

**A primer of chemistry : including analysis / by Arthur Vacher.**

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A  
PRIMER OF CHEMISTRY  
INCLUDING  
ANALYSIS

BY  
ARTHUR VACHER



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## P R E F A C E.

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THIS little book represents a ten years' experience in teaching the rudiments of Chemistry and Analysis. Its arrangement is new, as will be evident at a glance over the table of contents.

It is carefully graduated so that the student can proceed step by step. He should make all the experiments and calculations up to p. 46. Commencing again at p. 76 he should practise each of the tables for analysis of single substances, and then make several analyses of unknown single substances. He should then practise the tables for the separation of metals; and lastly, make several analyses of unknown mixtures.

Some of the analytical tables were published in my abbreviated edition of FRESSENIUS'S Qualitative Analysis (1869). All, with the exception of Table III. *bis* (added by desire of a friend), were printed privately some time ago, and have been in constant use for years in my laboratory.

I have ventured upon employing the term *unit*



so as to avoid the terms *atom* and *molecule*, which appear to me unsuitable for ordinary use among beginners. I have also ventured, after very serious consideration, to introduce a new word, *antimetal*, to serve instead of *radical*. The subject of values I have endeavored to explain in a new and more absolute way.

The work is put forth as an attempt to present a general view of the elements of Inorganic Chemistry in a small compass, and to render their study as real and practical as possible.

## CONTENTS.

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### EXPERIMENTS WITH SOME OF THE ELEMENTS.

Hydrogen, 2; Oxygen, 3; Sulphur, 5; Chlorine, 6;  
Carbon, 7; Phosphorus, 7; Nitrogen, 8

### THE USE OF SYMBOLS.

List of Elements with Unit-weights and Symbols, 10;  
Definitions, 11

Arithmetical Questions on use of Symbols—

Given the percentage composition of a compound  
to find its formula, 12

Given the formula of a compound to find its per-  
centage composition, 13

Equations for previous experiments, 16

Arithmetical questions on the equations, 18

### EXPERIMENTS WITH SOME COMPOUNDS.

Actions of Hydric Sulphate—

On copper, 23; sodic chloride, 23; potassic nitrate,  
25; calcic fluoride, 25; potassic ferrocyanide,  
26; alcohol, 27



Actions of dilute hydric sulphate—

On iron, 27; zinc, 28; ferrous sulphide, 28

Actions of hydric chloride—

On calcic carbonate, 29; manganic binoxide, 30

Actions of hydric nitrate—

On silver, 30; mercury, 31; copper, 32; hydric chloride, 33; ferrous sulphate, 33

Actions of alkalies on acids—

Potash on hydric sulphate, 35; h. chloride, 36; h. nitrate, 36

Soda on hydric sulphate, h. chloride, h. nitrate, 36  
[Preparation of ammonia gas, 37]

Ammonia on hydric sulphate, h. chloride, h. nitrate, 37

[Ammonium hypothesis, 37]

Ammonia gas on hydric chloride gas, 38

[Action of heat on ammonic nitrate, 38]

Action of alkaline carbonates on acids, 39

Action of alkaline earths on acids, 39

Action of alkaline earthy carbonates on acids, 40

## FLAMES, 41.

## WEIGHTS AND MEASURES.

Definitions, 43

Rules for measure of gases, 43

Rules for specific gravity of gases, 44

Arithmetical questions on the measure of gases, 44

## CLASSIFICATION OF COMPOUNDS.

Definitions, 47

List of antimetals 48, and metals, 49

## LIST OF SUBSTANCES.

Elements, 50

Oxides of metals, 52; of non-metals, 55

Salts. Sulphides, 56; hyposulphite, 57; sulphates, 57; chlorides, 59; chlorate, 60; bromides, 60; iodides, 60; fluorides, 61; carbonates, 61; nitrates, 62; phosphates, 63; silicates, 64; borates, 64; manganate, 64; permanganate, 64; chromates, 64

Unclassed compounds, 65

Organic salts, 67

## ANALYSIS.

REAGENTS. Dry reagents, 68; test papers, 68; wet reagents, 69

## ANALYSIS OF SINGLE SUBSTANCES—

Preliminary Examination for metal, 75

Practice in same, 76

Preliminary examination for antimental, 80

Practice in same, 81

Solution, 82

Notes to same, and table of solubilities, 82

Examination of solution for metal, 84

Practice in same, 86

Examination of solution for antimental, 88

Practice in same, 88

Examination of insoluble substances, 89

Practice in same, 90

Practice in analysis of single substances, 91

## TABLES FOR SEPARATION OF METALS—

General Table, 92

Table I. for Group I., 93

Table II. for Group II., 94



Table III. for Group III., 95

Table III. *bis* for Group III., in presence of  
phosphates, &c., 96

Table IV. for Group IV., 97

Table V. for Group V., 98

Practice in separation of metals, 99

Practice in analysis of mixed substances, 99

## A

# PRIMER OF CHEMISTRY.

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## EXPERIMENTS WITH SOME OF THE ELEMENTS.

*The Pneumatic Trough.*—This is an instrument used in the collection of gases (*pneuma*, Greek for gas). The ordinary form consists of two parts made of earthenware, a pan and a so-called beehive shelf. To see how it is used, fill a bottle with air from the lungs by its means. Put some water in the trough, so as to rise about half an inch above the top of the shelf, take a bottle, lay it down in the water, and when it is full or nearly full, raise it cautiously on to the shelf, with the mouth downwards and over the top hole, allowing no water to escape. Now place one end of a long glass tube through the side hole of the shelf, and blow through the other end. The air will rise, and gradually take the place of the water in the bottle.

*The Hydrogen Apparatus.*—This consists of a narrow-mouthed bottle, fitted with a cork, through which passes a bent glass tube, the exit of the latter being joined with a long glass tube by means of a piece of india-rubber tube.

*To Cut and Bend the Glass Tube.*—Take a piece of soft tubing (soft = easily softened by heat), if one



end is not even scratch it with a triangular file a short distance from the end and then break it. Make a scratch about five inches from the end, and break the piece off. Hold the piece in an ordinary gas flame, turning it slowly round till the middle is soft, then take it away from the flame and bend it at right angles. Remove the sharp edges at each end with a file.

*To Prepare and Bore the Cork.*—Select a cork apparently larger than necessary to fit the bottle, wrap the cork in paper to keep it clean, and roll it under your foot to soften it. It will now probably fit the bottle tightly. Heat the point of a rat-tail rasp red hot, bore the cork through the middle, and then enlarge the hole carefully so that the glass tube, after slight warming at the end, will just fit into it.

## HYDROGEN.

*Preparation.*—Put some zinc into the bottle, fill it a third with water, and add hydric sulphate (sulphuric acid) to the extent of a fifth the volume of the water. If no effervescence occurs, the zinc is too pure, and two drops of platonic chloride solution, or a little cupric sulphate solution, must be added. Insert the cork with tube, allow the air to be expelled from the bottle, and then begin to collect the gas over the pneumatic trough. When the receiving bottle is full, close its mouth under water with a saucer or similar vessel, remove it from the trough, and set it mouth downwards on the table, the mouth being closed by the water in the saucer.

*Burns in Air.*—Raise the bottle, still keeping it inverted, apply a light immediately, turn the mouth upwards and pour in water without delay



to drive out the hydrogen. The hydrogen will burn with a pale flame.

*Produces Water when it Burns.*—Remove the delivery tube from the trough, light the gas as it issues from the tube, and hold a dry tumbler over the flame, its sides will soon become covered with dew. (Hydrogen signifies water generator.)

*Is lighter than Air.*—Collect a wide-mouthed bottle of hydrogen, and allow it to stand open mouth upwards for a short time, then apply a light. The bottle is full of air. If a light be applied too quickly, a harmless explosion will occur, which will be explained under Oxygen.

## OXYGEN.

*Preparation.*—If you have not a dry test tube, dry one by moving it to and fro mouth downwards in the Bunsen flame, and sucking out the steam with a glass tube. Fit the test tube like the bottle was fitted for making hydrogen, only let the tube in the cork be three inches long and straight. Support it horizontally above a Bunsen lamp, and place the pneumatic trough at a convenient distance. Mix a small quantity of potassic chlorate in powder with about a fifth of manganic binoxide, and put the mixture into the test tube, which should not be more than a third full. Apply a gentle heat, and collect the escaping gas. When the bottle is full, cover the mouth, and remove it from the trough. Oxygen, like hydrogen, is as transparent and odorless as air, but made in this way it is sometimes cloudy and smells of chlorine.

*It inflames smouldering Wood.*—Light a chip of wood, when it has been burning a short time blow



out the flame, leaving a spark, then plunge it into the oxygen; it will at once burst into flame and burn brilliantly.

*Charcoal burns brightly in it.*—Make some more oxygen, and instead of collecting it, direct the stream on to a lump of charcoal, a corner of which has been lighted. The charcoal will burn with dazzling light.

*Iron burns in it.*—Make some more oxygen, and direct the stream through a flame on to the point of a thin iron or steel wire. As soon as the iron is alight let the flame be removed, but keep the stream of gas well directed upon the burning point. The combustion is brilliant. If it stops, the oxide must be removed from the point of the wire, before the latter can be relighted. The product of the combustion consists of the black oxide of iron; it is thrown off in the form of hollow globules. A watch-spring burns beautifully; its elasticity may be previously removed by heating to redness. This experiment may be made more striking by using several steel wires twisted together like a rope, and procuring a good supply of oxygen, using a flask for the generating vessel, and a larger quantity of the mixture.

*A Mixture of Oxygen and Hydrogen explodes.*—Fill a soda-water bottle one-third with oxygen and two-thirds with hydrogen, and apply a light to the mixture. A loud explosion will occur. The two gases combine to produce water.

*A Mixture of Air and Hydrogen explodes.*—Fill a pint or quart bottle five-sevenths with air and two-sevenths with hydrogen, and apply a light to the mixture. An explosion will occur. The noise will be much less in this case, in consequence of the presence of nitrogen, which amounts to



four-fifths of the air, and takes no part in the change.

*Combustibles deflagrate with melted Potassic Chlorate.*—Heat some potassic chlorate in a wide test tube; the salt when melted should not occupy more than an inch of the tube. As soon as the salt appears to boil (from the escape of oxygen), take the tube out of the flame, hold it upright in a metal support, and drop into it a small piece or two of charcoal, then of white sugar, then of sulphur, then of shellac. Each will burn with great violence. This kind of combustion is called deflagration.

*Sulphur deflagrates on melted Potassic Nitrate.*—Melt some potassic nitrate in a test tube; the salt when melted should not occupy more than half an inch of the tube. Heat still more, take the tube out of the flame, hold it upright in a metal support, with a vessel of water underneath, and without delay drop in two or three lumps of sulphur. The latter will burn with a bright light. The heat is often so great the bottom of the tube is melted off, and falls down into the water beneath.

*A Mixture of Sugar and Potassic Chlorate deflagrates with Sulphuric Acid.*—Mix some powdered potassic chlorate with half its bulk of powdered sugar, put the mixture on a plate, and touch it with a rod dipped in sulphuric acid. Deflagration will take place.

## SULPHUR.

*Effect of Heat.*—Put some lumps of roll sulphur in a test tube, and apply heat very gently, so as just to melt it. It will be converted into a pale sherry-colored fluid. Pour some out into water, it will form little beads of the ordinary variety.



Continue heating what remains in the tube, it will acquire a dark color like treacle, and become so thick that the tube may be inverted. Still continue heating, and the fluid will become darker and thinner, and begin to boil, yielding a brown vapor, the color of which may be seen through the tube.

*Elastic Variety.*—Now, without delay, pour the sulphur gently into a jug of water, when it will solidify to elastic threads.

*Sulphur Burns to Sulphurous Acid.*—Put a small piece of sulphur on a porcelain crucible lid, and hold it in the flame till it is alight, then remove it. It will continue to burn, combining with the oxygen of the air to a gas (sulphurous acid) of well-known odor. Finally nothing will be left.

### CHLORINE.

*Preparation.*—When experimenting with this gas, you should as far as possible avoid inhaling it, and not allow it to escape unnecessarily into the air. Fit up a flask like the bottle was fitted up for making hydrogen, and support it over a Bunsen lamp, also have the pneumatic trough handy. Fill the flask about one-fifth with a mixture of four parts hydric chloride (hydrochloric acid) and one part water, add some manganic binoxide, and mix well by shaking. Apply a gentle heat, and collect the escaping gas. It has a pale green color (*chloros*, Greek for light green) and very powerful smell. As it is rather soluble in water, some persons prefer to collect it by displacement, that is, by passing it to the bottom of a bottle full of air, which it gradually displaces, being about two and a half times heavier.

*Bleaching Action.*—Moisten a piece of red paper



and put it into the bottle of chlorine, replacing the cover instantly. The paper will be bleached.

### CARBON.

*Preparation from Wood.*—Into a test tube put a piece of wood about two inches long, and support it with the mouth slightly downwards over a lamp, place a little dish underneath the mouth, and apply heat. Copious fumes will escape, some of which will condense and fall into the dish in the form of tar and water; finally, when no more vapor comes off, charcoal will be left.

*Charcoal from Sugar, Paper, Calico.*—Take thirty grammes loaf sugar, and powder it. Stand a pint beaker on a plate. In the beaker mix 10 c.c. water and 35 c.c. sulphuric acid, add the sugar, and stir well with a rod till it begins to rise. The mixture will swell up to a coherent mass of charcoal, nearly filling the beaker. It may be turned out on to the plate with a knife. The same experiment may be repeated with ordinary white blotting paper instead of sugar, and also with calico. In these cases, however, the mixture of water and sulphuric acid should be heated over a lamp before the addition of the paper or calico.

### PHOSPHORUS.

When freshly prepared it is a white, translucent, rather soft substance like wax, on keeping in water it acquires a reddish coating. It emits a pale light in the dark when exposed to air (the name signifies light-bearer). It is liable to take fire of its own accord, and is therefore kept in water.



*Spontaneous Inflammability.*—The most striking way to show this is as follows. Cut off a small piece with a knife—the phosphorus may be held by the fingers on the bench while being cut. Dry it on a cloth or on blotting paper, put it in a dry test tube, and treat it with a little bisulphide of carbon. The phosphorus will at once dissolve. Moisten a piece of blotting paper with the solution. The bisulphide of carbon being very volatile, evaporates in a minute, and leaves the phosphorus spread out over a large surface. The phosphorus will soon take fire, unless the solution were too weak.

*It Burns to Phosphoric Acid.*—In the middle of a common plate put a porcelain crucible lid, with the handle knocked off, and cover with a bell glass. Let everything be perfectly dry. Put a small piece of dry phosphorus on the crucible lid, touch it with a warmed glass rod to light it, and replace the bell glass. The phosphorus will burn, combining with oxygen, and producing phosphoric acid, which appears in the form of a white smoke, and falls like snow on the plate. When the combustion is finished, remove the bell and expose the acid a minute or two to the air, it will attract a quantity of moisture from the air and become wet. (A substance which attracts moisture from the air is called *hygroscopic*, if in so doing it becomes liquid, it is said to *deliquesce*.) Also test the acid with litmus paper, which will be turned red.

## NITROGEN.

*Preparation.* — Arrange an apparatus like the last, only take a soup plate instead of an ordinary plate, fill it with water, float the lid on a bung,



and let the bell glass have a stoppered opening at the top. Put in the lid a small piece of dry phosphorus, light it by touching with a warmed glass rod, and cover it with the bell. When the light has gone out, allow the white fumes time to subside into the water; an invisible gas remains, which is nitrogen. The air is a mixture of 4 parts nitrogen and 1 part oxygen. Notice that the water has risen in the bell, showing that a portion of the air has disappeared. Remove the stopper, and introduce a lighted piece of paper, the flame will be extinguished. The nitrogen generally smells of the phosphorus.

## THE USE OF SYMBOLS.

LIST OF ELEMENTS, WITH THEIR UNIT-WEIGHTS  
AND SYMBOLS.

## METALS.

<i>Name.</i>	<i>Weight of Unit.</i>	<i>Symbol.</i>
Silver ( <i>Argentum</i> ) . . .	108	Ag
Lead ( <i>Plumbum</i> ) . . .	207	Pb
Mercury ( <i>Hydrargyrum</i> ) .	200	Hg
Bismuth . . . . .	210	Bi
Copper ( <i>Cuprum</i> ) . . .	63·5	Cu
Tin ( <i>Stannum</i> ) . . . .	118	Sn
Antimony ( <i>Stibium</i> ) . .	122	Sb
Gold ( <i>Aurum</i> ) . . . . .	196·5	Au
Platinum . . . . .	197·5	Pt
Nickel . . . . .	58·7	Ni
Cobalt . . . . .	58·7	Co
Iron ( <i>Ferrum</i> ) . . . .	56	Fe
Manganese . . . . .	55	Mn
Zinc . . . . .	65·2	Zn
Chromium . . . . .	52·5	Cr
Aluminium . . . . .	27·4	Al
Barium . . . . .	137	Ba
Strontium . . . . .	87·5	Sr
Calcium . . . . .	40	Ca
Magnesium . . . . .	24	Mg
Potassium ( <i>Kalium</i> ) . .	39·1	K
Sodium ( <i>Natrium</i> ) . . .	23	Na
Hydrogen . . . . .	1	H



## NON-METALS.

<i>Name.</i>	<i>Weight of Unit.</i>	<i>Symbol.</i>
Oxygen . . . . .	16	O
Sulphur . . . . .	32	S
Chlorine . . . . .	35.5	Cl
Bromine . . . . .	80	Br
Iodine . . . . .	127	I
Fluorine . . . . .	19	F
Carbon . . . . .	12	C
Nitrogen . . . . .	14	N
Phosphorus . . . . .	31	P
Arsenic . . . . .	75	As
Silicon . . . . .	28	Si
Boron . . . . .	11	B

To each element is assigned a particular *Unit* of quantity, and also a *Symbol*, which represents that unit.

A *Compound* is any substance which is not an element.

The *Formula* of a compound is a collection of symbols which shows the elements present in the compound, and the amounts of those elements ; at the same time it represents the *Unit* of quantity of the compound.

The *Unit* of a compound is the sum of the quantities represented by the symbols composing the formula.

Thus— $\text{H}_2\text{O}$  is called the formula of water ;  $\text{H}_2\text{SO}_4$  the formula of hydric sulphate ;  $\text{KClO}_3$  the formula of potassic chlorate :

$\text{H}_2\text{O}$  signifies 2 units (2 parts) of hydrogen,

## 12 QUESTIONS ON THE USE OF SYMBOLS.

combined with 1 unit (16 parts) of oxygen, making 1 unit (18 parts) of water.

$\text{H}_2\text{SO}_4$  signifies 2 units (2 parts) of hydrogen, combined with 1 unit (32 parts) of sulphur, and 4 units (64 parts) of oxygen, making 1 unit (98 parts) of hydric sulphate.

$\text{KClO}_3$  signifies 1 unit (39.1 parts) of potassium combined with 1 unit (35.5 parts) of chlorine, and 3 units (48 parts) of oxygen, making 1 unit (122.6 parts) of potassic chlorate.

### QUESTIONS ON USE OF SYMBOLS.

*Given the percentage composition of a compound, to find its formula.*

1. The percentage composition of water is

Hydrogen . . . . .	11.11
Oxygen . . . . .	88.88

What is its formula?

The composition of water may be represented thus—

Hyd.<sub>11.11</sub>    Ox.<sub>88.88</sub>

putting H for Hyd.<sub>1</sub>, and O for Ox.<sub>16</sub>,

we have     $\text{H}_{\frac{11.11}{1}}$      $\text{O}_{\frac{88.88}{16}}$

=  $\text{H}_{11.11}$      $\text{O}_{5.55}$

=  $\text{H}_2\text{O}$

2. The percentage composition of hydric sulphate is—

Hydrogen . . . . .	2.04
Sulphur . . . . .	32.65
Oxygen . . . . .	65.31

What is its formula?



The composition of hydric sulphate may be represented thus—

$$\begin{array}{l}
 \text{Hyd.}_{2\cdot04} \quad \text{Sul.}_{32\cdot65} \quad \text{Ox.}_{65\cdot31} \\
 \text{putting H for Hyd.}_{1}, \text{S for Sul.}_{32}, \text{and O for Ox.}_{16}, \\
 \text{we have} \quad \frac{\text{H}_{2\cdot04}}{1} \quad \frac{\text{S}_{32\cdot65}}{32} \quad \frac{\text{O}_{65\cdot31}}{16} \\
 = \text{H}_{2\cdot04} \quad \text{S}_{1\cdot02} \quad \text{O}_{4\cdot08} \\
 = \text{H}_2\text{SO}_4
 \end{array}$$

3. The percentage composition of potassic chlorate is—

Potassium . . . . .	31·89
Chlorine . . . . .	28·95
Oxygen . . . . .	39·15

What is its formula?

The composition of potassic chlorate may be represented thus—

$$\begin{array}{l}
 \text{Pot.}_{31\cdot89} \quad \text{Chlor.}_{28\cdot95} \quad \text{Ox.}_{39\cdot15} \\
 \text{putting K for Pot.}_{39\cdot1}, \text{Cl for Chlor.}_{35\cdot5}, \text{and O for} \\
 \text{Ox.}_{16}, \\
 \text{we have} \quad \frac{\text{K}_{31\cdot89}}{39\cdot1} \quad \frac{\text{Cl}_{28\cdot95}}{35\cdot5} \quad \frac{\text{O}_{39\cdot15}}{16} \\
 = \text{K}_{\cdot816} \quad \text{Cl}_{\cdot815} \quad \text{O}_{2\cdot447} \\
 = \text{KClO}_3
 \end{array}$$

*Given the formula of a compound, to find its percentage composition.*

1. The formula of water is  $\text{H}_2\text{O}$ , what is its percentage composition?

The composition of water is—

$\text{H}_2$ . . . . .	Hydrogen	2
O . . . . .	Oxygen	16
		<hr/>
		18

# 14 QUESTIONS ON THE USE OF SYMBOLS.

18 parts of water contain 2 of hydrogen

$$\begin{array}{ccccccc} 1 & & \text{,,} & & \text{,,} & & \frac{2}{18} & & \text{,,} \\ 100 & & \text{,,} & & \text{,,} & & \frac{2 \times 100}{18} & & \text{,,} \\ & & & & & & = & & 11.11 \text{ of hydrogen.} \end{array}$$

Again—

18 parts of water contain 16 of oxygen

$$\begin{array}{ccccccc} 1 & & \text{,,} & & \text{,,} & & \frac{16}{18} & & \text{,,} \\ 100 & & \text{,,} & & \text{,,} & & \frac{16 \times 100}{18} & & \text{,,} \\ & & & & & & = & & 88.88 \text{ of oxygen.} \end{array}$$

Therefore the percentage composition required is—

Hydrogen . . . . .	11.11
Oxygen . . . . .	88.88

2. The formula of hydric sulphate is  $\text{H}_2\text{SO}_4$ , what is its percentage composition ?

The composition of hydric sulphate is—

$\text{H}_2$ . . . . .	Hydrogen	2
S . . . . .	Sulphur	32
$\text{O}_4$ . . . . .	Oxygen	64
		<hr/>
		98

98 parts of hydric sulphate contain 2 of hydrogen

$$\begin{array}{ccccccc} 1 & & \text{,,} & & \text{,,} & & \frac{2}{98} & & \text{,,} \\ 100 & & \text{,,} & & \text{,,} & & \frac{2 \times 100}{98} & & \text{,,} \\ & & & & & & = & & 2.04 \text{ of hydrogen.} \end{array}$$



Again—

98 parts of hydric sulphate contain 32 of sulphur

1	”	”	”	”	$\frac{32}{98}$	”
---	---	---	---	---	-----------------	---

100	”	”	”	”	$\frac{32 \times 100}{98}$	”
-----	---	---	---	---	----------------------------	---

= 32.65 of sulphur.

Again—

98 parts of hydric sulphate contain 64 of oxygen

1	”	”	”	”	$\frac{64}{98}$	”
---	---	---	---	---	-----------------	---

100	”	”	”	”	$\frac{64 \times 100}{98}$	”
-----	---	---	---	---	----------------------------	---

= 65.31 of oxygen.

Therefore the percentage composition required is—

Hydrogen . . . .	2·04
------------------	------

Sulphur . . . . .	32·65
-------------------	-------

Oxygen . . . . .	65·31
------------------	-------

3. The formula of potassic chlorate is  $\text{KClO}_3$ , what is its percentage composition?

The composition of potassic chlorate is—

K . . . Potassium 39·1

Cl	.	.	.	.	Chlorine	35.5
----	---	---	---	---	----------	------

O <sub>3</sub>	.	.	.	.	Oxygen	48·0
----------------	---	---	---	---	--------	------

122.6

122.6 parts of potassic chlorate contain . . . 39.1 of potassium

1 part of potassic chlorate contains . . .	$\frac{59.1}{122.6}$	”
--	----------------------	---

100 parts of potassic chlorate contain . . . .	$\frac{39.1 \times 100}{122.6}$	22
--	---------------------------------	----

= 31.89 of potassium.

# 16 EQUATIONS FOR PREVIOUS EXPERIMENTS.

Again—

$$\begin{array}{lcl}
 122\cdot6 \text{ parts of potassic chlo-} & & \\
 \text{rate contain . . . . .} & 35\cdot5 & \text{of chlorine.} \\
 1 \text{ part of potassic chlo-} & & \\
 \text{rate contains . . . . .} & \frac{35\cdot5}{122\cdot6} & \text{,,} \\
 100 \text{ parts of potassic chlo-} & & \\
 \text{rate contain . . . . .} & \frac{35\cdot5 \times 100}{122\cdot6} & \text{,,} \\
 & = 28\cdot95 & \text{of chlorine.}
 \end{array}$$

Again—

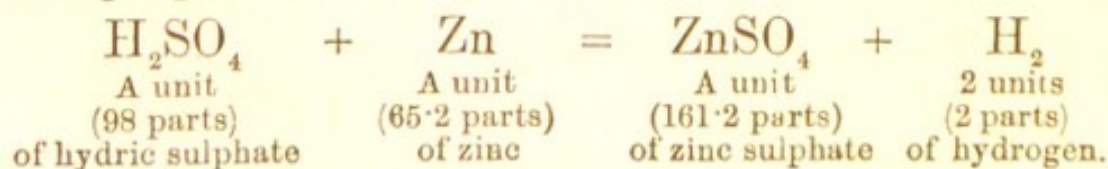
$$\begin{array}{lcl}
 122\cdot6 \text{ parts of potassic chlo-} & & \\
 \text{rate contain . . . . .} & 48 & \text{of oxygen.} \\
 1 \text{ part of potassic chlo-} & & \\
 \text{rate contains . . . . .} & \frac{48}{122\cdot6} & \text{,,} \\
 100 \text{ parts of potassic chlo-} & & \\
 \text{rate contain . . . . .} & \frac{48 \times 100}{122\cdot6} & \text{,,} \\
 & = 39\cdot15 & \text{of oxygen.}
 \end{array}$$

Therefore the percentage composition is—

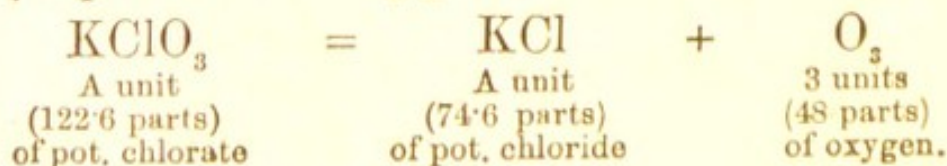
Potassium . . . . .	31·89
Chlorine . . . . .	28·95
Oxygen . . . . .	39·15

## EQUATIONS FOR PREVIOUS EXPERIMENTS.

The preparation of hydrogen—



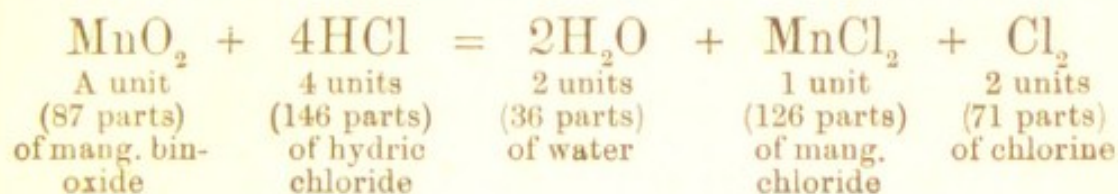
The preparation of oxygen—



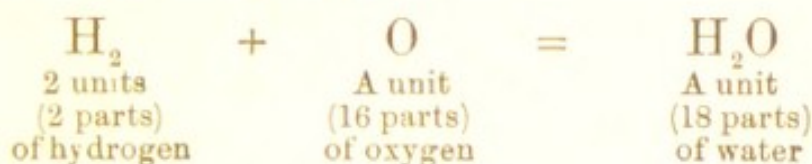


The manganic binoxide mixed with the potassic chlorate is not altered, it merely assists the decomposition.

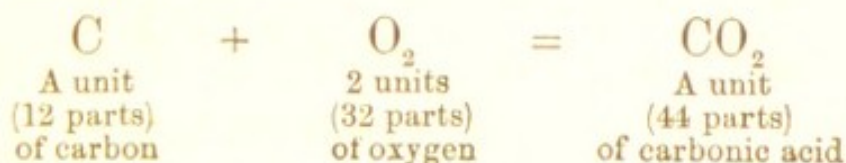
The preparation of chlorine—



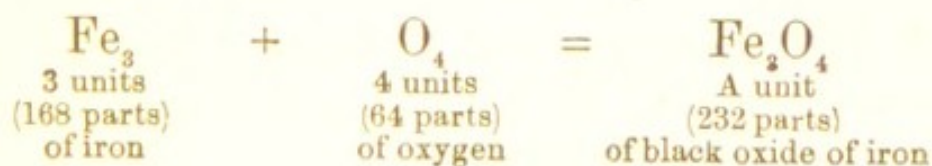
The burning of hydrogen—



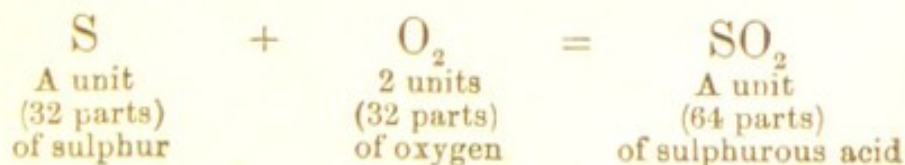
The burning of carbon—



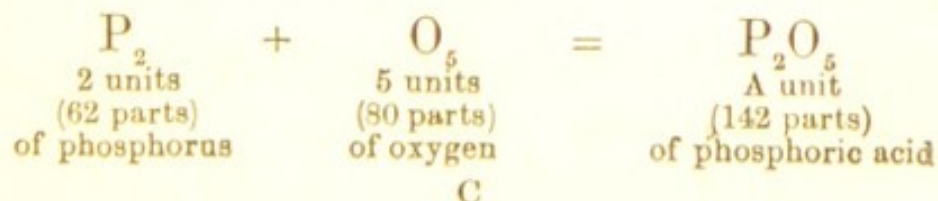
The burning of iron—



The burning of sulphur—



The burning of phosphorus—



QUESTIONS ON EQUATIONS FOR PREVIOUS  
EXPERIMENTS.

1. In a ton of water how many pounds of hydrogen and oxygen?

$H_2O$  contains  $H_2$ .

18 lbs. of water contain 2 lbs. of hydrogen

1	”	”	”	$\frac{2}{18}$	”	”
2240	”	”	”	$\frac{2 \times 2240}{18}$	”	”

= 249 lbs. of hydrogen.

Again—

$H_2O$  contains O.

18 lbs. of water contain 16 lbs. of oxygen

1	”	”	”	$\frac{16}{18}$	”	”
2240	”	”	”	$\frac{16 \times 2240}{18}$	”	”

= 1991 lbs. of oxygen.

*Ans.* 249 lbs. of hydrogen.

1991 lbs. of oxygen.

2. If I burnt a ton of hydrogen, how many lbs. of oxygen would be required, and how many lbs. of water would be produced?

$H_2$  requires O.

2 lbs. of hydrogen require 16 lbs. of oxygen

1	”	”	”	$\frac{16}{2}$	”	”
2240	”	”	”	$\frac{16 \times 2240}{2}$	”	”

= 17,920 lbs. of oxygen.

Again—

2240 lbs. of hydrogen + 17,920 lbs. of oxygen =  
20,160 lbs. of water.



Or directly—

$H_2$  produces  $H_2O$ .

2 lbs. of hydrogen produce 18 lbs. of water

1	"	"	"	$\frac{18}{2}$	"
2240	"	"	"	$\frac{18 \times 2240}{2}$	"

= 20,160 lbs. of water.

*Ans.* 17,920 lbs. of oxygen.  
20,160 lbs. of water.

3. If I burnt a ton of iron, how much oxygen would be used, and how much black oxide would be produced?

$Fe_3$  requires  $O_4$ .

168 lbs. of iron require 64 lbs. of oxygen

1	"	"	$\frac{64}{168}$	"
2240	"	"	$\frac{64 \times 2240}{168}$	"

= 853 lbs. of oxygen.

Again—

2240 lbs. of iron + 853 lbs. of oxygen = 3093 lbs. of black oxide of iron.

Or directly—

$Fe_3$  produces  $Fe_3O_4$ .

168 lbs. of iron produce 232 lbs. of black oxide

1	"	"	$\frac{232}{168}$	"	"
2240	"	"	$\frac{232 \times 2240}{168}$	"	"

= 3093 lbs. of black oxide of iron.

*Ans.* 853 lbs. of oxygen.  
3093 lbs. of black oxide of iron.

4. If I burnt a ton of phosphorus, how many lbs. of oxygen would be used, and how much phosphoric acid would be produced?

*Ans.* 2890 lbs. of oxygen. 5130 lbs. of phosphoric acid.

5. If I decomposed a ton of potassic chlorate, how much potassic chloride and oxygen would be obtained?

*Ans.* 1363 lbs. of potassic chloride. 877 lbs. of oxygen.

6. If I want a ton of oxygen, how much potassic chlorate would have to be taken?

*Ans.* 5721 lbs.

7. In a ton of hydric sulphate how much hydrogen? In liberating the latter, how much zinc must be used? How much zinc sulphate would be left?

*Ans.* 46 lbs. of hydrogen. 1490 lbs. of zinc. 3684 lbs. of zinc sulphate.



## EXPERIMENTS WITH SOME COMPOUNDS.

### ACTIONS OF HYDRIC SULPHATE.

1. On copper (preparation of sulphurous acid and cupric sulphate).
2. On sodic chloride (preparation of hydric chloride gas and solution).
3. On potassic nitrate (preparation of hydric nitrate and hydropotassic sulphate).
4. On calcic fluoride (preparation of hydric fluoride and etching glass).
5. On potassic ferrocyanide (preparation of carbonic oxide).
6. On spirit of wine (preparation of olefiant gas).

### ACTIONS OF DILUTE HYDRIC SULPHATE.

7. On iron (preparation of hydrogen and ferrous sulphate).
8. On zinc (preparation of hydrogen and zinc sulphate).
9. On ferrous sulphide (preparation of hydric sulphide and ferrous sulphate. Action of the former on various metallic solutions).

### ACTIONS OF HYDRIC CHLORIDE.

10. On calcic carbonate (preparation of carbonic acid, and action of the latter on lime water).
11. On manganic binoxide (preparation of chlorine).

### ACTIONS OF HYDRIC NITRATE.

12. On silver (preparation of argentic nitrate,

precipitation of argentic chloride and reduction of the latter).

13. On mercury (preparation of mercuric nitrate, conversion of this into mercuric oxide, and reduction of the latter).
14. On copper (preparation of nitric oxide and cupric nitrate, conversion of the latter into cupric oxide, and reduction of the latter).
15. On hydric chloride (preparation of aqua regia).
16. On ferrous sulphate (preparation of ferric sulphate. Test for nitric acid).

#### ACTION OF ALKALIES ON ACIDS.

17. Potash on hydric sulphate (neutralizing, preparation of potassic sulphate, and hydro-potassic sulphate).
18. Potash on hydric chloride (preparation of potassic chloride).
19. Potash on hydric nitrate (preparation of potassic nitrate).
20. Soda on hydric sulphate, h. chloride and h. nitrate.
- [21. Preparation of ammonia gas.]  
Ammonia on h. sulphate, h. chloride, and h. nitrate.  
[Ammonium hypothesis.]
22. Ammonia gas on hydric chloride gas.
- [23. Ammonic nitrate heated (preparation of nitrous oxide).]

#### ACTION OF ALKALINE CARBONATES ON ACIDS.

#### ACTION OF ALKALINE EARTHS ON ACIDS.

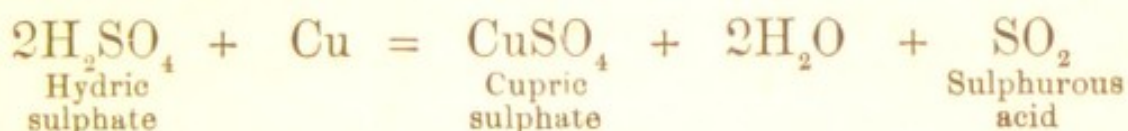
#### ACTION OF ALKALINE EARTHY CARBONATES ON ACIDS.



## ACTIONS OF HYDRIC SULPHATE.

## 1. HYDRIC SULPHATE ON COPPER.

Put some hydric sulphate in a Berlin dish, and add some copper nails or turnings. Apply heat, when the following change will take place :—



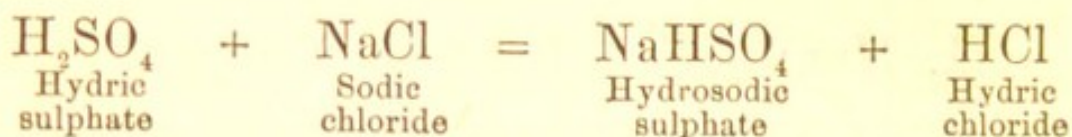
The sulphurous acid is the gas produced when sulphur burns; it is allowed to escape, and the experiment should therefore be done in a draught cupboard. As soon as the action has ceased the dish will contain the excess of hydric sulphate with a sandy deposit of anhydrous cupric sulphate ( $\text{CuSO}_4$ —anhydrous means without water). Pour away the hydric sulphate, treat the deposit with water, and warm; the deposit will dissolve to a blue liquid, discolored by the presence of a black undissolved substance. Take a disc of blotting paper, fold it into a quadrant, open it into a cone, place it in a funnel, and through this arrangement filter the fluid. Allow the clear blue liquid to stand; if after some time no crystals appear, evaporate (that is, boil away some of the water), and allow to stand again. The blue crystals are cupric sulphate containing water of crystallization ( $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ ).

## 2. HYDRIC SULPHATE ON SODIC CHLORIDE.

Fit up an apparatus like that used for chlorine, and have ready a dry soda-water bottle. In the flask put some lumps of rock salt; the ordinary table salt is not convenient, as it produces so much



frothing. Add some hydric sulphate, and warm ; the following change takes place :—



The hydric chloride is evolved as a gas. Collect it by displacement in the soda-water bottle, and allow the gas to escape for some time after the bottle appears full, so as to insure all air being expelled. The gas is clear ; when escaping in the air it appears opaque from combining with the watery vapor in the air. Now take away the lamp from the flask, and without delay remove the delivery tube carefully, and cover the bottle with the hand. Hold the bottle mouth downwards in water, and then remove the hand covering the mouth. The water will rush up and fill the bottle—that is, so far as the air was expelled. This shows the eagerness with which water dissolves hydric chloride.

Replace the lamp under the flask, and when the gas issues freely dip the delivery tube in half or a quarter of an inch of water at the bottom of a bottle ; the gas will be entirely absorbed. In this way a solution of hydric chloride containing several hundred volumes of the gas may be made. It is this solution which is generally called hydric chloride or hydrochloric acid, and was used in making chlorine. The water into which the tube dips is directed to be shallow, as if a momentary stoppage occurs in the evolution the water may be drawn up the tube, and even enter the flask.



## 3. HYDRIC SULPHATE ON POTASSIC NITRATE.

Take a stoppered retort and fix it over a Bunsen; slip a test tube over the neck, and let the tube rest in a basin of water, so that it may be nearly covered by the water. In the retort put 1 oz. of potassic nitrate (nitre) and 1 oz. (weighed) of hydric sulphate, and apply heat. The following change takes place:—



The hydric nitrate (nitric acid) distils over as a yellow liquid. It is accompanied by red fumes, which consist of hyponitric acid, oxygen and water, produced by the decomposition of a small portion, thus—



If the contents of the retort cake, apply a stronger heat till they melt. When no more fluid comes over, remove the test tube. Now warm the upper part of the retort cautiously in the flame, and pour out its contents on a slab of stone or a copper dish; they will set to a cake of hydropotassic sulphate. As we wished to get this we had to weigh out the quantities taken, and as  $\text{H}_2\text{SO}_4$  represents 98 parts, and  $\text{KNO}_3$  101.1 parts, equal weights were near enough. In most of these experiments it is not usual to weigh out the substances employed, and excess of one or the other makes no difference.

## 4. HYDRIC SULPHATE ON CALCIC FLUORIDE.

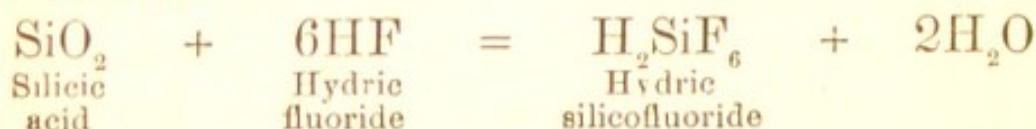
Take a piece of glass about two inches square, warm it in the Bunsen flame, rub some wax on it,



allow to cool, and write something on the wax with a sharp steel point. Now take a very small quantity of calcic fluoride (fluor spar), powder it very finely, put it into a platinum crucible, moisten it with a drop or two of hydric sulphate, and stir to a paste. Place the glass waxed side downwards on the platinum crucible, and warm the bottom of the crucible with great caution, so as not to melt the wax. Set the whole aside a few minutes, then remove the glass, melt the wax, and clean it off. The writing will be etched. The change which takes place by the action of hydric sulphate on calcic fluoride is as follows:—

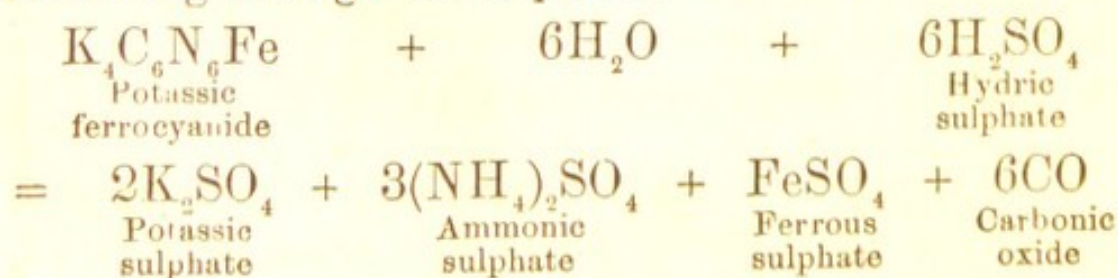


The hydric fluoride comes off in the form of pungent fumes. These attack the glass, which consists of silicic acid, soda and lime, by dissolving the former.



### 5. HYDRIC SULPHATE ON POTASSIC FERROCYANIDE.

Set up the apparatus used in making chlorine. Fill the flask one-fifth with hydric sulphate, add potassic ferrocyanide in powder to the amount of one-twentieth of the acid, and apply heat. The following change takes place:—





Three of the  $6\text{H}_2\text{O}$  required exist in the crystals of potassic ferrocyanide as water of crystallization, the rest is present in the hydric sulphate. The carbonic oxide escapes as a gas. Collect it in a bottle, light it, and pour in water. It burns to carbonic acid ( $\text{CO}_2$ ) with a pale blue flame.

## 6. HYDRIC SULPHATE ON SPIRIT OF WINE.

Same apparatus as in previous experiment. In the flask put  $2\frac{1}{2}$  measures of hydric sulphate and 1 measure of spirit of wine; methylated spirit will answer the purpose. Add a little sand to the mixture, and apply heat. The following change takes place:—

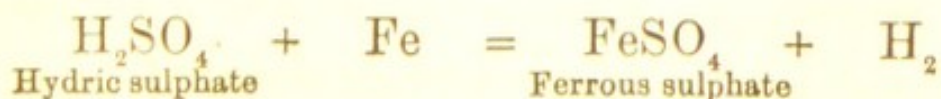


The sulphuric acid takes away the elements of water; however, this is not the only action; a quantity of carbon is separated, and sulphurous acid produced. The olefiant gas escapes. It is so called because it gives an oil when mixed with chlorine. Collect and light. It burns with a highly luminous flame to carbonic acid ( $\text{CO}_2$ ) and water.

## ACTIONS OF DILUTE HYDRIC SULPHATE.

### 7. DILUTE HYDRIC SULPHATE ON IRON.

Into a flask put 10 measures of water and 1 measure of hydric sulphate, add some iron wire and warm without boiling. The following change takes place:—



The escaping hydrogen has an unpleasant smell, as small portions of it are combined with carbon, sulphur, and phosphorus, elements present in the iron. When the action has ceased, and the acid will take up no more iron, filter. Pale green crystals of ferrous sulphate containing  $7\text{H}_2\text{O}$  may be obtained from this solution.

### 8. DILUTE HYDRIC SULPHATE ON ZINC.

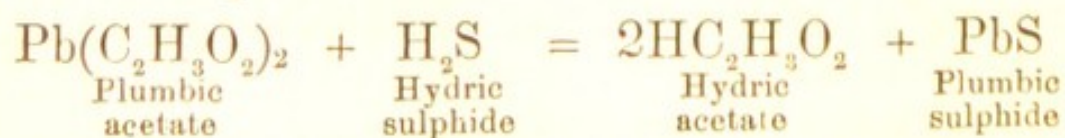
Already studied in making hydrogen. The change is exactly similar to the above. By filtering the residue in the generating bottle and setting aside, crystals of zinc sulphate containing  $7\text{H}_2\text{O}$  may be obtained.

### 9. DILUTE HYDRIC SULPHATE ON FERROUS SULPHIDE.

Set up the apparatus used for making hydrogen. No pneumatic trough will be required. In the bottle put some lumps of ferrous sulphide, add some water, and then hydric sulphate to the amount of one-tenth the volume of the water. The following change will take place:—



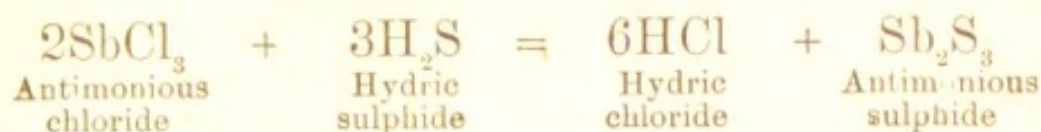
The hydric sulphide comes off as a gas; it smells like rotten eggs. Pass the gas into a very weak solution of plumbic acetate, a black precipitate of plumbic sulphide will be thrown down, thus—



Also pass the gas into a weak solution of anti-



monious chloride, when an orange precipitate of antimonious sulphide will be thrown down, thus—



Also pass the gas into a weak solution of arsenious acid, when a yellow precipitate of arsenious sulphide will be thrown down, thus—



Also light the gas as it issues from the tube, it will burn to water and sulphurous acid.

When the action is over, filter. Crystals of ferrous sulphate may be obtained from the solution, as after the action of dilute hydric sulphate on metallic iron.

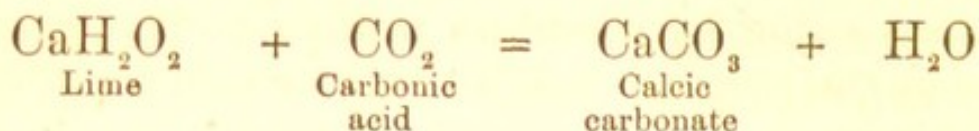
## ACTIONS OF HYDRIC CHLORIDE.

### 10. HYDRIC CHLORIDE ON CALCIC CARBONATE.

Same apparatus as for making hydrogen. In the bottle put some lumps of marble, add water, and then an equal bulk of hydric chloride. The following change takes place:—



The carbonic acid escapes as a gas, the calcic chloride dissolves in the water. Collect it over the trough. Introduce a lighted piece of paper into the gas, and it will be extinguished. Collect another bottle, add to the gas some lime water and shake, when a precipitate of calcic carbonate will fall, thus—



The same precipitate is produced by blowing into lime water through a tube, as the breath contains carbonic acid.

Lime water is made by shaking up a little lime with a quantity of water for a short time, and filtering. It contains about one of lime in 700.

### 11. HYDRIC CHLORIDE ON MANGANIC BINOXIDE.

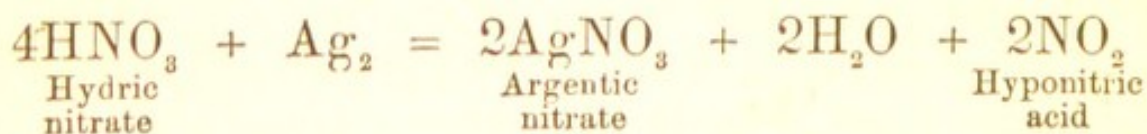
Already described.

### ACTIONS OF HYDRIC NITRATE.

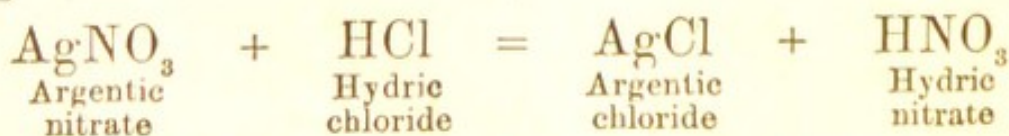
#### 12. HYDRIC NITRATE ON SILVER.

(EXPERIMENTS WITH A COIN.)

Put a sixpence in a test tube, add to it half an inch of hydric nitrate and half an inch of water, then warm. The following change takes place:—



The hyponitric acid escapes as a red gas. Half fill the tube with water; add a few drops of hydric chloride, and covering the tube with your hand, shake violently; a curdy precipitate of argentic chloride will fall, thus—



Add more hydric chloride, and if a farther precipitate is produced shake again, and so on till no

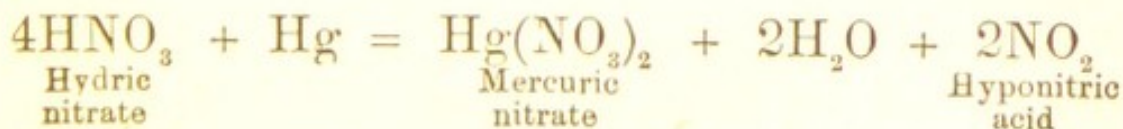


more precipitate is produced. Filter. The filtrate contains the copper in the coin which was dissolved with the silver in the hydric nitrate; the whole of the silver is in the precipitate. Take the filter out of the funnel, lay it between some folds of thick blotting paper, and press gently; then dry thoroughly on an iron plate. Mix with half its weight of dry sodic carbonate. Scoop a little hole in a piece of fine charcoal, put in it some of the mixture, and blowing across a yellow gas flame with the blowpipe, direct the flame on to the mixture. The silver will be reduced—that is, reconverted into metal.

In using the blowpipe with the Bunsen, push an inch of large india-rubber tube over the air-box, to stop up the holes, and turn the gas down, so that the whole of the flame may be diverted by a moderate blast.

### 13. HYDRIC NITRATE ON MERCURY.

Put a small globule of mercury in a test tube, add a little hydric nitrate and an equal bulk of water, then warm. The following change takes place :—



Evaporate the solution in a platinum capsule, when a yellowish residue will be left of mercuric nitrate. When dry, powder it, and heat it more strongly in the capsule; it will be decomposed, thus—





The mercuric oxide left appears black when hot, red when cold. Do not continue the heat too long, or the oxide itself will be driven away. Now take an ignition tube, put in it a little of the oxide, and heat it with the blowpipe, holding the tube in brass tongs with one hand, and with the other holding a match with a spark on it to the orifice; the oxide is decomposed and volatilized, the mercury sublimes to the cold part of the tube, and the oxygen escapes.

Ignition tubes are hard glass tubes (hard = difficult to melt), the shape of test tubes, but much smaller, used for igniting (heating to redness) small quantities of a substance. They are made thus:—Take some hard tubing of 5 mm. bore, and cut it into lengths of 12 cm.; hold one of these in the blowpipe flame, turning it round so that the middle may be uniformly softened; then remove it from the flame, and draw it out a few inches. You will thus have two tubes 6 cm. long, joined by a thin tube. The latter must be removed by the blowpipe, and the ends of the two tubes sealed.

#### 14. HYDRIC NITRATE ON COPPER.

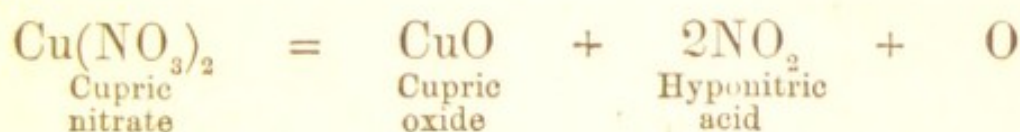
Set up the chlorine apparatus. In the flask put some scraps or nails of copper, add half a test-tubeful of water, and the same quantity of hydric nitrate, and apply heat. The following change takes place:—



The nitric oxide escapes, and should be collected over the trough. It is a colorless gas. On re-



moving the bottle from the trough the gas will be seen to turn red on mixing with the air. It unites with oxygen, forming hyponitric acid ( $\text{NO}_2$ ). Evaporate the blue solution in a dish till it is syrupy, then cool, when it will set to a crystalline mass of cupric nitrate. Take a small quantity of this, and ignite on a platinum capsule till it has turned entirely black. The following change takes place:—



The black residue is cupric oxide. The green substance which is formed intermediately is a compound of cupric nitrate and oxide, and is called basic cupric nitrate. Take a small quantity of the oxide, put it in a hole scooped in a piece of charcoal, put on it a small lump of potassic cyanide, and heat with the blowpipe. The copper will be at once reduced in the form of a spongy mass, which may be melted into a globule by further heat.

#### 15. HYDRIC NITRATE ON HYDRIC CHLORIDE.

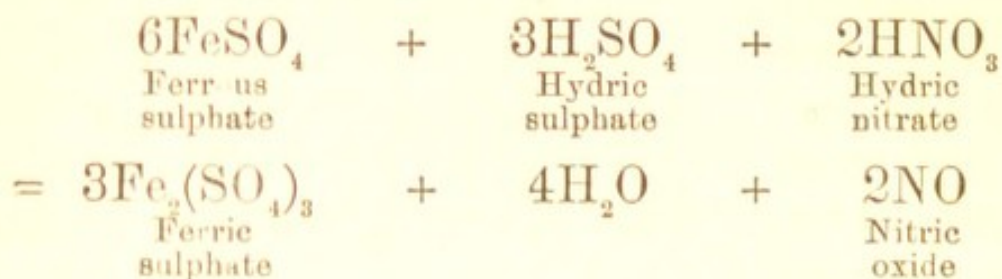
Put a little hydric chloride in a test tube, and add about a fourth of hydric nitrate. This mixture is called nitrohydrochloric acid or aqua regia. Warm it, when chlorine and hyponitric acid will escape. It is used for dissolving gold and platinum and a few compounds, and acts through the free chlorine which it gives.

#### 16. HYDRIC NITRATE ON FERROUS SULPHATE.

Put a crystal or two of ferrous sulphate in a test tube, add some water and a little hydric sul-



phate, and boil. A colorless solution will be obtained. Now add a drop of hydric nitrate, when the following change will be effected :—



The nitric oxide dissolves in the excess of ferrous sulphate to a dark fluid. Add another drop of hydric nitrate, and so on, when all at once the above change being completed, all the ferrous sulphate will have been converted into ferric sulphate, which is incapable of dissolving nitric oxide, and this will escape with sudden effervescence.

The above reaction is utilized as a test for a nitrate, the experiment being made as follows :— Powder a crystal of ferrous sulphate, and shake it up in a test tube with half an inch of cold water, when dissolved, add a minute quantity of the solution to be tested (take a drop of solution of potassic nitrate), and holding the tube slanting pour down the side carefully half an inch of hydric sulphate, so that it may form a layer at the bottom without mixing. A dark color will soon be apparent at the top of the hydric sulphate, which is rendered more evident by very gently shaking the tube, not mixing the fluids.

#### ACTION OF ALKALIES ON ACIDS.

The alkalies are potash (KHO), soda (NaHO), and ammonia (NH<sub>3</sub>). The first two are solids, the last a gas; all are very soluble in water. They have a very strong taste, and turn litmus



paper blue. Acids, on the contrary, turn litmus paper red. And if an alkali and an acid are mixed in proper proportion, the mixture will be neutral like water, that is, it will not affect litmus.

### 17. POTASH ON HYDRIC SULPHATE.

Dissolve a lump of potash in water in a Berlin dish. Now lay several strips of litmus paper on the bench side by side. Add some dilute hydric sulphate to the potash, stir with a glass rod, and then touch one of the strips of litmus with the rod. If the litmus turns blue, add more acid and so on, till the neutral point is gained. The following change will have taken place:—



The solution now tastes neither acid nor alkaline, but saline. Evaporate somewhat and set aside, when small sparkling crystals of anhydrous potassic sulphate will be formed. The mother liquor may be thrown away, and the crystals dried on blotting paper.

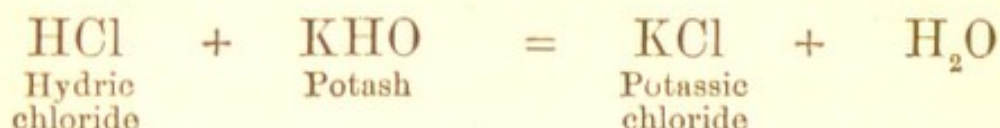
If hydric sulphate is half neutralized by potash, thus—



we get hydropotassic sulphate, the same substance which was left in the retort after making nitric acid. This is strongly acid to the taste and litmus. To do this experiment the proper way is to take a certain quantity of hydric sulphate, divide it in half, neutralize one-half and add the other half.

## 18. POTASH ON HYDRIC CHLORIDE.

Dissolve some potash in water, and neutralize with hydric chloride. The following change takes place:—



Evaporate to dryness, and potassic chloride will be left as a saline mass.

## 19. POTASH ON HYDRIC NITRATE.

Dissolve some potash in water, and neutralize with hydric nitrate. The following change takes place:—



Evaporate somewhat and crystallize. We have thus reconverted the hydric nitrate into potassic nitrate, from which it was originally made.

## 20. SODA ON HYDRIC SULPHATE, H. CHLORIDE AND H. NITRATE.

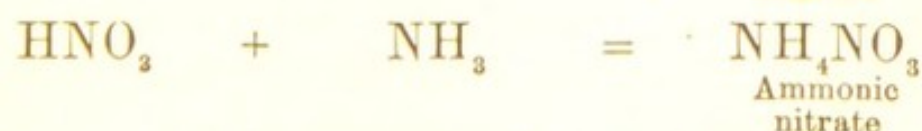
The action is exactly similar to that of potash on these acids. The equations are the same, substituting Na for K. The crystals of sodic sulphate are large, and consist of  $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ . In making sodic chloride, you will notice the reversion of hydric chloride into the substance from which it was originally obtained.



## AMMONIA ON HYDRIC SULPHATE, H. CHLORIDE, AND H. NITRATE.

[21. *Ammonia gas*.—As stated before, ammonia is a gas very soluble in water, having the composition  $\text{NH}_3$ . What is usually called ammonia is the solution. The gas is most readily obtained by simply boiling the solution. Take a small flask and fit a gas delivery tube to it. Put in it some of the strongest solution of ammonia (s.g. .880), heat gently, and collect the gas in a dry soda-water bottle by upward displacement, allowing the gas to escape into the air for some time after the bottle seems full, so as to make sure that the bottle is completely filled with the gas. Now take away the lamp from the flask, and without delay remove the delivery tube carefully, covering the mouth of the bottle with the hand. Hold the bottle mouth downwards in water, and then remove the hand covering the mouth. The water will rush up and fill the bottle—that is, so far as the air has been expelled. A like experiment was made with hydric chloride, which also is a gas very soluble in water.]

The action is exactly similar to that of potash on these acids. The equations may be written thus—



[*Ammonium hypothesis*.—Inasmuch as ammonia behaves with acids like potash and soda, we assi-

milate its formula to the formulæ of potash and soda by supposing that the gas is combined with a certain quantity of the water in which it is dissolved, thus— $\text{NH}_3 \cdot \text{H}_2\text{O}$ , and then arranging the symbols thus— $\text{NH}_4\text{HO}$ . The new formula  $\text{NH}_4\text{HO}$  resembles  $\text{KHO}$  and  $\text{NaHO}$ , the compound  $\text{NH}_4$  playing the part of the elements potassium and sodium.  $\text{NH}_4$  thus becomes a hypothetical metal, it is called ammonium, and is assigned the symbol Am for simplicity. The equations just given may now be written, so as to resemble the equations under the Action of Potash—



## 22. AMMONIA AND HYDRIC CHLORIDE MIXED AS GASES.

If these gases are mixed in equal volumes they immediately condense to a snow-like solid, consisting of ammoniac chloride ( $\text{NH}_4\text{Cl} = \text{AmCl} = \text{NH}_3 \cdot \text{HCl}$ ).

[23. *Action of heat on ammoniac nitrate. Preparation of nitrous oxide.*—Make a quantity of ammoniac nitrate (say an ounce), by neutralizing hydric nitrate with ammonia, evaporating to dryness, and fusing the residue. Transfer to a flask fitted with delivery tube and heat. The following change takes place:—

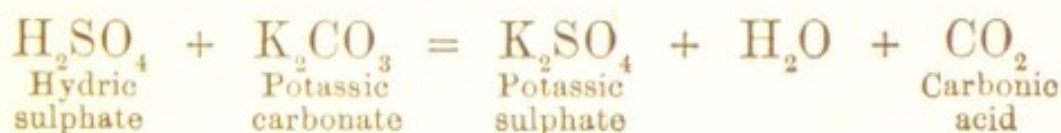




Nitrous oxide is a gas, and is to be collected over the trough. Hold a chip of wood with a spark on it in the bottle of gas, when the wood will burst into flame, as in the case of oxygen. There is one difference between nitrous oxide and oxygen—namely, the former will dissolve in water, the latter will not.]

#### ACTION OF ALKALINE CARBONATES ON ACIDS.

The alkaline carbonates are potassic carbonate ( $\text{K}_2\text{CO}_3$ ), sodic carbonate ( $\text{Na}_2\text{CO}_3$ ), and ammonic carbonate ( $\text{Am}_2\text{CO}_3$ ). They are soluble in water, possess alkaline reaction (alkaline reaction = power of blueing litmus), and neutralize acids like the alkalies, producing the same salts. In neutralizing carbonic acid is eliminated, and, being a gas, escapes. Thus, for example:—



Carbonic acid itself is slightly soluble in water, to which it imparts a faint acid reaction (acid reaction = power of reddening litmus). The dissolved carbonic acid escapes on boiling the water a short time. So if you wish to neutralize an alkaline carbonate exactly, boil the liquid a minute or so to drive out the dissolved gas.

#### ACTION OF ALKALINE EARTHS ON ACIDS.

The alkaline earths are baryta ( $\text{BaO}$ ), strontia ( $\text{SrO}$ ), lime ( $\text{CaO}$ ), and magnesia ( $\text{MgO}$ ). They

are more or less soluble in water, and have an alkaline reaction ( $\text{MgO}$  is barely soluble and barely gives alkaline reaction). They neutralize acids, forming salts.

#### ACTION OF ALKALINE EARTHY CARBONATES ON ACIDS.

The alkaline earthy carbonates are baric carbonate ( $\text{BaCO}_3$ ), strontic carbonate ( $\text{SrCO}_3$ ), calcic carbonate ( $\text{CaCO}_3$ ), magnesian carbonate ( $\text{MgCO}_3$ ). They are insoluble in water. They neutralize acids, forming salts like the alkaline earths.



## FLAMES.

*Sulphur.*—Fill an ignition tube with lumps of sulphur, hold it in a Bunsen flame with a pair of tongs, when the sulphur will soon boil, and the vapor will catch alight. Hold a white plate behind the flame and it will be seen to consist of two parts. The inside is red, and consists of sulphur vapor; the outside is blue, and consists of the vapor in the act of uniting with oxygen.

*Gas or Candle.*—Gas or candle consists principally of carbon and hydrogen. The flame consists of three parts. The central dark portion is the gas or candle vapor, this is surrounded by a luminous mantle where the hydrogen burns and the carbon is separated in an incandescent state, and the luminous mantle again is surrounded by a thin, scarcely visible coat where the carbon is burnt.

*Candle in Chlorine.*—Hydrogen will burn in chlorine, but not carbon. So if a lighted candle is held in a bottle of chlorine, the hydrogen will go on burning, but the carbon will be separated as a copious black smoke.

*Bunsen.*—In the Bunsen burner the gas mixes with air before it is burnt. The flame consists of two parts, the mixture of gas and air inside, the same mixture in the act of burning outside. If a match be rested on the tube, it will burn where it cuts the edges of the flame, but not in the middle. When the proportion of gas is too high, the flame is more or less yellow; when the proportion of air is too high, the flame descends the tube. A Bunsen flame does not blacken

anything held in it. The hottest part is two-thirds from the bottom.

*Blowpipe*.—The blowpipe flame consists of two parts. The inner part is called the reducing flame, as oxygen is here deficient; the outer part is called the oxidizing flame, as oxygen is here in excess.



## WEIGHTS AND MEASURES.

STANDARD OF LENGTH.—The length of a certain bar of metal preserved in Paris = *Metre* = 39·37 inches.

STANDARD OF CAPACITY.—The cube of  $\frac{1}{10}$  metre = *Litre* = 1·76 pint.

STANDARD OF WEIGHT.—The weight of water occupying the cube of  $\frac{1}{100}$  metre at  $4^{\circ}$  = *Gramme* = 15·432 grains.

Larger and smaller weights and measures are expressed by attaching the following prefixes to these standards :—

deca, hecto, kilo = 10, 100, 1000 respectively.

deci, centi, milli =  $\frac{1}{10}$ ,  $\frac{1}{100}$ ,  $\frac{1}{1000}$  respectively.

A millilitre is always called a cubic centimetre (c.c.)

A *crith* is ·0896 gramme, or the weight of 1 litre of hydrogen at  $0^{\circ}$ , 760 mm.

$0^{\circ}$ , 760 mm. are called the *normal temperature and pressure*.

A *crith-unit* of a substance is the quantity represented by its symbol or formula taken in criths.

## MEASURE OF GASES.

1. A crith-unit of an elementary gas measures 1 litre at the normal temperature and pressure.

A crith-unit of a compound gas measures 2 litres at the normal temperature and pressure.

Thus :

16	criths of oxygen . . . .	measure 1 litre.
14	„ nitrogen . . . .	measure 1 litre.
36.5	„ hydric chloride	measure 2 litres.
17	„ ammonia gas .	measure 2 litres.
44	„ carbonic acid .	measure 2 litres.

2. The volume of a gas varies directly as the temperature, measured from  $-273^{\circ}$ .

Or, putting  $v$  for the volume at  $t^{\circ}$   
and  $v'$  „ „ „  $t'^{\circ}$

$$273 + t : 273 + t' :: v : v'$$

3. The volume of a gas varies inversely as the pressure.

Or, putting  $v$  for the volume at  $p$  mm.  
and  $v'$  „ „ „  $p'$  mm.

$$p' : p :: v : v'$$

#### SPECIFIC GRAVITY OF GASES.

The specific gravity of a gas is the number of times it is heavier than hydrogen,  
*in other words*, the weight in criths of one litre at  $0^{\circ}$ , 760 mm.

From this we deduce the following rules :—

*a.* The s. g. of an elementary gas is its unit number.

*b.* The s. g. of a compound gas is half its unit number.

#### QUESTIONS ON THE MEASURE OF GASES.

1. What will 100 grammes of nitrous oxide measure at  $16^{\circ}$ , 730 mm. ?

The formula of nitrous oxide is  $\text{N}_2\text{O}$

$\therefore$  44 criths measure 2 litres at  $0^{\circ}$ , 760 mm.



We first find the volume of 100 grammes at  $0^{\circ}$ , 760 mm. ( $x$ ), and then correct it first for the temp. ( $y$ ), afterwards for the pressure ( $z$ ).

$$44 \times 0.896 \quad : \quad 100 \quad :: \quad 2 \quad : \quad x$$

$$x = \frac{200}{44 \times 0.896} = 50.73 \text{ (litres at } 0^{\circ}, 760 \text{ mm.)}$$

$$273 \quad : \quad 289 \quad :: \quad 50.73 \quad : \quad y$$

$$y = \frac{50.73 \times 289}{273} = 53.70 \text{ (litres at } 16^{\circ}, 760 \text{ mm.)}$$

$$730 \quad : \quad 760 \quad :: \quad 53.70 \quad : \quad z$$

$$z = \frac{53.70 \times 760}{730} = 55.91 \text{ (litres at } 16^{\circ}, 730 \text{ mm.)}$$

*Ans.* 55.91 litres.

2. What will 100 litres of carbonic oxide measured at  $-10^{\circ}$ , 840 mm. weigh?

We first reduce the volume to the normal temp. ( $x$ ), then to the normal pressure ( $y$ ), and afterwards find its weight ( $z$ ).

$$263 \quad : \quad 273 \quad :: \quad 100 \quad : \quad x$$

$$x = \frac{100 \times 273}{263} = 103.80 \text{ (litres at } 0^{\circ}, 840 \text{ mm.)}$$

$$760 \quad : \quad 840 \quad :: \quad 103.8 \quad : \quad y$$

$$y = \frac{103.8 \times 840}{760} = 114.73 \text{ (litres at } 0^{\circ}, 760 \text{ mm.)}$$

Now the formula of carbonic oxide is CO

$\therefore$  28 criths measure 2 litres at  $0^{\circ}$ , 760 mm.

We have therefore for the weight of the 114.73 litres—

$$2 : 114.73 :: 28 \times .0896 : z$$

$$z = \frac{28 \times .0896 \times 114.73}{2} = 143.92 \text{ (grammes)}$$

*Ans.* 143.92 grammes.

3. If I want 100 litres of oxygen at  $30^\circ$ , 800 mm., how many grammes of potassic chlorate must be taken?

We first reduce the gas to the normal temperature ( $x$ ), then to the normal pressure ( $y$ ), and lastly, find the weight of salt required ( $z$ ).

$$303 : 273 :: 100 : x$$

$$x = \frac{273 \times 100}{303} = 90.10 \text{ (litres at } 0^\circ, 800 \text{ mm.)}$$

$$760 : 800 :: 90.1 : y$$

$$y = \frac{90.1 \times 800}{760} = 94.84 \text{ (litres at } 0^\circ, 760 \text{ mm.)}$$

Now  $O_3$  requires  $KClO_3$

$\therefore$  3 crith-units of oxygen require 1 crith-unit of potassic chlorate.

$\therefore$  3 litres of oxygen at  $0^\circ$ , 760 mm., require 122.6 criths of potassic chlorate.

We have, therefore, for the weight of potassic chlorate required for 94.84 litres of oxygen—

$$3 : 94.84 :: 122.6 \times .0896 : z$$

$$z = \frac{122.6 \times .0896 \times 94.84}{3} = 347.27 \text{ (grammes)}$$

*Ans.* 347.27 grammes.



## CLASSIFICATION OF COMPOUNDS.

COMPOUNDS are divided into *Oxides* and *Salts*.

### *Oxides.*

An oxide is composed of an element in union with oxygen. Oxides are divided into *Oxides of Metals* and *Oxides of Non-metals*.

### *Salts.*

A *Salt* is a compound of an Antimetal with a Metal or Metals.

The *Antimetals* are of three kinds—

- a. Certain non-metals. The name of these in composition terminates in *ide*.
- b. Certain non-metals combined with oxygen. These are not known in the isolated state. Their name in composition terminates usually in *ate*. Sometimes, where there are two antimetals of the same non-metal, that containing less oxygen terminates in *ite*.
- c. Certain metals combined with oxygen. These are not known in the isolated state. Their name in composition terminates in *ate*.

The names of the metals in composition terminate usually in *ic*. Where a metal has two values the name corresponding to the lower one terminates in *ous*.

To each antimetal and metal is assigned a *value* which indicates the combining power of its unit.

The *Standard of Value* for antimetals is Cl, for metals Ag.

The value Cl is exactly antagonistic to the value Ag; that is, the unit of chlorine exactly unites with the unit of silver. Thus the formula for the

compound of silver and chlorine is  $\text{AgCl}$ . Thus again, the formula of plumbic chloride is  $\text{PbCl}_2$ , since the value of Pb is  $\text{Ag}_2$ . The formula of bismuthic chloride is  $\text{BiCl}_3$ , since the value of Bi is  $\text{Ag}_3$ . And again, the formula of argentic iodide is  $\text{AgI}$ , since the value of I is Cl. The formula of argentic sulphide is  $\text{Ag}_2\text{S}$ , since the value of S is  $\text{Cl}_2$ . The formula of argentic phosphate is  $\text{Ag}_3\text{PO}_4$ , since the value of  $\text{PO}_4$  is  $\text{Cl}_3$ .

## ANTIMETALS.

<i>Name in Composition.</i>	<i>Symbol or Formula.</i>	<i>Value.</i>
Sulphide . . . . .	S	$\text{Cl}_2$
Hyposulphite . . . . .	$\text{S}_2\text{O}_3$	$\text{Cl}_2$
Sulphite . . . . .	$\text{SO}_3$	$\text{Cl}_2$
Sulphate . . . . .	$\text{SO}_4$	$\text{Cl}_2$
Chloride . . . . .	Cl	
Chlorate . . . . .	$\text{ClO}_3$	Cl
Bromide . . . . .	Br	Cl
Iodide . . . . .	I	Cl
Fluoride . . . . .	F	Cl
Carbonate . . . . .	$\text{CO}_3$	$\text{Cl}_2$
Nitrite . . . . .	$\text{NO}_2$	Cl
Nitrate . . . . .	$\text{NO}_3$	Cl
Metaphosphate . . . . .	$\text{PO}_3$	Cl
Pyrophosphate . . . . .	$\text{P}_2\text{O}_7$	$\text{Cl}_4$
Phosphate . . . . .	$\text{PO}_4$	$\text{Cl}_3$
Arsenite . . . . .	$\text{AsO}_3$	$\text{Cl}_3$
Arsenate . . . . .	$\text{AsO}_4$	$\text{Cl}_3$
Silicate . . . . .	$\text{SiO}_4$	$\text{Cl}_4$
Borate . . . . .	$\text{BO}_3$	$\text{Cl}_3$
Manganate . . . . .	$\text{MnO}_4$	$\text{Cl}_2$
Permanganate . . . . .	$\text{MnO}_4$	Cl
Chromate . . . . .	$\text{CrO}_4$	$\text{Cl}_2$



## METALS.

<i>Name in Composition.</i>	<i>Symbol.</i>	<i>Value.</i>
Argentio . . . . .	Ag	
Plumbic . . . . .	Pb	Ag <sub>2</sub>
Mercurous . . . . .	Hg	Ag
Mercuric . . . . .	Hg	Ag <sub>2</sub>
Bismuthic . . . . .	Bi	Ag <sub>3</sub>
Cupric . . . . .	Cu	Ag <sub>2</sub>
Stannous . . . . .	Sn	Ag <sub>2</sub>
Stannic . . . . .	Sn	Ag <sub>4</sub>
Antimonious . . . . .	Sb	Ag <sub>3</sub>
Auric . . . . .	Au	Ag <sub>3</sub>
Platinic . . . . .	Pt	Ag <sub>4</sub>
Nickelic . . . . .	Ni	Ag <sub>2</sub>
Cobaltic . . . . .	Co	Ag <sub>2</sub>
Ferrous . . . . .	Fe	Ag <sub>2</sub>
Ferric . . . . .	Fe	Ag <sub>3</sub>
Manganous . . . . .	Mn	Ag <sub>2</sub>
Zincic . . . . .	Zn	Ag <sub>2</sub>
Chromic . . . . .	Cr	Ag <sub>3</sub>
Aluminic . . . . .	Al	Ag <sub>3</sub>
Baric . . . . .	Ba	Ag <sub>2</sub>
Strontic . . . . .	Sr	Ag <sub>2</sub>
Calcic . . . . .	Ca	Ag <sub>2</sub>
Magnesian . . . . .	Mg	Ag <sub>2</sub>
Potassic . . . . .	K	Ag
Sodic . . . . .	Na	Ag
Ammonic . . . . .	Am	Ag
Hydric . . . . .	H	Ag

## LIST OF SUBSTANCES.

## ELEMENTS.

Silver, Lead, Mercury, Bismuth, Copper, Tin, Antimony, Gold, Platinum, Nickel, Iron, Zinc, Aluminium. The preparation and properties of the foregoing metals belong to Metallurgy.

Cobalt, Manganese, Chromium, Barium, Strontium, Calcium, are not used. The last is the metallic basis of limestone.

Magnesium. A silvery metal, which burns readily to magnesia ( $MgO$ ).

Potassium. A soft, silvery metal, which tarnishes immediately in the air. It has to be kept in petroleum. When thrown on water, it is converted into potassic hydrate ( $KHO$ ), with liberation of hydrogen, the action being very energetic, and accompanied with combustion of the hydrogen.

Sodium. A soft, silvery metal, which tarnishes immediately in the air. It has to be kept in petroleum. When thrown on water, it is converted into sodic hydrate ( $NaHO$ ), with liberation of hydrogen, the action being less energetic than in the case of potassium.

Hydrogen. Obtained by the action of zinc on dilute hydric sulphate (p. 2). The lightest known gas. It burns to water.

Oxygen. Obtained by heating potassic chlorate mixed with manganic binoxide (p. 3). A gas which causes a smouldering match to burst into flame. It constitutes one-fifth of the air.



**Sulphur.** Found native. Flowers of sulphur are made by boiling sulphur and passing the vapor into a large cold chamber, in which it suddenly condenses. It burns to sulphurous acid ( $\text{SO}_2$ ).

**Chlorine.** Obtained by the action of hydric chloride on manganic binoxide (p. 6). A pale-green noxious gas.

**Bromine.** Occurs in the sea. A deep-red, heavy noxious fluid, very volatile, and having an odor like chlorine.

**Iodine.** Occurs in the sea and in seaweed. A black lustrous crystalline solid, with a faint smell. Readily converted by heat into a violet gas.

**Fluorine.** Occurs in fluor spar. Very difficult to isolate.

**Carbon.** Found native as diamond and graphite.

**Nitrogen.** Constitutes four-fifths of the air (p. 8).

**Phosphorus.** A wax-like substance, which shines in the dark, and is spontaneously inflammable, burning to phosphoric acid ( $\text{P}_2\text{O}_5$ , p. 8). Red phosphorus is a variety produced by heating the ordinary phosphorus at a certain temperature; it is dark-colored, opaque, brittle, does not shine in the dark, and is not spontaneously inflammable. Heated slightly above the temperature necessary to produce it, it is reconverted into the ordinary kind.

**Arsenic.** A brittle solid with metallic appearance. Readily volatilized by heat.

**Silicon.** Present, combined with oxygen, in flint (Lat. silex).

**Boron.** Present in borax.

## COMPOUNDS.

*Minerals are printed in italics.*

*As a rule minerals are insoluble in water.*

## OXIDES OF METALS.

*All metallic oxides are insoluble in water except  $\text{MnO}_3$ ,  $\text{Mn}_2\text{O}_7$ ,  $\text{CrO}_3$ ,  $\text{BaO}$ ,  $\text{SrO}$ ,  $\text{CaO}$ , and alkalis.*

$\text{PbO}$ . Plumbic oxide. Litharge. Massicot. Produced by heating lead in a current of air. Dissolves in warm dilute h. nitrate to pb. nitrate. Powder or scales.

$\text{Pb}_3\text{O}_4 = 2\text{PbO}.\text{PbO}_2$ . Red lead. Minium. Produced by heating litharge in a current of air.

$\text{PbO}_2$ . Plumbic binoxide. Peroxide of lead. Produced by warming red lead with dilute h. nitrate when the pb. oxide dissolves to pb. nitrate, and the pb. binoxide is left as a brown powder which may be collected on a filter, washed and dried. A brown powder.

$\text{HgO}$ . Mercuric oxide. Red oxide of mercury. Produced by igniting mercuric nitrate (p. 31). Decomposed by ignition into mercury and oxygen. A red powder. If made by precipitating mercuric chloride with soda it is yellow.

$\text{Cu}_2\text{O}$ . Cuprous oxide. Red oxide of copper. Suboxide of copper. A red powder.

$\text{CuO}$ . Cupric oxide. Black oxide of copper. Produced by igniting cupric nitrate (p. 33). A black powder.



$\text{CuH}_2\text{O}_2 = \text{CuO.H}_2\text{O}$ . Hydrocupric oxide. Cupric hydrate. Obtained as a light blue bulky precipitate on mixing solution of soda with solution of cu. sulphate. On boiling the mixture the cu. hydrate turns black, losing water and becoming cu. oxide.

$\text{SnO}_2$ . Stannic oxide. Binoxide of tin. *Tinstone*. Putty powder. Produced as an insoluble substance on treating tin with h. nitrate.

$\text{Sb}_2\text{O}_3$ . Antimonious oxide. A powder.

$\text{Sb}_2\text{O}_5$ . Antimonic acid (anhydrous).

$\text{FeO}$ . Ferrous oxide. Protoxide of iron.

$\text{FeH}_2\text{O}_2 = \text{FeO.H}_2\text{O}$ . Hydroferrous oxide. Ferrous hydrate. Obtained as a nearly white precipitate on mixing solution of soda with solution of ferrous sulphate. Turns green at once and afterwards brown from absorption of oxygen.

$\text{Fe}_2\text{O}_3$ . Ferric oxide. Sesquioxide of iron. Peroxide of iron. *Hematite*. *Specular iron*. *Oligist iron*. Rouge. Colcothar. Obtained by igniting ferrous sulphate.

$\text{FeH}_3\text{O}_3 = \frac{1}{2} (\text{Fe}_2\text{O}_3.3\text{H}_2\text{O})$ . Hydroferric oxide. Ferric hydrate. Obtained as a brown flocculent precipitate on mixing solution of soda with solution of ferric chloride.

$\text{Fe}_3\text{O}_4 = \text{FeO.Fe}_2\text{O}_3$ . Black oxide of iron. Magnetic oxide of iron. *Magnetite*.

$\text{FeCr}_2\text{O}_4 = \text{FeO.Cr}_2\text{O}_3$ . *Chromic iron*.

$\text{MnO}$ . Manganous oxide. Protoxide of manganese.

$\text{Mn}_2\text{O}_3$ . Manganic oxide. Sesquioxide of manganese.

$\text{MnO}_2$ . Manganic binoxide. Deutoxide of manganese. Peroxide of manganese. Black oxide of manganese. *Pyrolusite*. Manganese.

$\text{MnO}_3$ . Manganic acid (anhydrous).

$\text{Mn}_2\text{O}_7$ . Permanganic acid (anhydrous).

$\text{ZnO}$ . Zincic oxide. Zinc white. Produced by the combustion of zinc. A powder.

$\text{Cr}_2\text{O}_3$ . Chromic oxide. Sesquioxide of chromium. A greenish powder.

$\text{CrH}_3\text{O}_3 = \frac{1}{2}(\text{Cr}_2\text{O}_3 \cdot 3\text{H}_2\text{O})$ . Hydrochromic oxide. Chromic hydrate.

$\text{CrO}_3$ . Chromic acid (anhydrous). Red crystals.

$\text{Al}_2\text{O}_3$ . Aluminic oxide. Sesquioxide of aluminium. Alumina. *Corundum*. *Ruby*. *Sapphire*. *Emery* (impure).

$\text{AlH}_3\text{O}_3 = \frac{1}{2}(\text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O})$ . Hydroaluminic oxide. Aluminic hydrate. Hydrate of alumina. Obtained as a flocculent precipitate on mixing ammonia ( $\text{AmHO}$ ) with solution of alum ( $\text{AlAm}[\text{SO}_4]_2$ ).

#### Alkaline Earths.

$\text{BaO}$ . Baric oxide. Baryta. Lump.

$\text{SrO}$ . Strontic oxide. Strontia.

$\text{CaO}$ . Calcic oxide. Lime. Quicklime. Made by calcining (*i.e.*, igniting) limestone ( $\text{CaCO}_3$ ) in kilns, by which carbonic acid is driven off. Lump.

$\text{CaH}_2\text{O}_2 = \text{CaO} \cdot \text{H}_2\text{O}$ . Hydrocalcic oxide. Calcic hydrate. Hydrate of lime. Slaked lime. Produced by adding water to quicklime. Powder.

$\text{MgO}$ . Magnestic oxide. Magnesia. Calcined



magnesia. Made by calcining the artificial magnesian carbonate.

### Alkalies.

KHO. Hydropotassic oxide. Potassic hydrate. Potassa. Potash. Caustic potash. Fused lump.

NaHO. Hydrosodic oxide. Sodic hydrate. Soda. Caustic soda. Fused lump.

AmHO =  $\text{NH}_4\text{HO}$  =  $\text{NH}_3 \cdot \text{H}_2\text{O}$ . Ammonia. Hartshorn. (See p. 37.) Solution.

$\text{H}_2\text{O}$ . Hydric oxide. *Water*.

$\text{H}_2\text{O}_2$ . Hydric peroxide. Hydric binoxide. Hydroxyl. Solution.

### OXIDES OF NON-METALS.

$\text{SO}_2$ . Sulphurous acid (anhydrous). Produced by burning sulphur (p. 6), and by the action of copper on h. sulphate (p. 23). A gas of well-known odor, easily liquefied, and rather soluble in water.

$\text{SO}_3$ . Sulphuric acid (anhydrous). A silky solid, very hygroscopic.

$\text{Cl}_2\text{O}_5$ . Chloric acid (anhydrous).

$\text{Br}_2\text{O}_5$ . Bromic acid (anhydrous).

$\text{I}_2\text{O}_5$ . Iodic acid (anhydrous).

CO. Carbonic oxide. Produced by the action of potassic ferrocyanide on h. sulphate (p. 26). A gas, which burns to carbonic acid.

$\text{CO}_2$ . Carbonic acid. Produced by the action of calcic carbonate on h. chloride (p. 29). A gas, which precipitates lime water.

$\text{N}_2\text{O}$ . Nitrous oxide. Laughing gas. Produced by heating ammonic nitrate (p. 38). A gas,

which causes a smouldering match to burst into flame. It is (unlike oxygen) rather soluble in water.

NO. Nitric oxide. Produced by the action of copper on h. nitrate (p. 32). A colorless gas, which turns red when mixed with oxygen.

$N_2O_3$ . Nitrous acid (anhydrous).

$NO_2$ . Hyponitric acid (anhydrous).

$N_2O_5$ . Nitric acid (anhydrous).

$P_2O_3$ . Phosphorous acid (anhydrous).

$P_2O_5$ . Phosphoric acid (anhydrous). Produced by the combustion of phosphorus. Snow-like, very deliquescent, and soluble in water. Combines with water in three different proportions, forming metaphosphoric acid ( $HPO_3$ ), pyrophosphoric acid ( $H_4P_2O_7$ ), and ordinary phosphoric acid ( $H_3PO_4$ ).

$As_2O_3$ . Arsenious acid (anhydrous). Arsenic. White arsenic. Glassy or opaque lumps. Rather soluble in water. Readily sublimed.

$As_2O_5$ . Arsenic acid (anhydrous). Soluble in water. Lump.

$SiO_2$ . Silicic acid. Silica. *Quartz. Flint. Rock crystal. Amethyst. Sand. Chalcedony. Agate. Cornelian. Opal. Onyx.*

$B_2O_3$ . Boric acid (anhydrous). Soluble in water.

## SALTS.

## SULPHIDES.

*All in this list are insoluble in water except*  
 $Am_2S, H_2S.$

PbS. Plumbic sulphide. *Galena.*



$\text{HgS}$ . Mercuric sulphide. *Cinnabar*. Vermilion.

$\text{CuFeS}_2$ . *Copper pyrites*.

$\text{Sb}_2\text{S}_3$ . Antimonious sulphide. Crude antimony.  
*Grey antimony*.

$\text{FeS}$ . Ferrous sulphide. Lump.

$\text{FeS}_2$ . *Pyrites*. *Iron pyrites*. *Mundic*.

$\text{ZnS}$ . Zincic sulphide. *Blende*.

$\text{Am}_2\text{S} = (\text{NH}_4)_2\text{S} = 2\text{NH}_3 \cdot \text{H}_2\text{S}$ . Ammonic sulphide.  
Solution.

$\text{H}_2\text{S}$ . Hydric sulphide. Sulphuretted hydrogen.  
Hydrosulphuric acid. Produced by the action  
of ferrous sulphide on h. sulphate (p. 28). A  
gas having the smell of rotten eggs. Rather  
soluble in water.

#### HYPOSULPHITE.

$\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$ . Sodid hyposulphite. Soluble in  
water. Crystals.

#### SULPHATES.

*All in this list are soluble in water except*  
 $\text{BaSO}_4$ ,  $\text{SrSO}_4$ .  $\text{CaSO}_4$  *is but slightly soluble*.

$\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ . Cupric sulphate. Blue vitriol. Blue  
stone. Produced by the action of copper on  
h. sulphate (p. 23). Blue crystals. When  
heated it becomes anhydrous and white.

$\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ . Ferrous sulphate. Green vitriol.  
Copperas. Produced by dissolving iron in di-  
lute h. sulphate. Green crystals. When ignited  
it yields ferric oxide ( $\text{Fe}_2\text{O}_3$ ).

$\text{Fe}_2(\text{SO}_4)_3$ . Ferric sulphate. Produced by the ac-  
tion of h. nitrate on a solution containing fer-

rous sulphate and h. sulphate (p. 33). Brownish-white evaporated mass.

$\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ . Zincic sulphate. White vitriol. Produced by dissolving zinc in h. sulphate (p. 28). Crystals.

$\text{AlAm}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$ . Alum. Manufactured on a large scale. Crystals.

$\text{BaSO}_4$ . Baric sulphate. *Heavy spar*. *Barytes*. Permanent white. Produced as a precipitate when solutions of baric chloride and of a sulphate are mixed.

$\text{SrSO}_4$ . Strontic sulphate. *Celestine*.

$\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ . Calcic sulphate. *Selenite*. *Gypsum*. *Alabaster*. Gypsum, when calcined, loses its water, and becomes plaster of Paris.

$\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ . Magnesian sulphate. Epsom salts. Crystals.

$\text{K}_2\text{SO}_4$ . Potassic sulphate. Crystals.

$\text{KHSO}_4$ . Hydropotassic sulphate. Bisulphate of potash. Lump.

$\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ . Sodid sulphate. GLAUBER'S salt. Crystals. The anhydrous salt is produced by heating 2 units of sodic chloride with 1 unit of h. sulphate; it is the first step in making sodic carbonate, and is called salt cake.

$\text{Am}_2\text{SO}_4 = (\text{NH}_4)_2\text{SO}_4 = 2\text{NH}_3 \cdot \text{H}_2\text{SO}_4$ . Ammonic sulphate. Produced by boiling the ammoniacal liquor of gasworks, and passing the vapor into dilute h. sulphate. Crystals.

$\text{H}_2\text{SO}_4$ . Hydric sulphate. Sulphuric acid. Vitriol. Oil of vitriol. Manufactured by sending sul-



phurous acid, steam, and air into leaden chambers ( $\text{SO}_2 + \text{H}_2\text{O} + \text{O} = \text{H}_2\text{SO}_4$ ); the presence in the chambers of oxides of nitrogen is necessary to enable the constituents to combine. The sulphurous acid is produced by roasting pyrites. An oily liquid, s. g. 1.84. It evolves heat when mixed with water.

## CHLORIDES.

*All in this list are soluble in water except AgCl, HgCl.*

AgCl. Argentic chloride. *Horn silver*. Obtained as a curdy precipitate on mixing solution of ag. nitrate with solution of a chloride. It fuses readily, and when cold presents the appearance of a horny mass.

HgCl. Mercurous chloride. Calomel. Powder. Readily sublimed.

HgCl<sub>2</sub>. Mercuric chloride. Corrosive sublimate. Crystals. Readily sublimed.

SnCl<sub>2</sub>.2H<sub>2</sub>O. Stannous chloride. Made by dissolving tin in conc. h. chloride. Crystals.

SnCl<sub>4</sub>. Stannic chloride. Made by passing chlorine into the previous solution.

AuCl<sub>3</sub>. Auric chloride. Made by dissolving gold in aqua regia. Yellow solution.

PtCl<sub>4</sub>. Platinic chloride. Made by dissolving platinum in aqua regia. Yellow solution.

FeCl<sub>2</sub>. Ferrous chloride. Made by dissolving iron in h. chloride. Solution.

FeCl<sub>3</sub>. Ferric chloride. Made by passing chlorine into the previous; or by boiling ferrous chloride mixed with h. chloride, and adding h.

nitrate drop by drop. The change which takes place is exactly analogous to that given p. 34. Yellow solution.

$\text{ZnCl}_2$ . Zincic chloride. Made by dissolving zinc in h. chloride. Fused lump.

$\text{BaCl}_2 \cdot 2\text{H}_2\text{O}$ . Baric chloride. Made by dissolving baric carbonate in h. chloride. Crystals.

$\text{CaCl}_2$ . Calcic chloride. Made by dissolving calcic carbonate in h. chloride. Fused lump.

$\text{NaCl}$ . Sodid chloride. *Salt*.

$\text{AmCl} = \text{NH}_4\text{Cl} = \text{NH}_3 \cdot \text{HCl}$ . Ammonic chloride. Sal ammoniac. Crystalline lump or powder. Readily sublimed.

$\text{HCl}$ . Hydric chloride. Hydrochloric acid. Produced by the action of sodic chloride on h. sulphate (p. 23). A gas, very soluble in water.

#### CHLORATE.

$\text{KClO}_3$ . Potassic chlorate. May be obtained by saturating potash with chlorine, thus,  $6\text{KHO} + \text{Cl}_6 = 5\text{KCl} + \text{KClO}_3 + 3\text{H}_2\text{O}$ ; the two salts are separated by crystallization. Soluble in water. Crystals.

#### BROMIDES.

$\text{AmBr} = \text{NH}_4\text{Br} = \text{NH}_3 \cdot \text{HBr}$ . Ammonic bromide. Soluble in water. Crystalline powder.

$\text{HBr}$ . Hydric bromide. Hydrobromic acid. A gas, soluble in water.

#### IODIDES.

$\text{PbI}_2$ . Plumbic iodide. Obtained as a yellow precipitate on mixing solutions of plumbic



acetate and potassic iodide. Rather soluble in hot water, deposited as brilliant golden scales on cooling the solution.

$\text{HgI}_2$ . Mercuric iodide. Obtained as a brilliant red precipitate on mixing solutions of mercuric chloride and potassic iodide. On heating the dry substance it turns yellow, and the yellow turns red again when rubbed.

KI. Potassic iodide. Crystals. Soluble in water.

HI. Hydric iodide. A gas, soluble in water.

### FLUORIDES.

$\text{AlNa}_3\text{F}_6$ . *Cryolite*.

$\text{CaF}_2$ . *Fluor spar*.

HF. Hydric fluoride. Hydrofluoric acid. Fluoric acid. Obtained by the action of fluor spar on h. sulphate (p. 25). A gas, soluble in water.

### CARBONATES.

*All the carbonates are insoluble in water except those of K, Na, Am.*

$2\text{PbCO}_3 \cdot \text{PbH}_2\text{O}_2$ . White lead.

$\text{CuCO}_3 \cdot \text{CuH}_2\text{O}_2$ . *Malachite*.

$\text{FeCO}_3$ . Ferrous carbonate. *Sparry iron*. *Spathic iron*. *Clay ironstone* (impure).

$\text{ZnCO}_3$ . Zincic carbonate. *Calamine*.

$\text{BaCO}_3$ . Baric carbonate. *Witherite*.

$\text{SrCO}_3$ . Strontic carbonate. *Strontianite*.

$\text{CaCO}_3$ . Calcic carbonate. *Iceland spar*. *Calcite*. *Cale spar*. *Arragonite*. *Marble*. *Limestone*. *Chalk*. *Whiting*.

$\text{CaMg}(\text{CO}_3)_2$ . *Dolomite.*

$\text{MgCO}_3$ . Magnesian carbonate. *Magnesite.*

$3\text{MgCO}_3 \cdot \text{MgH}_2\text{O}_2$ . Ordinary carbonate of magnesia. Magnesia. Powder. Made by precipitating magnesian sulphate with sodic carbonate.

$\text{K}_2\text{CO}_3$ . Potassic carbonate. Potashes. Pearlash. Salt of tartar. Powder.

$\text{KHCO}_3$ . Hydropotassic carbonate. Bicarbonate of potash. Obtained by passing carbonic acid into solution of the previous salt. Powder.

$\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ . Sodic carbonate. Ordinary soda. Washing soda. Soda ash (dried). Made from salt by converting it first into sodic sulphate by treatment with h. sulphate, then heating the sodic sulphate with coal and limestone, and lastly exhausting the mass with water.

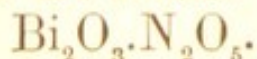
$\text{NaHCO}_3$ . Hydrosodic carbonate. Bicarbonate of soda. Made by passing carbonic acid into solution of the previous salt. Powder.

$\text{Am}_2\text{CO}_3 = 2\text{NH}_3 \cdot \text{H}_2\text{O} \cdot \text{CO}_2$ . Ammonic carbonate. Solution used as reagent.

$(\text{NH}_3)_3 \cdot \text{H}_2\text{O} \cdot (\text{CO}_2)_2$ . Ordinary carbonate of ammonia. Smelling salts. Crystalline lump.

#### NITRATES.

*All the nitrates are soluble in water except*



$\text{AgNO}_3$ . Argentic nitrate. Lunar caustic. Made by dissolving silver in h. nitrate (p. 30). Crystals or fused sticks.



$\text{Bi}_2\text{O}_3 \cdot \text{N}_2\text{O}_5$ . Subnitrate of bismuth. Made by dissolving bismuth in h. nitrate, and adding a quantity of water. It falls as a precipitate. Powder.

$\text{Sr}(\text{NO}_3)_2 \cdot 5\text{H}_2\text{O}$ . Strontic nitrate. Crystals.

$\text{KNO}_3$ . Potassic nitrate. Nitre. Saltpetre. Crystals.

$\text{NaNO}_3$ . Sodid nitrate. *Chili saltpetre*. Crystals.

$\text{AmNO}_3 = \text{NH}_4\text{NO}_3 = \text{NH}_3 \cdot \text{HNO}_3$ . Ammonic nitrate. Crystals. Made by neutralizing h. nitrate with ammonia (p. 38) or ammonic carbonate.

$\text{HNO}_3$ . Hydric nitrate. Nitric acid. Made by distilling h. sulphate with potassic or sodic nitrate (p. 25).

### PHOSPHATES.

*All the phosphates are insoluble in water except  $\text{CaH}_4(\text{PO}_4)_2$ , and the phosphates of K, Na, Am, H.*

$\text{Ca}_3(\text{PO}_4)_2$ . Calcic phosphate. *Phosphorite*. *Coprolite* (impure). Bone ash. Bone earth.

$\text{CaH}_4(\text{PO}_4)_2$ . Hydrocalcic phosphate. By mixing the previous salt with h. sulphate, a mixture of hydrocalcic phosphate and calcic sulphate is obtained, which is called superphosphate of lime.

$\text{MgAmPO}_4 \cdot 6\text{H}_2\text{O}$ . Ammonio-magnesian phosphate. Obtained as a crystalline precipitate when solution of sodic phosphate is added to a solution containing mg. sulphate, am. chloride, and ammonia.

$\text{Na}_2\text{HPO}_4 \cdot 12\text{H}_2\text{O}$ . Hydrosodic phosphate. Sodic phosphate. Crystals.

$\text{NaAmHPO}_4 \cdot 4\text{H}_2\text{O}$ . Microcosmic salt. Crystals.

$\text{H}_3\text{PO}_4$ . Hydric phosphate. Phosphoric acid.  
Solution.

### SILICATES.

*All silicates are insoluble in water except those of  
K, Na.*

Many minerals and rocks are composed of silicates.

Glass is a mixture of silicates.

Soluble glass is a compound of soda and silica.

### BORATES.

$\text{Na}_2\text{O} \cdot 2\text{B}_2\text{O}_3 \cdot 10\text{H}_2\text{O}$ . Borax. Crystals. Soluble in water.

$\text{H}_3\text{BO}_3 = \frac{1}{2}(3\text{H}_2\text{O} \cdot \text{B}_2\text{O}_3)$ . Hydric borate. Boric acid. Soluble in water.

### MANGANATE.

$\text{Na}_2\text{MnO}_4$ . Sodid manganate. Green solution.

### PERMANGANATE.

$\text{KMnO}_4$ . Potassic permanganate. Dark crystals or red solution.

### CHROMATES.

$\text{PbCrO}_4$ . Plumbic chromate. Chrome yellow.  
Obtained as a yellow precipitate on mixing solutions of k. bichromate and pb. acetate.

$\text{K}_2\text{CrO}_4$ . Potassic chromate. Yellow crystals.  
Soluble in water.

$\text{K}_2\text{CrO}_4 \cdot \text{CrO}_3$ . Potassic bichromate. Red crystals.  
Soluble in water.



## UNCLASSED COMPOUNDS.

$\text{BiOCl}$ . Oxychloride of bismuth. Pearl white. Obtained as a precipitate by mixing bismuthic chloride with a large quantity of water.

$\text{NiAs}$ . *Kupfernickel*.

$\text{NiAs}_2$ . *Arsenical nickel*.

$\text{NiSAs}$ . *Nickel glance*.

$\text{CoAs}_2$ . *Tin white cobalt*.

$\text{CoSAs}$ . *Bright white cobalt*. *Cobalt glance*.

$\text{FeSAs}$ . *Mispickel*. *Arsenical pyrites*.

$\text{CaOCl}_2$ . Chloride of lime. Bleaching powder. Made by passing chlorine into chambers containing lime. Partly soluble.

$\text{Na}_2\text{OCl}_2$ . Chloride of soda. Made in solution by passing chlorine into weak solution of soda.

$\text{NH}_3$ . Ammonia. A gas. (See p. 37.)

$\text{PH}_3$ . Hydric phosphide. Phosphuretted hydrogen. A gas.

$\text{AsH}_3$ . Hydric arsenide. Arseniuretted hydrogen. When zinc acts on dil. h. sulphate in the presence of a solution of arsenic, the hydrogen evolved is mixed with this gas. It is highly poisonous. MARSH'S test for arsenic is as follows:—Fit a tube drawn to a point to a bottle, in the bottle place zinc and dil. h. sulphate, insert the tube, and after the air has escaped light the gas. Hold a plate in the flame, and nothing but water will be deposited on the plate. Now lift the cork, and without delay add a little very weak solution of arsenic, light the gas again, and hold a plate in the flame. A shining deposit, called a

mirror, consisting of an exceedingly thin film of arsenic, will be obtained on the plate.

$\text{SbH}_3$ . Hydric antimonide. Antimonetted hydrogen. A mixture of hydrogen with this gas is obtained under similar circumstances to the above. If the above experiment is made with antimony instead of arsenic a similar mirror is obtained.

$\text{CH}_4$ . Marsh gas. Obtained by igniting a mixture of sodic acetate and soda-lime. (Soda-lime is a mixture of lime and soda.) A gas which burns with a pale flame.

$\text{C}_2\text{H}_4$ . Olefiant gas. Obtained by heating a mixture of alcohol and h. sulphate (p. 27). A gas which burns with a highly luminous flame.

$\text{CS}_2$ . Carbonic sulphide. Made by passing the vapor of sulphur over red-hot carbon. A very volatile stinking fluid. It dissolves phosphorus (p. 8).

$\text{AsS}$ . *Realgar*.

$\text{As}_2\text{S}_3$ . Arsenious sulphide. *Orpiment*. Obtained as a fine yellow precipitate on passing h. sulphide into acidified solution of arsenious acid.

$\text{SiF}_4$ . Silicic fluoride. Fluosilicic gas. Obtained by heating a mixture of sand, fluor spar, and h. sulphide.  $\text{SiO}_2 + 2\text{CaF}_2 + 2\text{H}_2\text{SO}_4 = 2\text{CaSO}_4 + 2\text{H}_2\text{O} + \text{SiF}_4$ .

$\text{H}_2\text{SiF}_6$ . Hydric silicofluoride. Hydrofluosilicic acid. Obtained in solution by passing the previous gas into water, silicic acid being thrown down at the same time.  $3\text{SiF}_4 + 2\text{H}_2\text{O} = 2\text{H}_2\text{SiF}_6 + \text{SiO}_2$ .



## ORGANIC SALTS MENTIONED IN THIS BOOK.

$\text{KCN} = \text{KCy}$ . Potassic cyanide. White lump. Soluble in water.

$\text{K}_4\text{Cy}_6\text{Fe} \cdot 3\text{H}_2\text{O}$ . Potassic ferrocyanide. Yellow prussiate of potash. Manufactured by heating nitrogenous refuse with k. carbonate and iron. Yellow crystals. Soluble in water.

$\text{K}_3\text{Cy}_6\text{Fe}$ . Potassic ferricyanide. Red prussiate of potash. Made by treating the former with chlorine. Red crystals. Soluble in water.

$\text{AmCyS}$ . Ammonic sulphocyanide. Crystals. Soluble in water.

$\text{Am}_2\text{C}_2\text{O}_4 \cdot \text{H}_2\text{O} = \text{Am}_2\bar{\text{O}} \cdot \text{H}_2\text{O}$ . Ammonic oxalate. Crystals. Soluble in water.

$\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot 3\text{H}_2\text{O} = \text{Pb}\bar{\text{A}}_2 \cdot 3\text{H}_2\text{O}$ . Plumbic acetate. Sugar of lead. Crystals. Soluble in water.

$\text{HC}_2\text{H}_3\text{O}_2 = \text{H}\bar{\text{A}}$ . Hydric acetate. Acetic acid.

## ANALYSIS.

## REAGENTS.

## DRY REAGENTS.

*Sodic carbonate* ( $\text{Na}_2\text{CO}_3$ ). The common soda-ash should be thoroughly dried in a dish over the Bunsen lamp.

*Potassic cyanide and sodic carbonate* ( $\text{KCy}$  and  $\text{Na}_2\text{CO}_3$ ). Grind in a mortar equal weights of potassic cyanide and dried sodic carbonate. Preserve the mixture in a well-closed bottle.

*Borax* ( $\text{Na}_2\text{O} \cdot 2\text{B}_2\text{O}_3$ ). The salt powdered.

*Sodiopotassic carbonate* ( $\text{KNaCO}_3$ ). Mix 20 grm. hydropotassic carbonate with 17 grm. hydrosodic carbonate. These salts are more easily obtained pure than the potassic and sodic carbonates, and when heated—as they always will be when used—they are at once converted into the latter. The mixture, when fused, consists of  $\text{K}_2\text{CO}_3 + \text{Na}_2\text{CO}_3$ , or  $\text{KNaCO}_3$ .  $\text{KNaCO}_3$  fuses at a lower temperature than either  $\text{K}_2\text{CO}_3$  or  $\text{Na}_2\text{CO}_3$ .

*Microcosmic salt* ( $\text{NaAmHPO}_4$ ). This salt should be put in a porcelain dish over the lamp, and dried up to a considerable extent, or it will be difficult to form a bead on the platinum wire. The bead consists of sodic metaphosphate ( $\text{NaPO}_3$ ).

## TEST PAPERS.

*Litmus paper.* Stir 1 part of powdered litmus with 10 parts of hot water, and filter. (It is slow in filtering, in consequence of the large



quantity and slimy nature of extraneous matter.) Boil the filtrate, and add h. nitrate till the blue color just turns red, then add soda till writing paper painted with the fluid dries of a neutral tint; that is, neither red nor blue. The paper should be painted one side, and when dry cut into slips of 1 by 7 cm. It is conveniently kept in a cardboard box.

Litmus paper is acted on as follows:—

Reddened by { Acids, and mostly soluble  
salts of Gr. I, II, III.\*

Blued by { Oxides and sulphides of Gr. IV, V.\*  
Carbonates of potassium, sodium,  
and ammonium.  
Silicates of potassium and sodium.  
Borax.

*Turmeric paper.* Digest 1 part of powdered turmeric with 6 parts of a mixture of methylated spirit and water in equal volumes. Filter, paint writing paper one side with this tincture, and cut into slips of 1 by 7 cm.

Turmeric paper is turned brown by the same substances which turn litmus blue; also by boric acid, more especially on drying. We simply use it as a test for the latter.

### WET REAGENTS.

Distilled water should always be used in making solutions, and they should be kept in stoppered bottles.

*Ammonia* (AmHO). Mix 100 c.c. of strongest ammonia (s. g. .880) with 200 c.c. water. The fluid will contain about 10 per cent. of the gas.

\* See p. 86.



*Ammonic carbonate* ( $\text{Am}_2\text{CO}_3$ ). Put 35 grm. of ordinary ammonic carbonate broken small into a bottle, add 20 c.c. strongest ammonia (s. g. .880) and 160 c.c. water. Shake occasionally till dissolved, allow to settle and pour off.

*Ammonic chloride* ( $\text{AmCl}$ ). To 20 grm. ammonic chloride recryst. add 100 c.c. water and shake till dissolved. Test the solution in a test tube with ammonic sulphide. If a black color is produced from the presence of iron, to the rest of the solution add a few drops of ammonia; allow to stand some time, filter, and neutralize exactly with h. chloride.

*Ammonic molybdate* ( $\text{Am}_2\text{MoO}_4$ ).\* Warm 10 c.c. ammonia in a test tube, add 5 grm. molybdic acid, and when a solution is obtained pour it into a mixture of 40 c.c. strong h. nitrate and 50 c.c. water. Allow to settle.

*Ammonic oxalate* ( $\text{Am}_2\bar{\text{O}}$ ). Boil 100 c.c. water, add 10 grm. ammonic oxalate, and when a solution is obtained add 200 c.c. water.

*Ammonic sulphide* ( $\text{Am}_2\text{S}$ ). This is best purchased, but it may be made as follows:—Take 100 c.c. ammonia and pass h. sulphide into it until it ceases to absorb any more. This produces hydroammonic sulphide. Now add 100 c.c. ammonia, when ammonic sulphide will be obtained. The reactions occurring are as follows:—



The solution is at first colorless, but soon turns

\* Mo is the symbol for the metal molybdenum.



yellow from oxidation. A similar yellow fluid may be produced at once from the colorless by the addition of a little sulphur. The yellow solution gives a white precipitate of sulphur with acids.

*Ammonic sulphocyanide* ( $\text{AmCyS}$ ). Put 10 grm. of the salt in a bottle, add 100 c.c. water, and shake till solution is effected.

*Argentie nitrate* ( $\text{AgNO}_3$ ). Put 5 grm. of the salt in a bottle, add 100 c.c. water, and shake till solution is effected.

*Baric carbonate* ( $\text{BaCO}_3$ ). Dissolve 30 grm. baric chloride in a litre of water, add ammonic carbonate till it causes no further precipitation, and allow to settle. Draw off the clear liquor, add fresh water, allow to settle again, and so on till a portion of the clear liquor gives no turbidity in a test tube with a drop of argentic nitrate. Lastly, stir up the sediment with 200 c.c. fresh water, and keep in this form, shaking the bottle before using.

*Baric chloride* ( $\text{BaCl}_2$ ). Put 10 grm. baric chloride in a bottle, add 100 c.c. water, and shake till solution is effected.

*Calcic sulphate* ( $\text{CaSO}_4$ ). Put 10 grm. finely-powdered gypsum into a bottle, add a litre of water, and shake occasionally. Allow the undissolved gypsum to settle, and pour off the clear fluid. This saturated solution contains about 1 part in 400.

*Chloride of soda* ( $\text{Na}_2\text{OCl}_2$ ). Take some soda (p. 74), and pass chlorine into it till it ceases to absorb any more. This is a convenient way of keeping chlorine in solution ; you have merely to dilute



this solution, and add h. chloride to neutralize the soda, and you get a solution of chlorine. Solution of chlorine in water does not keep well.

*Hydric chloride conc.* ( $\text{HCl}$ ). The ordinary hydrochloric acid contains about 30 per cent. of the pure gas.

*Hydric chloride dil.* ( $\text{HCl}$ ). Mix 100 c.c. of the conc. acid with 200 c.c. water.

*Hydric nitrate conc.* ( $\text{HNO}_3$ ). The ordinary nitric acid contains about 77 per cent. of the pure substance.

*Hydric nitrate dil.* ( $\text{HNO}_3$ ). Mix 50 c.c. of the conc. acid with 200 c.c. water.

*Hydric sulphate conc.* ( $\text{H}_2\text{SO}_4$ ). The ordinary sulphuric acid contains about 96 per cent. of the pure substance. It contains a little plumbic sulphate, which does not interfere with its use.

*Hydric sulphate dil.* ( $\text{H}_2\text{SO}_4$ ). To 250 c.c. water in a beaker or jug add 50 c.c. of the conc. acid; allow the plumbic sulphate to settle, and draw off the clear liquor.

*Hydric sulphide* ( $\text{H}_2\text{S}$ ). Fit up the following apparatus:—*A*, a generating bottle as for making hydrogen. *B*, a washing bottle, *i.e.*, a small bottle fitted with two bent tubes—one leading to the bottom, and the other just below the cork. *C*, a larger bottle fitted like *B*. Join the three bottles together with india-rubber. In *A* put a few lumps of ferrous sulphide, and fill the bottle one-third with dil. h. sulphate. *B* need not contain anything; it serves to collect any liquid which might come over from *A*. *C* contains



water, if you wish to make solution of h. sulphide, or the solution to be treated with the gas. During the passage of the gas keep shaking *C*, as this considerably facilitates absorption. When it is imagined that the fluid in *C* is saturated with the gas, take out the cork, cover the mouth with your hand, and shake; if the hand is not drawn in, the liquid is saturated.

In this way the unabsorbed hydric sulphide continually escapes into the air, and the experiment should be done in a draught cupboard; or, if in the country, in the open air. It is better also to burn the escaping excess of gas by passing it through a gas flame, and thus convert it into the less offensive sulphurous acid. Get a two-inch brass tube of the same diameter as the barrel of the Bunsen, in the side of which is soldered another shorter tube; fix the long tube upright on the top of the Bunsen by india-rubber, and attach the short tube by india-rubber to the exit of *C*.

When the operation is finished, take the cork out of the generating bottle, apply a light, and immediately fill it with water, then empty the liquid. If any lumps remain, wash them, and keep them in the bottle for future use.

The solution of h. sulphide soon loses all its strength in contact with the air. If the bottle is full, well closed and inverted, the solution will keep for months.

*Hydrosodic phosphate* ( $\text{Na}_2\text{HPO}_4$ ). Boil 50 c.c. water, add 4 gramm. of the salt, and when solution is effected add 50 c.c. water.

*Mercuric chloride* ( $\text{HgCl}_2$ ). Boil 50 c.c. water, add

4 grm. of the salt in powder, and when solution is effected add 50 c.c. water.

*Platinic chloride* ( $\text{PtCl}_4$ ). Put 2 grm. platinum foil clippings in a flask, add h. chloride conc. and about one-third its volume of h. nitrate conc., warm gently till dissolved. If after some time the action seems to have ceased and platinum still remains undissolved, pour off the liquor, add fresh acids, and continue the digestion. Transfer the solution to a dish, evaporate on a water bath to the consistence of syrup, and add 100 c.c. water.

*Potassic nitrite* ( $\text{KNO}_2$ ). Support a stoppered retort with the neck slanting a little upwards. Into the neck fit a tube so bent as to have a long limb perpendicularly downwards. In the retort put h. nitrate conc. and lumps of arsenious acid. Let the tube dip into 200 c.c. water in which 50 grm. potash ( $\text{KHO}$ ) have been dissolved. Warm the retort by the aid of a water bath, and pass the evolved nitrous acid into the potash till no more is absorbed.

*Soda* ( $\text{NaHO}$ ). To 50 grm. caustic soda broken small add 250 c.c. boiling water, and when a solution is obtained add 250 c.c. more water. Allow to settle, and draw off the clear liquor.

*Stannous chloride* ( $\text{SnCl}_2$ ). Mix 50 c.c. h. chloride conc. with 50 c.c. water, boil and add 10 grm. of the salt.



# ANALYSIS OF SINGLE SUBSTANCES (OXIDES AND SALTS).

TABLE A.—PRELIMINARY EXAMINATION FOR THE METAL.

EXPERIMENTS.	RESULTS.	INFERENCES.
1. Heat substance in ignition tube before blowpipe.	A sublimate of S	S
	A sublimate not S	Am. Hg. As
	Smell of $\text{NH}_3$	Am
	Globules of Hg	Hg
	Mirror of As	As
	Metallic globules, malleable	Pb. Ag. Sn
	" "	Sb. Bi
	Garlic odor	As
	The cold bead is—	
	blue	Co
	blue	Cu
	green	Cr
	brown, yellow or bottle green	Ni. Fe
	amethyst red	Mn
	The flame is colored—	
	green	$\text{Cu. BO}_3$
	yellowish green	Ba
	crimson	Sr
	red	Ca
	yellow	Na
	violet	K
	No action in any of above experiments.	Zn. Al. Mg

*Practice in Table A.*

(The object of this examination is by a few simple blowpipe experiments to get a fair idea of the metal present, and also to show how a metal may be tested for in the dry way.)

1. Take some ignition tubes (p. 32) and put into one a minute quantity (about as big as two or three pins' heads) of the substance, hold the end of the tube in a Bunsen flame, and if no action takes place apply the blowpipe flame. The following substances will give definite results :—

$\text{FeS}_2$ ,  $\text{CuFeS}_2$  decompose and give a sublimate of S.

$\text{HgCl}$ ,  $\text{HgCl}_2$ ,  $\text{AmCl}$ ,  $\text{As}_2\text{O}_3$ ,  $\text{As}_2\text{S}_3$ ,  $\text{HgI}$ ,  $\text{HgS}$  sublime without decomposition.

$\text{HgO}$  decomposes and gives a sublimate of Hg.

(Many other substances are decomposed, such as  $\text{FeSO}_4$ ,  $\text{ZnSO}_4$ , Alum,  $\text{KClO}_3$ , and nitrates.)

Among these results sublimate is most striking ; one of S is recognisable immediately ; one not S will probably be produced by Am, Hg or As. Compounds of these metals may be distinguished at once by the following experiment :—

Mix a pin's head of the powdered substance with 10 or 20 times its quantity of perfectly dry  $\text{Na}_2\text{CO}_3$  on a piece of paper by means of a penknife, put the mixture into an ignition tube, and apply the blowpipe flame. (If the  $\text{Na}_2\text{CO}_3$  is not perfectly dry the water will make a mess in the ignition tube.)

The following substances may be used :—



$\text{AmCl}$  gives a smell of  $\text{NH}_3$ .

$\text{HgCl}$  gives globules of  $\text{Hg}$ .

$\text{As}_2\text{O}_3$  gives a mirror of  $\text{As}$ , which is black or steely according to the quantity.

2. Take a piece of fine charcoal nearly free from fissures, cut it lengthwise in half with a saw, and scoop a cavity in the flat surface. Now mix a little  $\text{KCy} + \text{Na}_2\text{CO}_3$  on paper with a little of the substance in powder, put the mixture in the cavity, and apply a blowpipe flame.

If metallic globules are formed, allow the charcoal to cool, take out a large globule with the point of a penknife, put it in a mortar, and hit it with the pestle to see if it is brittle or malleable. If the globules are very small they may be separated from the flux and charcoal by scooping the whole mass out, grinding it in a mortar with water, and washing away all soluble and light particles under the tap. If any particles of metal are present they will remain and shine at the bottom, and it will be evident whether they are malleable or brittle. If fumes are noticed, take the charcoal quickly to your nose.

The following substances may be used:—

Oxides or salts of  $\text{Pb}, \text{Ag}, \text{Sn}$  give malleable globules.

“ “  $\text{Sb}, \text{Bi}$  “ brittle “  
Compounds containing  $\text{As}$  give a garlic odor.”

Some oxides and salts are reduced to metal by heating on charcoal alone, while many more require a flux of  $\text{Na}_2\text{CO}_3$ . The addition of  $\text{KCy}$ , however, which is the most powerful dry reducing agent, assists the action of the  $\text{Na}_2\text{CO}_3$ .

3. Take a piece of platinum wire three or four inches long, and make a loop at one end (the



nozzle of the blowpipe may be used for this purpose). Make the loop red hot in the Bunsen or blowpipe flame, dip it in borax, hold in the flame again, and so on, till a good transparent colorless bead is obtained. Now touch the bead with some of the substance, either in powder or solution, and hold in the outer blowpipe flame. Allow the bead to cool, and then observe its color. If the color is too faint, add more substance; if so dark as not to be distinguishable, heat the bead, jerk some off, and add more borax. To clean the wire, heat the bead and give the wire a sudden jerk.

The following substances may be used:—

Co compounds give a blue color.

Cu	„	„	blue color, but different from Co color.
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Cr	„	„	green color.
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Ni	„	„	brown or yellow color.
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Fe	„	„	brown, yellow, or bottle-green color.
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Mn	„	„	amethyst red color.
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4. Take a fresh piece of platinum wire (that used for the borax will not answer), dip it in h. chloride, conc. contained in a watch-glass, and hold it in the Bunsen flame; if it gives no color to the flame it is fit for use. Otherwise you must continue alternately dipping the wire in HCl, and heating it till this result is attained. Having got a clean wire, dip in the HCl again, then in the powdered substance, and hold in the flame. In applying the test to baric, strontic, or calcic sulphate, hold the substance on the wire in the reducing flame for some little while, then dip the wire in HCl; on now holding the wire in the flame, the color will be produced.



The following substances may be used :—

Cu compounds give a color, first blue then green.

Boracic acid gives a green color.

Ba compounds give a yellowish-green color.

Sr	”	”	crimson color.
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Ca	”	”	red color.
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Na	”	”	yellow color.
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K	”	”	violet color.
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TABLE B.—PRELIMINARY EXAMINATION FOR THE ANTIMETAL.

EXPERIMENTS.	RESULTS.	INFERENCES.
1. Warm or heat substance with strong HCl	$\text{CO}_2$ $\text{H}_2\text{S}$ Cl without striking change of color. Cl with change of color from red or yellow to green.	$\text{CO}_3$ $\text{S}$ $\left\{ \begin{array}{l} \text{ClO}_3 \cdot \text{NO}_3 \\ \text{MnO}_2 \cdot \text{PbO}_2 \end{array} \right.$ $\text{CrO}_4$
If no action, to last test tube add two volumes of water and boil	$\text{CO}_2$	$\text{CO}_3$
2. Warm substance with conc. $\text{H}_2\text{SO}_4$	$\text{HCl}$ or $\text{HF}$ $\text{Br}$ $\text{I}$	$\text{Cl.F}$ $\text{Br}$ $\text{I}$
3.	<i>No action in any of above experiments.</i>	$\text{SO}_4 \cdot \text{PO}_4 \cdot \text{BO}_3 \cdot \text{SiO}_4 \cdot \text{O}$



*Practice in Table B.*

(The object of this is to give an idea of the anti-metal present, and to show in what direction to apply wet reactions.)

1. Put a small quantity of the substance in a test tube, add half an inch HCl c. and warm.

The following substances give definite results :—

Carbonates give evolution of carbonic acid.

(Some, such as  $\text{BaCO}_3$ , require the addition of water.)

Sulphides (not  $\text{HgS}$ ,  $\text{FeS}_2$ , and  $\text{CuFeS}_2$ ) give evolution of  $\text{H}_2\text{S}$  (known by its smell).

Chlorates	} give evolution of Cl (known by its smell).
Nitrates	
$\text{MnO}_2$ , $\text{PbO}_2$	

Chromates give evolution of Cl, with change of color from red or yellow to green.

2. Put a small quantity of the substance in a test tube, add half an inch of  $\text{H}_2\text{SO}_4$  c. and warm.

The following substances give definite results :—

Chlorides (not Ag, Pb, Hg, Sn) give evolution of HCl.

Fluorides give evolution of HF.

Bromides	„	„	Br.
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Iodides	„	„	I.
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## SOLUTION.

Dissolve in water if possible. If not, powder finely and try to dissolve in an acid, using the acids in the following order:—HCl dil., HCl conc., HNO<sub>3</sub> dil., aqua regia.

*Notes to Solution.*

Put a little of the substance in a test tube, add water and warm. If it dissolves, this will be the way to make the solution. If it does not dissolve in water, the substance should be powdered finely; a hard mineral should be broken up with a hammer, stamped in a steel mortar, and then ground very finely in a mortar. It should then be warmed with the acids named till the right solvent is found.

The common solid substances

*Soluble in water, are—*

Oxides. CrO<sub>3</sub>, BaO, KHO, NaHO.

Sulphates of Cu, Fe, Zn, AlAm, Mg, K, Na, Am.

Chlorides of Hg'', Zn, Ba, Ca, Na, Am.

Chlorate of K.

Bromide of Am.

Iodide of K.

Carbonates of K, Na, Am.

Nitrates of Ag, Ba, Sr, K, Na, Am.

Phosphates of Na<sub>2</sub>H, NaAmH.

Borate of Na.

Chromate of K.



*Soluble in HCl conc. or dil., are—*

HgO, CuO, Sb<sub>2</sub>O<sub>3</sub>, Fe<sub>2</sub>O<sub>3</sub>, Fe<sub>3</sub>O<sub>4</sub>, MnO<sub>2</sub>, ZnO,  
Cr<sub>2</sub>O<sub>3</sub>, CaO, MgO, As<sub>2</sub>O<sub>3</sub>, PbS, Sb<sub>2</sub>S<sub>3</sub>, FeS,  
CaSO<sub>4</sub>, SnCl<sub>2</sub>, HgI<sub>2</sub>, CuCO<sub>3</sub>, FeCO<sub>3</sub>, ZnCO<sub>3</sub>,  
BaCO<sub>3</sub>, SrCO<sub>3</sub>, CaCO<sub>3</sub>, CaMg(CO<sub>3</sub>)<sub>2</sub>, MgCO<sub>3</sub>,  
Bi<sub>2</sub>O<sub>3</sub>.N<sub>2</sub>O<sub>5</sub>, Ca<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub>.

*Soluble in HNO<sub>3</sub> dil., are—*

PbO, PbI<sub>2</sub>, PbCO<sub>3</sub>, Pb<sub>3</sub>O<sub>4</sub> (the last, on addition  
of spirit of wine).

*Soluble in aqua regia, are—*

HgS, FeS<sub>2</sub>, CuFeS<sub>2</sub>, ZnS, HgCl.

*Insoluble in water and acids, are—*

SnO<sub>2</sub>, FeCr<sub>2</sub>O<sub>4</sub>, Al<sub>2</sub>O<sub>3</sub>, SiO<sub>2</sub> and silicates, PbSO<sub>4</sub>,  
BaSO<sub>4</sub>, SrSO<sub>4</sub>, AgCl, CaF<sub>2</sub>, AlNa<sub>3</sub>F<sub>6</sub>.

TABLE C.--EXAMINATION OF THE SOLUTION FOR THE METAL.

GROUP TESTS.	PRECIPITATES BY GROUP TESTS.	CHARACTERISTIC TESTS.
1. Add HCl	AgCl white HgCl white PbCl <sub>2</sub> white	AgCl insoluble in H <sub>2</sub> O, soluble in AmHO. HgCl insoluble in H <sub>2</sub> O, with AmHO turns to black NH <sub>2</sub> Hg <sub>2</sub> Cl. PbCl <sub>2</sub> soluble in H <sub>2</sub> O on boiling
2. Add H <sub>2</sub> S	PbS black HgS black Bi <sub>2</sub> S <sub>3</sub> black CuS black SnS brown SnS <sub>2</sub> yellow  As <sub>2</sub> S <sub>3</sub> yellow CdS yellow Sb <sub>2</sub> S <sub>3</sub> orange S white	Original solution gives with H <sub>2</sub> SO <sub>4</sub> white p. of PbSO <sub>4</sub> . " " with SnCl <sub>2</sub> white (HgCl) grey or black (Hg) p. " " with H <sub>2</sub> O and AmCl white p. of BiOCl. " " with AmHO blue color. " " with excess of HgCl <sub>2</sub> white p. of HgCl " " with Zn and HCl sponge of Sn, which dissolved in conc. HCl gives with excess of HgCl <sub>2</sub> white p. of HgCl.  Prelim. Exam.
3. Add AmCl, AmHO, and Am <sub>2</sub> S	NiS black CoS black FeS black  MnS pink CrH <sub>3</sub> O <sub>3</sub> green ZnS white AlH <sub>3</sub> O <sub>3</sub> white Ca <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub> white	Original solution gives with Zn and HCl in a platinum dish, a black stain.  Original solution gives with NaHO, green p. of NiH <sub>2</sub> O <sub>2</sub> which does not alter in the air. Borax bead. Fe". Original solution gives with freshly prepared solution of K <sub>3</sub> Cy <sub>6</sub> Fe, Prussian blue p. of Fe <sub>3</sub> (Cy <sub>6</sub> Fe) <sub>2</sub> . Fe". Original solution gives with AmCyS, red color. Original substance gives with a bead of Na <sub>2</sub> CO <sub>3</sub> and KNO <sub>3</sub> , green color. Original substance gives with a bead of Na <sub>2</sub> CO <sub>3</sub> and KNO <sub>3</sub> , yellow color. Original solution gives with AmHO, white p. of ZnH <sub>2</sub> O <sub>2</sub> readily soluble in excess. " " with AmHO, white p. of AlH <sub>3</sub> O <sub>3</sub> not readily soluble in excess. " " with Am <sub>2</sub> MoO <sub>4</sub> on warming, yellow p. and with Am <sub>2</sub> O white p.



# EXAMINATION OF THE SOLUTION FOR THE METAL—(continued).

GROUP TESTS.	PRECIPITATES BY GROUP TESTS.	CHARACTERISTIC TESTS.
4. Add $\text{Am}_2\text{CO}_3$	$\text{BaCO}_3$ white $\text{SrCO}_3$ white $\text{CaCO}_3$ white	Original solution gives with $\text{CaSO}_4$ , immediate p. " " " " p. after standing. " " " " no p.
5.		Mg. Solution containing previous group tests gives with $\text{Na}_2\text{HPO}_4$ on stirring a white cryst. p. of $\text{MgAmPO}_4$ .
		K. Cold conc. solution of original substance on a watch glass gives with $\text{PtCl}_4$ a yellow p. of $\text{K}_2\text{PtCl}_6$ when stirred.
		Am. Preliminary Exam. (Original solution gives with $\text{PtCl}_4$ a p. of $\text{Am}_2\text{PtCl}_6$ like $\text{K}_2\text{PtCl}_6$ ).
		Na. Preliminary Examination.

*Practice in Table C.*

*Note.*—If to a solution containing all the metals we were to add  $\text{HCl}$ , we should get the  $\text{Ag}$ ,  $\text{Hg}'$ , and most of the  $\text{Pb}$  precipitated as chlorides. These metals are called Group I.

The chlorides of Group I. having been filtered off, if we were to pass  $\text{H}_2\text{S}$ , the rest of the  $\text{Pb}$ , the  $\text{Hg}''$ ,  $\text{Bi}$ ,  $\text{Cu}$ ,  $\text{Cd}$ ,  $\text{Sn}$ ,  $\text{As}$ ,  $\text{Sb}$  would be precipitated as sulphides. These metals, including  $\text{As}$ , constitute Group II.

The sulphides of Group II. having been filtered off, if we were to add  $\text{AmCl}$  to keep up the  $\text{Mg}$  (which otherwise might be partly thrown down),  $\text{AmHO}$  to neutralize, and lastly,  $\text{Am}_2\text{S}$ , the  $\text{Ni}$ ,  $\text{Co}$ ,  $\text{Fe}$ ,  $\text{Mn}$ ,  $\text{Zn}$  would be precipitated as sulphides,  $\text{Cr}$  and  $\text{Al}$  as hydrates. These metals constitute Group III.

Group III. having been filtered off, if we were to add  $\text{Am}_2\text{CO}_3$  we should get the  $\text{Ba}$ ,  $\text{Sr}$ ,  $\text{Ca}$  thrown down as carbonates. These metals constitute Group IV.

There would remain, finally,  $\text{Mg}$ ,  $\text{K}$ ,  $\text{Na}$ ,  $\text{Am}$ , which have no common precipitant. These metals constitute Group V.

In practising this Table we begin by taking a little weak solution of  $\text{AgNO}_3$  in a test tube, we add a few drops of  $\text{HCl}$ , and thus get the chloride precipitated. To this precipitate we add some  $\text{AmHO}$  and warm, when a clear solution will be obtained. We next take a little weak solution of  $\text{HgNO}_3$ , add a drop or two of  $\text{HCl}$ , and get the  $\text{HgCl}$  thrown down, this we treat with a little  $\text{AmHO}$ , by which it will be turned black. And so on throughout the Table. *A few drops of each test will generally be sufficient.*



The following points must be observed:—

GROUP I.—The oxychlorides of Bi and Sb are liable to be precipitated here, but they will dissolve if more HCl be added.

GROUP II.—If the solution is not already acid, add HCl.  $\text{H}_2\text{S}$  water will be sufficient, but make sure that it is good by smelling.  $\text{Hg}''$  gives a white precipitate containing only a small proportion of sulphide, if the  $\text{H}_2\text{S}$  is added in small quantity; if more of the reagent is added, the precipitate will gradually turn black. Arsenites are precipitated immediately. Arsenates must be boiled with a large quantity of  $\text{H}_2\text{S}$  water—the precipitate consists of  $\text{As}_2\text{S}_3$  mixed with  $\text{S}_2$ .  $\text{CrO}_4$  and  $\text{Fe}'''$  decompose  $\text{H}_2\text{S}$ , throwing down  $\text{S}$ . To get the effect with the former the liquid must be warmed; the color will turn from yellow to green.

GROUP III.— $\text{AmHO}$  precipitates many of these metals by itself; enough should be added till after shaking the liquid smells distinctly of it.  $\text{Ca}_3(\text{PO}_4)_2$  is precipitated here, as it could only be held in solution by the agency of an acid, which would be neutralized by the  $\text{AmHO}$ .

GROUP IV.—Before applying the group test add  $\text{AmHO}$  till the solution smells, to make sure the liquid is not acid. If the liquid is acid, the addition of  $\text{Am}_2\text{CO}_3$  causes a violent effervescence, and no precipitate is produced till enough of the test has been added to neutralize the acid. In applying the characteristic test ( $\text{CaSO}_4$ ) add a large quantity, as it is a very weak solution.

GROUP V.—In testing for Mg, if no ammonia salts and free  $\text{NH}_3$  are present, add  $\text{AmCl}$  and  $\text{AmHO}$  before the  $\text{Na}_2\text{HPO}_4$ . It will be seen that Am gives with  $\text{PtCl}_4$  a similar precipitate to K. There is no precipitant for Na.

TABLE D.—EXAMINATION OF THE SOLUTION FOR THE ANTIMETAL.

*Test for the Antimetal indicated in the Preliminary Examination.*

## ANTIMETALS.

## CHARACTERISTIC TESTS.

Chloride	Original solution acidified with $\text{HNO}_3$ gives with $\text{AgNO}_3$ white p. of $\text{AgCl}$ , which is readily soluble in $\text{AmHO}$ .
Bromide.	(Original solution acidified with $\text{HNO}_3$ gives with $\text{AgNO}_3$ yellowish white p. of $\text{AgBr}$ sparingly soluble in $\text{AmHO}$ ). Original solution mixed with $\text{HCl}$ and a little $\text{Na}_2\text{O} \cdot \text{I}_2$ imparts brown color to $\text{CS}_2$ when shaken therewith.
Iodide.	(Original solution acidified with $\text{HNO}_3$ gives with $\text{AgNO}_3$ yellowish white p. of $\text{AgI}$ , very sparingly soluble in $\text{AmHO}$ ). Original solution mixed with $\text{HCl}$ and a little $\text{Na}_2\text{OCl}_2$ imparts violet color to $\text{CS}_2$ when shaken therewith.
Nitrate.	Original solution mixed with freshly prepared solution of $\text{FeSO}_4$ and $\text{H}_2\text{SO}_4$ conc. run down side of tube shows a brown color due to solution of $\text{NO}$ in $\text{FeSO}_4$ .
Chlorate.	Original substance on watch glass with $\text{H}_2\text{SO}_4$ conc. (cold) gives brown color and peculiar odor.
Sulphate.	Original solution acidified with $\text{HCl}$ gives with $\text{BaCl}_2$ white p. of $\text{BaSO}_4$ .
Phosphate.	Original ( $\text{HNO}_3$ ) solution warmed with $\text{Am}_2\text{MoO}_4$ gives yellow p.
Borate.	Original solution just acidified with $\text{HCl}$ , and turmeric paper dipped in, a brown color is given to the paper when dried.
Silicate.	<i>Generally insoluble.</i>

*Practice in Table D.*

Take a weak solution of a salt of each antimetal and apply the test given. It is best to take a salt of potassium, sodium, or ammonium, otherwise the metal may possibly interfere with the result.



TABLE E.—EXAMINATION OF INSOLUBLE SUBSTANCES.

1. For a Fluoride.  
(The substance warmed with conc.  $\text{H}_2\text{SO}_4$  in a platinum crucible gives fumes which etch glass.)  
Powder finely, put in platinum crucible, moisten well with conc.  $\text{H}_2\text{SO}_4$ , warm to drive off  $\text{HF}$ , ignite to drive off excess of  $\text{H}_2\text{SO}_4$ , dissolve residue (sulphate of the metal present) by heating with a mixture of equal volumes conc.  $\text{HCl}$  and water, and test the solution for the metal.
2. For a substance which gives metallic globules when heated on charcoal with  $\text{KCy}$  and  $\text{Na}_2\text{CO}_3$  in Preliminary Examination ( $\text{SnO}_2$ ,  $\text{AgCl}$ ,  $\text{PbSO}_4$ ).  
Powder finely, fuse in porcelain crucible with  $\text{KCy} + \text{Na}_2\text{CO}_3$ , boil with water, dissolve the insoluble globules of metal in  $\text{HNO}_3$  or  $\text{HCl}$  and test the solution for the metal.
3. For  $\text{BaSO}_4$  or  $\text{SrSO}_4$ .  
(The substance heated on charcoal with  $\text{Na}_2\text{CO}_3$  before the blowpipe, and the mass placed on a piece of bright silver and moistened, a brown stain is formed.)  
Powder very finely, fuse in platinum crucible with  $\text{KNaCO}_3$ , pour out into a copper dish, powder, boil with  $\text{H}_2\text{O}$  till no more grit remains and filter. Examine *filtrate* (alkaline sulphate) for  $\text{SO}_4$ . Wash the *residue* (baric or strontic carbonate) thoroughly with hot water, dissolve in warm dilute  $\text{HCl}$ , and examine for the metal.
4. For a Silicate or  $\text{Al}_2\text{O}_3$ .  
(A silicate heated in microcosmic bead shows an insoluble *skeleton*.)  
Powder very finely, fuse in platinum crucible with  $\text{KNaCO}_3$ , pour out into a copper dish, powder, treat with excess of dilute  $\text{HCl}$  in a dish, evaporate to dryness using a pestle to break up lumps, moisten with conc.  $\text{HCl}$ , warm, add water, warm, filter off the insoluble residue ( $\text{SiO}_2$ ) and examine the solution for the metal.
5. For Chromic Iron.—*Next page*.

## 5. For Chromic Iron.

Powder very finely. Fuse some  $\text{KHSO}_4$  in a platinum crucible, then project into it one-twelfth its amount of the powder, stir often and fuse for half an hour, first gently, then at a strong heat, till fumes of  $\text{H}_2\text{SO}_4$  cease. Then add  $\text{Na}_2\text{CO}_3$ , about half as much as the  $\text{KHSO}_4$ , fuse and add gradually  $\text{KNO}_3$  in quantity equal to that of the  $\text{Na}_2\text{CO}_3$ ; after some time increase the heat, stirring diligently with a platinum wire. Pour out into a copper dish, powder, boil with  $\text{H}_2\text{O}$  till no more grit remains and filter. Examine the *filtrate* (alkaline chromate) for  $\text{CrO}_4$ . Wash the *residue* ( $\text{Fe}_2\text{O}_3$ ) with hot water, dissolve in  $\text{HCl}$ , and test for Fe.

*Practice in Table E.*

Take  $\text{CaF}_2$ ,  $\text{SnO}_2$ ,  $\text{BaSO}_4$ , clay and chromic iron, and treat them according to the several methods.



## PRACTICE IN ANALYSIS OF SINGLE SUBSTANCES.

Go through the Preliminary Examination for the metal till you arrive at an indication.

Go through the Preliminary Examination for the antimental till you arrive at an indication.

Dissolve a small quantity in the proper solvent.

Take a portion of the solution, and add the group tests one after another till a precipitate is obtained. (A group test must never be used unless the previous group tests are present, as this would only lead to confusion. Thus  $\text{AmHO}$  and  $\text{Am}_2\text{S}$  precipitate many members of Groups I and II, and  $\text{Am}_2\text{CO}_3$  precipitates most metals of Groups I, II, III.) Then take another portion of the solution, and add the characteristic test for the metal indicated.

Finally, test for the antimental indicated in the Preliminary Examination.

The results should be written down, as shown by the following example:—

Ig. tube —, charcoal —, Bx. = Cu.

HCl —,  $\text{H}_2\text{SO}_4$  —

Dissolved in water.

HCl —.

$\text{H}_2\text{S}$  black p.      O.S. +  $\text{AmHO}$  = Cu.

O.S. + HCl +  $\text{BaCl}_2$  =  $\text{SO}_4$ .

Subst. =  $\text{CuSO}_4$ .

# TABLES FOR THE DETECTION OF METALS IN SOLUTIONS OF MIXED SUBSTANCES.

## GENERAL TABLE.

Add HCl and filter <i>Precipitate.</i> AgCl HgCl PbCl <sub>2</sub> Wash and examine by Table I.	GENERAL TABLE.		
	<i>Filtrate.</i> Pass H <sub>2</sub> S and filter. <i>Precipitate.</i> PbS HgS Bi <sub>2</sub> S <sub>3</sub> CuS CdS SnS SnS <sub>2</sub> Sb <sub>2</sub> S <sub>3</sub> As <sub>2</sub> S <sub>3</sub> Wash and examine by Table II.	<i>Filtrate.</i> Add AmCl, AmHO and Am <sub>2</sub> S and filter. <i>Precipitate.</i> NiS CoS FeS MnS ZnS CrH <sub>3</sub> O <sub>3</sub> AlH <sub>3</sub> O <sub>3</sub> Wash and examine by Table III.	<i>Filtrate.</i> Add Am <sub>2</sub> CO <sub>3</sub> and filter. <i>Precipitate.</i> BaCO <sub>3</sub> SrCO <sub>3</sub> CaCO <sub>3</sub> Wash and examine by Table IV. Mg K Na Am Examine by Table V.



TABLE I.

Treat on the filter with hot water.	<i>Filtrate.</i>	<i>Residue.</i> Treat on the filter with $\text{AmHO}$ .	
Add $\text{H}_2\text{SO}_4$ . White p. = <b>Pb</b> .		<i>Filtrate.</i> Add excess of $\text{HNO}_3$ . White p. = <b>Ag</b> .	<i>Residue.</i> is black = <b>Hg</b> '.

TABLE II.

Transfer to dish, warm with  $\text{Am}_2\text{S}$  and filter.

*Residue.* Wash, transfer to dish, boil with strong  $\text{HNO}_3$ , dilute and filter.

*Filtrate.* Add  $\text{H}_2\text{SO}_4$  dil., and filter.

*Residue.*

Heat with  $\text{HCl}$   
c. +  $\text{KClO}_3$ , filter,  
to filtrate add  
 $\text{SnCl}_2$  and warm.  
A black p. =  $\text{Hg}''$ .

*Precipitate.*  
=  $\text{Pb}$ .

*Filtrate.* Add excess  $\text{AmHO}$  and filter.

*Precipitate.*

Wash, dissolve in watch-glass in least quantity of  $\text{HCl}$ , and add  $\text{H}_2\text{O}$ . Milkiness =  $\text{Bi}$ .

*Filtrate.* (If blue,  $\text{Cu}$  is present). Add excess  $\text{HCl}$ , then excess  $\text{H}_2\text{S}$ , filter off p., boil it with  $\text{H}_2\text{SO}_4$  dil., filter off insoluble  $\text{CuS}$ , and add  $\text{H}_2\text{S}$ . A yellow p. =  $\text{Cd}$ .

*Filtrate.* Add  $\text{HCl}$  in excess, filter, wash the p. and dry it. Divide in 2 parts.

1. Boil with strong  $\text{HCl}$ , dilute, filter into platinum crucible lid, add  $\text{Zn}$  (black stain =  $\text{Sb}$ ). Remove  $\text{Zn}$ , boil p. with strong  $\text{HCl}$ , filter, and to f. add  $\text{HgCl}_2$  p. =  $\text{Sn}$ .

2. Fuse with  $\text{KCy} + \text{Na}_2\text{CO}_3$  in ignition tube. Mirror =  $\text{As}$ .



TABLE III.

Transfer to dish, treat with cold dilute HCl, stir well and filter.

<p><i>Residue.</i> Dissolve in HCl + <math>\text{KClO}_3</math>, nearly neutralize with NaHO, add <math>\text{KNO}_2</math> and <math>\text{H}_2\text{A}</math> till acid, allow to stand some hours and filter.</p>	<p><i>Filtrate.</i> Boil to expel <math>\text{H}_2\text{S}</math>, add a little strong <math>\text{HNO}_3</math>, boil, nearly neutralize with NaHO. When cold add excess <math>\text{BaCO}_3</math>, and filter.</p>	
<p><i>Precipitate.</i> Test in borax bead for <b>Co.</b></p>	<p><i>Precipitate.</i> Wash and divide into 3 parts. 1. Dissolve in HCl, and add AmCyS. A red color = <b>Fe.</b> 2. Boil with <math>\text{Na}_2\text{OCl}_2</math>, and filter. A yellow f. = <b>Cr.</b> 3. Boil with NaHO, filter, to f. add excess HCl, then excess AmHO, and warm. p. = <b>Al.</b></p>	<p><i>Filtrate.</i> Add dil. <math>\text{H}_2\text{SO}_4</math> drop by drop till in excess, filter off <math>\text{BaSO}_4</math>, evaporate to small bulk, add excess NaHO and filter.</p>
	<p><i>Precipitate.</i></p>	<p><i>Filtrate.</i></p>
	<p>Test in <math>\text{Na}_2\text{CO}_3</math> bead for <b>Mn.</b></p>	<p>Add <math>\text{H}_2\text{S}</math>. A white p. = <b>Zn.</b></p>

TABLE III., *bis*.

It is possible that with Gr. III. the following substances may be precipitated, Ba, Sr, Ca, Mg as phosphates, borates, fluorides, silicates, and  $\text{SiO}_2$ . The method below is given by FRESNIUS to meet this case.

Treat with cold dil. HCl and filter.

*Residue.* Wash, test a portion in microcosmic bead in outer bp. flame.

A skeleton =  $\text{SiO}_2$ .

A pale reddish brown color when cold = Ni.

A blue color = Co.

Incinerate rest of residue and test for F by heating in a pt. cr. with  $\text{H}_2\text{SO}_4$ .

If F is present, treat the contents of the pt. cr. with a little  $\text{H}_2\text{O}$  and add an equal volume of alcohol,  $\text{CaSO}_4$  will be left. If the color of the bead was ambiguous, precipitate traces of Fe by  $\text{AmHO}$ , evaporate to dryness, ignite gently, dissolve in aqua regia, evaporate nearly to dryness, add  $\text{KNO}_3$ , and HA till acid, allow to stand some hours and filter off yellow p. (Co). To f. add  $\text{NaHO}$ , filter and test p. in borax bead for Ni.

*Filtrate.* Boil to expel  $\text{H}_2\text{S}$ , filter if necessary, and divide in two parts.

1. Add  $\text{H}_2\text{SO}_4$  d. and filter. Wash and test the *precipitate* on pt. wire for Ba and Sr. Mix the *filtrate* with three volumes of alcohol, collect the p., dissolve in  $\text{H}_2\text{O}$ , and test for Ca with  $\text{Am}_2\text{O}$ .

2. Add strong  $\text{HNO}_3$  and boil. Test a small portion for Fe with  $\text{AmCyS}$ . To the rest add  $\text{FeCl}_3$  (to separate  $\text{PO}_4$  and  $\text{SiO}_4$ ) till a drop gives a yellowish p. on a watch glass with  $\text{AmHO}$ , evaporate to a small bulk, add  $\text{H}_2\text{O}$ , nearly neutralize with  $\text{Na}_2\text{CO}_3$ , add excess  $\text{BaCO}_3$ , allow to stand and filter.

*Precipitate.* Wash, boil for some time with  $\text{NaHO}$  and filter.

Dry the *residue* and test for Cr by fusing with  $\text{KClO}_3$  and  $\text{Na}_2\text{CO}_3$ .

Acidify the *filtrate* with HCl, add  $\text{AmHO}$  just in excess and boil. The p. may be  $\text{Al}_2\text{O}_3$  and  $\text{SiO}_2$ . Collect it on a filter and test a portion in microcosmic bead. If  $\text{SiO}_2$  is present, ignite rest of p. on pt. cr. lid, add  $\text{KHSO}_4$ , fuse, treat with HCl and test the solution with  $\text{AmHO}$  for Al.

*Filtrate.* Add HCl, boil to expel  $\text{CO}_2$ , add  $\text{AmHO}$  and  $\text{Am}_2\text{S}$ . Filter.

*Precipitate.* Wash with  $\text{H}_2\text{O}$  and a little  $\text{Am}_2\text{S}$ , treat with cold dil. HCl and filter.

Examine the *residue* for Ni and Co (if not already found) by washing, incinerating, dissolving in aqua regia, &c.

Boil the *filtrate* to expel  $\text{H}_2\text{S}$  entirely, add  $\text{HNO}_3$ , boil, filter off S if necessary, evaporate to small bulk, add excess  $\text{NaHO}$ , boil and filter.

*Precipitate.* Examine for Mn in  $\text{Na}_2\text{CO}_3$  bead. *Filtrate.* Test with  $\text{H}_2\text{S}$  for Zn.

*Filtrate.*

Add  $\text{H}_2\text{SO}_4$  d., boil, filter off  $\text{BaSO}_4$ , add excess  $\text{AmHO}$ , then  $\text{Am}_2\text{O}$ , filter off  $\text{CaO}$  and test for Mg with  $\text{Na}_2\text{HPO}_4$ .



TABLE IV.

Dissolve on filter in warm dil. HCl, and evaporate carefully to dryness. Dissolve a portion of the residue in a little water, to the solution add large volume  $\text{CaSO}_4$ , and allow to stand.

*No precipitate is formed = Ca.*

*A precipitate is formed after some time. = Sr.* Dissolve rest of residue in water, boil with  $\text{Am}_2\text{SO}_4$  and AmHO for some time, filter off  $\text{SrSO}_4$ , and to f. add  $\text{Am}_2\text{O}$ . A p. = Ca.

*A precipitate is formed immediately. = Ba.* Digest rest of residue with alcohol, powdering it in the dish with a pestle, filter off the  $\text{BaCl}_2$ , to f. add  $\text{H}_2\text{SO}_4$ , and filter. Wash p. with dilute alcohol, boil it with  $\text{Am}_2\text{SO}_4$  and AmHO for some time and filter.

*Residue.* Test for **Sr** on platinum wire in | *Filtrate.* Dilute and add  $\text{Am}_2\text{O}$ . A p. = Ca.  
Bunsen flame.

TABLE V.

To a portion of the solution add  $\text{Na}_2\text{HPO}_4$ , stir well, and allow to stand. A crystalline p. = **Mg**.

*If Mg is absent.* Evaporate rest of solution to dryness, ignite till white fumes cease, dissolve the residue in the least quantity of water, filter if necessary into a watch-glass, and test for K and Na as below.

*If Mg is present.* Evaporate rest of solution to dryness, ignite till white fumes cease, warm residue with a little water, add  $\text{BaH}_2\text{O}_2$  till alkaline, boil, filter, to f. add  $\text{Am}_2\text{CO}_3$ , warm gently, filter, evaporate f., ignite, dissolve residue in least quantity of water, add a drop of  $\text{HCl}$ , pour solution into watch-glass, and test for K and Na as below.

Dip a clean platinum wire into the solution, and hold it in Bunsen flame, a yellow color = **Na**. Then add  $\text{PtCl}_4$  to the solution and stir; a yellow p. = **K**. If no p., evaporate to dryness on water bath, add a drop or two of water, and observe whether yellow powder remains undissolved.

Warm the original substance with  $\text{NaHO}$  in a test tube. A smell of  $\text{NH}_3$  = **Am**.



## PRACTICE IN TABLES FOR DETECTION OF METALS IN SOLUTIONS OF MIXED SUBSTANCES.

Mix solutions of the metals of Group I, add the group test (HCl), filter off the precipitate, and proceed to separate the metals according to Table I. And so on with each group.

## PRACTICE IN ANALYSIS OF MIXED SUBSTANCES.

Three or four substances should be mixed together by another person and the mixture given to the student. He should go through the two Preliminary Examinations given for single substances, which will probably give an idea of some of the metals and antimetals present, and also enable him to conclude the absence of several metals and antimetals. He should then dissolve the substance in water or acids, as far as possible, and proceed with the solution, separating the metals according to the General Table. The antimetals must be looked for each by itself, the same tests being used as in the Analysis of Single Substances. If any part of the mixture remains insoluble in water and acids it must be collected and treated separately; one of the methods given in the Table for the Analysis of Insoluble Single Substances will generally suffice.

# INDEX.

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This Index refers only to the first 74 pages ; it does not include the Analytical Tables.

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- A** CETIC acid,  $\text{HC}_2\text{H}_3\text{O}_2$   
Acid reaction defined, 39  
Acids on alkalies, 34  
— on alk. carbonates, 39  
— on alk. earths, 39  
— on alk. earthy carbs., 40  
— on ammonia, 37  
— on soda, 36  
Agate,  $\text{SiO}_2$   
Air, composition, 9  
Alabaster, 58  
Alcohol on h. sulphate, 27  
Alkalies, 55  
— properties, 34  
— on acids, 34  
Alkaline reaction defined, 39  
— carbonates on acids, 39  
— earths, 54  
— earths on acids, 39  
— earthy carbs. on acids, 40  
Alum, 58  
Alumina,  $\text{Al}_2\text{O}_3$   
Aluminic hydrate, 54  
— oxide,  $\text{Al}_2\text{O}_3$   
Amethyst,  $\text{SiO}_2$   
Ammonia, reagent, 69  
— on acids, 37  
— gas, 37  
— gas on h. chloride gas, 38  
Ammoniacal liquor, use of, 58  
Ammonic bromide, 60  
— carbonates, 62  
— carbonate, reagent, 70  
— chloride, 60, 38  
— chloride, reagent, 70  
— molybdate, reagent, 70  
— nitrate decomposed, 38  
— oxalate, 67  
— oxalate, reagent, 70  
— sulphate, 58  
— sulphide, reagent, 70  
— sulphocyanide, reagent, 71  
Ammonio-magnesian phosphate, 63  
Ammonium, 37  
Antimetal defined, 47  
Antimetals, 48  
Antimonetted hydrogen, 66  
Antimonic acid,  $\text{Sb}_2\text{O}_5$   
Antimonious oxide,  $\text{Sb}_2\text{O}_3$



Antimonious sulphide,  $\text{Sb}_2\text{S}_3$

Antimony, crude,  $\text{Sb}_2\text{S}_3$

— grey,  $\text{Sb}_2\text{S}_3$

— mirror, 66

Aqua regia, 33

Argentio chloride, 59

— nitrate, 62

— nitrate, reagent, 71

Arithmetical questions on equations, 18

— on measure of gases, 44

— on use of symbols, 12

Arragonite,  $\text{CaCO}_3$

Arsenic, As, 51

—  $\text{As}_2\text{O}_3$ , 56

— acid,  $\text{As}_2\text{O}_5$

— Marsh's test for, 65

— minerals, 65, 66

Arsenical mirror, 65

— pyrites,  $\text{FeSAs}$

Arsenious acid, 56

— sulphide, 66

Arseniuretted hydrogen, 65

Auric chloride, 59

**B**ARIC carbonate, reagent, 71

— chloride, 60

— chloride, reagent, 71

— oxide,  $\text{BaO}$

— sulphate, 58

Baryta,  $\text{BaO}$

Barytes,  $\text{BaSO}_4$

Bismuth oxychloride, 65

— subnitrate, 63

Bleaching, with chlorine, 6

— powder, 65

Blende,  $\text{ZnS}$

Blowpipe used, 31

— flame, 42

Blue stone, 57

— vitriol, 57

Bone ash,  $\text{Ca}_3(\text{PO}_4)_2$

— earth,  $\text{Ca}_3(\text{PO}_4)_2$

Borates, 64

Borax, 64

— reagent, 68

Boric acid, 56, 64

Boron, 51

Bromic acid,  $\text{Br}_2\text{O}_5$

Bromides, 60

Bromine, 51

Bunsen flame, 41

**C**ALAMINE,  $\text{ZnCO}_3$

Calc spar,  $\text{CaCO}_3$

Calcic carbonate on h. chloride, 29

— chloride, 60

— fluoride on h. sulphate, 25

— hydrate, 54

— oxide, 54

— sulphate, 58

— sulphate, reagent, 71

Calcite,  $\text{CaCO}_3$

Calomel, 59

Candle flame, 41

— in chlorine, 41

Carbon, 7

Carbonates, 61

Carbonic acid, 29

— acid on lime water, 30

— acid in breath, 30

— oxide, 26

— sulphide, 66

- Carnelian,  $\text{SiO}_2$   
 Caustic, lunar,  $\text{AgNO}_3$ , 62  
 — potash,  $\text{KHO}$ , *see* Potash  
 — soda,  $\text{NaHO}$ , *see* Soda  
 Celestine,  $\text{SrSO}_4$   
 Chalcedony,  $\text{SiO}_2$   
 Chalk,  $\text{CaCO}_3$   
 Charcoal, 7  
 Chili saltpetre,  $\text{NaNO}_3$   
 Chlorate, 60  
 Chloric acid,  $\text{Cl}_2\text{O}_5$   
 Chlorides, 59  
 Chloride of lime, 65  
 — of soda, 65  
 — of soda, reagent, 71  
 Chlorine, 6  
 — equation for preparation, 17  
 — candle burnt in, 41  
 Chromates, 64  
 Chrome ironstone,  $\text{FeCr}_2\text{O}_4$   
 Chromic acid,  $\text{CrO}_3$   
 — hydrate,  $\text{CrH}_3\text{O}_3$   
 — iron,  $\text{FeCr}_2\text{O}_4$   
 — oxide,  $\text{Cr}_2\text{O}_3$   
 Cinnabar,  $\text{HgS}$   
 Classification of compounds, 47  
 Clay ironstone, impure  $\text{FeCO}_3$   
 Cobalt, bright white,  $\text{CoSAs}$   
 — glance,  $\text{CoSAs}$   
 — tin white,  $\text{CoAs}_2$   
 — minerals, 65  
 Colcothar made, 53  
 Compounds defined, 11  
 Compounds, classification of, 47  
 Copper on h. nitrate, 32  
 — on h. sulphate, 23  
 — compounds, *see* Cupric  
 Copper, black oxide of, 33  
 — red oxide of,  $\text{Cu}_2\text{O}$   
 — minerals, 57, 61  
 — pyrites,  $\text{CuFeS}_2$   
 Copperas, 57  
 Coppernickel,  $\text{NiAs}$   
 Coprolite, impure  $\text{Ca}_3(\text{PO}_4)_2$   
 Cork bored, 2  
 Corrosive sublimate, 59  
 Corundum,  $\text{Al}_2\text{O}_3$   
 Crith defined, 43  
 Crith-unit defined, 43  
 Cryolite,  $\text{AlNa}_3\text{F}_6$   
 Cubic centimetre defined, 43  
 Cuprous oxide,  $\text{Cu}_2\text{O}$   
 Cupric hydrate, 53  
 — nitrate, 32  
 — oxide, 33  
 — oxide made by precip., 53  
 — sulphate, 23, 57  
 — sulphate on soda, 53  
  
**D**EFLAGRATION, 5  
     Deliquescent defined, 8  
 Density of gases, rules for, 44  
 Diamond, C  
 Distillation, 25  
 Dolomite,  $\text{CaMg}(\text{CO}_3)_2$   
  
**E**LEMENTS, 10, 50  
     Emery, impure  $\text{Al}_2\text{O}_3$   
 Epsom salts,  $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$   
 Explosion of hydrogen and oxygen, 4  
 — of hydrogen and air, 4



**FERRIC** chloride, 59  
 — chloride on soda, 53  
 — hydrate, 53  
 — oxide, 53  
 — sulphate, 33  
**Ferrous carbonate**,  $\text{FeCO}_3$   
 — chloride, 59  
 — hydrate, 53  
 — oxide,  $\text{FeO}$   
 — sulphate, 28, 29  
 — sulphate ignited, 53  
 — sulphate on h. nitrate, 33  
 — sulphate on soda, 53  
 — sulphide,  $\text{FeS}$   
 — sulphide on h. sulphate, 28  
**Filtering**, 23  
**Flames**, 41  
**Flint**,  $\text{SiO}_2$   
**Fluor spar**,  $\text{CaF}_2$   
**Fluoric acid**, 25  
**Fluorides**, 61  
**Fluorine**, 51  
 — test for, 25  
**Formula** defined, 11  
 — to find from percentage composition, 12

## **GALENA**, $\text{PbS}$

Gas flame, 41  
**Gases**, collection of, 1  
 — measure of, &c., 43—46  
**Glass**, 64  
 — etched, 25  
 — soluble, 64  
 — tube cut and bent, 1  
**Glauber's salt**, 58  
**Gold chloride**, 59

**Gramme** defined, 43  
**Graphite**, C  
**Greek fire**, 8  
**Green vitriol**, 57  
**Gypsum**, 58

## **HARD** tubing defined, 32

Hartshorn,  $\text{NH}_3$   
**Heavy spar**,  $\text{BaSO}_4$   
**Hematite**,  $\text{Fe}_2\text{O}_3$   
**Horn silver**,  $\text{AgCl}$   
**Hydric acetate**,  $\text{HC}_2\text{H}_3\text{O}_2$   
**Hydric antimonide**, 66  
**Hydric arsenide**, 65  
**Hydric binoxide**,  $\text{H}_2\text{O}_2$   
**Hydric borate**, 64  
**Hydric chloride**, 23  
 — reagent, 72  
 — on ca. carbonate, 29  
 — on h. nitrate, 33  
 — on mn. binoxide, 6  
 — on potash, 36  
 — gas on ammonia gas, 38  
**Hydric fluoride**, 25  
**Hydric nitrate**, 25  
 — reagent, 72  
 — on copper, 32  
 — on ferrous sulphate, 33  
 — on h. chloride, 33  
 — on mercury, 31  
 — on potash, 36  
 — on pb. oxide, 52  
 — on red lead, 52  
 — on silver, 30  
 — on tin, 53  
**Hydric phosphate**,  $\text{H}_3\text{PO}_4$ , 56  
**Hydric phosphide**,  $\text{PH}_3$

- Hydric silicofluoride, 66  
 Hydric sulphate, 58  
 — reagent, 72  
 — on alcohol, 27  
 — on ca. fluoride, 25  
 — on calico, 7  
 — on copper, 23  
 — on ferrous sulphide, 28  
 — on iron, 27  
 — on paper, 7  
 — on potash, 35  
 — on k. ferrocyanide, 26  
 — on k. nitrate, 25  
 — on sodic chloride, 23, 58  
 — on sugar, 7  
 — on zinc, 2  
 Hydric sulphide, 28  
 — reagent, 72  
 Hydroaluminic oxide, 54  
 Hydrocalcic oxide, 54  
 — phosphate, 63  
 Hydrochloric acid, *see* Hydric chloride  
 Hydrochromic oxide,  $\text{CrH}_3\text{O}_3$   
 Hydrocupric oxide, 53  
 Hydroferric oxide, 53  
 Hydroferrous oxide, 53  
 Hydrofluoric acid, 25  
 Hydrofluosilicic acid, 66  
 Hydrogen, 2  
 — equation for preparation, 16  
 — from iron and h. sulphate, 27  
 Hydropotassic carbonate, 62  
 — oxide, *see* Potash  
 — sulphate, 25, 35  
 Hydrosodic carbonate, 62  
 — oxide, *see* Soda  
 Hydrosodic phosphate, 63  
 — reagent, 73  
 Hydrosulphuric acid, 28, 72  
 Hydroxyl,  $\text{H}_2\text{O}_2$   
 Hygroscopic defined, 8  
 Hyponitric acid, 25, 30, 31, 33  
 Hyposulphite, 57
- I**CELAND spar,  $\text{CaCO}_3$   
 Ignition tubes, 32  
 Iodic acid,  $\text{I}_2\text{O}_5$   
 Iodides, 60  
 Iodine, 51  
 Iron, burnt in oxygen, 4  
 — on h. sulphate, 27  
 — compounds, *see* Ferrous and Ferric  
 — minerals, 53, 57, 61  
 — black oxide of,  $\text{Fe}_3\text{O}_4$ , 4  
 — magnetic oxide of,  $\text{Fe}_3\text{O}_4$ , 4  
 — pyrites,  $\text{FeS}_2$
- K**UPFERNICKEL,  $\text{NiAs}$
- L**AUGHING gas,  $\text{N}_2\text{O}$ , 38  
 Lead compounds, *see* Plumbic  
 — mineral, 56  
 — red,  $\text{Pb}_3\text{O}_4$ , 52  
 — sugar of, 67  
 — white,  $2\text{PbCO}_3 \cdot \text{PbH}_2\text{O}_2$   
 Lime, 54  
 — water, 30  
 — chloride of, 65  
 — superphosphate of, 63



Limestone,  $\text{CaCO}_3$   
 — calcined, 54  
 Litharge,  $\text{PbO}$ , 52  
 Litmus paper, 68  
 — action of substances on, 69  
 Litre defined, 43  
 Lunar caustic,  $\text{AgNO}_3$ , 62

# **MALACHITE**, $\text{CuCO}_3 \cdot \text{CuH}_2\text{O}_2$

Magnesia,  $\text{MgO}$ , 54, 50  
 —  $3\text{MgCO}_3 \cdot \text{MgH}_2\text{O}_2$ , 62  
 Magnesic oxide, 54, 50  
 — sulphate,  $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$   
 Magnesite,  $\text{MgCO}_3$   
 Magnesium, 50  
 Magnetite,  $\text{Fe}_3\text{O}_4$   
 Manganate, 64  
 Manganese,  $\text{Mn}$   
 —  $\text{MnO}_2$   
 — black oxide of,  $\text{MnO}_2$   
 Manganic acid,  $\text{MnO}_3$   
 — binoxide,  $\text{MnO}_2$   
 — binoxide on h. chloride, 6  
 — oxide,  $\text{Mn}_2\text{O}_3$   
 Manganous oxide,  $\text{MnO}$   
 Marble,  $\text{CaCO}_3$   
 Marsh gas,  $\text{CH}_4$ , 66  
 Massicot,  $\text{PbO}$ , 52  
 Mercuric chloride, 59  
 — chloride, reagent, 73  
 — iodide, 61  
 — nitrate, 31  
 — oxide, 52  
 Mercurous chloride, 59  
 Mercury on h. nitrate, 31  
 — mineral, 57

Mercury, red oxide of, 52  
 Metals, 10, 50, 49  
 Metaphosphoric acid, 56  
 Metre defined, 43  
 Microcosmic salt, 64  
 — reagent, 68  
 Minium,  $\text{Pb}_3\text{O}_4$ , 52  
 Mirror of antimony, 66  
 — of arsenic, 65  
 Mispickel,  $\text{FeSAs}$   
 Mundic,  $\text{FeS}_2$

**NEUTRAL** defined, 35  
 Neutralizing, 35  
 — in presence of carbonic acid, 39  
 Nickel, arsenical,  $\text{NiAs}_2$   
 — glance,  $\text{NiSAs}$   
 — minerals, 65  
 Nitrate, test for, 34  
 Nitrates, 62  
 Nitre,  $\text{KNO}_3$   
 Nitric acid, *see* Hydric nitrate  
 Nitric acid, anhydrous,  $\text{N}_2\text{O}_5$   
 — oxide made, 32  
 — oxide from  $\text{FeSO}_4$  and  $\text{HNO}_3$ , 33  
 — oxide on ferrous sulphate, 34  
 Nitrogen, 8  
 Nitrohydrochloric acid, 33  
 Nitrous acid,  $\text{N}_2\text{O}_3$   
 — oxide, 38  
 Nomenclature, 47  
 Non-metals, 11, 51  
 Normal temperature and pressure, 43  
 Notation, 10

**OIL** of vitriol,  $\text{H}_2\text{SO}_4$ , 58

Olefiant gas,  $\text{C}_2\text{H}_4$ , 27

Oligist iron,  $\text{Fe}_2\text{O}_3$

Onyx,  $\text{SiO}_2$

Opal,  $\text{SiO}_2$

Organic salts, 67

Orpiment,  $\text{As}_2\text{S}_3$ , 66

Oxide defined, 47

Oxides, 52—56

Oxidizing flame, 42

Oxygen, 3

— equation for preparation, 16

— from mercuric oxide, 32

**PEARLASH**,  $\text{K}_2\text{CO}_3$

Percentage composition, to  
find from formula, 13

Permanganate, 64

Permanganic acid,  $\text{Mn}_2\text{O}_7$

Phosphates, 63

Phosphoric acid, 8, 56

Phosphorite,  $\text{Ca}_3(\text{PO}_4)_2$

Phosphorous acid,  $\text{P}_2\text{O}_3$

Phosphorus, 7

— red, 51

Phosphuretted hydrogen,  $\text{PH}_3$

Plaster of Paris, 58

Platinic chloride, reagent, 74

Plumbic acetate, 67

— binoxide, 52

— chromate, 64

— iodide, 60

— nitrate, 52

— oxide, 52

— sulphide,  $\text{PbS}$

Pneumatic trough, 1

Potash,  $\text{KHO}$

Potash produced from potas-  
sium, 50

— on h. chloride, 36

— on h. nitrate, 36

— on h. sulphate, 35

Potashes,  $\text{K}_2\text{CO}_3$

Potassa,  $\text{KHO}$ , *see* Potash

Potassic bichromate, 64

— chlorate, 60

— chlorate, experiments with,  
3—5

— chromate, 64

— cyanide, 67

— cyanide and sodic carb., 68

— ferricyanide, 67

— ferrocyanide, 67

— ferrocyanide on h. sulphate,  
26

— hydrate, *see* Potash

— nitrate, 36

— nitrate on h. sulphate, 25

— nitrate, expt. with, 5

— nitrite, reagent, 74

— permanganate, 64

— sulphate, 35

Potassium, 50

Pressure, correction for, 44

Putty powder,  $\text{SnO}_2$

Pyrites,  $\text{FeS}_2$

— roasted, 59

— arsenical,  $\text{FeSAs}$

— copper,  $\text{CuFeS}_2$

Pyrolusite,  $\text{MnO}_2$

Pyrophosphoric acid, 56

**QUARTZ**,  $\text{SiO}_2$



# REACTION, alkaline and acid, 39

Realgar,  $\text{AsS}$

Reducing flame, 42

Reduction, 31

Rock crystal,  $\text{SiO}_2$

— salt,  $\text{NaCl}$

Rouge made, 53

Ruby,  $\text{Al}_2\text{O}_3$

# SAL AMMONIAC, 60

Salt defined, 47

Salt,  $\text{NaCl}$

— cake, 58

— Epsom,  $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$

— Glauber's, 58

— microcosmic, 64, 68

— smelling, 62

— of tartar,  $\text{K}_2\text{CO}_3$

Saltpetre,  $\text{KNO}_3$

— Chili,  $\text{NaNO}_3$

Salts, 56—64

— organic, 67

Sand,  $\text{SiO}_2$

Sapphire,  $\text{Al}_2\text{O}_3$

Selenite,  $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$

Silica,  $\text{SiO}_2$

Silicates, 64

Silicic acid,  $\text{SiO}_2$

— fluoride, 66

Silicon, 51

Silver on h. nitrate, 30

— mineral, 59

— compounds, *see* Argentic

Smelling salts, 62

Soda,  $\text{NaHO}$

Soda, produced from sodium, 50

— reagent, 74

— on acids, 36

— on cupric sulphate, 53

— on ferric chloride, 53

— on ferrous sulphate, 53

— (carb.), 62

— ash, 62

— lime, 66

— chloride of, reagent, 71

Sodic carbonate, 62

— carbonate, reagent, 68

— carbonate and pot. cy., 68

— chloride on h. sulphate, 23, 58

— hydrate, *see* Soda

— hyposulphite, 57

— manganate, 64

— metaphosphate, 68

— phosphate, 63

— phosphate, reagent, 73

— sulphate, 58

Sodiopotassic carbonate, 68

Sodium, 50

Soft tubing defined, 1

Sparry iron,  $\text{FeCO}_3$

Spathic iron,  $\text{FeCO}_3$

Specific gravity of gases, 44

Specular iron,  $\text{Fe}_2\text{O}_3$

Stannic chloride, 59

— oxide, 53

Stannous chloride, 59

— reagent, 74

Strontia,  $\text{SrO}$

Strontianite,  $\text{SrCO}_3$

Strontic nitrate,  $\text{Sr}(\text{NO}_3)_2 \cdot 5\text{H}_2\text{O}$

Sulphates, 57

Sulphides, 56

Sulphur, 5  
 — elastic, 6  
 — flame, 41  
 — flowers of, 51  
 Sulphuretted hydrogen, *see* Hydric sulphide  
 Sulphuric acid, *see* Hydric sulphate  
 — anhydrous, 55  
 Sulphurous acid, 6, 23, 55  
 Symbol defined, 11  
 Symbols, list of, 10

TEMPERATURE, correction for, 44

Tin on h. nitrate, 53  
 — compounds, *see* Stannous and Stannic  
 — mineral, 53  
 — stone,  $\text{SnO}_2$   
 Turmeric paper, 69  
 — action of substances on, 69

UNCLASSED compounds, 65  
 Unit defined, 11

Unit-weights of elements, 10

VALUES, 47—49  
 Vermilion,  $\text{HgS}$

Vitriol, 58  
 — blue, 57  
 — green, 57  
 — white, 58

WATER produced from hydrogen, 3

Weights and measures, 43

White lead, 61  
 — pearl,  $\text{BiOCl}$ , 65  
 — permanent,  $\text{BaSO}_4$ , 58  
 — vitriol, 58

Whiting,  $\text{CaCO}_3$

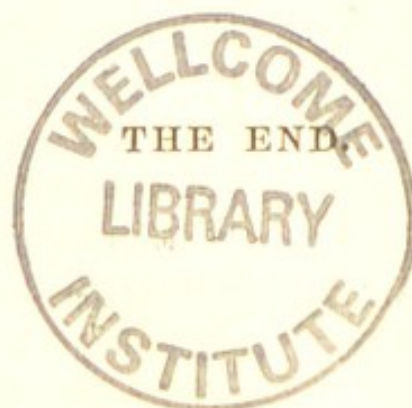
Witherite,  $\text{BaCO}_3$

Wood, destructive distillation of, 7

ZINC on h. sulphate, 2  
 — minerals, 57, 61  
 — white, 54

Zincic chloride, 60

— oxide, 54  
 — sulphate, 28  
 — sulphide,  $\text{ZnS}$





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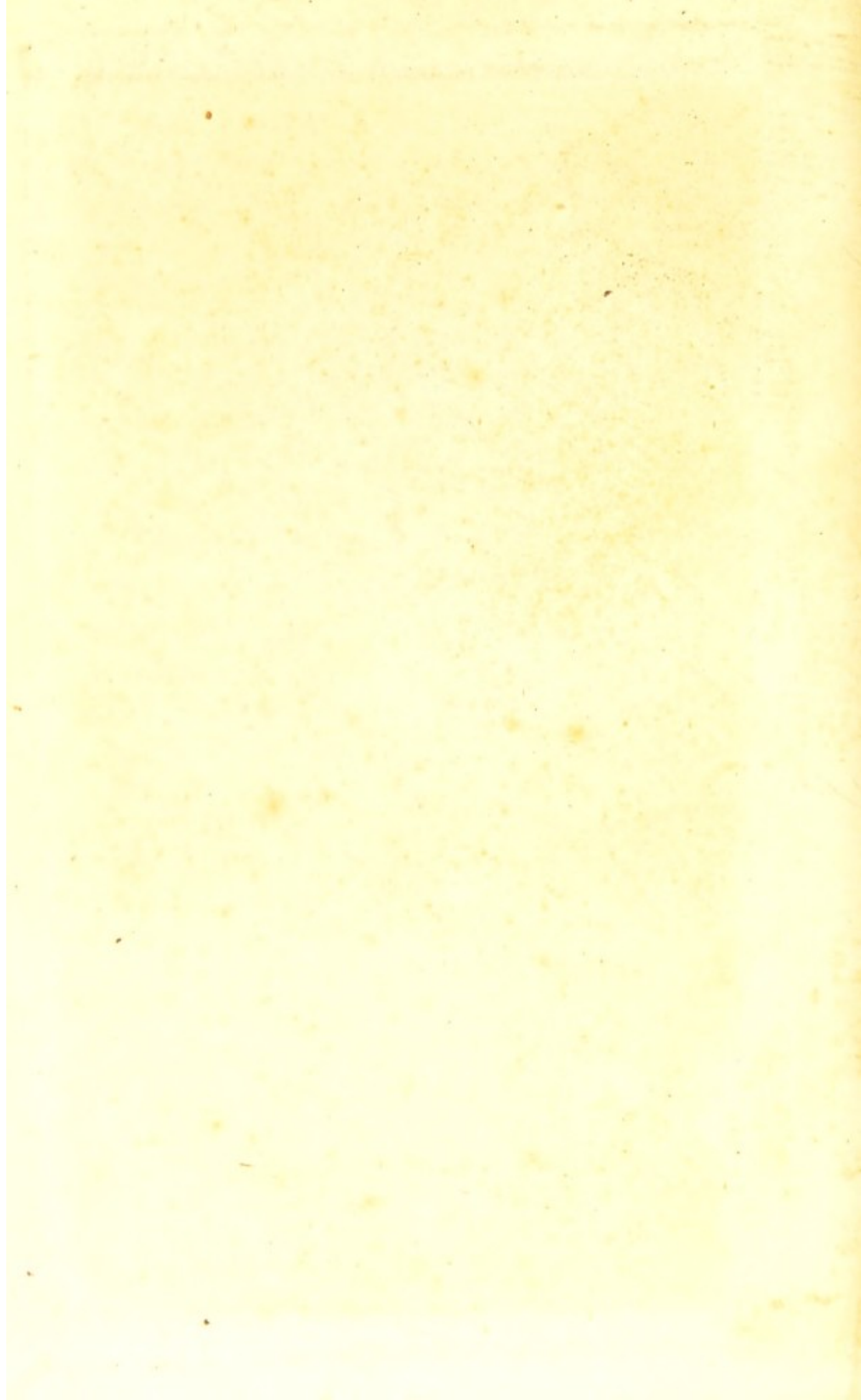
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