A.THE ATMOSPHERE .

1.The atmosphere is made up of air. Air is a mixture of colourless , odourless gases which is felt as wind(air in motion).All living things breath in air for respiration . Plants use air for respiration and photosynthesis.

2.The main gases present in the atmosphere/air:

Gas	Approximate % composition by volume
Nitrogen	78.0
Oxygen	21.0
Carbon(IV)oxide	0.03
Noble gases	1.0
Water vapour	Vary from region

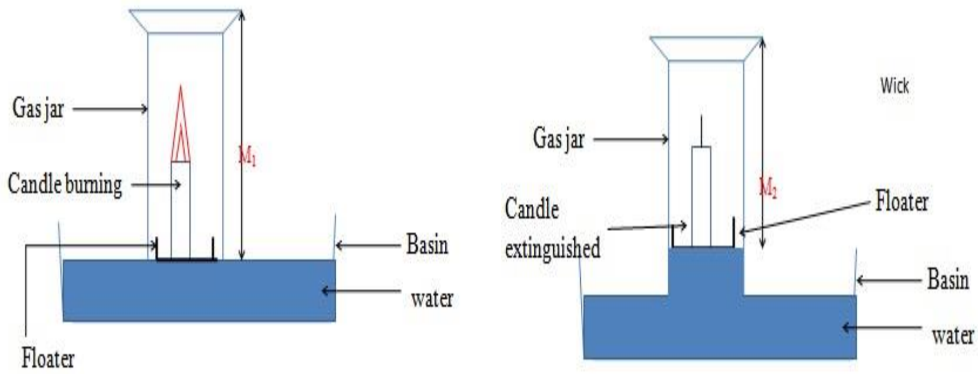
3. The following experiments below shows the presence and composition of the gases in air/atmosphere

(a)To find the composition of air supporting combustion using a candle stick

Procedure

Measure the length of and empty gas jar M_1. Place a candle stick on a petri dish. Float it on water in basin/trough. Cover it with the gas jar. Mark the level of the water in the gas jar M_2. Remove the gas jar. Light the candle sick. Carefully cover it with the gas jar. Observe for two minutes. Mark the new level of the water M_3.

Set up of apparatus



Sample observations

Candle continues to burn then extinguished/goes off
Level of water in the gas jar rises after igniting the candle
Length of empty gas jar = M_1= 14cm
Length of gas jar **without** water before igniting candle = M_2= 10 cm
Length of gas jar **with** water before igniting candle = $M_1 - M_2$= 14- 10 = 4 cm
Length of gas jar **with** water after igniting candle = M_3 = 8 cm
Length of gas jar **without** water after igniting candle = $M_1 - M_3$ = 10 -8 = 2 cm

Explanation
Candle burns in air. In a closed system(vessel),the candle continues to burn using the part of air that support burning/combustion. This is called the **active part of air**.The candle goes off/extinguished when all the active part of air is used up.The level of the water rises to occupy the space /volume occupied by the used active part of air.
The experiment is better when very dilute **sodium/potassium hydroxide** is used instead of water . Dilute Potassium/ sodium hydroxide absorb **Carbon(IV)oxide** gas that come out from burning/combustion of candle stick. From the experiment above the % composition of the:

(i)active part of air can be calculated:
$\underline{M_2 - M_3}$ x 100% => $\underline{10- 8}$ x 100% = **20%**

M_2 10cm

(ii)inactive part of air can be calculated:

100% **-20%** = **80%** // $\frac{M_3}{M_2}$ => $\frac{8}{10cm}$ x 100% = **80%**

(b)To find the composition of active part of air using heated copper turnings.

Procedure

Clamp a completely packed/filled open ended glass tube with copper turnings. Seal the ends with glass/cotton wool.

Label two graduated syringes as "A" and "B" Push out air from syringe "A". Pull in air into syringe "B".

Attach both syringe "A" and "B" on opposite ends of the glass tube.

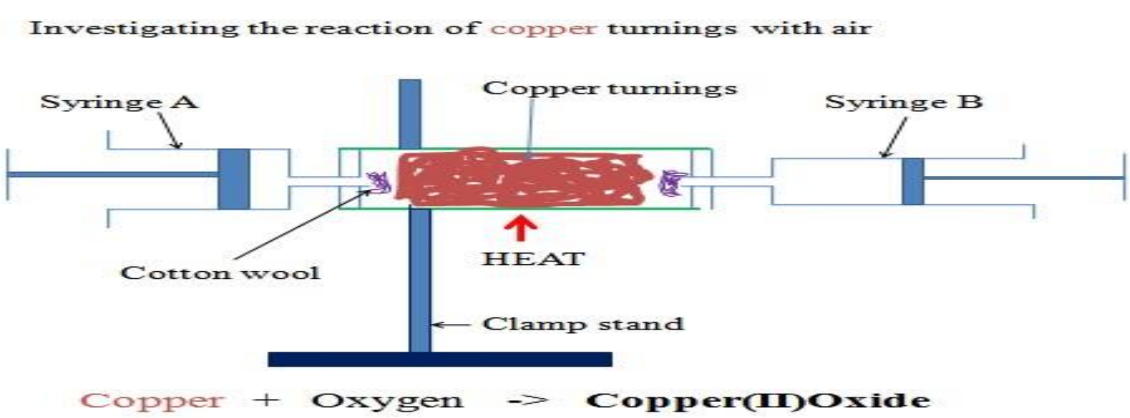
Determine and record the volume of air in syringe "B" V_1.

Heat the glass tube strongly for about three minutes.

Push all the air slowly from syringe "B" to syringe "A" as heating continues. Push all the air slowly from syringe "A" back to syringe "B" and repeatedly back and forth.

After about ten minutes, determine the new volume of air in syringe "B" V_2

Set up of apparatus



Sample observations

Colour change from brown to black

Volume of air in syringe "B" before heating V_1 = 158.0cm3
Volume of air in syringe "B" after heating V_2 = 127.2cm3
Volume of air in syringe "B" used by copper $V_1 - V_2$ = 30.8cm3

Sample questions

1.What is the purpose of

(i) glass/cotton wool

To prevent/stop copper turnings from being blown into the syringe/out of the glass tube

(ii) passing air through the glass tube repeatedly To ensure all the active part of air is used up

(iii) passing air through the glass tube slowly

To allow enough time of contact beteewn the active part of and the heated copper turnings.

2. State and explain the observations made in the glass tube.

Colour change from brown to black

Brown copper metal reacts with the active part of air/oxygen to form black copper(II)oxide. Chemical equation

Copper + Oxygen -> Copper(II)oxide

$2Cu(s) + O_2(g) \rightarrow 2CuO(s)$

The reaction reduces the amount/volume of oxygen in syringe "B" leaving the inactive part of air. Copper only react with oxygen when heated.

3. Calculate the % of

(i)active part of air

$$\% \text{ active part of air} = \frac{V_1 - V_2}{V_1} \times 100\% \Rightarrow \frac{30.8\text{cm3}}{158.0\text{cm3}} \times 100\% = \mathbf{19.493\%}$$

(ii) inactive part of air Method 1

$$\% \text{ inactive part of air} = \frac{V_2}{V_1} \times 100\% \Rightarrow \frac{127.2\text{cm3}}{158.0\text{cm3}} \times 100\% = \mathbf{80.506\%}$$

Method 2

% inactive part of air = 100% -% active part of air

=> 100 % - 19.493 % = **80.507**%

4.The % of active part of air is theoretically higher than the above while % of inactive part of air is theoretically lower than the above. Explain.

Not all the active part of air reacted with copper

5.State the main gases that constitute:

(a)active part of air.

Oxygen

(b) **inactive part of air**

Nitrogen, carbon(IV)oxide and noble gases

6.If the copper turnings are replaced with magnesium shavings the % of active part of air obtained is extraordinary very high. Explain.

Magnesium is more reactive than copper. The reaction is highly exothermic. It generates enough heat for magnesium to react with both oxygen and nitrogen in the air.

A white solid/ash mixture of Magnesium oxide and Magnesium nitride is formed. This considerably reduces the volume of air left after the experiment.

Chemical equation

Magnesium + Oxygen -> magnesium (II)oxide

$2Mg(s) + O_2(g) \rightarrow 2MgO(s)$

Magnesium + Nitrogen -> magnesium (II)nitride

$3Mg(s) + N_2(g) \rightarrow Mg_3N_2(s)$

(c)To find the composition of active part of air using alkaline pyrogallol.

Procedure

Measure about 2cm3 of dilute sodium hydroxide into a graduated gas jar. Record the volume of the graduated cylinder V_1.

Place about two spatula end full of pyrogallol/1,2,3-trihydroxobenzene into the gas jar. Immediately place a cover slip firmly on the mouth of the gas jar. Swirl thoroughly for about two minutes.

Invert the gas jar in a trough/basin containing water. Measure the volume of air in the gas jar V_2

Sample observations

Colour of pyrogallol/1,2,3-trihydroxobenzene change to **brown**.

Level of water in gas jar rises when inverted in basin/trough.

Volume of gas jar /air in gas jar V_1= **800cm3**

Volume of gas jar /air in gas jar after shaking with alkaline pyrogallol/1,2,3trihydroxobenzene V_2= **640 cm3**

Sample questions

1. Which gas is absorbed by alkaline pyrogallol/1,2,3-trihydroxobenzene

Oxygen

2. Calculate the

(i) % of active part of air

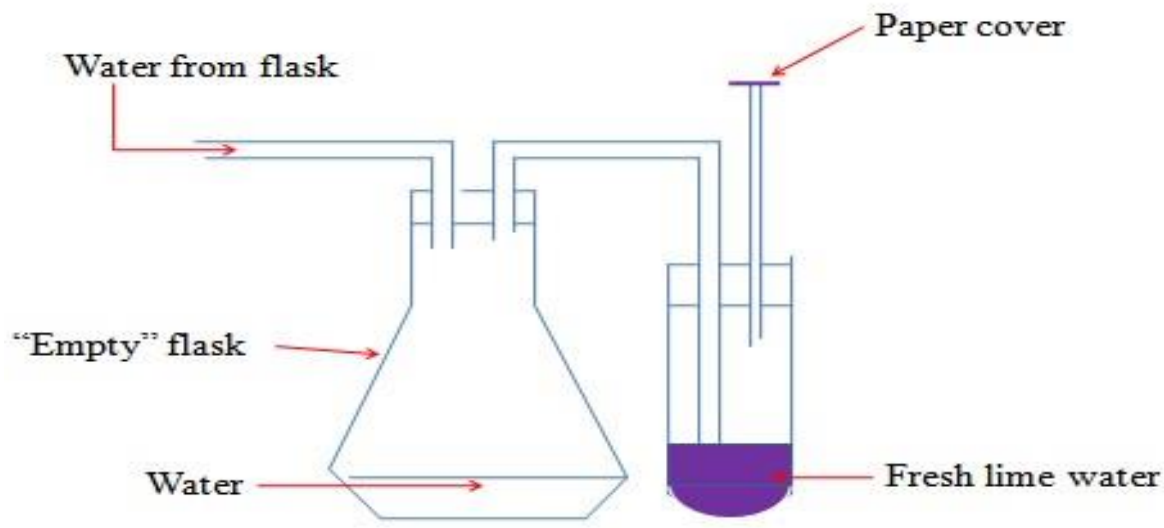
$$\frac{V_1 - V_2 \text{ x } 100\%}{V_1} \Rightarrow \frac{(800\text{cm3} - 640 \text{ cm3}) \text{ x } 100\%}{800\text{cm3}} = \underline{\mathbf{20\%}}$$

(ii) % of inactive part of air

$$\frac{V_2 \text{ x } 100\%}{V_1} \Rightarrow \frac{640 \text{ cm3 x } 100\%}{800\text{cm3}} = \underline{\mathbf{80\%}}$$

(d)To establish the presence of carbon(IV)oxide in air using lime water

Pass tap water slowly into an empty flask as in the set up below



<u>Sample observation questions</u>

1.What is the purpose of paper cover?

To ensure no air enters into the lime water.

2. What happens when water enters the flask?

It forces the air from the flask into the lime water.

3. What is observed when the air is bubbled in the lime water

A white precipitate is formed. The white precipitate dissolves on prolonged bubbling of air.

4. (a) Identify the compound that form:

(i)lime water

Calcium hydroxide / $Ca(OH)_2$ **(ii)white precipitate**

Calcium carbonate/ $CaCO_3$

(iii)when the white precipitate dissolves

Calcium hydrogen carbonate/ $CaHCO_3$

(b)Write the chemical equation for the reaction that tale place when:

(i) white precipitate is formed

Calcium hydroxide + carbon(IV)oxide -> Calcium carbonate + water

$Ca(OH)_2(aq) + CO_2(g) \rightarrow CaCO_3(s) + H_2O(l)$

(ii) white precipitate dissolves

Calcium carbonate + water**+** carbon(IV)oxide -> Calcium hydrogen carbonate

$CaCO_3$(s) + H_2O(l) + CO_2 (g) -> $CaHCO_3$(aq)

5. State the chemical test for the presence of carbon (IV)oxide gas based on 4(a) and (b)above:

Carbon(IV)oxide forms a white precipitate with lime water that dissolves in excess of the gas.

6. State the composition of carbon(IV)oxide gas by volume in the air.

About 0.03% by volume

B.OXYGEN.

a) Occurrence.

1.Fifty 50% of the earths crust consist of Oxygen combined with other elements e.g.oxides of metals

2.About 70% of the earth is water made up of Hydrogen and Oxygen.

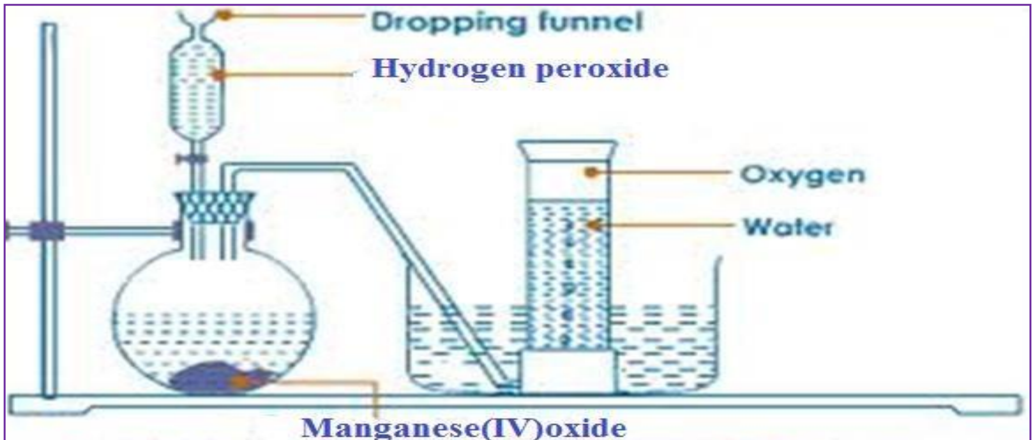
3.About 20% by volume of the atmospheric gases is Oxygen that form the active part of air.

b)School laboratory preparation.

Oxygen was first prepared in 1772 by Karl Scheele and later in 1774 by Joseph Priestly.It was Antony Lavoisier who gave it the name "Oxygen" Procedure

Method 1: **Using Hydrogen peroxide**

Half fill a trough/basin with tap water. Place a bee hive shelf/stand into the water. Completely fill the a gas jar with water and invert in onto the bee hive shelf/stand. Clamp a round bottomed flask and set up the apparatus as below.



Preparation of Oxygen from Hydrogen peroxide

Collect several gas jars of Oxygen covering each sample.

Sample observation questions

1.**What is observed when the hydrogen peroxide is added into the flask**

Rapid effervescence/bubbling/fizzing

2.Describe the colour and smell of the gas

Colourless and odourless.

3.(a)Name the method of gas collection used.

-Over water

-Upward delivery

-Down ward displacement of water

(b)What property of Oxygen make it to be collected using the method above

-Slightly soluble in water

4.What is the purpose of manganese(IV)oxide?

Manganese(IV)oxide is **catalyst**.

A catalyst is a substance that speeds up the rate of a chemical reaction but remain chemically unchanged at the end of the reaction.

Hydrogen peroxide decomposes slowly to form water and Oxygen gas.

A little Manganese(IV)oxide speeds up the rate of decomposition by **reducing** the time taken for a given volume of Oxygen to be produced.

5.Write the equation for the reaction.

Hydrogen peroxide -> Water + Oxygen

$2H_2O_2$ (aq) -> $2H_2O$ (l) + O_2 (g)

6. Lower a glowing splint slowly into a gas jar containing Oxygen gas. State what is observed.

The glowing splint relights/rekindles

Oxygen relights/rekindles a glowing splint. This is the confirmatory test for the presence of Oxygen gas

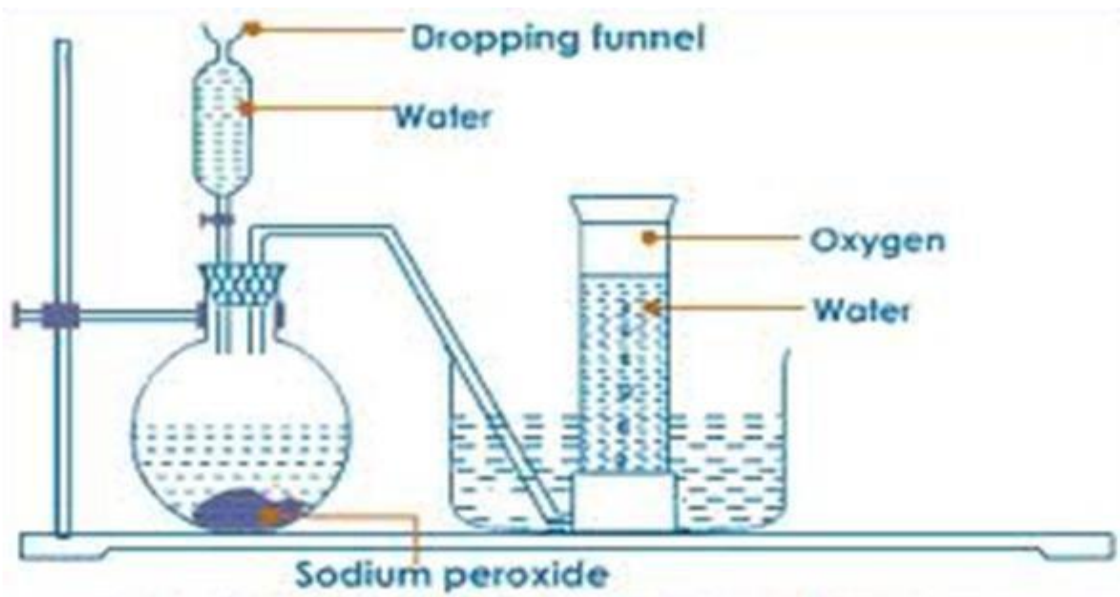
Method 1: **Using Sodium peroxide**

Half fill a trough/basin with tap water. Add four drops of phenolphthalein indicator.

Place a bee hive shelf/stand into the water.

Completely fill a gas jar with water and invert in onto the bee hive shelf/stand.

Clamp a round bottomed flask and set up the apparatus as below.



Preparation of Oxygen from Sodium peroxide and Water

Collect several gas jars of Oxygen covering each sample.

Sample observation questions

1.**What is observed when water is added**

(i)into the flask containing sodium peroxide

Rapid effervescence/bubbling/fizzing

(ii)phenolphththalein

Remains colourless /Phenolphthalein indicator is colourless in neutral solution

2. Describe the colour and smell of the gas

Colourless and odourless.

3.(a)Name the method of gas collection used.

-Over water.Oxygen is slightly soluble in water.

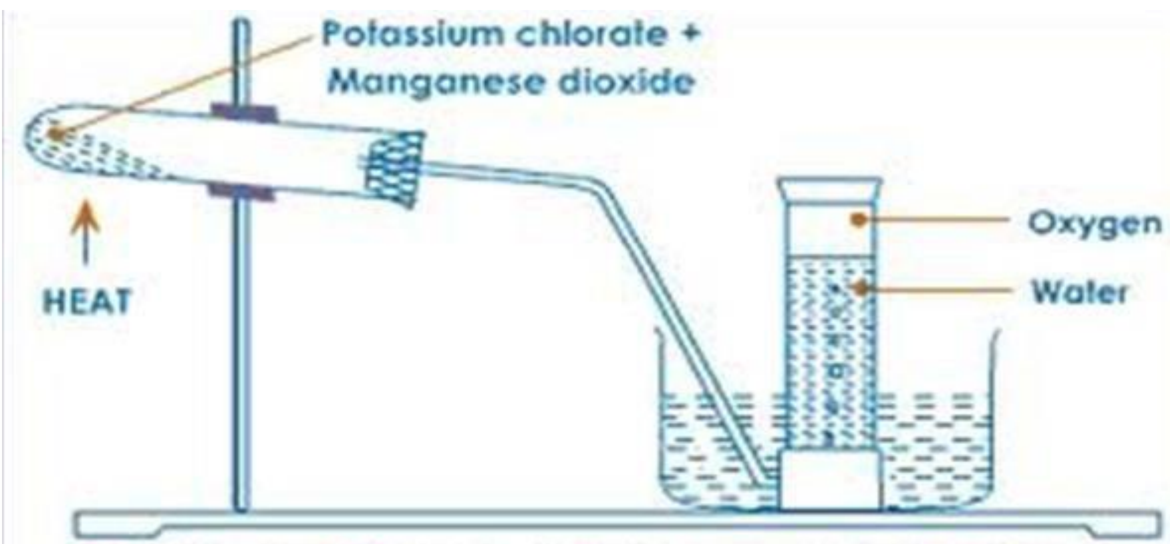
4. Test the gas by lowering a glowing splint slowly into a gas jar containingthe prepared sample.

The glowing splint relights/rekindles. This confirms the presence of Oxygen gas

5.Write the equation for the reaction.

Sodium peroxide + Water -> Sodium hydroxide + Oxygen

$2Na_2O_2$ (aq) + $2H_2O$ (l) -> $4NaOH$(aq) + O_2 (g)



Preparation of Oxygen from heating Potassium chlorate(V)

1. Test the gas by lowering a glowing splint slowly into a gas jar containing the prepared sample.

The glowing splint relights/rekindles.

This confirms the presence of Oxygen gas

2.Write the equation for the reaction.

Potassium Chlorate(V) -> Potassium Chloride + Oxygen

$2KClO_3$ (aq) -> $2KCl$(aq) + $3O_2$ (g)

3.What is the purpose of manganese(IV)oxide?

Manganese(IV)oxide is **catalyst**.

A catalyst is a substance that speeds up the rate of a chemical reaction but remain chemically unchanged at the end of the reaction.

Potassium Chlorate(V) decomposes slowly to form potassium chloride and Oxygen gas.

A little Manganese(IV)oxide speeds up the rate of decomposition by **reducing** the time taken for a given volume of Oxygen to be produced.

(c)Uses of Oxygen

1. Oxygen is put in cylinders for use where natural supply is not sufficiently enough. This is mainly in:

(i)Mountain climbing/Mountaineering-at high altitudes, the concentration of air/oxygen is low. Mountain climbers must therefore carry their own supply of oxygen for breathing.

(ii) Deep sea diving-Deep sea divers carry their own supply of Oxygen.

(iii) Saving life in hospitals for patients with breathing problems and during anaethesia.

2. A mixture of oxygen and some other gases produces a flame that is very hot. (i) **Oxy-acetyline/ethyne** flame is produced when Ethyne/acetylene gas is burnt in pure oxygen. The flame has a temperature of about 3000^oC.It is used for **welding /cutting metals**.

(ii)**Oxy-hydrogen** flame is produced when Hydrogen is burn in pure oxygen. The flame has a temperature of about 2000^{o}C.It is used also for **welding /cutting metals**.

3. **Oxy-hydrogen** mixture is used as rocket fuel
4. A mixture of charcoal , petrol and liquid Oxygen is an explosive.

(d) Chemical properties of Oxygen /combustion.

Oxygen is a very reactive non metal. Many elements react with oxygen through burning to form a group of compounds called **Oxides**.

Burning/combustion is the reaction of Oxygen with an element/substances.

Reaction in which a substance is added oxygen is called **Oxidation reaction**.

Burning/combustion is an example of an oxidation reaction.

Most **non metals** burns in Oxygen/air to form an Oxide which in solution / dissolved in water is **acidic** in nature. They turn blue litmus red.e.g. Carbon(IV)oxide/CO_2 , Nitrogen(IV)oxide/ NO_2 , Sulphur(IV)oxide/ SO_2

Some non metals burns in Oxygen/air to form an Oxide which in solution / dissolved in water is **neutral** in nature. They **don't** turn blue or red litmus. e.g. Carbon(II)oxide/CO, Water/ H_2O.

All **metals** burns in Oxygen/air to form an Oxide which in solution/dissolved in water is **basic/alkaline** in nature. They turn red litmus blue.e.g. Magnesium oxide/MgO, Sodium Oxide/ Na_2O ,Copper(II)oxide/CuO Elements/substances burn **faster** in pure Oxygen than in air. Air contains the inactive part of air that **slows** the rate of burning of substances/elements.

(i)Reaction of metals with Oxygen/air

The following experiments show the reaction of metals with Oxygen and air.

I. Burning Magnesium

Procedure

(a)Cut a 2cm length piece of magnesium ribbon. Using a pair of tongs introduce it to a Bunsen flame. Remove it when it catches fire. Observe.

Place the products in a beaker containing about 5cm3 of water. Test the solution/mixture using litmus papers (b)Cut another 2cm length piece of magnesium ribbon. Using a pair of tongs introduce it to a Bunsen flame. When it catches fire, lower it slowly into a gas jar containing Oxygen.

Place about 5cm3 of water into the gas jar. Test the solution/mixture using litmus papers. Test the solution/mixture using litmus papers

Observations (a)In air

Magnesium burns with a bright blindening flame in air forming white solid/ash /powder. Effervescence/bubbles/ fizzing Pungent smell of urine. Blue litmus paper remains blue. Red litmus paper turns blue

(b) In pure Oxygen

Magnesium burns **faster** with a very bright blindening flame pure oxygen forming white solid/ash /powder. No effervescence/bubbles/ fizzing. No pungent smell of urine. Blue litmus paper remains blue. Red litmus paper turns blue

Explanation

Magnesium burns in air producing enough heat energy to react with both Oxygen and Nitrogen to form **Magnesium Oxide** and **Magnesium nitride.** Both Magnesium Oxide and Magnesium nitride are white solid/ash /powder.

Chemical equations

Magnesium + Oxygen -> Magnesium Oxide

$2Mg(s) + O_2(g) \rightarrow 2MgO(s)$

Magnesium + Nitrogen -> Magnesium **Nitr**ide

$3Mg(s) + N_2(g) \rightarrow Mg_3N_2(s)$

Magnesium Oxide dissolves in water to form a basic/alkaline solution of Magnesium hydroxide

Chemical equations

Magnesium Oxide + Water -> Magnesium hydroxide

$2Mg(s) + O_2(l) \rightarrow 2MgO(s)$

Magnesium Nitride dissolves in water to form a basic/alkaline solution of Magnesium hydroxide and producing **Ammonia gas**. Ammonia is also an alkaline/basic gas that has a pungent smell of urine.

Chemical equations

Magnesium Nitride + Water -> Magnesium hydroxide + Ammonia gas

Mg_3N_2 (s) + $6H_2O$ (l) -> $3Mg(OH)_2$ (aq) + $2NH_3$(g)

II. Burning Sodium

Procedure

(a)**Carefully** cut a very small piece of sodium . Using a deflagrating spoon introduce it to a Bunsen flame. Remove it when it catches fire. Observe. Place the products in a beaker containing about 20cm3 of water. Test the solution/mixture using litmus papers

(b) **Carefully** cut another very small piece of sodium. Using a deflagrating spoon introduce it to a Bunsen flame. When it catches fire, lower it slowly into a gas jar containing Oxygen.

Place about 20 cm3 of water into the gas jar. Test the solution/mixture using litmus papers. Test the solution/mixture using litmus papers

Observations (a)In air

Sodium burns with a **yellow** flame in air forming a **black** solid. Blue litmus paper remains blue. Red litmus paper turns blue

(b) In pure Oxygen

Sodium burns **faster** with a golden **yellow** flame in pure oxygen forming a **yellow** solid. Effervescence/bubbles/ fizzing. Gas produced relights glowing splint.Blue litmus paper remains blue. Red litmus paper turns blue.

Explanation

(a)Sodium burns in air forming black **Sodium Oxide**

Chemical equations

Sodium + Oxygen/air -> Sodium Oxide

$4Na(s)$ + $O_2(g)$ -> $2Na_2O(s)$

Sodium Oxide dissolves in water to form a basic/alkaline solution of Sodium hydroxide Chemical equations

Sodium Oxide + Water -> Sodium hydroxide

$Na_2O(s)$ + H_2O (l) -> $2NaOH(aq)$

(b)Sodium burns in pure oxygen forming yellow **Sodium peroxide**

Chemical equations

Sodium + Oxygen -> Sodium peroxide

$2Na(s) + O_2(g) \rightarrow Na_2O_2\ (s)$

Sodium peroxide dissolves in water to form a basic/alkaline solution of Sodium hydroxide. Oxygen is produced.

Chemical equations

Sodium Oxide + Water -> Sodium hydroxide + Oxygen

$2Na_2O_2\ (s) + 2H_2O\ (l) \rightarrow 4NaOH(\mathbf{aq}) + O_2\ (l)$

III. Burning Calcium

Procedure

(a)Using a pair of tongs hold the piece of calcium on a Bunsen flame. Observe. Place the products in a beaker containing about 2cm3 of water. Test the solution/mixture using litmus papers

(b)Using a pair of tongs hold another piece of calcium on a Bunsen flame. Quickly lower it into a gas jar containing Oxygen gas .Observe.

Place about 2cm3 of water. Swirl.

Test the solution/mixture using litmus papers

Observations (a)In air

Calcium burns with difficulty producing a faint **red** flame in air forming a **white** solid. Blue litmus paper remains blue. Red litmus paper turns blue

(b) In pure Oxygen

Calcium burns with difficulty producing a less faint **red** flame Oxygen forming a **white** solid. Blue litmus paper remains blue. Red litmus paper turns blue

Explanation

(a)Calcium burns in air forming white **calcium Oxide.** Calcium Oxide coat/cover the calcium preventing further burning. Chemical equations

Calcium + Oxygen/air -> calcium Oxide

$2Ca(s) + O_2(g) \rightarrow 2CaO(s)$

Small amount of Calcium Oxide dissolves in water to form a basic/alkaline solution of Calcium hydroxide. The common name of Calcium hydroxide is **lime water.**

Chemical equations

Calcium Oxide + Water -> Calcium hydroxide

$CaO(s)$ + H_2O (l) -> $Ca(OH)_2$ (aq)

IV. Burning Iron

Procedure

(a)Using a pair of tongs hold the piece of Iron wool/steel wire on a Bunsen flame. Observe.

Place the products in a beaker containing about 2cm3 of water. Test the solution/mixture using litmus papers

(b)Using a pair of tongs hold another piece of Iron wool/steel wire on a Bunsen flame.

Quickly lower it into a gas jar containing Oxygen gas .Observe.

Place about 2cm3 of water. Swirl. Test the solution/mixture using litmus papers

Observations

(a)In air

Iron wool/steel wire burns producing a **Orange** flame in air forming a **brown** solid. Blue litmus paper remains blue. Red litmus paper turns faint blue

(b) In pure Oxygen

Iron wool/steel wire burns producing a golden **Orange** flame in Oxygen forming a **Brown** solid. Blue litmus paper remains blue. Red litmus paper turns faint blue

Explanation

(a)Iron burns in air forming brown **Iron(III) Oxide**

Chemical equations

Iron + Oxygen/air -> Iron(III) Oxide

$4Fe(s)$ + $3O_2(g)$ -> $2Fe_2O_3(s)$

Very small amount of Iron(III)Oxide dissolves in water to form a weakly basic/alkaline **brown** solution of Iron(III) hydroxide.

Chemical equations

Calcium Oxide + Water -> Iron(III) hydroxide

$Fe_2O_3(s)$ + $3H_2O$ (l) -> $2Fe(OH)_3$ (**s**)

V. Burning Copper

Procedure

(a)Using a pair of tongs hold the piece of copper turnings/shavings on a Bunsen flame. Observe.

Place the products in a beaker containing about 2cm3 of water. Test the solution/mixture using litmus papers

(b)Using a pair of tongs hold another piece of Copper turnings/shavings on a Bunsen flame. Quickly lower it into a gas jar containing Oxygen gas .Observe. Place about 2cm3 of water. Swirl. Test the solution/mixture using litmus papers

Observations

(a)In air

Copper turnings/shavings burns with difficulty producing a **green** flame in air forming a **black** solid. Blue litmus paper remains blue. Red litmus paper turns faint blue

(b) In pure Oxygen

Copper turnings/shavings burns less difficulty producing a **green** flame in Oxygen forming a **Brown** solid. Blue litmus paper remains blue. Red litmus paper turns faint blue

Explanation

(a)Copper burns in air forming black **Copper(II) Oxide**

Chemical equations

Copper + Oxygen/air -> Copper(II) Oxide

$2\,Cu(s) + O_2(g) \rightarrow 2CuO(s)$

Very small amount of Copper(II)Oxide dissolves in water to form a weakly basic/alkaline **blue** solution of Copper(II) hydroxide.

Chemical equations

Copper(II) Oxide + Water -> Copper(II) hydroxide

$CuO(s) + H_2O\ (l) \rightarrow Cu(OH)_2\ (\mathbf{s})$

(i)Reaction of non metals with Oxygen/air

The following experiments show the reaction of non metals with Oxygen and air.

I. Burning Carbon

Procedure

(a)Using a pair of tongs hold a dry piece of charcoal on a Bunsen flame. Observe. Place the products in a beaker containing about 2cm3 of water. Test the solution/mixture using litmus papers

(b)Using a pair of tongs hold another piece of dry charcoal on a Bunsen flame. Quickly lower it into a gas jar containing Oxygen gas .Observe.
Place about 2cm3 of water. Swirl. Test the solution/mixture using litmus papers

Observations

-Carbon **chars** then burns with a **blue** flame -
Colourless and odourless gas produced

-Solution formed turn blue litmus paper faint red.
Red litmus paper remains red.

Explanation

Carbon burns in air and faster in Oxygen with a blue non-sooty/non-smoky flame forming Carbon (IV) oxide gas.
Carbon burns in limited supply of air with a blue non-sooty/non-smoky flame forming Carbon (IV) oxide gas.
Carbon (IV) oxide gas dissolve in water to form weak acidic solution of Carbonic (IV)acid.

Chemical Equation

Carbon + Oxygen -> Carbon(IV)oxide
(excess air/oxygen)

$C(s) + O_2(g) \rightarrow CO_2(g)$ (in excess air)

Carbon + Oxygen -> Carbon(II)oxide
(limited air/oxygen)

$2C(s) + O_2(g) \rightarrow 2CO(g)$ (in limited air)

Carbon(IV)oxide + Water -> Carbonic(IV)acid
$CO_2(g) + H_2O(l) \rightarrow H_2CO_3(aq)$ (very weak acid)

II. Burning Sulphur

Procedure

(a)Using a deflagrating spoon place sulphur powder on a Bunsen flame. Observe.

Place the products in a beaker containing about 3cm3 of water. Test the solution/mixture using litmus papers

(b) Using a deflagrating spoon place sulphur powder on a Bunsen flame. Slowly lower it into a gas jar containing Oxygen gas. Observe.

Place about 5cm3 of water. Swirl. Test the solution/mixture using litmus papers.

Observations

-Sulphur burns with a **blue** flame

-Gas produced that has pungent choking smell -Solution formed turn blue litmus paper faint red.

Red litmus paper remains red.

Explanation

Sulphur burns in air and faster in Oxygen with a blue non-sooty/non-smoky flame forming Sulphur (IV) oxide gas.

Sulphur (IV) oxide gas dissolve in water to form weak acidic solution of Sulphuric (IV)acid.

Chemical Equation

Sulphur + Oxygen -> Sulphur(IV)oxide

$S(s) + O_2(g) \rightarrow SO_2(g)$ (in excess air)

Sulphur(IV)oxide + Water -> Sulphuric(IV)acid

$SO_2(g) + H_2O(l) \rightarrow H_2SO_3(aq)$ (very weak acid)

III. Burning Phosphorus

Procedure

(a)Remove a small piece of phosphorus from water and using a deflagrating spoon (with a lid cover)place it on a Bunsen flame.

Observe.

Carefully put the burning phosphorus to cover gas jar containing about 3cm3 of water. Test the solution/mixture using litmus papers

(b) Remove another small piece of phosphorus from water and using a deflagrating spoon (with a lid cover) place it on a Bunsen flame.

Slowly lower it into a gas jar containing Oxygen gas with about 5 cm3 of water. Observe.

Swirl. Test the solution/mixture using litmus papers.

Observations

-Phosphorus catches fire before heating on Bunsen flame

-Dense white fumes of a gas produced that has pungent choking **poisonous** smell

-Solution formed turn blue litmus paper faint red.

Red litmus paper remains red.

Explanation

Phosphorus is stored in water.On exposure to air it instantaneously fumes then catch fire to burn in air and faster in Oxygen with a **yellow** flame producing dense white acidic fumes of Phosphorus(V) oxide gas.

Phosphoric(V) oxide gas dissolve in water to form weak acidic solution of Phosphoric (V)acid.

Chemical Equation

Phosphorus + Oxygen -> Phosphorous(V)oxide

$4P(s) + 5O_2(g) \rightarrow 2P_2O_5(s)$

Phosphorous(V)oxide + Water -> Phosphoric(V)acid

$P_2O_5(s) + 3H_2O(l) \rightarrow 2H_3PO_4(aq)$ (very weak acid)

(e) Reactivity series/competition for combined Oxygen.

The reactivity series is a list of elements/metals according to their affinity for oxygen.

Some metals have higher affinity for Oxygen than others.

A metal/element with higher affinity for oxygen is placed higher/on top of the one less affinity.

The complete reactivity series of metals/elements

Platinum	**Pt**

Most reactive

Element/Metal	**Symbol**
Potassium	K
Sodium	Na
Calcium	Ca
Magnesium	Mg
Aluminium	Al
Carbon	**C**
Zinc	**Zn**
Iron	**Fe**
Tin	**Sn**
Lead	**Pb**
Hydrogen	**H**
Copper	**Cu**
Mercury	**Hg**
Silver	**Ag**
Gold	**Au**

Least reactive

Metals compete for combined Oxygen. A metal/element with higher affinity for oxygen removes Oxygen from a metal lower in the reactivity series/less affinity for Oxygen.
When a metal/element gains/acquire Oxygen, the **process** is called **Oxidation**.
When a metal/element donate/lose Oxygen, the **process** is called **Reduction**.

An element/metal/compound that undergo Oxidation is called **Reducing agent**.
An element/metal/compound that undergo Reduction is called **Oxidizing agent**.

A reaction in which **both** Oxidation and Reduction take place is called a **Redox** reaction.

Redox reaction between Magnesium and copper(II)Oxide Procedure

Place about 2g of copper (II)oxide in a crucible with a lid. Place another 2g of Magnesium powder into the crucible. Mix thoroughly.
Cover the crucible with lid. Heat strongly for five minutes.
Allow the mixture to cool. Open the lid. Observe.

Observation

Colour change from black to brown. White solid power formed.

Explanation

Magnesium is higher in the reactivity series than Copper. It has therefore higher affinity for Oxygen than copper.
When a mixture of copper(II)oxide and Magnesium is heated, Magnesium reduces copper(II)oxide to brown copper metal and itself oxidized to Magnesium oxide.
Magnesium is the reducing agent because it undergoes oxidation process.
Copper(II)oxide is the oxidizing agent because it undergo **redox** reduction process.
The mixture should be cooled before opening the lid to prevent **hot** brown copper from being **reoxidized** back to black copper(II)oxide. The reaction of Magnesium and Copper(II)oxide is a reaction

Chemical equation

Reduction process

Oxidation process

1. Copper (II)oxide + Magnesium -> Magnesium oxide + Copper
(black) (white ash/solid) (brown)
CuO(s) + Mg(s) -> Mg**O**(s) + **Cu**(s)
(Oxidizing Agent) (Reducing Agent)

2. Zinc (II)oxide + Magnesium -> Magnesium oxide + Zinc
(yellow when hot) (white ash/solid) (grey)
ZnO(s) + Mg(s) -> Mg**O**(s) + **Zn**(s) (Oxidizing agent)
(Reducing agent)

3. Zinc (II)oxide + Carbon -> Carbon(IV) oxide gas + Zinc
(yellow when hot) (colourless gas) (grey)
ZnO(s) + C(s) -> C**O₂**(g) + **Zn**(s) (Oxidizing agent)
(Reducing agent)

The reactivity series is used during extraction of metals from their ore.An ore is a rock containing mineral element which can be extracted for commercial purposes. Most metallic ores occur naturally as:

(i)**ox**ides combined with Oxygen

(ii)**sulph**ides combined with Sulphur

(iii)**carbon**ates combined with carbon and Oxygen.

Metallic ores that naturally occur as metallic sulphides are first **roasted** in air to form the corresponding oxide. Sulphur(IV)oxide gas is produced. e.g.

Copper(I) sulphide + Oxygen -> Copper(I)Oxide + Sulphur(IV)oxide
$Cu_2S(s)$ + $O_2(g)$ -> 2Cu(s) + $SO_2(g)$

Zinc(II) sulphide + Oxygen -> Zinc(II)Oxide + Sulphur(IV)oxide
ZnS(s) + $O_2(g)$ -> Zn(s) + $SO_2(g)$

Lead(II) sulphide + Oxygen -> Lead(II)Oxide + Sulphur(IV)oxide
PbS(s) + $O_2(g)$ -> Pb(s) + $SO_2(g)$

Iron(II) sulphide + Oxygen -> Iron(II)Oxide + Sulphur(IV)oxide
FeS(s) + $O_2(g)$ -> Fe(s) + $SO_2(g)$

Metallic ores that naturally occur as metallic carbonates are first **heated** in air. They **decompose**/split to form the corresponding oxide and produce Carbon (IV) oxide gas. e.g.

Copper (II)carbonate -> Copper(II)oxide + Carbon(IV)oxide
$CuCO_3(s)$ -> $CuO(s)$ + $CO_2(g)$

Zinc (II)carbonate -> Zinc(II)oxide + Carbon(IV)oxide $ZnCO_3(s)$ -> $ZnO(s)$ + $CO_2(g)$

Lead (II)carbonate -> Lead(II)oxide + Carbon(IV)oxide $PbCO_3(s)$ -> $PbO(s)$ + $CO_2(g)$

Iron(II)carbonate -> Iron(II)oxide + Carbon(IV)oxide
$FeCO_3(s)$ -> $FeO(s)$ + $CO_2(g)$ Metallic ores