions of nut-galls produces a yellowish white precipitate.

SECTION XX.

SALTS OF MANGANESE.

NITRATE OF MANGANESE.

Experiment 1. If to a mixture of the black oxyd of manganese and nitric acid, a little sugar be added, and heat applied, the oxyd will be dissolved, and form nitrate of manganese. See Manganese.

MURIATE OF MANGANESE.

Experiment 1. When muriatic acid is digested on black oxyd of manganese, an abundance of oxy-muriatic acid is disengaged, and muriate of manganese is formed, which crystallizes on evaporation.

Experiment 2. If red oxyd of manganese be treated in the same manner, the result is oxy-muriate of manganese.

SULPHATE OF MANGANESE.

Experiment 1. If the white or red oxyd of manganese be dissolved in sulphuric acid, the result is sulphate of manganese.

Experiment 2. If the black oxyd be used in the same manner, oxygen gas will be liberated, and sulphate of manganese formed.

Remark. There are two combinations of sulphuric acid and the oxyd of manganese; one with the *white*, and another with the *red* oxyd. The sulphate crystallizes and the oxy-sulphate gelatinizes. The other compounds of this metal with acids, are but little known.

The salts of manganese, are characterised by the following properties:

1. Alkalies throw down from them, a red or white precipitate, which become black when exposed to the air;
2. Prussiate of potash occasions a yellowish white precipitate;
3. Hydro-sulphuret of potash forms a white precipitate; and,
4. Gallic acid produces no change.

SECTION XXI.

SALTS OF CHROMIUM.

The salts of this metal are but very little known. They possess, as far as facts are able to determine, the following properties:

1. Prussiate of potash occasions a brown colour;
2. Infusion of nut-galls affords a brown precipitate; and,
3. Hydro-sulphuret of potash produces a green precipitate, which becomes yellow on the addition of nitric acid. The oxyd of chromium is soluble in the nitric, muriatic, phosphoric, sulphurous, and oxalic acids. See Chromium.

SECTION XXII.

SALTS OF MOLYBDENUM.

NITRATE OF MOLYBDENUM.

Experiment 1. If molybdenum be digested in nitric acid by the assistance of heat, the nitrate of molybdenum will be formed.

Remark. If the quantity of metal be greater than the acid can dissolve, the solution is blue; but where a small quantity of molybdenum is dissolved in a considerable proportion of acid, the solution is yellowish brown.

MURIATE OF MOLYBDENUM.

Experiment 1. If the oxyd of molybdenum be dissolved in muriatic acid, the result will be muriate of molybdenum, which is of a blue colour.

SULPHATE OF MOLYBDENUM.

Experiment 1. If the oxyd of molybdenum be dissolved in sulphuric acid, a yellowish brown or a blue solution of sulphate of molybdenum will result.

Remark. The other salts of molybdenum are but little known. See Molybdenum.

SECTION XXIII.

SALTS OF URANIUM.

NITRATE OF URANIUM.

Experiment 1. If uranium or its oxyd be dissolved in nitric acid, nitrate of uranium will be formed, which on evaporation, will yield crystals in hexagonal tables or in four flat sided prisms. This salt is composed of 61 oxyd, 25 acid, and 14 water.

Experiment 2. If this salt be exposed to a strong heat, it acquires a lemon yellow colour, and is converted into sub-nitrate of uranium.

MURIATE OF URANIUM.

Experiment 1. When oxyd of uranium is dissolved in muriatic acid, the solution, on evaporation, will yield crystals, having the form of four sided tables, of muriate of uranium.

SULPHATE OF URANIUM.

Experiment 1. If the oxyd of uranium be digested in sulphuric acid, it will be dissolved, and form sulphate of uranium, which crystallizes in prisms or tables. This salt is composed of 18 acid, 70 oxyd, and 12 water.

ACETATE OF URANIUM.

Experiment 1. Oxyd of uranium readily dissolves in acetic acid, and yields acetate of uranium in long slender transparent four sided prisms, terminated by four sided pyramids. See Uranium.

The salts of uranium give the following appearances:

1. The pure alkalies afford a yellow precipitate;
2. Prussiate of potash produces a brownish red precipitate;
3. Hydro-sulphuret of potash occasions a brownish yellow precipitate; and,
4. Infusion of galls imparts a chocolate coloured precipitate.

SECTION XXIV.

SALTS OF TUNGSTEN.

This genus of salts is still unknown. From the difficulty of obtaining the metal in a state of purity, none of its combinations have been particularly examined. See Tungsten.

SECTION XXV.

SALTS OF TITANIUM.

NITRATE OF TITANIUM.

Experiment 1. When carbonate of titanium is dissolved in nitric acid, nitrate of titanium is formed, which crystallizes in the form of elongated rhombs, having two opposite angles truncated so as to represent six sided tables.

MURIATE OF TITANIUM.

Experiment 1. Carbonate of titanium dissolved in muriatic acid, forms muriate of titanium, which crystallizes in cubes.

SULPHATE OF TITANIUM.

Experiment 1. The carbonate of titanium treated in the same manner with sulphuric acid, forms sulphate of titanium, which does not crystallize.

Remark. The salts of titanium exhibits the following properties:

1. Carbonated alkalies occasion a flaky precipitate;
2. Prussiate of potash, a yellowish brown precipitate;
3. Hydro-sulphuret of potash, a dirty bottle green; and,
4. The infusion of galls produces a fine red precipitate.

When a rod of tin is plunged into a solution of titanium, the liquid assumes a red colour: a rod of zinc occasions a deep blue colour. See Titanium.

SECTION XXVI.

SALTS OF COLUMBIUM.

Owing to the scarcity of this metal, the experiments have been few, and confined to a few chemists; consequently its combinations have been but imperfectly examined. Oxyd of columbium is said to be very readily soluble in some of the vegetable acids, as the oxalic, tartaric, and citric, but scarcely soluble in sulphuric, nitric, and muriatic acids. No change is said to take place when prussiate of potash, or hydro-sulphuret of potash is added to a solution of this metal; but infusion of nut-galls throws down an orange coloured precipitate.

SECTION XXVII.

SALTS OF CERIUM.

The salts of this metal, although more known than those of columbium, are few in number.

Of the combination of this metal with acids, we have the nitrate, muriate, sulphate, carbonate, acetate, &c. which are either of a white or a yellow colour. The salts of cerium are decomposed by several of the reagents, viz.

1. Hydrosulphuret of potash; which throws down, form their solution, a white precipitate.

2. Prussiate of potash, which gives a milk white precipitate; and,

3. Oxalate of ammonia, which occasions a white precipitate insoluble in nitric and muriatic acids. See Cerium.

PART XVIII.

OF COMPOUND COMBUSTIBLES.

SECTION I.

OF ALCOHOL.

Experiment 1. If wine, beer, or other fermented liquor be distilled, the product will be *ardent spirits;* and,

Experiment 2. If this product be again distilled, with a gentle heat, either by itself, or from potash, dry muriate of lime, &c. the liquid called alcohol, or spirit of wine will be obtained.

Remark. The pure inflammable part of spirit is called alcohol. As ardent spirits are obtained by the distillation of various fermented liquors, it is obvious that they receive various names according to the nature of the substance employed. Thus *brandy* is obtained from wine, *rum* from the fermented juice of the sugar cane; *whiskey* and *gin* from the fermented infusion of *malt* or *grain*, or from *cyder*, &c. As ardent spirits, therefore, contains at least three ingredients, viz. water, pure spirit or alcohol, and some essential oil, it is evident that when distilled, the first portion which comes over (if the spirit be not strong) is nothing more than the *rectified spirits* of commerce. In the distillation of alcohol, the object is to separate as much as possible the water, with which it is diluted in the form of spirit. This, we have said, may be effected either by repeated distillation, or by the use of potash or dry muriate of lime, which has the property of keeping down the aqueous portion, whilst the alcohol rises. For conducting the process on a large scale, the common still is used; but for small experiments, the common retort and receiver may be employed. The specific gravity of alcohol, prepared in this manner, is 0.791 at 68°, or 0.796; but the alcohol of commerce is seldom under 0.837. Alcohol is a transparent fluid. It cannot be frozen. It is very volatile, and boils at 173½°. It combines with water in various proportions, and forms spirits of different degrees of strength. A mixture of alcohol and water, or any liquor whose specific gravity is 0.920, is *proof spirit*. When spirits are under this, or weaker than 0.920, they are said to be *under proof*; when stronger, to be above proof. Alcohol is decomposed by passing its vapour through a red hot porcelain or metallic tube, affording several products. It is composed, according to the recent experiments of Saussure, of oxygen 37.85, carbon 43.65, azote 3.52, and ashes 0.04. Alcohol dissolves phosphorus and sulphur in small proportion; the fixed alkalies, and some of the salts. The strong acids decompose it. The colour of the flame of alcohol is tinged by various bodies. Alcohol is a proper solvent of resins and essential oils; but does not act on gummy matter.

SECTION II.

OF ETHERS.

SULPHURIC ETHER.

Experiment 1. If a mixture of equal parts of sulphuric acid and alcohol be distilled in a glass retort, to which a large receiver is attached, a product will come over and condense, which is sulphuric ether.

Experiment 2. If to this fluid some chalk be added, and again distilled, the rectified or purified ether will be the result.

Remark. Ether is produced by the action of the acid on the alcohol: there remains in the retort a black carbonaceous matter. It is a colourless fluid, whose specific gravity, when pure, is 0.632 at 60°. It is very volatile, and boils at 98 degrees, and in a vacuum at—20°. It produces a considerable degree of cold by evaporation. According to Saussure, it is composed of 58.20 carbon, 22.14 hydrogen, and 19.66 oxygen. When passed through an ignited tube it is decomposed, and converted into oil, charcoal, water, and a great proportion of carburetted hydrogen gas. It receives some of the metallic oxyds, as those of gold and silver, and dissolves some metallic salts.

It is converted into *sweet oil of wine* by sulphuric acid. It is inflamed spontaneously by oxymuriatic acid. It dissolves several oleaginous substances, and unites with alcohol forming various preparations sold under the name of *sweet spirit of vitriol, Hoffman's anodyne drops, golden tincture, &c.*

NITRIC ETHER.

Experiment 1. If nitric acid and alcohol be mixed in proper proportion, on standing a yellow coloured fluid will form on the surface, which is nitric ether. Or,

Experiment 2. If a mixture of nitric acid of the specific gravity 1.283 and alcohol, be distilled in a retort, the product will be nitric ether.

Remark. From the retort should pass a tube, that goes to the bottom of a tall glass jar, half filled with a saturated solution of common salt in water. Several of these jars are connected together by tubes, and from these a tube passes to convey the gaseous products to the water trough. The ether condenses on the surface of the liquid in these jars. It contains at first a little nitrous and acetic acids, from which it is purified by agitation with chalk in a close phial, until it ceases to redden vegetable blues. Nitric ether thus prepared has a pale yellow colour, and a very strong etherial odour.

Its taste is strong and quite peculiar. It is rather heavier than alcohol, but much more volatile than sulphuric ether. Hence it only moistens bodies for a moment, and produces a considerable cold by its evaporation. The heat of the hand is sufficient to make it boil. According to Thenard nitric ether contains 48.52 oxygen, 28.45 carbon, 14.49 azote, and 8.54 hydrogen.

MURIATIC ETHER.

Experiment 1. If a mixture of muriatic acid and alcohol be distilled in a retort connected with Woulfe's bottles, partly filled with water, a product will be obtained called muriatic ether.

Experiment 2. If a mixture of alcohol, and oxy-muriate of potash, according to Van Mons, be distilled the same product will be obtained.

Remark. If the temperature be as low as 70°, the ether will assume the liquid state; but above this it takes the form of gas. Muriatic ether is composed of 36.61 carbon, 29.31 oxygen, and 10.64 hydrogen. In order to obtain it in a liquid state, the jars should be surrounded with ice. The nature of this compound was first investigated by Gehlen in 1804, and Thenard, in 1807.

ACETIC ETHER.

Experiment 1. If a mixture of alcohol and acetic acid, according to the count de Lauraguais, be distilled, and the operation repeated twelve times, acetic ether will be obtained.

Remark. This compound was discovered by the count in 1759. It seems to be a kind of combination of acetic acid and alcohol. It boils at 160° and when inflamed, it burns with a yellowish white flame, acetic acid being evolved.

Besides the ethers already enumerated, there are others lately discovered, which are formed by using other acids, as the phosphoric, &c. As they are but little known, we refer the reader to the more extensive and voluminous work of Dr. Thomson.

SECTION III.

VOLATILE OILS.

As oils, properly speaking, are divided into two kinds, which are denominated by the terms fixed and volatile, we shall treat in this place of volatile or essential oils. From the products obtained, when the volatile oils are burnt, it has been concluded that they are compounds of hydrogen and carbon; but no exact analysis has been made of them.

They are distinguished by the following properties:

1. Liquid, as often liquid as water; sometimes viscid.
2. Very combustible.
3. An acrid taste and a strong fragrant odour.
4. Volatilized at a temperature not higher than 212 degrees.
5. Soluble in alcohol and imperfectly in water.
6. Evaporate without leaving any stain on paper.

Volatile oils are almost all obtained from vegetables, and they exist in every part of plants except the cotyledons of the seed, were they have never been found. They are sometimes obtained from plants by simple expression. But in general they are procured, by mixing the vegetable substances containing them with water and distilling.

The oil comes over along with the water, and swims on its surface in the receiver. In this way is obtained the essential oils of almost all vegetable substances, such as mint, peppermint, rosemary, lavender, &c. Volatile oils evaporate very readily in the open air; are soluble in alcohol; and are decomposed by sulphuric acid.

SECTION IV.

FIXED OILS.

To this class of oils belong such as require a higher temperature to volatilize them, at or above 600 degrees. They are insoluble in water and alcohol, and leave a greasy stain upon paper. Fixed, called also fat and expressed oils are obtained partly from animals, partly from vegetables by simple expression; such as whale oil, olive oil, linseed oil, &c. They gradually absorb oxygen when exposed to the air, and become solid. Some oils retain their *transparency* after they have become solid, such are drying oils, those that become opaque are called *fat oils*. The drying oils are those of linseed, nut, poppy and hempseed oils, which acquire the property of drying more completely after they have been boiled, which is done either alone or with the addition of litharge, or other drying substance as it is termed. If they are set on fire, as is done in some cases, the oil becomes of more consistence, and approaches the nature of varnish. In this state they are used in the manufacture of printers' ink.

The combination of fixed oils with potash or soda, forms *hard soap*, and with oxyd of lead, the basis of the different *plasters*. Oils are composed essentially of hydrogen and carbon, some become *rancid*, and change their apparent, as well as chemical properties; either by exposure to air or an increase of temperature; and if the temperature be considerable, or a high heat be used in their production, they become empyreumatic.

SECTION V.

OF BITUMENS.

BITUMENOUS OILS.

1. Naptha is an oil of a brownish yellow colour, and is considered as a volatile oil, as it possesses some of the properties of those oils. Its specific gravity varies from 0.730 to 0.878. It is found in the earth. When darker coloured and less fluid, it is called *petroleum*. If petroleum be distilled, naptha is obtained from it.

2. Maltha, or sea-wax, is a solid substance found in a lake in Siberia, which seems to possess the character of a solid volatile oil, as it is soluble in alcohol, &c.

PROPER BITUMENS.

The general properties of that class of bitumens, which Dr. Thomson calls proper bitumens, are as follows:

1. They are either solid or of the consistence of tar.
2. Their colour is brown or black.
3. They leave a peculiar smell, called bitumenous.
4. They melt when heated, and burn with a bright flame, giving out much smoke and a peculiar flavour.
5. They are insoluble in water or alcohol.
6. They do not combine with alkalis.
7. Acids have little action upon them.

There are several kinds, which we shall briefly notice, viz.

1. *Asphaltum*, which is usually black, and found in great abundance in the island of Trinidad.

2. *Mineral Tar*, called also Barbadoes tar, from the place in which it is generally found, is of a blackish colour, and appears to be composed of petroleum and asphaltum.

3. *Mineral Caoutchouc*, which is found in Derbyshire, England, and approaches the nature of vegetable caoutchouc.

4. *Retinasphaltum*, composed of resin, asphaltum, and earths, found in Derbyshire accompanying Bovey coal.

5. *Pit-coal*, of which there are several varieties, such as brown-coal, black-coal, glance-coal, &c.; composed of different proportions of bitumen, charcoal, &c.

CONCLUSION.

It was our intention to have embraced animal and vegetable chemistry; but as these subjects are principally matters of fact without affording extemporaneous experiments, and as they are of themselves extensive, we have thought it better to defer treating of them, and to refer the reader to the more voluminous works of Thomson, Murray, and other authors.

THE END.

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