Introduction to Chemistry

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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 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 form 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 , plastics.

(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/spoon fulls 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/spoon fulls 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 medicines require 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 involve jnteraction 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.Laboaratory 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 use.
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 a 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 a 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) Pipette

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 require 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. Volumetric flask.

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

5. Dropper/teat pipette

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 number of drops needed are counted by pressing the rubber gently at a time

(b)Apparatus for measuring mass

1. Beam balance

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. Electronic/electric balance.

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 alchohol /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 watch/clock 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 require practice.

(e) Apparatus for scooping

1. Spatula

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. Deflagrating spoon

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. Test tube.

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. Boiling/ignition tube.

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. Beaker.
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 centimetres”
“1l” beaker has a maximum calibrated/graduated volume of “one litre” /“1000 cubic centimetres”
“5 l” beaker has a maximum calibrated/graduated volume of “two litres” /“2000 cubic centimetres”

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 spirage.
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 centimetres”
“500ml” Conical flasks hold a maximum volume of “500ml” /“1000 cubic centimetres”

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 spirage. 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 flask 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.Gas jar

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 spirage).

1. Filter funnel

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.

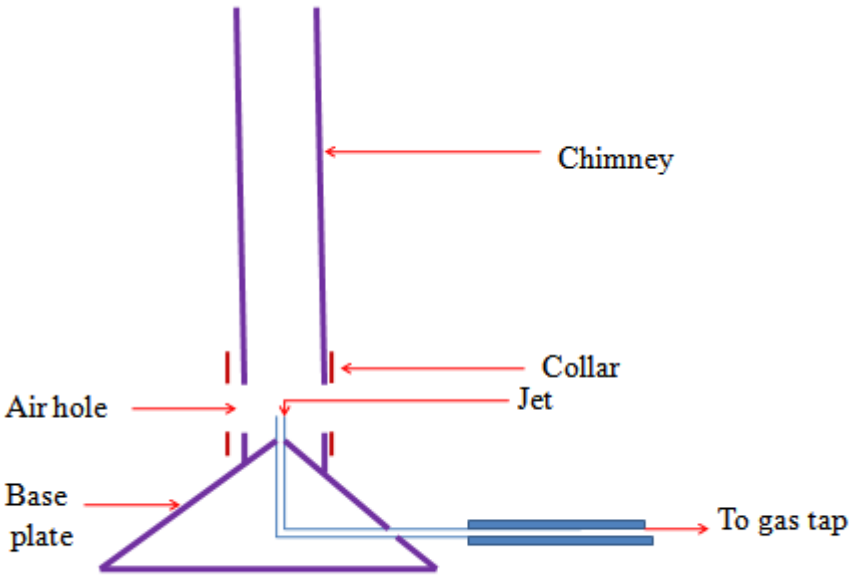
2. Thistle funnel
A thistle funnel is a wide mouthed glass apparatus that narrow drastically at the bottom to a very long extension.
The long extension is usually drilled through a stopper/cork.
A liquid solution can thus be directed into a stoppered container without spirage
3. Dropping funnel
A dropping 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 spirage at the rate determined by adjusting the tap.
4. Separating funnel
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 spirage. 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/immiscibles. This requires practice.

(h) Apparatus for heating/Burners

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.Bunsen burner
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 odour/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 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 make 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**

Luminous flame has **three** main regions: (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	Non-luminous flame has **four** main regions: (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.

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 manganate(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 refered 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) exist 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 has 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.
4.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.

(ii) 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 scews 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	Aluminium, Copper and Magnesium	Making aircraft, utensils, 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.**

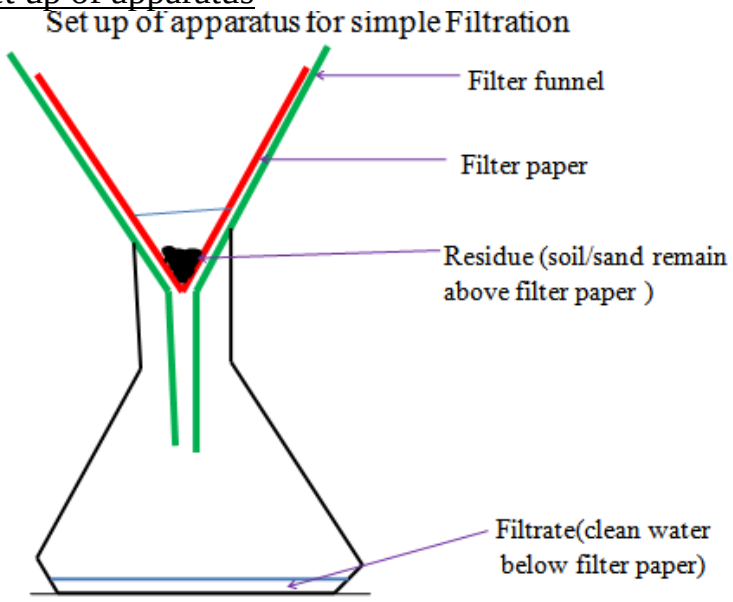
Experiment
Put some sand in a beaker. Add about 200cm3 of water. Allow sand to settle.
Pour off water carefully into another beaker.

Observation
Sand settles at the bottom as sediments.
Less clean water is poured out.

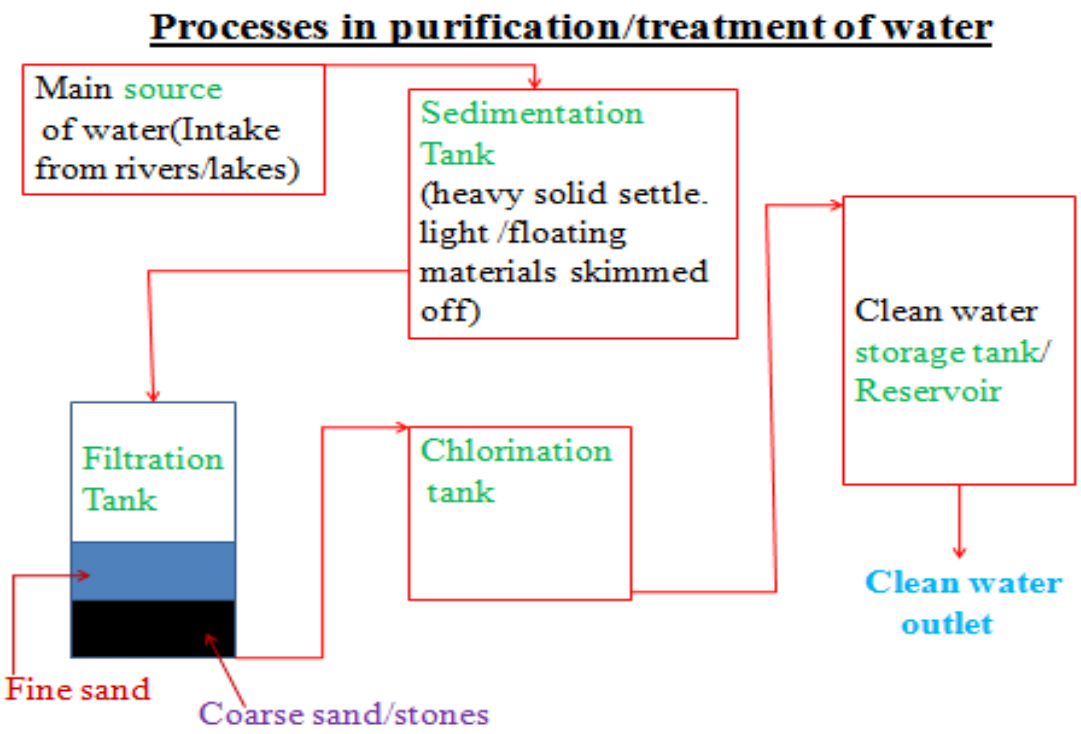
Explanation
Sand does not dissolve in water. Sand is denser than water and thus settles at the bottom as **sediment**. When poured out, the less dense water flows out.

(b)Filtration

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



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



(c)Evaporation

Evaporation is a method of separating a solute/solid from its solution. This involves heating a solution (solvent and solute)to vapourize the solvent out of the solution mixture leaving pure solute/solid. If a mixture contain insoluble solid, they are filtered out.

Experiment: **: To separate a mixture of soil and salt(sodium chloride) .**

Procedure:

Put one spatula end full of soil on a filter paper.

Put one spatula full of common salt/sodium chloride into the same filter paper. Mix well using the spatula,.

Place about 200cm3 of water into a beaker.

Put the contents of the filter paper into the water. Stir thoroughly using a glass/stirring rod for about one minute.

Fold a filter paper into a filter funnel.

Pour half portion of the contents in the beaker into the filter funnel.

Put the filtrate into an evaporating dish. Heat on a water bath.

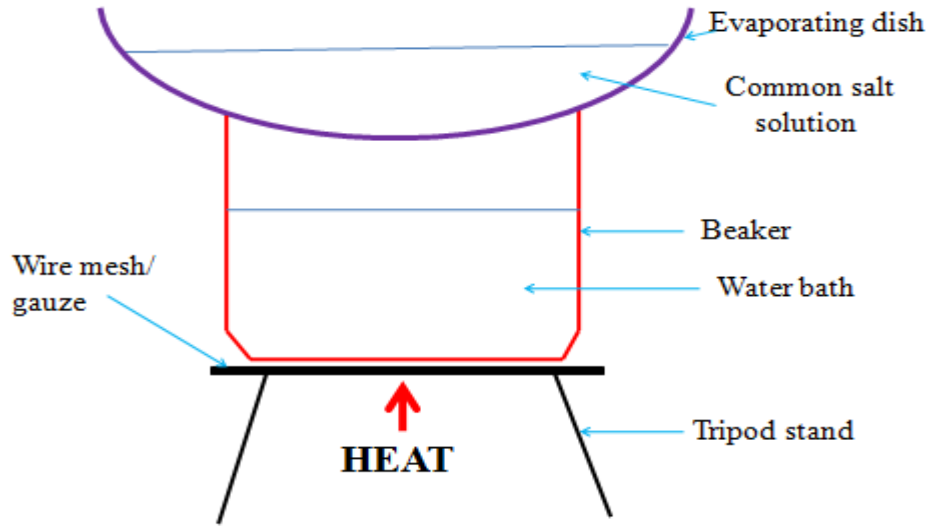
Observation

(i)On mixing

Colourless crystals and brown soil particles appear on the filter paper.

(ii)On adding water

Common soil dissolves in water. Soil particles do not dissolve in water.
(iii)On filtration
Colourless liquid collected as filtrate below the filter funnel/paper.
Brown residue collected above the filter funnel/paper.
(iv)On evaporation
Colourless crystals crystals collected after evaporation
Explanation
Solid mixture of sand and common salt take the colours of the two.
On adding water, common salt dissolve to form a solution .
Soil does not because it is insoluble in water and thus forms a suspension.
On filtration, a residue of insoluble soil does not pass through the filter paper.
It is collected as residue.
Common salt solution is collected as filtrate.
On heating the filtrate, the solvent/water evaporate/vapourize out of the evaporating dish leaving common salt crystals.
Vapourization/evaporation can take place even without heating.
This is the principle/process of drying wet clothes on the hanging line.
Set up of apparatus



(d) Distillation
Distillation is an improved evaporation where both the solute and the solvent in the solution are separated /collected. Distillation therefore is the process of separating a solution into constituent solid solute and the solvent. It involves heating the

solution to evaporate/vapourize the solvent out. The solvent vapour is then condensed back to a liquid.

Experiment: To obtain copper(II)sulphate (VI) crystals and water from copper (II) sulphate(VI) solution.

Procedure:
Put one spatula end full of copper(II)sulphate (VI) crystals into a 250cm3 beaker.
Place about 200cm3 of water into the beaker.
Stir thoroughly using a glass/stirring rod for about one minute.
Pour half portion of the contents in the beaker into a round bottomed/flat/conical flask broken porcelain/sand/glass into the flask.
Put a few pieces of b Stopper the flask.
Connect the flask to a liebig condenser using delivery tube.
Place a 200cm3 clean empty beaker/conical flask as a receiver at the end of the liebig condenser.
Circulate water in the liebig condenser.
Heat the flask strongly on a tripod stand with wire mesh/gauze until there is no more visible **boiling bubbles** in the flask.

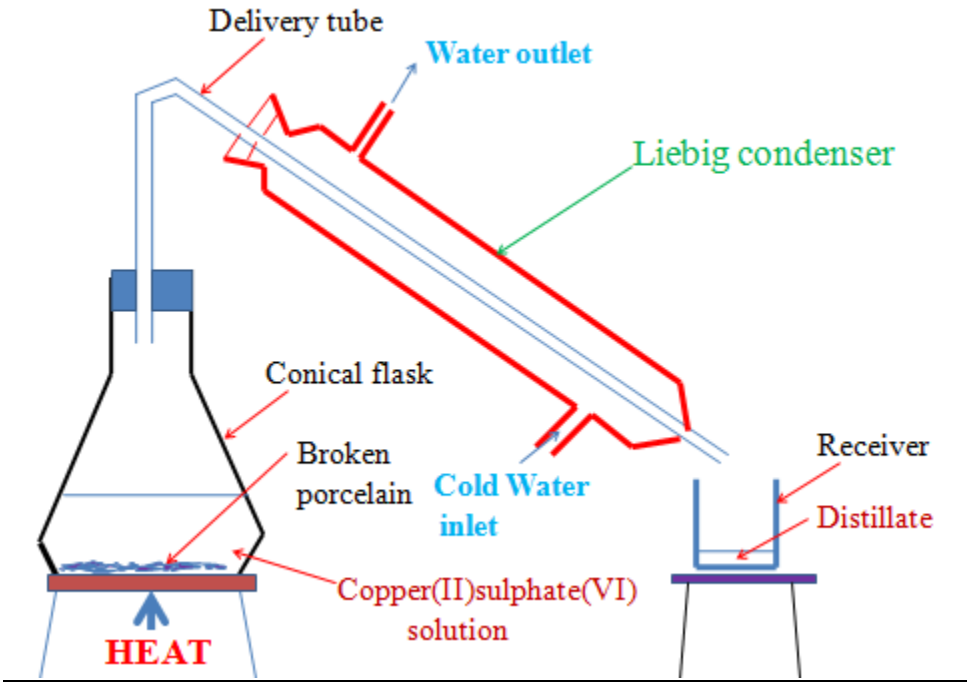
Observation
Copper (II)sulphate (VI) crystals dissolve in water to form a blue solution.
On heating, colourless liquid is collected in the receiver.
Blue crystals are left in the flask.
(if gently heated further, the blue crystals turn to white powder)

Explanation
On heating blue Copper (II)sulphate (VI) solution, the colourless liquid solvent evaporate/vapourize .
The liquid vapour/gas passes through the delivery tube to the liebig condenser.
The liebig condenser has a cold water **inlet** near the receiver and cold water **out** let.
This ensures efficient cooling. If the cold water **outlet/inlet** is reversed, the water circulation would be less efficient.
The water in the receiver would be warm.In the liebig condenser, the cold water,condenses the liquid vapour into liquid.
The condensed liquid collects in the receiver as **distillate**.
The solute of blue Copper (II)sulphate (VI) crystals is left in the flask as **residue**.
During simple distillation,therefore, the solution is heated to vapourize /evaporate the solvent/one component which is condensed at a different part of the apparatus.
The purpose of pieces of broken porcelain/porous pot/glass/sand/ is to:

(i)prevent bumping of the solution during boiling.
(ii)ensure smooth and even boiling.

Salty sea water can be made pure through simple distillation.
Any mixture with a large difference /40^{o}C in boiling point can be separated using simple distillation.

Set up of apparatus



(e)Fractional distillation

Fractional distillation is an improved simple distillation used specifically to separate miscible mixtures with very **close /near** boiling points.

Fractional distillation involves:
(**i**)Heating the mixture in a conical/round bottomed /flat bottomed flask.
The pure substance with a lower boiling point and thus more volatile evaporates/boils/vapourizes first.
e.g.
Pure ethanol has a boiling point of 78^{o}C.Pure water has a boiling point of 100 ^{o}C at sea level/one atmosphere pressure.
When a miscible mixture of ethanol and water is heated, ethanol vapourizes /boils/ evaporates first because it is more volatile.
(**ii**)The conical/round bottomed /flat bottomed flask is connected to a long glass tube called **fractionating column**.

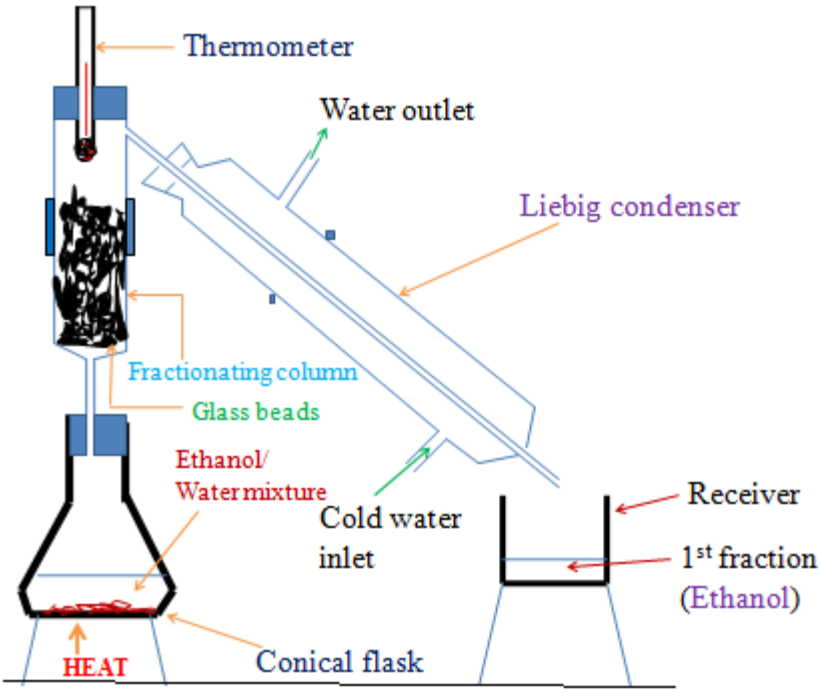
The purpose of the fractionating column is to offer areas of condensation for the less volatile pure mixture.
The fractionating column is packed with glass beads/broken glass/ porcelain/ shelves to increase the surface area of condensation of the less volatile pure mixture.
(**iii**)When the vapours rise they condense on the glass beads/broken glass /porcelain / shelves which become hot.
When the temperature of the glass beads/broken glass/porcelain/shelves is beyond the boiling point of the less volatile pure substance, the pure substance rise and condensation take place on the glass beads/broken glass/porcelain/shelves at a higher level on the fractionating column.
The less volatile pure substance trickles/drips back down the fractionating column or back into the conical/round bottomed /flat bottomed flask to be heated again.
e.g.
If the temperature on glass beads/broken glass/porcelain/shelves is beyond 78^oC, the **more volatile** pure ethanol rise to condense on the glass beads/broken glass /porcelain/shelves **higher** in the fractionating column.
Water condenses and then drip/trickle to the glass beads/broken glass /porcelain /shelves **lower** in the fractionating column because it is **less volatile.**

(**iv**)The fractionating column is connected to a liebig condenser. The liebig condenser has a cold water inlet and outlet circulation.
The more volatile mixture that reach the top of the fractionating column is condenses by the liebig condenser into a receiver. It is collected as the first fraction.

(**v**)At the top of the fractionating column, a thermometer is placed to note/monitor the temperature of the boiling mixtures .
Pure substances have constant/fixed boiling point. When one mixture is completely separated, the thermometer reading rises.

e.g. The thermometer reading remains at78^oC when ethanol is being separated.
When no more ethanol is being separated, the mercury/alcohol level in the thermometer rises.
(**vi**)The second /subsequent fractions are collected in the receiver after noting a rise the mercury/alcohol level in the thermometer.
e.g.
The thermometer reading rises to 100^oC when water is being separated. It is passed through the liebig condenser with the cold water inlet and outlet circulation. It is collected different receiver as the second/subsequent fraction.

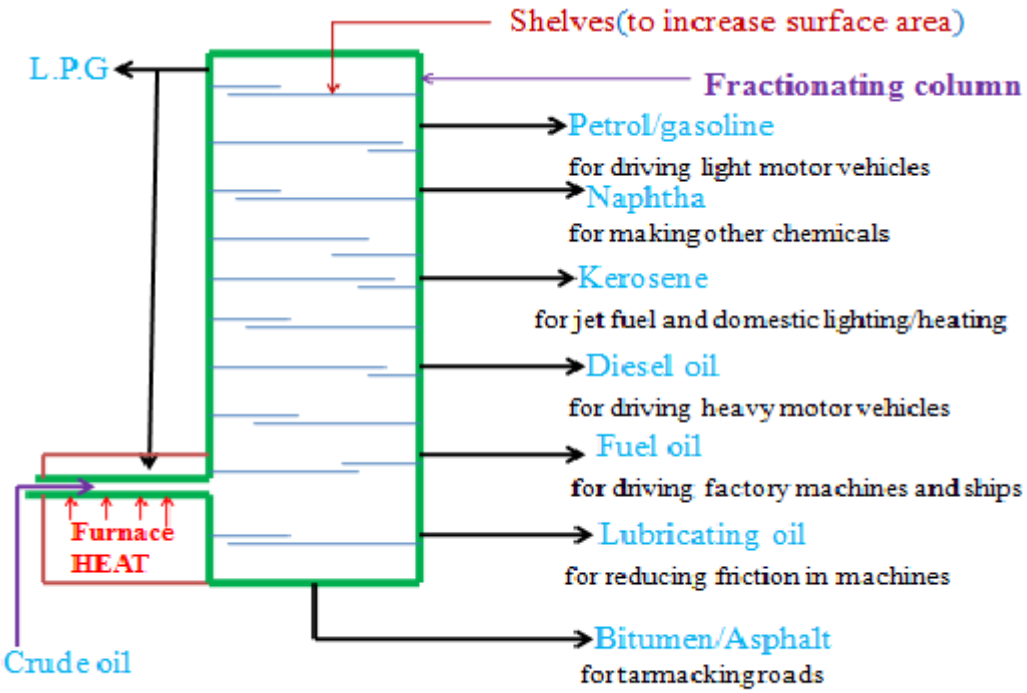
(vii)Each fraction collected should be confirmed from known physical/chemical properties/characteristic.
e.g.
Ethanol
Ethanol is a colourless liquid that has a characteristic smell .When it is put in a watch glass then ignited, it catches fire and burn with a blue flame.
Water
Water is a colourless liquid that has no smell/odour .When it is put in a watch glass then ignited, it does not catch fire.
Set up of apparatus



Fractional Distillation of miscible ethanol/water mixture

Industrial application of Fractional distillation
On a large scale,fractional distillation is used:
(i) In fractional distillation of crude oil in an oil refinery.
Crude oil is a mixture of many fractions. When heated in a furnace, the different fractions separate out according to their boiling point. In Kenya,fractional distillation takes place at Changamwe in Mombasa.
(ii) In fractional distillation of air.

Air contain a mixture of three main useful gases which are condensed by coolin to very low temperature (-200^{o}C) to form a liquid. The liquid is then heated. Nitrogen is the most volatile(-196 ^{o}C) and thus comes out as the first fraction. Argon (at -186 ^{o}C) is the second fraction. Oxygen (at -183 ^{o}C) is the last fraction. The three gases are very useful industrial gases.



Industrial fractional distillation of crude oil in an oil refinery

(f)Separation of immiscibles (Using a separating funnel)

Two or more liquids that form layers on mixing are immiscible. Immiscible mixture arrange themselves according to their densities

i.e The denser liquid sink to the bottom. The less dense liquid floats on the denser one. Immicible mixtures can be separated from each other by using a **separating funnel**.

Experiment: To separate an immiscible mixture of paraffin and water.

Procedure

Place about 100cm3 of water into a 250cm3 beaker. Add about 100cm3 of paraffin into the beaker. Stir.

Transfer the mixture into a separating funnel. Allow to settle for about one minute. Open the tap, run out the lower layer out slowly into a clean beaker. Close the tap when the upper layer is very close to the tap.

Run out the intermediate small amount of the mixture near the tap into a beaker. Discard it.
Run out the remaining upper layer into a fresh beaker.
Place a portion of upper and lower layer into a watch glass separately after separating each. Ignite.

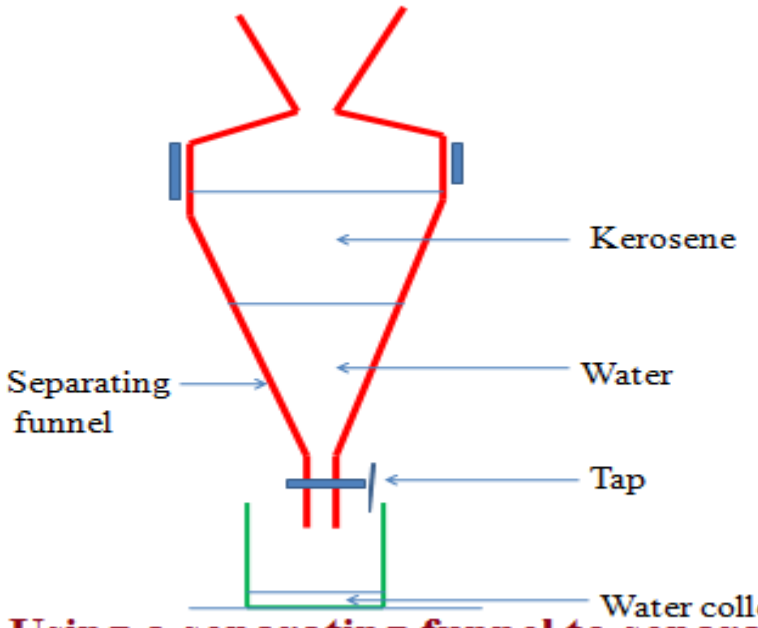
Observation

Water and paraffin are both colourless liquids.
Two layers are formed on mixing.
Colourless odourless liquid collected first. It does not catch fire.
A colourless liquid with characteristic smell collected later/second. It catches fire and burn with a yellow smoky flame.

Explanation

Water and paraffin are immiscible. Water is denser than paraffin. When put in a separating funnel, paraffin float on water. On opening the tap, water runs out. A mixture of water and paraffin at the junction of the two is discarded. It is not pure.

Set up of apparatus

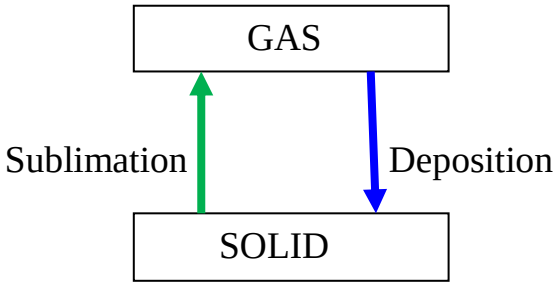


Using a separating funnel to separate a mixture of water/ paraffin

(g)Sublimation/deposition

Some solids on heating do not melt to a liquid but change directly to a gas. The process by which a solid changes to a gas is called **sublimation**. The gas cools

back and changes directly to a solid. The process by which a gas changes to a solid is called **deposition.** Sublimation and deposition therefore are the same but opposite processes.



Some common substances that undergo sublimation/ deposition include:
(i)Iodine (ii)Carbon(IV)oxide (iii)Camphor
(iv) ammonium chloride (v)Iron(III)chloride (vi)Aluminium(III)chloride
(vii) benzoic acid

If a mixture has any of the above as a component, then on heating it will change to a gas and be deposited away from the source of heating.

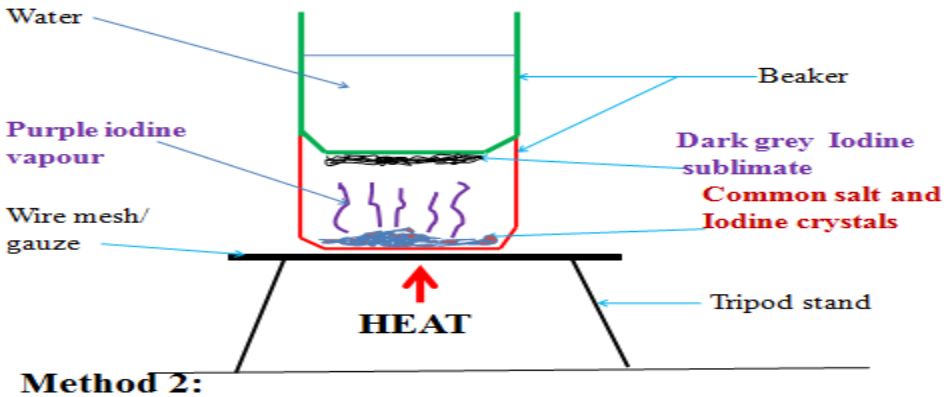
Procedure

Place about one spatula full of ammonium chloride crystals into a clean dry 100cm3 beaker. Add equal amount of sodium chloride crystals into the beaker. Swirl to mix.

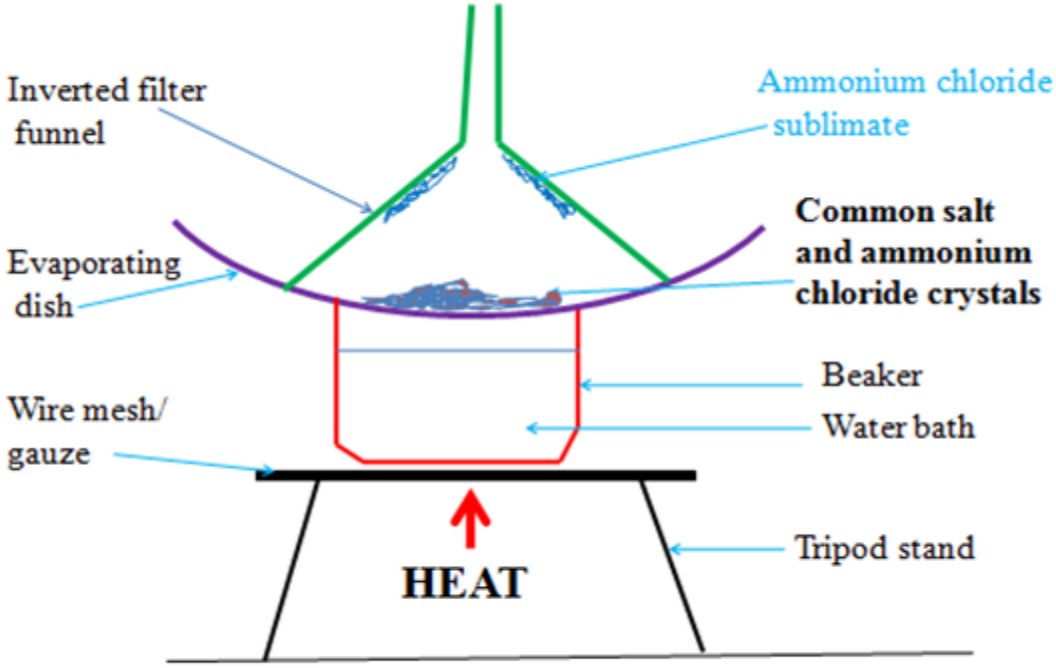
Place the beaker on a tripod stand.

Put about 100cm3 of water into another beaker. Place carefully the beaker containing water on top of the beaker containing the solid mixture. Light/ignite a burner and heat the solid.

Set up of apparatus:



Method 2:
Using sublimation to separate common salt and Iodine crystals



Method 1

Using sublimation to separate common salt and ammonium chloride

Observation

(i)With ammonium chloride/common salt mixture

White fumes produced .
White sublimate deposited
Colourless residue left

(ii)With Iodine/common salt mixture

Purple fumes produced .
Dark grey sublimate deposited
Colourless residue left

Explanation

(i)On heating a mixture of ammonium chloride and common salt, a white fumes of ammonium chloride is produced. The white fumes solidify as white sublimate on the cooler parts. Common salt remains as residue.

Chemical equation:

Ammonium chloride **solid** $\rightleftharpoons$ Ammonium chloride **gas**

$NH_4Cl(s) \rightleftharpoons NH_4Cl(g)$

(ii)On heating a mixture of Iodine and common salt, a purple fumes of Iodine vapour is produced. The purple fumes solidify as dark grey sublimate on the cooler parts. Common salt remains as residue.

Chemical equation:

Iodine **solid** ⇌ Iodine **gas**

I_2(**s**) ⇌ I_2 (**g**)

(h)Chromatography

Chromatography is a method of separating components of a solution mixture by passing it through a medium where the different components move at different rates. The medium through which the solution mixture is passed is called **absorbent material**.

Paper chromatography is a method of separating coloured dyes by using paper as the absorbent material.

Since dyes are insoluble/do not dissolve in water, ethanol and propanone are used as suitable solvents for dissolving the dye.

Practically, a simple paper chromatography involve placing a dye/material on the absorbent material, adding slowly a suitable soluble solvent on the dye/material using a dropper, the solvent spread out on the absorbent material carrying the soluble dye away from the origin.

The spot on which the dye is initially/originally placed is called **baseline**. The farthest point the solvent spread is called **solvent front**.

The farthest a dye can be spread by the solvent depend on:

(i) density of the dye-the denser the dye, the less it spread from the basely ne by the solvent.

(ii) Stickiness of the dye-some dyes sticks on the absorbent material more than other thus do not spread far from baseline.

Experiment: To investigate the colours in ink

Procedure

Method 1

Place a filter paper on a an empty beaker. Put a drop of black/blue ink in the centre of the filter paper. Wait for about one minute for the ink drop to spread. Using a clean teat pipette/dropper add one drop of ethanol/propanone. Wait for about one minute for the ink drop to spread further. Add about twenty other drops of ethanol waiting for about one minute before each addition. Allow the filter paper to dry.

Experiment: To investigate the colours in ink

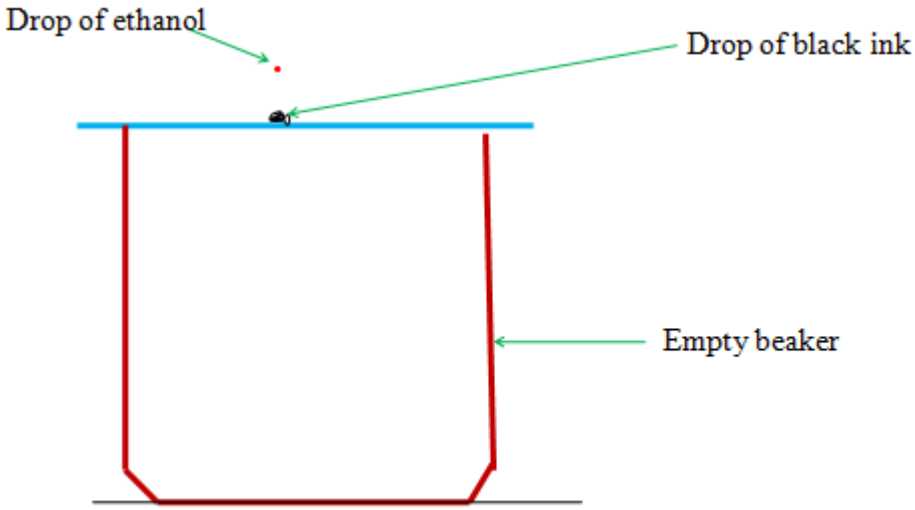
Procedure

Method 2

Cut an 8 centimeter thin strip of a filter paper. At about 3cm on the strip, place a drop of ink. Place the filter paper in a 10cm length boiling tube containing 5cm3 of ethanol. Ensure the cut strip of the filter paper just dips into the ethanol towards the ink mark. Cover the boiling tube. Wait for about twenty minutes. Remove the boiling tube and allow the filter paper to dry.

Set up of apparatus

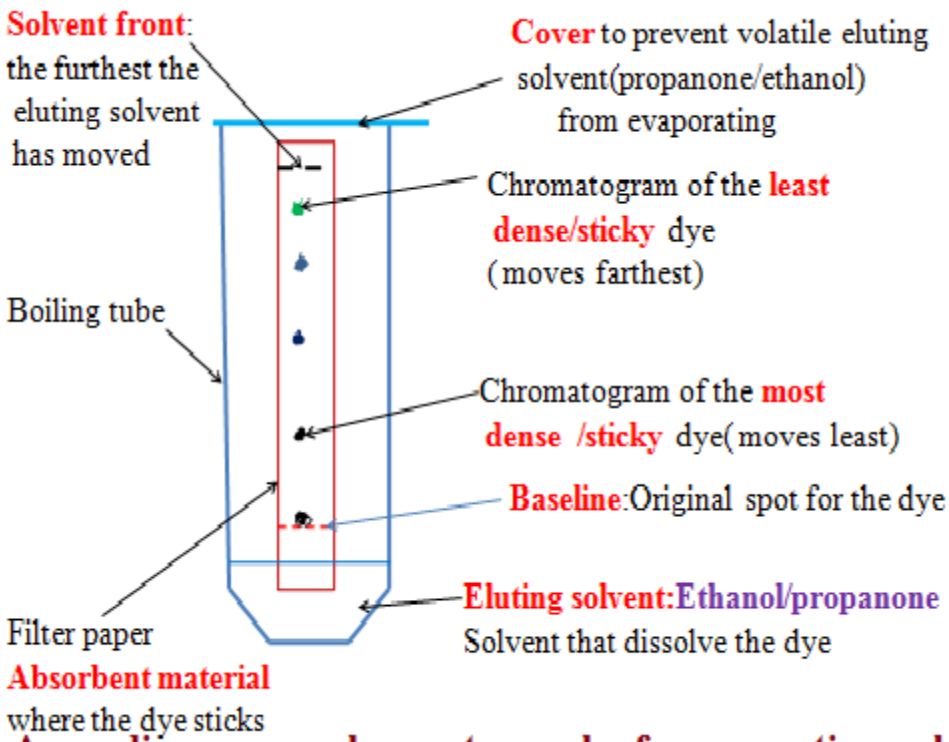
Method 1



Paper chromatography for separating ink dyes

Set up of apparatus

Method 2



Ascending paper chromatography for separating coloured dyes

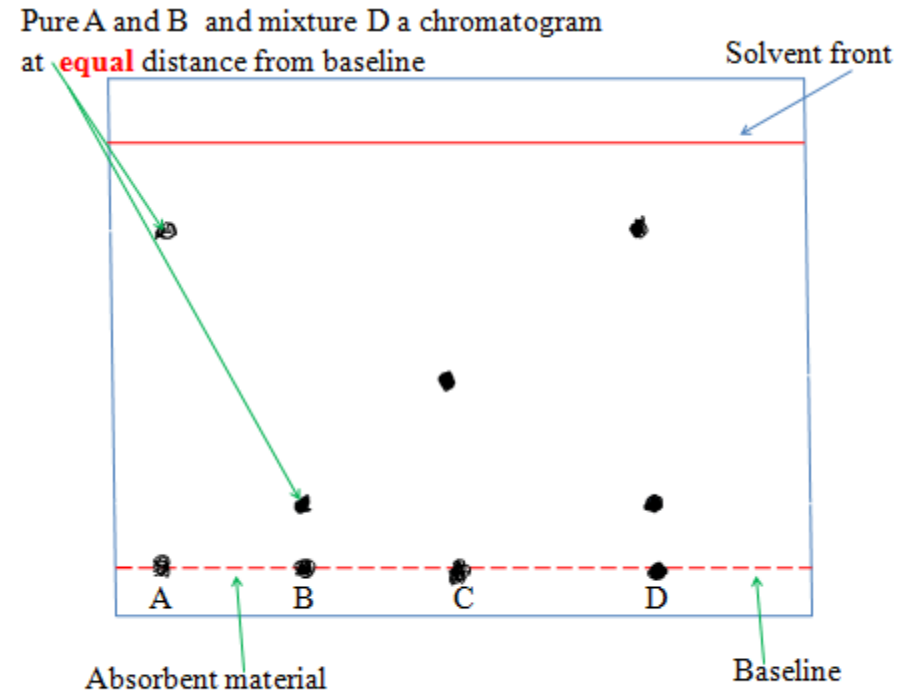
Explanation

When a drop of ink is placed on an absorbent material it sticks. On adding an eluting solvent, it dissolves the dye spread out with it. The denser and sticky pure dye move least. The least dense/sticky pure dye move farthest. A pure dye will produce the same chromatogram/spot if the same eluting solvent is used on the same absorbent material. Comparing the distance moved by a pure dye with a mixture ,the coloured dyes in a mixture can be deduced as below:

Example 1

The chromatogram of pure dyes A, B ,C and a dye mixture D is shown below
Determine the pure dyes present in D. On the diagram show:

(i)the solvent front
(ii)baseline
(iii)the most soluble pure dye



Chromatogram showing pure A,B,C and mixture D

(i) Solvent extraction

Solvent extraction is a method of separating oil from nuts/seeds. Most nuts contain oil. First the nuts are crushed to reduce their size and increase the surface area. A suitable volatile solvent is added. The mixture is filtered. The filtrate solvent is then allowed to crystallize leaving the oil/fat. If a filter paper is rubbed/smeared with the oil/fat, it becomes translucent. This is the test for the presence of oil/fat.

Experiment: To extract oil from Macadamia nut seeds

Procedure

Crush Macadamia nut seeds form the hard outer cover .Place the inner soft seed into a mortar. Crush(add a little sand to assist in crushing).

Add a little propanone and continue crushing. Continue crushing and adding a little propanone until there is more liquid mixture than the solid. Decant/filter. Put the filtrate into an evaporating dish. Vapourize the solvent using solar energy /sunlight. Smear/rub a portion of the residue left after evaporation on a clean dry filter paper.

Observation /Explanation

Propanone dissolve fat/oil in the macadamia nuts. Propanone is more volatile(lower boiling point)than oil/fat. In sunlight/solar energy, propanone evaporate/vapourize leaving oil/fat(has a higher boiling point).Any seed like corn,

wheat , rice, soya bean may be used instead of macadamia seed. When oil/fat is rubbed/ smeared on an opaque paper, it becomes translucent.

(j) Crystallization

Crystallization is the process of using solubility of a solute/solid to obtain the solute/solid crystals from a saturated solution by cooling or heating the solution.
A crystal is the smallest regular shaped particle of a solute. Every solute has unique shape of its crystals.
Some solutions form crystals when heated. This is because less solute dissolve at higher temperature. Some other solutions form crystals when cooled. This is because less solute dissolve at lower temperature.

Experiment; To crystallize copper(II)sulphate(VI)solution

Procedure:

Place about one spatula full of hydrated copper sulphate(VI) crystals into 200cm3 of distilled water in a beaker. Stir. Continue adding a little more of the hydrated copper sulphate (VI) crystals and stirring until no more dissolve. Decant/filter. Cover the filtrate with a filter paper. Pierce and make small holes on the filter paper cover. Preserve the experiment for about seven days.

Observation/Explanation

Large blue crystals formed
When hydrated copper(II)sulphate crystals are placed in water, they dissolve to form copper(II)sulphate solution. After some days water slowly evaporate leaving large crystals of copper(II)sulphate. If the mixture is heated to dryness, small crystals are formed.

Physical/Temporary and Chemical changes

A physical/temporary change is one which **no new** substance is formed and is **reversible** back to original.
A chemical/permanent change is one which **a new** substance is formed and is **irreversible** back to original.

The following experiments illustrates physical and chemical changes

(a)Heating ice

Place about 10g of pure ice in a beaker. Determine its temperature.Record it at time “0.0” in the table below. Heat the ice on a strong Bunsen flame and determine its temperature after every 60seconds/1minute to complete the table below:

Time/minutes	0	1	2	3	4	5	6	7	8
Temperature (^oC)	-2	0	0	40	80	90	95	95	96

Plot a graph of time against Temperature(y-axes)
Explain the shape of your graph
Melting/freezing/fusion/solidification and **boiling /vaporization /evaporation** are the two physical processes.
Melting /freezing point of pure substances is fixed /constant.
The boiling point of pure substance depend on **external** atmospheric **pressure**.
Melting/fusion is the physical change of a **solid** to **liquid**.
Freezing is the physical change of a **liquid** to **solid**.
Melting/freezing/fusion/solidification are therefore two **opposite** but **same** reversible physical processes i.e

A (**s**) A(**l**)

Boiling/vaporization/evaporation is the physical change of a **liquid** to **gas**.
Condensation/ liquidification is the physical change of **gas** to **liquid**.
Boiling/vaporization/evaporation and condensation/ liquidification are therefore two **opposite** but **same** reversible physical processes i.e

B (**l**) B(**g**)

Practically
(i) Melting/liquidification/fusion involves **heating** a solid to **weaken** the strong bonds holding the solid particles together.
Solids are made up of very strong bonds holding the particles **very close** to each other (**Kinetic Theory of matter**).
On heating these particles gain energy/heat from the surrounding heat source to form a liquid with **weaker** bonds holding the particles close together but with some degree of **freedom**.
(ii)Freezing/fusion/solidification involves cooling a liquid to reform /rejoin the very strong bonds to hold the particles **very close** to each other as solid and thus lose their degree of **freedom** (**Kinetic Theory of matter**).
Freezing /fusion / solidification is an **exothermic** ($-\Delta H$)process that require particles holding the liquid together to lose energy to the surrounding.
(iii)Boiling/vaporization/evaporation involves **heating** a liquid to completely **break/free** the bonds holding the liquid particles together.
Gaseous particles have high degree of **freedom** (**Kinetic Theory of matter**).
Boiling /vaporization / evaporation is an **endothermic** ($+\Delta H$) process that require/absorb energy from the surrounding.

(iv)Condensation/liquidification is **reverse** process of boiling /vaporization / evaporation.
It involves gaseous particles losing energy to the surrounding to form a liquid.

**********END**********

The other documents available on this website include;

- All secondary school schemes of work.
- Form 1-form 4 revision papers in all subjects.
- Marking schemes to most of the revision papers.
- K.C.S.E past papers.
- University past papers.
- K.A.S.N.E.B past papers e.g. C.P.A
- Primary school schemes of work.
- Primary school revision papers to all classes.
- Marking schemes to primary school past papers.
- K.C.P.E past papers.