FORM ONE CHEMISTRY UPDATED NOTES

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For FI-F4 All Subjects Notes

TOPIC 1:

INTRODUCTION TO CHEMISTRY

Chemistry is a branch of Science. Science is basically the study of living and non-living things. The branch of science that study living things is called Biology. The branch of science that study non-living things is called Physical Science.

Physical Science is made up of:

(i) Physics- the study of matter in relation to energy

(ii) Chemistry- the study of the composition of matter.

Chemistry is thus defined as the branch of science that deals with the structure composition, properties and behavior of matter.

Basic Chemistry involves studying:

(a) States/phases of matter

Matter is anything that has weight/**mass** and occupies space/**volume.** Naturally, there are basically **three** states of matter.

(i) Solid-e.g. soil, sand, copper metal, bucket, ice.

(ii)Liquid- e.g. water, Petrol, ethanol/alcohol, Mercury (liquid metal).

(iii) gas- e.g. Oxygen, Nitrogen ,Water vapour.

A solid is made up of particles which are very closely packed. It thus has a definite/fixed shape and fixed/definite volume /occupies definite space. It has a very high density.

A liquid is made up of particles which have some degree of freedom. It thus has no definite/fixed shape. It takes the shape of the container it is put. A liquid has fixed/definite volume/occupies definite space.

A gas is made up of particles free from each other. It thus has no definite/fixed shape. It takes the shape of the container it is put. It has no fixed/definite volume/occupies every space in a container.

(b) Separation of mixture

A mixture is a combination of two or more substances that can be separated by physical means. Simple methods of separating mixtures at basic chemistry level include:

i) **Sorting/picking-**this involve physically picking one pure substance from a mixture with another/other. e. g. sorting maize from maize beans mixture.

ii) **Decantation-**this involve pouring out a liquid from a solid that has settled /sinking solid in it. e. g. Decanting water forms sand**.**

iii) **Filtration-**this involves sieving /passing particles of a mixture through a filter containing small holes that allow smaller particle to pass through but do not allow bigger particle to pass through.

iv) **Skimming-**this involve scooping floating particles. E.g. cream from milk

(c) Metals and non-metals

Metals are shiny, ductile(able to form wires), malleable(able to form sheet) and coil without breaking. E.g. Iron, gold, silver, copper. Mercury is the only **liquid metal** known.

Non-metals are dull, not ductile (do not form wires), not malleable (do not form sheet) and break on coiling/brittle. E.g. Charcoal, Sulphur, pla-stics.

(d) Conductors and non-conductors

A conductor is a solid that allow electric current to pass through. A non-conductor is a solid that do not allow electric current to pass through.

All metals conduct electricity. All non-metals do not conduct electricity except carbon **graphite**.

(e) Drugs

A drug is a natural or synthetic/man-made substance that when taken changes/alter the body functioning. A natural or synthetic/man-made substance that when taken changes/alter the abnormal body functioning to normal is called **medicine**. Medicines are thus drugs intended to correct abnormal body functions. . Medicines should therefore be taken on **prescription** and **dosage**.

A prescription is a medical instruction to a patient/sick on the correct type of medicine to take and period/time between one intake to the other.

A dosage is the correct quantity of drug required to alter the abnormal body function back to normal. This is called **treatment**. It is the professional work of qualified doctors/pharmacists to administer correct prescription and dosage of drugs/medicine to the sick. Prescription and dosage of drugs/medicine to the sick use medical language.

Example

(i) **2 x 4** ; means "**2**" tablets for **solid** drugs/spoonfuls for **liquid** drugs taken "**4**" times for a duration of one day/24 hours and then repeated and continued until all the drug given is finished.

(ii) **1 x 2** ; means "**1**" tablets for **solid** drugs/spoonfuls for **liquid** drugs taken "**2**" times for a duration of one day/24 hours and then repeated and continued until all the drug given is finished.

Some drugs need minimal prescription and thus are available without pharmacist/ doctor's prescription. They are called **O**ver **T**he **C**ounter (OTC) drugs. OTC drugs used to treat mild headaches, stomach upsets, common cold include:

(i) Painkillers
(ii) Anti-acids
(iii) cold/flu drugs.

All medicine requires correct intake dosage. When a prescription dosage is not followed, this is called drug **misuse/abuse.** Some drugs are used for other purposes other than that intended. This is called **drug abuse**.

Drug abuse is when a drug is intentionally used to alter the normal functioning of the body. The intentional abnormal function of the drug is to make the victim have false feeling of well being. The victim lack both mental and physical coordination.
Some drugs that induce a false feeling of well being are illegal. They include heroin, cocaine, bhang, Mandrax and morphine.
Some abused drugs which are not illegal include: Miraa, alcohol, tobacco, sleeping pills.

The role of chemistry in society

(a) Chemistry is used in the following:

(i) Washing/cleaning with soap:
Washing/cleaning is a chemical process that involves interaction of water, soap and dirt so as to remove the dirt from a garment.
(ii) Understanding chemicals of life
Living thing grow, respire and feed. The formation and growth of cells involve chemical processes in living things using carbohydrates, proteins and vitamins.
(iii) Baking:
Adding baking powder to dough and then heating in an oven involves interactions that require understanding of chemistry.
(iv) Medicine:
Discovery, test, prescription and dosage of drugs to be used for medicinal purposes require advanced understanding of chemistry
(v) Fractional distillation of crude oil:
Crude oil is fractional distilled to useful portions like petrol, diesel, kerosene by applying chemistry.
(vi) Manufacture of synthetic compounds/substances
Large amounts of plastics, glass, fertilizers, insecticides, soaps, cements, are manufactured worldwide. Advanced understanding of the chemical processes involved is a requirement.
(vii) Diagnosis/test for abnormal body functions.
If the body is not functioning normally, it is said to be sick/ill. Laboratory test are done to diagnose the illness/sickness.

(b) The following career fields require Chemistry as one of subject areas of advanced/specialized study:

(i) Chemical engineering/chemical engineer
(ii) Veterinary medicine/Veterinary doctor
(iii) Medicine/Medical doctor/pharmacist/nurse
(iv) Beauty/Beautician
(v) Teaching/Chemistry teacher.

The School Chemistry Laboratory

Chemistry is studied mainly in a science room called a school chemistry **laboratory**. The room is better ventilated than normal classroom. It has electricity, gas and water **taps**. A school chemistry laboratory has a qualified professional whose called Laboratory technician/assistant.

All students user in a school chemistry laboratory must consult the Laboratory technician/assistant for all their laboratory work. A school chemistry laboratory has chemicals and apparatus.

A chemical is a substance whose composition is known. All chemical are thus labeled as they are. This is because whereas physically a substance may appear similar, chemically they may be different.

All Chemicals which are not labeled should never be used. Some chemicals are toxic/poisonous, explosive, corrosive, caustic, irritants, flammable, oxidizing, carcinogenic, or radioactive.

Care should always be taken when handling any chemical which have any of the above characteristic properties.

Common school chemistry laboratory chemicals include:

(i) Distilled water

(ii) Concentrated mineral acid which are very corrosive (on contact with skin they cause painful open wounds)

(iii) Concentrated alkali/bases which are caustic (on contact with skin they cause painful blisters)

(iv) Very many types of salts

The following safety guideline rules should be followed by chemistry laboratory users:

(i) Enter the laboratory with permission in an orderly manner without rushing/pushing/scrabbling.

(ii) Do not try unauthorized experiments. They may produce flammable, explosive or toxic substances that affect your health.

(iii) Do not taste any chemical in the laboratory. They may be poisonous.

(iv) Waft gas fumes to your nose with your palm. Do not inhale/smell gases directly. They may be highly poisonous/toxic.

(v) Boil substances with mouth of the test tube facing away from others and yourself. Boiling liquids spurt out portions of the hot liquid. Products of heating solids may be a highly poisonous/toxic gas.

(vi) Wash with lots of water any skin contact with chemicals immediately. Report immediately to teacher/laboratory technician any irritation, cut, burn, bruise or feelings arising from laboratory work.

(vii) Read and follow safety instruction. All experiments that evolve/produce poisonous gases should be done in the open or in a fume chamber.

(viii) Clean your laboratory work station after use. Wash your hand before leaving the chemistry laboratory.

(ix) In case of fire, remain calm, switch of the source of fuel-gas tap. Leave the laboratory through the emergency door. Use fire extinguishers near the chemistry laboratory to put of medium fires. Leave strong fires wholly to professional fire fighters.

(x) Do not carry unauthorized item from a chemistry laboratory.

An apparator /apparatus are scientific tools/equipment used in performing scientific experiments. The conventional apparator used in performing scientific experiments is called **standard** apparator/apparatus. If the conventional standard apparator/apparatus is not available, an **improvised** apparator/apparatus may be used in performing scientific experiments. An improvised apparator/apparatus is one used in performing a scientific experiment **for** a standard apparator/apparatus.

Most standard apparatus in a school chemistry laboratory are made of glass because:

(i) Glass is transparent and thus reactions /interactions inside are clearly visible from outside
(ii) Glass is comparatively cheaper which reduces cost of equipping the school chemistry laboratory
(iii) Glass is comparatively easy to clean/wash after use.
(iv) Glass is comparatively unreactive to many chemicals.

Apparatus are designed for the purpose they are intended in a school chemistry laboratory:

(a) Apparatus for measuring volume

1. Measuring cylinder

Measuring cylinders are apparatus used to measure volume of liquid/ solutions. They are calibrated/ graduated to measure any volume required to the maximum. Measuring cylinders are named according to the maximum calibrated/graduated volume e.g.

“10ml” measuring cylinder is can hold maximum calibrated/graduated volume of “10mililitres” /“10 cubic centimetres”

“50ml” measuring cylinder is can hold maximum calibrated/graduated volume of “50mililitres” /“50 cubic centimetres”

“250ml” measuring cylinder is can hold maximum calibrated/graduated volume of “250mililitres” /“250 cubic centimetres”

“1000ml” measuring cylinder is can hold maximum calibrated/graduated volume of “1000mililitres” /“1000 cubic centimetres”

2. Burette

Burette is a long and narrow/thin apparatus used to measure small accurate and exact volumes of a liquid solution. It must be clamped first on a stand before being used. It has a tap to run out the required amount out. They are calibrated/ graduated to run out small volume required to the maximum 50ml/50cm3.

The maximum 50ml/50cm3 calibration/ graduation reading is at the **bottom** .This ensure the amount run **out** from a tap **below** can be determined directly from **burette reading** before and after during volumetric analysis.

Burettes are expensive and care should be taken when using them.

3. (i) <u>Pipette</u>

Pipette is a long and narrow/thin apparatus that widens at the middle used to measure and transfer small very accurate/exact volumes of a liquid solution.

It is open on either ends.

The maximum 25ml/25cm3 calibration/ graduation mark is a visible **ring** on one thin end.

To fill a pipette to this mark, the user must suck up a liquid solution upto a level above the mark then adjust to the mark using a finger.

This requires practice.

(ii) Pipette filler

Pipette filler is used to suck in a liquid solution into a pipette instead of using the mouth. It has a suck, adjust and eject button for ensuring the exact volume is attained. This requires practice.

4. <u>Volumetric flask.</u>

A volumetric flask is thin /narrow but widens at the base/bottom. It is used to measure very accurate/exact volumes of a liquid solution.

The maximum calibration / graduation mark is a visible **ring.**

Volumetric flasks are named according to the maximum calibrated/graduated volume e.g.

"250ml" volumetric flask has a calibrated/graduated mark at exact volume of "250mililitres" /"250centimetres"

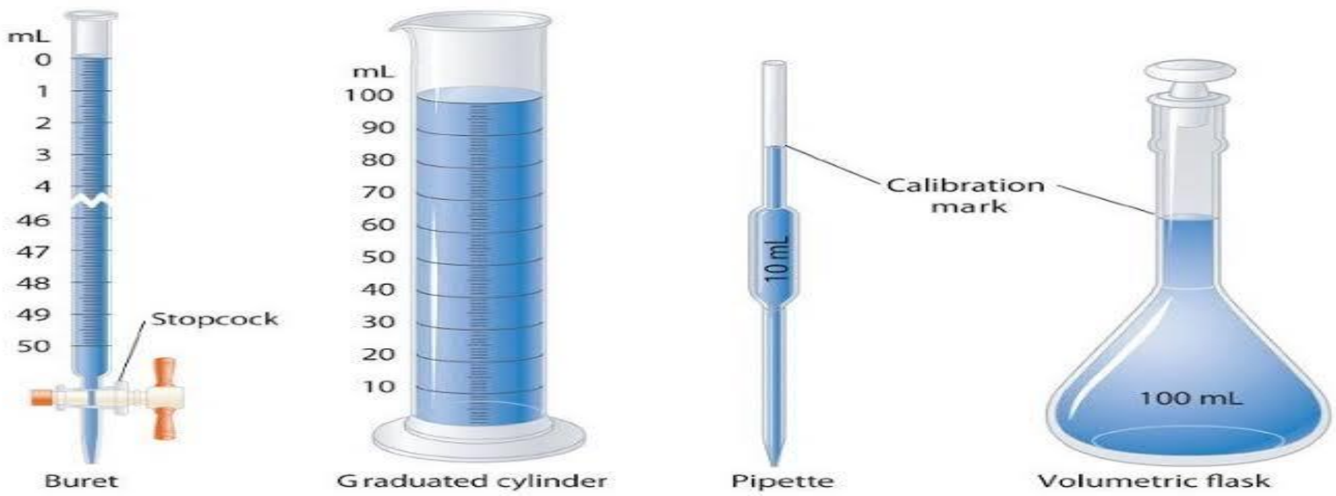
"1l" volumetric flask has a calibrated/graduated mark at exact volume of "one litre" /"1000 cubic centimeters"

"2l" volumetric flask has a calibrated/graduated mark at exact volume of "two litres" /"2000 cubic centimeters"

5. <u>Dropper/teat pipette</u>

A dropper/teat pipette is a long thin/narrow glass/rubber apparatus that has a flexible rubber head.

A dropper/teat pipette is used to measure very small amount/ drops of liquid solution by pressing the flexible rubber head. The numbers of drops needed are counted by pressing the rubber gently at a time



(b) Apparatus for measuring mass

1. <u>Beam balance</u>

A beam balance has a pan where a substance of unknown mass is placed. The scales on the opposite end are adjusted to "balance" with the mass of the unknown substance. The mass from a beam balance is in **grams**.

2. <u>Electronic/electric balance.</u>

An electronic/electric balance has a pan where a substance of unknown mass is placed. The mass of the unknown substance in **grams** is available immediately on the screen.

(c) Apparatus for measuring temperature

A thermometer has alcohol or mercury trapped in a bulb with a thin enclosed outlet for the alcohol/mercury in the bulb.

If temperature rises in the bulb, the alcohol /mercury expand along the thin narrow enclosed outlet. The higher the temperature, the more the expansion

Outside, a calibration /graduation correspond to this expansion and thus changes in temperature.

A thermometer therefore determines the temperature when the bulb is fully dipped in to the substance being tested. To determine the temperature of solid is thus very difficult.

(d) Apparatus for measuring time

The stop <u>watch/clock</u> is the standard apparatus for measuring time. Time is measured using hours, minutes and second.

Common school stop watch/clock has start, stop and reset button for determining time for a chemical reaction. This requires practice.

(e) Apparatus for scooping

1. <u>Spatula</u>

A spatula is used to **scoop** solids which do not require accurate measurement. Both ends of the spatula can be used at a time.

A solid scooped to the **brim** is “one spatula end full” A solid scooped to **half brim** is “half spatula end full”.

2. <u>Deflagrating spoon</u>

A deflagrating spoon is used to **scoop** solids which do not require accurate measurement mainly for heating. Unlike a spatula, a deflagrating spoon is longer.

(f) Apparatus for putting liquids/solid for heating.

1. <u>Test tube.</u>

A test tube is a narrow/thin glass apparatus open on one side. The end of the opening is commonly called the “the mouth of the test tube”.

2. <u>Boiling/ignition tube.</u>

A boiling/ignition tube is a wide glass apparatus than a test tube open on one side. The end of the opening is commonly called the “the mouth of the boiling/ignition tube”.

3. <u>Beaker.</u>

Beaker is a wide calibrated/graduated lipped glass/plastic apparatus used for transferring liquid solution which do not normally require very accurate measurements

Beakers are named according to the maximum calibrated/graduated volume they can hold e.g.

“250ml” beaker has a maximum calibrated/graduated volume of “250mililitres” /“250 cubic centimeters”

“1l” beaker has a maximum calibrated/graduated volume of “one litre” /“1000 cubic centimeters”

“5 l” beaker has a maximum calibrated/graduated volume of “two litres” /“2000 cubic centimeters”

4. Conical flask.

A conical flask is a moderately narrow glass apparatus with a wide base and no calibration/graduation. Conical flasks thus carry/hold exact volumes of liquids that have been measured using other apparatus. It can also be put some solids. The narrow mouth ensures no spillage.

Conical flasks are named according to the maximum volume they can hold e.g. "250ml" Conical flasks hold a maximum volume of "250mililitres" /"250 cubic centimeters"

"500ml" Conical flasks hold a maximum volume of "500ml" /"1000 cubic centimeters"

5. Round bottomed flask

A round bottomed flask is a moderately narrow glass apparatus with a wide round base and no calibration/graduation. Round bottomed flask thus carry/hold exact volumes of liquids that have been measured using other apparatus. The narrow/thin mouth prevents spillage. The flask can also hold (weighed) solids. A round bottomed flask must be held/ clamped when in use because of its wide narrow base.

6. Flat bottomed flask

A flat bottomed flask is a moderately narrow glass apparatus with a wide round base with a small flat bottom. It has no calibration/graduation.

Flat bottomed flasks thus carry/hold exact volumes of liquids that have been measured using other apparatus. The narrow/thin mouth prevents spirage. They can also hold (weighed) solids. A flat bottomed flask must be held/ clamped when in use because it's flat narrow base is not stable.

(g) Apparatus for holding unstable apparatus (during heating).

1. Tripod stand

A tripod stand is a three legged metallic apparatus which unstable apparatus are placed on (during heating).Beakers. Conical flasks, round bottomed flask and flat bottomed flasks are placed on top of tripod stand (during heating).

2. Wire gauze/mesh

Wire gauze/mesh is a metallic/iron plate of wires crossings. It is placed on top of a tripod stand:

(i) Ensure even distribution of heat to prevent cracking glass apparatus

(ii) Hold smaller apparatus that cannot reach the edges of tripod stand

3 Clamp stand

A clamp stand is a metallic apparatus which tightly hold apparatus at their "neck" firmly.

A clamp stand has a wide metallic base that ensures maximum stability. The height and position of clamping is variable. This require practice

4. Test tube holder

A test tube holder is a hand held metallic apparatus which tightly hold test/boiling/ignition tube at their "neck" firmly on the other end.

Some test tube holders have wooden handle that prevent heat conduction to the hand during heating.

5. Pair of tong.

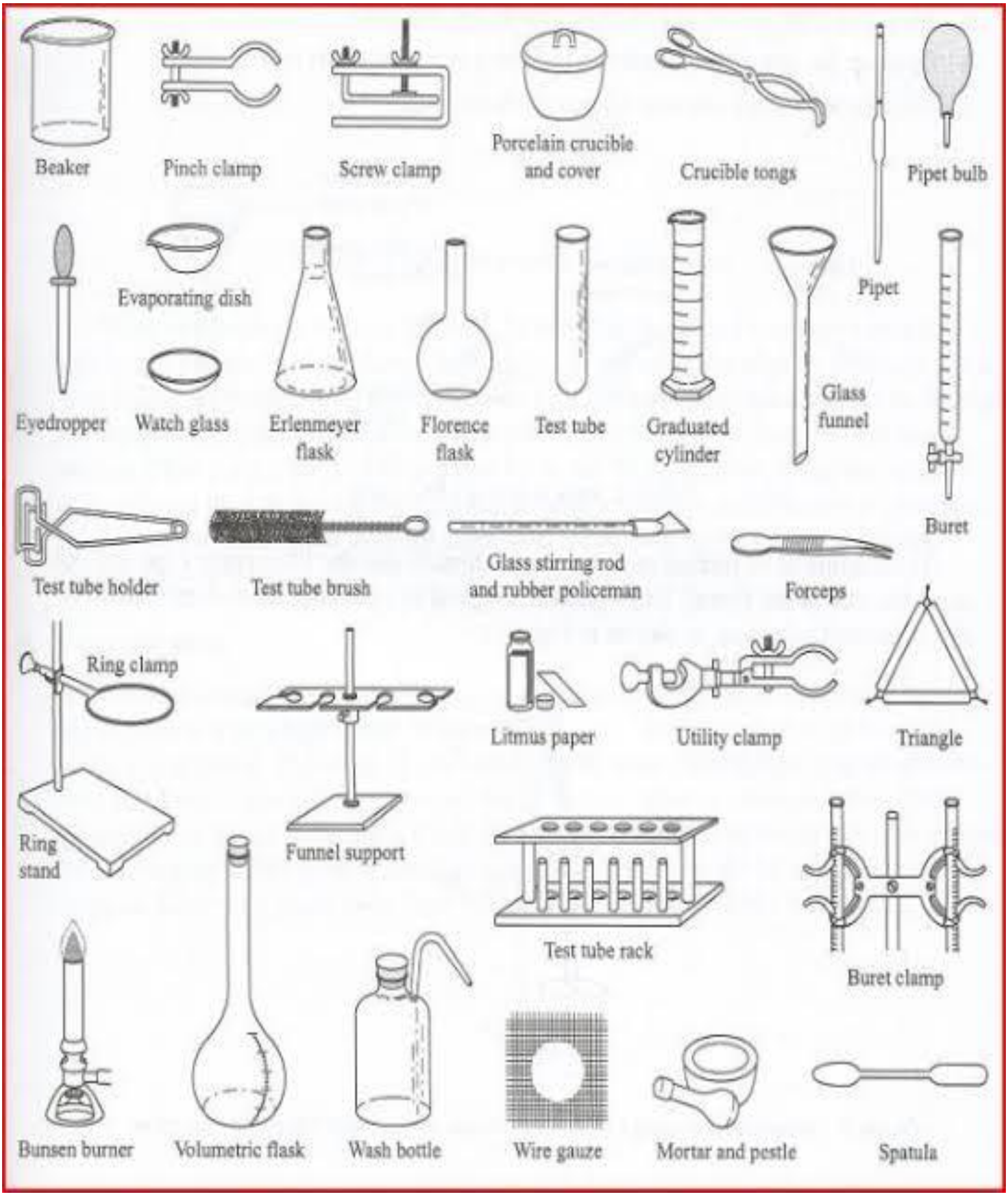
A pair of tong is a scissor-like hand held metallic apparatus which tightly hold firmly a small solid sample on the other end.

6. <u>Gas jar</u>

A gas jar is a long wide glass apparatus with a wide base.

It is open on one end. It is used to collect/put gases.

This requires practice.



(h) Apparatus for holding/directing liquid solutions/funnels (to avoid spillage).

1. <u>Filter funnel</u>

A filter funnel is a wide mouthed (mainly plastic) apparatus that narrow drastically at the bottom to a long extension.

When the long extension is placed on top of another apparatus, a liquid solution can safely be directed through the wide mouth of the filter funnel into the apparatus without spirage.

Filter funnel is also used to place a filter paper during filtration.

2. <u>Thistle funnel</u>

A thistle funnel is a wide mouthed glass apparatus that narrow drastically at the bottom to a very long extension.

The long extension is usually drilled through a stopper/cork.

A liquid solution can thus be directed into a stoppered container without spillage

3. <u>Dropping funnel</u>

A dropping funnel is a wide mouthed glass apparatus with a tap that narrow drastically at the bottom to a very long extension.

The long extension is usually drilled through a stopper/cork.

A liquid solution can thus be directed into a stoppered container without spillage at the rate determined by adjusting the tap.

4. <u>Separating funnel</u>

A separating funnel is a wide mouthed glass apparatus with a tap at the bottom narrow extension.

A liquid solution can thus be directed into a separating funnel without spillage. It can also safely be removed from the funnel by opening the tap.

It is used to separate two or more liquid solution mixtures that form layers/immiscible. This requires practice.

(h) <u>Apparatus for heating/Burners</u>

1. Candle, spirit burner, kerosene stove, charcoal burner/jiko are some apparatus that can be used for heating.

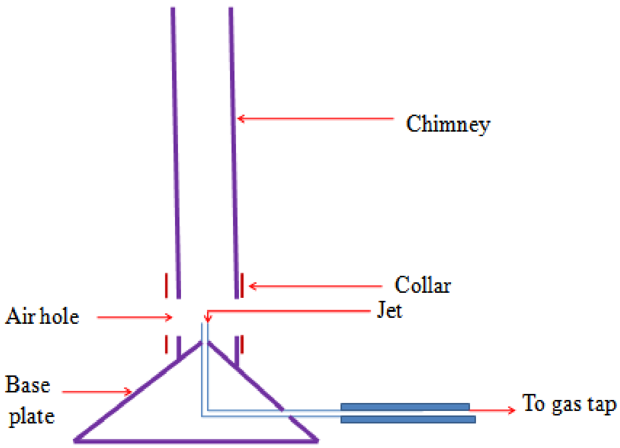
Any flammable fuel when put in a container and ignited can produce some heat.

2. <u>Bunsen burner</u>

The Bunsen burner is the **standard** apparatus for heating in a Chemistry school laboratory.

It was discovered by the German Scientist Robert Wilhelm Bunsen in1854.

(**a**)Diagram of a Bunsen burner



Parts of a bunsen burner

A Bunsen burner uses butane/laboratory gas as the fuel. The butane/laboratory gas is highly flammable and thus usually stored safely in a secure chamber outside Chemistry school laboratory. It is tapped and distributed into the laboratory through gas pipes.

The gas pipes end at the gas tap on a chemistry laboratory bench .If opened the gas tap releases butane/laboratory gas. Butane/laboratory gas has a characteristic odor/smell that alerts leakages/open gas tap.

The Bunsen burner is fixed to the gas tap using a strong rubber tube.

The Bunsen burner is made up of the following parts:

(i) **Base plate** –to ensure the burner can stand on its own

(ii) **Jet-a hole** through which laboratory gas enters the burner

(iii) **Collar/sleeve**-adjustable circular metal attached to the main chimney/burell with a side hole/entry. It controls the amount of air entering used during burning.

(iv) **Air hole**- a hole/entry formed when the collar side hole is in line with chimney side hole. If the collar side hole is **not** in line with chimney side hole, the air hole is said to be "closed" If the collar side hole is **in line** with chimney side hole, the air hole is said to be "open"

(v) **Chimney**- tall round metallic rod attached to the base plate.

(**b**)**Procedure for lighting/igniting a Bunsen burner**

1. Adjust the collar to ensure the air holes are closed.
2. Connect the burner to the gas tap using a rubber tubing. Ensure the rubber tubing has no side leaks.
3. Turn on the gas tap.
4. Ignite the top of the chimney using a lighted match stick/gas lighter/wooden splint.
5. Do not delay excessively procedure (iv) from (iii) to prevent highly flammable laboratory gas from escaping/leaking.

(c)**Bunsen burner flames**

A Bunsen burner produces two types of flames depending on the amount of air entering through the air holes.

If the air holes are **fully open**, a **non luminous** flame is produced. If the air holes are **fully closed**, a **luminous flame** is produced. If the air holes are **partially** open/ closed, a **hybrid** of non luminous and luminous flames is produced.

Characteristic differences between luminous and non-luminous flame

Luminous flame	Non-luminous flame
1. Produced when the air holes are fully/completely closed.	1. Produced when the air holes are fully/completely open.
2. when the air holes are fully/ completely closed there is incomplete burning/ combustion of the laboratory gas	2.when the air holes are fully/ completely open there is complete burning/ combustion of the laboratory gas
3. Incomplete burning/ combustion of the laboratory gas produces fine unburnt carbon particles which make the flame sooty/smoky	3. Complete burning/ combustion of the laboratory gas does not produce carbon particles. This makes the flame non-sooty /non- smoky.
4. Some carbon particles become white hot and emit light. This flame is thus bright yellow in colour producing light. This makes luminous flame useful for lighting	4. Is mainly blue in colour and is hotter than luminous flame. This makes non-luminous flame useful for heating
5. Is larger, quiet and wavy/easily swayed by wind	5.Is smaller, noisy and steady

<u>**Luminous flame has three main regions:**</u> (i)the top yellow region where there is incomplete combustion/burning (ii)the region of unburnt gas below the yellow region where the gas does not burn (iii) blue region on the sides of region of unburnt gas where there is complete burning	<u>**Non-luminous flame has four main** regions:</u> **(i)**the top colourless region (ii) Blue region just below where there is complete burning. It is the hottest region **(iii)** green region surrounded by the blue region where there is complete burning (Ii) The region of unburnt gas at the innermost surrounded by green and blue regions. No burning takes place here

Scientific apparatus are drawn:

(i) Using a proportional **two** dimension (**2D**) cross-sections. Three dimensions (3D) are not recommended.

(ii) Straight edges of the apparatus on a scientific diagram should be drawn using ruler.

(iii) Curved edges of the apparatus on a scientific diagram should be drawn using free hand.

(iv) The bench, tripod or clamp to support apparatus which cannot stand on their own should be shown.

TOPIC 2:
CLASSIFICATION OF SUBSTANCES

Substances are either pure or impure. A pure substance is one which contains only one substance. An impure substance is one which contains two or more substances. A pure substance is made up of a pure solid, pure liquid or pure gas.
A mixture is a combination of two or more pure substances which can be separated by physical means. The three states of matter in nature appear mainly as mixtures of one with the other.
Common mixtures include:

(a)Solutions/solid-liquid dissolved mixture
Experiment:
To make a solution of copper (II) sulphate (VI)/Potassium magnate(VII) /sodium chloride
Procedure
Put about 100 cm3 of water in three separate beakers. Separately place a half spatula end full of copper (II) sulphate (VI), Potassium manganate (VII) and sodium chloride crystals to each beaker. Stir for about two minutes.
Observation
Copper (II) sulphate (VI) crystals dissolve to form a blue solution
Potassium manganate (VII) crystals dissolve to form a purple solution
Sodium chloride crystals dissolve to form a colourless solution

Explanation
Some solids, liquids and gases dissolve in some other liquids.
A substance/liquid in which another substance dissolves is called solvent.
A substance /solid /gas which dissolves in a solvent is called solute.
When a solute dissolves in a solvent it forms a uniform mixture called **solution**.
A solute dissolved in water as the solvent exists in another state of matter called **aqueous state.**
Water is referred as the **universal solvent** because it dissolves many solutes. A solute that dissolves in a solvent is said to be **soluble**. Soluble particles uniformly spread between the particles of water/solvent and cannot be seen.

Solute + Solvent -> solution
Solute + Water -> aqueous solution of solute

The solute dissolved in water gives the **name** of the solution e. g.
1. Sodium chloride solution is a solution formed after dissolving sodium chloride crystals/solid in water. Sodium chloride exists in aqueous state after dissolving.
Sodium chloride + Water -> Sodium chloride solution
NaCl(**s**) + (aq) -> NaCl(**aq**)

2. Ammonia solution is a solution formed after dissolving ammonia gas in water. Ammonia exists in aqueous state after dissolving.

Ammonia gas + Water -> aqueous ammonia

NH_3 (**g**) + (aq) -> NH_3 (**aq**)

3. Copper (II) sulphate (VI) solution is a solution formed after dissolving Copper (II) sulphate (VI) crystals/solid in water. Copper (II) sulphate (VI) exists in aqueous state after dissolving.

Copper (II) sulphate (VI) + Water -> Copper (II) sulphate (VI) solution

$CuSO_4$(**s**) + (aq) -> $CuSO_4$ (**aq**)

4. Potassium manganate(VII) solution is a solution formed after dissolving Potassium manganate(VII) crystals/solid in water.

Potassium manganate(VII)exist in aqueous state after dissolving.

Potassium manganate(VII) + Water -> Potassium manganate(VII) solution

$KMnO_4$(**s**) + (aq) -> $KMnO_4$ (**aq**)

(b)Suspension/ precipitates/solid-liquid mixture which do not dissolve

Experiment: To make soil, flour and Lead (II) Iodide suspension/precipitate

Procedure

Put about 100 cm3 of water in three separate beakers. Separately place a half spatula end full of soil, maize and lead (II) Iodide to each beaker. Stir for about two minutes.

Observation

Some soil, maize and lead (II) Iodide float in the water

A brown suspension/precipitate/particles suspended in water containing soil

A white suspension/precipitate/particles suspended in water containing flour

A yellow suspension/precipitate/particles suspended in water containing Lead (II) iodide. Some soil, maize and lead (II) Iodide settle at the bottom after some time.

Explanation

Some solid substances do not dissolve in a liquid. They are said to be **insoluble** in the solvent .When an insoluble solid is put in liquid:

(i) Some particles remain **suspended/floating** in the liquid to form a **suspension /precipitate**.

(ii) Some particles **sink/settle** to the bottom to form **sediments** after being allowed to stand.

An **insoluble** solid acquire the colour of the suspension/precipitate .e.g.

1. A white suspension /precipitate have some fine white particles suspended /floating in the liquid. **Not** "white solution"

2. A blue suspension /precipitate has some fine **blue** particles suspended /floating in the liquid.

3. A green suspension /precipitate has some fine **green** particles suspended /floating in the liquid.

4. A **brown** suspension /precipitate has some fine **brown** particles suspended /floating in the liquid.

5. A yellow suspension /precipitate has some fine yellow particles suspended /floating in the liquid.

(c) (i) Miscibles /Liquid-liquid mixtures

To form water-ethanol and Kerosene-turpentine miscibles

Procedure

(i) Measure 50cm3 of ethanol into 100cm3 beaker. Measure 50cm3 of water. Place the water into the beaker containing ethanol. Swirl for about one minute.

(ii) Measure 50cm3 of kerosene into 100cm3 beaker. Measure 50cm3 of turpentine oil. Place the turpentine oil into the beaker containing kerosene. Swirl for about one minute.

Observation

Two liquids do not form layers.

Ethanol and water form a uniform mixture.

Kerosene and turpentine oil form uniform mixture

Explanation

Ethanol is miscible in Water. Kerosene is miscible in turpentine oil. Miscible mixture form uniform mixture. They do not form layers. The particles of one liquid are smaller than the particles of the other. The smaller particles occupy the spaces between the bigger particles.

(i) Immiscibles /Liquid-liquid mixtures

To form water-turpentine oil and Kerosene-water miscibles

Procedure

(i) Measure 50cm3 of water into 100cm3 beaker. Measure 50cm3 of turpentine oil. Place the oil into the beaker containing water. Swirl for about one minute.

(ii) Measure 50cm3 of water into 100cm3 beaker. Measure 50cm3 of kerosene. Place the kerosene into the beaker containing water. Swirl for about one minute.

Observation

Two liquids form layers.

Turpentine and water do not form a uniform mixture.

Water and kerosene do not form uniform mixture

Explanation

Kerosene is immiscible in Water. Water is immiscible in turpentine oil. Immiscible mixtures do not form uniform mixtures. They form layers. The size of the particles of one liquid is almost equal to the particles of the other. The particles of one liquid cannot occupy the spaces between the particles of the other. The heavier particles settle at the bottom. The less dense particles settle on top.

(d)Solid-solid mixtures/Alloys

Before solidifying, some heated molten/liquid metals dissolve in another metal to form a uniform mixture of the two. On solidifying, a uniform mixture of the metals is formed. A uniform mixture of two metals on solidifying is called **alloy**. In the alloy, one metallic particle occupies the spaces between the metallic particles of the other.

c) Common alloys of metal.

Alloy name	Constituents of the alloy	Uses of the alloy
Brass	Copper and Zinc	Making screws and bulb caps
Bronze	Copper and Tin	Making clock springs, electrical contacts and copper coins
Soldier	Lead and Tin	Soldering, joining electrical contacts because of its low melting points and high thermal conductivity
Duralumin	Aluminum, Copper and Magnesium	Making aircraft, utensils, and windows frames because of its light weight and corrosion resistant.
Steel	Iron, Carbon ,Manganese and other metals	Railway lines, car bodies girders and utensils.
Nichrome	Nichrome and Chromium	Provide resistance in electric heaters and ovens
German silver	Copper, Zinc and Nickel	Making coins

METHODS OF SEPARATING MIXTURES

Mixtures can be separated from applying the following methods:

(a) Decantation

Sediments can be separated from a liquid by pouring out the liquid. This process is called **decantation.**

Experiment

Put some sand in a beaker. Add about 200cm3 of water. Allow sand to settle. Pour off water carefully into another beaker.

Observation

Sand settles at the bottom as sediments.

Less clean water is poured out.

Explanation

Sand does not dissolve in water. Sand is denser than water and thus settles at the bottom as **sediment**. When poured out, the less dense water flows out.

(b)<u>Filtration</u>

Decantation leaves suspended particles in the liquid after separation. Filtration is thus improved decantation.Filtration is the method of separating insoluble mixtures/particles/solids from a liquid.

Experiment: To separate soil and water using filtration

Fold a filter paper to fit well into a filter funnel. Place the funnel in an empty 250 cm3 beaker.

Put one spatula end full of soil into 50cm3 of water. Stir. Put the soil/water mixture into the filter funnel.

Observations

Clean water is collected **below** the filter funnel.

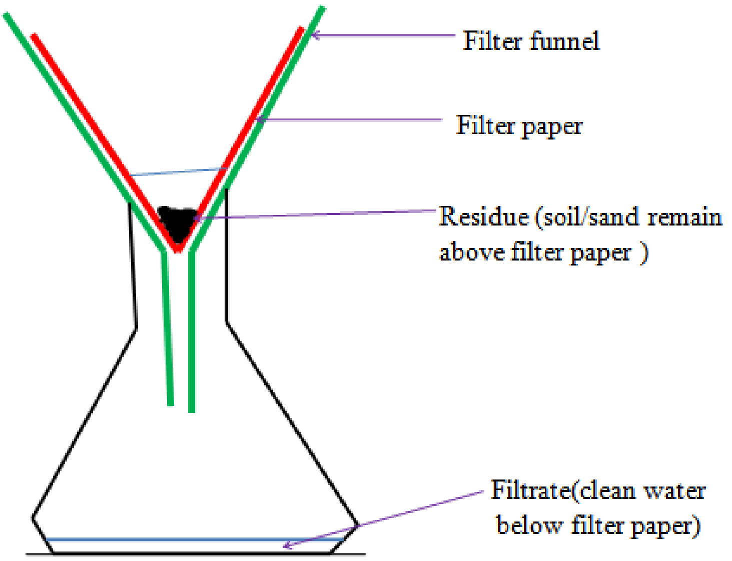
Soil remains **above** the filter paper.

Explanation

A filter paper is **porous** which act like a fine sieve with very small **holes**. The holes allow smaller water particles to pass through but do not allow bigger soil particles. The liquid which passes through is called **filtrate**. The solid which do not pass through is called **residue**.

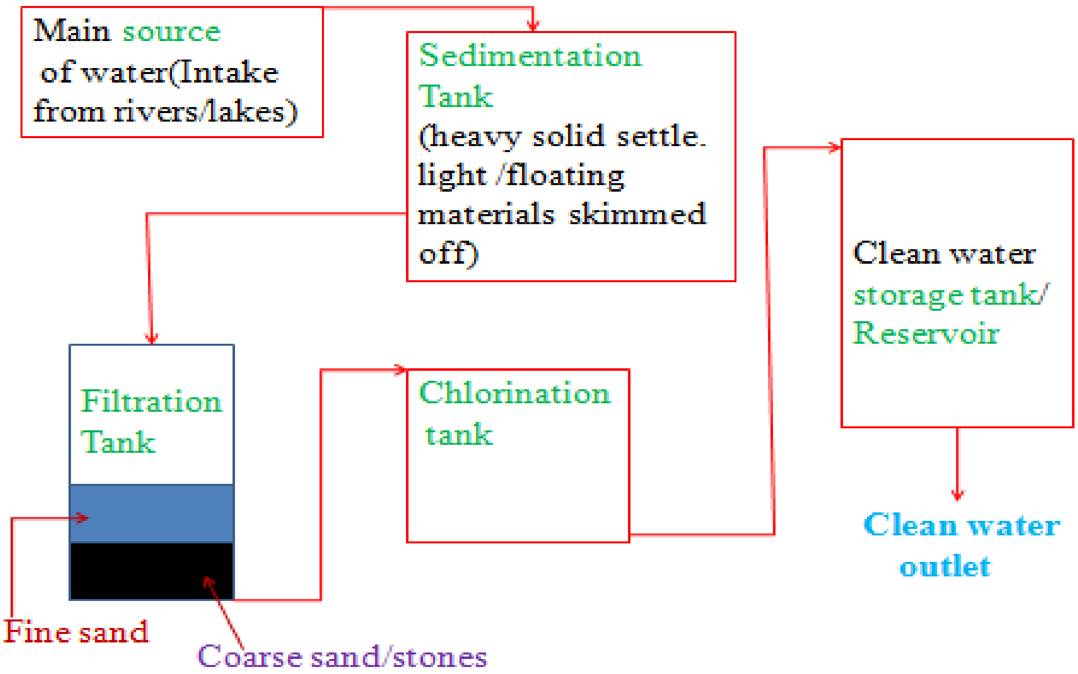
Set up of apparatus

Set up of apparatus for simple Filtration



In industries, filtration is used in engine filters to clean up air.

Processes in purification/treatment of water



TOPIC 3:
AIR OXYGEN AND COMBUSTION

A.THE ATMOSPHERE

1. The atmosphere is made up of air. Air is a mixture of colourless, odorless 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

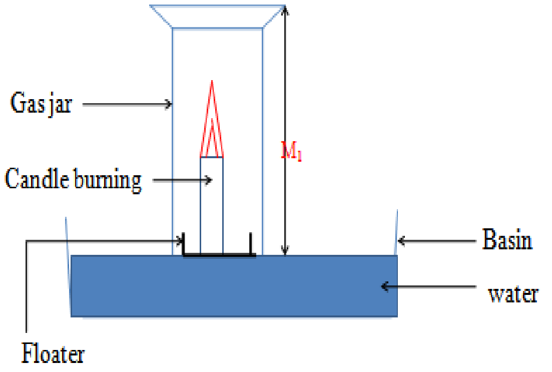
3. The following experiments below shows the presence and composition of the gases in air/atmosphere

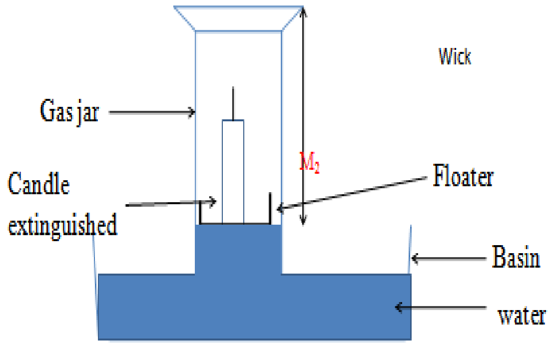
(a)To find the composition of air supporting combustion using a candle stick

Procedure

Measure the length of an 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 comes out from burning/combustion of candle stick.

From the experiment above the % composition of the:

(i) Active part of air can be calculated:

$$\frac{M_2 - M_3}{M_2} \times 100\% \Rightarrow \frac{10 - 8}{10\text{cm}} \times 100\% = \mathbf{20\%}$$

(ii) Inactive part of air can be calculated:

$$100\% - \mathbf{20\% = 80\%} \quad // \quad \frac{M_3}{M_2} \Rightarrow \frac{8}{10\text{cm}} \times 100\% = \mathbf{80\%}$$

(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.

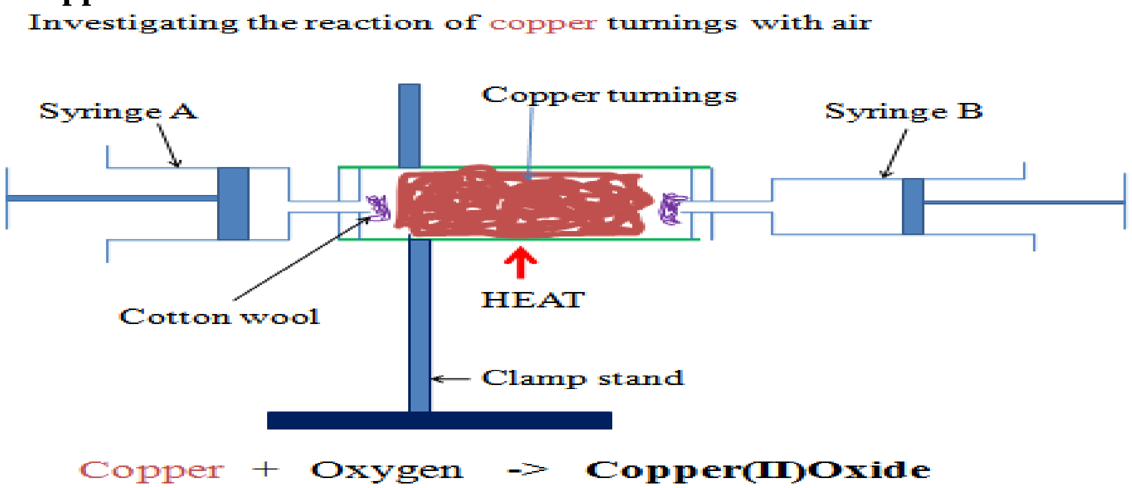
Determine and record the volume of air in syringe “B” V_1.

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 between 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

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

(ii) Inactive part of air

Method 1

% inactive part of air = $\frac{V_2 \times 100\%}{V_1}$ => $\frac{127.2\text{cm3} \times 100\%}{158.0\text{cm3}}$ = **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)	->	$2MgO(s)$
Magnesium	+	Nitrogen	->	magnesium (II) nitride
$3Mg(s)$	+	N_2 (g)	->	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 V1= **800cm3**

Volume of gas jar /air in gas jar after shaking with alkaline pyrogallol/1, 2, 3-trihydroxobenzene 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

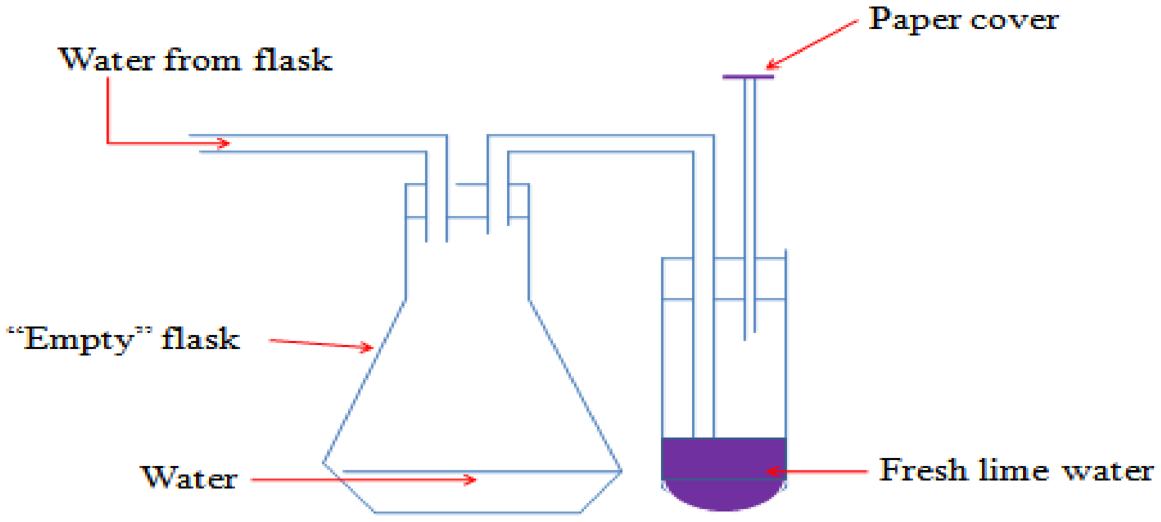
$$\frac{V_1-V_2}{V_1} \times 100\% \Rightarrow \frac{(800cm3 - 640\ cm3)}{800cm3} \times 100\% = \mathbf{20\%}$$

(ii) % of inactive part of air

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

(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



Sample observation questions

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

$CaCO_3(s) + H_2O(l) + CO_2(g) \rightarrow CaHCO_3(aq)$

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 earth's 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.

TOPIC 5:
HYDROGEN

Occurrence

Hydrogen does not occur free in nature. It occurs as Water and in Petroleum.

School laboratory Preparation

Procedure

Put Zinc granules in a round/flat/conical flask. Add dilute sulphuric (VI) /Hydrochloric acid.
Add about 3cm3 of copper (II) sulphate (VI) solution.
Collect the gas produced over water as in the set up below.
Discard the first gas jar. Collect several gas jars.

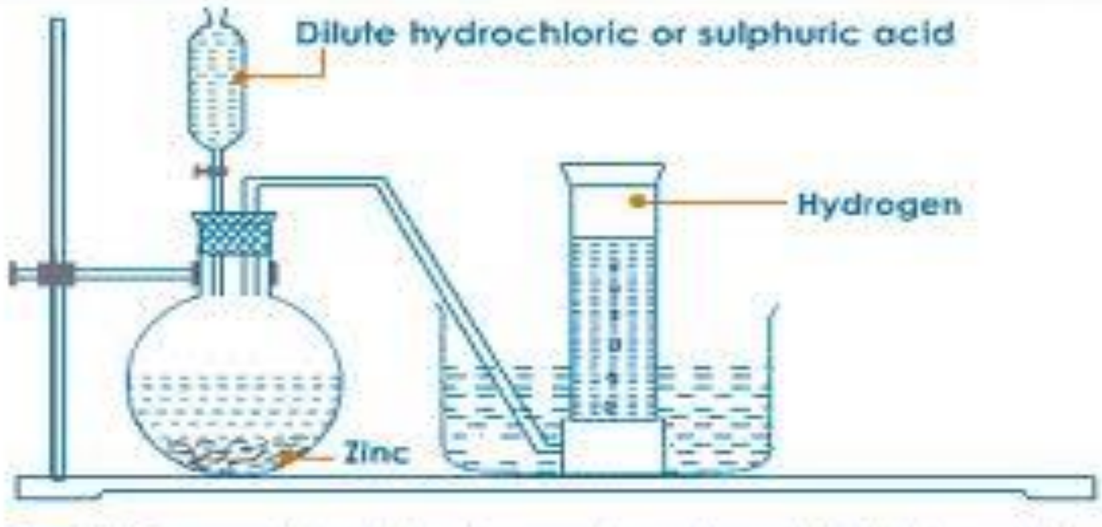


Fig. 9.7 Preparation of hydrogen from zinc with dilute acids

Observation/Explanation

Zinc reacts with dilute sulphuric (VI)/hydrochloric acid to form a salt and produce hydrogen gas.
When the acid comes into contact with the metal, there is rapid effervescence/ bubbles /fizzing are produced and a colourless gas is produced that is collected:
(i) Over water because it is insoluble in water
(ii) Through downward displacement of air/upward delivery because it is less dense than air.
The first gas jar is impure. It contains air that was present in the apparatus.
Copper (II) sulphate (VI) solution act as catalyst.

Chemical equation

(**a**) Zinc + Hydrochloric acid -> Zinc chloride + Hydrogen

$Zn(s) + 2HCl (aq) \rightarrow ZnCl_2 (aq) + H_2 (g)$

Ionic equation

$Zn (s) + 2H^+ (aq) \rightarrow Zn^{2+} (aq) + H_2 (g)$

Zinc + Sulphuric (VI) acid -> Zinc Sulphate (VI) + Hydrogen

$Zn(s) + H_2SO_4 (aq) \rightarrow ZnSO_4 (aq) + H_2 (g)$

Ionic equation

$Zn (s) + 2H^+ (aq) \rightarrow Zn^{2+} (aq) + H_2 (g)$

(b) Chemical equation

Magnesium + Hydrochloric acid -> Magnesium chloride + Hydrogen

$Mg(s) + 2HCl (aq) \rightarrow MgCl_2 (aq) + H_2(g)$

Ionic equation

$Mg (s) + 2H^+ (aq) \rightarrow Mg^{2+} (aq) + H_2 (g)$

Magnesium + Sulphuric (VI) acid -> Magnesium Sulphate(VI) + Hydrogen

$Mg(s) + H_2SO_4 (aq) \rightarrow MgSO_4 (aq) + H_2(g)$

Ionic equation

$Mg (s) + 2H^+ (aq) \rightarrow Mg^{2+} (aq) + H_2 (g)$

(c) Chemical equation

Iron + Hydrochloric acid -> Iron (II) chloride + Hydrogen

$Fe(s) + 2HCl (aq) \rightarrow FeCl_2 (aq) + H_2 (g)$

Ionic equation

$Fe (s) + 2H^+ (aq) \rightarrow Fe^{2+} (aq) + H_2 (g)$

Iron + Sulphuric (VI) acid -> Iron (II) Sulphate (VI) + Hydrogen

$Fe(s) + H_2SO_4 (aq) \rightarrow FeSO_4 (aq) + H_2 (g)$

Ionic equation

$Fe (s) + 2H^+ (aq) \rightarrow Fe^{2+} (aq) + H_2 (g)$

Note

1. Hydrogen cannot be prepared from reaction of:

(i)Nitric (V) acid and a metal. Nitric (V) acid is a strong oxidizing agent. It **oxidizes** hydrogen gas to **water**.

(ii) Dilute sulphuric (VI) acid with calcium/Barium/Lead because Calcium sulphate (VI), Barium sulphate (VI) and Lead (II) sulphate (VI) salts formed are insoluble. Once formed, they **cover/coat** the **unreacted** calcium/Barium/Lead **stopping** further reaction and producing very small amount/volume of hydrogen gas.

(iii) Dilute acid with sodium/potassium. The reaction is **explosive.**

Properties of Hydrogen gas

(a)Physical properties

1. Hydrogen is a **neutral**, colourless and **odorless** gas. When mixed with air it has a characteristic pungent choking smell

2. It is insoluble in water thus can be collected over water.
3. It is the lightest known gas. It can be transferred by inverting one gas jar over another.

(b)Chemical properties

(i)Burning

I. Hydrogen does not support burning/combustion. When a burning splint is inserted into a gas jar containing Hydrogen, the flame is extinguished /put off.

II. Pure dry hydrogen burn with a blue quiet flame to form water. When a stream of pure dry hydrogen is ignited, it catches fire and continues to burn with a blue flame.

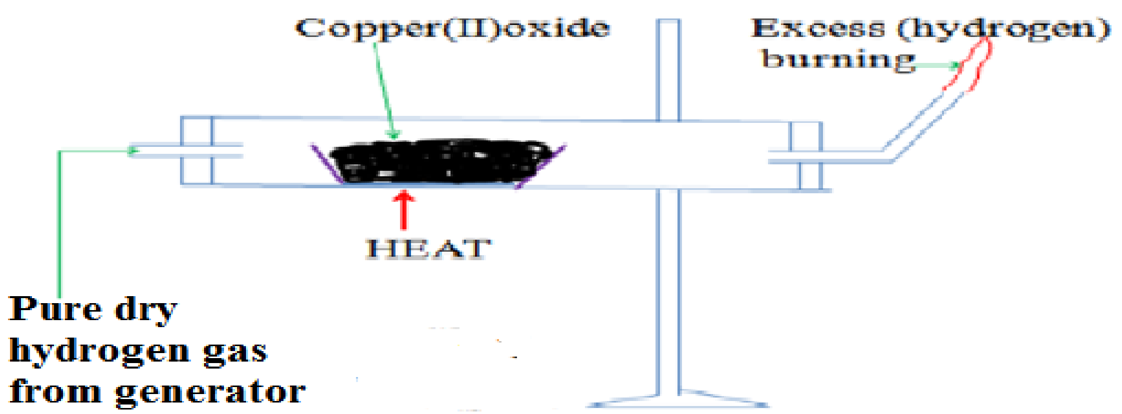
III. Impure (air mixed with) hydrogen burns with an explosion. Small amount/ volume of air **mixed** with hydrogen in a test tube produce a small explosion as a “pop” sound. This is the confirmatory test for the presence of Hydrogen gas. A gas that burns with a “pop” sound is confirmed to be Hydrogen.

(ii)Redox in terms of Hydrogen transfer

Redox can also be defined in terms of Hydrogen transfer.
(i)Oxidation is removal of Hydrogen
(ii)Reduction is addition of Hydrogen
(iii)Redox is simultaneous addition and removal of Hydrogen

Example

When a stream of dry hydrogen gas is passed through black copper (II) oxide, hydrogen gas gains the oxygen from copper (II) oxide.
Black copper (II) oxide is reduced to brown copper metal.
Black copper (II) oxide thus the Oxidizing agent.
Hydrogen gas is oxidized to Water. Hydrogen is the Reducing agent.
Set up of apparatus



Reduction of Copper(II)Oxide by Hydrogen gas

(**a**)Chemical equation
(i) In glass tube
Copper (II) Oxide + Hydrogen -> Copper + Hydrogen gas

(oxidizing agent) (reducing agent)

(**black**) (brown)

$CuO (s) + H_2(g) \rightarrow Cu(s) + H_2O(l)$

(ii) when excess Hydrogen is burning.

Oxygen + Hydrogen -> Water

$O_2 (g) + 2H_2 (g) \rightarrow 2H_2O (l)$

(**b**)Chemical equation

(i) In glass tube

Lead (II) Oxide + Hydrogen -> Lead + Hydrogen gas

(oxidizing agent) (reducing agent)

(brown when hot/ yellow when cool) (grey)

$PbO (s) + H_2 (g) \rightarrow Pb(s) + H_2O (l)$

(ii) when excess Hydrogen is burning.

Oxygen + Hydrogen -> Water

$O_2 (g) + 2H_2 (g) \rightarrow 2H_2O(l)$

(c)Chemical equation

(i) In glass tube

Iron (III) Oxide + Hydrogen -> Iron + Hydrogen gas

(oxidizing agent) (reducing agent)

(Dark grey) (grey)

$Fe_2O_3 (s) + 3H_2 (g) \rightarrow Fe(s) + 3H_2O (l)$

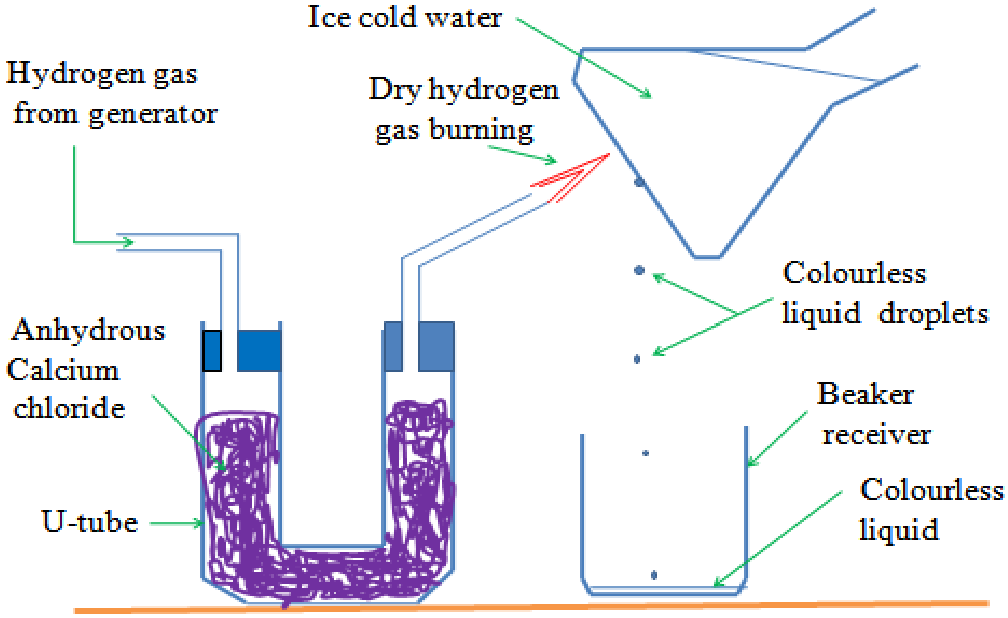
(ii) when excess Hydrogen is burning.

Oxygen + Hydrogen -> Water

$O_2 (g) + 2H_2 (g) \rightarrow 2H_2O (l)$

(iii) Water as an Oxide as Hydrogen

Burning is a reaction of an element with Oxygen. The substance formed when an element burn in air is the oxide of the element. When hydrogen burns, it reacts/ combines with Oxygen to form the **oxide of Hydrogen**. The oxide of Hydrogen is called water. Hydrogen is first dried because a mixture of Hydrogen and air explode. The gas is then ignited .The products condense on a cold surface/flask containing a freezing mixture. A freezing mixture is a mixture of water and ice.



Burning Hydrogen:To show Water is an Oxide of Hydrogen

The condensed products are collected in a receiver as a colourless liquid.

Tests

(**a**) When about 1g of **white** anhydrous copper (II) sulphate (VI) is added to a sample of the liquid, it turns to **blue**. This confirms the liquid formed is water.

(**b**) When blue anhydrous cobalt (II) chloride paper is dipped in a sample of the liquid, it turns to **pink**. This confirms the liquid formed is water.

(**c**)When the liquid is heated to boil, its **boiling point** is **100°C** at sea level/one atmosphere pressure. This confirms the liquid is **pure water.**

TOPIC 6:
ACIDS, BASES AND INDICATORS

INTRODUCTION TO ACIDS, BASES AND INDICATORS

1. In a school laboratory:
   (i)An acid may be defined as a substance that turns litmus red.
   (ii)A base may be defined as a substance that turns litmus blue.

Litmus is lichen found mainly in West Africa. It changes its colour depending on whether the solution it is in, is basic/alkaline or acidic. It is thus able to identify/show whether another substance is an acid, base or neutral.

(iii)An indicator is a substance that shows whether another substance is a base/alkaline,acid or neutral.

2. Common naturally occurring acids include:

Name of acid	Occurrence
1.Citric acid	Found in ripe citrus fruits like passion fruit/oranges/lemon
2.Tartaric acid	Found in grapes/baking powder/health salts
3.Lactic acid	Found in sour milk
4.Ethanoic acid	Found in vinegar
5.Methanoic acid	Present in ants, bees stings
6.Carbonic acid	Used in preservation of fizzy drinks like coke, Lemonade, Fanta
7.Butanoic acid	Present in cheese
8.Tannic acid	Present in tea

3. Most commonly used acids found in a school laboratory are not naturally occurring. They are manufactured. They are called **mineral acids**.

Common mineral acids include:

Name of mineral acid	Common use
Hydrochloric acid (HCl)	Used to clean/pickling surface of metals Is found in the stomach of mammals/human beings
Sulphuric(VI) acid (H_2SO_4)	Used as acid in car battery, making battery, making fertilizers
Nitric(V)acid (HNO_3)	Used in making fertilizers and explosives

4. Mineral acids are manufactured to very high concentration. They are **corrosive** (causes painful wounds on contact with the skin) and attack/reacts with garments/clothes/metals.

In a school laboratory, they are mainly used when added a lot of water. This is called **diluting**. Diluting ensures the concentration of the acid is safely low.

5. Bases are opposite of acids. Most bases do not dissolve in water.
Bases which dissolve in water are called **alkalis**.
Common alkalis include:

Name of alkali	Common uses
Sodium hydroxide (NaOH)	Making soaps and detergents
Potassium hydroxide(KOH)	Making soaps and detergents
Ammonia solution(NH_4OH)	Making fertilizers, softening hard water

Common bases (which are not alkali) include:

Name of base	Common name
Magnesium oxide/hydroxide	Anti acid to treat indigestion
Calcium oxide	Making cement and neutralizing soil acidity

6. Indicators are useful in identifying substances which look-alike.
An acid-base indicator is a substance used to identify whether another substance is alkaline or acidic.
An acid-base indicator works by changing to different colors in neutral, acidic and alkaline **solutions/dissolved** in water.

Experiment: To prepare simple acid-base indicator

Procedure

(a)Place some flowers petals in a mortar. Crush them using a pestle. Add a little sand to assist in crushing.
Add about 5cm3 of propanone/ethanol and carefully continue grinding.
Add more 5cm3 of propanone/ethanol and continue until there is enough extract in the mortar.
Filter the extract into a clean 100cm3 beaker.

(b)Place 5cm3 of filtered wood ash, soap solution, ammonia solution, sodium hydroxide, hydrochloric acid, distilled water, sulphuric (VI) acid, sour milk, sodium chloride, toothpaste and calcium hydroxide into separate test tubes.

(c)Put about three drops of the extract in (a)to each test tube in (b). Record the observations made in each case.

Sample observations

Solution mixture	Colour on adding indicator extract	Nature of solution
wood ash	green	Base/alkaline
soap solution	green	Basic/alkaline
ammonia solution	green	Basic/alkaline
sodium hydroxide	green	Basic/alkaline
hydrochloric acid	Red	Acidic
distilled water	orange	Neutral
sulphuric(VI)acid	Red	Acidic
sour milk	green	Basic/alkaline
sodium chloride	orange	Neutral
Toothpaste	green	Basic/alkaline
calcium hydroxide	green	Basic/alkaline
Lemon juice	Red	Acidic

The plant extract is able to differentiate between solutions by their nature. It is changing to a similar colour for similar solutions.
(i) Since lemon juice is a known acid, then sulphuric (VI) and hydrochloric acids are similar in nature with lemon juice because the indicator shows similar colors. They are acidic in nature.
(ii) Since sodium hydroxide is a known base/alkali, then the green colour of indicator shows an alkaline/basic solution.
(iii) Since pure water is neutral, then the orange colour of indicator shows neutral solutions.

7. In a school laboratory, commercial indicators are used. A commercial indicator is cheap, readily available and easy to store. Common indicators include: Litmus, phenolphthalein, methyl orange, screened methyl orange, bromothymol blue.

Experiment:
Using commercial indicators to determine acidic, basic/alkaline and neutral solutions
Procedure
Place 5cm3 of the solutions in the table below. Add three drops of litmus solution to each solution. Repeat with phenolphthalein indicator, methyl orange, screened methyl orange and bromothymol blue.

Sample results

Substance/ Solution	Indicator used				
	Litmus	**Phenolphthalein**	**Methyl orange**	**Screened methyl orange**	**Bromothymol blue**
wood ash	Blue	Pink	Yellow	Orange	Blue
soap solution	Blue	Pink	Yellow	Orange	Blue
ammonia solution	Blue	Pink	Yellow	Orange	Blue
sodium hydroxide	Blue	Pink	Yellow	Orange	Blue
hydrochloric acid	Red	Colourless	Red	Purple	Orange
distilled water	Colourless	Colourless	Red	Orange	Orange
sulphuric(VI)acid	Red	Colourless	Red	Purple	Orange
sour milk	Blue	Pink	Yellow	Orange	Blue
sodium chloride	Colourless	Colourless	Red	Orange	Orange
Toothpaste	Blue	Pink	Yellow	Orange	Blue
calcium hydroxide	Blue	Pink	Yellow	Orange	Blue
Lemon juice	Red	Colourless	Red	Purple	Orange

From the table above, then the colour of indicators in different solution can be summarized.

Indicator	Colour of indicator in		
	Acid	Base/alkali	Neutral
Litmus paper/solution	Red	Blue	Colourless
Methyl orange	Red	Yellow	Red
Screened methyl orange	Purple	Orange	Orange
Phenolphthalein	Colourless	Purple	Colourless
Bromothymol blue	Orange	Blue	Orange

The universal indicator

The universal indicator is a mixture of other indicator dyes. The indicator uses the pH scale. The pH scale shows the **strength** of bases and acids. The pH scale ranges from 1-14.These numbers are called **pH values**:

(i) pH values 1, 2, 3 shows a substance is **strongly acid**

(ii) pH values 4, 5, 6 shows a substance is a **weakly acid**
(iii) pH value 7 shows a substance is a **neutral**
(iv) pH values 8, 9, 10, 11 shows a substance is a **weak base/alkali.**
(v) pH values 12, 13, 14 shows a substance is a strong **base/alkali**

The pH values are determined from a pH chart. The pH chart is a multicolored paper with each colour corresponding to a pH value.i.e
(i) **red** correspond to pH 1, 2, 3 showing strongly acidic solutions.
(ii)**Orange/** yellow correspond to pH 4, 5, 6 showing weakly acidic solutions.
(iii)**Green** correspond to pH 7 showing neutral solutions.
(iv)**Blue** correspond to pH 8, 9, 10, 11 showing weakly alkaline solutions.
(v)**Purple**/**dark blue** correspond to pH 12,13,14 showing strong alkalis.
The universal indicator is available as:
(i) Universal indicator **paper**/**pH paper**
(ii) Universal indicator **solution.**

When determining the pH of a unknown solution using
(i) pH paper then the pH paper is dipped into the unknown solution. It changes/turn to a certain colour. The new colour is marched/compared to its corresponding one on the pH chart to get the pH value.

(ii) universal indicator **solution** then about 3 drops of the universal indicator **solution** is added into about 5cm3 of the unknown solution in a test tube. It changes/turn to a certain colour. The new colour is marched/compared to its corresponding one on the pH chart to get the pH value.

Experiment: To determine the pH value of some solutions
(a)Place 5cm3 of filtered wood ash, soap solution, ammonia solution, sodium hydroxide, hydrochloric acid, distilled water, sulphuric (VI) acid, sour milk, sodium chloride, toothpaste and calcium hydroxide into separate test tubes.

(b)Put about three drops of universal indicator solution or dip a portion of a piece of pH paper into each. Record the observations made in each case.

(c)Compare the colour in each solution with the colors on the pH chart provided. Determine the pH value of each solution.

Sample observations

Solution mixture	Colour on the pH paper/adding universal indicator	pH value	Nature of solution
wood ash	Blue	8	Weakly alkaline
soap solution	Blue	8	Weakly alkaline
ammonia solution	green	8	Weakly alkaline
sodium hydroxide	Purple	14	Strongly alkaline
hydrochloric acid	red	1	Strongly acidic
distilled water	green	7	Neutral
sulphuric(VI)acid	red	1	Strongly acidic
sour milk	blue	9	Weakly alkaline
sodium chloride	green	7	Neutral
toothpaste	Blue	10	Weakly alkaline
calcium hydroxide	Blue	11	Weakly alkaline
Lemon juice	Orange	5	Weakly acidic

Note
1. All the mineral acids Hydrochloric, sulphuric (VI) and nitric (V) acids are strong acids
2. Two alkalis/soluble bases, sodium hydroxide and potassium hydroxide are strong bases/alkali. Ammonia solution is a weak base/alkali. All other bases are weakly alkaline.
3. Pure/deionized water is a neutral solution.
4. Common salt/sodium chloride is a neutral salt.
5. When an acid and an alkali/base are mixed, the final product has pH 7 and is neutral.

Properties of acids
(a)Physical properties of acids
1. Acids have a characteristic sour taste
2. Most acids are colourless liquids
3. Mineral acids are odorless. Organic acids have characteristic smell
4. All acids have pH less than 7
5. All acids turn blue litmus paper red, methyl orange red and phenolphthalein colourless.
6. All acids dissolve in water to form an acidic solution. Most do not dissolve in organic solvents like propanone, kerosene, tetrachloromethane, petrol.

(b)Chemical properties of acids
1. <u>Reaction with metals</u>
All acids react with reactive metals to form a salt and produce /evolve hydrogen gas.

Metal + Acid -> Salt + Hydrogen gas

Experiment: **reaction of metals with mineral acids**.

(a)Place 5cm3 of dilute hydrochloric acid in a small test tube. Add 1cm length of polished magnesium ribbon. Stopper the test tube using a thump. Light a wooden splint. Place the burning splint on top of the stoppered test tube. Release the thump stopper. Record the observations made.

(b)Repeat the procedure in (a) above using Zinc granules, iron filings, copper turnings, aluminum foil in place of Magnesium ribbon

(c)Repeat the procedure in (a) then (b) using dilute sulphuric (VI) acid in place of dilute hydrochloric acid.