CHAPTER 1: DIVERSITY OF MATTER

1.1.0 INTRODUCTION TO INTEGRATED SCIENCE

Science is a body of systematized knowledge that helps us to comprehend, explain phenomena, predict and control nature.

Science can be broadly grouped into two branches. These are:

1. **Pure Science** 2. **Applied Science**

Main Branches	**Sub - Branches**
Chemistry	Organic, Inorganic, Physical
Biology	Botany, Zoology, Microbiology
Physics	Atomic, heat, light, Sound, Electricity and Magnetism

Table 1.1.1

The knowledge uncovered by the study of the pure sciences is then applied to the way we live e.g. pure chemistry deals with chemicals and their reactions in nature and applied chemistry links these reactions to useful fields such as agriculture, medicine, pharmacy, engineering, food science, industry etc.

CAREERS IN SCIENCE AND TECHNOLOGY

(I) Pharmacist : CHEMISTRY

Biology - effects of chemicals on the body

Maths - calculation of quantities and concentrations

(II) Civil Engineer : PHYSICS

Maths - to calculate areas, stress of materials etc.

Chemistry - how certain materials will react together.

(III) Nurse : BIOLOGY

Chemistry - understanding how drugs work

Physics - the accurate use of machines and instruments

Maths - the dosage of medicine

(IV) Astronaut : PHYSICS

Maths - distance, time, energy calculations

Chemistry - chemistry of rocket fuels, chemistry on the body

Biology - how the body functions in space

Science therefore, is an integrated subject which relies on more than one of the pure sciences to make it relevant to our daily lives.

TECHNOLOGY

Technology is not only the application of sciences but also the ability to

- read and write about technological practices
- be aware and recognize technological developments
- use technological knowledge to solve everyday problems.

IMPORTANCE OF SCIENCE

1. Science educates us about things concerning us and the world as a whole.
2. Science offers reliable knowledge that can be used as basis to cure diseases, communicate across the world, make our homes more comfortable, and produce more and better crops and many other things.
3. Science helps us to solve some problems.

1.1.1 THE SCIENTIFIC METHOD

This is a method of collecting information and forming ideas which must be systematic and reliable. There are several important steps in the scientific method. These are:

Identification of problem: - decide exactly what you want to do after careful examination (e.g. eradicating the anopheles mosquito).

State the aim: - the main reason for your investigation (e.g. the anopheles mosquito causes malaria which is killing the populace).

Data collection: - find out all you can about the problem and decide on what to do, use and measure, how to go about it. (E.g. male mosquitoes breed in greens they are vegetarians, others also breed in stagnant waters, ponds, poodles, lorry tyres, empty cans, filthy places, gutters etc. The use of hoes, cutlasses, rakes, oil, and insecticide mosquito nets etc)

Formulate hypothesis: - this is the statement which you will aim to prove or disprove by your investigation (e.g. keeping the environment clean can eradicate mosquitoes)

Experimentation: - carry out practical work to find out the solution(s) to the problem (e.g. clearing the environment of filth, weeding, spraying breeding places with insecticides, covering barrels of water, cover beds with mosquito nets etc.)

Recording and analysis of data: - use of tables, charts and graphs to interpret your results and draw conclusions.

Further experiments: - carry out further experiments to check and test for unexpected outcomes (e.g. further experiments on mosquito nets and insecticide sprays).

Evaluation: - look critically at all aspects of your investigation and make suggestions for improvement (e.g. keeping the environment free from weeds can curb the breeding of mosquitoes, however grass grows so quickly thus, mosquito

nets which have been treated with insecticide can be used side by side in addition to insecticide sprays.

The quest for knowledge and curiosity are necessary to arrive at the truth, facts and solutions to problems.

Discoveries have been made by many great scientists using the scientific method. In 1926 for instance, **Alexander Fleming** observed and examined the bacteria Staphylococcus. Then one day he noticed a mass of fluffy mould growing on the cultures, which became dark green after sometime. He called it Penicillium notatum. Five days later he noticed that it secreted a substance which penetrated the culture medium. A clear zone was found with no staphylococci around regions where the mould grew. This meant that Penicillium could have produced a substance that fights bacterial growth.

This theory was not accepted till after the Second World War when **Howard Florey** read Flemings work and conducted further experiments.

In 1896, **Henri Becquerel** investigated the action of bright sunlight and uranium salt on photographic plates. The plates were securely wrapped and placed near the uranium compounds yet became fogged. This suggested that, uranium spontaneously emitted some rays known as Becquerel rays. Later on Roentgen and Curies conducted further investigations, modified it, and then came out with the fact that uranium gives off particles spontaneously and this was known as radioactivity.

Archimedes (287 – 212 B.C) made a discovery. The then King of Sicily tasked a goldsmith to make a crown from a piece of pure gold. There were doubts upon completion although it had the same weight as the original piece of gold. Archimedes was to find out why without damaging the crown. (He stumbled upon the solution whiles taking his bath). He took the crown and a piece of pure gold having the same weight as the crown and immersed each in turn in a trough

full of water. He found out that the crown displaced more water than the piece of gold. This means that, the crown had a greater volume than the piece of gold although they had the same weight.

This showed that the density of the crown was less than that of pure gold thus, proving that the crown was not made of pure gold. Archimedes continued his work in this field and put forward his principle which states: "*The upthrust on an object immersed in a liquid is equal to the weight of the liquid it displaces*.

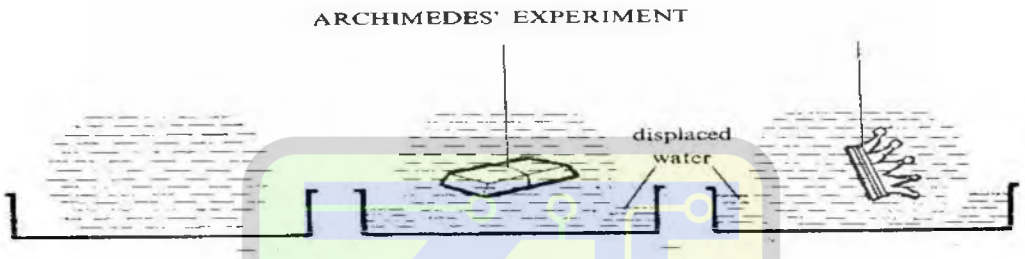


Fig 1.1.1 Archimedes' experiment

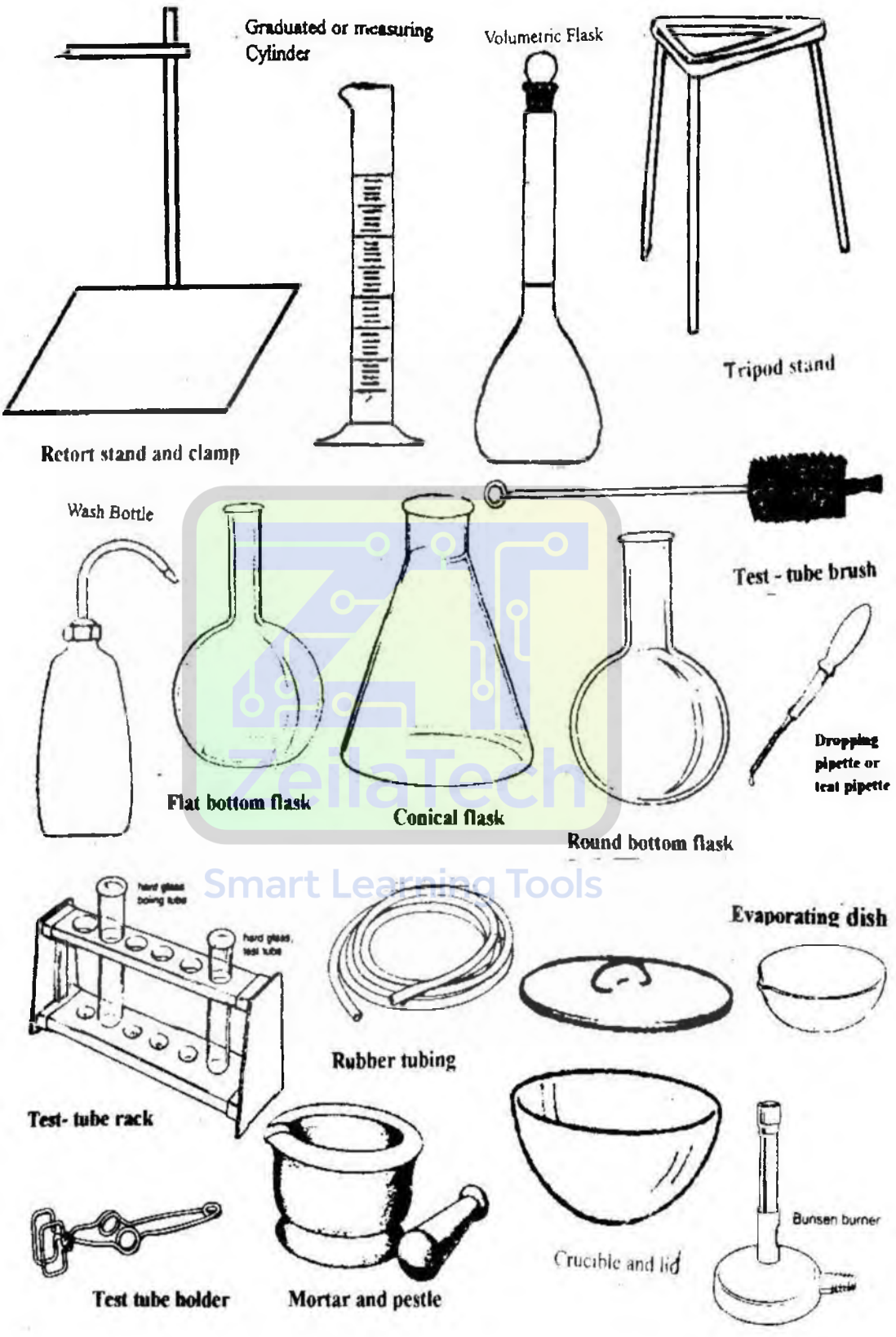
*"There is a common problem of flooding in your community, Outline the scientific methods you would follow to arrive at a solution to this problem"

1.1.2 SAFETY PRECAUTIONS IN THE LABORATORY

2. Do not chew food substances in the laboratory because the hands, counters and glassware may contain substances that can contaminate food.
3. Do not eat in the laboratory because some chemicals in the lab might be poisonous or emit radiations which contaminate the food being eaten.
4. Do not wash hands with an unknown colourless liquid in a beaker because a liquid may (appear colourless but may) be a dangerous

chemical/toxic/corrosive/injurious/poisonous and could cause serious burns.

5. Do not open a gas tap before looking for a match to light the Bunsen burner because such practices causes fire outbreaks.
6. Do not drop large pieces of sodium metal into water because this practice will cause a violent reaction and explosions
7. In mixing a strong acid with water do not pour water into acid but rather pour the acid gently and slowly into the water. Allow the mixture to cool.
8. Avoid spillage and skin/cloth contact because the liquid might be corrosive.
9. Wear protective clothing and do not walk barefooted in the laboratory because one is exposed to the risk of stepping on splashed chemical/ a fallen pin/ pointed object or a piece of broken glass.
10. Avoid smelling directly the gas evolved from a chemical reaction because it might be injurious or poisonous to one's health when inhaled directly.
11. When boiling a substance in alcohol do not use naked flame to avoid fire, pour alcohol into a suitable container, put the substance into the alcohol and place the container containing alcohol in a water bath.
12. Plastic gloves on the hands can be worn to offset heat. Others include goggles, aprons, gas masks etc.
13. Close all taps before leaving the laboratory. The laboratory will be filled with flammable gas if the taps are left on overnight or a period of time.



Some Laboratory Equipment

SAFETY SYMBOLS

These are signs that may be fixed to doors, benches, tables, cupboards and other spots to give information to those around the vicinity. However these signs are subject to regulations which may differ from those requiring hazard warning symbols on equipment or bottles, although in some cases the same basic symbol may be used. Such safety symbols include the following:

Warning Signs:

These are enclosed in a triangle and are on a yellow background. They usually give warnings of a hazard. Examples are given below:

Toxic

Flammable

Electrical hazard

Explosive

Irritant/harmful

Containers of Hazardous Chemical:

These normally bear a hazard warning symbol and certain approved risk phrase. For vehicles the symbol is contained within a square.

Toxic chemical Corrosive materials Highly flammable Oxidizing

Prohibitory Signs:

These signs indicate behaviour which is disallowed. Examples include:



No open flames Non portable water No smoking

Others:

Mandatory signs show the specific action to be taken e.g. an eye protection must be worn. The eye wash sign and first aid signs are examples of safe conditions sign.

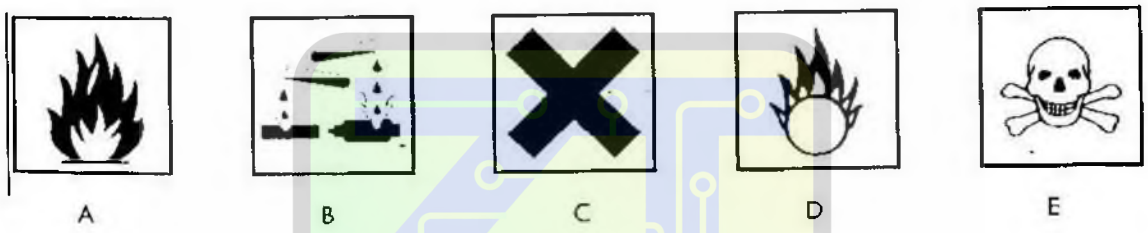



First aid Eyewash sign Eye protection sign Fire Extinguisher sign Radioactive sign Biohazard sign

Item	Examples and Essential Features
Biohazards	Biohazard materials represent a threat to the body of a living organism.
Corrosive substances	These also indicate hazards to human skin. Concentrated acids and alkali are usually corrosive e.g. are H_2SO_4, HCl, NaOH etc.
Irritant/ harmful materials	Examples include ethanol, bleaching powder and calcium Oxide.
Explosive materials	Examples are gun powder, a mixture of oxygen and hydrogen

Oxidizing materials	Examples include potassium permanganate and hydrogen peroxide
Toxic or poisonous chemicals	Examples include mercury, potassium cyanide, and lead ethanoate
Flammable materials	These materials catch fire readily. Examples include butanol, petrol, ethanol, diesel, ether
Radioactive materials	Examples are alpha, beta and gamma.

Study the diagram carefully



a. Identify each symbol.

b. Give an example of chemical or substance represented by each of the safety symbol.

1.2. MEASUREMENTS

In the olden days, the length of the King of England's foot was adopted as the unit, *foot*, his arm's length as the *yard*, and the first segment of his thumb as the *inch*, all these are now established as the **Imperial System** of measurement.

The decimal system of units was adopted in 1791; this was devised by a committee of the French Academy. **The Metric system** was devised by the British who selected the gram and centimeter as the basic units of mass and length.

In 1960, the world scientific community agreed to adopt the **SI unit** (Systemè International d'unites). Seven independent quantities were identified and given units to form the basis of the system. These are:

QUANTITY	BASIC UNIT	SYMBOL
Mass	kilogram	kg

Length	metre	m
Time	second	s
Temperature	kelvin	K
Electric current	ampere	A
Luminous intensity	candela	cd
Amount of substance	mole	mol

Table 1.2.1

Many other units in the system are made up from multiples and combinations of the basic units. Some of these units would have had long complicated names if expressed in the basic unit only. Many have also been given special names of scientists connected with that field of study. Examples of derived units are represented as follows:

Table 1.2.2

QUANTITY	SI UNIT	SYMBOL
Force	newton	$N - kgms^{-2}$
Work & Energy	joule	J - Nm
Quantity of electricity	coulomb	C - As
Power	watt	$W - Js^{-1}$
Electric potential	volt	$V - WA^{-1}$
Electric resistance	Ohm	$\Omega - VA^{-1}$

For convenience sake numbers in SI units are often written to a power of 10 to indicate multiples of the unit. Examples are represented below:

Table 1.2.3

Decimal multiples and Sub – multiples

PREFIX	SYMBOL	MULTIPLE
tera	T	10^{12}

giga	G	10^9
mega	M	10^6
kilo	K	10^3
hecto	h	10^2
deca	da	10
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}
femto	f	10^{-15}
alto	a	10^{-18}

Measuring quantities accurately teaches us some values such as honesty, integrity truthfulness, consistency etc.

1.2.1 DENSITY AND RELATIVE DENSITY

Density of a substance is defined as its mass per unit volume,
i.e. p= m/v. Its unit = kg/m^3.

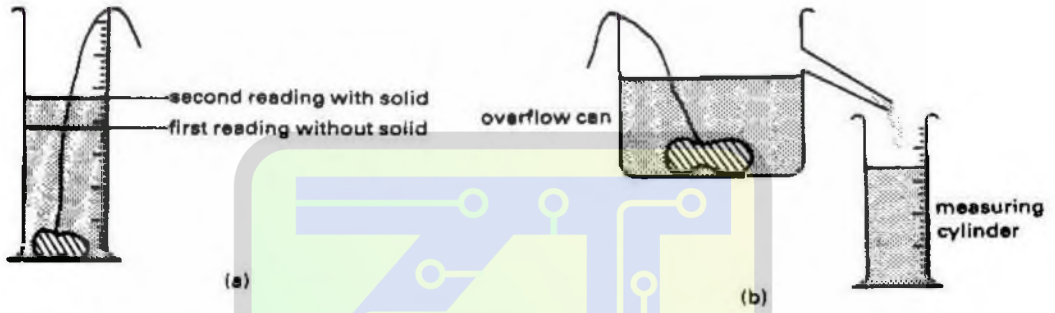
Determination of density of water:

1. Weigh a dry empty beaker (M).
2. Pour water into the beaker and weigh (M_1).
3. Pour a convenient volume of water into a beaker using a pipette or burette (V).
4. Subtract M from M_1 to get the mass of water.
5. Divide the mass by the volume to get the density of water.

Determination of the density of an irregular solid e.g. stone

- The stone is weighed on a beam balance and its mass is recorded as (M).

- A measuring cylinder is partly filled with water and the initial level is recorded as (V_1)
- A string is tied to the stone and lowered gently until it is completely immersed in the water and the new level is recorded as (V_2)
- The volume of the stone is determined as $V_2 - V_1$
- The density of the stone is thus, $\frac{\text{Mass of stone}}{\text{Volume of stone}} = \frac{M}{V} = \frac{M}{V_2 - V_1}$



(b) Is an alternative method using the Eureka can.

Finding volume by displacement

2001 Nov Question

I. A salt solution is made by dissolving 50g of the salt in 250cm^3 of water. Calculate the density of the solution in kgm^{-3}.

Mass (m) 50g + 250 = 300g $\rightarrow$ 0.3kg

Volume (v) 250cm^3 $\rightarrow$ 0.00025m^3 [10^{-2}cm] ^{m3} = [10^{-6}]

Density = Mass/Volume

= 0.3kg/0.00025

= 1200kgm^{-3}

The **relative density** of a substance is the density/mass of the substance compared with the density of water or the mass of equal volume of water. The formula could be represented as follows:

Relative Density = $\frac{\text{Density of substance}}{\text{Density of water}}$ or $\frac{\text{Mass of substance}}{\text{Mass of equal volume of water}}$

The relative density bottle:

This bottle has a glass stopper which has a fine hole through it. The purpose of this stopper is to enable the bottle to be filled with exactly the same volume of liquid every time. The excess liquid escapes through the hole.

Determination of relative density

1. Weigh the relative density bottle empty (M)
2. Weigh the R.D bottle full of salt solution (M_1)
3. Empty the bottle, dry it and refill with water and weigh again (M_2)

Results:

Mass of empty bottle = M

Mass of bottle full of salt solution = M_1

Mass of bottle full of water = M_2

Mass of salt solution = $M_1 - M$

Mass of water = $M_2 - M$

$$\text{Relative Density of salt solution} = \frac{\text{Mass of salt solution}}{\text{Mass of equal volume of water}} = \frac{M_1 - M}{M_2 - M}$$

Again relative density can be determined using Archimedes' Principle which states that: "*The upthrust on an object immersed in a liquid is equal to the weight of the liquid it displaces*".

An object experiences an upward force when it is immersed in a liquid. This force is due to the pressure exerted on it by the liquid. This upward force is what is referred to as the *upthrust* on the object.

If a piece of solid is immersed in water, it will displace its own volume of water. The upthrust is thus, the weight of its own volume of water (*apparent weight*).

Weight of body in air (Real weight) = W_0

Weight of the body in water (Apparent weight) = W_1

Weight of water displaced = apparent loss in weight

$=W_0–W_1$ (By Archimedes Principle)

∴ Apparent loss in weight of body = Natural weight – Apparent weight

This shows that the apparent loss in weight of the body or the upthrust on it should be equal to the weight of water displaced, thus verifying Archimedes principle.

Worked example:

In determining the relative density of a piece of stone, it is first weighed in air, and then water as illustrated in fig 1.5 below.

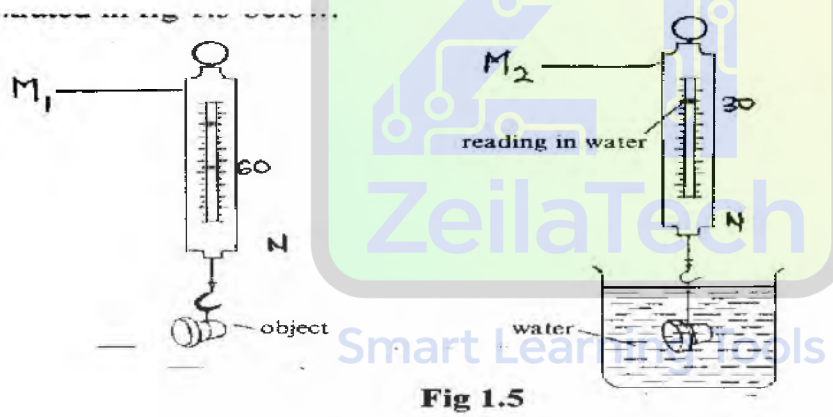


Fig 1.5

(a) Read and record:

I. The mass, m_1, of the stone in air. **60N**

II. The mass, m_2, of the stone in water. **30N**

(b) Calculate the:

I. Apparent loss of weight of the stone in water. **60 – 30 = 30N**

II. Relative density of stone, using the relation,

$$\text{R.D.} = \frac{m_1}{m_1 - m_2} = \frac{60}{60 - 30} = \frac{60}{30} = 2.0$$

(c) Explain the apparent loss of weight of the stone.

Explanation: When a body is immersed in a fluid it experiences an upthrust/upward force which reduces its weight measured in the fluid.

Table 1.2.4 Differences between density and relative density

DENSITY	RELATIVE DENSITY
It has units kgm^{-3}	It has no units.
It is a measured quantity.	It is a comparison between two measured quantities.
It involves masses and volumes of substances.	It involves the mass of a substance and that of water.

<u>The principle of floatation</u>

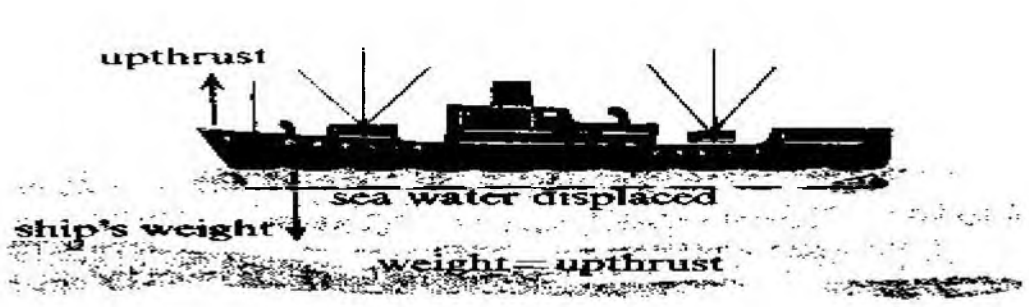
A floating body displaces its own weight of fluid in which it floats.

If the density of an object is less than that of a liquid, it will float when placed in that liquid.

Again an object will float in a liquid if the upthrust is equal to the weight of the liquid displaced. OR

An object will float in water if that object can displace enough water such that the weight of water displaced equals that of the object.

<u>The ship</u> is made with material (iron & steel) which is eight times denser than water yet it floats in water because of its hollow structure which enables it to displace a large volume of water. The weight of the volume of water displaced then equals the weight of the ship, hence it floats. fo



The weight of sea water displaced by the ship must be equal to the weight of the ship.

A ship

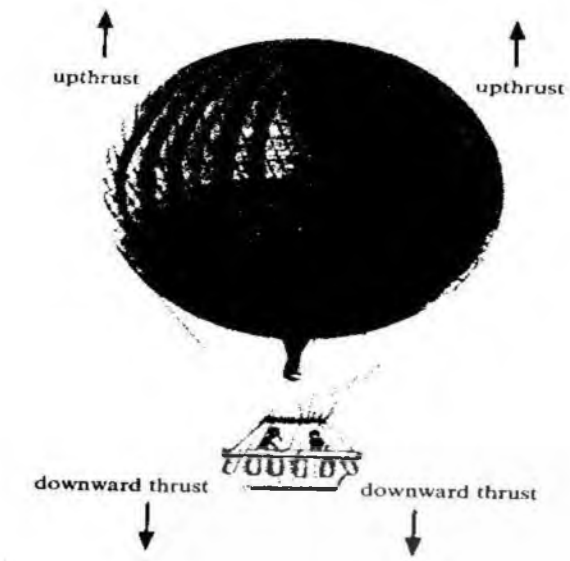
The submarine:

- Initially a submarine floats on the sea as its weight is supported by the upthrust from the water
- the upthrust is equal to the weight of the submarine
- the submarine takes in water which increases its weight
- the submarine sinks when its weight becomes greater than the upthrust
- the submarine rises to the surface when water is pumped out of it and its weight decreases.

Balloons: Helium and hydrogen are gases used to fill balloons because their densities are lesser than that of air. A balloon if filled with one of such a gas whose density is less than that of air. The weight of the volume of air displaced by the balloon is greater than the weight of the balloon. The upthrust is then equal to its weight. A balloon filled with air from our breath (cold air) does not rise up because cold air is denser than that of hot air.

The upthrust on the balloon will be lesser than the weight of the balloon, it will not rise.

'The weight of air displaced by the balloon must be equal to the weight of the balloon'.



A balloon

MEASURING INSTRUMENTS

1. Quantity: Length

(i) Ruler, metre rule or surveyor's tape: are used to measure lengths and the measurement is accurate to the nearest 0.5mm.

(ii) Vernier Calipers: are used to measure short distances between two points to the precision of 0.1mm.

(iii) Inside Calipers: are used to measure the internal diameter of circular objects

(iv) Outside Calipers: are used to make external measurements.

(v) Micrometer screw gauge: is used to measure extremely short distances such as the diameter of a wire or the thickness of a sheet of metal to the precision of 0.01mm.

2. Spherometer: to measure the curvature of a spherical surface.

3. Opisometer: to measure curved lines.

4. Pipette: used by chemists to measure the pre-determined volume of a liquid.

5. Measuring Cylinders: to measure the volumes of liquids

6. Watches and clocks: to measure time

7. Barometer: to measure atmospheric pressure.

8. Voltmeter: to measure electric potential.

9. Ammeter: to measure electric current.

10. Photometer: to measure luminous intensity

11. Balances: to measure mass

12. Hydrometers: used to measure the density of acids, alcohol and other liquids. By measuring the density of acid in the car battery, hydrometers can show whether a car battery is charged.

Hydrometer is a weighted bulb with long marked stem. The weight keeps the hydrometer erect and it sinks to the mark on the stem, showing the density of the liquid.

Using the hydrometer to determine the density of liquid:

→ Lower the hydrometer gradually into the liquid and leave it in.

→ Read the value on the hydrometer

→ The reading is the relative density of the liquid

→ The density of the liquid is obtained by multiplying the relative density by the density of water ($1gcm^{-3}$)

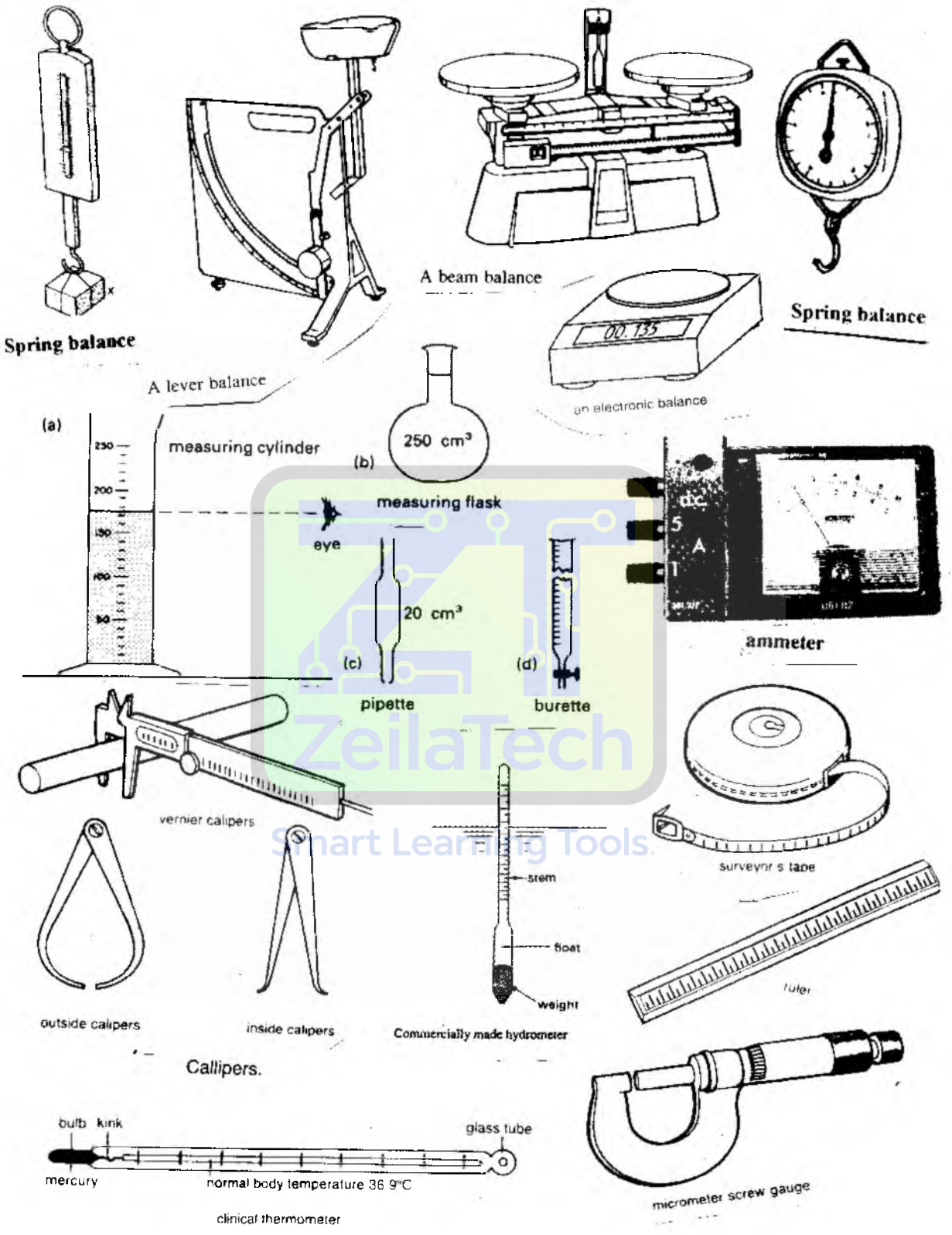


Fig 1.7 Examples of some measuring instrument

1.3 DIVERSITY OF LIVING AND NON LIVING THINGS

Diversity means a wide range of differences that a scientist can see when looking at a large number of different organisms.

There are some basic life processes that unite all living organisms. These life processes distinguish living things from non – living things. They are as follows:

Locomotion: this is the change in position of the whole body or part of the body.

Nutrition: it is the taking in or manufacturing food in order to carry out other life processes.

Irritability: is the response to changes in the surroundings or to stimuli.

Growth: is the irreversible increase in size and weight.

Reproduction: is the ability to make more of the same kind.

Excretion: is the removal of toxic waste metabolic products from the body.

Respiration: release of energy from food with or without the use of oxygen.

***Classification*:** is the grouping of things or the sorting out of things into groups according to their common characteristics.

History of classification $\Rightarrow$ this involved two persons they were:

Aristotle (early classification) and Linnaeus (binomial system)

Aristotle (384 – 322BC); a Greek biologist produced the first classification of living things. He classified animals by looking at the way they moved. He thus put together animals that can fly, run or swim.

The only thing they have in common is movement.

He again used appearance and size in classifying plants. He grouped plants as herbs, shrubs or trees.

Herbs are short, delicate plants, the stems of which rarely become woody. The shoot system dies off at the end of a growing season e.g. of annuals include maize, yam, garden eggs; perennials include canna lily, ginger, Crotalaria.

Shrubs grow larger than herbs and often form woody tissues e.g. Hibiscus and Allamanda.

Trees are large, woody plants which grow much taller than shrubs and produce much thicker stems or trunks e.g. Flamboyant.

Carolus Linnaeus (1707 – 1778) a Swedish naturalist based his classification on natural relationships. He called a group of organisms capable of reproducing 'species'. His system of classification is still in use today and it is called the natural system of classification because it puts all organisms with the same structure together. He brought about the binomial system. The binomial system is a system of nomenclature in which every organism is given a two – part Latin name. The first part is the Genus to which all organisms belong and always begins with a capital letter. The second part is the species to which the organisms belong and this always begins with a small letter.

E.g.	Genus	Species	Common name
	Homo	sapien	man
	Zea	mays	maize

Classification schemes:

(I) Living things ⇒ The various schemes as listed in increasing order of similarities in features, as one goes down the list according to Linnaeus system of classification are: -

Kingdom → Phylum → Class → Order → Family → Genus → Species

(II) Non – living things ⇒ the schemes are metals and non- metals.

Importance of Classification:

1. Allows biologists to identify and follow similarities and differences in organisms.
2. Allows any one group to be described using one or a few words.

3. Allows new organisms to be identified and classified
4. Forms a new common pool of knowledge that allows easy communication between all biologists.

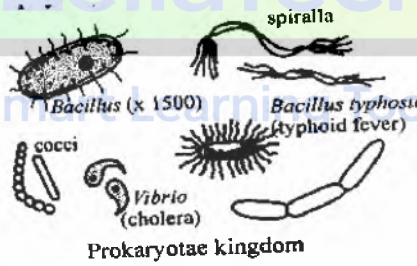
The **Linnaeus system** of classification for living organisms are: Kingdom, Phylum, Class, Order, Family, Genus, Species.

Kingdom is divided into 5 main groups.

- Kingdom Prokaryotea / Monera
- Kingdom Protoctista
- Kingdom Fungi
- Kingdom Plantae
- Kingdom Animalia

Kingdom Prokaryotae / Monera (bacteria)

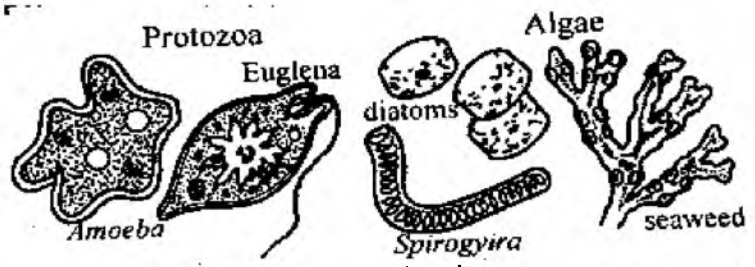
- Most are microscopic, about one micrometer (μm) in diameter.
- They have no nucleus and no membrane – bound organelles.
- The cytoplasm is surrounded by a cell wall.
- Many posses' flagella which help them to move e.g. are Escherichia coli, vibrio (cholera), Bacillus typhus's (typhoid fever), Treponema (syphilis)



Prokaryotae kingdom

Kingdom Protoctista (protozoa and algae)

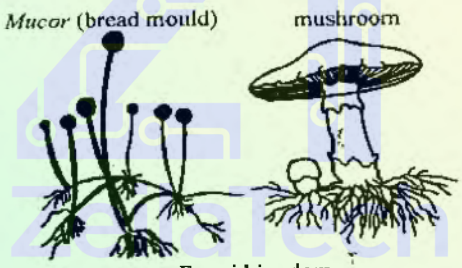
- These are often unicellular.
- They are eukaryotic (posses a membrane – bound nucleus) e.g. Include Amoeba, Trypanosome, Euglena, Plasmodium, Algae, Spirogyra, and Seaweed etc.



Protoctista kingdom

Kingdom Fungi (fungi)

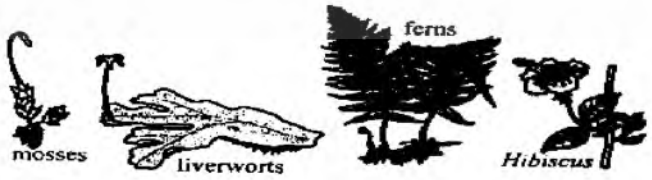
- All are eukaryotic and multicellular
- They have no roots, stems, or leaves
- They are not photosynthetic
- The vegetative body is called mycelium
- They have no cellulose cell wall
- Their mode of nutrition is parasitic e.g. Rhizopus (mould), Agaricus (mushroom).



Fungi kingdom

Kingdom Plantae (plants)

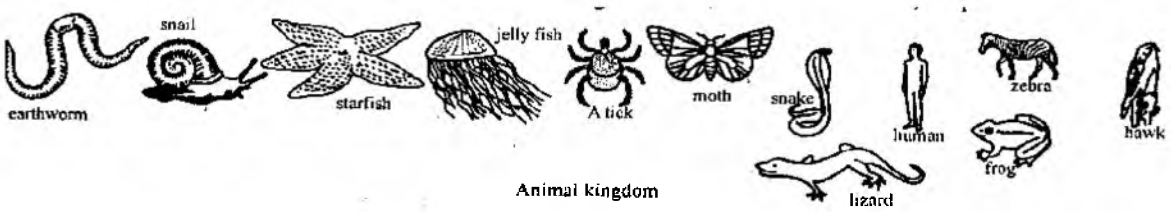
- All are multicellular, eukaryotic and photosynthetic.
- They have cellulose cell wall e.g. mosses, liverworts, ferns, maize, and pine tree etc.



Plantae Kingdom

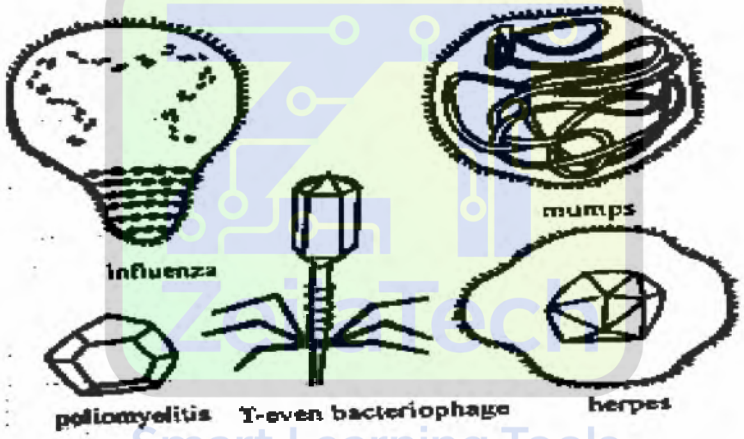
Kingdom Animalia (animals)

- All are multicellular, eukaryotic and non – photosynthetic.
- Almost all are capable of locomotion
- They possess nerve tissue for co – ordination e.g. liver fluke, grasshopper, Tilapia, frog, lizard, leopard, man etc.



Viruses

- They are called particles, basically made up of proteins and either DNA or RNA.
- They do not posses a nucleus, cytoplasm or cell membrane.
- They can reproduce only in a living cell.
- They have a variety of shapes e.g. rods, spirals, spheres and hexagons.
- All known viruses cause diseases e.g. sore throat, yellow fever, poliomyelitis, foot and mouth disease in cattle, herpes, AIDS etc.



Types of viruses

Non – Living Things

Elements: metals and non-metals

In 1860, Dimitri Mendeleev, a Russian scientist classified elements by predicting that some of the families of elements contained elements yet to be discovered. His system of classification is the periodic classification.

He discovered that the properties of the elements changed gradually as their atomic number increased.

He frequently came across an element that showed similar properties to an earlier one.

With these two discoveries he arranged elements in order of increasing atomic number or the number of electrons in an atom of each element, so that those with similar properties came under one another in a vertical column.
Below are the first eighteen elements on the periodic table arranged into groups of metals, semi metals and non metals.

Metals	**Semi metals**	**Non metals**
Lithium (Li)	Boron (B)	Hydrogen (H)
Beryllium (Be)	Silicon (Si)	Helium (He)
Sodium (Na)	*Beyond 1st 18*	Carbon (C)
Magnesium (Mg)	*Germanium (Ge)*	Nitrogen (N)
Aluminium (Al)	*Arsenic (As)*	Oxygen (O)
	Antimony (Sb)	Fluorine (F)
	Tellurium (Te)	Neon (Ne)
	Astatine (At)	Phosphorus (P)
		Sulphur (S)
		Chlorine (Cl)
		Argon (Ar)

Living Societies:

The basic unit of any social group is the family. It is a nuclear family when it consists of a husband, a wife and children.

Another type of family is the extended family which consists of a larger number of people. An extended family may be a clan.

A clan is a number of families all of whom claim to have descended from a common ancestor.

Ethnic group is a collection of clans. Members of an ethnic group have one common ruler.

REVISION QUESTIONS

1. (i) Name the five major kingdoms in the classification of living organisms.
   (ii) Give an example of an organism in each of the kingdoms
2. (i) Give three reasons for classifying organisms.
   (ii) What is the binomial system of nomenclature?

1.4 MATTER

Matter is anything that has mass and occupies space.

Mass is the amount of matter contained in an object.

MATTER

1. ***Matter* is anything that has mass and occupies space.**
2. ***Matter* is anything that has mass and volume**
3. **Examples of matter:** include all the materials in our surroundings i.e. Air, Wood, Water, Paper, Rock, Plastic, Sand, Animal, Kerosene, Glass, Petrol, Fruit etc

Mass: the amount of matter contained in an object.

***Weight*:** is the force that the object exerts on the ground due to the force of gravity.

Volume:

PARTICULATES NATURE OF MATTER

The tiny particles which form the building blocks or basic units of matter are:

I. Atom
II. Molecule
III. Ion

They are the particulates nature of matter

ATOM:

1. **Smallest particle of an element that exhibits the properties of the element and can take part in a chemical reaction.**
2. Smallest particle of an element that retains the properties of that element in a chemical reaction.
3. It is made up of a nucleus with positively charged protons and neutral neutrons surrounded by negatively charged electrons in a shell.
4. It has equal numbers of protons and electrons making it neutral.

   Examples: Hydrogen atom(H), Carbon atom (C), Oxygen atom (O), Sodium atom (Na), Potassium atom(K), Fluorine (H) etc.

MOLECULE:

1. **The smallest particle that exits separately. It can be made up of either one kind of atom or atoms of different elements joined together e.g. Cl_2, H_2O, O_2,**
2. A molecule is a small particle of element or compound that exist as chemically bounded group of atoms that exist as separate unit.

   Atoms that group together to form a molecule may be of the same element or different elements. Often molecules made up of different elements are referred to as compounds.
3. A molecule could be **monoatomic** - Elements whose atoms exist in single i.e. mostly the inert gase e.g. He, Ne, Ar, etc.
4. A molecule could be **diatomic** - Molecules containing two atoms e.g. O_2, Cl_2, I_2, N_2 etc.
5. A molecule could be **triatomic** - Molecules containing three atoms e.g. O_3
6. A molecule could be a **compound** e.g. H_2O, NH_3, $C_{12}H_{22}O_{11}$ etc.

ION:

1. **Is a positively or negatively charged particle. It is formed when an atom gains or loses electron(s).**
2. It consists of an atom or a group of atoms that has positive or negative charge(s).
3. **TYPES OF IONS**
   There are two types. These are **cation** and **anion**.

1. **Cation:** positively charged ion. It is formed when an atom loses electrons
   Examples: Sodium ion (Na^+), Potassium ion(K^+), Magnesium ion(Mg^{2+}), Aluminium ion(Al^{3+}), Iron (III) iron(Fe^{3+}), Iron (II) ion (Fe^{2+}), Cu^+,
2. **Anion:** negatively charged ion. It is formed when an atom gains electrons.
   Examples: Chlorine ion (Cl^-), Bromine ion ($B r^-$), Oxygen ion (O^{2-}), Nitrogen ion (N^{3-})

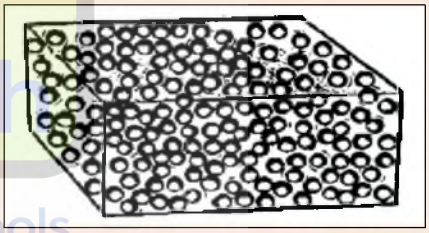
4. Polyatomic ions are called **radicals**. E.g. SO_4^{2-} , NO^{3-}, CO^{3-} etc.

A pure substance is one that is made up of only one kind of matter e.g. sodium chloride and Aluminium metal.

STATE OF MATTER

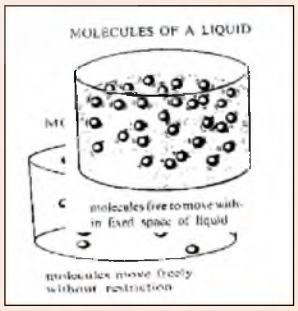
Matter exists in three different states
1. Solid state (i.e. solid)
2. Liquid state (i.e. liquid)
3. Gaseous state (i.e. gas)

CHARACTERISTICS OF SOLIDS



1. Tightly or closely packed by strong attractive forces.
2. Do not flow or cannot be poured.
3. Have fixed volume.
4. Dense and cannot be easily compressed.
5. Solids have definite shape.
6. Particles have lowest kinetic energy compared to those in liquids and gases.
7. Particles in solids cannot move but only vibrate.
   E.g. stones, wood, iron, ice cubes etc

CHARACTERISTICS OF LIQUID

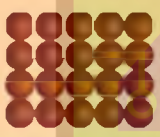
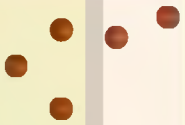


1. Particles more separated than in solids
2. Forces of attraction among constituent particles are weaker than those in solids but stronger than those in gases.
3. They flow or can be poured.
4. They have definite volume.
5. They have no definite shape but take or assume the shape of the containing vessel.
6. They cannot be compressed easily.
7. The constituent particles have higher kinetic energy than those in solids but lower than those in gases.
8. The constituent particles undergo random motion.
   E.g. water, oil palm, petrol, kerosene etc.

CHARACTERISTICS OF GASES

1. Have no definite shape.
2. Have no definite volume or size.
3. There is little or no attractive forces among gas particles.
4. They undergo random motion and occupy the entire space of which they are contained.
5. Compressible.
6. The constituent particles have highest kinetic energy compared to solids and liquids.
7. Most gases cannot be seen but can be felt e.g. air.
   Examples: Steam or water vapour, Chlorine, Air, Methane, Oxygen, Argon,, Hydrogen gas, Neon, Smoke, Carbon dioxide

The table below is a great guide to the relationship between solids, liquids and gases:

	SOLIDS	LIQUIDS	GASES
Arrangement of molecules	Regular, close to each other	Random or irregular close to each other	Random and wide apart
Movement of molecules	Very little movement in the form of vibrations	Molecules can move around each other	Quick movement in random direction
Diagram			
Strenght of bond between molecules	Strong bonding	weak bonding	very loose bonding
Examples	a rock	water	water vapor

DIFFERENCES BETWEEN ICE (SOLID) AND WATER (LIQUID)

ICE (SOLID)	WATER (LIQUID)
1. It is solid form of the compound H_20	1. It is liquid form of the compound H_20.
2. It cannot flow or cannot be poured.	2. It can flow or can be poured.
3. Constituent particles are closely packed.	3. Constituent particles are loosely packed.
4. Constituent particles have low kinetic energy.	4. Constituent particles have high kinetic energy.
5. It has definite shape.	5. It has no definite shape but assume the shape of the containing vessel.

DIFFERENCES BETWEEN ICE (SOLID) AND VAPOUR OR STEAM (GAS

ICE (SOLID)	WATER VAPOUR OR STEAM (GAS)
1. It is solid	1. It is gas of the same compound
2. It cannot flow or cannot be poured.	2. It moves randomly to occupy any space available.
3. Constituent particles are closely packed together.	3. Constituent particles are far apart.
4. It has definite shape.	4. It has no definite shape.
5. Constituent particles have low kinetic energy.	5. Constituent particles have very high kinetic energy.

SIMILARITIES BETWEEN ICE AND WATER

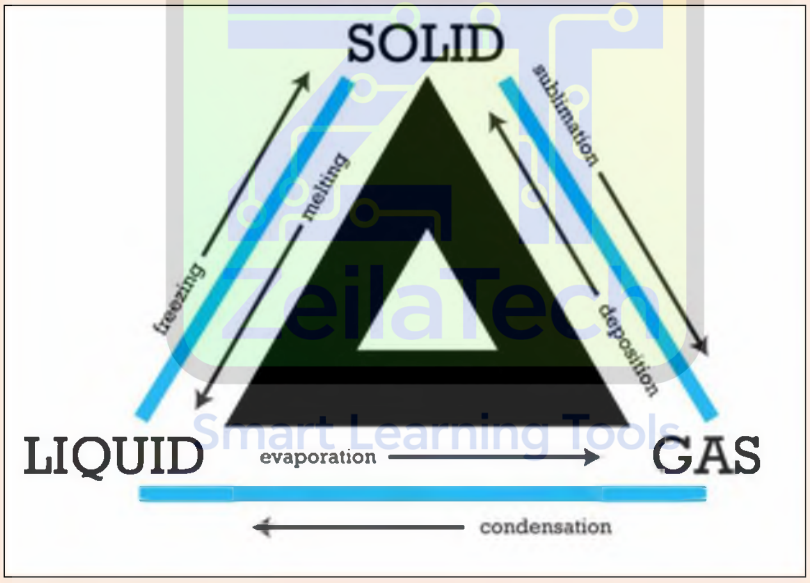
1. Both have definite volume.
2. Both are made up of the same chemical composition

MAJOR DIFFERENCES BETWEEN WATER (LIQUID) AND VAPOUR OR STEAM (GAS)

WATER (LIQUID)	WATER VAPOUR OR STEAM (GAS)
It is the liquid form of the compound, H_2O	It is gaseous form of the compound, H_20
It can flow or can be poured	It moves randomly to occupy any space available
Constituent particles are closely packed together compared to that of gas.	Constituent particles are far apart
It has no definite shape but takes the shape of the containing vessel.	It has no definite shape.
Constituent particles have low kinetic energy compared to that of gas.	Constituent particles have very high kinetic energy

CHANGE OF STATES OF MATTER

Matter can be changed from one state to another, in each case energy is either absorbed (given to it) or released (taken from it).



Physical processes involved in change of state of matter.

1. Melting.
2. Freezing or solidification (opposite of melting).
3. Evaporation or vapourisation.
4. Condensation (opposite of vapourisation).
5. Sublimation
6. Deposition (opposite of sublimation).

1. **Melting: -** It is a process by which a substance changes from the solid state to the liquid state. Heat is absorbed in this process. E.g. ice cubes melt to water. The temperature at which a substance melts is called the **melting point of that substance**. E.g. Margarine or butter, Wax or candle, Ice.
2. **Freezing/Solidification: -** the process by which a substance changes from the liquid state into the solid state. Heat is released in the process e.g. water to ice block, Cooking oil (e.g. palm oil), Milk.

3. **Vaporization/Evaporation:** - the process by which a substance changes from the liquid state into the gaseous state. Heat is absorbed in the process. E.g. water to water - vapour.

i. Factors affecting evaporation

1. Temperature
2. Nature of liquid
3. Surface area of the liquid
4. Wind effect
5. Pressure
6. Relative humidity

Examples of substances that can be observed evaporating are Water, Kerosene, Alcohol, Petrol.

ii. Boiling point: Boiling point of a liquid is the temperature at which the liquid changes to gas.

Factors affecting boiling point

1. Pressure.
2. Nature of liquid.
3. Wind effect.
4. Presence of dissolved material e.g. salt in the liquid.
5. Surface area of the liquid exposed to the atmosphere.

DIFFERENCES BETWEEN BOILING AND EVAPORATION

BOILING	EVAPORATION
1. It occurs throughout the bulk liquid	1. It occurs only at the surface of the liquid.
2. Does not result in cooling. There is heat gain	2. Evaporation results in cooling. There is heat loss
3. Bubbles can be observed the liquid.	3. No bubble is observed,
4. It occurs at definite temperature or at one constant temperature for any one particular liquid	4. It occurs at any temperatures.
5. A decrease in pressure lowers the boiling temperature.	5. A decrease in pressure increases the rate of evaporation.

4. ***Condensation:*** - the process by which a substance changes from the gaseous state to the liquid state. Heat is released in the process e.g. conversion of water vapour to water.

5. ***Sublimation:*** - the process by which a substance changes from solid state into the gaseous state without first changes into the liquid state or vice versa. Heat is either released or absorbed. E.g. camphor ball (naphthalene) reducing in size, Iodine crystals, Sulphur, and Crystals of ammonium chloride (NH4Cl) i.e Ammonium salts, dry ice, dry carbon (IV) oxide

6. **Deposition (opposite of sublimation):** - This is the process in which a gas changes directly to a solid without going through the liquid state. It occurs when gas particles become very cold. For example, when water vapor in the air contacts a very cold windowpane, the water vapor may change to tiny ice crystals on the glass. The ice crystals are called frost.

ELEMENTS

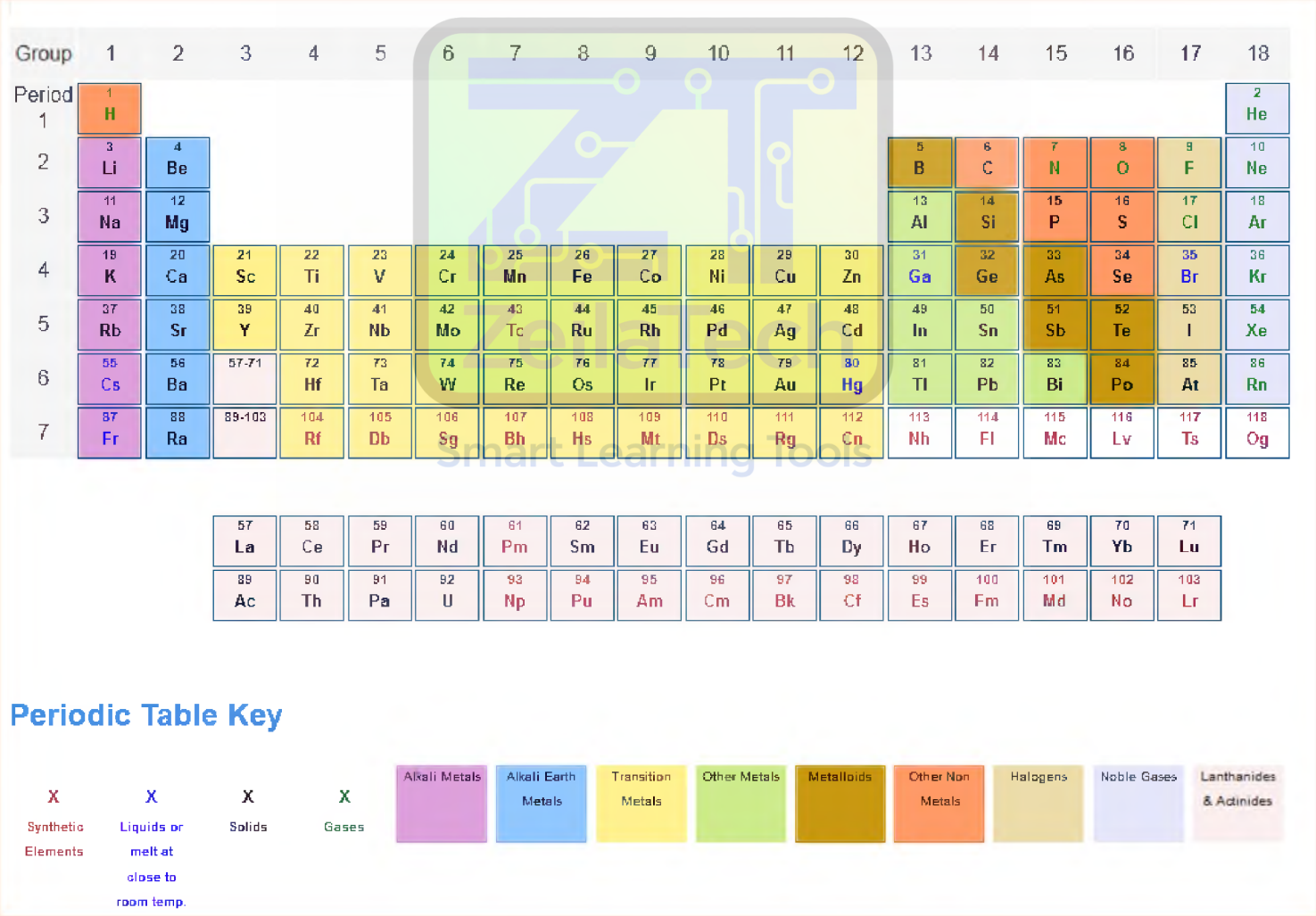
1. **Element: is a substance which cannot by any known chemical process be split into two or more simpler substances. It consists of only one type of particle or atom.**

2. **The simplest form of matter that cannot be broken down into simpler substances by any known chemical or physical processes.**

All things on Earth are made up of elements. There are about 106 different elements and each is represented by a symbol e.g. *Hydrogen* by **H**. When the elements are arranged in order of ascending atomic weight, a periodicity of chemical properties is observed. If the elements are arranged in a table such that elements with similar properties appear in the same column, a periodic table is formed.

3. THE PERIODIC TABLE

Is the arrangement of elements with increasing atomic numbers.



i. Elements are listed in order of increasing atomic number.

ii. They are specially arranged for every column to contain elements with similar properties. These columns are called ***groups.***

iii. For each element in a group the number of outer electrons is the same.

iv. Each new row has one more full shell as you go down any group. As atoms get bigger, they have more full shells of electrons.
v. Outer shells of electrons however, are increasingly far from the nucleus.
vi. The inner shells provide 'shielding' from the attraction of positive nucleus.
vii. There is always a gradual change in properties across horizontal rows.
viii. These rows are called **periods**.
ix. In each period there is a change from metallic to non-metallic character e.g. from *sodium* to *argon* in the third period.

MIXTURE

***Mixture:* -** is the physical combination of two or more substances. A mixture does not have a definite composition. Mixtures can be separated by physical means. The properties of the substances in a mixture are not altered by mixing.

Chromatograph is a method that can be used to separate complex mixtures.

Types of mixtures

1. **Solid - solid mixtures:** - these are formed from the mixing of two or more solid particles physically.

Examples include;

i. gari and sugar
ii. sand and salt mixture
iii. sand, salt and iron filings mixture
iv. salt and sugar mixture
v. charcoal and iron filings mixture

2. **Solid - liquid mixtures:** - these are formed when solid particles are mixed with a liquid physically.

Examples include;

i. common salt and water mixture
ii. sugar and water mixture
iii. salt and petrol mixture
iv. sand and kerosene mixture
v. gari and water mixture

3. **Liquid - liquid mixtures:** - these are formed from the mixing of two or more different liquids.

Examples include;

i. water and frytol oil mixture
ii. gas oil and petrol mixture
iii. petrol and palm oil mixture
iv. water and alcohol mixture
v. water, kerosene and petrol mixture.

4. **Gas - gas mixture:** - this is a mixture of two or more different gases.

Examples include;

i. oxygen acetylene mixture used in welding
ii. nitrogen oxygen mixture
iii. Air i.e is made up of 78% nitrogen, 21% oxygen, 0.03% carbon dioxide 1% rare gases, variable water vapour.

REASONS WHY AIR IS CONSIDERED AS A MIXTURE:

i. It cannot be represented by a chemical formula or has no definite molecular formula;
ii. Its composition varies from place to place
iii. Its components can be separated by a physical means.
iv. Its components retain their individual properties.

COMPOUNDS

Compounds: - are formed when two or more elements chemically combine e.g. NaCl, H_2O,NH_3

DIFFERENCES BETWEEN COMPOUNDS AND MIXTURES

Compounds	Mixtures
1. A new substance is formed	1. No new substance is formed
2. It contains one substance only, thus pure.	2. Contains more substances, thus impure.
3. Components are combined in fixed proportions	3. Components are combined in varying different proportions
4. Constituents cannot be separated by physical means	4. Constituents can be separated by physical means
5. Elements do not maintain their individual properties	5. Components maintain their individual properties

TRIAL QUESTIONS

Classify the following materials into elements, mixtures and compounds

1. *Water 2.Salt 3. Iron filings 4. Sea water 5. Glass 6.Air 7. Titanium 8. Clay 9. Sulphur*

PHYSICAL AND CHEMICAL CHANGES.

Physical change

A change where no new chemical substance is formed is called a physical change. Physical changes are usually easily reversible and there is no apparent loss or gain in weight of the materials involved.

Characteristics of physical changes

1. No new substance is formed.
2. It is easily reversible.
3. Not accompanied by great heat change
4. There is no change in mass.
5. Individual components retain their properties.

Examples of physical change

1. Melting of ice.
2. Boiling a liquid.
3. Heating a wire by electricity.
4. Magnetization of iron.
5. Dissolving sugar in water.
6. 6 . Mixing sand and sugar.
7. Freezing of water.
8. 8 . Grinding of chalk.
9. Pounding some cassava into fufu.
6. Melting of candle or wax.

Chemical change

This is a change where a new (chemical) substance is formed. Chemical changes are usually irreversible. In chemical changes there is a loss or gain in weight of the materials involved. Usually chemical changes are accompanied by a great heat change.

Characteristics of chemical changes

1. New substances are formed.
2. It is irreversible.
3. Accompanied by great heat change.
4. There is a change in mass.
5. Individual components change their properties.

Examples of chemical change

1. Burning substance such as wood into ash.
2. Rusting of iron.
3. Reaction between NaOH and HCl.
4. Fermentation.
5. Decomposition of substances by electricity
6. Precipitation of a solid by the reaction of two solutions.

DIFFERENCES BETWEEN PHYSICAL AND CHEMICAL CHANGES	
PHYSICAL CHANGE	**CHEMICAL CHANGE**
1. No new substance is formed	1. New substances are formed
2. It is easily reversible	2. It is irreversible
3. Not accompanied by great heat change	3. Accompanied by great heat change
4. There is no change in mass	4. There is a change in mass
5. Individual components retain their properties	5. Individual components change their properties

Compounds are formed when different elements are chemically combined. The forces, which hold these atoms together, are known as chemical bonds. These bonds are of two types; 1. Ionic or Electrovalent bonds

2. Covalent bond

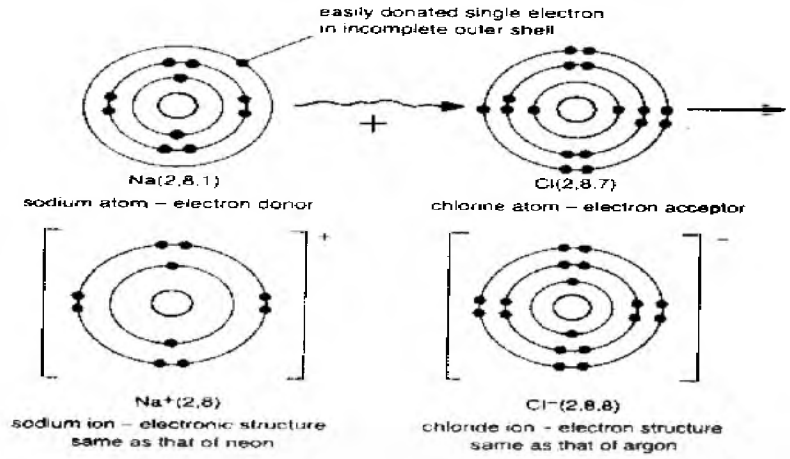
Formation of Ionic bonds & compounds: -

Ionic bond formation is as a result of transfer of electrons from one atom to another giving cations and anions. In the transfer, the positive charge cancels the negative charge making the compound formed neutral. Bonds formed are as a result of electrostatic force. The transfer is usually from a metal to a non - metal. Examples of ionic compounds are:

- Sodium Chloride (NaCl); $CuSO_4$; $MgCO_3$; NaOH; $CaCO_3$; HNO_3
- Copper (II) trioxonitrate ($CuNO_3$); Potassium Oxide (K_2O)
- Calcium Chloride ($CaCl_2$); Magnesium Chloride ($MgCl_2$)
- Calcium Oxide (CaO) – Calcium burnt in oxygen forms calcium oxide. The reaction between the atoms is written as: $Ca + O \rightarrow Ca^{2+} + O^{2-} \rightarrow Ca^{2+}O^{2-}$ (solid).

Below is a diagrammatic representation of the formation of ionic bond between Sodium and Chlorine. When hot Sodium is placed in Chlorine gas the reaction is as follows: $Na^+ + e^- \rightarrow Na^+$ $Cl + e^- \rightarrow Cl^-$

$Na + Cl = NaCl$



Ionic bonding of sodium and chlorine

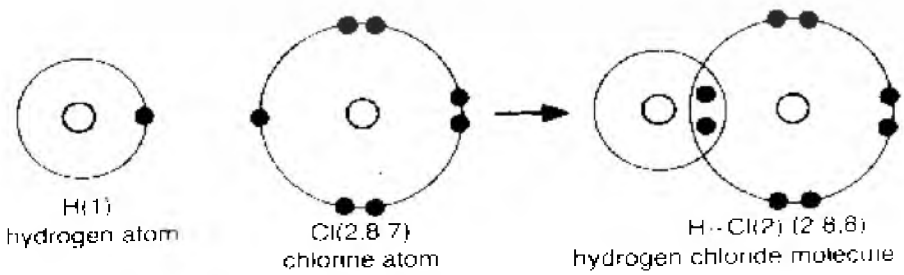
Formation of Covalent Compounds

The compound formed by the process of electron sharing between atoms to achieve fully filled shells is called covalent compounds. The bonds formed here are weaker and usually formed between non – metals.

A covalent bond formed between atoms is sometimes shown as a short line drawn between the symbols of atoms e.g. H – H, Cl – Cl, O = O, N = N, These bonds are referred to as single, double, and triple. Examples of covalent compounds are:

- Ethanol ($CH_3 CH_2 OH$),
- Ammonia (NH_3)
- Hydrogen Chloride (HCl),
- Carbon dioxide (CO_2)
- Water (H_2O),
- Chlorine (Cl_2) etc.

Outermost electrons shells are only shown in this diagram.



Covalent bonding in hydrogen chloride

Table 1.4.1 Differences between ionic and covalent bonds

IONIC BOND	COVALENT BOND
1. There is electron transfer	There is sharing of electrons
2. Formed between metals & non metals	Formed between non metals
3.The bond formed is stronger	The bond formed is weaker
4. Found in ionic compounds	Found in covalent compounds

Table 1.4.2 Differences between Ionic and Covalent Compounds

IONIC COMPOUNDS	COVALENT COMPOUNDS
All are mostly solids	All are mostly liquids and gases
Have high melting points	Have low melting point
Have high boiling points	Have low boiling point
Conduct electricity in aqueous state	No electricity conduction in aqueous state
Soluble in water or polar solvent	Insoluble in water or polar solvent
Insoluble in non polar solvent	Soluble in non polar solvent

IUPAC naming of compounds

- Naming gives one name to one compound
- It gives information about the oxidation state and the number of atoms combining to form the compound.

The oxidation number of an atom is the charge the atom carries in its pure state or in its compound.

Rules determining oxidation states of compounds.

1. The oxidation number of:

   (a) An element in its uncombined or atomic or molecular form is zero (0).

   E.g. H, $H_2 \Rightarrow 0$; Na $\Rightarrow 0$; Cl, $Cl_2 \Rightarrow 0$

   (b) An ion of a single atom is equal to the charge on the ion

   E.g. $Cl^- \Rightarrow -1$; $O^{2-} \Rightarrow -2$; $Cu^+ \Rightarrow +1$

   (c) An oxygen atom is -2 except in peroxides e.g. H_2O_2 and K_2O_2 where it is -1 and superoxides e.g. KO_2 where it is -1/2.

   E.g. $H_2O \Rightarrow 2(+1) + (-2) = 0$

   $H_2O_2 \Rightarrow 2(+1) + 2(-1) = 0$

   (d) Hydrogen is -1 in metal hydrides

E.g. NaH $\Rightarrow$ +1 + (-1) = 0

2. The total of the oxidation numbers of all atoms in a neutral substance is zero.

E.g. HCl $\Rightarrow$ +1 -1 = 0

$H_2SO_4 \Rightarrow 2(+2) + (+6) + 4(-2) = 0$

3. The total of the oxidation numbers of all atoms of a radical is equal to the charge carried by the radical (a radical is a polyatomic ion).

E.g. $CO_3^{2-} \Rightarrow +4 +3 (-2) = -2$

$PO_4^{3-} \Rightarrow +5 +4 (-2) = -3$

$SO_3^{2-} \Rightarrow +4 +3 (-2) = -2$

- Some elements e.g. (Cu, Fe) have more than one oxidation state; they are said to show variable oxidation states.
- All metals show a positive oxidation state.

BINARY COMPOUNDS

These are compounds containing atoms of two different elements only. One of the two elements attracts electrons more towards itself than the other element does (electronegative). It therefore has a negative oxidation state. They are found nearer the right hand side of the periodic table.

Rules applied in naming binary compounds

1. The suffix –'ide' replaces the last two or three letters in the name of the more electronegative element e.g. Chlorine – Chloride, Oxygen – Oxide, Nitrogen – Nitride, Sulphur – Sulphide, Hydrogen – Hydride etc.
2. The modified name of the more electronegative element is written second.
3. The name of the less electronegative element is written first. It is not modified. The oxidation state is placed in parenthesis in capital Roman numerals immediately after the name of the element, e.g. Iron + Sulphur = Iron (II) Sulphide or Iron (III) Sulphide.

If the element exhibits only one oxidation state, this is not shown,

e.g. Potassium + iodine $\Rightarrow$ potassium iodide

Aluminium + chlorine $\Rightarrow$ Aluminium chloride.

Old or trivial names are used for some compounds

e.g. $H_2O \Rightarrow$ water;

$CO_2 \Rightarrow$ Carbon dioxide;

$NH_3 \Rightarrow$ Ammonia;

CO ⇒ Carbon monoxide etc.

IONS

Rules for naming simple ions

1. The oxidation state is not shown for cations of elements with fixed (only one) oxidation state, the name of the element is written plus the word ion;

E.g. Zn^{2+} ⇒ Zinc ion

H^+ ⇒ Hydrogen ion

NH_4^+ ⇒ Ammonium ion

2. The oxidation state is written in Roman Capital numerals, in parenthesis, immediately after the name of the element for cations of elements with variable oxidation states;

E.g. Cu^+ ⇒ Copper (I) ion; Fe^{2+} ⇒ Iron (II) ion

Cu^{2+} ⇒ Copper (II) ion; Fe^{3+} ⇒ Iron (III) ion

3. Anions take the suffix –'ide' as does the more electronegative component of a binary compound, plus the word ion;

E.g. Cl^- ⇒ Chloride ion; Br^- ⇒ Bromide ion

S^{2-} ⇒ Sulphide ion; O^{2-} ⇒ Oxide ion

OXOANIONS: - are radicals in which oxygen atom(s) are bonded to a central atom. Names are based on the oxidation number of the central atom and the number of oxygen atom(s) bonded to it

1. The suffix '-ate' replaces the last two or three letters in the name of the central atom.
2. The oxidation number of the central atom is given in Roman capital numerals, in parenthesis, after its name.
3. The number of oxygen atoms is placed before the name of the central atom as 'dioxo'; 'trioxo' etc; there is no prefix for one oxygen atom.
4. The word ion is added to the name ;

E.g. CO_3^{2-} ⇒ trioxocarbonate (IV) ion SO_3^{2-}

NO_3^- ⇒ trioxonitrate (V) ion NO^{2-}

SO_4^{2-} ⇒ tetraoxosulphate (VI) ion ClO^-

HCO_3^- ⇒ hydrogen trioxocarbonate (IV) ion ClO^{4-}

OH^- ⇒ Hydroxide ion MnO^{4-}

OXOACIDS: - are compounds containing one or more hydrogen atoms and an oxoanion. They are named the same way as oxoanions but the word 'acid' replaces the word 'ion' in the name of the oxoanion;

E.g. $HNO_3 \Rightarrow$ trioxonitrate (V) acid H_2SO_3 H_3PO_4

$H_2SO_4 \Rightarrow$ tetraoxosulphate (VI) acid HCO_3 H_2CO_3

$HClO \Rightarrow$ oxochlorate (I) acid HNO_2 $HClO_3$

BASES:- are divided into oxides and hydroxides;

Oxides are named as binary compounds;

E.g. $Fe_2O_3 \Rightarrow$ Iron (III) oxide

$Na_2O_2 \Rightarrow$ Sodium peroxide

$AlCl_3 \Rightarrow$ Aluminium Chloride

Hydroxides are also named as binary compounds, that is, the name of the *cation* is written first, followed by the *oxidation* number if it varies, then the word hydroxide is added; e.g. $NaOH \Rightarrow$ Sodium hydroxide

$Ca(OH)_2 \Rightarrow$ Calcium hydroxide

$Cu(OH)_2 \Rightarrow$ Copper (II) hydroxide

$Fe(OH)_2 \Rightarrow$ Iron (II) hydroxide

SALTS: - are formed when a metal (or ammonium) cation replaces the hydrogen(s) of an acid. They are divided into *binary salts* and *oxoacid salts*.

Binary salts are formed from the combination of the names of the cation and the anion; e.g. $NH_4Cl \Rightarrow$ ammonium chloride

$CuCl_2 \Rightarrow$ Copper (II) chloride

$FeS \Rightarrow$ Iron (II) Sulphide

Oxoacid salts are salts of the oxoacid e.g. Na_2SO_4 is a salt of H_2SO_4. They are named by writing the cation, followed by its oxidation number if it is variable. The name of the oxoanion is then added.

E.g. $ZnCO_3 \Rightarrow$ Zinc trioxocarbonate (IV) Na_2SO_4

$KMnO_4 \Rightarrow$ Potassium tetraoxomanganate (VII) Na_2CO_3

$CuSO_4 \Rightarrow$ Copper (II) tetraoxosulphate (VI) $NaNO_3$

Other Salts:

- Are named as combination of names of cations and anions e.g. Sodium Cyanide.
- Others have water molecules as part of their structures. The name of hydrated salt is followed by number of water molecules;

  e.g. $CuSO_4.5H_2O \Rightarrow$ Copper (II) tetraoxosulphate (VI) pentahydrate

$Na_2CO_3.10H_2O \Rightarrow$ Sodium trioxocarbonate (IV) decahydrate

Name the following compounds

1. $(NH_4)_2 SO_4$ 2. $KMnO_4$
3. $CuSO_4$ 4. $ZnCO_3$
5. $NaHCO_3$ 6. H_2SO_3
7. H_3PO_4 8. HNO_2
9. Cu $(OH)_2$ 10. MnO_4^-

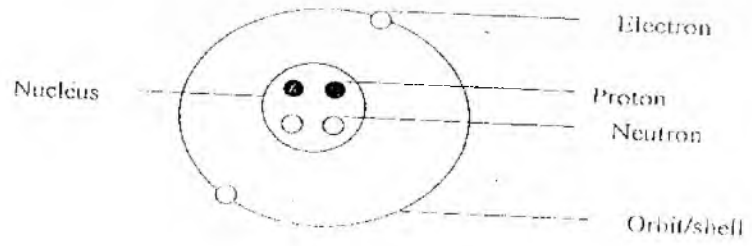
{Cations: Na^+, K^+, Mn^{2+}, Mg^{2+}, Ca^{2+}, Zn^{2+}, Al^{3+}, NH_4^+, Li^+, Cu^{2+}, Cu^+ Fe^{2+}, Fe^{3+} }.
{ Anions: Cl^-, Br^-, F^-, O^{2-}, SO_4^{2-}, CO_3^{2-}, HCO_3^-, NO_3^-}

1.4.3 Atomic and Mass number, Isotopes, &Relative atomic mass.

Materials are made up of very tiny particles called atoms. Because of their tiny nature it takes millions to form a full stop at the end of a sentence. To deduce the structure of the atom scientist fired fast moving particles to atoms to fall to pieces. One piece represents the atom till date.

In the nucleus are protons and neutrons. Proton number is equal to the number of electrons around the shells; it is also equal to the **atomic number**. Atomic number is represented as Z, a subscript, e.g. $_zO$ or $_8O$.

Electrons have almost no mass thus; the mass of an atom of an element depends on the sum of the protons and the neutrons. The mass of the atom therefore becomes its mass number. **Mass numbers**, also called **nucleons** are represented as A, a superscript, e.g. ^ANa or ^{23}Na. Mass numbers are also horizontally written as: Hydrogen- 1, Helium- 4, Lithium- 7, Sodium- 23, Uranium- 238, etc.



Atomic structure

An atom with a known or specified number of neutrons and protons is called a **nuclide,** examples include: $_1{}^1H$, $_2{}^4He$, $_3{}^7Li$, etc.

Many elements have atoms of the same element with the same atomic number but different mass numbers. They are called Isotopes. E.g. $_{6}^{12}C$, $_{6}^{13}C$, $_{6}^{14}C$; $_{1}^{1}H$, $_{1}^{2}H$, $_{1}^{3}H$; $_{8}^{16}O$, $_{8}^{17}O$, $_{8}^{18}O$; $_{12}^{24}Mg$, $_{12}^{25}Mg$, $_{12}^{26}Mg$ and so on.
The **mass spectrometer** is the instrument used to determine isotopes.

Relative Atomic Mass

Atoms of different elements have different masses. These very small masses cannot be weighed directly but can be compared. Such compared masses are the relative atomic masses.

The atom chosen for comparison with all other atoms is the carbon- 12 isotope. The scale of relative atomic mass obtained is called the carbon- 12 scale.
Definitions:

- *Relative atomic mass* of an element is the weighted average mass of its isotopes compared with an atom of carbon- 12. Or
- *Relative atomic mass* of an element is the ratio of the mass of one atom to 1/12 the mass of one atom of carbon- 12. Or
- *Relative atomic mass* of an element is the number of times the mass of one atom of the element is heavier than 1/12 of the mass of one atom of carbon – 12.

On the carbon- 12 scale one unit is equal to 1/12 of the mass of one atom of carbon- 12. Relative atomic mass has no unit, because it is a comparison of masses in the same unit, but when it is given, **u**, it is called the atomic mass unit.

1.4.4 Calculations using the mole concept

Substances are made up of tiny particles – atoms, molecules, ions. They are so small that we sometimes use units such as dozen (12), gross (144) etc. For particles 'Avogadro' constant is used.
It is an extremely large number – 602 000 000 000 000 000 000 000 or 6.02×10^{23}.
The unit formed is the amount of substance, which is the mole. (Symbol n; SI unit = mol)

A mole of any substance contains 6.02×10^{23} particles of that substance.
The mass (m) of one mole = Molar mass or 6.02×10^{23} particles of any substance.
Numerically molar mass is equal to the relative atomic mass of an atom, but its unit is gram per mole, i.e. $gmol^{-1}$.

If **R.A.M** of Gold (Au) is 127, then the molar mass of Au will be $127gmol^{-1}$.

Trial Questions

The relative atomic masses of the following elements are: H = 1.0, C = 12, N = 14, O = 16, Na = 23, S = 32, Cl = 35.5, Cu = 63.etc.

Calculate the formula mass (molar mass) of:

1. $HNO_3 = (1 \times 1) + (14 \times 1) + (16 \times 3) = 63gmol^{-1}$
2. $NH_4NO_3 = (14 \times 1) + (1 \times 4) + (14 \times 1) + (16 \times 3) = 80gmol^{-1}$
3. $HCl = (1 \times 1) + (35.5 \times 1) = 36.5gmol^{-1}$
4. $Na_2SO_4 = (23 \times 2) + (32 \times 1) + (16 \times 4) = 142gmol^{-1}$
5. $H_2SO_3 = (1 \times 2) + (32 \times 1) + (16 \times 3) = 82gmol^{-1}$
6. $C_6H_{12}O_6 = (12 \times 6) + (1 \times 12) + (16 \times 6) = 180gmol^{-1}$
7. $H_2SO_4 = (1 \times 2) + (32 \times 1) + (16 \times 4) = 98gmol^{-1}$
8. $CuSO_4 = (63 \times 1) + (32 \times 1) + (16 \times 4) = 159gmol^{-1}$
9. $NaCl = (23 \times 1) + (35.5 \times 1) = 58.5gmol^{-1}$
10. $NH_3 = (14 \times 1) + (1 \times 3) = 17gmol^{-1}$

Revision Questions

Calculate the molar mass of the following:

1. $CaCO_3$
2. MgO
3. $AgNO_3$
4. $NaHCO_3$
5. Na_2CO_3
6. $CaCl_2$
7. K_2MnO_4
8. $FeCl_3$
9. $Ca(OH)_2$
10. PbO_2

R.A.M $\rightarrow$ Pb = 207, Ca = 40, Mg = 24, Ag = 108, Mn = 54.9, K = 39.1, Fe = 55.8

The general relation between the mass (m) and the amount of solute is given by:

$$n = \frac{m}{M}$$

Where n = amt of substance (mol)

m = mass (g)

M = molar mass ($gmol^{-1}$)

(i) The atomic mass of any element = 1mol.

If 40g of Ca = 1mol

$\therefore$ 20g of Ca = $\frac{20g}{}$ $\times$ 1mol

$$= \frac{40g}{0.5mol}$$

(ii) How many moles of H_2SO_4 are there in 10g of the substance?

Molar mass of $H_2SO_4 = (1\times 2) + (32 \times 1) + (16 \times 4) = 98gmol^{-1}$

$\therefore$ 10g of $H_2SO_4 = \frac{10}{98} \times 1mol$

$= \underline{0.102mol}$

Revision Questions: Find out the number of moles in these substances:

1. 70.5g of sugar ($C_{12}H_{22}O_{11}$)
2. 35g of H_2SO_4
3. 85g of $NaNO_3$
4. 60g of $C_6H_{12}O_6$
5. 41.5g of trioxonitrate (V) acid - {HNO_3}
6. 120g of trioxocarbonate (IV) ion - {CO_3^{-}}
7. 123g of Copper (II) trioxocarbonate (IV) - {$CuCO_3$}
8. 100g of $CaCO_3$
9. 426g of Na_2SO_4
10. 40g of $MgSO_4$

1.4.5 Preparation of solutions of given concentrations

The quantity of substance in solution can be expressed in units of moles or grams. When expressed in moles per cubic decimeter it is referred to as *concentration* (C). When it is expressed in grams it is called *mass concentration*.

The unit of concentration relates to the moles of solute per litre of solution. Its unit is $moldm^{-3}$ or M. **Note $moldm^{-3}$ = molarity = M.**

This concentration of a solution can also be defined as the amount of substance (in moles) per unit volume (dm^3 i.e. $1000cm^3$) of a solution.

Mass concentration is therefore, the quantity of substance in grams per unit volume (dm^3 i.e. $1000cm^3$) of a solution. The unit is gdm^{-3}.

Concentration in **$moldm^{-3}$ x molar mass = gdm^{-3}.**

$$C = \frac{n}{v}$$

Where c - concentration ($moldm^{-3}$)

n - Amt of solute (mol)

v - Volume (dm^3)

And $n = \frac{m}{M}$; Where m - mass (g)
M - molar mass ($gmol^{-1}$)

Worked example:

2.0dm^3 of an aqueous solution contains 25.5g Sodium chloride. Calculate the concentration of the solution in $moldm^{-3}$.

Ans: c = n/v; but n = m/M $\therefore$ n = 25.5 / 58.5 = 0.436moles.

C = n/v = 0.436/2.0 = $0.22moldm^{-3}$.

A solution whose exact concentration is known is a **Standard Solution**.

Molar Solution: is a solution obtained by dissolving 1 mole of a substance in 1dm^3 of water. Or a concentration of 1M of any solution is a molar solution.

To prepare 1dm^3 of 1M NaCl solution:

First determine the mass of NaCl required;

C = n/v; n = m/M; C = 1, v = 1dm^3, M = $58.5gmol^{-1}$.

$\Rightarrow$ n = 1mol; m = 58.5g

$\therefore$ 58.5g of NaCl crystals are needed to prepare 1dm^3 of 1M NaCl solution

Procedure:

1. Weigh and record the 58.5 NaCl pellets into the beaker.
2. Transfer all the solute from the beaker into the 1dm^3 volumetric flask. Wash the inside of the beaker well with distilled water.
3. Shake the flask to mix well
4. Top the water up to the mark with a dropper till bottom of meniscus is on the graduation mark
5. Shake the flask well again to ensure proper mixing; label the flask with the name and concentration of the solution; e.g. **1M of NaCl.**

To calculate the concentration of the solution when 0.200 mol of Sodium trioxocarbonate (IV) is dissolved in water to make 0.500dm^3 of solution.

$$C = \frac{0.200mol}{0.500dm^3} = 0.400dm^{-3}$$

- If the mass is given then calculate amount of solute in moles before proceeding to C above.

- Convert cm^3 to dm^3 before using the formula ; $1dm^3 = 1000cm^3$

Worked example

Calculate the mass of Sodium trioxocarbonate (IV) (Na_2CO_3) to be weighed to prepare $250cm^3$ of a 1M solution.

Volume of solution = $250cm^3 = 0.250dm^3$

Amt of Na_2CO_3 in $0.250dm^3$ of 1M solution.

Concentration: $n = c \times v$

$\Rightarrow \quad n = 1 \times 0.250$

$\Rightarrow \quad n = \underline{0.250mol}$

Mass 0f Na_2CO_3 in 0.250mol

$\Rightarrow n = \frac{m}{M}$ $\quad \therefore m = n \times M$

$m = 0.250mol \times 106gmol^{-1}$

$= \underline{26.5g}$

Revision Questions

- Find the relative molecular mass of ammonia (NH_3). How much ammonia would you need to make $1dm^3$ of a 1M solution of ammonia?
- I have $1dm^3$ of a 0.1M solution of ammonia in water. What mass of ammonia does it contain?
- A bottle in a laboratory describes a solution as 2M hydrochloric acid. What mass of hydrogen chloride is present in $1dm^3$ of this solution?
- Find the formula mass of magnesium tetraoxosulphate (VI) ($MgSO_4$). What mass of $MgSO_4$ would you need to make: (a) $1dm^3$ of 1M $MgSO_4$? (b) $1dm^3$ of 1/10M $MgSO_4$?
- Calculate the concentration of 30.5g of salt dissolved to produce $500cm^3$ of solution.
- A solution is prepared by dissolving 5g of NaOH in $250cm^3$ of water. Calculate the concentration of the resulting solution in (a) $moldm^{-3}$ (b) gdm^{-3}

Solution: (a) $n = m/M = 5/40 = 0.125mol.$

$C = n/v = 0.125/0.250 = \underline{0.5moldm^{-3}}$

(b) C x Molar mass = 0.5 x 40

$= \underline{20gdm^{-3}}$

Dilution of Solution

This is done when more solvent is added to the solution, as a result the volume of the solvent increases whiles the amount of substance remains the same.

It is a practical process which takes place in everyday human activities. Dilution is carried out in our homes and industries. It is not left out in food preparation, in the preparation of herbs and medicines, food processing, paint production and many other processes.

Stock Solution: is a concentrated solution from which dilute solutions are prepared.

The law of dilution:

Amount of solute in undiluted solution = Amount of solute in diluted solution.

Parts per million (ppm) is another way to express concentration. This unit of concentration is used to express concentration of very dilute solutions.

$$ppm = \frac{\text{grams of solute}}{\text{grams of solution}} \times 10^{-6}$$

OR $\frac{\text{mg of solute}}{\text{L solution}}$; $\frac{\text{mg of solute}}{\text{kg of solution}}$

In dilution it is only the volume of the solvent which is increased; the amount of substance in the more dilute solution remains the same.

Therefore $n_{\textit{concentrated solution}} = n_{\textit{dilute solution}}$

And, since n = c x v

C *conc*. x V *conc*. = c *dil* x V*dil, OR*

C *conc*. x V *conc*. = c *dil* x (V *conc*. + V *water*)

TRIAL QUESTIONS:

1994 Questions:

1. An atom contains **11** electrons

   (a) Draw an electron configuration with the atom.

   (b) State with reasons, the type of chemical bond that the element can form with chlorine (atomic number 17).

1995 Questions:

2. (a) State the three main particles of an atom and state their charges.

   (b) What is sublimation?

   (i) Name two substances that can sublime.

1996 Questions:

3. (i) Distinguish between a covalent bond and an ionic bond.

   (ii) For each of the ionic and covalent bond, give one example each of a compound which contains the bond.

   (iii) Give two characteristics of each of the covalent and ionic compounds.

1997 Questions:

4. Atomic number of an atom **Y** is 17 and its mass is 35.
   (α) Indicate the number of protons, electrons and neutrons in the atom.
   (β) Draw the electron configuration of the atom showing positions of the protons and electrons as well as the arrangement of electrons in the various shells.

1998 Questions:

5. (i) Draw and label the structure of an atom.
   (ii) What type of particles are produced when an atom
   (α) Gains electrons? (β) Loses electrons?

2001 Questions:

6. Name the type of bonds present in each of the following substances.
   (α) Ammonium chloride (β) calcium chloride (γ) carbon dioxide

2003 Questions:

7. Tabulate three differences between covalent and ionic compounds.

2005 Questions:

8. (a) (i) State the three states of matter.

(ii) Sketch and label diagrams to show the comparative intermolecular distances in each of the three states of matter.

b) (i) What is IUPAC nomenclature?

(ii) Give IUPAC names for the following compounds.

(α) $Fe(OH)_3$ (β) H_2SO_4 (γ) KNO_3

(c) Give two differences between condensation and sublimation

2006 SSCE:

9. The chemical formula of a compound is $KMnO_4$

(α) Give the IUPAC name of the compound.

(β) Determine the oxidation number of **Mn** in the compound.

2007 WASSCE:

10. (a) Explain how covalent bonds are formed.

(b) From the following list of compounds indicate which are covalent or ionic

(i) Ethanol
(ii) Potassium oxide
(iii) Hydrogen chloride
(iv) Copper (II) trioxonitrate (V)
(v) Sulphur

(c) Explain the following terms: (i) relative atomic mass (ii) Isotopes

2010 GBCE:

11. (a) An atom has 8 protons and 9 neutrons in its nucleus. Determine the

(i) Mass number
(ii) Number of electrons in the atom

(b) When limestone is heated strongly, quicklime (CaO) and carbon dioxide are produced

(i) Write a balanced chemical equation for the reaction

(ii) Calculate the mass of limestone needed to produce 112g of quicklime.

c) Calculate the mass of sodium of sodium chloride (NaCl) needed to prepare $500cm^3$ of 0.1M concentration. [Na = 23.0; Cl = 35.]

OBJECTIVE QUESTIONS

Write the letter of the choice that best answers the question or completes the statement

1. In the formation of an ionic compound, atoms of one of the combining elements must
   A. Convert neutrons to electrons
   B. Lose protons
   C. Gain protons
   D. Gain electrons
2. The arrangement of electrons in the shells of a magnesium atom is represented as
   A. 8, 2, 2. B. 2, 4, 6.
   C. 2, 8, 2. D. 2, 2, 8.
3. Mixture of sodium chloride and ammonium chloride can be separated by
   A. Crystallisation B. Distillation
   C. Filtration D. Sublimation
4. The maximum number of electrons which can be placed in the third shell of an atom is
   A. 3 B. 8
   C. 10 D. 18
5. Mixture of ethanol and water can be separated by
   A. Condensation B. Distillation
   C. Evaporation D. Filtration
6. The process by which a solid substance changes directly into the gaseous state is known as
   A. crystallization B. evaporation
   C. fumigation D. sublimation
7. Which of the following chemical formulae correctly represent, iron(II) tetraoxosulphate(VI)
   A. $FeSO_3$ B. $FeSO_4$
   C. $Fe_2(SO_3)_3$ D. $Fe_2(SO_4)_3$
8. Which of the following substances changes directly from the solid phase to the gas phase at room temperature?
   A. fats B. ice
   C. naphthalene D. wax
9. An atom is said to be electrically neutral if
   A. neutrons are in the nucleus
   B. protons are in the nucleus
   C. the number of protons and neutrons in the nucleus are equal
   D. the number of protons and electrons are equal
10. The nucleus of an atom is positively charged because
    A. Electrons revolve around the nucleus
    B. The protons are in the nucleus
    C. The neutrons are in the nucleus
    D. The number of protons and electrons in an atom are equal
11. 

When a reagent bottle in the laboratory has the hazard warning sign above posted on it, it implies that the content of the bottle is
   A. corrosive. B. highly flammable.
   C. highly toxic. D. radioactive.
12. Which of the following characteristics about ionic compounds is **true**?
    A. They have low melting points.
    B. They have high boiling points.
    C. They do not conduct electricity in solution.
    D. They do not form crystalline solids.

13. The IUPAC name for $Fe(OH)_2$ is
    A. Ferrous hydroxide
    B. Ferric hydroxide
    C. Iron(II) hydroxide
    D. Ferrous(II) hydroxide
14. Which of the following formulae represents an organic compound?
    A. CO B. CO_2
    C. $NaHCO_3$ D. $C_6H_{12}O_6$
15. The IUPAC name for CO_2 is
    A. carbon(IV) oxide
    B. carbon(II) oxide
    C. carbon oxide(II)
    D. carbon oxide(IV)
16. 

If the hazard warning sign shown above is seen on a reagent bottle, it implies that the content is
    A. corrosive
    B. highly inflammable
    C. irritant
    D. oxidizing
17. If a bond formed by two atoms is ionic, then
    A. the two atoms share a pair of electrons
    B. there is transfer of at least one electron from one atom to the other
    C. the two atoms transfer neutrons to each other
    D. no electron transfer occurs between the atoms
18. The IUPAC name for the compound with the formula $CuSO_4$ is
    A. Copper(II) tetraoxosulphate(VI)
    B. Copper(I) tetraoxosulphate(VI)
    C. Copper trioxosulphate(IV)
    D. Copper(IV) trioxosulphate(II)
19. The difference between a solid and a liquid can be explained on the basis that
    A. a solid has a changing shape while a liquid has a fixed shape and volume
    B. solid particles are far apart and in erratic motion but liquid particles vibrate at fixed positions
    C. solid particles have fixed mass and volume

whereas liquid particles have changing mass and volume.

D. Solid particles are in fixed position in a fixed structure but liquid particles are free to move around.

20. Which of the following statements about an atom is **true**?
    A. The atomic number is greater than the mass number
    B. The L electron shell is the closest shell to the nucleus
    C. Neutrons are contained in the nucleus of the atom
    D. Protons outnumber electrons in a neutral atom.

Use the following characteristics of substances to answer questions **21** *and* **22**.

I. High melting point
II. High solubility in water
III. Low melting point
IV. High electrical conductivity in solution

21. Which of the above characteristics are **true** of ionic compounds?
    A. I and II only
    B. I and III only
    C. I and IV only
    D. I, II and IV only
22. Characteristics **IV** above is **true** of NaCl because it
    A. forms ions in solution
    B. dissolves in water to form a solution
    C. produces a tasty solution
    D. forms a colourless solution
23. The IUPAC name for HNO_3 is
    A. dioxonitrate(III) acid
    B. trioxonitrate(IV) acid
    C. trioxonitrate(V) acid
    D. trioxonitrate(III) acid
24. Which of the following electronic configurations is that of sodium?
    A. 2, 1, 8 B. 2, 2, 7
    C. 2, 7, 2 D. 2, 8, 1
25. All the following statements in Dalton's atomic theory have been modified in recent years **except**
    A. all elements are made up of tiny indivisible particles called atoms
    B. atoms cannot be created, destroyed or sub-divided
    C. atoms of same elements have same properties and same mass
    D. atoms of different elements have different properties and different masses.

26. When ammonium chloride salt is heated gently, it changes from
    A. gas to liquid
    B. liquid to gas
    C. solid to gas
    D. solid to liquid
27. Which of the following characteristics is **true** of ionic compounds? They
    A. have low melting points
    B. have high boiling points
    C. do not conduct electricity in solution
    D. do not form crystalline solids

28. The nucleus of an atom contains
    A. electrons and protons
    B. neutrons and protons
    C. neutrons and electrons
    D. protons, electrons and neutrons.

29. Nucleons consist of
    A. electrons, protons and neutrons
    B. neutrons and electrons
    C. electrons and protons
    D. protons and neutrons [2005, Que – 12]
30. An atom of an electron **X** has **21** protons and **23** neutrons. What is the number of electrons in it?
    A. 2 B. 21
    C. 23 D. 44
31. The oxidation number of manganese in the compound $KMnO_4$ is
    A. 4 B. 5
    C. 6 D. 7
32. The IUPAC name of the compound $Mg(HCO_3)_2$ is magnesium hydrogen
    A. trioxocarbonate (III)
    B. trioxocarbonate (IV)
    C. trioxocarbonate (V)
    D. trioxocarbonate (II)
33. In which of the following states is matter fluid?
    A. Solid and liquid only
    B. Liquid and gas only
    C. Gas and solid only
    D. Liquid, solid and gas
34. Which of the following statements about a neutron is **correct**? A neutron
    A. is positively charged
    B. is negatively charged
    C. does not carry a charge
    D. has a variable charge
35. The collective name for particles contained in the nucleus of an atom is
    A. electrons B. neutrons
    C. nucleons D. protons
36. The electronic configuration of the element $^{40}_{18}Ar$ is
    A. 2, 18 B. 2, 8, 8
    C. 2, 8, 8, 2 D. 2, 8, 19, 4
37. Which of the following groups of substances is made up of elements **only**?
    A. Argon, magnesium, phosphorus
    B. Chlorine, air, nitrogen

C. Magnesium, bronze, hydrogen
D. Petrol, alcohol, water

38. There is no observable change in the quantity of substance during a chemical reaction or during a physical change. The above statement expresses the law of
A. conservation of energy.
B. conservation of matter.
C. definite proportions.
D. multiple proportions.

39. What is the chemical formula of the substance formed when Al^{3+} ions react with Cl^-?
A. AlCl B. $AlCl_3$
C. $AlCl_2$ D. Al_3Cl

40. An element **A** has two electrons in its outer shell. Another element **B** has six electrons in its outer shell. The **most** likely compound which can be formed by the combination of the two elements is
A. AB B. AB_2
C. A_2B D. A_2B_3

41. Which of the following processes is a physical process?
A. Electrolysis
B. Evaporation
C. Photosynthesis
D. Respiration

42. Which of the following chemical formulae correctly represents aluminium tetraoxosulphate(VI)?
A. $Al(SO_4)_2$ B. Al_2SO_4
C. $Al_2(SO_4)_3$ D. $Al_3(SO_4)_2$

43. A helium nucleus has two protons. How many electrons must be present in its shell to make it a neutral atom?
A. - 4 B. - 2
C. + 2 D. + 4

44. The following are all physical properties of matter **except**
A. capillarity.
B. heat.
C. viscosity.
D. volume.

45. Which of the following statements describes a pure substance?
A. Components retain their characteristic properties.
B. Components are indistinguishable.
C. It has fixed composition.
D. It has variable composition.

46. When the particles making up a substance are closely packed, fixed in position and regularly arranged, the substance is likely to be in the
A. gaseous state.
B. liquid state.
C. plasma state.
D. solid state.

47. Safety **devices** to be used in a chemistry laboratory include
I. A pair of goggles II. Nose guard
III. Crash helmet IV. Hand gloves
A. I, II and III only
B. I, II and IV only
C. II, III and IV only
D. I, II, III and IV

48. Which of the following chemical formulae represents Lead (II) oxide?
A. Pb_2O B. PbO
C. PbO_2 D. Pb_2O_4

49. Which of the following compounds does **not** show covalent characteristics?
A. Ammonia gas
B. Ethanol
C. Hydrogen chloride
D. Sodium chloride

50. An atom of sodium becomes an ion when it
A. gains one electron.
B. loses one electron.
C. gains two electrons.
D. loses two electrons.

51. In an electrically neutral atom the
A. number of protons and neutrons are equal.
B. mass number is given by the sum of protons and electrons.
C. number of protons is more than the number of electrons.
D. number of protons is equal to the number of electrons.

52. The electron configuration of chlorine is
A. 2, 7, 8. B. 2, 7, 7.
C. 2, 8, 7. D. 2, 8, 2.

53. Which of the following safety symbols warns against risk of electrical shock?

A. 
B. 
C. 
D. 

54. Which of the following compounds in **not** ionic?
A. Magnesium oxide
B. Potassium trioxonitrate(V)
C. Sodium tetraoxosulphate(IV)
D. Sulphur(IV) oxide

55. A non-metal, **X**, combines chemically with aluminium (Al = 13) to form a compound. What is the chemical formula of the compound? [Electron configuration of **X** is $1s^2 2s^2 2p^6 3s^2 3p^5$]

A. AlX_2 B. AlX_3
C. Al_2X D. Al_2X_3

Use the illustration of the hazard symbol below to answer questions 56 and 56.

56. If the hazard symbol is shown on a reagent bottle, it implies that the content is
A. corrosive. B. irritant.
C. oxidizing. D. radioactive.
57. An example of a chemical substance that is associated with this symbol is
A. ethanol.
B. calcium oxide.
C. mercury.
D. potassium hydroxide.
58. The electron configuration of sodium is
A. 2,1,8. B. 2,2,7.
C. 2,7,2. D. 2,8,1.

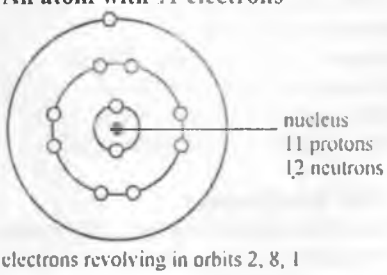
THEORY QUESTIONS (SECTION B)

SSSCE 1994 July Questions

1. An atom contains 11 electrons.
(a) Draw the electronic configuration of the atom.
(b) State with reasons, the type of chemical bond that the element can form with chlorine (atomic number 17).

SSSCE 1994 July Answers

1. (a) **An atom with 11 electrons**



(b) (i) The element will form ionic bond with chlorine.

(ii) **Reasons**
The element will lose an electron to attain chemical stability while chlorine accepts that electron to become chemically stable.

SSSCE 1995 July Questions

2. (a) Name the **three** main particles of an atom and state their charges.
(b) Describe how you would obtain a pure sample of sodium chloride from a mixture of sodium chloride and sand. [Q. 1 d]
(c) (i) What is *sublimation*?
(ii) Name **two** substances that can sublime. [Q. 5 b]

SSSCE 1995 July Answers

2. (a) **Particles in an atom**

Particle	Charge
Electron	–1
Proton	+1
Neutron	Nil

(b) **Separation of sodium chloride from sand**
1. Add water to the mixture of sodium chloride and sand
2. Stir to dissolve sodium chloride
3. Filter sand off
4. Collect the dry crystallized salt.

(c) (i) **Sublimation**
Sublimation is a change of a solid substance directly to the gaseous state.

(ii) **Substances that sublime**
Iodine crystal, naphthalene ball, ammonium chloride, dry ice, solid carbon dioxide

SSSCE 1996 July Questions

3. (a) Distinguish between a *covalent bond* and an *ionic bond*.
(b) For each of the ionic and covalent bond, give **one** example each of a compound which contains the bond.
(c) Give **two** characteristics of each of the covalent compounds and ionic compounds.

SSSCE 1996 July Answers

3. (a) (i) **Ionic bond**
Ionic bonds are formed as a result of the electrical attraction between a positive and a negative ion.

(ii) **Covalent bond**
Covalent bonds are formed as a result of sharing of electrons between atoms, one from each atom.

(b) (i) **Example of ionic bonds**
1. sodium chloride (NaCl)
2. magnesium chloride ($MgCl_2$)
3. calcium chloride ($CaCl_2$)
4. magnesium oxide (MgO)

(ii) **Example of covalent bonds**
1. water, H_2O
2. methane, CH_4
3. carbon(IV) oxide, CO_2

(c) (i) **Characteristics of ionic compounds**
1. Usually crystalline solids
2. Have high melting and boiling point
3. Conduct electricity when dissolved in solution
4. Insoluble in organic solvents
5. Consist of ions

(ii) **Characteristics of covalent compounds**
1. Usually liquids and gases
2. Low melting and boiling points
3. Do not conduct electricity
4. Soluble in organic solvents
5. Made up of molecules

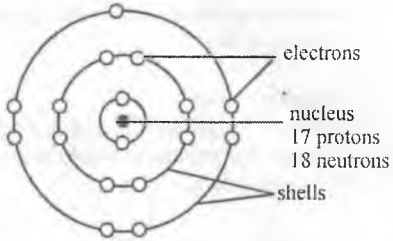
SSSCE 1997 July Questions

4. Atomic number of atom Y is 17 and its mass is 35.
   (a) Indicate the number of protons, electrons and neutrons in the atom.
   (b) Draw the electron configuration of the atom showing the positions of the protons and electrons as well as the arrangement of electrons in the various shells.

SSSCE 1997 July Answers

4. (a) Number of protons = 17
   Number of electrons = 17 since the atom is neutral
   Number of neutrons = mass number (A) – atomic number (Z)
   Number of neutrons = 35 – 17 = 18

(b) **An atom with atomic number 17**



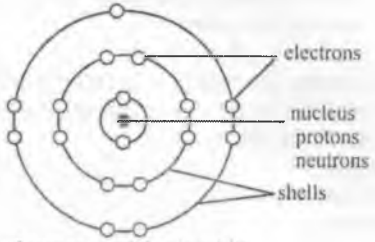
electrons revolving in orbits 2, 8, 7

SSSCE 1998 July Question

5. (a) Draw and label the structure of an atom.
   (b) What type of particles are produced when an atom
   (i) gains electrons?
   (ii) loses electrons?

SSSCE 1998 July Answers

5. (a) **Structure of an atom**



electrons revolving in orbits

(b) (i) **Particles produced when an atom gains electrons**
Anion (negative particles)

(ii) **Particles produced when an atom loses electrons**
Cation (positive particles)

SSSCE 2001 July Question

6. Name the type of bonds present in each of the following substance;
   (a) ammonium chloride,
   (b) calcium chloride,
   (c) carbon dioxide.

SSSCE 2001 July Answers

6. **Substance and bonds**

Substance	Type of bond
ammonium chloride	ionic bond
calcium chloride	ionic bond
carbon dioxide	covalent bond

SSSCE 2001 Nov Question

7. (a) State the name of each of the following processes:
   (i) conversion of an atom to positive ion;
   (ii) combination of hydrogen and hydroxyl ions;
   (iii) reaction between an alkanols and alkanoic acids.
   (b) Give **two** reasons why carbon dioxide is used in putting off fire. **[Q. 3 c]**

SSSCE 2001 Nov Answers

7. (a) (i) **Conversion of an atom to positive ion**
Oxidation

(ii) **Combination of hydrogen and hydroxyl ions**
Neutralisation

(iii) **Reaction between an alkanols and alkanoic acids**
Esterification

(b) **Suitability of CO, for extinguishing fire**
1. It does not support combustion.
2. It is heavier than air.
3. It produces no toxic compounds.

SSSCE 2002 July Questions
7. Describe briefly how a mixture of granulated sugar and sand can be separated. [Q. 1 b (ii)]

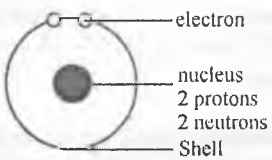
SSSCE 2002 July Answers
7. **Mixture sugar and sand**
1. Add water to the mixture and stir to dissolve the sugar.
2. Filter the mixture and collect the sand as residue
3. Crystallize the sugar solution or evaporate the filtrate to collect the sugar.

SSSCE 2003 July Questions
8. Tabulate **three** differences between covalent compounds and ionic compounds. [Q. 3 b (ii)]

SSSCE 2003 July Answers
8. **Differences between covalent and ionic bonds**
go to **Page 93 Question 3** for Answer

SSSCE 2003 Nov Questions
9. (a) Draw and label the structure of the helium atom ($^{4}_{2}He^{2+}$) [Q. 2 b (i)]
(b) Name the ion formed when an atom
(i) gains electrons
(ii) loses electrons [Q. 2 b (ii)]

SSSCE 2003 Nov Answers
9. (a) **Structure of the helium atom**



electrons revolving in orbits

(b) (i) **Particles produced when an atom gains electrons**
Anion (negative particles)

(ii) **Particles produced when an atom loses electrons**
Cation (positive particles)

SSSCE 2004 Nov Questions
10. What name is given to each of the following processes?
(a) The reaction between an acid and a base.
(b) The breakdown of a compound by heat energy.
(c) The absorption of heat energy to enable a reaction to take place.
(d) The addition of a substance to hasten the rate of chemical reaction.
(e) The passage of a solid substance into the gaseous state without passing through the liquid state. [Q. 3 a]

SSSCE 2004 Nov Answers
10. (a) **Reaction between an acid and a base**
Neutralization

(b) **Breakdown of a compound by heat energy**
Thermal decomposition

(c) **Absorption of heat energy to enable a reaction**
Endothermic reaction

(d) **Addition of substance to hasten rate of reaction**
Catalysis

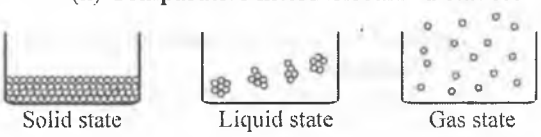
(e) **Passage of a solid substance into the gaseous state**
Sublimation

SSSCE 2005 July Questions
11. (a) (i) State **the three** states of matter.
(ii) Sketch and label diagrams to show the comparative intermolecular distances in each of the three states of matter. [Q. 1 a]
(b) (i) What is **IUPAC** nomenclature?
(ii) Give **IUPAC** names for the following compounds:
(α) $Fe(OH)_3$
(β) H_2SO_4
(γ) KNO_3 [Q. 4 a]

SSSCE 2005 July Answers
11. (a) (i) **States of matter**
(α) Solid state

(β) Liquid state
(γ) Gaseous state

(ii) **Comparative intermolecular distances**



(b) (i) **IUPAC nomenclature**
IUPAC nomenclature is the systematic naming of organic and inorganic compounds.

(ii) **Some IUPAC names**

Formula	**IUPAC name**
$Fe(OH)_3$	Iron(III) hydroxide
H_2SO_4	Tetraoxosulphate(VI) acid
KNO_3	Potassium trioxonitrate(V)

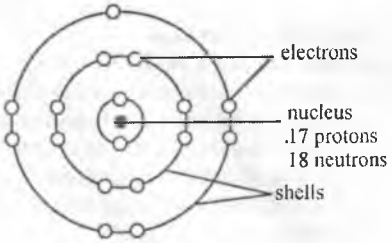
WASSCE 2004 NIGERIA Questions

12. (a) An element has an atomic mass of 35. If it has 18 neutrons,
(i) Determine the number of protons in each atom of the element.
(ii) Draw and label the atomic structure showing the electronic configuration of the element.
(b) What are:
(i) isotopes,
(ii) allotropes.
Give **one** example each of elements that exhibit **isotopy** and **allotropy**.

WASSCE 2004 NIGERIA Answers

12. (i) Number of protons, Z = mass number – neutron number, N
Z = 35 – 18 = 17 protons

(ii) **Atomic structure**



electrons revolving in orbits 2, 8, 7

(c) (i) **Isotopes**
Isotopes are two or more atoms of the same element having the same number of protons but different number of neutrons E.g. carbon

(ii) **Allot ropes**
The different forms of an element that exist in the same physical state are called allotropes. E.g. carbon (diamond, coal, e.t.c)

SSSCE 2006 Nov Questions

13. The chemical formula of a compound is $KMnO_4$.
(a) Give the IUPAC name of the compound.

(b) Determine the oxidation number of Mn in the compound.

SSSCE 2006 Nov Answers

13. (a) **IUPAC name of the compound $KMnO_4$**
Potassium tetraoxomanganate (VII)

(b) **Oxidation number of Mn in the compound**
Let x represent Mn
Oxidation number of K = +1 and O = – 2
The algebraic sum of the oxidation number in the formula is = 0
x + 1 + (– 2 x 4) = 0
x – 7 = 0
x = 7

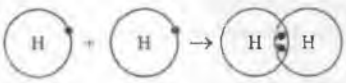
WASSCE 2007 May Question

14. (a) Explain how *covalent bonds are formed.*

(b) Give **one** example each of covalent and ionic compounds.

WASSCE 2007 May Answer

14. (a) **How covalent bonds are formed**
Covalent compounds are formed by the sharing of pair(s) of electrons between the two atoms involved. When non-metal atoms combine with other non-metal atoms, covalent bonding occurs. For example when two hydrogen atoms form a covalent bond sharing two electrons (one from each atom), both achieve the helium number of 2.



Formation of hydrogen molecule

(b) (i) **Examples of covalent compounds**
Water H_2O, carbon dioxide CO_2, Ammonia (NH_3), etc.

(ii) **Examples of ionic compounds**
Sodium chloride NaCl, calcium chloride $CaCl_2$, Magnesium chloride $MgCl_2$, etc.

WASSCE 2007 Nov Questions

15. (a) From the following list of compounds indicate which are covalent or ionic:
(i) ethanol,
(ii) potassium oxide,
(iii) hydrogen chloride,
(iv) copper(II) trioxonitrate,
(v) sulphur. [Q. 1 b]
(b) Describe how you would obtain a pure sample of sodium chloride from a mixture of sodium chloride and sand.

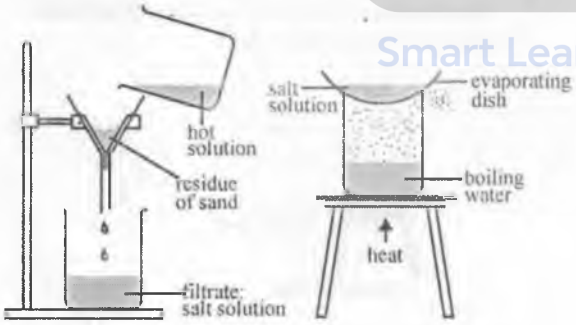
WASSCE 2007 Nov Answers

15. (a) **Covalent or ionic bond**

Compound	Type of bond
Ethanol	covalent
Potassium oxide	ionic
Hydrogen chloride	ionic
Copper (II) trioxonitrate	ionic
Sulphur	covalent

(b) **Separation of a mixture of common salt and sand**

1. Add distilled water to the mixture in a beaker
2. Warm the mixture and stir to dissolve the salt
3. Pour the mixture through a filter paper in a filter funnel, collecting the solution passing through into another beaker.
4. The sand remains in the filter paper, and it may be washed and dried.
5. Evaporate the filtrate in an evaporating basin over a steam bath
6. The salt is crystallized and collected



WASSCE 2008 Nov Questions

16. Write the *IUPAC* names of the following inorganic compounds:
(a) Cu_2O, [Q. 4 d (i)]
(b) PbO_2. [Q. 4 d (ii)]

WASSCE 2008 Nov Answers

16. **IUPAC names of**

Cu_2O	Copper(I) oxide
PbO_2	Lead(IV) oxide

WASSCE 2009 Nov Questions

17. (a) Classify the following compounds as covalent or ionic:
NaCl, Na_2O, NH_3 and HCl(g), [Q. 1 c (i)]
(b) Explain why ionic compounds have higher boiling points than covalent compounds.

WASSCE 2009 Nov Answers

17. (a) **Compounds as covalent or ionic**

NaCl	Ionic compound
Na_2O	Ionic compound
NH_3	Covalent compound
HCl(g)	Covalent compound

(b) **Why ionic compounds have higher boiling points**

Ionic compounds have high boiling points because they have strong electrovalent bonds (electrostatic force) between the ions. Therefore large amounts of energy are needed to break the strong electrostatic force between the particles in their crystal lattice.

WASSCE 2010 Nov Questions

18. The atomic number of atom **X** is 17 and its mass number is 35.
(a) Indicate the number of protons, electrons and neutrons in the atom.
(b) Draw electron configuration of the atom showing positions of the protons and the arrangement of the electrons in the various shells.

WASSCE 2010 Nov Answers

18. (a) **Protons, electrons and neutrons in atom with mass number 35**

(b) **Electron configuration of atom, mass number 35**

WASSCE 2011 May Questions

19. Study the table below and use it to answer the questions that follow.

Atom/Element	*Atomic number*	*Mass number*
V	10	18
W	18	39
X	15	33
Y	10	20
Z	11	23

(a) How many neutrons are there in atom **X**?
(b) Which of the atoms will readily form an ion?
(c) Which of the atoms will form an ion with a positive charge of +3?

(d) (i) Indicate the atoms that are isotopes.
(ii) Explain your answer in (a) (iv) (a) above. **[Q. 1 a]**

WASSCE 2011 May Answers

19. (a) **Number of neutrons in atom X**
Neutron number = mass number – atomic number
N = A – Z
N = 33 – 15
N = 18 neutrons

(b) **Atoms that will readily form an ion**
Atoms **X** and **Z** will readily form an ion because they have an excess of 5 and 1 electron (s) in their outer shell respectively.

(c) **Atom that will form an ion with a positive charge of +3**
Atom **X** will form an ion with a positive charge of +3.

(d) (i) **Atoms that are isotopes**
Atoms **V** and **Y** are isotopes of the same element.

(ii) **Why atoms V and Y are isotopes**
Because both atoms V and Y have the same atomic number.

WASSCE 2011 Nov Questions

20. (a) Explain the term *oxidation number* of an atom.
(b) Determine the oxidation number of manganese (Mn) in potassium permanganate ($KMnO_4$). **[Q. 1 c]**

WASSCE 2011 Nov Answers

20. (a) **Oxidation number of an atom**
The oxidation number of an atom is the charge the atom carries in its pure state or in its compound.
Or
Oxidation number is the number of electrons an atom share, loses, or gains from other atoms when chemical bonds are formed.

(b) **Oxidation number of Mn in $KMnO_4$**
Let **x** represent Mn
Oxidation number of K = +1 and O = – 2
The algebraic sum of the oxidation number in the formula is =0
x + 1 + (– 2 x 4) = 0
x – 7 = 0
x = 7

TEST OF PRACTICAL WORK

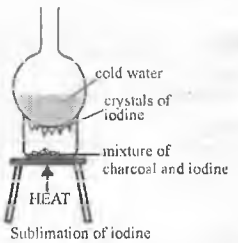
SSSCE 1993 July Questions

1. Describe briefly how each of the following mixtures could be separated
(a) Iron filings and sand
(b) Crystals of iodine and charcoal.

SSSCE 1993 July Answers

1. (a) **Iron Filings and sand**
Iron filings could be separated from sand by using a bar magnet.
1. Place a mixture of iron filings and sand on a watch glass
2. Gently pass a bar magnet over the surface of the watch glass
3. The iron filings are attracted by the magnet and cling to it
4. Removed the iron filings into a separate dish
5. The sand is non-magnetic and remains on the watch glass

(b) **Crystals of iodine and charcoal**
1. Place the mixture of iodine and charcoal in beaker
2. Stand the beaker on tripod gauze.
3. Fill a flask with cold water and place on the beaker.
4. Heat the beaker gently over a low flame.
5. Iodine sublimes and forms dense purple vapour which condenses on the flask to form a sublimate of pure iodine.
6. Continued heating until no violet vapour is seen to be coining from the mixture.
7. The charcoal is left at the bottom of the beaker since it does not sublime.



Sublimation of iodine

SSSCE 1994 July Questions

2. (a) State **one** use of the following apparatus in the laboratory?
(i) Fume chamber,
(ii) Volumetric flask,
(iii)Pipette,
(iv)Burette. **[Q. 1 a]**
(b) Name the apparatus, which is used to
(i) Separate a mixture of palm oil and water.
(ii) Isolate precipitate of silver chloride from sodium trioxonitrate(V) solution.

(iii) Grind lumps of chemical compounds in the laboratory.

SSSCE 1994 July Answers

2. (a) (i) **Use of fume chamber**
Fume chamber is for preparing and preventing of poisonous gases from spreading.

(ii) **Use of volumetric flask**
Volumetric flask is used to measure required volume of liquid or to prepare a standard solution.

(iii) **Use of pipette**
Pipette is used to measure a predetermined volume of a liquid or taking and delivering of a known quantity of a liquid accurately.

(iv) **Use of burette**
Burette is used to measure a known volume of a liquid or used in acid-base titrations to deliver variable volume of a liquid.

(b) (i) **Separation of a mixture of palm oil and water**
Separating funnel

(ii) **Separation of silver chloride from sodium nitrate solution**
A funnel or filter paper and conical flask

(iii) **To grind lumps of chemical compounds**
Mortar and pestle

SSSCE 1995 July Questions

3. (a) Give two examples for each of the following;
(i) Oxidizing agent,
(ii) Acidic gases,
(iii) Coloured salts ,
(iv) Cations that give coloured precipitates when drops of sodium hydroxide are added and do not dissolve when the sodium hydroxide is in excess. [Q. 1 a]

(b) Name an apparatus you would use in the laboratory to
(i) Measure 10.0 cm^3 of a liquid,
(ii) Weigh 10.0 g of a solid,
(iii) Keep substances dry.

SSSCE 1995 July Answers

3. (a) (i) **Example of oxidizing agent**
Chlorine, Oxygen, Bromine, Hydrogen peroxide, Potassium tetraoxomanganate(VII), Sulphur(IV) oxide

(ii) **Example of acidic gases**
Chlorine, Hydrogen chloride gas, Hydrogen sulphide, Carbon(IV) oxide, Sulphur(IV) oxide, Sulphur(VI) oxide

(iii) **Example of coloured salts**
Iron(II) chloride, Copper(II) tetraoxosulphate(VI) (blue) $CuSO_4$, Iron(II) tetraoxosulphate(VI) (green) $FeSO_4$

(iv) **Cations that give colour precipitates are**
Iron(II) ions, Fe^{2+} (green), Iron(III) ions, Fe^{3+} (green), Copper(II) ions Cu^{2+} (light blue)

(b) (i) **Apparatus used to measure 10.0 cm^3 of a liquid**
A pipette/burette/measuring cylinder

(ii) **Apparatus used to weigh 10.0 g of a solid**
Spring balance or chemical balance or digital balance or beam balance or top pan balance

(iii) **Apparatus used to keep substances dry**
Desicator

SSSCE 1996 July Questions

4. For each of the following methods of separating mixtures, give one mixture that the method can be used to separate;
(a) Filtration ,
(b) Sublimation,
(c) Distillation,
(d) Use of separating funnel,
(e) Chloromatography.

SSSCE 1996 July Answers

4. (a) **Mixtures that can be separated by filtration**
Sand and water, Suspension of chalk dust and water, Water and stains through layers of filter beds

(b) **Mixtures that can be separated by sublimation**
Iodine crystals and sand, ammonium chloride and sand, Naphthalene and any other solid, which do not sublime.

(c) **Mixtures that can be separated by distillation**
Ethanol, muddy water, crude oil, palm wine, akpeteshie

(d) **Mixtures that can be separated by the use of separating funnel**
Water and oil, any two immiscible liquids

(e) **Mixtures that can be separated by chromatography**
Ink, dye, urine, flower extracts, blood.

SSSCE 1999 July Questions

5. Some hazard symbols usually displayed on chemical containers are listed below.

A B C D E

(a) What does **each** symbol signify?
(b) Give **one** name of the chemical, which can be associated with each symbol.

SSSCE 1999 July Answers

5. (a) **Name of hazard symbols**
A Highly inflammable
B toxic/poison
C irritant/harmful
D oxidizing
E corrosive

(b) **Chemicals associated with symbol A**
Petrol, ethanol, ether, butanal, propanol

Chemicals associated with symbol B
Lead compounds e.g. lead or ethanoate, mercury compounds e.g. mercury or iodide, cyanide compounds e.g. potassium cyanide

Chemicals associated with symbol C
Ethanol, calcium oxide, bleaching powder

Chemicals associated with symbol D
Potassium tetraoxomanganate(VII), hydrogen peroxide, ammonium trioxonitrate(V)

Chemicals associated with symbol E
Sodium hydroxide, potassium hydroxide, hydrochloric acid, traoxosulphate(VI) acid

SSSCE 2001 July Questions

6. Explain briefly the danger involved in each of the following activities in the laboratory;
(a) Smelling an unknown gas with nose very close to the test tube containing the gas,
(b) Setting up a biological experiment without a control experiment,
(c) Adding water to concentrated mineral acids,
(d) Wearing rubber slippers.

SSSCE 2001 July Answers

6. (a) **Danger involved in smelling an unknown gas**
Unknown gas could be poisonous, harmful, choking or irritating to the body

(b) **Experiment without a control**
Comparism cannot be made to draw reasonable conclusion

(c) **Adding water to concentrated mineral acids**
Such a practice may generate heat or an explosion

(d) **Wearing rubber slippers in the laboratory**
One could slip and fall off as a result of spills on the ground and cause breakages or get burnt by solutions thus hurting oneself.

SSSCE 2001 Nov Questions

7. Explain briefly one danger involved in each of the following activities in the laboratory:
(a) washing the hand with an unknown colourless liquid in a beaker.
(b) opening a gas tap before looking for a match to light the Bunsen burner.
(c) dropping a large piece of sodium metal into water.
(b) chewing some food substance.

SSSCE 2001 Nov Answers

7. (a) **Washing the hand with an unknown liquid**
The unknown colourless liquid could be a dangerous chemical, which could cause serious burns to the hand.

(b) **Opening a gas tap before looking for a match**
The gas will leak into the surrounding air and lighting a match afterwards will cause fire outbreaks.

(c) **Dropping a large piece of sodium metal into water**
Sodium metal reacts violently with water to form sodium hydroxide which is corrosive and may cause burns when it explodes.

(d) **Chewing some food substance**
Hand, counters and glassware may contain substances that can contaminate food. Some chemicals emit radiations which will contaminate the food being eaten.

SSSCE 2002 Nov Questions

8. Study carefully the diagrams of the devices illustrated below and answer the questions that follow.

B

(a) Identify the device **B** above.
(b) Describe how the device **B** is used.

SSSCE 2002 Nov Answers

8. (a) **Name of device**
B a pipette

(b) **How the device B is used**

1. dip the tip of the pipette well below the surface of the liquid
2. fill pipette by sucking the liquid from the top
3. use pipette filter if solution is poisonous
4. place the fore finger at the open end and the tip
5. hold pipette horizontally
6. shake well and release the liquids through the tip

SSSCE July 2003 Questions

9. Some pure liquid which was stored in three different containers was found to have been contaminated with water at different degrees. In order to obtain the pure liquid back, the set up below was used to distil the mixture, M_1, M_2, M_3 in the laboratory. An initial volume of 250.0cm^3 of each of the three mixtures was used in the exercise. The pure liquid recovered in each case was collected into a beaker and then transferred into a measuring cylinder.

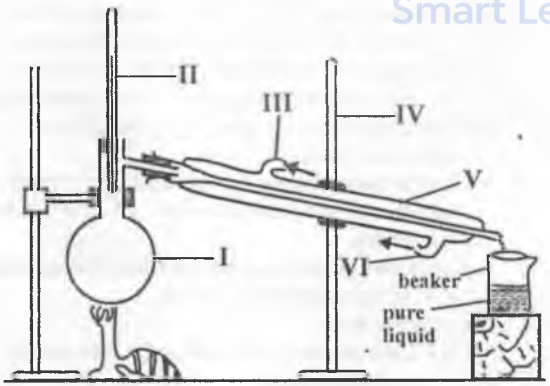
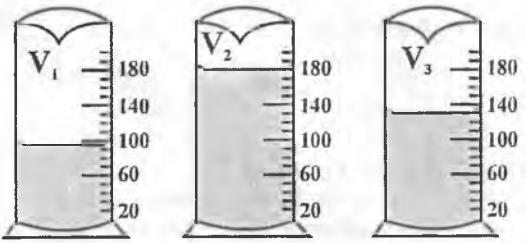


Fig (b) shows the volumes $V = V_1$, V_2 and V_3 of each pure liquid recovered from the 250.0cm^3 volume used which correspond to the mixtures M_1, M_2 and M_3 respectively.
Study the diagrams carefully and answer the questions that follow:



(a) Name the parts of the set up labelled **I, II, III, IV, V** and **VI**.
(b) Explain the function of the part labelled **V**.
(c) Read and record the volumes $V = V_1$, V_2 and V_3 of the pure liquid collected.
(d) (i) Arrange the **three** original mixture M_1, M_2 and M_3 in an ascending order of degree of purity.
(ii) Support your answer for (*d*) (i) with reasons.
(e) Calculate the percentage purity of the original mixture M_2.

SSSCE July 2003 Answers

9. (a) **Names of parts**
I Boiling flask or distillation flask or round bottom flask
II Thermometer
III water inlet
IV retort stand or clamp
V Leibig condenser
VI water outlet

(b) **Functions of V**
1. The cold water in the jacket of the condenser cools the vapour of the liquid coming from the flask.
2. This causes the vapour to condense and to be collected as liquid without the vapour escaping.

(c) **Volumes of liquid collected**
V_1 95 cm^3
V_2 180 cm^3
V_3 130 cm^3

(d) (i) Ascending order of degree of purity
$M_1 < M_3 < M_2$

(ii) **Reasons**: The most contaminated mixture will yield the least of pure liquid (M_1) while the least contaminated mixture will yield the greatest pure liquid (M_2).

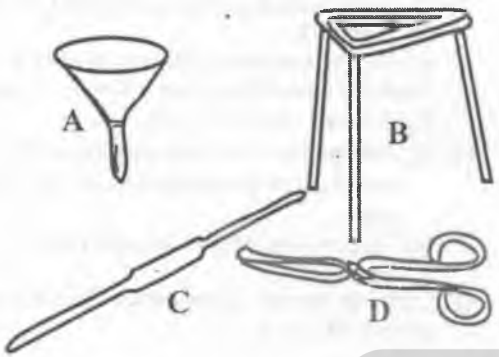
(e) % Purity of M,

$$\frac{180}{250} \times 100$$

$$= 72\%$$

SSSCE 2004 July Questions

10. Study carefully the laboratory devices illustrated below and use them to answer the questions that follows.



(a) Identify each of the devices **A, B, C** and **D**.

(b) (i) State **one** use of each of the devices **A, C** and **D**.

(ii) Describe how each of the devices **C** and **D** is used.

(c) Name the apparatus that can be used in the laboratory to undertake the following activities.

(i) measurement of 25.0 cm^3 of a solution.

(ii) picking a few pellets of a substance from a container.

(iii) keeping a substance dry.

(iv) grinding a solid substance into powder.

SSSCE 2004 July Answers

10. (a) **Name of devices**

A	funnel
B	tripod stand
C	pipette
D	tongs

(b) (i) (α) **Uses of a funnel**
For pouring solutions into beaker, bottles etc

(β) **Uses of a pipette**
For delivering a predetermined volume of liquid substance specially during titration

(γ) **Uses of a tongs**
For holding hot object

(ii) **How the pipette is used**

1. Dip the tip of the pipette well below the surface of the liquid
2. Fill the pipette by sucking the liquid from the top
3. Use the pipette filler if the solution is poisonous or dangerous
4. Place the fore fingers at the open end and the tip
5. Hold pipette horizontally
6. Shake well and release the liquid through the tip

(ii) **How the tong is use**

1. Insert the thumb and the forefinger into the handles
2. Push the fingers apart to open the blades
3. Press the opened blade firmly around the object, while pulling to lift the object

(c) Apparatus

(i) **Apparatus to measurement of 25.0 cm^3 of a solution**
Pipette

(ii) **Apparatus for picking a few pellets of a substance**
Spatula

(iii) **Apparatus for keeping a substance dry**
Desicator

(iv) **Apparatus for grinding a solid into powder**
Pestle and mortar

SSSCE 2004 Nov Questions

11. (a) (i) State **four** general rules which are to be observed in a school science laboratory.

(ii) Explain the reason(s) behind **two** of the rules you have stated in (i) above.

(b) Distinguish between boiling tube and test tube.

12. (a) Name **four** components of the experimental set up used for the distillation of liquids in the laboratory.

(b) State **one** function of each of the components you have named in (a) above.

(c) Explain the;

(i) Circumstance that will make it necessary to distill a liquid.

(ii) Physical property that makes distillation possible.

(d) Name **one** process that can be carried out on a liquid to achieve a similar result as that of distillation.

SSSCE 2004 Nov Answers

11. (a) (i) **Laboratory general rules**

1. Always wear safety glasses
2. Always add acid to water and not the water to the acid
3. Always wear suitable footwear
4. Do not taste any chemicals unless you are told to do so by your teacher
5. Do heat flammable liquids with a naked flame: always heat them in water or some other suitable heating vessel
6. Do not run in the laboratory
7. Do not enter laboratories without permission
8. Wash your hands after any practical work, etc

(ii) **Reasons behind the rules stated**

1. Safety glasses protects the eye from dangerous chemicals
2. Adding acid to water prevents the mixture from exploding

(iii)**Boiling tube and test tube**

Boiling tube is used basically for boiling whiles the test tube is use for holding small quantities of liquids.

12. (a) **Components of the experimental set up used for distillation**

Boiling flask, distillation flask and round bottom flask, Thermometer, retort stand or clamp, Leibig condenser.

(b) **Functions of component**

Boiling flask: To hold the liquid being distilled

Thermometer: To determine the temperature of the liquid in the flask

Retort stand or clamp: To hold the flask and condenser in place

Leibig condenser: To condense vapour (steam) to liquid

(c) (i) **When to distill a liquid**

When there are impurities in a liquid and the pure liquid is needed.

(ii) **Physical property that makes distillation possible**

Physical property that makes distillation possible is the different boiling points of the liquids.

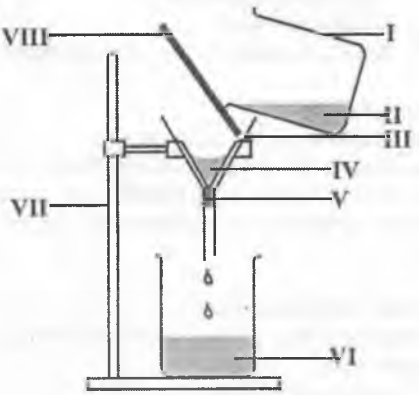
(d) **Alternatives of distillation**

Fractional distillation, crystallization, chromatography, decantation sedimentation

SSSCE 2005 July Questions

13. The figure below is an illustration of a set used in a schools laboratory to separate the components of a suspension.

Study the figure carefully and answer the questions that follow



(a) Name the parts labelled **I, II, III, IV, V, VI, VII** and **VIII**.

(b) (i) State **one** function of each of the parts labelled **V, VII** and **VIII.**

(ii) Name **two** materials that can be used for the part labelled **V**.

(c) Give **one** example of a suspension whose components can be separated with the set up.

(d) State **two** precautions that should be taken during the performance of the exercise involving the set-up. **[Q. 2]**

SSSCE 2005 July Answers

13. (a) **Names of the parts labelled**

I	beaker
II	suspension
III	funnel
IV	residue
V	filter paper
VI	filtrate
VII	retort stand
VIII	glass rod

(b) (i) **Functions of**

V To separate solids from the suspension, in which they are suspended, which can be removed from the filter paper and dried

VII To hold the funnel firmly in place

VIII To carefully pour the suspension down the funnel

(ii) **Materials for the part V**

1. Cotton wool
2. A piece of material (gray baft)

3. Glass wool
4. Foam

(c) **Suspensions that can be separated by this method**
1. Chalk water suspension
2. Clay water suspension
3. Sulphur in water
4. Powdered charcoal or carbon in water

(d) **Precaution**
1. Avoid splattering of the suspension
2. Ensure that the filter paper is firmly held in place to prevent the residue from entering the filtrate
3. Care must be taken to avoid breakage of glass ware

SSSCE 2005 Nov Questions

14. (a) State the colour of **each** of the following substances:
(i) tincture of iodine;
(ii) milk of magnesia;
(iii)hydrogen peroxide.
(b) State **one** uses of **each** of the substances listed in (a) above.
(c) Three gas jar containing hydrogen, carbon dioxide and ammonia have lost their labels in the laboratory. Using a table, indicate the tests, observations and conclusions that can enable you to identify **each** of the gases. [Q. 4]

SSSCE 2005 Nov answers

14. (a) **Colour of the following substances**
(i) Tincture of iodine – Brown
(ii) Milk of magnesia – White, milky suspension
(iii) Hydrogen peroxide – Colourless

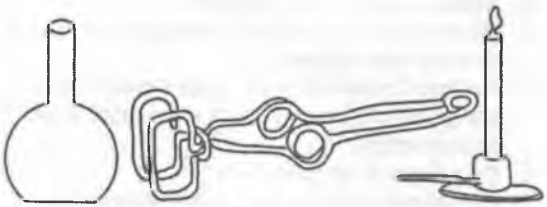
(b) **Uses of the following substances**
(i) **Tincture of iodine**: as an antiseptic
(ii) **Milk of magnesia**: as antacid in laxatives
(iii)**Hydrogen peroxide**: Antiseptic, for bleaching natural and synthetic fibres, purifying gas and liquid waste materials produced by industrial plants, etc.

(c) **Tests and observation of gases**

Test	Observation	Inference / Conclusion
Gas + moist blue litmus paper	Litmus turned red	Hydrogen or carbon dioxide
Gas + moist red litmus paper	Litmus turned blue	Ammonia
Gas + lighted splint	Pop sound is heard	Hydrogen gas
Gas bubbled through lime water	Lime water turned milky	Carbon dioxide
Dip a glass rod into conc. Hydrochloric acid and then into jar containing gas	White fumes are formed	Ammonia

WASSCE 2008 Nov Questions

15. (a) The figures below are illustration of laboratory apparatus.
Study the figure carefully and answer the questions that follow.



(i) Identify each of the apparatus **A, B** and **C**.
(ii) State **one** use of each of the apparatus mentioned in (i).
(b) State **one** method of separation for each of the following mixtures:
(i) muddy water and alcohol;
(ii) palm oil and water;
(iii)water and sand;
(iv) iodine crystals and sand.
(c) Describe briefly what would be observed in each of the following activities in the laboratory:
(i) a glowing splint is placed in a gas jar containing oxygen gas;
(ii) a drop of methyl orange is put into 5 cm^3 of sodium hydroxide solution;
(iii)a burning match is placed in a gas jar of hydrogen. [Q. 1]

WASSCE 2008 Nov Answers

15. (a) (i) **Identification of the apparatus**
A flat bottomed flask
B test tube holder
C Bunsen burner

(ii) **Use of apparatus**
A (flat bottomed flask): For holding solutions in the laboratory
B (test tube holder): For holding test tubes during heating
C (Bunsen burner): For heating substances in the laboratory

(b) **Separation of mixtures**

Mixture	Method of separation
muddy water and alcohol	Distillation
palm oil and water	Separating funnel
water and sand	Filtration
iodine crystals and sand	Sublimation

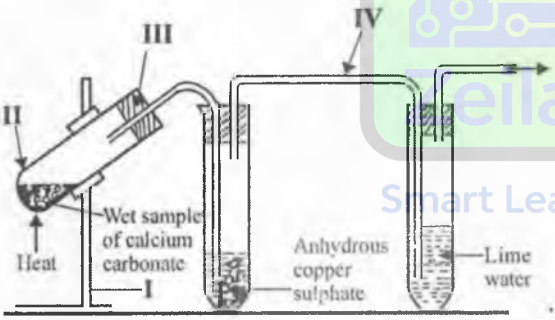
(c) Activity and observation

Activity	Observation
a glowing splint is placed in a gas jar containing oxygen gas	the glowing splint will burst into flames
a drop of methyl orange is put into 5 cm^3 of sodium hydroxide solution	Yellow colouration appears
a burning match is placed in a gas jar of hydrogen	A pop sound is heard and the flame goes out

WASSCE 2010 Nov Questions

16. (a) State the reason why **each** of the following laboratory practices is **not** appropriate and recommend the **correct** method of conducting **each** of the practices:
    (i) smelling evolving gas with the test tube pointing at the nose;
    (ii) covering a reagent bottle containing sodium hydroxide solution with a glass stopper;
    (iii) picking a hot object with bare fingers. [Q. 1 a]

(b) The figure below is an illustration of a simple experiment carried out by a student in the laboratory.
Study the figure carefully and answer the questions that follow.



(i) Name the parts labelled **I, II, III** and **IV**.
(ii) What will happen to the sample of wet calcium carbonate when it is strongly heated?
(iii) Write a balanced chemical equation for the reaction that takes place in (*b*) (ii).
(iv) At the end of the experiment, what happens to the,
    (α) anhydrous copper sulphate;
    (β) lime water.
(v) Name **one** other substance that can be used instead of the anhydrous copper sulphate.

WASSCE 2010 Nov Answers

16. (a) **Correct method of conducting laboratory practices**

Laboratory practice	Wrong method	Correct method
smelling evolving gas with the test tube pointing at the nose	The gas may be poisonous and it may have irritating or choking smell when it is inhaled	Direct the test tube away from the nose and move the gas towards the nose using hand (fanning) and smell the gas carefully
covering a reagent bottle containing sodium hydroxide solution with a glass stopper	glass stopper will get stuck in the reagent bottle making it difficult to open	Wooden cork or rubber should be used to cover the reagent bottle instead
picking a hot object with bare fingers	The hot object may burn the fingers and hand and cause scar	Use test tube holder, a pair of tongs or a piece of cloth

(b) (i) **Names of the parts labelled**
I retort stand
II hard glass test-tube
III rubber bung
IV delivery tube

(ii) **After heating wet calcium carbonate**
After strong heating the calcium carbonate will decompose to form calcium oxide and carbon dioxide. Water is also given off.

(iii) **Balanced chemical equation in (*b*) (ii)**
$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

(iv)(α) **What happens to the anhydrous copper sulphate**
The water in the test tube evaporates and condenses and turns the white colour of the anhydrous copper sulphate to a blue colour.
$CuSO_4(s) + 5H_2O(l) \rightarrow CuSO_4.5H_2O$
white water blue

(β) **What happens to the lime water**
The lime water turns milky

(v) **Other substance instead of the anhydrous copper sulphate**
Anhydrous cobalt(II) chloride crystals
$CoCl_2(s) + 6H_2O(l) \rightarrow CoCl_2.6H_2O$

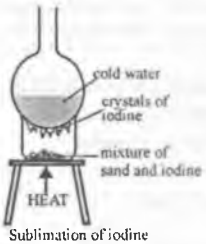
WASSCE 2011 Nov Questions

17. (a) Describe **briefly** how a mixture of iodine crystals and sand could be separated in the laboratory.
    (b) Name the method of separating the mixture described in (i).

WASSCE 2011 Nov Answers

17. (a) **Separation a mixture of iodine crystals and sand**

1. Place the mixture of iodine and sand in beaker
2. Stand the beaker on tripod gauze.
3. Fill a flask with cold water and place on the beaker.
4. Heat the beaker gently over a low flame.
5. Iodine sublimes and forms dense purple vapour which condenses on the flask to form a sublimate of pure iodine.
6. Continued heating until no violet vapour is seen to be coining from the mixture.
7. The sand is left at the bottom of the beaker since it does not sublime.



Sublimation of iodine

Or

1. Put the mixture in evaporating dish/test tube/beaker
2. Mix mixture with KI solution to dissolve iodine
3. Filter to obtain sand
4. Recrystalise iodine from solution
5. Dry solid iodine

(b) **Name of separating method**
Sublimation

1 D; 2 C; 3 D; 4 D; 5 B; 6 D;7 B; 8 C; 9 D; 10 B; 11 B; 12 B; 13 C; 14 D; 15 A; 16 C; 17 B; 18 A; 19 D; 20 C; 21 D; 22 A; 23 C; 24 D; 25 D; 26 C; 27 B; 28 B; 29 D; 30 B; 31 D; 32 B; 33 B; 34 C; 35 C; 36 B; 37 A; 38 B; 39 C: 40 C; 41 B; 42 C; 43 B; 44 B; 45 B; 46 D; 47 B; 48 B; 49 D; 50 B; 51 D: 52 C; 53 B; 54 D; 55 B; 56 B; 57 A; 58 D.

23. Amount of substance

1 A; 2 A; 3 C; 4 B; 5 A; 6 D; 7 C: 8 C; 9 B; 10 C; 11 C; 12 B; 13 A; 14 C; 15 B; 16 A; 17 D; 18 A; 19 C; 20 A; 21 B; 22 B; 23 D; 24 D; 25 B; 26 D; 27 A; 28 A; 29 B; 30 C; 31 B; 32 A; 33 D; 34 A; 35 D; 36 D;37 B; 38 A.

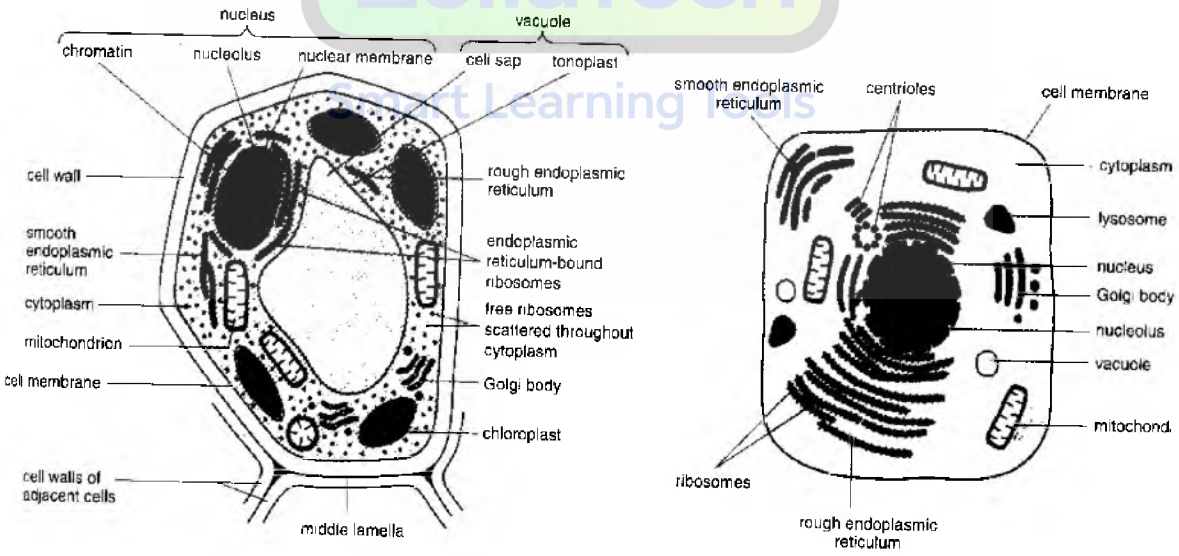
The cell is the basic unit of life. All living things are made up of cells, just as bricks are building blocks of houses. Cells are basically made up of cytoplasm and nucleus this is called the **protoplasm**.

Cells can be single, they are unicellular, and examples include paramecium, amoeba, and euglena. Other cells are in multiples, they are multicellular, and examples include plants and animals.

Cells are so tiny that they need to be stained with a dye (iodine or methylene blue) for the different parts to show clearly under a microscope.

Table 1.5.1 Differences between plants and animals cells

Plant cells	**Animal cells**
Definite shapes	Irregular shapes
Cellulose cell wall outside the cell membrane	No cellulose cell wall outside the cell membrane
Large permanent vacuole	Contain small temporary vacuole
Possess chloroplasts containing chlorophyll	No chloroplast, therefore no chlorophyll
Stores starch as carbohydrate food reserve	Stores glycogen as carbohydrate food reserve



Typical plant cell and typical animal cell

1.5.1 Structure and functions of the cell

- Organelles → minute, membrane-bound structures in the cytoplasm e.g. are nucleus, vacuole etc.
- Chloroplasts → large, egg-shaped or disc-shaped organelles which contain green pigment, chlorophyll which traps energy in sunlight for photosynthesis.
- Vacuoles → provide turgidity in plant cells. They are fluid-filled spaces in the cytoplasm bounded by a single membrane called tonoplast.
- Cell wall → protects and supports the cell contents. It is a structure surrounding the cell membrane.
- Ribosomes → are sites for protein synthesis. They are minute structures found in large numbers in cells. Some are free in the cytoplasm while others are bounded to the outer surface of the endoplasmic reticulum.
- Endoplasmic reticulum → it is a network of channels bounded by a membrane and founded throughout the cytoplasm which connects to the nuclear and cell membrane.
- Nucleus → is the life functioning unit of the cell. It contains threadlike structures called chromosomes. This organelle controls the reactions inside the cell and plays an important part when the cell divides.
- Mitochondrion → it is the site for cellular respiration to produce energy.
- Lysosomes → it contains enzymes involved in digestive breakdown of material in the cell. These enzymes also defend the cell against attack by bacteria, viruses and toxic substances. Chemicals from Lysosomes destroy old and worn out cells including themselves, for this reason they are often referred to as 'suicide sacs'.

Levels of organization of cells in living organisms:

A tissue is a group of specialized similar cells that perform the same function.

Name of tissue	Cells forming tissue	Main function
in plants		
photosynthetic tissue	palisade mesophyll cells	produces food
strengthening tissue	sclerenchyma cells of the pericycle	provides support
epidermal tissue	epidermal cells	covers the plant surface
vascular tissue	xylem vessels, phloem sieve tube elements	transports water, transports organic food
in animals		
blood tissue	red blood cells	carries oxygen around the body and removes carbon dioxide and other waste material from cells
skeletal tissue	osteocytes	provides support
nerve tissue	nerve cells (neurones)	conducts and co-ordinates nerve impulses
muscle tissue	muscle cells	contracts to bring about movement

Examples of plant and animal tissue.

An organ is a group of different tissues which perform the same function(s)

An organ system consists of two or more organs working together to perform a specific function.

The organ system coordinate or work together to enable living organisms carry out all life processes and exist on their own.

Examples of organs and their main functions

Name of organ	Names of tissues forming organ	Main functions
in plants		
root	root hairs, piliferous layer, cortex, endodermis, pericycle, xylem and phloem	absorbs water and mineral salts from soil and supports the plant
stem	epidermis, collenchyma, parenchyma, vascular bundles	transports water and mineral salts, supports the leaves, flowers and fruit
leaf	epidermis, palisade mesophyll, spongy mesophyll, vascular bundles	makes food, transpires, exchanges gases
in animals		
heart	papillary muscles, cardiac muscles	pumps food and oxygen around the body
kidneys	cortex, medulla	excretes waste metabolic substances, regulates water levels

gan systems and their functions

Name of syste...	Main organs	Functions
in plants		
root system	roots and their branches	absorbs water and mineral salts, supports the plant
shoot system	stems, leaves, buds, flowers, fruits	makes food, transports organic food, water and mineral salts, reproduces
in animals		
digestive system	stomach, intestines, liver, pancreas	digests and absorbs food
circulatory system	heart, arteries, veins, capillaries	carries food and oxygen round the body
sensory system	eyes, skin, nose, ears, tongue	detects stimuli

The levels of cell organization in plants and animals are five in all. They are as follows: - Cells → tissue → organ → organ system → organism. The arrow means from.

Specialized cells are cells structurally adapted to perform a specific function, examples are:

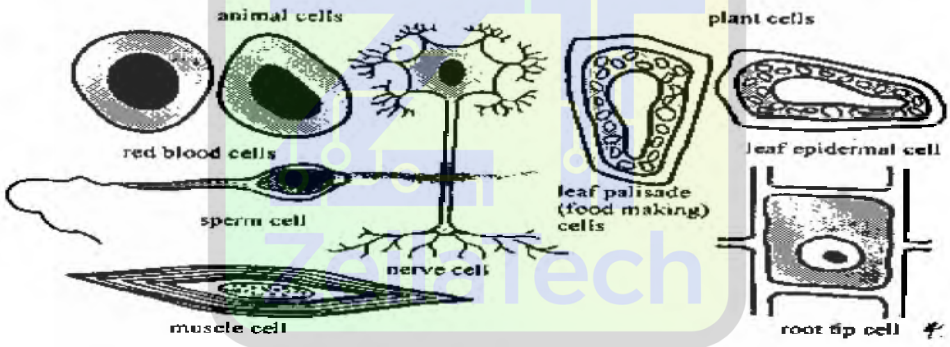
Animal specialized cells and their functions

- Stem cell → this is an undifferentiated cell from which specialized cells e.g. blood cells develop.
- Sperm cell → to fertilize eggs
- Ovum → designed to be fertilized
- Red blood cell → carries oxygen to parts of the body
- Muscle cells → contracts for movement
- White blood cells → fights diseases and infection
- Phagocytes → these are some white blood cells in the lymph nodes and blood that destroy bacteria by engulfing (swallowing up) and digesting them in an amoeboid fashion.

- Lymphocytes → these are antibodies, proteins, produced by white blood cells that destroy antigens, chemical substances produced by pathogens.
- Nerve cells → transmits nerve impulses from one part of the body to another

Plant specialized cells and their functions

- Root tip cell → divides to give rise to different tissues
- Leaf epidermal cell → allows light to enter the leafs so as to reach the photosynthetic tissues below them
- The palisade cell → absorbs CO_2 and light needed for photosynthesis
- Root hair cell → increases surface area to absorb water and minerals
- Guard cells → opens and closes to conserve water
- Xylem cells → transports water and mineral salts.



Examples of specialized cell

1.5.2 CELL DIVISION

This is the process whereby living organisms start life as a single cell and give rise to all other cells of the organism. Without cell division, scratches would never heal and blemishes will never disappear. If your red blood cells did not divide and reproduce, you will die. There are two processes of cell division. These are **mitosis** and **meiosis**.

Principle of Mitosis

All living things are made up of one or more cells. Cells are formed from pre-existing cells by cell division. Cell division occurs by a purpose of binary fission – a form of asexual reproduction in which (nucleus + cytoplasm) one cell divides into

two equal parts. It is by means of cell division that multicellular organism grows starting from a single cell.

It occurs in both germ (sex) and somatic (body) cells. All the body cells of a given species have a definite number of chromosomes. These chromosomes exist in pairs, in humans there are 23pairs making 46 chromosomes and onion 8pairs making 16.

A cell with the full number of chromosomes is said to be **diploid**.

- Mitosis involves an equal division of chromosomes into two cells.
- Each daughter cell receives exactly the same *number* and *type* of chromosomes as were present in the parent cell.
- Mitosis is active during embryonic development, growth, repair of injury, and the replacement of body-covering during moulting (losing of outer layer of skin hair, fur or feathers)
- It takes place during the growth of an organism and found in all parts capable of growth and repair, differentiation and rejuvenation. In plants it takes place at root of a seedling, in mammals it takes place in root hair cells, roots of nails, malphighian layer of the skin, bone marrow, lymph nodes and injured area.
- Two daughter cells are produced which are diploid.

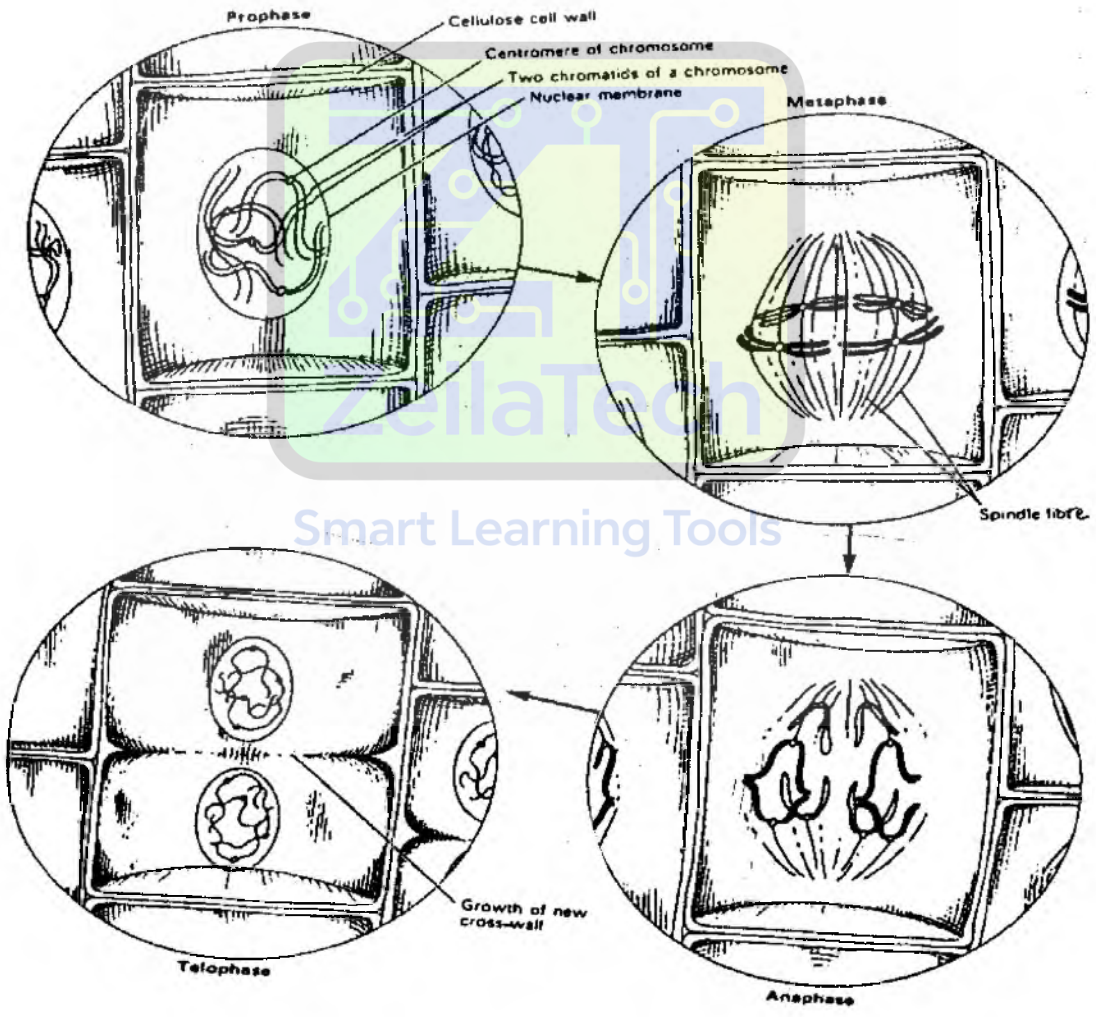
Continuous changes occurring in mitosis are divided into four stages:

- **Prophase** → the chromosomes first appear as long, slender threads, they dehydrate and become shorter and thicker. Each chromosome appears to consist of two threads called **chromatids** and is joined together at a point called **centromere**. The nuclear membrane and the nucleolus disappear. Spindle fibres then form in the cytoplasm.
- **Metaphase** → at this stage the spindle formation is completed. The chromosomes then collect around the middle of the spindle with their centromeres on the equator.
- **Anaphase** → the centromere divides to separate the two chromatids of each chromosome. Each of the separating chromatids is pulled by its spindle fibre to the opposite poles of the spindle. The centromere takes the lead.
- **Telophase** → at this stage sister chromatids arrives at the poles. A new nuclear membrane is formed and a nucleolus reappears in each nucleus.

In plant cells a new cell wall forms to divide the cytoplasm into two parts. In animal cells the cell membrane divides the cytoplasm into two, to form two daughter cells.

Significance of mitosis

- It takes place during growth of organisms e.g. in the development of a fertilized egg (zygote)
- It is significant in the repair of worn out tissues
- It is the basis of asexual reproduction.
- It ensures the constancy of the chromosome.



Cell division by mitosis

Meiosis also called reduction division occurs to produce gametes in organisms which reproduce sexually. It takes place in the formation of gametes (sex cells). In plants it can be found in the anther and ovaries of flowers. In mammals it is observed in the testes and ovaries. It occurs within the reproductive organs, prior to the formation of pollen and embryo sacs in flowering plants, and in the formation of sperms and egg in animals. In meiosis the daughter cells end up with half the total number of chromosomes present in parent cells. The diploid cell undergoes two successive divisions forming haploid (four daughter cells.

Meiosis occurs in two phases each of which involves five stages.

The four continuous changes are:

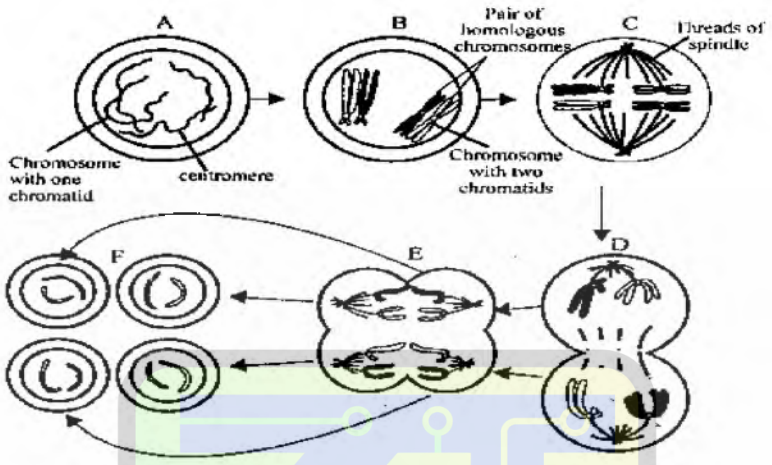
- **Prophase I**: chromosomes are single throughout their entire lengths at their centromere. The pair of chromosomes, bivalent, lies closely together for all parts of the chromosomes to correspond exactly. The bivalent homologous pair lying side by side begins to shorten and thicken; here the chromatids making up each chromosome begins to appear. The chromatids get attached to those of its homologous pair at certain points called chiasmata (singular: chiasma) while they repel each other at other points.
- **Metaphase I:** the chromosomes lie at the equatorial region of the spindle with bivalents keeping together.
- **Anaphase I:** members of the pair of the whole homologous chromosome move apart, towards both poles.
- **Telophase I**: at the end of this first meiotic division only half the numbers of chromosomes are found at each pole. The cytoplasm then divides, so forming two daughter cells, each known as a haploid. After the second meiotic division, the chromatids of each chromosome become separated and lie in different cells resulting in the production of four haploid cells. Thus the division is termed reduction division.

Importance of meiosis

1. Meiosis halves the chromosome number. The normal number is restored during fertilization. If this were not the case, the chromosome number

would double at fertilization and the offspring produced would be different from their parents.

2. The formation of chiasmata brings about a new combination of genes in the gamete which can lead to genetic variation.



Cell division by meiosis

Table 1.5.2 Differences between Mitosis and Meiosis

Mitosis	Meiosis
Occurs in somatic (non -sex) cells such as root and stem apices and cambium in plants, and in dividing body cells in animals.	Occurs in reproductive cells such as the ovule and anther in flowering plants and in ovary and testis in animals.
Homologous chromosomes do not cross over	Crossing – over of homologous chromosomes occurs
Two daughter cells are formed	Four daughter cells are formed
Occurs during growth, repair of the body and as the basis of asexual reproduction	Occurs during the formation of gametes, as the basis of sexual reproduction
Cell division occurs once	Cell division occurs twice

QUESTIONS:

1998 Questions:

1. (a) (i) What is a specialized cell?
   (ii) Give two examples of specialized cells and in each case state its function.
   (b) (i) Draw and label a typical plant cell.
   (ii) Give the functions of three labeled organelles.
2. Predict what would happen to a cell if its mitochondria failed to work.
3. (a) What is the function of chloroplasts?
   (b) Why are chloroplasts not found in animal cells?

1. 6 ROCKS

Rocks are aggregates of one or more minerals. The major types of rocks are Igneous, Sedimentary and Metamorphic rocks.

Igneous rocks: - are rocks formed when molten lava cools down and solidifies. They are massive. Their texture varies from glassy to coarsely crystalline, depending upon the rate of cooling of magma e.g. granite, gabbro, diorite, basalt. They do not contain fossils. They are formed inside the earth, under great pressure and heat. They do not occur in layers and most of them are crystalline. There are two main groups:

- Volcanic (these have been poured out onto the earth's surface, and they are called lavas) e.g. basalt.
- Plutonic (these have solidified deep in the earth's crust and then reach the surface only by being exposed by erosion) e.g. granite.

Sedimentary rocks: - are produced by the breaking up of pre – existing rocks and the deposits of their materials. They are usually composed of particles of rocks which have been deposited, usually in layers (stratified), by water, wind or moving ice. Sedimentary rocks are non – crystalline. They contain fossils e.g. gravels, loess, limestone, conglomerate, dolomite, common salt, coal, clay, gypsum, nitrates.

Metamorphic rocks: - are rocks whose structure and appearance have been changed by great heat, or great pressure, or both. Any rock can be changed to a metamorphic rock e.g. Marble (from limestone), Slate (from clay), Gneiss (from granite), Quartzite (from sand), Graphite (from coal) and Schist (from shale).

Weathering of Rocks

Weathering: - is the gradual breakdown of rocks into smaller and smaller particles by agents such as water, sudden change in temperature, wind, atmospheric oxygen and roots of plants.

Rocks can be weathered physically, chemically and biologically.

Physical Weathering

This occurs when rocks crack and crumble as a result of warming by the sun and rapid cooling after sunset.

Water may enter the cracks, freeze and expand, causing bigger cracks and breakdown of the rocks.

Sharp edges of rock fragments, carried by rivers or streams, rub and wear down rock surfaces over which they pass.

Wind may also blow sand against rocks and weather them.

Effects of Temperature on Weathering of Rocks

- high temperature causes the rock to expand
- low temperature causes the rock to contract
- the uneven expansion and contraction of rock minerals cause cracking and disintegration of rocks into smaller particles.

Chemical Weathering

This occurs largely due to the action of atmospheric oxygen in the tropics. The moist and hot conditions help bring about quick oxidation of iron compounds in some rocks which break up easily to give rise to laterite soils.

- Oxidation: - is the combination of atmospheric oxygen and oxygen contained in rain water with rock minerals or compounds which breaks easily e.g. $Fe_2O + O_2 \rightarrow Fe_2O_3$ + ferric oxide (hematite).

- ❖ Hydration: - involves the rigid attachment of water to substances like rock minerals making them soft and porous for easy breakdown.
- ❖ Hydrolysis: - minerals in rocks reacts with water and disintegrates e.g. $CaSiO_3 + 2H_2O \rightarrow H_2SiO_3 + Ca(OH)_2$
- ❖ Carbonation: - is the process by which hydrogen carbonate (HCO_3^-) ions combine with rock minerals, which cause disintegration.

Biological Weathering

This involves the penetration of rocks by roots of plants exerting considerable pressures, which eventually split some rocks. The activities of earthworms, termites and other soil organisms have similar effects.

2001 July Questions:

1. (i) Distinguish between igneous rocks and sedimentary rocks, giving one example of each.
   (iii) Describe briefly the effects of temperature on weathering of rocks.

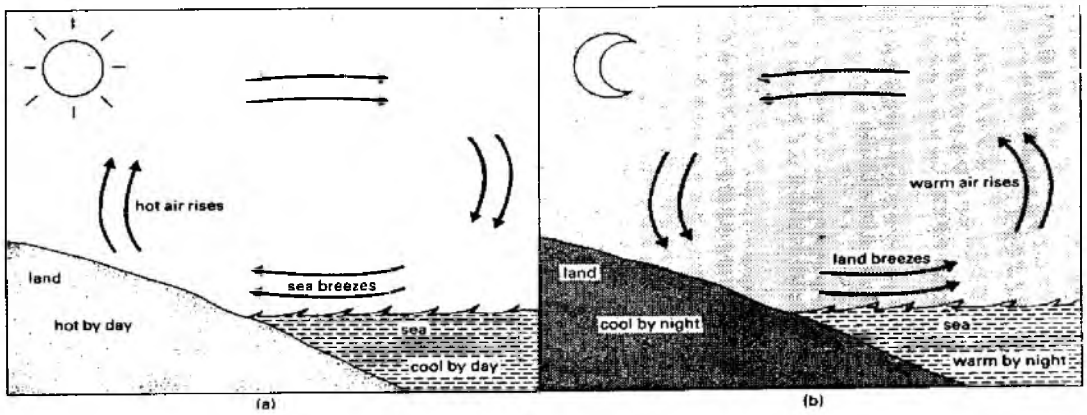
SECTION 2: CYCLES

2.1.0 AIR MOVEMENT

LAND AND SEA BREEZES

It requires less heat to raise the temperature of a solid than it does for a liquid. Liquids keep their heat longer than do solids. Fluids (liquids and gases) expand when heated, so its density becomes less, it thus rises and takes heat along with it. This movement of fluid forms a current, called convection current. **Convection current** is thus, the flow of heat energy in fluids involving the mass motion of the fluid molecules.

When the sun rises, it heats both land and sea. The temperature of the land becomes higher than the sea. The warmer air, over the land, rises, and is replaced by cooler air coming in from the sea. Convection current is formed, and produces a breeze (i.e. a light wind) coming from the sea; this is a sea breeze, illustrated in Figure below:



Land and Sea breezes

By midday, both land and sea are at the same temperature and the breeze stops. During the evening, the sun stops heating the land and sea, and both starts to cool. By late evening, the sea is warm and the land is cool. This forms convection current, due to the warmer air rising above the sea.

Land breeze is formed, as cooler air from the land blows out to sea to replace the warmer air. At night, both land and sea are at the same temperature and the land breeze stops.

Convectional current involved at homes, offices and industries.

Ventilation of rooms: the supplying of fresh air to a room or building. In tropical houses, windows should be placed low down near the floor for cool air to enter. The air becomes warm in the room, and the warm air rises and escapes through ventilation holes high up on the walls.

Cooling of engines

Domestic hot water system

Air conditioning: cold, dry air from the air conditioner sinks into the floor. It becomes warm and moist, due to expired air from the occupants of the room. The warm rising and the cold air sinking form convection current. The air conditioner extracts the warm, moist, air, filters it, and then cools it for recirculation.

Refrigerators: the freezer is part of the refrigerator which is cooled by the refrigeration engine. The freezer is placed at the *top* of the refrigerator, as it

forms convection currents by *cooling* the air. The cold air sinks to the bottom of the cabinet.

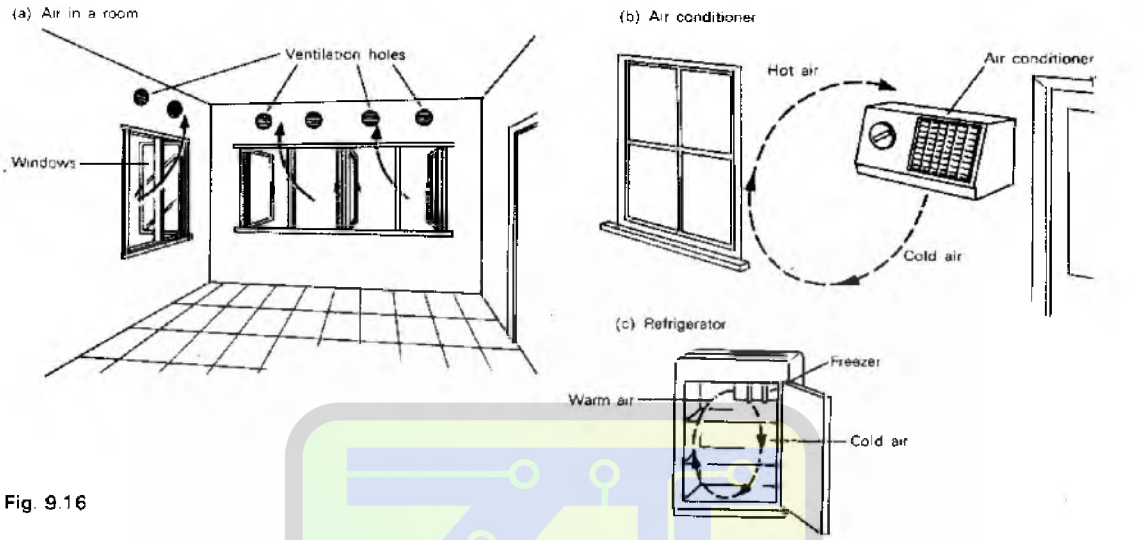
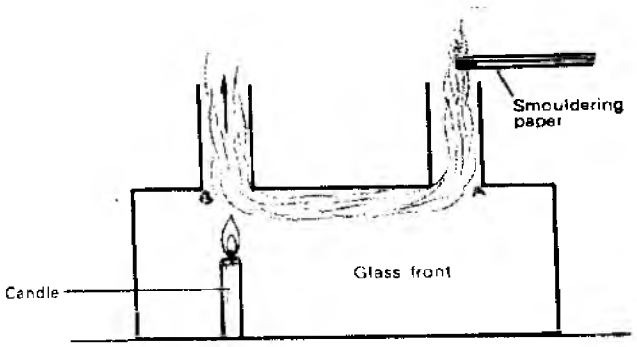


Fig. 9.16

Applications of convection currents in air

Demonstration of conventional current in gases using smoke box

1. Make a small box with a glass front; the box has no bottom, but stands on a glass plate, and is made airtight with 'plasticine'.
2. Place two glass tubes in holes in the top of the box.
3. Put the lighted candle beneath tube (B) as shown below.
4. Place some smouldering paper (paper soaked in potassium nitrate smoulders readily) on tube (A).Observe the air currents by means of the smoke.



Smoke box

Observation:

The smoke from the lighted candle travels in the opposite direction indicating the movement of air in the smoke box. This is because the air above the candle is heated and becomes lighter. Hence lighter air rises up the tube (B) immediately above it.

In this way, cooler air from outside comes down through the other tube (A) to take its place and so the air is set into circulation.

The smoke from the smouldering paper mixes with the cold air coming down the tube (B).

This shows the direction of the convection current of air. This experiment is applied by people using smoke to force out rat from their holes.

2.1.1 AIR MASSES

These are large, horizontally uniform bodies of air with similar temperature and humidity characteristics; which form over a source region; e.g. cold land areas of northern Canada, the north central part of Russia, the warm tropical areas in oceans closer to the equator.

Types of air masses:

- Continental polar (dry lower, upper moist)
- Maritime polar (moist)
- Continental tropical (dry)
- Maritime tropical (moist lower, upper dry)

Air masses move at speeds of up to 800km per day. They mostly retain the temperature and moisture characteristics of the source region. When it slows and stagnates over a new location the air may again begin to acquire a new temperature and moisture equilibrium with the surface.

TRADE WINDS: - these are winds that blow towards the equator.

Westerlies are trade winds that blow towards the poles. When Westerlies converge with cold air currents they are called Easterlies. **Easterlies** are therefore sinking cold dense air moving from the poles to the equator.

2.1.3 Effects of moving air masses

- The air masses play a dominant role in transporting pollutants from the industrialized countries to peasant farmers in Africa and Asia.
- CFC's are sent into the atmosphere by air masses, where they destroy the ozone layer.
- Pollution of the air and destruction of biodiversity – when harmful gases such as Sulphur dioxide and Nitrogen oxides are blown from one region to another.
- Moving air mass can spread smoke from burning bush when the warmer and lighter smoke is displaced by the cold and heavier air.
- They produce thundery conditions - as two air masses meet over the oceans (having moist lower layers but drier upper layers, one of them will tend to be lifted up) causes instability. Large cumulus clouds develop to produce intense thundery conditions.
- Moving air masses have effect on climate – as a cold front passes the weather changes very rapidly. The wind now blows from the north – west and the temperature falls. Short but often heavy falls of rain occur.
- Causes very severe and destructive damage when moving air masses come into contact to form a front to create storms.

A **storm** is created when two air masses come into contact to form a **front** and the contrasts in temperature and humidity are sufficiently great, or if wind directions of the two touching masses are opposite.

The changes that accompany some fronts may be so mild that they go unnoticed. Others are noticed only as a day with breezes and dusty winds. Still other fronts are accompanied by rapid and violent weather change, this is a major storm.

In the transitional zones, (between latitudes 30^0 and 65^0 north and south of the equator), unstable weather conditions create huge fronts called **cyclones**. Cyclones are strong winds that whirl round while moving. This is as a result of intermingling of polar and subtropical air.

Tornadoes, hurricanes, typhoons are terms which describe cyclones in different parts of the world.

Table 2.1.1 Differences between air masses and storms

AIR MASSES	STORMS
Have a source region	Do not have a source region
Have large body of air with nearly the same temperature and moisture conditions	Have rapid and violent range of weather changes with wide range of temperature, moisture and other conditions
Generally not destructive even though it can result in hazy periods of air pollution	Damage caused by storms are very severe and destructive
Are not associated with lightning and strong wind even though it can speed up to 800km a day	Storms are mostly associated with lightning, cracking sounds and strong winds.

Early warning signs of approaching storms

- The air seems unusually calm as a few clouds appear, then thicken as the wind begins to gust (a sudden brief rush of wind).
- Lightning is usually seen, accompanied by thunder.
- There is evidence of strong winds blowing in different directions depending on the types of storm.
- Overall wind speed increases as strong gust and intense rain showers occur.

Precautions against the effects of storms

- Avoid being in an open space when storms are approaching.
- A safe place could be inside a car or a building with metal frames.
- Meteorologists should be able forecast procedures on early warning signs for citizens to take cover.

REVISION QUESTIONS

1. (i) What are conventional currents?

   (ii) Explain briefly how smoke from burning bush is spread by moving air masses

2. (i) What is sea breeze?

   (ii) Sketch and label a diagram to show the occurrence of sea breeze.

2.2.0 NITROGEN CYCLE

Nitrogen is essential for plant growth and reproduction because it is a characteristic constituent element of proteins. Nitrogen starvation in plants is characterized by a general yellowing of the leaf, and stunted growth.

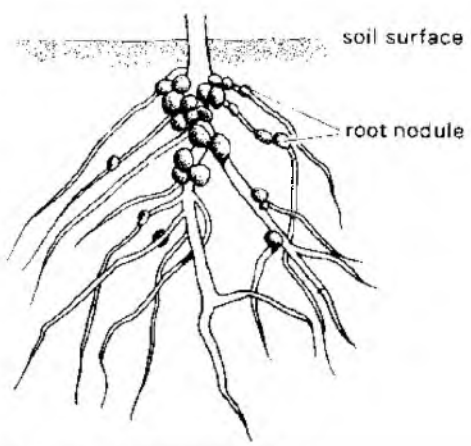
Nitrogen compounds are being continuously added to and lost from the soil in many ways. These compounds are often lost from the soil through 'leaching action' of rain, when it rains nitrogenous compounds get washed out from the soils and from cultivated soils as constituents of crops harvested thereof. To retain soil fertility, a balance must be maintained between the supply and losses of this important soil nutrient. This is normally achieved mainly by nature but can sometimes be assisted by man artificially.

The whole process goes on in nature in the form of a cycle of addition and depletion called the nitrogen cycle.

The natural nitrogen cycle:

Plants use nitrates to make proteins. Proteins are an important class of food used for body building. They are nitrogen – containing organic compounds. The plants are eaten by herbivorous animals; the protein is digested by animals. Some of the protein is used to form flesh; any excess is excreted as urea. The urea returns directly to the soil.

Bacteria decompose urea to ammonia (NH_3). When animals die, bacteria feed on the carcasses and decompose the protein to ammonia. Bacteria (nitrifying bacteria) again, feed on the ammonia to form nitrites and then oxidized to nitrates [trioxonitrates (V)] through a process called nitrification; Nitrates in the soil are absorbed by plants and the cycle is repeated. **Nitrification** is therefore the process by which nitrifying bacteria oxidizes ammonia to nitrates. It is hindered in waterlogged soils as well as in soil deficient in lime. It can only occur



Root nodules of a legumminous plant

if there is sufficient air in the soil and if the soil is not too acidic. **Nitrifying bacteria** prefer alkaline soils and are of two kinds.

(i) Nitrosomonas, which convert ammonia to nitrites and;

(ii) Nitrobacter, which convert nitrites to nitrate.

Leguminous plants (e.g. beans, peas) are able to absorb nitrogen directly from the air with the help of bacteria on their roots. It is this bacteria contained in their nodules which use atmospheric nitrogen to make protein. The bacteria which cause nitrogen fixation does no harm to the plants they live on. This species of bacteria, Rhizobium enter the roots of leguminous plants by way of the root hairs and cause swellings called nodules on the young roots. The bacteria live in the nodules and synthesize organic nitrogenous compounds from the carbohydrates of the host and nitrogen of the air. The nodules are hence a store of nitrogenous compounds. When the host plant dies or is removed, any roots that remain in the soil decay. When this happen the nitrogenous compounds are set free into the soil where they can be used by other plants.

Nitrogen fixation can also occur by electrical discharges (lightning) during thunderstorms. Oxides of nitrogen (nitrogen oxide) are formed from oxygen and nitrogen and these react with water, forming **nitric acid** {trioxonitrate (IV) acid} which enters the soil. This acid combines with other salts to form **nitrates** {trioxonitrate (IV)}.

A group of soil bacteria called denitrifying bacteria in waterlogged soils break down nitrates. This releases oxygen and nitrogen into the air. The process whereby certain bacteria and fungi reduce nitrates in the soil to nitrogen gas is called **denitrification**. Denitrifying bacteria prefers acidic soils.

The nitrogen cycle is completed when plants absorb nitrates from the soil and build them into proteins. These are then eaten by animals.

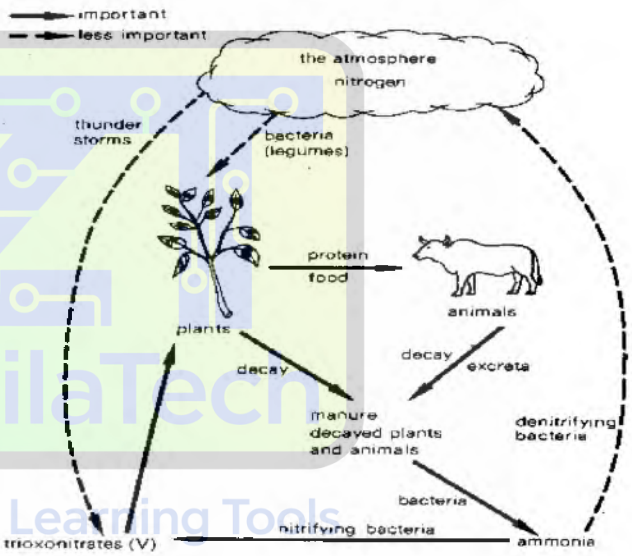
The natural nitrogen cycle

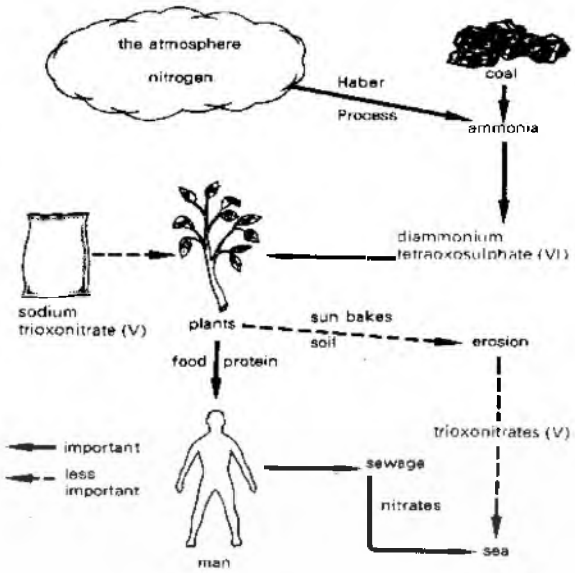
2.2.1 Importance of nitrogen cycle to plants and animals

- Improvement of soil fertility
- Plants absorb nitrates from the soil and build them into proteins.
- These plants grow and are eaten by animals
- Atmospheric nitrogen is used to manufacture ammonia by Haber process.
- The ammonia is then converted into nitrogen compounds essential to life.

<u>The artificial nitrogen cycle</u>

The farming and social activities of humans break the natural nitrogen cycle. All the manure from excreta and decay is not returned to the soil. The soil therefore becomes poorer in nitrates. Artificial fertilizers are put into the soil to supply sufficient nitrates for the plants. More fertilizers were needed, so the Haber process was invented to make ammonia which is converted into a compound used as fertilizer. Another form of ammonia is also manufactured, at the gas works from coal. Lime is also used to fertilize the soil by making it alkaline; this increases the activity of the nitrifying bacteria and decreases the activity of the denitrifying bacteria. The losses in nitrates due to man's activities can be replaced by fertilizers.





The artificial nitrogen cycle

SECTION 3: Systems

3.1.1 SKELETAL SYSTEM

A skeleton is the hardest part of an animal's body to which muscles are attached. It is the body's framework bound together by bones, cartilages and ligaments.

Types of skeleton:

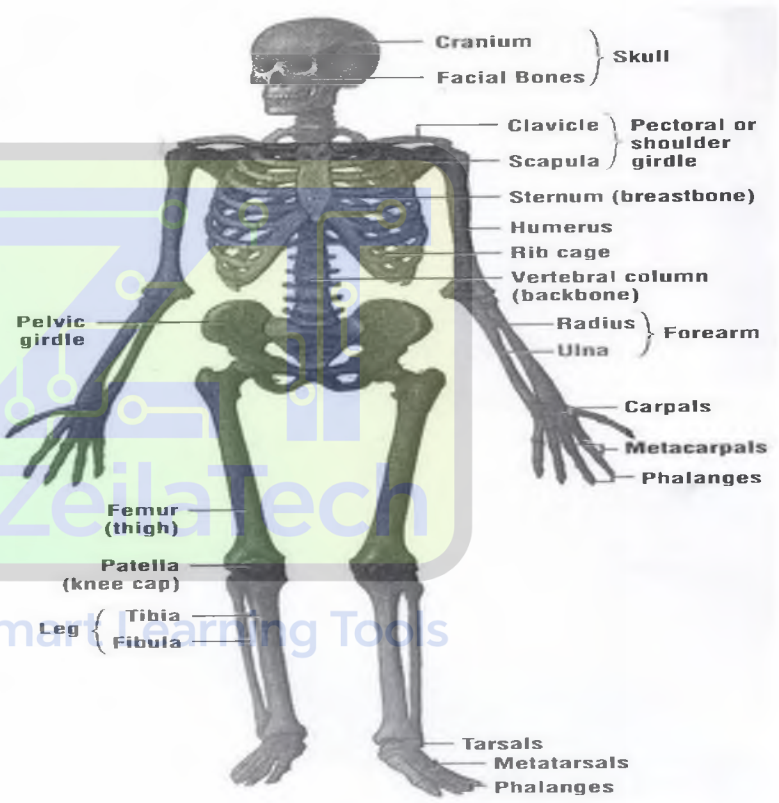
Exoskeleton: - covers outside the body and consists of chitin and cuticle. Common in arthropods i.e. crabs, scorpions, prawns and some insects.

Endoskeleton consists of 206 individual bones lying within the main body muscles. Found in humans, goats, monkeys, cats and dogs.

The endoskeleton consists of two divisions.

(a) *The axial skeleton:* - this is made up of 28 bones of the *skull*, the tiny bones of the middle ear, the backbone, and the 12 pairs of *ribs* that join with the breastbone. The axial skeleton is the central supporting part of the skeleton and consists of the bones of the *skull*, backbone (*vertebral column*), *ribs* and breastbone.

(b) *The appendicular skeleton*: - made up of the shoulder blades (*pectoral girdles*), hips (*pelvic girdles*), and the arm, hands as well as feet and leg bones (*limbs*).



Functions of the skeleton

- **Support**: - It provides a framework which supports all the softer parts of the body.
- **Movement**: - It provides a system of rods and levers for movement.

- **Protection**: - It provides protection for delicate organs e.g. the skull protects the brain, vertebral column protects the spinal cord etc.
- **Manufacture of blood cells**: - Red blood cells and some white blood cells are manufactured in the marrow of long bones.
- **Shape**: - The skeleton provides and maintains the shape of the body. It enables organisms to be easily recognized by the shape given by the skeleton.
- **Storage of mineral salt**: - It helps to store important mineral salts such as calcium and phosphorus, hence some bones are sources of food or minerals for some animals e.g. bone meal as livestock feed.
- **Respiration**: - It also aids in respiration. The thoracic bone of the rib caged together with the muscles attached to them assist in respiration i.e. Inhalation and exhalation.
- **Muscle attachment**: - It provides places for the attachment of muscles. Muscles are attached to bones by means of tendons.

Joints

A joint is the point of contact of two or more bones of the skeleton.

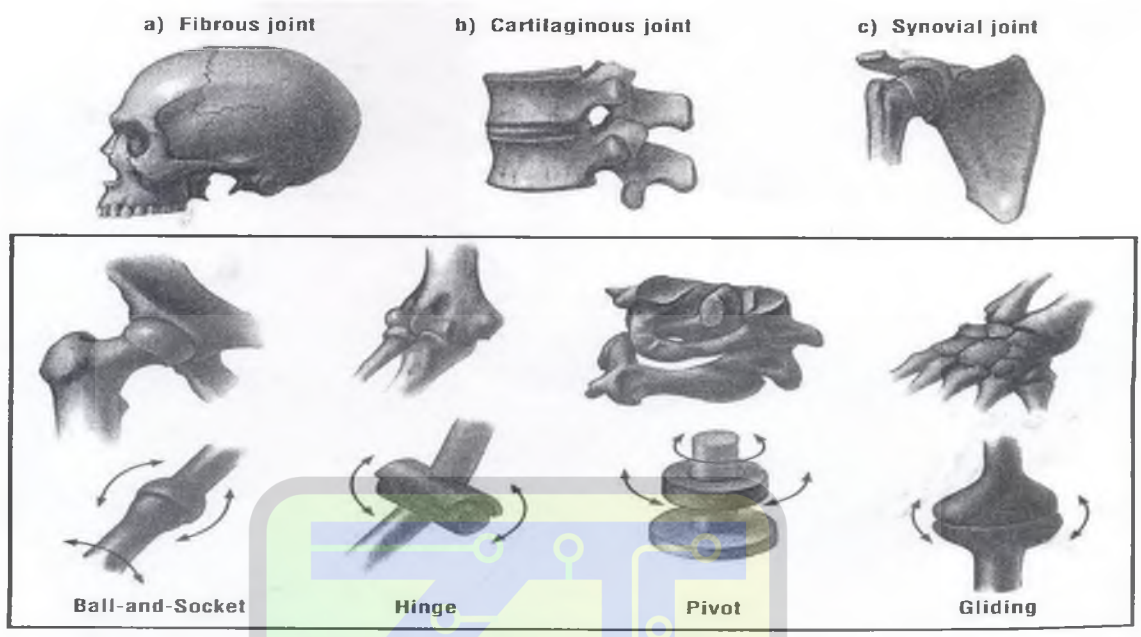
Joints can be classified as:

(a) immovable or fibrous joints e.g. those of the skull which have no gaps between the bones i.e. bones are fused together thus permits no movement,

(b) slightly movable or cartilaginous e.g. those of the vertebral column that are capable of restricted movement, and

(c) freely movable or synovial joints e.g. those found in legs and arms that can move freely.

Movable joints can also be classified according to the type of movement the joints permit as shown in Figure below:



Classification of joints

Types of joints

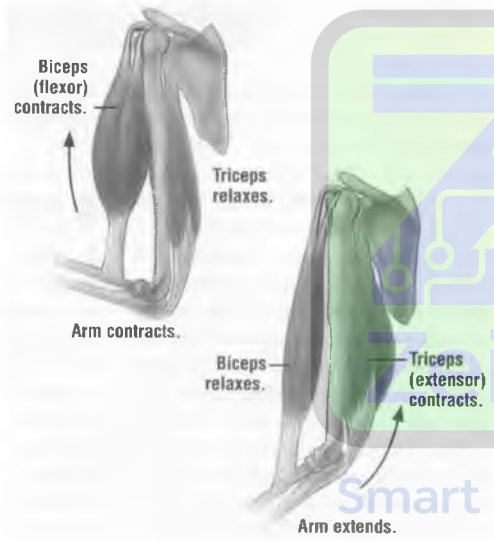
- **Hinge joint**: - this joint allows movement in one plane only, examples are found at the elbow and knee.
- **Ball and socket joint**: - allows movement in all planes examples are found at the shoulder and hip.
- **Gliding joint**: - this joint can be found where one bone moves over the surface of another, examples are found at the wrist and ankle.
- **Fixed or immovable joint**: - this joint does not allow movement; example is the skull, cranium/coccyx.
- **Pivot joint**: - This joint allows rotation of certain parts of the body on other parts, example can be found between the atlas and the axis.

Components of joint

- Bone
- Cartilage – prevents bones rubbing together.

- Ligament – attach or hold bone to bone. It is made up of yellow elastic tissue therefore a certain amount of flexibility.
- Tendon – attach muscle to bone. Made up of white fibrous tissue therefore are strong and flexible. This is necessary as when muscle contracts the bone will therefore move.
- Synovial membrane – secretes synovial fluid into the synovial cavity.
- Synovial fluid – this is contained in the synovial cavity. It lubricates the bones and enables them to move smoothly over each other thereby reduces friction.

3.1.2 Interaction of muscle and skeleton



Many muscles work in pairs, causing the limbs to either bend or straighten. Muscles cannot push bones into the desired position, antagonistic pairs alternate to move the long bones in opposite directions. The biceps and triceps muscles are antagonistic pairs. The contraction of the biceps muscles causes the arm to bend, while the contraction of the triceps muscle causes the arm to extend. The central nervous system ensures that the biceps and triceps do not attempt to pull against each other.

Skeletal Disorders:

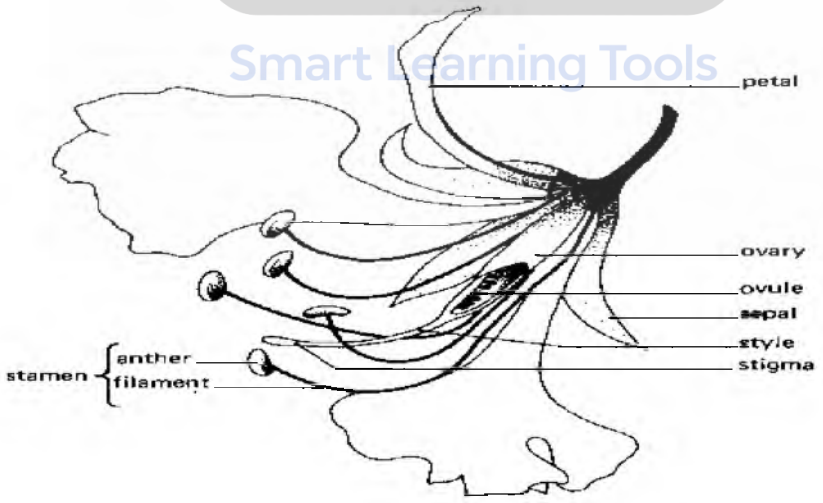
- Osteoporosis: - occurs when bones become thinner, more porous and easily broken. It accompanies ageing and related hormonal changes.
- Arthritis: - an inflammation of the joints which causes swelling. The swelling and pain may be caused by wear and tear of cartilage tissues, hardening of cartilage etc.

Injuries to bones and joints:

- Fractures: - are always the results of accidents. They are broken bones associated with wounds.
- Sprains: - are injuries to the tendons and ligaments around joints, which occur as a result of less serious accidents.
- Dislocation: - results from injuries to joints. The most common ones occur in the shoulder joints and the joints in the fingers and toes.

3.2 REPRODUCTION AND GROWTH IN PLANTS

A flower is the sexual reproductive part of a flowering plant, which may produce fruits and seeds.



A half flower of Delonix

Parts of a flower

There are four whorls of a flower namely Calyx. Corolla, Androecium and Gynaecium.

Calyx: - This is the outermost whorl which consists of a number of sepals. *Sepals* are small, green leaf like structures that surround the carpel and stamen. They protect the flower at the bud stage.

Corolla: - This lies within the calyx and consists of a number of petals. *Petals* are colourful parts of the flower that attract pollinators. A slight swelling at the base of each petal is called *nectary* which produces sugary liquid called *nectar*.

Androecium: - This is the male reproductive parts of the flower and consists of a number of stamens. *Stamen*, the male part of the flower consists of a *stalk*, called the *filament* and an anther in which pollen grains are formed.

Gynaecium: - This is the female reproductive parts of the flower and is composed of one or more carpels (pistils). *Pistil*, the female part of the flower, consists of three main parts namely: stigma, style and ovary.

The stigma: is the sticky part on which pollen grains will land and grow.

The style: is the slender stalk by which the pollen grains reach the ovary.

The ovary: contains the ovule which is attached to the ovary wall by a short stalk.

The ovule: contains the embryo sac that holds the egg cell. A small hole in the wall of the ovule is called the micropyle through which sperm nuclei enter.

A complete flower having all four floral parts i.e. carpels, stamens, petals sepals e.g. lilies and tomatoes.

An incomplete flower lacks one or more of these structures.

Types of flowers

1. Bisexual: - This is a flower that has both the male and female reproductive parts. Also called hermaphroditic flower e.g. Flamboyant, Pride of Barbados, Hibiscus, tomato etc.
2. Unisexual: - This is a flower with only one of the reproductive parts, i.e. either the androecium or gynaecium e.g. Pawpaw, Paretusa, Watermelon, Gourd etc.

3.2.2 Pollination and Fertilization

Pollination is the transfer of pollen grains from the anther of a flower to the stigma of the same flower or another flower of the same species, which may or may not be on the same plant.

Types of pollination

Self Pollination: - is the transfer of pollen grains from the anther of a flower to the stigma of the same flower or another flower on the same plant.

Cross Pollination: - is the transfer of pollen grains from the anther of one flower to the stigma of a flower on another plant of the same species thus, involving two separate plants.

Agents of Pollination

The major agents are: Insect and Wind.

Others agents include:

- Water currents in aquatic habitats
- Gravity – pollen grains can accidentally fall by gravity onto the stigma of a flower
- Bats – flowers of silk cotton tree opens at night, bats that are active use their long tongues to lap nectar. Pollen is thus transferred from flower to flower

Comparison of adaptations of insect pollinated and wind pollinated flowers.

INSECT POLLINATED	WIND POLLINATED
Large and conspicuous	Small and inconspicuous
Petals are brightly coloured	Petals are dull in colour
Highly scented	Not scented
Petals have nectar	Petals have no nectar
Small, compact stigma enclosed in the flower	Large, feathery stigma hanging outside the flower.
Produce large, heavy rough pollen grains.	Produce small, light, smooth pollen grains
Produce small quantities of pollen grains	Produce large quantities of pollen grains
Stamens have short, thick filament and small anthers not swinging freely in the air	Stamens have long, thin filaments with the anthers swinging freely in the air

Table 3.2.1

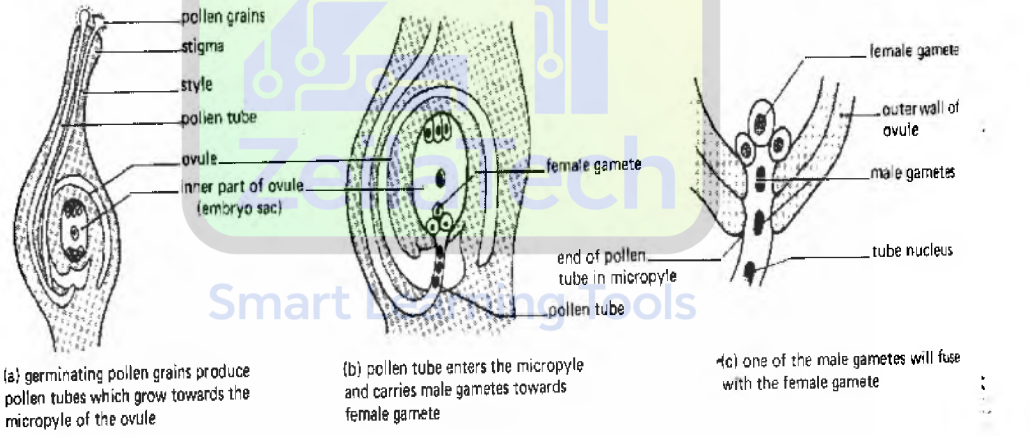
Fertilization

The process of fertilization entails the male cell/gamete/nucleus fusing with the female cell/gamete/nucleus in the ovule to form a zygote. The other male nucleus fuses with the definitive nucleus to form the endosperm.

After fertilization the zygote develops into an embryo by repeated divisions. The embryo consists of the seed leaves (cotyledons), plumule (future shoot), and the radicle (future root).

Stages of fertilization

- Pollen grains germinate to form a pollen tube
- Pollen tube grows down the style towards the embryo sac
- Tip of pollen tube breaks and sex cells enter the embryo sac through the micropyle
- Matured male sex cells from the pollen grains fuse with the female sex cells to form a zygote or the embryo and endosperm.



Stages of fertilization

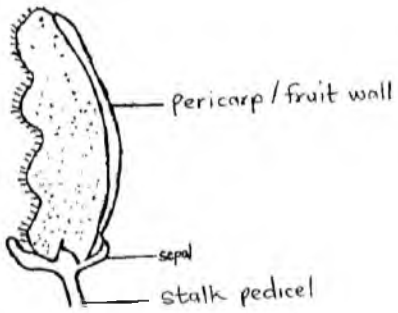
3.2.3 FRUITS

A fruit is a fertilized ovary containing seeds. After fertilization, the ovary wall develops into the fruit wall or pericarp. A fruit has two scars (1) point of attachment of the stigma (2) point of attachment of the receptacle.

The outermost layer of the fruit is the epicarp.

The middle layer of the fruit is the mesocarp.

The inner layer of the fruit is the endocarp.



A typical fruit

Types of fruits:

*Dry *Succulent

Dry fruits: the pericarp dries out when the fruit ripens e.g. cowpea, cotton, okro, cola, maize grain, and cashew fruit. Dry fruits are either dehiscent or indehiscent. Dehiscent fruits are those whose pericarp splits open to release seeds e.g. legumes and pods. Indehiscent are those whose pericarp does not split open e.g. maize, sunflower, cashew nut, rice plant etc.

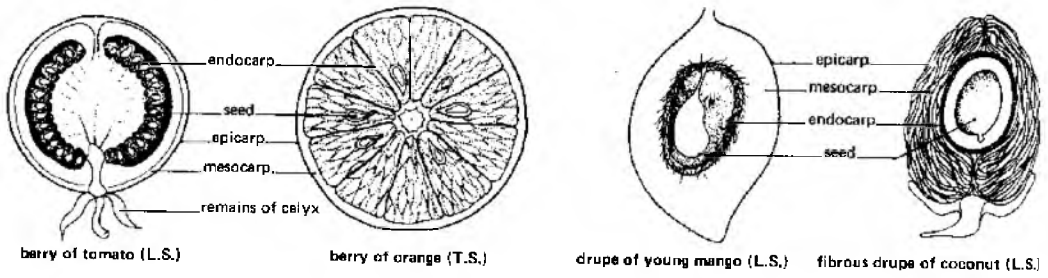
Succulent fruits: the pericarp remains juicy and fleshy when the fruit ripens. A succulent fruit can be:

Serosis: it is a fleshy false fruit e.g. pineapple

Pome: it has a fleshy outer covering e.g. pear, apples,

Berry: it has thin or membranous epicarp, fleshy mesocarp and endocarp are fused with many seeds e.g. tomato, guava, pawpaw, pepper.

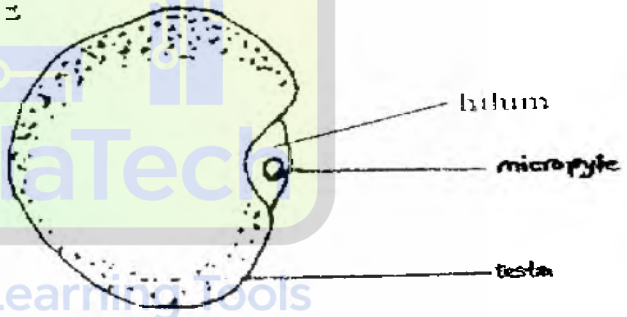
Drupe: the mesocarp is fleshy and fibrous with a hard or stony endocarp containing only one seed e.g. mango coconut.



Berries and drupes

Functions of fruit

1. Protection: - they protect ovules from damage by rain, and also winds which would absorb all the moisture from them, eaten by animals, from bacteria and fungi, which would cause their death and decay.
2. Nourishment: - fruit supplies young developing seeds food and water. Food materials are stored in the fruit wall of succulent fruits, and from here they reach the young seeds through the placenta and seed stalk.
3. Seed dispersal: - man/animals eat fleshy fruits, and discard the seeds some distance away from the parent plant. Sometimes some small seeds with very hard covering are swallowed, passes through the animals digestive system undamaged. They may be scattered far away from the parent plant depending upon the animals' habits and movement.



In certain fruits, the fruit wall bursts or splits open when the fruit is ripe as occurs in the fruit of the balsam and the flamboyant. Tension in the fruit wall causes the seeds to be thrown at a great distance away from the parent plant.

3.2.4 SEED STRUCTURE

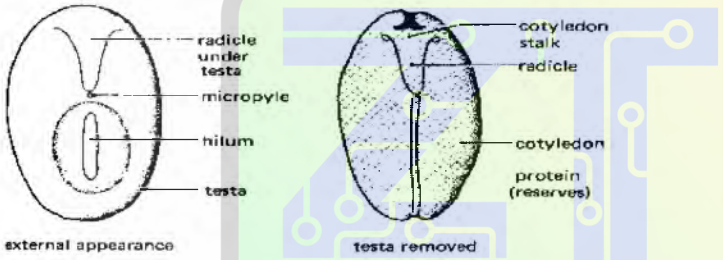
Seed is a fertilized ovule consisting of an embryo, endosperm and a testa (a protective tissue)

A typical seed

Testa or seed coat: - a protective tissue formed from the outer layers of the ovule. It has a scar, the *hilum*, which is where it was attached to the seed stalk inside the fruit; the *micropyle* is a small hole near the hilum, which is where the pollen tube enters the ovule. It is also the place where most of the water is absorbed before germination.

Embryo: - consists of one or more seed leaves (*cotyledons*), the young shoot (*plumule*) and the young root (*radicle*).

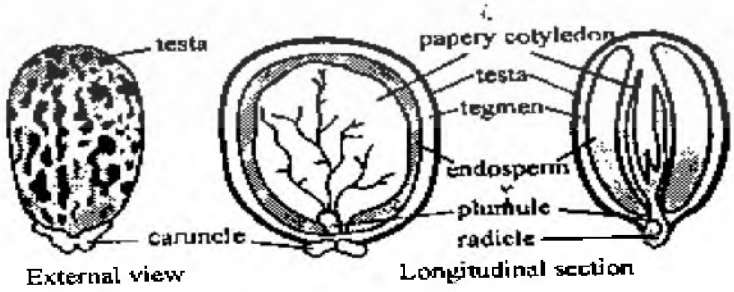
Endosperm: - a massive tissue in which food is stored. Its function is taken over by cotyledons in most seeds.



Cowpea (non – endospermous seed)

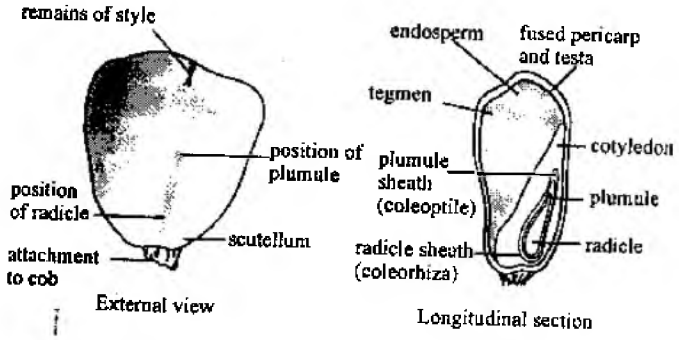
Endospermous seeds: in such seeds the endosperm is not completely used up and therefore persists as a large food storage tissue e.g. maize.

Non-endospermous seeds: in such seeds most of the food in the endosperm is absorbed by the cotyledons e.g. cowpea



Castor oil seed {endospermous & dicot}

At one end of the seed is a spongy knob, *caruncle*, which absorbs moisture during germination. The endosperm stores the oil and is covered by a thin tegmen.



Grain of maize (endospermous)

The grain is a monocotyledonous and endospermous. The endosperm contains starch and protein.

Features and functions of maize grain

- Coleoptile: - serves as a plumule sheath and protects the plumule while in the soil.
- Coleorhiza: - serves as a sheath which protects the short and blunt tip of radicle.
- Endosperm: - serves as food store and absorbs water during germination.

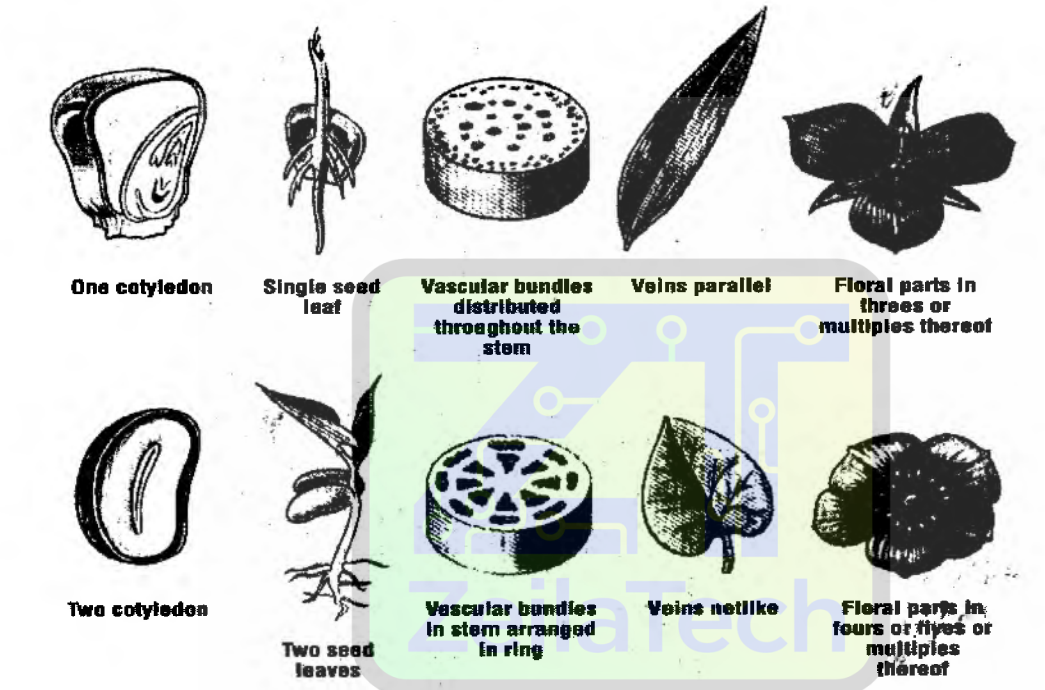
Table 3.2.2 Differences between a seed and a fruit

Seed	**Fruit**
Has a single scar	Has two scars
Developed from the ovule	Developed from the ovary
Testa formed from integuments	Pericarp formed from ovarian wall
Contains embryo	Contains seeds

Table 3.2.3 Differences between monocotyledons and dicotyledons

Monocotyledons	**Dicotyledons**
Has one cotyledon	Has two cotyledons
Endosperm present	Endosperm absent
Pericarp and testa fused together	Pericarp and testa are separated.

Leaf has parallel veins long and narrow	leaf broad and branching network of veins
No leaf stalk	Leaf stalk present and leaf blade.
Examples are: maize, guinea corn, onions, lilies, palms, plantain and bamboo	Examples are: mango, peppers, beans, yam, silk cotton tree, Flamboyant, Caesalpinia



The differences between monocotyledon and dicotyledon

3.2.5 Dispersal of fruits and seeds

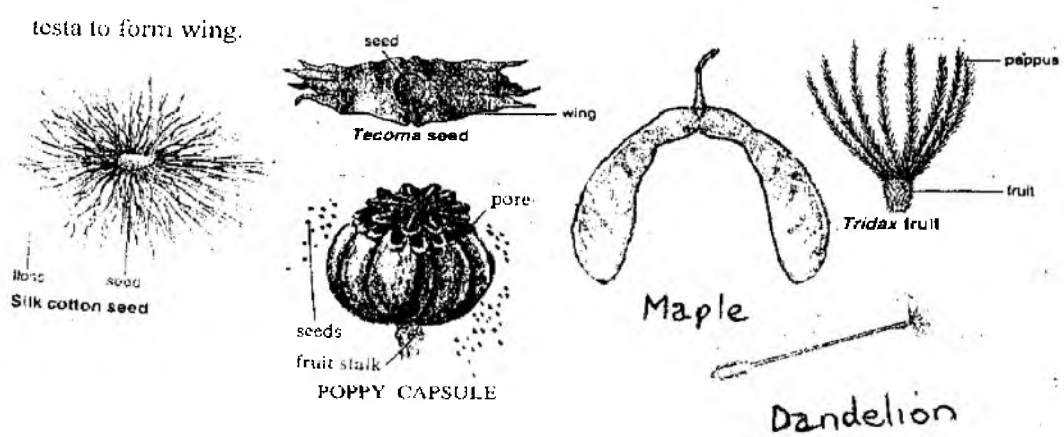
Agents of dispersal

(a) Wind (b) Water (c) Animals (d) Explosive mechanism/Self

Wind Dispersal

Fruits and seeds dispersed by wind develop features to make them light and easily carried away by wind from their parents e.g. Tridax sp, Combretum sp/Samara, Maple, Ash, Hopea.

The main adaptations are: small sizes, light in weight, development of floss/entangled mass of thread, calyx modified to form a pappus/parachute, expansion of testa to form wing.



Wind dispersal

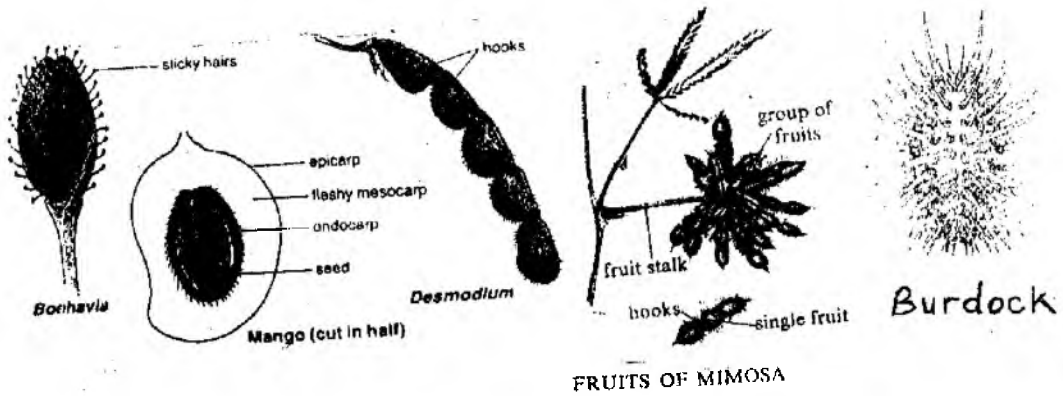
Water dispersal

Such fruits and seeds dispersed by water have spongy/fibrous mesocarp/ numerous air spaces which reduces the relative density causing it to float passively in water. When washed ashore the pericarp rots and the embryo grows out through the endocarp e.g. white mangrove Avicennia nitida

Water dispersal

Animal dispersal

Those animals include humans, monkeys. Fruits dispersed by animals are succulent or have features which cause them to become attached to the fur or clothes of mammals. Some are large and brightly coloured, some are eaten and the seeds thrown away, some have hooks/spines on the seed coat by which they may become attached to fur, skin or clothing, some fruits may also be sticky.

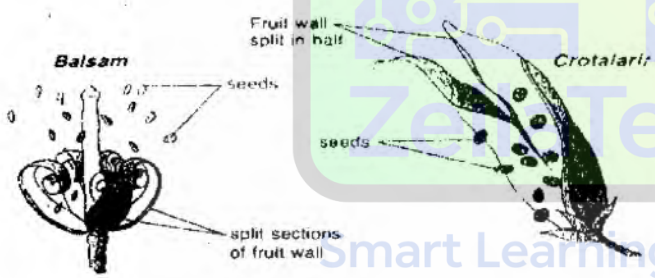


Animal dispersal

Self Dispersal/Explosive mechanism

Turgidity of the pericarp makes the fruits split open and seeds are hurled out away from parent plant.

Unequal drying of pericarp sets in tension, which develops gradually until a large force develops, to split open the fruit and throw away the seeds. Such fruits are: balsam, Cowpea, Crotalaria, Pride of Barbados, Rose periwinkle, Okro, Flamboyant etc.



Self dispersal

Advantages of seed and fruit dispersal

- It eliminates competition for space and avoids overcrowding.
- It eliminates competition for nutrients and sunlight.
- There is colonization of new habitats and distribution of plants
- It eliminates or minimizes epidemic diseases as seedlings are not overcrowded

Disadvantages of seed and fruit dispersal

- External agents of dispersal may not be available at the right time.
- The fruit may be carried to areas where conditions may not be favourable to establish.

3.2.6 SEED GERMINATION

Germination is the process whereby the embryo of a seed grows into a seedling.

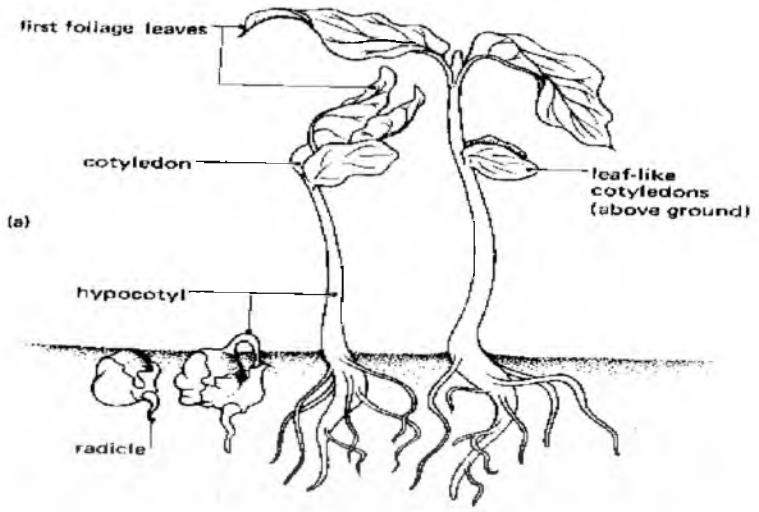
Viable seed: - is a live and mature seed that can germinate under favourable conditions.

Dormant seed: - is a live, mature and dry seed that fails to germinate under favourable conditions. During this state of dormancy the embryo is resting and its metabolic activities are low, lasting for a few days to several months.

Types of germination

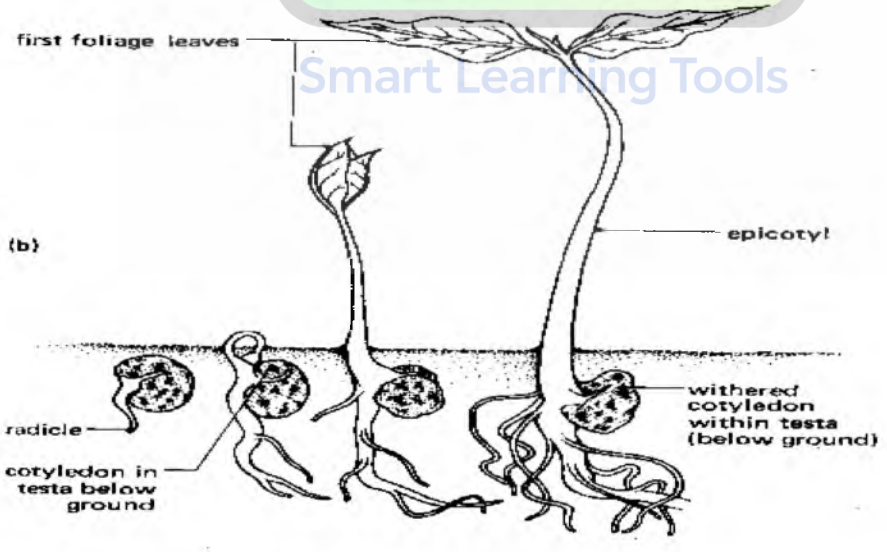
The seed absorbs water through the testa and the micropyle, the seed swells and the testa splits, allowing the radicle to emerge and grow downwards into the soil.

In some seeds the cotyledons are pushed above the ground and become the first new leaves, due to the rapid elongation of the **hypocotyl.** This type of germination is known as **epigeal germination** e.g. can be found in castor oil seed, flamboyant, cowpea, groundnut, tomato, garden eggs, lettuce, and cabbage.



Stages of germination of cowpea – epigeal

In others the cotyledons remain below the ground as a result of rapid elongation of the **epicotyl**. This type of germination is known as **hypogeal germination** e.g. can be found in wheat, maize, yam bean seeds, Bambara beans, etc.



Hypogeal germination of yam bean seed

Conditions necessary for germination

- Adequate moisture
- Suitable temperature
- oxygen

Aim: - Investigating the conditions necessary for germination

1. Set up four test tubes labeled A, B, C, and D as shown in Fig 3.2.16.
2. Put tubes A, C and D in a warm place.
3. Put tube B in a refrigerator.

The test tubes should have the following conditions:

A. Water, warmth and air.

B Water and air (no warmth).

C Warmth and air (no water).

D Water and warmth (no air)

4. Observe the test tubes for about a week.

Observation:

A. Seeds germinated because it had all the conditions necessary for germination.

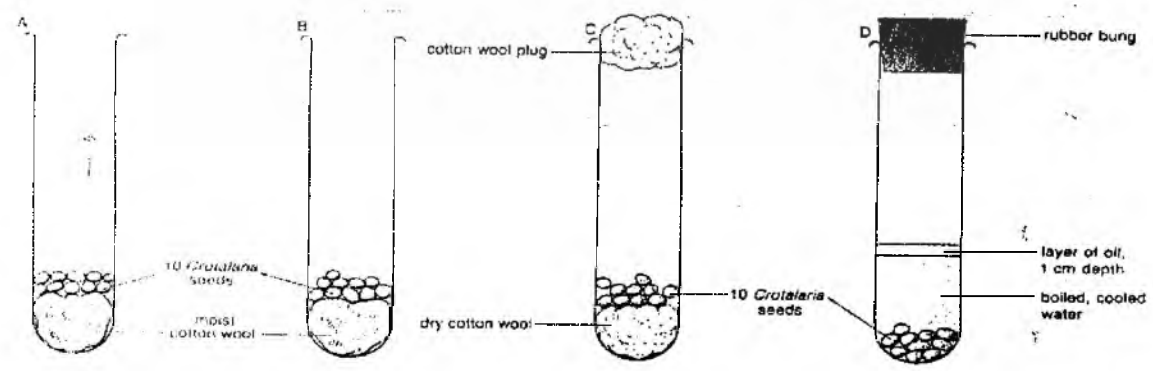
B. Seeds did not germinate because of lack of favourable temperature.

C. Seeds did not germinate because of lack of water.

D. Seeds did not germinate because of lack of air.

Conclusion:

This shows that, viable seeds can germinate only when water, air and suitable temperature are provided. If any of them is absent, germination will not occur.



Activity for investigation

3.2.7 Vegetative reproduction

Vegetative propagation is an asexual form of production in which parts of the plant detached from the parent plant and then developed into an adult plant.

Methods of vegetative propagation

1. Natural propagation methods
2. Artificial propagation methods

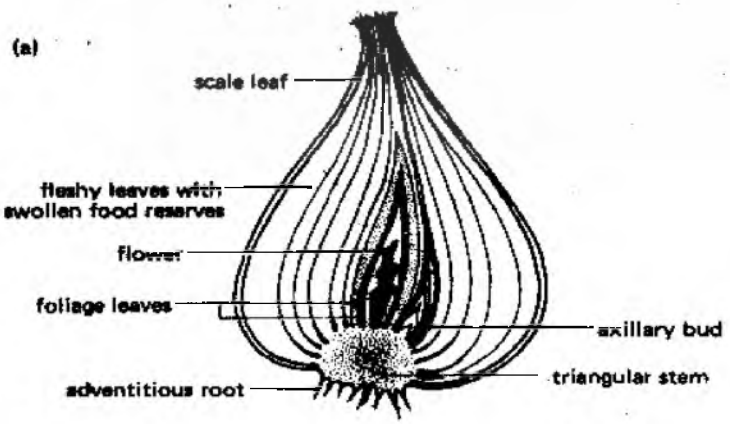
1. Natural Propagation:

- propagation by bulbs
- propagation by rhizomes
- propagation by corms
- propagation by stolons or runners
- propagation by sucker
- propagation by stem tuber

Propagation by bulb:

A bulb has a short, brown conical stem which grows vertically underground. Adventitious roots arise directly from the base of the stem with very short internodes. The food is stored in fleshy inner leaf bases (bulbs) which serve as storage organ for the plant e.g. onion, garlic, spider lily etc.

The whole bulb is planted and the terminal buds produce aerial shoots, while axillary buds produce daughter bulbs.

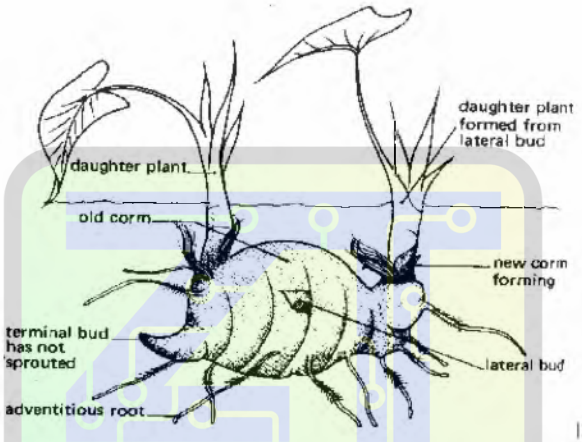


Bulb of onion

Propagation by corms:

A corm is a short, modified stem surrounded by brown scale leaves which grows vertically underground with long internodes and adventitious roots arising from the nodes. The stem is thick with stored food e.g. cocoyam. Caladium sp, Colocasia sp, Gladiolus etc.

Corms are propagated by planting the whole corm or sections of the corm singly in soil. The axillary buds develop into daughter corms.

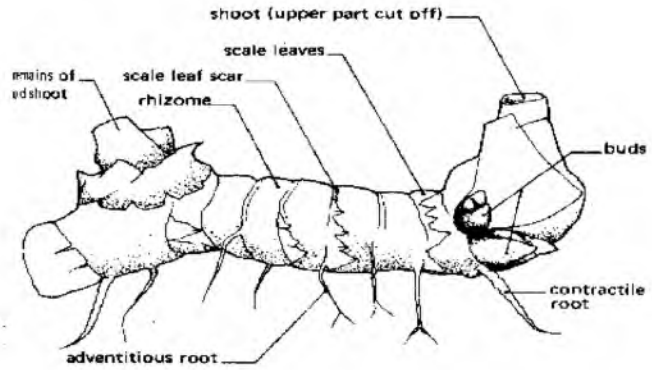


Corm of cocoyam (Xanthosoma)

Propagation by rhizomes:

A rhizome is a horizontal, underground stem, with terminal buds that form aerial shoots, and buds that develop into lateral branches e.g. Canna lily, ginger, turmeric, Zoysia grass.

The whole rhizome can be planted or cut into pieces, each piece having two or three buds and planted in the soil and watered regularly. The buds sprout and grow into new aerial shoots after a few days.

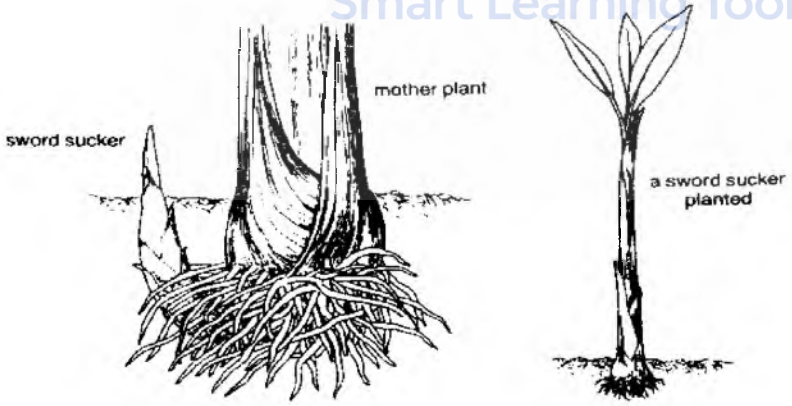


Rhizome of canna-lily (Canna)

Propagation by sucker:

A sucker is a lateral outgrowth from the underground part of the stem of certain plants. They grow obliquely to the soil level and produce new aerial shoots with adventitious roots e.g. plantain and banana.

A sucker is propagated by cutting carefully, and uprooting the young sucker close to the parent stem and transplanting in the soil.

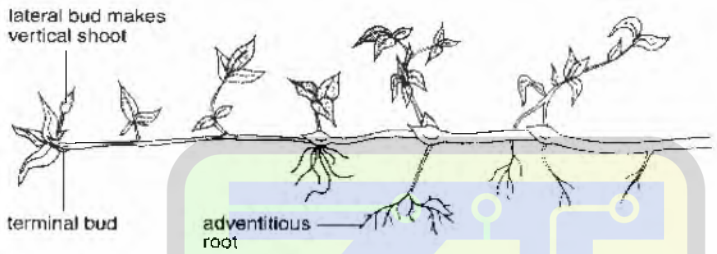


Common planting materials of bananas

Propagation by Stolons or runners:

A runner is a thin, creeping stem which grows horizontally along the surface of the ground. The stem has long internodes and produces adventitious roots at its nodes. Aerial shoots develop from the nodes e.g. sweet potato, Desmodium, doob grass, moss verbena.

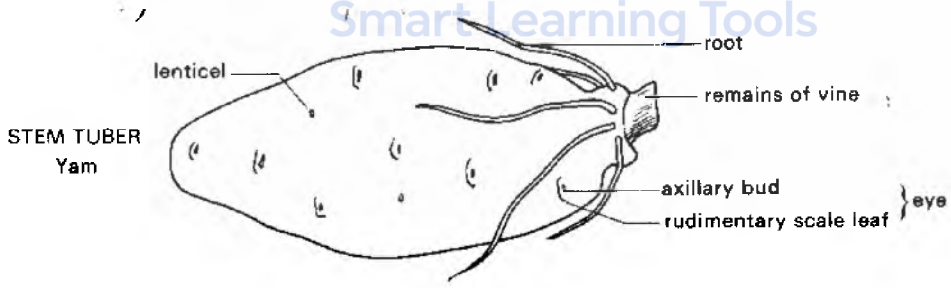
The stem of runners is cut into pieces with each piece having at least two nodes. One end of the piece of stem is pushed into the soil. The buds at the nodes sprout into new plants.



A runner of Desmodium.

Propagation by stem tuber:

Stem tuber is swollen underground stem e.g. potato and yam. It is propagated by cutting the big tuber into setts, each sett containing many eyes.



Stem tuber of yam

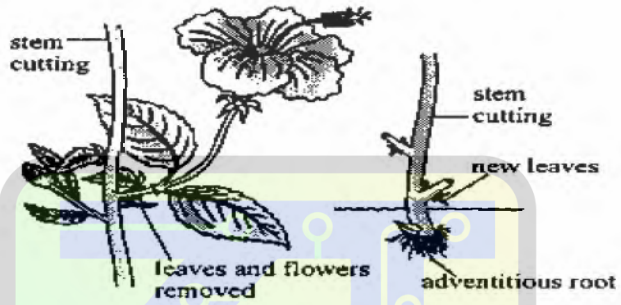
2. Artificial Propagation:

- Stem cutting
- Budding

- Grafting
- Layering

Propagation by stem cutting:

Cut stem obliquely (at an angle) just below a node. Each cutting has 3 to 5 nodes. Push lower end with one node of cutting into the soil. Adventitious roots develop from the node in the soil while aerial shoots grow from the nodes above the soil surface e.g. cassava, sugarcane, Croton, Hibiscus.



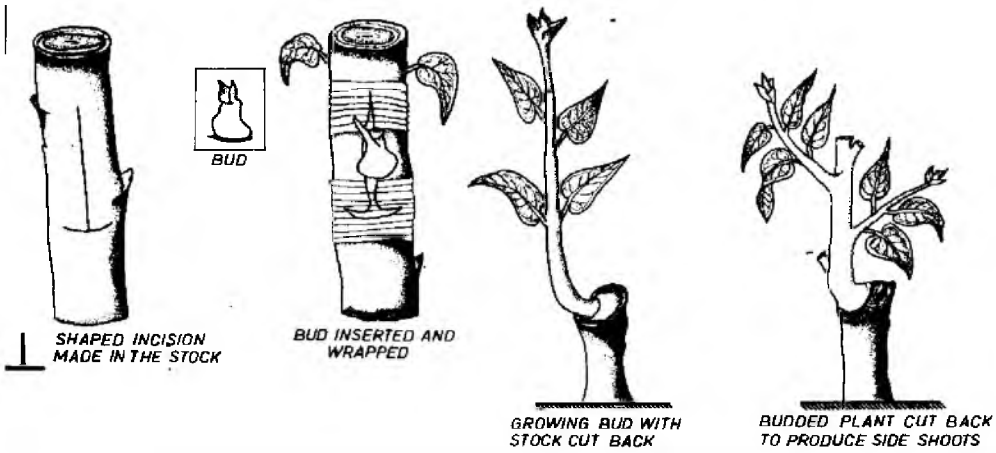
Stem cuttings

Propagation by budding:

Budding is a form of grafting but the only difference is that, in grafting a shoot is used for the scion, whereas a bud with part of the bark of the plant is used as the scion in budding. Both systems have the same advantages and are based on the same principle. However, with budding many buds can be obtained from a single plant, while in grafting shoots have to be taken from several plants if many operations are to be performed.

The scion (a dormant bud on a silver of stem) is carefully removed from one plant with a sharp knife and inserted into a T - shaped cut in the bark of another plant called the stock. A polythene bag is used to bind firmly together the scion and stock.

The bud on the scion develops and bears fruits of the plant from which it was removed e.g. citrus trees and roses.



Budding

Advantages of budding

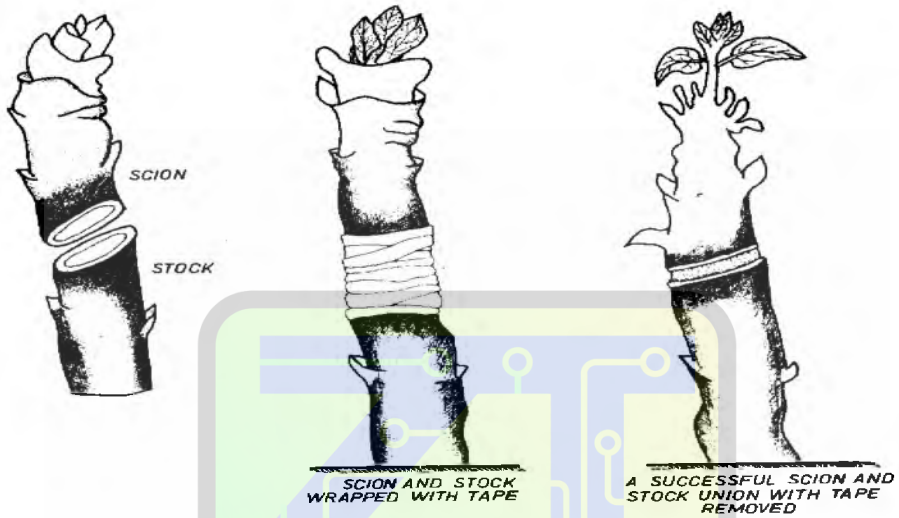
- Changing undesirable variety to a desirable variety.
- Combination of good qualities of two different plants of the same species into one plant.
- Perpetuation of some varieties which cannot be propagated by any other means.
- Growing of two or more kinds of fruits/flowers on one plant/tree.
- Rapid method of developing new varieties of plants/crops.
- Hastens seed selection
- Hastens maturity or fruiting time/ develops faster

Propagation by grafting:

Grafting is the art of joining parts of a plant together in such a way that they will unite and continue to grow as one plant **OR** the union of the cambium layers of two woody stems/stock and scion. The part of the graft combination which is to become the upper portion of the plant is called the scion and the lower portion of the graft called the stock or rootstock.

Grafting is usually done in the peak of the growing season e.g. grape fruit trees and lime trees to orange trees and also grafting a white flowered bougainvillea to a pink or red one. Grafting and budding are normally done on plants which either cannot be reproduced from seeds or are liable to produce different characteristics when propagated from seeds.

The scion (short length of stem with one bud) is cut slanted and joined to the stock (cut end of the stem of another plant). The cambia of the stock and scion must make contact and then bound together. The cuts soon heal and then continue to grow as one plant and bear the fruits of the plant from which the scion was removed.



Grafting

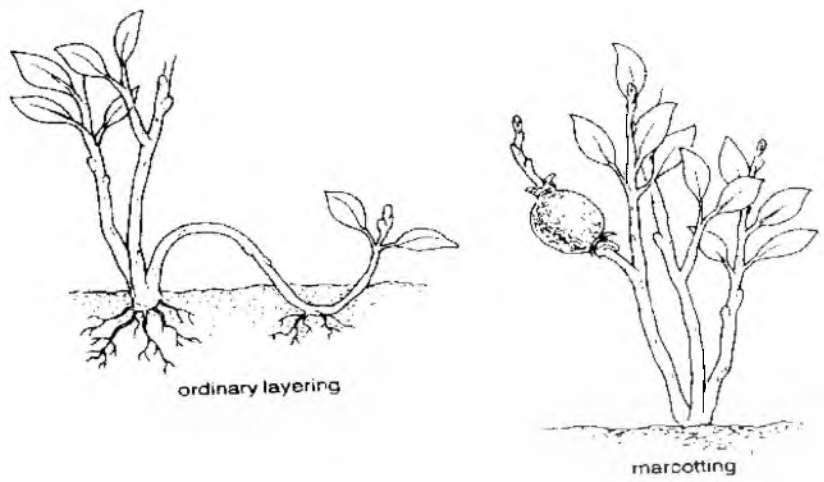
Differences between Scion and Stock

SCION	STOCK
The part of the plant that is attached to the stock	The part of the plant to which the scion is attached/part of the root in the soil.

Propagation by layering:

Layering means bending a branch of the stem or shoots down to the ground without breaking it. It should have a number of nodes. It is pushed into the soil and held in place with two pegs. The two ends of the shoot are allowed to remain above ground level. It is then watered regularly till adventitious roots develop, then the rooted twig is cut off and transplanted in a fertile soil e.g. Roses, Bougainvillea, Petra volibilis, Cocoa, Coffee, Kola etc.

Marcotting (air layering) is another way of layering, but this time round the layering is done on the branch as it still stands. A ball of soil is tied around the stem of a plant. Mangoes, Citrus and roses can easily be propagated by air layering.



Layering and Marcotting

Table: 3.3 Differences between sexual and asexual reproduction

Sexual reproduction	Asexual reproduction
Requires two parents unless a parent is hermaphrodite	requires only one parent
New varieties are produced due to mixing of characters of both parents	no new varieties are produced as identical characters are repeated over generations
Involves fusion of nuclei of gametes to form zygotes	does not involve fusion of nuclei , zygotes are not formed

Advantages of vegetative propagation

1. Desirable characteristics are retained, as the offspring are identical to the parent plant.

2. Plants that do not produce viable seeds can only be propagated through vegetative means e.g. cassava, Irish potato etc.

Disadvantages of vegetative reproduction

- ❖ No new varieties are formed
- ❖ Less resistant offspring/progeny

- ❖ Lack of dispersal leading to competition
- ❖ Diseases are carried from parents to offspring
- ❖ Colonization of new areas unlikely
- ❖ Many individuals can be destroyed by natural disasters.

REVISION QUESTIONS

2000 Questions

1. Describe briefly the process of fertilization in flowering plants

2001 July Questions

2. (i) Distinguish between epigeal and hypogeal germination, giving one example in each case.
   (ii) State three factors necessary for germination.

2001 Nov Questions

3. (i) Distinguish between self pollination and cross pollination.
   (ii) State five characteristics of insect pollinated flowers.
4. Describe briefly the characteristics of fruits dispersed by each of the following agents. (α) water (β) Mammal (γ) Wind

2002 July Questions

5. (i) What is a complete flower?
   (ii) Name three parts of a flower and state one function of each part you have named.

2002 Nov Questions

6. (i) Distinguish between pollination and fertilization.
   (ii) State four adaptations of wind dispersal fruits and seeds.

2004 Nov Questions

7. Describe briefly the events which occur in a flower from pollination to the formation of the embryo.

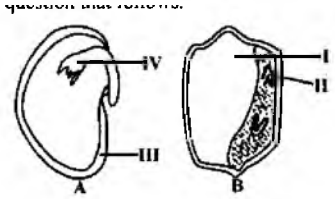
2005 July Questions

8. (i) What is a flower?

   (ii) Draw and label a fully complete flower.

PRACTICAL QUESTIONS

1. Study the diagrams below and answer the questions that follow.



(a) Identify the type of seed illustrated in A and B.

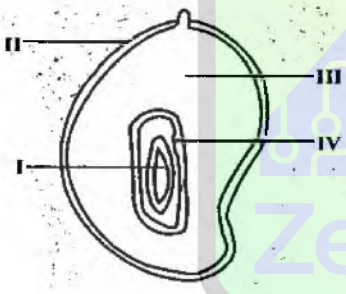
(b) Name the parts labeled I, II, III and IV.

(c) Tabulate two structural differences between the two types of seeds.

(d) (i) State what would be observed when a drop of iodine is added to the part labeled in B

(ii) Give reasons for your answer.

2. The diagram below is an illustration of the longitudinal section of a fruit. Study the diagram carefully and answer the questions that follow.



(a) Name one fruit which has its parts similar to the one illustrated.

(b) Name the parts labeled I, II, III and IV.

(c) (i) State the type of fruit illustrated.

(ii) Support your answer with one reason.

(d) Describe each of the parts labeled III and IV when the fruit ripens

(e) (i) Explain how the fruit is dispersed.

(ii) Give two advantages and two disadvantages of dispersal of fruits.

(f) Name two plants whose fruits are dispersed by wind

CHAPTER 2: SECTION 1

DIVERSITY OF MATTER

4.1 ACIDS, BASES AND SALTS

ACIDS: According to the Bronsted – Lowry's concept acid is a proton donor. They produce hydroxonium H_3O^+ (aq); often written as H^+ (aq), ions in its aqueous solution. E.g. H_2SO_4, HNO_3, HCl etc.

Strong acid: it is an acid which ionizes completely in aqueous solution e.g. HCl.

Weak acid: is an acid which ionizes only partly e.g. ethanoic acid (CH_3COOH). Thus a strong acid gives solutions with a high concentration of hydrogen ions. In a solution of a weak acid the hydrogen ion concentration will be many times smaller.

Properties of Acids

1. Acids have sour, sharp taste, e.g. of sour taste in acids in everyday life are vinegar & lemon. Their sour taste is due to acetic and citric acid.
2. Acids turn litmus red, methyl orange red and phenolphthalein colourless.
3. Acids react with bases to form salts and water only

   e.g. $H_2SO_4 + CuO \rightarrow CuSO_4 + H_2O$.
4. Acids react with many metals to form salt and produce hydrogen gas

   e.g. $Zn + 2HCl \rightarrow ZnCl_2 + H_2$
5. Acids react with carbonates to form salts and water and liberate carbon dioxide e.g. $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$
6. Acids are very corrosive when concentrated
7. Acids have pH less than 7.

Uses of tetraoxosulphate (VI) acid $\rightarrow$ H_2SO_4

- Paints and pigments

- Detergents and soaps
- Fibres and fabrics
- Dye stuffs
- Car batteries
- Agricultural chemicals/ fertilizers
- Chemicals and plastics
- Metallurgy in cars

BASES

Base is a proton acceptor. They produce hydroxide (OH^-) ions in their aqueous solution. Bases which are soluble in water are called alkalis. Some common alkalis are: NaOH, KOH, Ca $(OH)_2$ and NH_3. All these form colourless solutions.

Insoluble bases occur naturally in the earth examples include: Al_2O_3, Fe_2O_3, & Cu $(OH)_2$

Properties of bases

1. Bases have a bitter taste
2. Bases have a soapy or slippery feel.
3. Bases change red litmus blue.
4. Bases react with acids to give salts and water only in neutralization reactions.
5. Bases react with ammonium salts to give ammonia gas.
6. Bases are very corrosive in solid or concentrated forms
7. Bases have pH greater than 7.

Uses of Sodium hydroxide $\rightarrow$ NaOH

- In the manufacture of soap
- Manufacture of paper
- Manufacture of synthetic fabric / textile
- In the purification of bauxite / the extraction of Aluminium
- In the laboratory as strong alkali / for neutralization reaction
- For absorbing carbon dioxide.

When Sodium hydroxide solution is said to be alkaline it means:

- it contains an excess of hydroxyl ions
- it turns red litmus blue
- its pH is greater than 7

Laboratory preparation of ammonia gas $\rightarrow$ NH_3

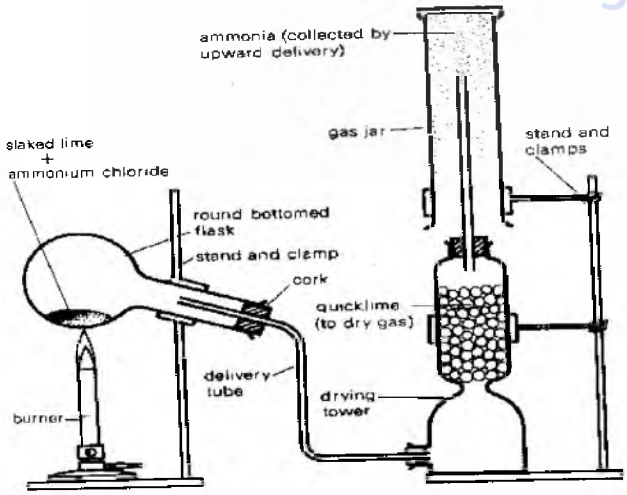
Ammonia is produced when proteins decay or are burnt. It can be made in small amounts by heating animal products such as hooves and horns.

- Put a mixture of slaked lime [$Ca(OH)_2$] and ammonium chloride in a round – bottomed hard glass flask.
- Mount the flask on a retort stand in a sloping position, mouth downwards.
- Connect a delivery tube to a drying tower which contains quicklime (Calcium Oxide) is used to dry ammonia gas because it does not readily react with the gas or it does not dissolve the gas.
- Place an inverted gas – jar above the drying tower.
- Heat the solids in the flask and collect ammonia gas by upward delivery (*because the gas is less dense than air*). It will have been dried by the quick lime

A balanced equation for the reaction of ammonia is as follows:

$2NH_4Cl + Ca(OH)_2 \rightarrow CaCl_2 + 2H_2O + 2NH_3$

Precaution: The round bottomed flask points downwards to prevent the water produced from running back into the hot flask which can easily crack it.



Preparation of ammonia gas

Laboratory tests for gases

(α) Test for Ammonia

- hold moist red litmus paper to gas
- litmus paper turns blue
- **OR** dip glass rod into concentrated HCl. bring the glass rod close to the gas.
- dense white fumes forms to indicate the presence of ammonia.

Identifying ammonia gas physically

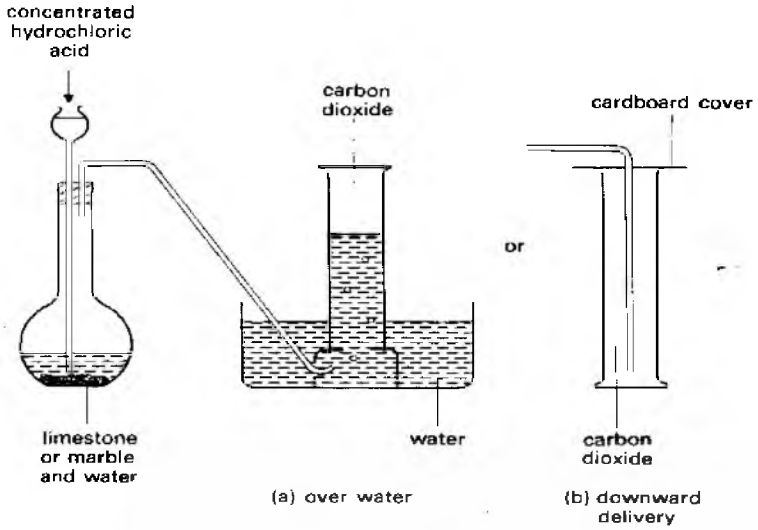
- it is colourless
- it has a pungent smell / choky smell / smells like urine.
- changes red litmus paper blue
- insert the end of the delivery tube in a beaker of water and the water is pushed up the delivery tube / fountain is formed
- pass the gas through copper sulphate solution and it will turn deep blue

(β) Test for Carbon dioxide

- pass gas through lime water
- lime water turns milky / chalky

Carbon dioxide is used in putting off fire because

- it does not support combustion
- it is heavier than air
- it produce no toxic compounds



Preparation of carbon dioxide

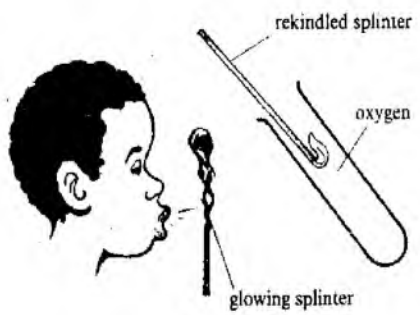
- Place $CaCO_3$ /Marble chips into flat bottom flask
- Tightly fit cork / rubber bung with thistle funnel and a delivery tube
- Pour dilute acid / HCl / HNO_3 through thistle funnel into the flask
- The gas generated passes through the delivery tube
- This is then collected by downward delivery (*because CO_2 is denser than air*) in a gas jar.

A balanced equation for the reaction is as follows:

$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$

Properties of carbon dioxide: -

- It is a colourless gas with a very faint smell.
- It has a sharp pleasant taste.
- It is slightly soluble in water, which dissolves its own volume at room temperature, and forms carbonic acid. This is a weak acid and turns litmus pink.



(χ) Test for Oxygen

- dip a glowing splint into the test tube
- it rekindles / busts into flame indicating the presence of oxygen.

Properties of oxygen

- Oxygen is a colourless and odourless gas
- It is neutral to litmus
- Its soluble in water and this supports marine life
- It is slightly heavier than air
- It supports life and combustion

Oxidation: this is the addition of oxygen to a substance / loss of hydrogen OR Increase in oxidation number or state.

Natural processes that require oxygen

- tissue respiration
- burning / combustion
- rusting / corrosion

Artificial processes that require oxygen

- welding
- cutting of metals
- manufacture of steel
- diving / mountain climbing
- artificial respiration
- extraction of gold
- H_2SO_4 preparation

(δ) Test for Hydrogen

- a mixture of hydrogen and air explodes with a shrill noise when lit
- **OR** with oxygen or air it forms an explosive mixture/ pop sound.

Uses of hydrogen

1. For filling meteorological balloons
2. For converting coal to petrol
3. In hardening of oils into fats / production of margarine
4. As a rocket fuel (liquid gas).
5. In the oxy – hydrogen flame used for welding

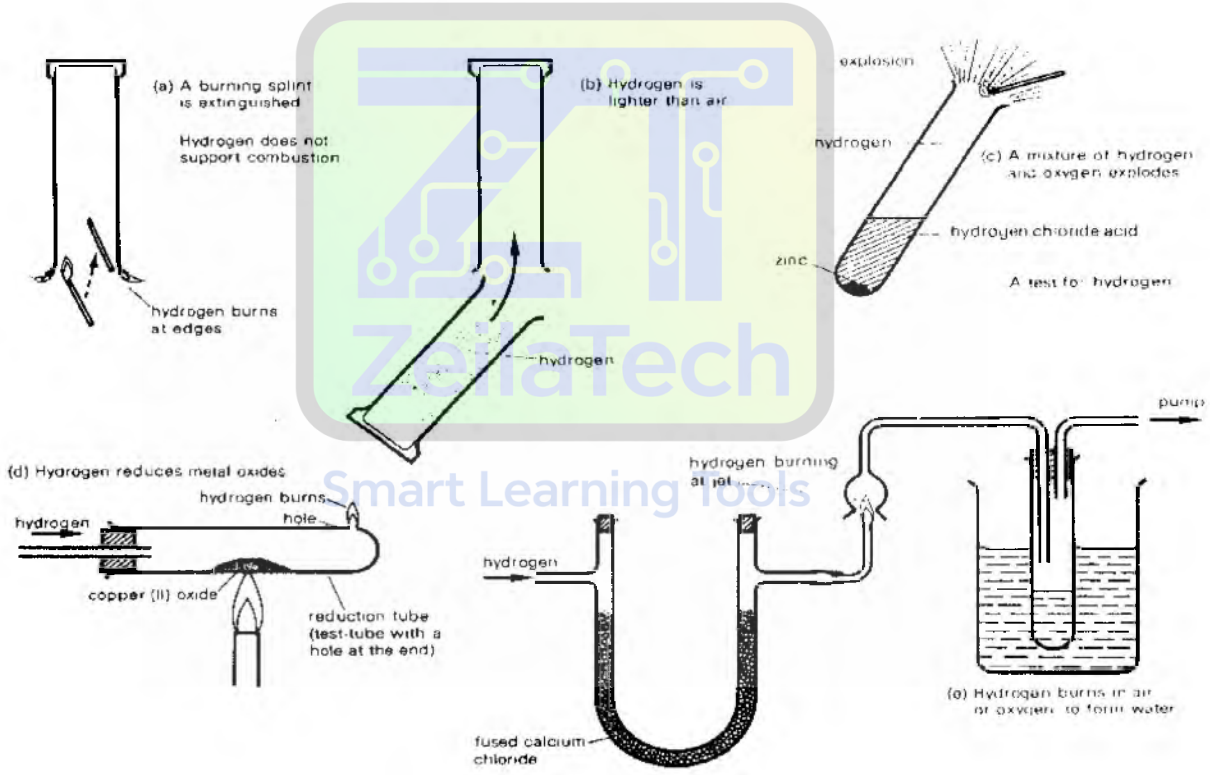
6. In the industrial manufacture of hydrochloric acid.
7. In the manufacture of ammonia by Haber process.

Physical properties of hydrogen

- it is colourless, odourless gas
- it is not soluble in water
- its density is less than that of air; it is the lightest gas known

Chemical properties of hydrogen

- it does not support combustion (test b).
- It burns readily in air to form water (test f).
- With oxygen or air, it forms an explosive mixture (test d).
- It reduces some metal oxides to the metal (test e)



The properties of hydrogen

Effects of carbon monoxide on human health

- Carbon monoxide binds to haemoglobin more strongly than oxygen

- It readily combines with haemoglobin to form a stable compound.
- The stable compound is called carboxyhaemoglobin
- Tissues are starved of oxygen
- Suffocation / death may follow.

SALTS

A salt is a substance formed when the hydrogen atom of an acid is replaced with a metal or ammonium ion in a reaction. Salt is dissolved to form brine.

OR It is the main product formed when an acid reacts with a base. Examples of salt include NaCl, $CuSO_4$, Zn $(NO_3)_2$, $MgCl_2$, $MgSO_4$, KCl etc

Salts occur in larger amounts in nature than acids and bases. Common salt i.e. Sodium Chloride occurs in sea water and in the earth as the mineral rock salt.

These equations show the reaction between each of the following pairs of substances

(α) $HCl + NaOH \rightarrow NaCl + H_2O$

(β) $H_2SO_4 + Cu(OH)_2 \rightarrow CuSO_4 + 2H_2O$

Types of salt

- Normal Salt
- Acidic Salt
- Basic Salt
- Double Salt

A normal salt is formed when all the hydrogen atoms in an acid are completely replaced by a metal. Examples include NaCl, Na_2CO_3, $MgSO_4$, $NaNO_3$, $CaCO_3$, K_2SO_4, $ZnCl_2$, K_2CO_3, $CaSO_4$, $(NH_4)_2SO_4$etc.

An acid salt is formed when the hydrogen atom in an acid is partially or incompletely replaced. Examples include $NaHSO_4$, $NaHCO_3$, Ca $(HCO_3)_2$, $KHSO_4$.

Basic Salts are formed when insufficient acid is present to neutralize a given base / alkali. Examples include Basic magnesium chloride – Mg(OH)Cl, Basic zinc chloride – Zn(OH)Cl, Basic lead carbonate – $Pb(OH)_2$. $2PbCO_3$

Double salts are made from equimolar aqueous mixture of two salts normally called alums e.g.

(i) Aluminium potassium bistetraoxosulphate (VI) decahydrate → KAl $(SO)_4.12H_2O$,

(ii) Aluminium potassium (Potash) alum → $Al_2(SO_4)_3K_2SO_4.24H_2O$

(iii) Chromium potassium (chromic) alum → Cr $(SO_4).K_2SO_4.24H_2O$

(iv) Iron (III) ammonium alum → $Fe_2(SO_4)_3(NH_4)_2SO_4.24H_2O$

1.1.3 Methods of preparation of salts

(α) *Neutralization*: is a chemical reaction between an acid and a base to produce a salt and water only.

A solution of tetraoxosulphate (VI) acid is neutralized by potassium hydroxide solution of the same concentration. The balanced chemical equation for the reaction is as follows: $H_2SO_4 + 2KOH \rightarrow K_2SO_4 + 2H_2O$

To demonstrate that all the reactants in neutralization reaction has been used up:

- Dip red litmus paper and blue litmus paper in a solution
- If litmus papers do not change colour then all the reactants have been used.

(β) *Precipitation*: involves the mixing together of two solutions of two soluble salts or compounds resulting in the formation of insoluble salt. The precipitate is filtered, washed with distilled water and dried.

These pairs of chemical solutions can react to give a precipitate

- Lead nitrate and Sodium Carbonate
- Lead nitrate and potassium chloride
- Silver nitrate and calcium chloride
- Barium chloride and sulphuric acid
- Lead nitrate and sodium chloride

Example of the reaction between lead nitrate and sodium chloride is as follows:

$Pb(NO_3)_2$ (aq) + 2NaCl (aq) → $PbCl_2$ (s) + $2NaNO_3$ (aq)

(γ) Acid + Salt. The method of adding acid to salt results in the formation of salt.

e.g. $H_2SO_4 + 2NaCl \rightarrow Na_2SO_4 + 2HCl$

Worked example:

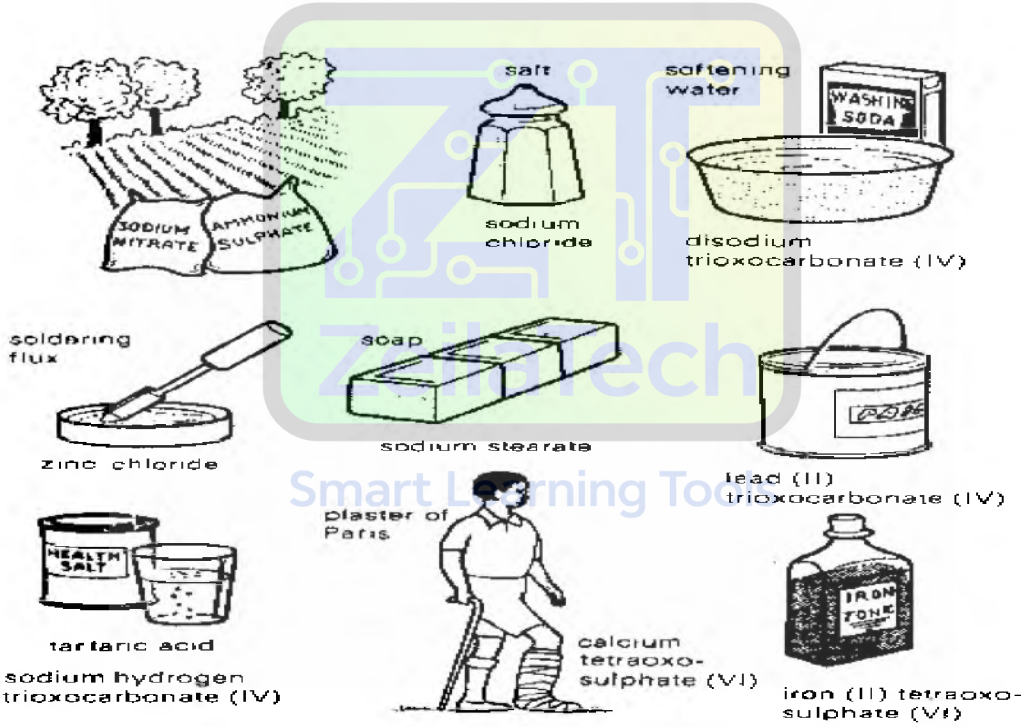
State the reagents that can be used to prepare each of the following salts:

- **$CuSO_4$** → H_2SO_4 and $Cu(OH)_2$ / CuO / $CuCO_3$

- **KCl** → HCl and KOH / K_2CO_3
- **$ZnCO_3$** → H_2CO_3 and ZnO
- **NH_4Cl** → HCl and NH_3
- **KNO_3** → HNO_3 and $KOH/ K_2CO_3/ KHCO_3$

Uses of salts:

Many common salts are used for everyday purposes. Fig 1.4 shows some of these salts:



Some uses of salts

Table 4.1 Solubility's of some common salts

The table below summarizes the solubility's of common salts in water

Salts	Solubility
Nitrites	All are soluble

Sulphates	All are soluble except barium and lead sulphate (calcium sulphate is only slightly soluble)
Chlorides	All are soluble except silver and lead (lead chloride is soluble in hot water
Carbonates	All are insoluble except potassium, sodium and ammonium carbonates
Sulphides	All are insoluble except sodium, potassium and ammonium sulphides

NOTE: All common salts of potassium, sodium and ammonium are soluble in water.

Common chemicals and their classification

ACIDS	NEUTRAL	BASES	SALTS
Vinegar (2.9)	Urine (6.0)	ammonia (11.9)	common salt
HCl (0.0)	Rainwater (6.5)	milk of magnesia (10.5)	soap
Orange juice	pure water (7.0)	lime water (11.0)	health salt
Bee sting		blood (7.4)	
Lemon juice (2.3)		toothpaste (9.9)	
Wine (3.5)		borax solution (9.2)	
Coffee (black) 5.0		baking soda solution (8.4)	
Tomato juice (4.1)		NaOH (14.0)	

Acid – base Indicators are used to:

- determine the end-point in acid-base titrations
- determine whether a substance or solution is acidic, basic or neutral

3 common indicators

Indicator	In acids	In alkalis
Litmus	red	blue

Methyl orange	red	yellow
Phenolphthalein	colourless	pink

Universal Indicator and pH scale

The concentrations of acids and alkalis are measured in terms of pH. This pH varies from 0 to 14. A concentrated solution of a strong acid will give a pH value of 0, while a strong solution of a strong alkali will have a pH value of 14. In neutral solutions, the pH is 7. When water is said to be neutral for instance, it means it contains equal amounts of hydrogen ions and hydroxyl ions OR it has no effect on litmus OR the pH is 7.

The pH value of a solution can be measured by its effect on indicators. Indicators are chemicals which change colour when the pH of the solution changes. For example, litmus is red in solutions of pH up to a value of about 6.5, and blue in solutions of pH from 7.5. When the pH value is from 6.5 to 7.5, litmus is purple. Litmus is extracted from the microrganic plant *lichen.*

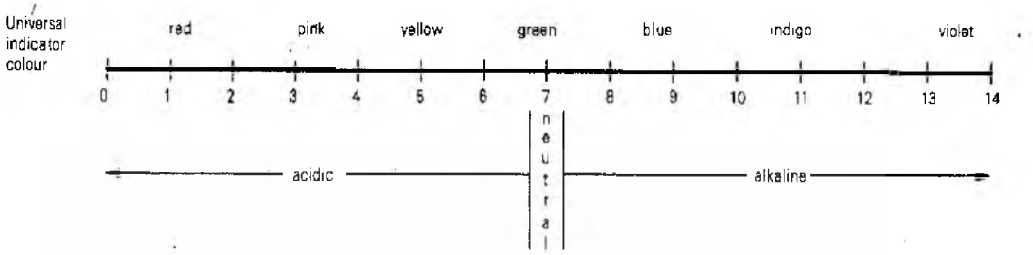
There are many other indicators which have different ranges. By selecting suitable indicators, they can be made to cover the whole range from pH 0 to pH 14. A good example is the 'Universal Indicator' paper. They are made just like litmus paper. By testing a solution with this 'universal indicator', the pH of a solution can be found approximately by comparing the colour obtained with the given scale.

However, there are limitations with the use of the pH scale for highly dilute and concentrated solutions this is because their pH falls outside pH = 0 to pH = 14.

<u>Testing with universal indicator</u>

To find the pH of a solution, just take a piece of indicator paper and dip it into the solution. The part which is dipped changes colour. Compare the colour obtained with the colour on the given scale and read the pH.

If the pH is more than 7, the sample is alkaline. If it is below 7, it is acidic.



The pH scale

REVISION QUESTIONS

1993 Questions

1. (a) What is a salt?

(b) Name one example each of the following (i) a normal salt (ii) an acidic salt (iii) a double salt.

1995 Questions

2. (i) What is pH scale?

(ii) Give the range of a pH scale and explain its significance.

(iii) Compare the H^+ concentration of 0.1M CH_3COOH with 0.1M HCl.

3. What is neutralization?

1999 Questions

4. (a) State the reagents that can be used to prepare each of the following salts.

(i) $CuSO_4$ (ii) $ZnCO_3$ (iii) KCl

(b) Indicate whether a reaction will occur or not when each of the following pair of substances are mixed.

(α) Copper and dilute hydrochloric acid

(β) Red hot iron and water

(γ) Sodium trioxocarbonate (IV) and trioxocarbonate (IV) acid. In cases where a reaction occurs, write down a chemical equation for the reaction.

2001 Questions

5. Give two main uses of sodium hydroxide

2002 Questions

6. What is the difference between a normal salt and acid salt? Give one example of each type of salt.

7. (a) (i) Explain the following statements:

(α) Pure water is neutral (β) sodium hydroxide solution is alkaline.

(b) Give two uses of each of

(α) Acid-base indicators (β) sodium trioxocarbonate (IV)

8. (i) Define the term acid and base according to Bronsted-Lowry concept

(ii) Describe how it can be demonstrated that all reactants in a neutralization reaction have been used up.

INTRODUCTION TO AGRICULTURE

Simple farm tools and implements

Agricultural tools or implements are designed to help the hands to apply force in farm operations. The simple tools such as cutlass, hoe, rake etc. are used by small scale farmers. The functions of such tools are: -

Cutlass: - is used for clearing land and for all operations requiring cutting of sticks. It may also be used for transplanting seedlings and digging holes.

Hoe: - is mainly used for making heaps. It is also effective in turning up soil, thus loosening the surface soil in order to promote plant growth and to destroy weeds. The West Indian hoe is used for making ridges and for uprooting stumps of tough plants such as elephant grass.

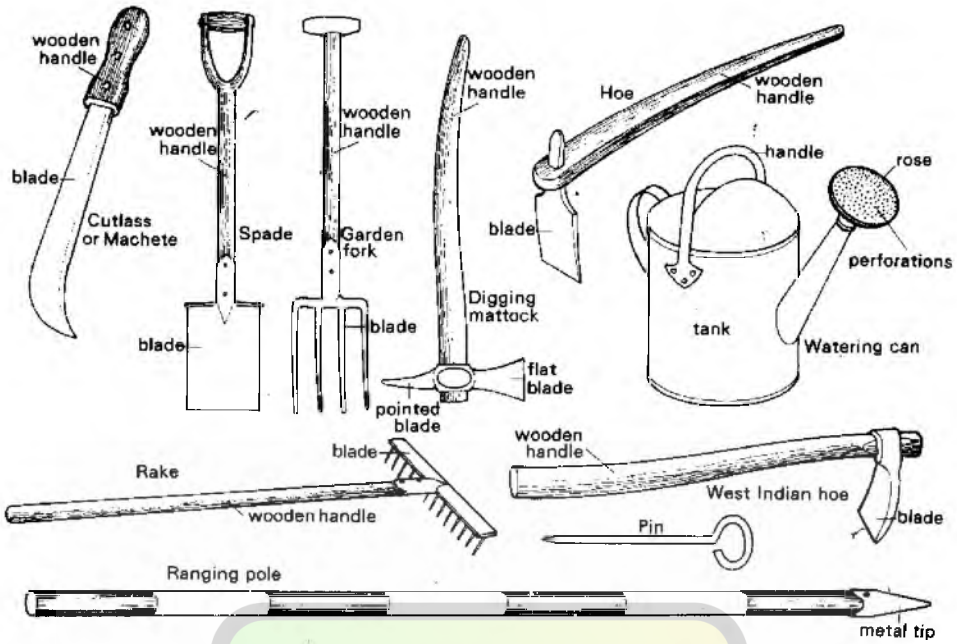
Spade: - is used for lifting the soil and completely turning over. It is also used for leveling and for digging holes when transplanting.

Garden fork: - is used for turning manure during compost making and for spreading manure in the open field. It is also used for loosening the soil before transplanting and for uprooting obstinate stumps.

Rake: - is used for leveling soil surface and breaking large soil crumbs into smaller ones. It is also used for removing stones and weeds from seedbeds and for covering vegetable seeds when they are broadcast.
Digging mattock: - is used for digging and uprooting small stumps.
Axe: - is used for felling trees and cutting logs and for uprooting big stumps during land preparation.
Hand trowel: - is used for transplanting seedlings from the nursery to the bed and for spreading manure and digging shallow holes on beds.
Head pan: - is used for harvesting crops, mixing fertilizer, collecting seeds, removing weeds and stones, and for transporting soil and compost to various parts of the garden.
Garden line: - is used for lining up beds and for making straight rows when planting.
Measuring stick: - is used for measuring out beds and spacing seeds and seedlings.
Watering can: - is used for sprinkling water over young seedlings and for general irrigation during the dry season. The spout has a perforated metal sheet over its mouth called rose.
Arrows and pins: - are steel pins with a ring at one end and a point at the other. They are used for marking chain lengths.
Tapes: - are used for taking short or detailed measurements. There are steel tapes and linen tapes of varying lengths.
Ranging poles: - are wooden poles used for marking surveyed stations or intermediate stations. They are particularly useful for marking straight lines.

WAYS OF MAINTAINING FARM TOOLS

- Keep tools clean after use.
- Keep tools in a termite free area.
- Use tools for the purpose for which they were intended.
- Keep tools in a safe and dry place.
- Oil or grease tools when they are to be stored for a long time.
- Sharpen tools before use.
- Repair all broken or damaged parts.
- Keep tools in a tool box.



Some farm tools and implements

BACKYARD GARDEN

A piece of land usually located near a house, used for the cultivation of crops or the rearing of farm animals.

BENEFITS OF BACKYARD GARDEN

- Serves as a hobby/leisure.
- Provides supplementary food.
- Provides supplementary income.
- Gives the gardener practical experience in farming.
- Helps in exercising the body.

FACTORS TO CONSIDER WHEN CHOOSING A SITE FOR A GARDEN

- Nearness to the farmer's residence.
- Topography or nature of the land.
- Nearness to a market.
- Access to road
- Nearness to a source of water.
- Protection against stray animals.
- Availability of labour.
- Fertility of the soil

- Soil type.

IMPORTANCE OF PRICKING OUT IN A VEGETABLE NURSERY

- Reduces competition for water and nutrients
- Improves light penetration
- Hardening the seedling

CONDITIONS UNDER WHICH SEEDBEDS ARE USED

Raised seedbeds

- In high rainfall areas
- Poor drainage or waterlogged areas
- During rainy seasons.

Sunken beds

- Low rainfall areas
- When there is the need to conserve moisture
- During the dry season

FARM RECORDS: - are the documents written down for the day-to-day activities on the farm.

REASONS FOR KEEPING FARM RECORDS

- It gives account of performance on the farm
- Enables weaknesses in the farming enterprise to be traced.
- Provides information for evaluation and decision making.
- Makes it possible to exercise managerial control.
- Enables the farmer to assess income generated.
- Provides information on tax assessment.
- Provides information for planning and budgeting
- To check movement of tools.
- To help the farmer to obtain loan.

SOIL AND SOIL CONSERVATION

Soil is the weathered part of loose organic and inorganic materials of the earth crust where plants grow.

FUNCTIONS OF SOIL

- The soil serves as a major source of nutrients, which are essential for plant growth and development.
- The soil provides mechanical support for the root system of plants.
- The soil supplies air as a source of oxygen which plant roots require for respiration.
- The soil is a habitat for macro and micro organisms such as earthworms, termites, bacteria and fungi which influence soil fertility

FACTORS AFFECTING SOIL FORMATION

The kind of soil which finally develops from the parent material derived from weathered rocks is dependent on such factors as: -

- Climate
- Vegetation
- Nature of parent material
- Topography/ slope of land
- Length of time

Climate: - factors which are directly related to the climate such as rainfall, temperature, sunshine, relative humidity and wind help in soil formation because continuous chemical and physical weathering releases nutrients into the soil. Rainfall for instance facilitates leaching which could make a soil acidic or alkaline. Wind may also blow sand against rocks and weather them. Continuous chemical and physical weathering releases nutrients into the soil. Continuous expansion and contraction of rocks causes rocks to weather to form soil.

Vegetation: - provides organic matter for the soil through absorption of nutrients from various depths within the soil by plant roots. Decaying organic matter also produces some acids, which aid in the weathering of rocks so speed up mature soil formation.

Nature of parent material: - the texture and mineral composition of the soil is influenced by the nature of parent materials for example sandstones gives rise to

sandy soils and limestone give rise to shallow soils. However, when a rock undergoes chemical decomposition, water dissolves certain minerals in a rock; it therefore, results in elements and chemical compounds that differ from parent material.

Topography or slope of land: - may either hasten or delay the effect of climate on soil reaction. Topography helps in drainage: the movement of water down a slope is often coupled with the movement of important nutrients and fine particles, so vegetation in hollows is often better supplied with nutrients than those on ridges.

Time: - with time the parent material is exposed to weathering forces which disintegrates into minerals of the soil, it will also take time for the plants to grow, die and decay to become part of the soil.

COMPONENTS OF SOIL

- *Minerals* supply nutrients to green plants. Most soils have 80% of the soil particles minerals.
- *Plant and animal matter* consist of organic material in various stages of decay. Soil organisms include plant roots, microbes and such animals as worms, insects and small mammals. Bacteria and fungi decompose dead plants and animals.
- *Water/moisture* is absorbed by plants through their roots. It enters the soil, dissolves minerals and nutrients and forms a soil solution. Much drains away but some remains in the pore spaces.
- *Air/oxygen* replaces the water that drains from the larger pore spaces.

SOIL SEDIMENTATION: - experiment to show that soil is made up of different sized particle.

Procedure: -

- Put a sample of soil in measuring cylinder.
- Add about four times its volume of water to it.
- Add sodium bicarbonate to the mixture to aid in the dispersion of the particles.

- Cover the mouth of cylinder; shake vigorously for about 2 minutes.
- Place the cylinder on bench to allow the contents to settle.

Observation: - it will be seen that the fractions have settled in layers. The heavy, coarse gravels have settled first. This is followed in succession by sand, silt and clay. The humus or organic materials remain floating in the water or settle on top of the clay.
Conclusion: - garden soil is a mixture of particles of different sizes.

SOURCES OF ORGANIC MATTER

- Compost / decayed plant and animal materials.
- Farmyard manure / poultry droppings / dung of cattle, goats and sheep.
- Green manure – annual legumes in rotation to fix nitrogen in the soil.
- Human waste / night soil / sewage.

FUNCTIONS OF ORGANIC MATTER / HUMUS

- Improves the fertility of the soil thus enhances plant nutrition.
- Improves the moisture holding capacity of the soil.
- Improves aeration or drainage of the soil.
- Enhances microbial activity.
- Improves soil structure
- Regulates the temperature of the soil.

PHYSICAL PROPERTIES OF SOIL

- *Soil texture* – refers to particle size of soil determined by feeling soil when wet.
- *Water retaining ability* – proportion of water that soil holds.
- *Air content* – proportion of air in soil.
- *Porosity / Permeability* – implies how easily water passes through the soil.
- *Capillarity* – refers to how well water rises up in soil depending on size of air space between soil particles.

PROPERTIES OF SANDY SOIL

- Particles are large / coarse / loose / rough / gritty.
- Well aerated / large air spaces.
- Cannot retain water.
- Low nutrient / low mineral holding capacity.

PROPERTIES OF CLAY SOIL

- Particles are small / fine /smooth / compact.
- Poorly aerated / small air spaces.
- Poor drainage / can retain water / waterlogged / holds water.
- Can be moulded / sticky when wet.
- Easily cracks when dry.
- Has high mineral nutrient / high mineral holding capacity

PROPERTIES OF LOAMY SOIL

- Particle sizes are between that of sandy soil and clay soil.
- Fairly or moderately aerated / has air spacing between that of clay and sandy soils.
- Has moderate water holding capacity.
- Contains right proportion of plant and animal nutrients.
- Contains equal quantities of clay and sand particles.

Suitability of loam for crop production

- Easy to till.
- Good water retention capacity
- Good aeration
- Good humus content
- Minimum leaching of nutrients.

SOIL PROFILE: - this is a total sequence of layers and bedrock in vertical section, description of the subsections is as follows: -

HORIZON **A** / TOP SOIL

- Colour is dark brown.
- Contains a lot of organic matter / humus / nutrient.
- Layer is exposed to frequent erosion or weathering.
- Good crumb structure
- Region of eluviations; on account of leaching of nutrients from it to the subsoil.

- Soil organisms are found here e.g. earthworms, ants, termites, beetle, centipede etc.

Benefits of soil organisms to crops

- They feed on dead plant materials / leaf litter which they pull into their burrows.
- Dead and decaying soil organisms increase the organic matter / humus in the soil.
- Their burrowing activities create holes /spaces in the soil which improve soil aeration and drainage.
- They assist in the decomposition / disintegration of organic matter leading to the release of nutrients to the soil.
- Their activities assist in the mixing of soil with organic matter/improve nutrient recycling in the soil.
- Their faeces are also useful.

Destructive effects of the organisms

- Eats the roots of crops such as tubers or corms which destroy the plants.
- They interfere with root absorption.
- They feed on useful soil organisms.
- They cause damage to roots of crops / underground storage organs.
- They make mounds which are impediments to agricultural implements.

HORIZON **B** / SUB SOIL

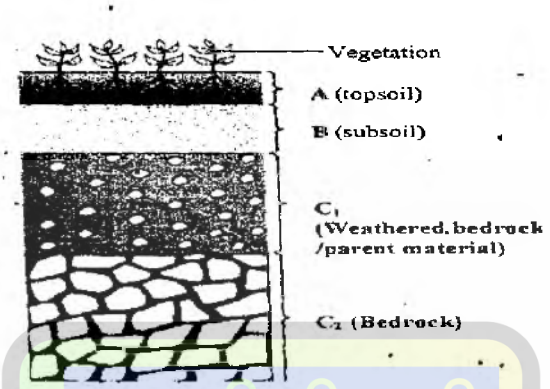
- Colour is reddish brown.
- Contains materials leached from the top soil or contains little organic matter.
- Layer is sandy clay.
- Layer is exposed to frequent erosion or weathering.
- Good crumb structure.

HORIZON $\mathbf{C_1}$ / WEATHERED ROCK

- Contains no organic matter.
- Contains gravels / crumbs of parent rock material.
- Hard / not permeable to water.

HORIZON C_2 / PARENT ROCK / BED ROCK

- Contains no organic matter.
- Hard / compact / not permeable.
- Contains mainly unweathered rocks.



Soil profile

IMPORTANCE OF SOIL PROFILE

- The depth and quality of the top soil helps the farmer to decide the types of crops to grow.
- To know the type of implement to use.
- To know the water retaining capacity and aeration of soil, using the texture and structure of the soils.
- The colour of the top soil can be used to predict the organic matter content of the soil.

Characteristics a farmer would look out for in a soil profile

- Colour and depth of the top soil.
- Looseness or compactness of the subsoil.
- Nature and chemical composition of the bedrock / weathered rock layer.

FERTILE SOIL: - is the one that supplies the right types of plant nutrients, under appropriate conditions of soil pH and toxicity.

SOIL FERTILITY: - is a measure of the nutrient supplying ability of a soil.
Factors contributing to soil fertility

- Adequate supply of nutrients.
- Organic matter content.
- Soil reaction of pH.
- Physical characteristics (texture, depth, structure, consistency).
- Absence of injurious substances.
- Nature of the soil.

Ways by which soil can loose its fertility

- *Soil erosion* – the removal and carrying away of the top soil by the action of water and wind.
- *Bush fire/burning of vegetation before cropping* – important mineral elements such as carbon, nitrogen, phosphorus and sulphur burn away and are lost. Humus in the top soil may also be burnt and lost. Burning also kills important soil organisms. The soil laid bare after burning, may be eroded leading to loss of fertility.
- *Over cropping/continuous cultivation* – crops remove minerals from the soil during growth in little amounts so over cropping will exhaust all nutrients so also the soils fertility.
- *Denitrification*
- *Crop removal or overgrazing*.
- *Excessive or improper irrigation and drainage practice*.
- *Surface mining and quarrying*.
- *Excessive use of fertilizer*
- *Deforestation*
- *Poor farming and tillage methods*.
- *Dumping of non-biodegradable waster on land*
- *Leaching* – water rapidly seeps through the soil during heavy rainfall and washes down some important nutrients to lower levels below the reach of shallow rooted crops.
- *Surface compaction* – this is caused by people and livestock continually walking over farmlands to cause soil particles to compact or compress, reducing air content and absorption of oxygen as in footpaths.

EROSION BY WATER

There are four distinct types namely: -

1. *Raindrop erosion* – this occurs when raindrops splash on bare lands as a result of the impact on soil surface. In vegetations not much soil is splashed.
2. *Sheet erosion* – this is the uniform removal of soil on sloping lands. It takes place gradually and often continues until small channels start forming on the soil surface.
3. *Rill erosion* – is the removal of soil by water through well defined small channels (rills). The channels are wavy and dispersed.
4. *Gully erosion* – the rills are capable of becoming bigger and deeper in time to form gullies.

CONTROL OF EROSION CAUSED BY WATER

- Steepest slopes should be left under forest and permanent pastures and not cultivated.
- Soil fertility and productivity must be maintained to ensure continuous vegetation.
- The use of fertilizer, lime and manure can be used to promote vegetation growth.
- Conservation methods such as contour ploughing, strip cropping and cover crop planting must be practiced.
- Whenever appropriate mechanical control measures such as terracing and silt pits construction must be applied.
- Ploughing across gullies and planting grass crops reduce speed of run offs.
- Dam well developed gullies or grassed to reduce the rate of water flow.

EROSION CAUSED BY WIND

This is brought about by strong winds example harmattan winds from Sahara desert of West Africa. When the soil dries up it is carried by wind easily.

CONTROL OF EROSION CAUSED BY WIND

- Vegetative cover – the plants on the land slows down speed of wind, prevent movement of particles, improve soil structure and prevent evaporation of water.
- Moisture content of the soil – avoid working the soil dry. Wet soils do not move easily thus are stable.

- Soil characteristics – keep the soil surface rough. When the soil has clods with rough surfaces they are not blown by winds, lighter ones are blown away easily.
- Creating wind breaks
- Any other mechanical measures could be taken.

Effects of erosion on agricultural productivity

- Humus and other soil nutrients and soil microbes are normally confined to the top soil, erosion transports this top soil and its content away hence the soil nutrients are not available for plant use.
- The microbes which cycle nutrients are not available leading to poor agricultural productivity.

SOIL CONSERVATION: - this is the rational use of the soil to yield the greatest sustainable benefit to present generations while maintaining its fertility and protecting it from deterioration through natural and human-induced causes.

SOIL CONSERVATION PRACTICES / MAINTAINING SOIL FERTILITY

Soil is a renewable natural resource, to retain its fertility these soil conservative practices could be employed. Most of these soil conservation methods also control erosion. Controlling erosion ensures the retention of plant nutrients in top soils. The methods include: -

- Cover cropping – growing cover crops such as grasses, sweet potatoes, crotalaria (rattle box) or any broad leaved crop to hold soil particles together and prevent rainfall directly hitting the soil to loosen it.
- Re-afforestation
- Bush fallowing
- Terracing – terraces (flat horizontal areas where crops are cultivated) are constructed following the contours of land (across the sides of the hill). This reduces the speed of water running down the slopes.
- Contour ploughing – ploughing is carried out along the contours and not up and down the hill to reduce the speed of water running down the slopes.
- Crop rotation – the alternation of legumes and non-legumes in rotation improves the nitrogen content of the soil through their ability to fix nitrogen in their roots.

- Manuring – this is the addition of organic matter to the soil
    - Green manuring – growing of green manure crops, example annual legumes in rotation (short lived) should be planted to fix nitrogen in the soil.
    - Application of compost – applying decomposed heaps of plant and animal remains to the soil. The mixture could include household refuse, weeds and animal excreta.
    - Farmyard manure – applying rotten mixture of bedding straw and excreta of farm animals.
- Mulching – is the act of covering the soil surface with a layer of any suitable material.

  Advantages of mulching
    - Keeps soil cool.
    - Increases water infiltration.
    - Keeps the soil moist / prevents loss of water.
    - Improves soil structure
    - Increases organic matter content of the soil.
    - Keeps down weeds.
    - Increases microbial and marcrobial activities.
    - Controls soil pH.
    - Prevents soil erosion.
- Controlling soil acidity – dissolved minerals provide additional H^+ and OH^- in varying amounts. Soils with more hydrogen ions than hydroxyl ions are acidic, while those with more hydroxyl ions than hydrogen ions are alkaline. Low soil pH, (below 4) or high pH, (above 9) inhibits the activities of soil microorganisms causing most soil mineral elements to become insoluble (precipitate out) which are in themselves toxic to plant roots.

Factors contributing to soil acidity

- Excess irrigation – this increases leaching which leads to soil acidity.
- Leaching – this leaves behind a high concentration of hydrogen ions, enough to cause acidity.
- Continuous cropping of heavy feeders (tuber crops) – over a number of cropping seasons removes considerable amounts of basic ions from the soil leaving behind a high concentration of hydrogen ions making the soil acidic.

- Excessive use of organic manure
  - The decomposition of organic matter by bacteria leads to soil acidity.
  - Large amount of humus produced holds on its surface hydrogen and aluminium ions making the soil acidic.
  - During decomposition carbon dioxide produced is hydrolyzed into carbonic acid that causes soil acidity.

Effects of soil acidity

- Acidic soils render the action of agro-chemicals like herbicides and nematicides ineffective.
- In acidic soils essential elements such as phosphorus and molybdenum are precipitated and made unavailable to plants thus making them toxic to plants.
- Trace elements like aluminium and manganese are soluble in acidic soils making them toxic to plants.
- Inhibits the performance of soil microorganisms in nitrogen fixation as well as inhibits the absorption by plants of essential elements like calcium and magnesium.

Correction of soil acidity

- Reduction in the use of nitrogenous acid forming fertilizers on the soil can improve the practice of acidic soils.
- The use of liming – this is the process whereby certain calcium compounds or ashes are added to the soil to reduce acidity of the soil.

  The materials used include:
  - Limestone $\longrightarrow$ $CaCO_3$
  - Quicklime $\longrightarrow$ CaO
  - Slaked lime $\longrightarrow$ $Ca(OH)_2$
  - Calcium silicate $\longrightarrow$ $CaSiO_3$
  - Shell meal and palm bunch which contains calcium and magnesium.

Benefits of liming

- It corrects soil acidity
- Makes phosphorus and molybdenum available to plants or enhances the absorption and utilization of essential elements.
- Increases calcium which promotes soil particle aggregation or improves soil structure.

- Soil microorganisms perform their function of nitrogen fixation.
- Efficiency and effective use of agrochemicals such as herbicides.

Improvement practice adopted for vegetable crop production in saline soils

- Water regularly to leach the excess salts beyond the root zone
- Add gypsum ($CaSO_4.2H_2O$) to the soil to remove the salt elements.

Functions and deficiency symptoms of some selected essentials plant nutrients

Nutrient	Function	Deficiency symptoms
nitrogen	a major constituent of plant protein; found in some other organic compounds associated with plant life	chlorosis (yellowing) of older leaves; stunted growth
phosphorus	required for respiration and metabolism; required for cell division because it is a constituent of nucleoproteins; required for seed germination, root development, seed and fruit formation; hastens maturation of crops and fruit ripening; strengthens plant structure against insects lodging	older leaves have purple/green colour; slender stems in grass plants; poor root and bark development; stunting of green parts of plants
potassium	catalyses most physiological functions; regulation of water; aids nitrate absorption from the soil; neutralises organic acids; strengthens plant straw and stalk against lodging, fungal and bacterial attack	chlorosis of leaves; marginal browning of leaves; curling of leaves; delayed maturity of plants
calcium	constituent of leaf lamina; aids growth process in the meristematic regions; corrects soil acidity; strengthens plant cell walls with calcium pectate; controls the toxicity of trace elements like Al_3^+, Mn_2^+ and Na_2^+ in plants; neutralises acidity in plants; helps in the translocation and storage of carbohydrates	difficulties in nitrogen absorption by plants; plant seedlings die; reduces soil cation exchange capacity
magnesium	constituent of plant leaf chlorophyll and therefore essential for photosynthesis	chlorosis of leaf veins (vein clearing); necrosis (death) of older leaves; stunted growth
sulphur	occurs in amino acids, hence it is a constituent of plant protein; influences protein synthesis, chlorophyll formation and biological nitrogen fixation	stunted growth; reduction in plant hormonal activities
manganese	regulation of oxidation–reduction reactions in plants; catalyst in chlorophyll activities	the top of young leaves show yellowish-green discoloration
molybdenum	nitrogen fixation through its influence in the plant enzyme system; metabolism of nitrates into amino acids and proteins	reduced nitrogen fixation; poor nitrogen transformation into plant protein
boron	regulation of various plant physiological activities	death of young plants; irregular spots on young leaves and buds; decreases the rate of water absorption and of the translocation of carbohydrates

PLANT NUTRIENTS

- Major or macro nutrients
- Minor or micro nutrients (trace elements)

Macro nutrients – are required in large amounts for efficient performance of plants examples are carbon, nitrogen, phosphorus, potassium, sulphur, calcium, and magnesium.

Sources of macro nutrients

- Carbon and oxygen – obtained directly from the air by higher plants.
- Hydrogen – obtained from soil moisture.
- Nitrogen, phosphorus, potassium (NPK) – can be supplied in the form of commercial fertilizers and farm manures.
- Calcium and magnesium – supplied through liming with CaO, $Ca(OH)_2$, $CaCO_3$ etc.
- Sulphur – goes into the soil in rain water or superphosphate, sulphate of ammonia and farm manure.

Micro nutrients – are nutrients required in small amounts mg/ha or less. They include boron, copper, zinc, molybdenum, iron, cobalt, manganese, sodium and chlorine.

Sources of micro nutrients

- These come from parent rocks on which the soil will be sitting.
- A secondary source is soil organic matter which releases the elements on decomposition for plant use.

Ways by which nutrients are lost from the soil

- Crop removal
- Leaching
- Erosion
- Burning
- Oxidation of organic materials
- Reduction of organic materials.

FERTILIZERS: - are substances naturally or artificially composed, added to the soil to lead to increased growth and bigger yields.

KINDS OF FERTILIZERS

- Inorganic fertilizers also called artificial manures are imported by the Ministry of Agriculture and soil to farmers. It does not contain humus so continual application must be avoided.
- Organic fertilizers are manures or decomposed organic matter derived from plant and animal sources.

The advantages of organic fertilizers over inorganic fertilizers

- Improves the structure of the soil or improves the fertility and physical conditions of the soil or binds the soil together.
- Helps the soil to retain water.
- Helps the soil to resist leaching.
- Serves as mulch for the soil.
- Enhances the growth of microorganisms.
- Supply both micro and macro nutrients.
- Makes the soil less compacted aiding in the increase of air in the soil.
- Release nutrients slowly into the soil and hence remains in the soil for a long time or have a more lasting effect.
- It is relatively cheaper.
- Prolong application does not cause pollution or has no negative side effects.

TYPES OF FERTILIZERS

- Complete or compound fertilizers – they contain 2 or 3 major plant nutrient such as NPK, NP, NK or PK.
- Simple or straight fertilizers – they may contain only one of the three major nutrients. They are divided into three classes namely:
  - Nitrogenous fertilizers – supplied in two forms either in nitrate or in ammonia examples include urea, potassium nitrate and ammonium nitrate.
  - Phosphatic fertilizers – examples are triple super phosphate, single super phosphate, basic slag and rock phosphate.
  - Potash fertilizers – examples are muriate of potash (KCl), sulphate of potash and magnesium sulphate.

METHODS OF FERTILIZER APPLICATION

- Broadcasting – in this process fertilizer is spread as uniformly as possible. It may be either left on the soil or ploughed into it before planting or after.
- Localized placement – fertilizer is applied with special reference to the position of plant or seed, examples are as follows:
  - Band placement – a 5cm deep furrow is made 5cm away from seed or seedling along the row and fertilizer put in.

- Drilling method – the fertilizer is applied with a drill as the same time as the seed is sown.
- Plough sole method – fertilizer is placed in a continuous band at the bottom of the plough furrow. Each band is covered as the succeeding furrows are turned over.
- Ring method – fertilizer is applied in a circular way equidistant from the plant. The fertilizer is not made to touch the plant.
- Side dressing – fertilizer is applied as a second application to plants already grown in the field
- Foliar method – special liquid fertilizer is diluted to the required concentration before it is applied to the leaf of some plants.

FACTORS TO BE CONSIDERED DURING FERTILIZER APPLICATION

- Type of crop – some crops need more nutrients and others need just a little therefore, the amount to be applied will vary with the crop type.
- Type of soil – the type of nutrients supplied should depend on the fertility status of the soil.
- Climatic factors – in high rainfall areas where leaching of nutrients is likely to be greater more frequent application of fertilizer is required.
- Economic factors – addition of fertilizer may increase crop yields which come with the added cost of the fertilizer.
- Management – other inputs are required for crop production thus, it will be a management decision on the amount of fertilizer to be used.

REVISION QUESTIONS:

1. a. (i) State three types of soil erosion.

   (ii) Explain the effects of erosion on agricultural productivity. (6 marks)

   b. Describe a simple experiment used for the determination of soil texture. (4 marks)

   c. (i) State four advantages of incorporating organic matter into the soil.

   (ii) State two conditions under which raised seedbeds are used. (6 marks)

   d. (i) What is a fertilizer?

   (ii) Describe briefly two methods of fertilizer application. (4 marks)

2. a. (i) State the major components of soil.
   (ii) Give two farming practices which prevent soil erosion. (5 marks)
   b. (i) What is a fertile soil?
   (ii) State three ways in which earthworms improve soil fertility. (5 marks)
   c. (i) What is soil?
   (ii) State three factors that affect soil formation. (5 marks)
   d. (i) Explain the term liming as applied to soil.
   (ii) State three advantages of liming. (5 marks)

3. a. (i) What are macronutrients?
   (ii) List three macronutrients required for crop production.
   (iii) State two ways in which nutrients are lost from the soil. (7 marks)
   b. State three qualities of loam that makes it suitable for crop production. (3 marks)
   c. (i) Describe briefly the effects of temperature on weathering of rocks.
   (ii) Distinguish between igneous rocks and sedimentary rocks giving one example of each. (7 marks)
   d. List three sources of organic matter to the soil. (3 marks)

4. a. (i) Explain the term mulching.
   (ii) Give two advantages of mulching. (4 marks)
   b. (i) State three factors that cause depletion of soil fertility.
   (ii) State two conditions under which sunken beds are used. (5 marks)
   c. (i) What is a backyard garden?
   (ii) State three importance of backyard garden. (6 marks)
   d. (i) State two ways of maintaining farm tools.
   (ii)State three reasons for keeping farm records. (5 marks)

5. Describe an improvement practice that could be adopted for vegetable crop production in the following soil conditions:
   (i) Acidic soil;
   (ii) Saline soil. (4 marks)

4.3 WATER

¾ of our body is composed of water. As we loose water through excretion, perspiration etc stock should be replenished through drinking, foods etc. Meat and fish =75% of water, green vegetables = 90% of water.

Sources of water: -

- Rivers
- Streams
- Boreholes or wells
- Springs
- Lagoons
- Rain
- Lakes
- Sea
- Pipe-borne
- pond

Uses of water: -

- **Domestic** - drinking to prevent dehydration, cooking, bathing, washing, irrigation, cooling.
- **Industrial** - to turn turbines of hydroelectric generators to generate electricity; fishing along the banks of lakes created by Akosombo, Weija, Bui, Kwanyaku dams etc; #For irrigation to provide water for plant growth throughout the year e.g. Bui, Dawhenya and Okyereko dams support irrigation; #In brewing and textile industries to produce finished goods.
- **Transport** – bulk cargo like petroleum products and timber is transported over water from one place to the other.
- **Recreational** - in such activities as swimming, skiing and surfing.
- **Extinguishing fire** – fire service personnel use water under high pressure to put out fire.
- **Life processes : -**

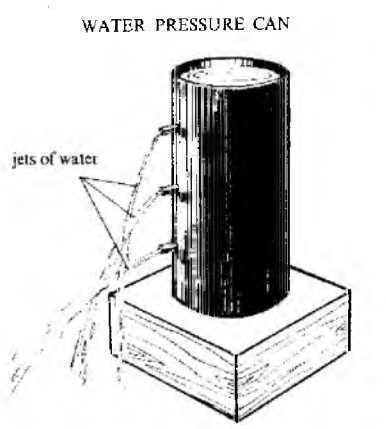
- as a solvent to transport and distribute food nutrients;
- as a solvent medium for chemical reactions to take place;
- as a liquid medium through which waste products are flushed out e.g. in urine and sweat;
- means of keeping the body cool.

Physical properties of water:

1. Pure water is colourless, odourless and tasteless liquid.
2. Water freezes at 0^0C and boils at 100^0C at one atmospheric pressure.
3. The density of water at maximum at 4^0C is 1.00g/cm^3. Ice and cold water (less than 4^0C) floats on top of warm water and freezing takes place from

the surface of water downwards. This is very important for maintaining underwater life in cold environments.

4. Water is a very weak electrolyte (poor conductor of electricity. it becomes a good conductor when a small amounts of ionic compounds is dissolved in it.)
5. It is neutral to litmus
6. It has high surface tension; it appears to form a thick skin on its surface.



(The purity of water is tested by its physical properties)

Investigating the pressure exerted by water at different depths

- Pick an empty Milo tin and make three holes A, B and C.
- Cellotape the holes and fill the tin with water to the brim
- Remove the cellotape and observe.

Observation: -

Water gushes out furthest from the hole made at the lowest part (A) of the column of water, thus pressure in water increases with depth.

Application: -

- Reservoirs used to store water should have their base made thick and strong to be able to withstand the high pressures at the lower part of the column of water.
- The concrete barrier built across rivers during the construction of hydroelectric power stations is made thick with a lot of reinforcement to be able to withstand the high pressures on the river bed. This is because large volumes of water collect behind the concrete barrier.

Types of dissolved substances that may be present in water

- Air/ Oxygen/ Carbon dioxide/ gases
- Dissolved salts of potassium, sodium and ammonium
- Acids/ soluble base- alkali.

Investigating the presence of dissolved substances in water

- Clean an evaporating dish
- Pour some water into the dish

- Heat the water gently until all of it evaporates
- Concentric rings of solids remain in the dish. This indicates the presence of dissolved substances in water

OR

- Clean a beaker
- Pour some water into it
- Heat the water gently
- Bubbles of air appear on the sides of the beaker.

Chemical properties of water:

1. It is a universal solvent; it is an excellent solvent and most substances dissolve in it to some extent forming aqueous solutions. (Substances dissolved in water are said to be aqueous)
2. Oxides of non-metals dissolve in water to form acid solutions. Oxides of metals which are soluble in water form alkaline solutions.
3. Water reacts with many metals liberating hydrogen.
4. Water molecule is said to be polar: Water has one oxygen atom bounded to hydrogen atoms to form one water molecule. The overall result is a molecule which has positive side and negative side, instead of being electrically neutral, the charge is unevenly distributed between the H-atoms and the O-atom; the bond is thus said to be polarized. This allows two molecules of water to attract each other.

Test for water in the lab

- Water added to anhydrous copper (II) tetraoxosulphate (VI), the reagent turns from white to blue. **OR**
- Water added to anhydrous cobalt (II) chloride, the reagent turns from blue to pink.

Investigating the polarity of water molecules

- Pour water into a burette
- Rub a piece of lint or car duster on a glass rod
- Open the top of the burette to allow a gentle stream of water flow out of it.
- Bring the glass rod close to the stream of water flowing out of the burette.

- Repeat the activity by pouring kerosene into a clean dry burette.

CONCLUSION: - the stream of water is deflected towards the glass rod. Unlike charges attract. Since the rod is charged, it could be inferred that the water molecules are also charged to explain why water molecules get attracted the glass rod.

Kerosene is non-polar since kerosene molecules are not attracted by the glass rod.

Reasons why water serves as a solvent for most substances

- Water is dipolar i.e. it has positive and negative ends
- Most substances are polar like water
- Since like dissolves like/polar substances dissolve in polar solvents (they dissolve in water).

Hardness of water:

Hard water is water that does not lather easily with soap. This results from rain water trickling across rocks and through the ground and dissolving various amounts of chemical compounds as it does so. Calcium and magnesium ions in water are the most common cause of hardness. There are two types of hardness, temporary and permanent.

Chemicals used to remove both temporary and permanent hardness of water

- Na_2CO_3 – washing soda
- $Ca(OH)_2$ – calcium hydroxide
- $NaAl(CO_3)_2$ – Sodium Aluminium carbonate

Temporary Hardness:-

Temporary hardness of water is hard water that can be softened by boiling. This occurs when calcium and/ or magnesium hydrogen carbonates are dissolved in the water. This happens when rain water which has dissolved some carbon (IV) oxide from the atmosphere forming a weak acidic solution falls on rocks containing calcium or magnesium carbonate.

$$CaCO_3(s) + H_2O(l) + CO_2(g) \longrightarrow Ca(HCO_3)_2(aq)$$

Softening hard water

Ways by which Temporary Hardness of water can be removed.

- On boiling

- the bicarbonates of calcium/magnesium breakdown
- to give a precipitate of calcium/magnesium carbonate

$Ca(HCO_3)_2\ (aq) \xrightarrow{heat} CaCO_3(s) + CO_2\ (g) + H_2O\ (l)$

$Mg(HCO_3)_2(aq) \xrightarrow{heat} MgCO_3(s) + CO_2\ (g) + H_2O\ (l)$

Alternate:

- adding washing soda (sodium carbonate)
- the carbon reacts with calcium ions/ magnesium ions
- to give a precipitate of calcium/magnesium carbonate.

$Na_2CO_3 + Mg(HCO_3)_2 \longrightarrow 2NaHCO_3\ (aq) + MgCO_3(s)$

$Na_2CO_3 + Ca(HCO_3)_2 \longrightarrow 2NaHCO_3\ (aq) + CaCO_3(s)$

Permanent Hardness:-

This is caused by calcium and/or magnesium sulphates dissolved in the water. These compounds occur naturally and, although, calcium sulphate is only slightly soluble it dissolves sufficiently to cause hardness. Permanent hardness cannot be removed by boiling. It can be softened by:-

- **Precipitation**: - i.e. addition of washing soda, (sodium carbonate) to the water. $CaSO_4\ (aq) + Na_2CO_3\ (aq) \longrightarrow CaCO_3(s) + Na_2SO_4\ (aq)$ this removes calcium ions from the solution as insoluble calcium trioxocarbonate (IV), ($CaCO_3$) which precipitates out and can be filtered off.

Ion exchange: - certain complex sodium compounds remove dissolved ions from hard water and replace them with their own.

$$CaSO_4 + \text{Na complex} \longrightarrow \text{Ca complex} + Na_2SO_4$$

This is done with a modern ion exchanger which contains a solid mixed-bed resin. The mixed-bed resin made of beads of polymers such as polystyrene is treated to absorb sodium ions. The hard water containing the calcium/magnesium ions is allowed to wash through the mixed-bed resin and sodium ions replace the calcium ions to obtain the useful resin.

Distillation: - this removes all the dissolved solids, but is expensive. Water is more volatile than minerals and when heated, it vapourises first leaving minerals

behind. The water vapour is condensed back to liquid on contact with a cooler surface and is called distilled water. Mineral salts including those responsible for hardness remain in the container.

Disadvantages of hardwater: -

1. Wastes soap
2. Tends to make white clothes grey when they are laundered.
3. Prevents efficient reaction of chemicals in dyeing and tanning industries.
4. Deposits 'fur' (calcium carbonate) in kettles, pipes and boilers causing inefficiency and wastage of fuel. The build up of scale in boiler pipes can cause blockages which may result in serious explosions.

Advantages of hardwater: -

1. Provides calcium which is essential for bones and teeth.
2. Does not dissolve lead from lead pipes.
3. Is better for some manufacturing processes such as brewing.

Disadvantages of soft water: -

1. Dissolves lead in lead pipes.
2. Lack of calcium and magnesium salts for strong bones and teeth formation.
3. May cause lead poisoning
4. Unpleasant taste

Advantages of soft water: -

1. It lathers easily with soap.
2. It is better for some manufacturing processes such as dyeing and tanning.

Treatment of water for public consumption: -

In town water plants, the following processes are carried out: -

1. Water is exposed to the atmosphere and sunlight to add oxygen to water and remove undesirable odour.
2. Water is passed through sand and gravel beds to remove both organic and inorganic debris/ large suspended particles.
3. Alum is added to quicken the rate of sedimentation/ removal of fine suspended particles.

4. Chlorine is added to kill the bacteria, microbes and other germs.
5. Addition of calcium hydroxide to control or adjust the pH of the water.

4.3.1 WATER MOVEMENT

Water movements along the sea side vary at various levels. Sometimes it is higher up on the beach and at other times it is lower. Tides are the rhythmic rising and falling of the sea. It occurs on daily basis. Tides can be high or low and these are the daily pattern of changes in the level of the sea.

Causes: - the gravitational pull of the moon on the earth causes the tide. The earths pull on the moon, makes it orbit the earth, the moons pull makes the oceans move.

Spring tides and neap tides are caused by the position of the moon, relative to the earth and the sun.

Spring tides: - occurs as a result of the combined pull of the sun and the moon causing a very big change in the level of the sea when the earth, sun and moon are in a straight line at the same time of full moon or new moon. It occurs twice in a month, that is, at full moon and new moon.

Neap tides: - are weaker tides in the sea level when the sun and the moon are perpendicular or at right angles to each other and their pull partly cancels each other out. It occurs twice in a month, that is, at a quarter moon and last quarter moon.

Tidal waves: -

This refers to the swell of water created by the tides

Flood tides: - the incoming or rising tides. Flood tides move and deposit any floating material onto and up the beach.

Ebb tides: - the outgoing or falling tides. Ebb tides wash away sand from the shore or coastline as they recede.

Effects of tidal waves

1. They cause currents/strong flow of water which leads to the loss of large portions of land to the sea by washing away stones, sand, houses and other debris around the areas of coastline/shore; this has been a problem in Keta and this has led to the construction of a sea defense wall to protect the whole town from being washed away.

2. Tides flush out the water in estuaries and lagoons (shallow channels or lakes next to the sea) and cause sea currents near the shore.
3. The swell or surge of tidal wave deposits sand and debris on the coastline.
4. At very high tides fishermen are not able to go fishing.

Advantages of tidal waves

- Rocky intertidal zone inhabits a variety of marine plants and animals.
- Sea creatures (horse shoe crab & grunion fish) lay their eggs on the spring high tide because they have evolved strong tidal and semi-lunar rhythms. They therefore time their mating to coincide with the high spring tides.
- Tidal energy could be harnessed to generate electricity. (A large mass of water flows through a narrowing channel (bay or estuary); the funneling process tends to accelerate the movement of the water. The mass of water at the front slows down, however resulting in a wall of water that surges towards the channel which could be harnessed to generate electricity.
- The tides mix salt water and fresh water in the estuaries (where river meets the sea) a nursery area for many sea animals.

4.4 HYDROLOGICAL CYCLE

Distribution of earth's water

Of the earth's total water supply, almost 97% is salty or saline (seas/ocean) and only 3% fresh. Out of the 3% fresh water supply almost 70% is frozen and locked up in ice and glaciers and about 30% is in or below the ground.

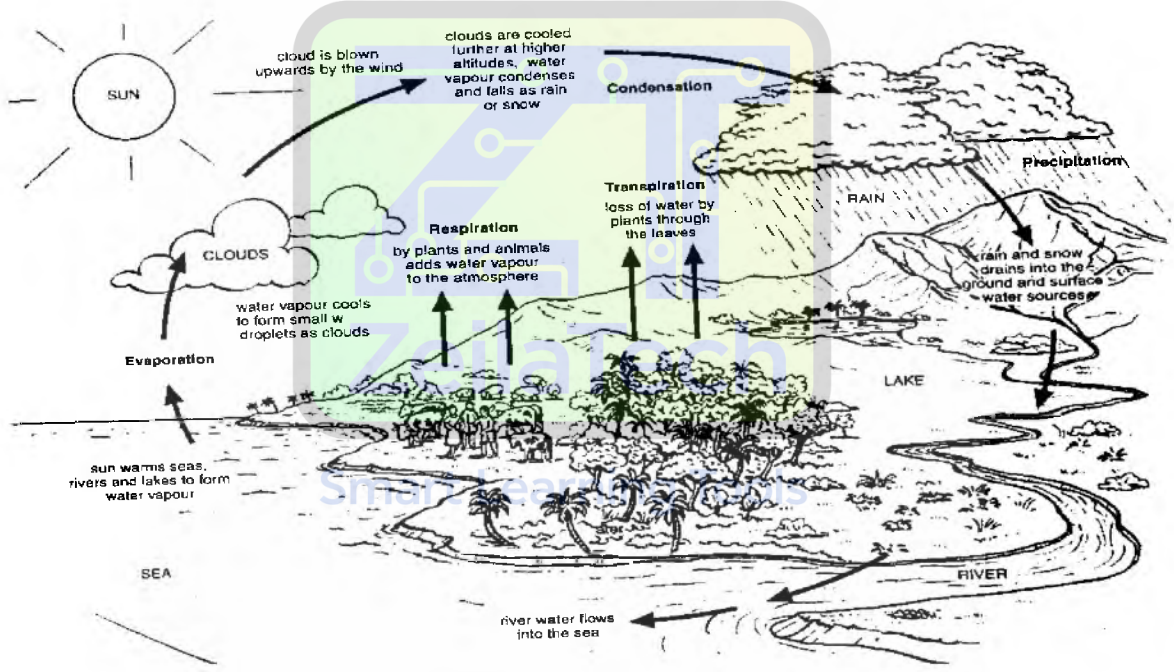
Out of the earth's total water supply only 0.3% can be used by humans. Though this quantity is minute yet it does not run out because the water cycle renews the supply of fresh water. The earth is called a blue planet because more than ⅔ of its surface is covered with water. The water cycle is a continuous movement of water between the earth's surface and the atmosphere.

Heat from the sun evaporates water from the sea. As vapour rises into the atmosphere it cools and condenses into liquids to form clouds. Winds carry the clouds above until it becomes saturated and falls back as rain, hail or snow by the process of **precipitation**.

After precipitation the following occur: -

- Infiltration: - water seeps or percolates into the permeable and dry soils.
- Run off: - water runs or flows over the earth's surface into streams and rivers and eventually into the sea.
- Evaporation: - the water evaporates and the cycle begins

Underground water gets back into the water cycle through natural springs and wells. Plant roots also take up some water and give it off as water vapour through transpiration.



The water cycle

Importance of hydrological cycle to plants and animals

1. The cycle helps to maintain the earth's total water supply which sustains animal and plant life.
2. It causes cooling; when the water evaporates it takes away some heat (during perspiration in animals and transpiration in plants).
3. Plants need the cycle for photosynthesis.

4. Animals drink water directly to quench their thirst and indirectly through foods to avoid dehydration.
5. Water softens the soil for plant growth.
6. Rain falls to infiltrate permeable and dry soils to maintain underground water which virtually comes out as natural springs and wells.
7. Supply of constant fresh water supply to animals to prevent water-related diseases.
8. Animals respire to give out water vapour whiles plants also transpire to give off water vapour which help to continue the cycle.
9. It affects the even distribution of temperature on the earth's surface as water vapour regulates the temperature as is carried from one place to another.
10. It prevents the poles from getting increasing hotter; this is because whenever the water freezes into ice heat is released and when the ice melts it absorbs heat. It is this absorption and release of heat that prevents the poles from getting hotter.

Sources of water contamination

Agricultural waste: - these include commercial fertilizers and pesticides. When these are washed into water bodies poisons animals and plants or disturbs the balance of the ecosystem. **Eutrophication** occurs as a consequence of the accumulation of nitrates and phosphates in water bodies. These nutrients cause rapid growth of algae to spread over the surface of water blocking out light and producing toxins. The algae dies, decomposes using up oxygen in the process to produce harmless products such as carbon (IV) oxide, water and other compounds with unpleasant scent. This will kill fish and other animals from lack of oxygen.

Industrial waste pumped into rivers and water bodies contaminates the water and kills animals.

Domestic waste: -the effluent from septic system and cesspool can contain bacteria, viruses, nitrates, heavy metal, detergents and a variety of household hazardous chemicals that are poured down the drain.

Mining waste: - contains toxic materials such as mercury and cyanide which contaminates water bodies as a result of improper disposal practices.

Hospital and Radioactive waste: - waste from hospitals contributes to water contamination in communities where hospitals are located. For instance Korlebu Teaching Hospital in Accra is a major source of contamination to the Korle Lagoon.

Harmful effects of water contamination

Water-borne diseases: - these are diseases that spread through contaminated water with faeces and urine. Such diseases are cholera, diarrhoea, typhoid or enteric fever, amoebic dysentery, Hepatitis A. They are caused by microorganisms or bacteria in the water.

Water-based diseases: - these are diseases that spread through water contaminated with parasites. Such diseases are river blindness (Onchocerciasis), Schistosomiasis or bilharzias, hookworm and guinea worm. They are caused by parasitic worms which enter the human body through contact with infected water.

Methods of controlling the vector of Schistosomiasis: -

- Introduction of fish to eat immediate host (water snail)
- Eliminate the water snail with molluscide
- Clearing vegetation around pond
- Prevention of the infected person from urinating/defecating into water
- Avoid bathing in infected water.

Water-related insect diseases: - these are carried by insects such as mosquitoes and flies that breed in or near dirty and stagnant water.

Water-washed diseases: - occur in places where water is scarce and people cannot wash themselves or their clothes regularly. These include trachoma (eye infection causing soreness and blindness), scabies (caused by mites, skin sores and itchiness) and leprosy.

Pollutants: are substances which when released into the environment are harmful to living organisms.

Summary of water pollutants

- Agrochemicals – pesticides/ weedicides/ fertilizers.
- Oxides of metals/ mercury
- Release of factory waste in water (Industrial waste).
- Release of hot water from factories.

- Oil spillage - (Crude oil/ petroleum products)
- Release of untreated sewage into water. (Urine, faeces/ sewage)
- Silt
- Dumping of domestic waste into water (Soap/detergent, rubbish)

Ways of preventing water pollution

1. Treatment of raw sewage before discharged into water.
2. Recycling of industrial waste before discharged into water
3. Educating farmers about correct usage of fertilizers to limit run-off into water bodies

Effects of water pollution

1. Water is rendered unsafe for domestic use
2. Depletion of oxygen in water bodies
3. Development of algae blooms/ eutrophication
4. It results in the death of aquatic organisms
5. Water may be coloured

Ways by which treated water is wasted

- Children playing with taps
- Washing of cars at washing bays
- Watering lawn and gardens during rainy season.
- Washing and brushing of teeth under running taps
- Dripping taps and leaking pipes waste a lot of water
- Homes that use water closets waste a lot of water through frequent flushing of toilet and urine.

Water conservation methods

- Taking shorter showers
- Be prompt in repairing leaky pipes
- Run only full loads of laundry and dishes
- Grey water reuse(water from sink, washing machine, dish washer in the home)
- Household water treatment which includes: -

- Boiling

- Chlorine treatment: - adding of one teaspoon of chlorine to every 20L of water
- Flocculation: - adding alum to allow sedimentation and filtering the water off.
  - Rain water harvesting system: - a method of collecting and storing rain water for future use. This system should have four main parts
  - A catchment's surface such as a roof
  - A container for storage such as a plastic or tin water tank.
  - A connection or delivery system between the catchment's and the container such as a gutter
  - A system for drawing the stored water out of the container such as a tap or pump
  - Safe storage water: - water should be collected in clean containers with lids and covers. When cups are used to draw the water such cups should always be kept clean.

Waste water treatment

To avoid contaminating natural or drinking water supplies such provisions should be put in place.

- *Septic tank*: - an underground tank into which raw household sewage flows. These tanks have long PVC pipes sticking out.
- *Soakaway*: - underground pit lined with stones to filter the waste water. The solid waste collects in the pit and the water soaks into the ground.

Rivers

A river is a collection of running water from springs, streams and rivulets. Rivers contain dissolved mineral salts.

Some rivers are sources of water borne diseases, especially if human sewage is allowed into it. Rivers, however, purify themselves a good deal. The fish in them eat up some of the refuse; so do insects of all kinds living in the water. Water plants also aid by giving off oxygen which purifies the organic matter. So great is the effect of these animals and plants that a river

sometimes completely purifies itself even after receiving the sewage of great cities. All the same, it is not safe to drink unboiled river water, though it may be used for washing.

REVISION QUESTIONS

1993 Questions

1. (i) Name three sources of natural water and two cations which causes hardness in water.

(ii) State three advantages of hard water.

1994 Questions

2. In the treatment of water supply, the water is first passed through a gravel and sand bed. Potash is then added followed by the addition of chlorine. State the reasons for each step in the process.

1995 Questions

3. (i) Differentiate between soft water and hard water.

(ii) Give two disadvantages of hard water.

(iii) Name two chemicals that can be used to remove both temporal hardness and permanent hardness in water.

(iv) Give four economic activities associated with water.

1999 Questions

SECTION3: SYSTEMS

4.5 EXCRETORY SYSTEM

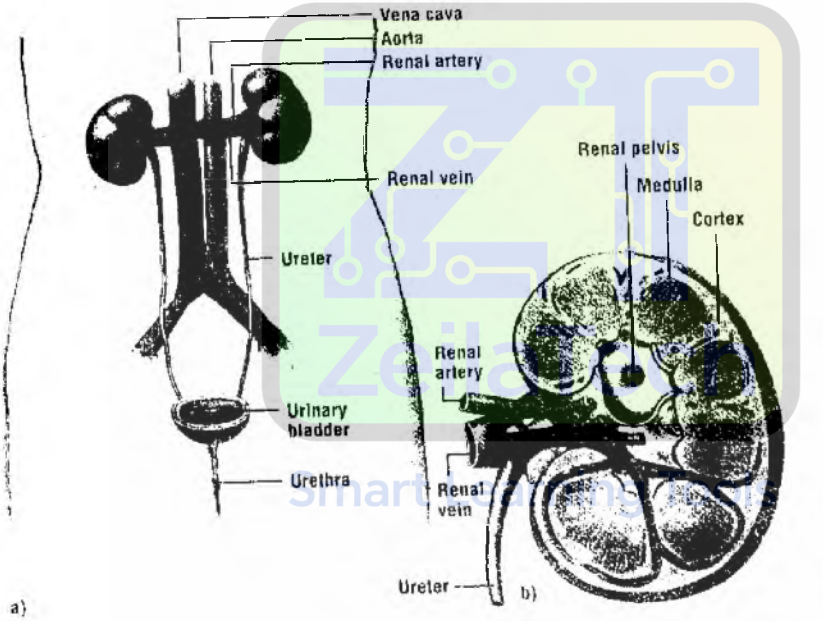
Excretion: - This is any process through which metabolic waste product is removed from the body of an organism to avoid the accumulation of toxic waste

which can harm the body e.g. of such materials include urea, mineral salts, uric acid, bile pigment carbon dioxide etc.

Egestion: - is the removal of the undigested component of food from the body of an organism (i.e. most materials in faeces).

3.1.2

Excretory Organs	Excretory Products
KIDNEY	Water, urea, uric acid, used hormones, other nitrogenous substances, drugs, broken down alcohol etc.
LIVER	Bile pigments, urea, excess cholesterol
SKIN	Water, excess salts, traces of urea
LUNGS	Carbon dioxide, water vapour.



Structure of the human excretory system.

The kidneys are dark red, bean shaped organs sited about the waist level of humans connected to the urinary bladder by two ureters which carries flow of urine from urinary bladder through the urethra to the outside.

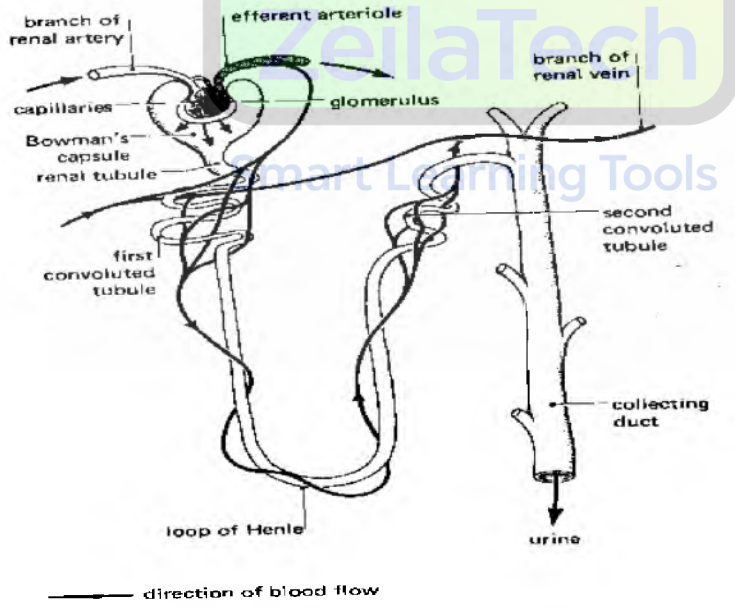
Kidney is wrapped in a protective membrane called the renal capsule. It has got two distinct layers. The outer darker part called the renal cortex and the inner part called renal medulla. The central part is called the pelvis. A unit of the kidney is the nephron and each kidney is made up of millions of these tubules.

These tubules (nephrons) are responsible for forming urine. The nephrons empty the urine it forms into a collecting duct which drains into the pelvis. The urine flows out of the kidneys through the ureters into the urinary bladder. The sphincter muscle relaxes periodically emptying the bladder through the urethra to the outside.

FUNCTIONS OF THE KIDNEYS

- They form urine (they remove urea, excess water & salts and other nitrogenous waste from the body)
- Through selective re-absorption, the kidneys are able to conserve useful materials like glucose and mineral salts.
- They regulate the salt and water balance in the body (osmoregulation)

URINE FORMATION



A single nephron and its associated blood vessels

Blood carrying urea enters the kidney through the renal artery, small branches from the renal artery, the *afferent arterioles*, supply the nephrons with

blood. As the afferent arteriole entering the capillary bed called *glomerulus* is larger than the efferent arteriole, a high pressure is created in the glomerulus causing certain substances such as amino acids, glucose, water, mineral salts, vitamins, hormones, urea to filter through the two thin layers of cells separating the cavity of the capsule from the capillaries. The filtration under pressure of the useful metabolites is *ultra-filtration*. Blood cells and blood proteins are not filtered out because they are too large to pass through the filter.

The filtrate, (*glomerular filtrate*) undergoes *selective re-absorption* back into the blood of the useful metabolites (glucose, amino acids etc). This happens as the filtrate passes along the *proximal tubule* and about 75% of water as well as glucose are reabsorbed into the blood by osmosis.

The concentrated filtrate now passes into the *loop of Henle* where water is reabsorbed according to the body's needs, thus, an exercising person who has lost a lot of water through perspiration will have more water being reabsorbed from the urine making it concentrated and dark in colour.

As the filtrate moves into the *distal tubule* a general 'tidying up' occurs. The pH of the blood is regulated and any useful material is reabsorbed.

The urine now trickles down the collecting duct into the pelvis. It then moves down the ureters by gravity and peristalsis to the urinary bladder where it is stored.

When approximately 200mL of the urine has been collected, the bladder stretches lightly, and nerves signal the brain about the condition of the bladder. Should the bladder fill to 400mL, more stretch receptors are activated and the message becomes more urgent. If one continues to ignore the messages, the bladder continues to fill, and after 600mL of urine accumulates, voluntary control is lost. The sphincter relaxes; urine enters the *urethra* and is voided.

3.1.3 DISORDERS OF THE URINARY SYSTEM

- **Bedwetting:** - (a) medical causes include infection and relaxation of sphincter muscles. This can be treated with antibiotics or surgical operation.

(b) Laziness, psychological problems, eating or drinking too much in the evening.

- **Kidney stones (renal calculi):** - they may form in the kidney or renal pelvis from crystals of calcium oxalate deposited from urine, which may be infected. Stones may occasionally develop when uric acid level is too high, usually from

over consumption of meat and low fluid intake. Stones may cause bleeding (secondary infection). Small kidney stones tend to travel down the ureter towards the bladder; their movement is accompanied by severe pain. If stone is too large, surgery is conducted to remove it or with lithotripsy – a procedure that uses shock waves generated outside the body to disintegrate the stones. Sound waves bounce off soft tissue but penetrate the stone, the collision of waves that bounce off soft tissue with those that penetrate the stone cause the stone to explode. After a few days, tiny granules from the stone can be voided through the excretory system.

- **Urine retention**: - this is the inability to pass stored urine.

Causes- (1) caused by spasm of the urinary sphincter

(2) Or blocking of the sphincter by a calculus or stone.

(3) Loss of muscle tone in the bladder after a shock or surgical operation

(4) Due to nerve damage resulting from spinal cord or injury or multiple sclerosis

- **Kidney failure**: - results from damaged kidneys after an infection, shock to the body or an accident. The waste products (urea & salts) of such a person may not be filtered out thus, stay and accumulate in the body and cause poisoning. Treatment: - a dialysis machine can be used to filter and clean the blood.

THE SKIN OF MAMMALS

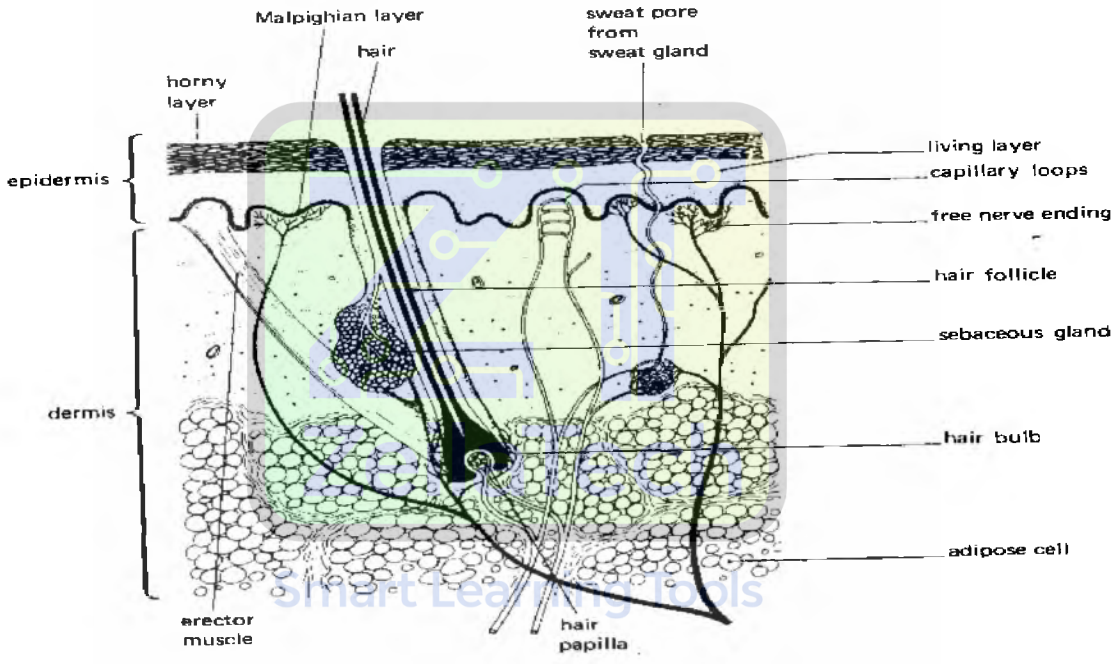
The skin excretes salts, water, traces of urea in the form of sweat when the body is exposed to the temperature in excess of internal body temperature. The water component absorbs heat from the skin cells as the sweat passes up the duct of the sweat gland. When the external environment is sufficiently hot and dry, the water evaporates; if not it wets the skin.

The skin is made of two layers: -

- The outer layer (epidermis)
- The inner layer (dermis)

The *epidermis* comprises three regions namely: -

- Cornified or horny layer: - It is the upper region which consists of flat dead cells. Its function is to protect the skin against mechanical injury, the entry of microbes and prevents excess water loss.
- Granular layer: - It lies below the cornified layer with deposits of keratin which replaces the cornified layer as they continually peel off. It contains live cells.
- Malpighian: - It lies below the granular layer, made up of living cells and contains the pigment melanin which determines the colour of the skin. These pigments protect the body against harmful ultra violet rays.



Vertical section through the mammalian skin

The *dermis* lies below. It is made up of relatively few cells and many fibres that make the skin tough and slightly elastic. It contains blood capillaries, nerve endings, lymphatic vessels, muscles, fat cells, hair follicles, skin glands (sebaceous & sweat gland). The sebaceous gland secretes *sebum* an oily substance which helps to keep the hairs supple and waterproof. It also keeps the epidermis supple and acts as a mild antiseptic.

FUNCTIONS OF THE SKIN

- **Protection:** - it protects the underlying tissues from mechanical injury.

It prevents the entry of pathogens & microbes

It prevents water loss from the body.

- **Sensory organ**: - sensory nerve endings receive the stimuli of touch, pain, heat and cold so protects the body against harm. It makes the body sensitive to touch, pain, heat, pressure etc.
- **Excretory organ**: - the sweat glands remove traces of urea, salts and water from the blood and excrete them in the form of sweat.
- **Thermoregulator**: - the skin helps in regulating body temperature. Heat in the body produced from respiration and muscular exercise is distributed to all parts of the body by the blood. Excess heat is lost from the body mostly in sweat and also in urine, faeces, breath by conduction, convection and radiation. Evaporation of sweat from the body causes cooling. The body loses or gains heat directly through the skin.

EXCRETION IN FLOWERING PLANTS

Unlike animals, flowering plants lack structured excretory organs, but they do have special ways of getting rid of their waste. The main waste products formed are: -

- Water → by transpiration through guttation(excess water dripping out of leaf surfaces)
- Carbon dioxide → by-product of aerobic respiration
- Oxygen → by-product of photosynthesis

Other waste products include:

- Tannins
- Resins,
- Alkaloids

- Gums
- Mucilages
- Lignin
- Latex
- Excess salts
- Autocyanins

These are mostly stored in the leaves of deciduous trees, fruits, petals, and bark of woody plants which falls off eventually and so removes waste.

REVISION QUESTIONS

1. Explain the following terms:
   (i) Ultra filtration
   (ii) Selective reabsorption
   (iii) Osmoregulation

(b) Name **three** structures found in the dermis of the mammalian.

(c) (i) Distinguish between excretion and egestion.

(ii) Give **two** excretory products of each of the following organs

(α) Lungs (β) Kidney (γ) Skin

(iii) Name **three** disorders associated with the urinary system in humans and state the remedy for each.

2. (i) Enumerate **four** functions of the mammalian skin.
   (ii) Name **one** structure in the skin which is associated with each function you have enumerated in (i).

(b) (i) Name **two** excretory products of plants.

(ii) Describe how urine is formed in humans.

(c)Explain why animals have specialized excretory organs but plants do not.

(d) (i) List **two** excretory products of humans.

(ii) Indicate where each of the products listed in (d) (i) is formed.

4.6 FORCE, MOTION & PRESSURE

FORCE: - It is a pull or a push, which causes a change in the motion of a body / changes the direction of a body in motion / changes the shape of a body.

EFFECTS OF FORCE: -

1. Makes objects move
2. Changes the shape and direction of an object.
3. Changes the speed of an object in motion
4. Stops a body which is in motion.
5. Transfers energy from one object to another.

GROUP OF FORCE: - Forces are grouped into two. They are contact and non-contact.

1. Contact Force: - forces in which two objects are touching.
2. Non-contact Force: - forces in which the two objects do not touch.

DIFFERENT TYPES OF FORCE: -

- **Frictional force** (contact force): - this is the force that opposes the relative/sliding motion between two surfaces that are in contact with another e.g. car tyre on road surface.

Usefulness of friction to humans: -

- Friction enables humans to walk because it prevents the feet from slipping.
- Friction enables ladders to have a firm support on the ground to support humans when climbing.
- Bicycle or lorry tyres are able to move to carry humans because friction prevents the tyres from sliding.
- Enables humans to grip objects firmly to enable us to pull, push and lift objects.
- Enables humans to use nails or bolts to fasten pieces together.
- Enables humans to strike matches to make fire
- Enables us to write.

Advantages of friction: -

- Prevents bodies from sliding off.
- Aids motion
- Enables vehicles to brake without sliding.

Disadvantages of friction: -

- Friction slows things down or resists movement.
- Generates heat in machines.
- Promotes wear and tear.

Methods of reducing friction: -

- It can be reduced by polishing surface to make them smoother.
- By using oil as lubrication.
- Greasing.
- Painting.
- Galvanizing
- Using rollers or ball bearing.

- **Viscous drag** (contact force): - this is often called air resistance. It is the opposing force that resists motion of an object in a fluid e.g. a parachute in flight. Viscosity is the measure of how much resistance a gas or liquid offers; or the thickness of a fluid. Viscous drag on a parachute slows the fall of a parachute – an advantage. Viscous drag can slow a boat moving through water, thus most boats are streamlined with pointed fronts or prows to reduce drag.

Rational behind the construction of aircrafts and boats in streamlined forms.
Streamlined shapes present a small surface area to air/water, thus air/water resistance is minimum so aircrafts/boats easily move through them.

- **Upthrust** (contact force): - the force that pushes an object up and makes it seem to weigh less in fluids. The upward pushing force of fluids (upthrust) keeps boats and ships afloat and aeroplanes fly.
- **Gravitational force** (non-contact): - the force of attraction between objects and the force with which the earth pulls objects towards itself e.g. a mango falling from a tree. The force with which the earth pulls on an object is also called the weight of the object 1N – 1kg. Gravitational force in space holds the stars and planets in place. The planets circle the sun,

and the moon circles the earth because of gravity. Gravity on the moon is six times more than gravity on the earth. This means that objects on the moon weigh $1/6^{th}$ of what they weigh on earth. This means that when an object is dropped on the moon it would take six times longer to reach the ground than if you dropped it on earth. A kilogram of salt weighs 15N on earth and would weigh 2.5N on the moon.

- **Magnetic force** (non-contact force): - this is the force of attraction or repulsion between magnets or magnetic materials. Unlike poles of magnet attract and like poles repel each other.
- **Electrostatic force** (non-contact force): - the force of attraction or repulsion between charged particles which are stationary. Most objects have an equal number of negative and positive charges, but rubbing objects together can transfer some of the charges from one object to the other e.g. combing your hair during dry harmattan season can generate a crackling noise, which is a sign of static electricity.
- **Centrifugal force**: - the force that keeps an object in a circular motion directed towards the centre of the circle. Centripetal force is the force that causes acceleration towards the centre in a circular motion.

Archimedes Principle states that when a body is totally or partially immersed in a fluid, it experiences an upthrust equal to the weight of fluid displaced.

Law of floatation states that a floating body displaces its own weight of fluid in which it floats.

A boat will float lower in fresh or warm water because it is less dense than salty and cold water.

When the upthrust is greater than or equal to the weight of the object pushing downwards, the object will float; but if the upthrust is less than the weight of the object pushing downwards, the object will sink.

A boat will float if the weight of the water it displaces is more than or equal to the weight of the boat.

THE ASCENT OF A KITE

- The kite has a streamline shape thus, offering less resistance to air;
- As the kite is pulled along it displaces its own weight of air causing it to float.

- The greater the speed at which it is pulled the greater the upthrust/force underneath and the higher it ascends in the air.

PRINCIPLE UNDERLYING THE FLIGHT OF A PAPER KITE.

- As one drags the kite against the wind while running air pressure underneath the kite becomes greater than the pressure on the kite.
- The kite is then lifted up by greater pressure.
- The kite being less dense than air ascends high into the sky.
- In ascending, the kite displaces some amount of air
- When the weight of the air displaced is equal to the weight of the kite, it ascends and floats.

FLOATATION OF BALLOON FILLED WITH HYDROGEN GAS

- The average density of the balloon containing hydrogen gas is less than the density of air.
- The weight of air which will be displaced by the balloon with hydrogen gas is greater than that of the balloon.
- The balloon is acted upon by a resultant upward force equal to the difference between the weight of the balloon and weight of air / the resultant force provides the lifting power of the balloon.

FLIGHT OF AEROPLANES

Aeroplanes have streamline shapes to create pressure differences. The pressure difference is to produce forces acting on both surfaces of the aerofoil to lift it up.

- The average density of the aeroplane must be equal to the density of the surrounding air.
- The weight of the displaced air is equal to the weight of the aeroplane.

FLOATATION OF SHIPS

A ship floats on water because its hollowness makes it have a large volume and its average density is smaller than that of the sea water. It displaces an amount of water equal to its weight. A piece of metal on the other hand will sink because its volume is small hence the density becomes greater than that of sea water.

FLOATATION OF SUBMARINES

- Initially a submarine floats on the sea as its weight is supported by the upthrust from the water.

- The upthrust is equal to the weight of the submarine.
- The submarine takes in water which increases its weight.
- The submarine sinks when its weight becomes greater than the upthrust.
- The submarine rises to the surface when water is pumped out of it and its weight decreases.

MOTION

A force can make an object move; it can change the direction of an object, speed up, slow down or stop an object in motion.

WAYS BY WHICH MOTION CAN BE DEFINED AND MEASURED

- Distance: - this is the measurement of length and this tells us the total length travelled.
- Displacement: - this is the measurement of distance in a straight line (direction).
- Speed: - tells us how fast something is moving.

$$\text{Speed} = \frac{\text{distance travelled}}{\text{time taken}}$$

- Velocity: - also tells us how fast something is moving in which direction.

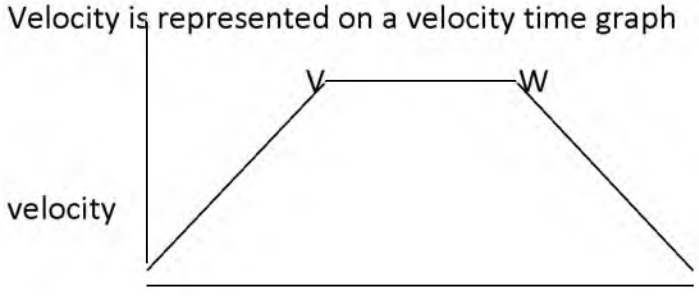
$$\text{Velocity} = \frac{\text{displacement}}{\text{time taken}}$$

- Acceleration: -is the change or difference in speed or velocity with time.

$$\text{Acceleration} = \frac{\text{change in velocity}}{\text{time taken}}$$

- Deceleration: - the rate of decrease of velocity with time.

Velocity is represented on a velocity time graph



U 0 X

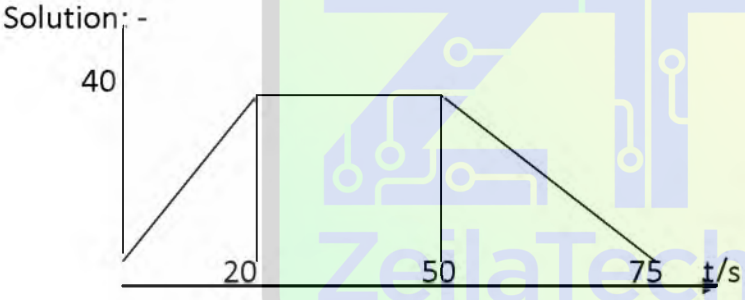
time

The graph shows the motion of a body. At U, the body is at rest. Between **U** and **V** it is moving with increasing velocity. Between **V** and **W** it is moving with a constant velocity. Between **W** and **X** it is moving with a decreasing velocity.

A body starts from rest and attains a velocity of $40ms^{-1}$ in 20seconds. It maintains this velocity for 30seconds and then comes to a rest in 25seconds.

- Sketch the velocity time graph for the motion.
- Calculate the acceleration of the body.
- Calculate the total distance covered by the body.

Solution: -



Acceleration = velocity/time

= 40/20

= $2ms^{-2}$

Total distance = ½h (a + b), where **a** and **b** are parallel sides of the trapezium.

= ½ x 40 (30 + 75)

= 2100m

Acceleration can be positive when speeding up or negative when slowing down, that is deceleration; the unit is ms^{-2}.

A full bus goes past two bus stops. When it passes bus stop 1, its velocity is $40kmh^{-1}$. When it goes past bus stop 2 five minutes later, its velocity is $60kmh^{-1}$. Calculate its acceleration.

$$\text{Acceleration} = \frac{60 - 40}{5} = \frac{20\text{kmh}^{-1}}{5\text{m}}$$

Convert kmh^{-1} to ms^{-1}

$$= \frac{20 \times 1000\text{m}}{60 \times 5} = 66.7\text{ms}^{-2}$$

Momentum: - is the measure of mass and velocity of a body in motion. All moving objects have momentum. Stationary objects have no momentum because their velocity is zero. Momentum comes from the Latin word meaning moving power. Unit = kgms^{-1}.

Momentum = mass x velocity

An object of mass 4kg moving with initial velocity of 20ms^{-1} accelerates for 10secs and attains a final velocity of 60ms^{-1}. Calculate: (i) the acceleration (ii) initial momentum.

Solution:

(i) $\text{Acceleration} = \frac{\text{change in velocity}}{\text{time taken}} = \frac{40}{10} = 4\text{ms}^{-1}$

(ii) Momentum = mass x velocity $= 4 \times 20 = 80\text{kgms}^{-1}$

QUANTITIES

Scalar quantity: - is a quantity which has magnitude only.

Examples of scalar quantities:

Mass	Time	Volume	Pressure	Speed
Work	Length	Area	Temperature	
Energy	Distance	Density	Power	

Vector quantity: - is a quantity which has both magnitude and direction.

Examples of vector quantities:

Weight	Velocity	Acceleration
Force	Displacement	Momentum

TYPES OF MOTION

Motion can be uniform – the same speed in a straight line, it can be accelerated – speeding or slowing down. The different types of motion include:

Linear motion: - the motion between two points in a straight line e.g. an athlete running a 100m dash race.
Circular motion: - the motion of an object in a circle e.g. a car moving in a roundabout.
Rotational motion: - the motion in which a body spins on its own axis e.g. the movement of a wheel or the rotation of the earth on its axis resulting in day and night.
Vibrational motion: - the back and forth movement of a particle or body e.g. the movement of a plucked stretched skin.
Random motion: - The direction of motion is undefined and can change at any instant e.g. the movement of a drunkard or the motion of a car whose driver has lost control of it.

NEWTON'S LAWS OF MOTION

Isaac Newton (1643 – 1727) studied forces and their effects; explained force of gravity and how the moon's gravitational pull causes tides. The unit of force, newton (N) is named after him.

Newton's first law of motion: - states that "a body continues in its state of rest or uniform motion in a straight line unless compelled by an external force to act otherwise".

According to this law all objects have Inertia – 'the measure of how easy or difficult it is for a body to change its motion'. This means that if a body is at rest, it resists being set into motion, and when moving, resists being brought to a stop. An object's mass is a precise measure of its inertia, the larger the mass of an object, the greater its inertia.

Practical examples of inertia

Passengers being thrown forward when a moving vehicle stops suddenly
Passengers being thrown backward when a vehicle takes off suddenly.

When a vehicle stops suddenly, passengers are thrown forwards, sometimes with disastrous results. The passengers' momentum carries them forwards even though the vehicle has stopped. When a vehicle suddenly starts passengers are thrown backwards. Seatbelts are worn to overcome this inertia.

Importance of wearing seatbelts

- When moving vehicle brakes suddenly
- Passengers continue to move at the speed at which the vehicle was travelling
- This may cause passenger to hit their heads/bodies against objects in front of them or thrown out of the vehicle
- Seatbelts hold the passengers firmly to the seats to avoid injuries.

Newton's second law of motion: - states that "the rate of change of momentum of a body is directly proportional to the force acting on it and it takes place in the direction of force". Mathematically F = m x a; the size of the force that acts on an object is a product of its mass and its acceleration. This means that the acceleration of an object increases with force and decreases with mass. Although forces act in pairs and are always equal and opposite some forces do not cause movement as others do. Consider pushing a wall, it will not move because it is anchored to the ground and has much greater mass than you, now that you are lighter; the force that you put on the wall causes you to move or accelerate backwards.

Newton's third law of motion: - states that "for every action, there is an equal and opposite reaction" e.g. a ball thrown against a wall returns in the opposite direction. This is because the wall also exerts some force on the ball as the ball on the wall.

Forces act in pairs e.g. gravity pulls down on a book resting on a table and the table pushes up on the book with the same sized force, but in the opposite direction.

CENTRE OF GRAVITY

Centre of gravity is the point inside or outside the body where the resultant weight of all the constituent particles appears to act; In other words the balancing point of an object.

For regular-shaped objects, the centre of gravity is at the geometric centre of the body, e.g. for a circle it is at the centre; for a rectangle, it is at the intersection of the diagonals; for a triangle, it is at the centroid, the point where the medians intersect. For irregular-shaped objects it is determined by the use of a plumbline – a string with small weight attached. The procedure is as follows:

- Cut an irregularly-shaped piece of cardboard
- Make three small holes well spaced round the edge of the cardboard.
- Suspend the cardboard, using the rod of a clamp, or a stout pin in a clamp, from one of the holes.
- Suspend a plumbline in front of the card.
- Mark the position of string of the plumbline on the card by two small crosses.
- Repeat the exercise for the other two holes.
- Join each pair of crosses with a straight line. The three straight lines pass through a point P; this is the centre of gravity.

STABILITY AND EQUILIBRIUM

An object is stable if a small displacement of its centre of gravity does not cause it to fall. Stability then is a measure of the difficulty of causing a body to fall over. Stable objects have a low centre of gravity. It is not too difficult to balance a book on your head. But balancing a pile of books is not easy because for a pile of books the centre of gravity is raised.

An object is in a stable state if an imaginary vertical arrow drawn from the centre of gravity passes through the base. When the centre of gravity passes the edge of its base, its weight then has a turning effect and the object starts to topple over.

Ways to make an object more stable

Lower its centre of gravity

Widen its base.

Why a body balances at its centre of gravity

With the pivot at the centre of gravity there is no turning force acting on the body; OR when the pivot is not at the centre of gravity a turning force acts on the body.

Location of load compartment of a bus

A bus with its load compartment under the passengers' seat makes the bus more stable. This is because its centre of gravity is low, when the load compartment is on top of the bus; the bus becomes less stable and can topple over when negotiating a curve.

When a body is moved slightly from a particular position, the centre of gravity is also shifted. The shifting of the centre of gravity may result in: -

Raising the centre of gravity above its former position,
Lowering the centre of gravity below its former position or
The centre of gravity remaining at the same level.

This explains the three main types of equilibrium. A body is in a state of equilibrium, if left undisturbed, will remain at its position. However, if the body is displaced slightly, three outcomes results: -

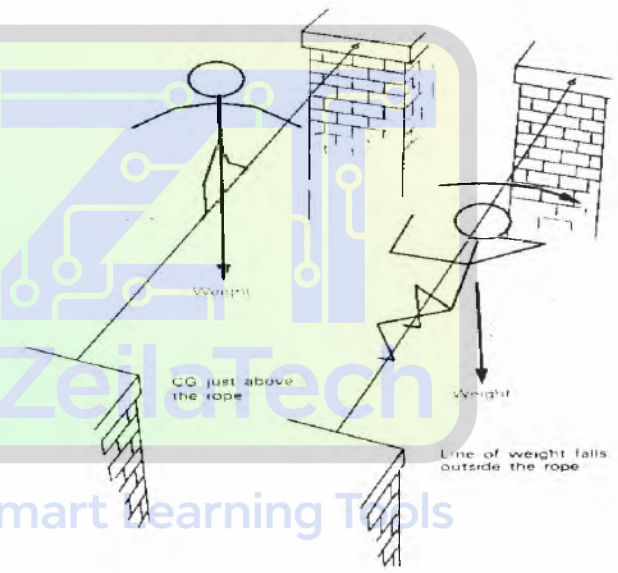
Stable equilibrium: - if an object returns to its original position after a slight force has been applied to it to displace it.

Neutral equilibrium: - if an object moves but remains in its position after a slight force have been applied to it to displace it.

Unstable equilibrium: - if an object moves away from its original position and assumes a new position after a slight force has been applied to it to displace it.

BALANCING

An object is balanced if its centre of gravity is directly above the place of support. A simple demonstration of this is an acrobat who remains balanced so long as his centre of gravity is above the rope. His hands are stretched out, so that by lowering one of them, he can rapidly adjust his centre of gravity to be above the rope. If his centre of gravity is to one side of the rope, he tends to fall.



Spinning a pan with a finger or stick involves locating a point under a pan where you can support its weight and start spinning. It balances, because half of its weight tries to fall to one side, and half tries to fall to the other side. The two forces cancel each other out. The balancing point is the centre of gravity.

MOMENT OF FORCE

This is the turning effect of force. When two or more forces act at different points on a body, the forces tend to produce rotation of the body. Each of the forces

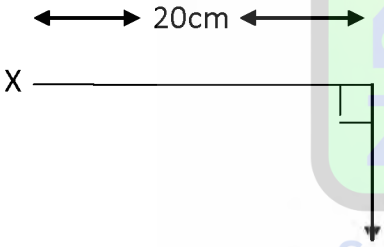
produces a turning effect about a point on the body. The point about which the moment acts is called the fulcrum or pivot.

Moment of force depends on:

The size of the force

The perpendicular distance from the pivot.

Moment of force about a point can be defined as the product of the force and the distance from the pivot to the line of action of force; expressed in Nm or Ncm.

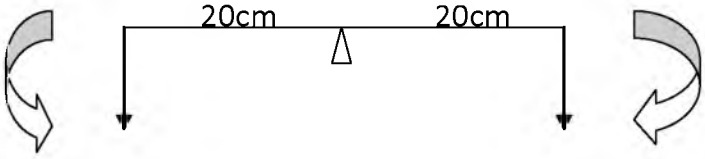


The moment of the 10N force about the point X is 10 x 20 = 200Ncm.

10N

Moment of force

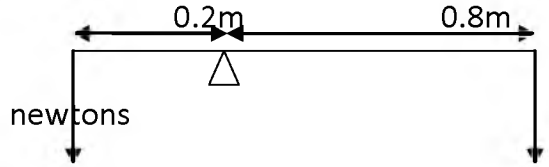
Principle of moments: - if the forces are in different directions at different points, the resultant moment may be clockwise or anticlockwise. The principle of moments states that when a body is in equilibrium, the sum of the anticlockwise moments about any point is equal to the sum of the clockwise moments.



50N 50N

50x20 = 1000Ncm 50 x 20 = 1000Ncm

1. Calculate the force needed at the right hand end of the beam so that it will be in equilibrium.



SOLUTION: let **X** be force in newtons

Clockwise moment = **X** x 0.8Nm

Anticlockwise moment = 40 x 0.2Nm

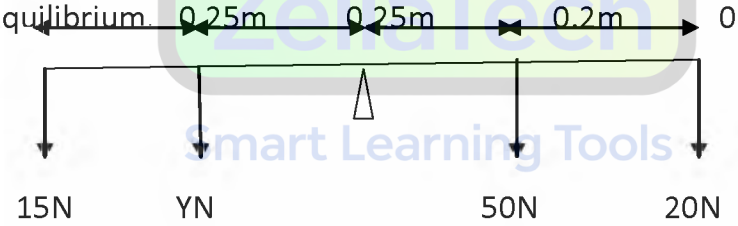
40N **X**N Using principle of moments

40 x 0.2 = **X** x 0.8

X = 40 x 0.2 = 10N

0.8

2. Calculate the force needed 25cm from the left hand end of the beam so that it will be in equilibrium.



Solution: Clockwise moments = 20 x 0.5 + 50 x 0.2 = 20N

Anticlockwise moments = 15 x 0.5 + Y x 0.25 = 7.5 + 0.25Y

Using the principle of moments:

20 = 7.5 + 0.25Y

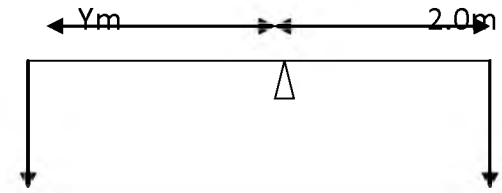
12.5 = 0.25Y

Y = 12.5

0.25

Y = 50N

3. A boy of weight 80.0N sits at a distance of 2.0m from the pivot of a see-saw. What distance from the other end should another boy of weight 40.0N sit to keep the see-saw in equilibrium?



80 x 2.0 = 40 x Y

$\frac{80 \times 2.0}{40} = Y$

4.0m = Y

- Explain why it is easier to roll a heavy barrel with a long crow than with a short crow. A large moment can be produced with a small force if the distance is long. The long crow bar produces a greater turning effect about a given point than what a shorter bar produces.

PRESSURE: - this is the force per unit area. P = F/A. Unit of pressure is Nm^{-2} or pascal (Pa).

Force which acts on a surface produces pressure. By increasing the surface area of a solid you can decrease the pressure. For instance it is easier to break an egg at the flat side than at the pointed side this is because

- The area at the pointed side is small and large at the flat side.
- Pressure is evenly distributed in the egg,
- Since pressure is inversely proportional to area,
- Much pressure is required to break the egg at the pointed edge.

EFFECTS OF PRESSURE ON SOLIDS

The force per unit area is low enough for the surface when weight is spread over a large surface for example heavy as the elephant is, does not sink into the soft forest soil because its feet are broad thus reducing the pressure on the soil (force

per unit area). However, a large force on a small area produces a high pressure e.g. a nail with a pointed end being hammered to bore into a wood.

A cement block of weight 120N has sides of length 10cm, 20cm and 24cm.Calculate the pressure exerted by the block when it is lying on the side with the (a) least area (b) greatest area.

(a) Least area: $0.1 \times 0.2 = 0.02m^2$

Pressure exerted (F/A) = $\frac{120}{0.02}$

= 6000Pa

(b) greatest area: $0.2 \times 0.24 = 0.048m^2$

pressure exerted (F/A) = $\frac{120}{0.048}$

= 2500Pa

Note that the greatest pressure results when the force is distributed over the least area.

EFFECTS OF PRESSURE IN LIQUIDS.

The pressure deep in water is greater than it is near the top, for example when swimming under water the swimmer feels the pressure of the water at the deep end much greater than at the shallow end. This pressure in water is hydrostatic pressure.

Factors that affect pressure at a point in a liquid:

- The depth of the liquid below the surface.
- The density of the liquid p.

To show the relation between pressure and depth, a tall can with holes at different heights is filled with water. The water coming out of the can from a lower hole is ejected further than the one above it. The reason is that water lower down the can is at a higher pressure. Hence the pressure in a liquid increases with depth.

A column of liquid has height, h and covers a surface area A. the density of liquid p.

Volume of the liquid = base area x height (hA)

Mass of the liquid = density x volume (hAp)

Weight of the liquid = mass x g (hApg)

Pressure liquid exerts = force/area

= hApg/A

= hpg

- Calculate the pressure at a point 2.0m below the surface of a lake [density of water = 1000kgm^{-3}, g = 10ms^{-2}].

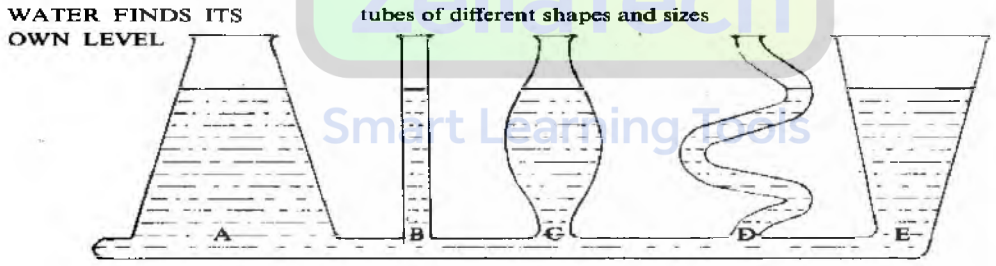
  Pressure = depth, h x density, p x acceleration, g.

  P =hpg

  P = 1000 x 2 x 10

  =20 000Pa.

Water finds its own level. The level of the surface of the liquid in the tube does not depend on the shape of the tube or container. The level in all other tubes is the same due to the pressure in the horizontal tube linking all other tubes. With this amount of liquids in tanks could be gauged.



Water finds its own level

In the diagram above, five vessels of different shapes and sizes are connected by a common horizontal tube. When water is poured into one of the vessels it will flow into the other vessels. Irrespective of the shapes and sizes of the vessels, their water levels are all at the same height. As there is no movement of water along the horizontal tube, the pressure along it must be the same at all points,

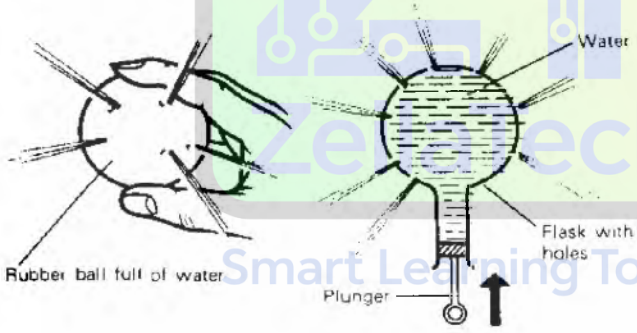
e.g. at A, B, C, D, and E. this demonstrates that pressure of any column of liquid depends only on its height.

Transmission of pressure

The pressure at any point in a liquid acts equally in all directions. This is sometimes called Pascal's principle. It follows that when pressure is transmitted through a liquid, it is transmitted equally in all directions.

Demonstration:

- Fill a plastic bag with water
- Punch holes in the bag
- Exert pressure on it, water squirts out the holes equally in all directions.



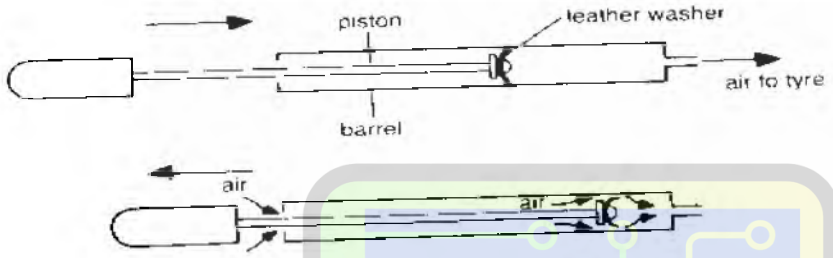
EFFECTS OF PRESSURE IN THE AIR/GAS

Atmospheric pressure is exerted on all things in all directions because air has weight. The atmosphere exerts a pressure of approximately 100kPa or 100 000Pa at the surface of the earth. Everything on the earth's surface is used to this pressure. An average sized man with a surface area of 2sqmetres has to endure a thrust on his body of 200kN. The blood exerts a pressure, a little above this, to compensate.

When we use a straw to drink, the suction action reduces the amount of air in the straw. Atmospheric pressure acting on the surface of the drink forces it up the straw into our mouths.

THE BICYCLE PUMP

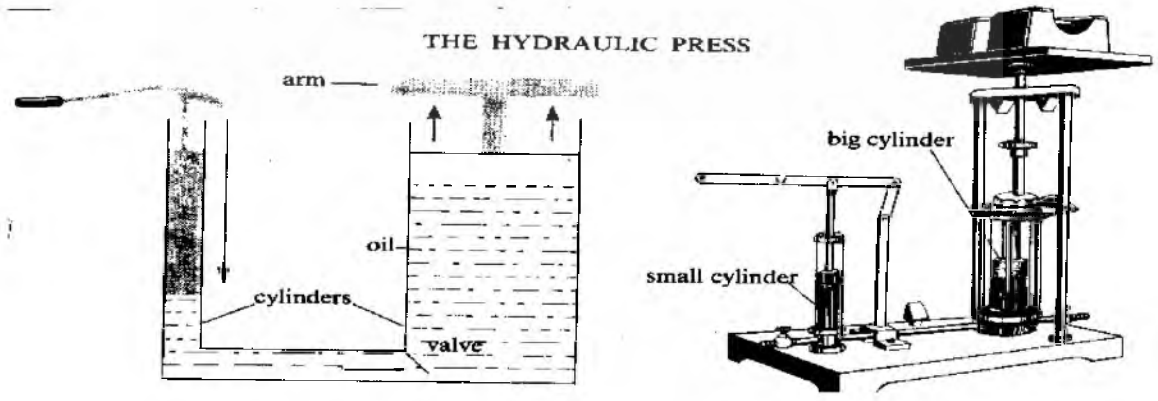
When the piston is pushed in, the pressure in the barrel increases and air is forced pass the tyre valve because the pressure in the pump is greater than the pressure in the tyre. When the piston is pulled out, the pressure in the barrel is reduced. The tyre valve is closed by a greater pressure in the tyre. Atmospheric pressure forces air past the leather washer into the barrel ready for the next stroke.



The bicycle pump

How the hydraulic press works

A small force is applied to the effort piston. The generated pressure is equally transmitted throughout the liquid to the load piston; this produces a larger force at the load piston to lift, compress or crush.



Hydraulic press

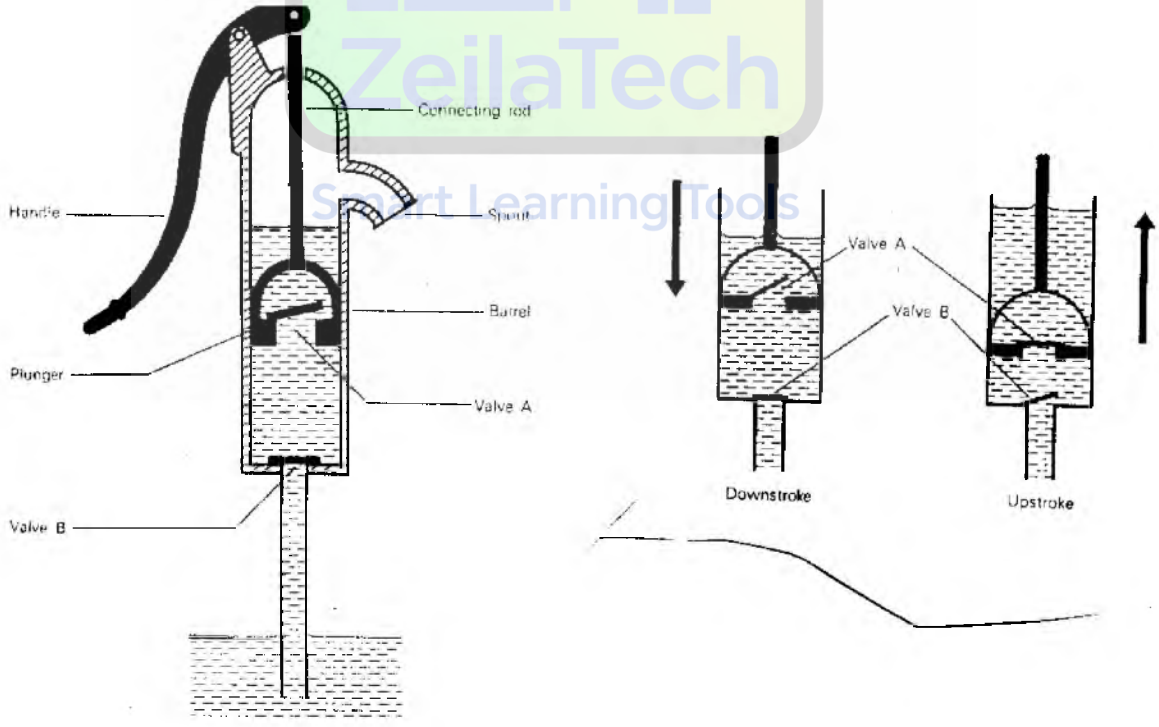
Water Pump

A pump is a device that moves fluids in one direction only, from chamber to chamber with the aid of valves. The commonest is the lift pump.

During an upstroke valve **A** closes and valve **B** opens. A partial vacuum is formed beneath the plunger and atmospheric pressure pushes the water up the pipe into the barrel lowering the plunger (down stroke).

During a down stroke valve **A** opens and valve **B** closes, the water in the barrel is pushed through valve A above the plunger. On the next upstroke, the water is drawn into the barrel as before and water above the plunger is carried upwards and leaves through the spout.

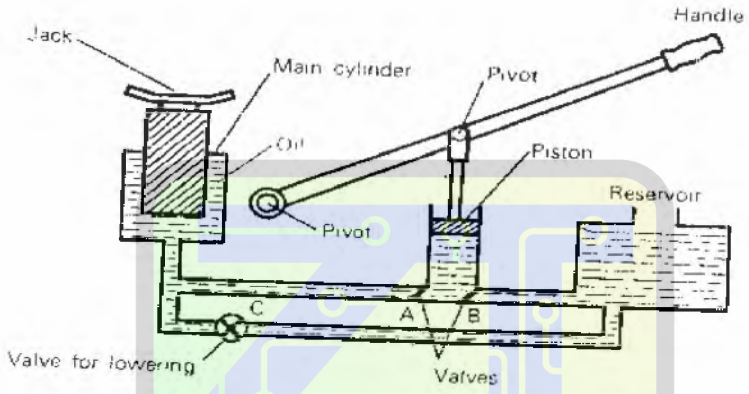
Atmospheric pressure can support a column of water 10m high. When the pipe is longer than 10m the atmospheric pressure cannot push water into the pump. Practical working limit is 9m because a complete vacuum cannot be formed due to leaks at the valves.



Lift pump

Hydraulic jack:

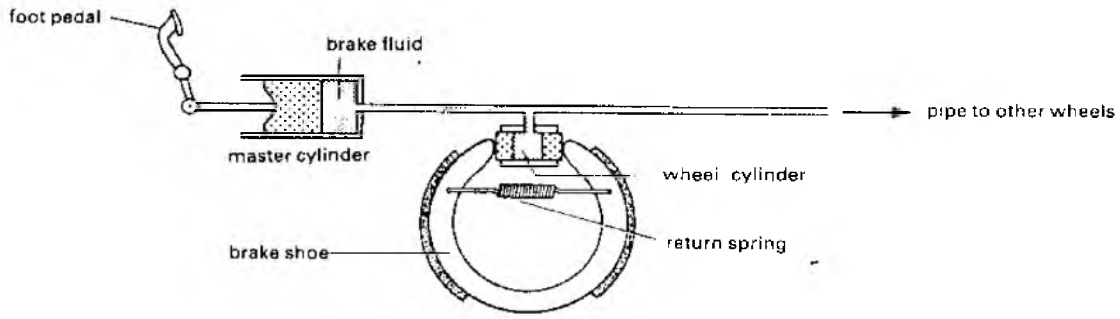
Effort is applied to handle; this forces down a small piston in a barrel. Valve **A** opens and valve **B** shuts. The oil in the jack is forced into the main cylinder, where the hydraulic pressure is applied to a piston which raises a jack. The handle is now raised; valve **A** closes and valve **B** opens. Oil comes in from the reservoir and fills the barrel below the piston. The effort is applied again, and the jack lifted farther. The use of the reservoir allows a small barrel to be used with the piston which supplies the effort. To lower the jack, valve **C** is opened, and oil is pushed back into the reservoir. Valve **C** is closed after using the jack.



Hydraulic jack

Car brakes:

Hydraulic brakes use a system similar to the hydraulic jack. The handle is replaced by the brake pedal, or the brake handle. The piston pushes into a master cylinder, from which lead pipes to all the brakes. Valve **B** is closed when the pedal is depressed; the pressure transmitted through the oil acts on small pistons in the brake drums, and applies the brakes. When the pedal is released the springs on the brakes (pedal) cause the oil to be returned to the master cylinder. The reservoir supplies oil to the system, through valve **B**, if any oil is needed to replace oil lost by leaking.



The braking system of a car

REVISION QUESTIONS: FORCE, MOTION AND PRESSURE

1. (a) (i) Distinguish between a scalar quantity and a vector quantity.

   (ii) Give one example each of a scalar quantity and a vector quantity. [4 marks]

   (b) Explain briefly why it is easier to break an egg pressing its flat sides rather than the pointed edges.

   [3 marks]

   (c) (i) Define *pressure.*

   (ii) A block of metal 150.0N has dimensions of 10.0cm by 20.0cm by 25.0cm. Calculate the pressure exerted by the block when it is lying on its largest surface. [4 marks]

   (d) (i) State the principle of floatation.

   (ii) Explain the principle underlying the flying of paper kite. [5 marks]

   (e) Give an example each of the following types of motion.

   (i) Linear (ii) Rotational (iii) Circular (iv) Random [4 marks]

2. (a) (i) What is moment of a force about a point?

   (ii) Explain why it is easier to roll a heavy barrel with a long crow bar than with a short crow bar

   [4 marks]

(b) State the type of equilibrium involved in each of the following instances:

(i) A right circular cone resting on its apex;

(ii) An inflated ball lying on a horizontal ground;

(iii) A rectangular prism resting on one of its flat sides on a horizontal surface. [3marks].

(c) A uniform half-metre rule, pivoted at the 20cm mark, balances horizontally when a mass of 50g is suspended from the 4cm mark. Calculate the mass of the metre rule. [4marks]

(d) Explain each of the following observations:

(i) A balloon filled with hydrogen gas floats in air.

(ii) A ship made of steel floats on sea but a piece of metal sinks when dropped in the sea.

(iii) Aircrafts and boats are constructed in a streamlined form. [9 marks]

3. (a) (i) What is friction?

(ii) Give two

(α) Advantages of friction.

(β) Disadvantages of friction.

(γ) Ways of reducing friction. [8 marks]

(b) Explain

(i) Why it is more suitable to locate the load compartment of a bus under the passenger seats than at the top of the bus.

(ii) The importance of wearing seat belts [7 marks]

(c) (i) What is inertia?

(ii) Give two practical examples of inertia. [4 marks]

4. (a) Name three devices whose operations depend on the effect of pressure on fluids. [3marks]

(b) Explain how a submarine operates [4marks]

(c) (i) What is centre of gravity of a body?

(ii) Explain why a body balances at its centre of gravity. [4marks]

(d) A rectangular block weighing 5000N rests on its longer side on a table.

(i) Make a sketch to illustrate the forces acting on the metal block.

(ii) Calculate the mass of the metal block. [5marks]

(e) Explain how a kite ascends in flight.

[5marks]

5.1 HEAT ENERGY

Heat is a form of energy that changes the state of matter by increasing or decreasing its temperature.

It flows from a higher temperature to a lower temperature.

When two objects of different temperatures are placed together, heat will be transferred from the hotter one to the colder one until both attain the same degree of hotness. The two objects with the same temperature are said to be at **Thermal equilibrium**.

The larger the mass of a substance, the more heat is needed to raise its temperature. Similarly, more heat is lost as a larger mass cools. Heat can therefore, be thought of as the quantity of thermal energy that a body contains, and represented by Q.

The quantity of heat contained in a body depends upon:

- The nature of the body
- The mass of the body
- The temperature of the body

The SI unit for heat is joules (J). It is measured with Calorimeter.

SOURCES OF HEAT

- Sun
- Fire
- Friction
- Fossil fuels
- Electricity
- Chemical reactions
- Nuclear reactions

- Biomass etc.

Conversion of different forms of energy to heat

Other forms of energy can be converted into heat energy.

- Kinetic and chemical energy are converted into heat energy when a match is struck.
- Chemical reactions produce heat when a burning match is put into pieces of paper.

Temperature & Measurement

Temperature, the measure of degree of hotness of a body is expressed in degree Celsius (^{0}C) and kelvin (K) as well as Fahrenheit which is now becoming obsolete. Temperature is measured with the thermometer.

Temperature is a scalar quantity because it has magnitude but no direction.

On the Celsius scale the upper fixed point is 100^{0}C (temperature of boiling water) and the lower fixed point is 0^{0}C (temperature of pure melting ice).

The temperature at which particles have no kinetic energy (i.e. temperature so cold that there is no vibration) is called the **absolute zero** and is calculated to be -273^{0}C.

On the Kelvin scale of temperature the absolute zero is its lower fixed point. Since there are no negative temperatures on the Kelvin scale and all objects on the Earth have their molecules in continual motion, the ice point becomes 273K and the normal boiling point of water is 373K. Therefore 1K rise in temperature is equal to 1^{0}C rise.

The Celsius and Kelvin scales are related by the expression T = 273 + θ, where T is in Kelvin and θ is in degrees Celsius.

Convert the following temperatures from ^{0}C to K

(1) 245^{0}C $\rightarrow$ 273 + 245 = 518K

(2) 75^{0}C $\rightarrow$ 273 + 75 = 348K

(3) -112^{0}C $\rightarrow$ 273 – 112 = 161K

Table 5.1: Distinction between heat & temperature

HEAT	TEMPERATURE
It is a form of energy	Measures the degree of hotness or

	coldness
Measured in joules	Measured in ^{0}C /K /^{0}F
Measured with a calorimeter	Measured with a thermometer

Table 5.1.2: Thermometers & their specific uses

NAME	SPECIFIC USES
(1).Constant thermometers	For very accurate temperature measurements usually at the national laboratories.
(2).Liquid – in – glass thermometers	
(a)Mercury-in-glass thermometer	For measuring temperatures of substances in labs, homes, industries. Its temperature range is -39^{0}C to 360^{0}C.
(b)Clinical thermometers	Its temperature range is about 34^{0}C to 43^{0}C to determine the temperatures of humans and animals.
(c)Alcohol-in-glass thermometer	Its temperature range is -115^{0}C to 78^{0}C for measuring very low temperatures of substances in laboratories, homes and industries.
(d) Maximum & Minimum thermometers	For measuring day maximum temperatures and minimum night temperatures.
(3)Pyrometers	It is used in poultry farms. It can measure temperatures up to 3000^{0}C
(4) Thermocouples	It ranges from 25^{0}C to 1150^{0}C. Used in industries and labs for higher temperatures e.g. molten Aluminium and steel factories.
(5)Resistance thermometers	It is used to determine temperatures of substances within the range of -200^{0}C to 1100^{0}C.

Liquid- in- glass thermometers

Most liquids expand when heated and contract when cooled. This fact is used in the constructing liquid- in -glass thermometers. Alcohol and Mercury are the main liquids used in such thermometers.

Advantages of Mercury over Alcohol

- Mercury has a higher boiling point (357^{0}C) than that of alcohol (78^{0}C).
- Mercury is opaque and easily seen whereas alcohol has to be coloured.

- Mercury does not wet glass but alcohol wets glass leading to inaccurate readings.
- Mercury does not vapourise as alcohol does.
- Mercury is a better conductor of heat than alcohol and therefore responds more rapidly to changes in temperatures.

Advantages of Alcohol over Mercury

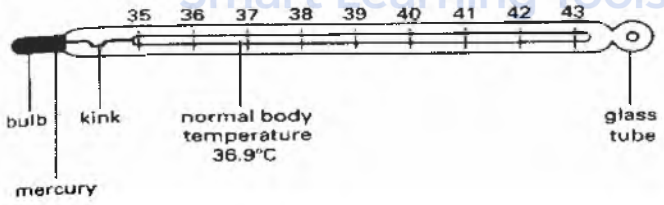
- Alcohol has very low melting point (-115^0C) than Mercury (-39^0C) thus alcohol-in-glass thermometers can be used to measure temperatures below (-39^0C).
- Alcohol expands more than Mercury for the same temperature change and so it is easier to detect a change in Alcohol than in Mercury.

Reasons why water is not a good thermometric liquid

- Water wets glass and clings to the tube making reading difficult and inaccurate.
- It has irregular expansion at certain temperatures.
- It vapourises and later condenses in the tube i.e. it has very small temperature range.

Clinical thermometer

This is a Mercury-in-glass thermometer used by doctors and nurses to determine the temperatures of patients.



A clinical thermometer

Its usage:

- Place thermometer under tongue or armpit
- Mercury expands and forces its way to pass the constriction
- Thermometer is removed

- Mercury cools and contracts breaking mercury thread at the constriction
- Mercury beyond the constriction stays in the tube and shows body temperature.
- Flick wrist to return mercury to the bulb.
- Sterilize with antiseptic solution or with methylated spirit.

Reasons why clinical thermometer should not be sterilized in boiling water

- Clinical thermometer has a short range of temperature (34^0C to 43^0C),
- Boiling water has a temperature of 100^0C,
- Thus when a clinical thermometer is sterilized in boiling water, the mercury will expand excessively due to high boiling point of water, [*Boiling point of a liquid is the temperature at which a liquid changes to vapour at atmospheric pressure*]
- The excessive expansion of the mercury will then force the clinical thermometer to crack.

<u>Measurement of heat</u>

Objects are considered hot because their particles have a high kinetic energy. Materials respond to energy changes in different ways. The ability of a body to absorb energy is called heat capacity.

The **heat capacity** of an object therefore, is the quantity of heat energy required to raise its temperature by 1 kelvin (1K) or 1 degree Celsius (1^0C).

SI unit for heat capacity = JK^{-1} or J^0C^{-1}.

Two solids **X** and **Y** are of heat capacities $400JK^{-1}$ and $546JK^{-1}$ respectively. What this statement means is that: Solid **X** needs 400J of heat to change/increase its temperature by 1K while solid **Y** needs 546J of heat to change/increase its temperature by 1K.

The specific heat capacity is appropriate for unit mass of a substance rather than deal with different value for every object.

Specific heat capacity of a substance is the heat energy required to raise the temperature of 1Kg of it by 1K or 1^0C.

<u>Worked examples</u>:

1. How many joules of heat are given out when a piece of iron of mass 15kg cools from 70^0C to 10^0C? Specific heat capacity of iron is $460Jkg^{-1}K^{-1}$.

$Q = m\ c\ \Delta T$ or $mc\ (\theta_2 - \theta_1)$

Where Q = quantity of heat

C = specific heat capacity

θ_2 = final temperature

θ_1 = initial temperature

Solution:

m = 15kg; $c = 460 Jkg^{-1}K^{-1}$; $\Delta T = 70 - 10 = 60^0C$

$\therefore Q = 15 \times 460 \times 60$

=414000J

= 414KJ

2. A metal of mass 25kg was heated from 5^0C to 10^0C. Calculate the quantity of heat given to the metal. (S.H.C of the metal is $4200 Jkg^{-1}K^{-1}$).

m = 25kg; $\theta_2 = 10^0C$; $\theta_1 = 5^0C$; $c = 4200 Jkg^{-1}K^{-1}$; Q = ?

$Q = m\ c\ \Delta T$ $= 25 \times 4200 \times (10 - 5)$ $= 25 \times 4200 \times 5$ = 525000J

= 525KJ

3. Some quantity of water of mass 4.0kg is heated from 36^0C to 86^0C. If the specific heat capacity of water is $4200 J/kg^0C$, calculate the amount of heat used.

Amount of heat (Q) = $m \times \Delta t \times c$

$= 4 \times (86 - 36) \times 4200$

$= 4 \times 50 \times 4200$

= 840000J

= 840KJ

4. Calculate the quantity of heat released when a piece of Aluminium of mass 800g and specific heat capacity of $900 Jkg^{-1}K^{-1}$ cools from 75^0C to 55^0C.

$Q = mc\Delta t$ $=0.8 \times 900 \times (75 - 55)$ =14400J = 14.4KJ

5. Calculate the S.H.C of a substance of energy 400J, which is required to change its temperature from 15^0C to 28^0C. Given that the mass of the substance is 15g.

c = ?; Q = 400J; $\theta_1 = 15^0$C; $\theta_2 = 28^0$C; m = .015kg

$\frac{Q}{m\Delta t} = \frac{mc\Delta t}{m\Delta t}$ $\therefore c = \frac{Q}{m\Delta t}$ $c = \frac{400}{.015\ (28 - 15)}$

$= \frac{400}{0.015 \times 13^0\text{C}}$

$= 2051\text{Jkg}^{-1}\text{K}^{-1}$

6. The temperature of a certain metal block of mass 60g is raised to 80^0C. The block is placed in 150g of water at 20^0C. Suppose the final temperature of the water is 25^0C. Calculate the specific heat capacity of the metal.

S.H.C of water = $4200\text{Jkg}^{-1}\text{K}^{-1}$.

Heat lost by the metal = Heat gained by water

$0.06 \times \mathbf{c} \times (80 - 25)$ J = $0.15 \times 4200 \times (25 - 20)$ J

$0.06 \times \mathbf{c} \times 55 = 0.15 \times 4200 \times 5$

make **c** the subject of the formula

$\mathbf{c} = \frac{0.15 \times 4200 \times 5}{0.06 \times 55}$

$= 955\text{Jkg}^{-1}\text{K}^{-1}$

7. What is the final temperature of the mixture when 200g of warm water at 80^0C is added to 300g of cold water at 10^0C and thoroughly stirred?

S.H.C of water = $4200\text{Jkg}^{-1}\text{K}^{-1}$.

Heat lost by warm water = Heat gained by cold water

$mc\Delta t = mc\Delta t$

$0.2 \times 4200 \times (80 - x) = 0.3 \times 4200 \times (x - 10)$

divide both sides by 4200

$\frac{0.2 \times 4200 \times (80 - x)}{4200} = \frac{0.3 \times 4200 \times (x - 10)}{4200}$

$0.2\ (80 - x) = 0.3\ (x - 10)$

$16 - 0.2x = 0.3x - 3$

bring like terms together

$16 + 3 = 0.2x + 0.3x$

$19 = 0.5x$

$x = 38^0C$

Effects of heat

When heat is applied to a body there is:

- Expansion: - when a substance is heated, the molecules gain energy and increases which results in the overall increase in length, size and volume of the substance.
- Rise in temperature: - when a substance is heated the average kinetic energy of its molecules increases, since kinetic energy is directly proportional to its absolute temperature, thus an increase in kinetic energy results in rise in temperature.
- Change of state: - when solids are heated, the molecules gain heat energy (K.E) used in breaking down the forces of attraction between its molecules which no longer holds them in the regular pattern. As a result, the space – lattice collapses and the solid melts. When liquids are heated, the average K.E of its molecules increases. Some molecules are able to acquire or gain enough K.E to be able to break their barrier surfaces to exist as gas or vapour.
- Vapourization: - is the process of changing or forming freely the molecules of liquid into bubbles of vapour/gas when its molecules having acquired maximum K.E are able to break through their surfaces.

Thermal Expansion

Expansion refers to the increase in size of objects when heated. Generally, substances expand when heated because the distances between their molecules increase with the rise in temperature. As the temperature of the body increases, the particles vibrate more energetically, and therefore take up more space. This increase in volume with increased temperature is called **thermal expansion**.

Solids, liquids and gases normally expand when heated and contract when cooled. Different substances expand at different rates. For example a thick glass jug will crack when hot water is poured into it while a thin glass jug will not. The reasons are that:

- glass is a poor conductor of heat
- In thick glass expansion is not uniform
- Differential expansion causes glass to crack
- In thin glass expansion is uniform.

Again a glass filled with a fruit drink to the brim and placed in a freezer, cracks after freezing. The reasons are that:

- water expands in volume
- when it changes from liquid to solid (freezes)
- no space was provided for expansion when it freezes
- as a result the glass bottle cracks due to the force exerted by the frozen water.

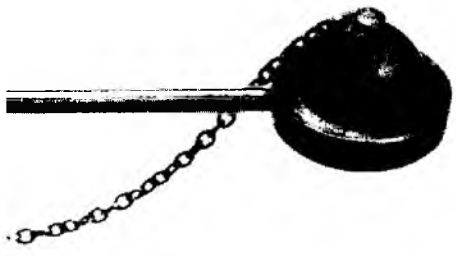
Large structures, such as bridges, roads and buildings, would suffer structural damage had it not been the precautions taken to limit the effects of expansion and contraction. For that matter expansion gaps are built into roads and railway lines.

Demonstrating expansion in solids

Procedure: Take a metal ball, a ring whose diameter is slightly greater than the diameter of the ball such that the ball passes through the ring when both are cold.

With the aid of a pair of thongs, heat the metal ball for a few minutes and try to pass it through the ring carefully.

Observation: it will be observed that the ball no longer passes through the ring and this shows that the ball has been increased in size when it was heated, hence solids expand when heated.



The ball- and- ring experiment

Expansion in Liquids

Liquids have no definite shape; they can only have volume expansion.
Expansion in liquids is made use of in liquid-in-glass thermometers
Space is left at the top of bottled drinks to allow room for expansion

Anomalous expansion of water

When water is heated between $0^{o}C$ to $4^{o}C$, it contracts, as a result, there will be a decrease in volume, an increase in density and attains a maximum density of $1g/cm^{3}$ at $4^{o}C$.
Also between $4^{o}C$ and $100^{o}C$, water behaves like all other liquids and expands uniformly, which results to an increase in volume and a decrease in density. The behaviour of water between $0^{o}C$ and $4^{o}C$ is termed anomalous/irregular expansion of water.

Biological importance

In Polar Regions, where we have deeper waters when ice is formed on the surface of water there is water at $4^{0}C$ which is beneath the surface in which fish and other aquatic organisms can survive.

Expansion of gases

Gases are compressible and can be stopped from expanding, the pressure of a trapped gas, which is not allowed to expand increases.

The pressure increases because the molecules are always moving fast and hitting each other and the sides of the container.

If the temperature rises, the molecules move faster, the collision becomes more vigorous and the pressure increases.

If the gas expands when heated, its expansion is used to do work as in the car engine.

Various application of expansion

- thermostat and bimetallic thermometers
- sagging of electric cables

- bursting of inflated hot tyres
- gaps are left at regular intervals along a railway line to allow room for expansion.
- Fire alarms: a form of thermostat can be used as a fire alarm. A bimetallic strip bends over, when made sufficiently hot by a fire, to make contact with a screw. This completes an electric circuit which rings a bell and sounds an alarm.

Gaps left between railway lines

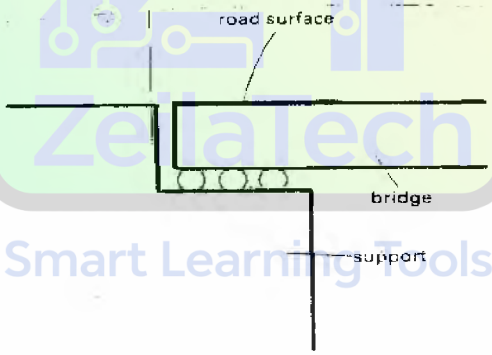
Advantages of expansion

- Liquid- in- glass thermometers work using the principle of expansion.
- Wheels can be fitted into rims by applying the principle of expansion.
- Very tight metal lids over bottles can be removed by pouring hot water over the lid.
- The bimetallic thermometers work using the principle of expansion.

Disadvantages of expansion

- Cracking of glass when hot water is poured in it
- Bursting of plastic water pipes
- Sagging of overhead cables
- Buckling of railway lines: heat causes railway lines to expand, and coldness causes them to contract. To allow for expansion or contraction, gaps are left between the rails or the rails are tapered. Expansion of railway lines causes the lines to push against each other and bend.

- Crackling noises heard from metal roofing sheets during very hot weather conditions. ____This is because during such weathers metal sheets expand but the nails that hold the sheets prevent the metal sheets from moving out of their place. The metal sheets thus bends and the bending movement creates the noise.
- Buckling of steam pipes: when steam passes through the pipe, it causes expansion. If the pipe is long, the expansion can buckle the pipe. To prevent this, expansion joints are put in it.
- Deformed bridge structure: the iron girders of bridges expand and contract with the changes in temperature of the weather. To stop the bridge structure from being deformed, one end only is fixed, and the other end is mounted on rollers.
- Pendulums and balance wheels: the pendulums in clocks and the balance wheels in watches regulate the time. Changes in temperature cause expansion; at higher temperatures, the clock, or watch, goes too slowly because the pendulum or balance wheel expands; at lower temperatures, an opposite effect is seen.



Expansion of a bridge

The Bimetallic strip

It consists of two dissimilar metals (Aluminium & iron) joined together. The metals expand differently on heating, causing the strip to bend.

Bimetallic strip

It can be used to show that different metals have different degrees of expansion. In the above set-up, Aluminium expands more than iron when heated. It can be used in making a thermostat.

A *thermostat* is a device used to regulate temperature changes or for maintaining a steady temperature in electrical appliances.

The principle on which the thermostat functions

- A bimetallic strip, _____ an electric circuit which gets heated by the current
- the strip expands towards the metal with the least expansion and breaks the circuit
- when the strip cools it makes contact for current to flow again

Devices that use thermostat

Refrigerator/deep freezer/fridge
Car radiator
Electric pressing iron
Electric incubator
Electric kettle
Air conditioners
Microwave oven
Electric rice cooker

Modes of transfer

Conduction: - is a type of heat transfer in which molecules pass on their energy by collision with neighbouring molecules .Only energy is transferred but molecules retain their position.

Metals are good conductors of heat; other solids are poor conductors or insulators.

A temperature gradient is formed in solids conducting heat.

Liquids are generally poor conductors of heat with the exception of liquid metal (mercury) which is liquid at room temperature. Gases are also poor conductors however; conduction is not able to take place in vacuum.

A girl holding a long metal rod with one end in fire will feel a burning sensation in the palm; the reasons are:

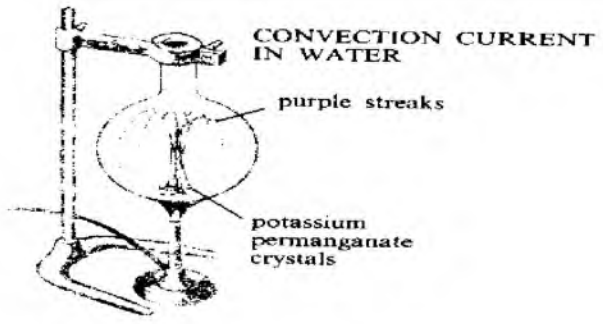
- a metal is a good conductor of heat
- hence the heat travels from the end of the metal in the fire to the opposite end
- nerves sensitive to heat in the palm/skin are stimulated and the heat is felt in the palm.

Convection: - is the main method of heat transfer in liquids and gases (fluids). The heat transfer is by movement of the molecules themselves. Heat is transferred in liquids and gases by convection currents. Convection currents are caused by density changes due to expansion of liquids and gases caused by heating. Convection currents are used in: ventilation, air conditioning, refrigeration.

Convection therefore, is the transfer of heat energy by the circulation of a fluid as a result of temperature difference within the fluid,

Demonstrating convection

1. Set up a beaker of cold water on a gauze and tripod.
2. Place a small crystal of potassium permanganate at the bottom of the beaker using a spatula.
3. Using a weak Bunsen flame, gently heat the beaker of water
4. Note the pattern of movement of the water as the potassium permanganate dissolves.

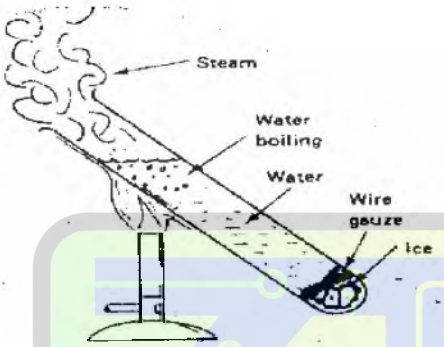


Demonstrating convection

Observation:

- Water warms up at the bottom and expands as the beaker of water is heated gently
- The heated molecule at the bottom move upwards and are then replaced by colder and heavier ones above
- A current of coloured water is seen moving throughout the water.

Consider the set – up below carefully



1. Which mode of transfer occurs in liquids?
2. Why is the ice wrapped in metal gauze?
3. State and explain what will happen to the ice after 30 minutes of heating the top of the tube
4. What conclusion can you draw from your results?

Solution:

1. Convection
2. To prevent the ice from floating to the top of the test tube
3. The ice will not melt

Explanation

During heating, the top region of the water becomes heated. Since water is a poor conductor of heat, it cannot conduct heat to the lower region of the test tube.

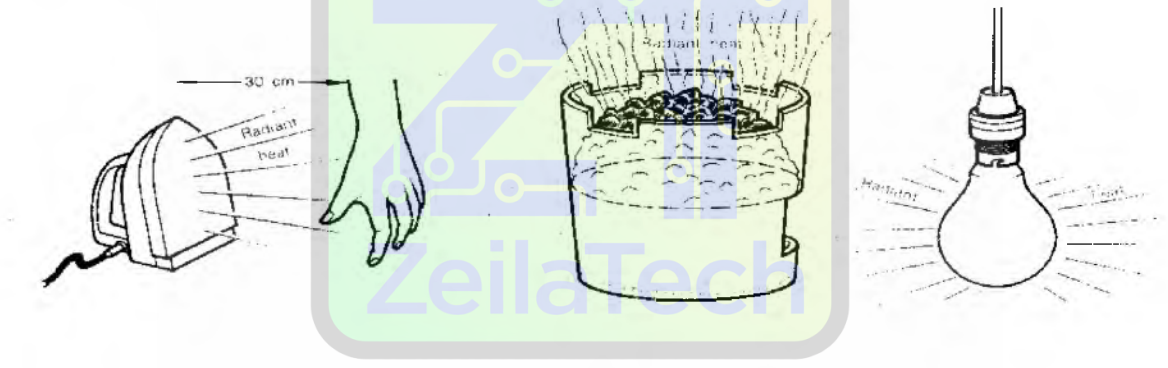
Convection of heat cannot take place because the hot water on top becomes less dense and thus cannot sink to the bottom to transfer its heat.

4. Water is a poor conductor of heat.

Radiation: - this type of heat transfer requires no material medium for its propagation and hence is the way in which heat is transferred across vacuum and there is no movement of molecules. Heat reaches the earth from the sun; between the sun and the earth is space, so there is no material medium to transfer the sun's heat. This is how come the sun's heat energy reaches the earth. Heat radiation does not need a material medium, it transfers heat through vacuum.

One can feel the heat given out by a bulb when it has been switched on and the hand is placed beneath it. The heat could not have reached the hand by conduction (air is a poor conductor of heat); the heat could not have reached the hand by convection (convection currents take heat upwards) the heat must have reached the hand by radiation.

(a) An electric light bulb (b) A charcoal fire (c) An electric iron



Demonstration of radiant heat

Black surfaces are good absorbers of heat; shining surfaces are poor absorbers.

Black surfaces are good emitters of heat; shining surfaces are poor emitters.

Application of heat radiation

- Vacuum flask
- Aluminium roofs
- Shining petrol tanks
- Black car radiators.

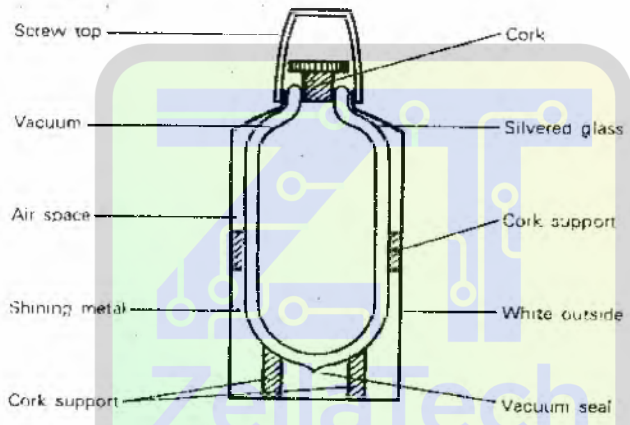
<u>The Thermos Flask</u>

This is a device designed to keep hot substances hot and cold substances cold. It has been designed to minimize heat loss or heat gain by conduction, convection and radiation

Conduction is reduced by using good thermal insulator for the walls and for the stopper. The stopper may be cork or plastic, and the glass inner vessel is usually supported by a glass or plastic base.

Convection & conduction are eliminated by making the inner vessel a doubled walled container, which is the evacuated.

Radiation is reduced by silvering the inner and outer walls of the inner vessel, thus making it a bad absorber and a bad emitter of radiation.



The thermos flask

The laws of radiation of heat are:

- Heat radiation travels in straight lines.
- Heat radiation warms a body only if the radiation falls directly on the body.
- Bodies radiate heat only if their temperature is higher than their surroundings.
- Good absorbers of heat radiation are good emitters of heat radiation.

Change of state of matter

Heat causes a change of state and, during the time the change of state occurs, the temperature remains constant. The heat supplied at constant temperature to change the state of a substance is called the **latent heat**. If a solid

changes to a liquid, the **latent heat of fusion** is needed to cause the change. The latent heat of fusion is absorbed in the change from solid to liquid, and given out during the change from liquid to solid. If a liquid changes to a gas, the **latent heat of vaporization** is needed to cause the change. The latent heat of vaporization is absorbed in the change from liquid to gas and given out in the change from gas to liquid.

Latent heat of fusion: the amount of heat required to convert a substance from the solid state at its melting point to the liquid state without change in temperature.

Latent heat of vaporization: the amount of heat required to change a liquid to gas or the vice versa without a change in temperature.

Worked example:

Calculate the amount of heat required to melt 150.0g of ice at 0^0C [specific latent heat of fusion for water is 336KJkg^{-1}] Heat required (Q) = specific latent heat (L) x Mass of ice (M).

1kg = 336KJ

$\therefore$ 150g $= \frac{150}{1000} \times 336$

$= 50.40$KJ

Liquids become colder when it evaporates. Heat is required to cause evaporation, and this is called latent heat. The latent heat needed for evaporation is taken from the liquid, thus causing it to become colder.

When latent heat is lost a cooling effect is produced, for instance the fingers feel cold after it is placed in alcohol and then removed this is because the alcohol absorbs latent heat from the finger for it to evaporate. The loss of water from the skin leaves the finger colder.

Again Iced cubes produce a better cooling effect than cold water, the reason is that iced cubes absorbs extra heat called latent heat from the material it is cooling, for it to change from the solid state to cold water. It thus absorbs more heat than cold water.

Effects of latent heat

- Steam possesses a large quantity of heat energy due to the high specific latent heat of vaporization of water. It is a fact used in various types of steam engines
- An important factor in body temperature control in mammals is the evaporation of sweat. The rate of evaporation of sweat depends on the relative humidity of the atmosphere. In conditions where the relative humidity is high, the rate of evaporation is reduced, causing physical discomfort.
- The high specific latent heat of vaporization of water accounts for the fact that rivers and lakes do not dry up rapidly in tropical climates.

Explain the following observations:

(i) Steam from boiling water causes severer burns on the body than boiling water

- as water boils at constant temperature of 100^0C
- bubbles of water vapour bursts and escape as steam
- thus steam has acquired extra energy (latent heat) than boiling water to enable it to escape
- hence the amount of heat energy in steam is more than energy molecules of boiling water

  - steam releases latent heat of vaporization when it condenses.

(ii) An earthenware pot (local clay pot) keeps water cool.

- an earthenware pot has pores
- through which water evaporates
- taking latent heat from the water(thereby keeping the water cool)

Evaporation:

This is the process by which molecules escape from the surface of a substance. Evaporation causes cooling by removing latent heat of vaporization. The molecule of a substance that evaporates takes latent heat energy from the surface, leaving the surface cold. Evaporation takes place when liquid changes to vapour beneath its boiling point.

After a fall of rain, the pools of water left behind slowly dries up; the water in the pools has obviously changed to water vapour at atmospheric pressure and atmospheric temperature and then disappeared. Hence water, or indeed any liquid, can change to vapour without the liquid being boiled. When a liquid changes to vapour beneath its boiling point, it is said to have evaporated.

Factors affecting rate of evaporation

- Temperature → the higher the temperature, the faster the rate of evaporation. For this reason wet cloths dry faster on a warm day than on a cool day.
- Relative humidity → evaporation is faster when relative humidity is low thus; wet clothes dry faster during harmattan season since humidity is low during harmattan. Humidity refers to the amount of water vapour/moisture in the atmosphere.
- Wind → The higher the speed of the wind the higher the rate of evaporation. For this reason also wet clothes tend to dry faster on a windy day.
- Surface area → the greater the exposed surface area, the faster the rate of evaporation. Wet clothes on line will dry faster when it is spread than when folded.

Explain why a quantity of water in a large bowl evaporates faster than the same quantity in a tall small bowl?

- A larger surface area of liquid is exposed to the atmosphere in the larger bowl than the smaller one,
- Thus, a greater number of molecules on the surface have required energy for escape Or
- Leave the surface of the water in the larger bowl than in the small tall bowl.

Natural phenomena due to evaporation

Humidity is the cause of many natural phenomena this accounts for humidity measurements as important factors in weather forecasting.

Dew: During the night, the air temperature drops, as the earth cools, and if the temperature falls below the dew point, then dew is deposited on grass and leaves. The lower the air temperature falls, the heavier the dew is. [*Dew point is the temperature at which cool air is saturated with water vapour*].

Clouds: Warm air blowing along the ground may be forced to rise over a mountain; this cools the air and also forms a cloud. Warm air rises from the ground and gradually becomes colder as it ascends. If the temperature of the air falls below the dew point, condensation takes place and clouds are formed.

Mist: Condensation of water into droplets in the air forms a mist of cloud at ground level. Rapid cooling produces a mist.

Fog: Fog is caused when a mist condenses in a town or other dusty locality. Water condenses on dust or soot particles present in the air.

Rain: Water vapour evaporates into the atmosphere to condense as clouds. When condensation is sufficiently great, the water droplets in a cloud become too heavy for upward air currents to support them. The droplets then fall as rain.

Table 5.1.3: Differences between evaporation & boiling

EVAPORATION	**BOILING**
Occur on the surface of the substance	Occurs throughout the whole liquid
Can occur in both liquids and solids	Occur in only liquids
It produces a cooling effect	Does not produce a cooling effect
Can occur at any temperature	Occur at a fixed temperature (*called the boiling point*).

Ventilation:

This involves the removal of stale air and introduction of fresh air into the building.

Importance of ventilation

- Removes excess heat from a building
- Removes bad odour and stale air in a room
- Prevents suffocation by providing sufficient oxygen and removing carbon dioxide
- Reduces the growth and spread of certain diseases/infection (droplet infection such as whooping cough, influenza and tuberculosis)
- Prevents the accumulation of unwanted gases (e.g. carbon dioxide) in a building.

Factors affecting effective ventilation

- The position of the windows – windows must be oppositely placed

- Windows – each room must have an adequate number of windows and they must be large.
- Wind – the direction of the wind should be considered.
- Building alignment – houses must be oriented such that fresh air can easily enter the rooms and move freely throughout the rooms.

REVISION QUESTIONS

1995 Questions

1. (i) Explain the statement, the specific capacity of water is 4200Jkg^{-1}K^{-1}.

(ii) Water of mass 400.0g at 30.0^{o}C is mixed with 200g of water at 80^{o}C. Neglecting heat losses, calculate the temperature of the mixture (specific heat capacity of water is = 4200Jkg^{-1}K^{-1})

1996 Questions

2. Explain why clinical thermometers are normally sterilized in alcohol and not in boiling water.

1998 Questions

3. State two differences between convection and radiation of heat.

2000 Questions

4. (i) Define latent heat of fusion

(ii) Distinguish between latent heat of fusion and latent heat of Vapourization

(iii) Two solids A and B are of heat capacities 400JK^{-1} and 546JK^{-1} respectively. Explain this statement.

2002 Nov Questions

5. (i) Distinguish between heat and temperature

(ii) Explain why a thick glass jug would crack when hot water is poured into it while a thin glass jug will not.

2004 Questions

6. (i) Define latent heat of fusion

(ii) Determine the amount of heat required to melt 150.0g of ice at $0^{o}C$. (Specific latent heat of fusion for water is $336kJKg^{-1}$)

2005 July Questions

7. Explain the following observations:

(i) A boy holding a long metal rod with one end in the fire feels a burning sensation in the palm

(ii) A clinical thermometer breaks when used to measure the temperature of boiling water.

2005 Nov Questions

8. (i) Define specific heat capacity.

(ii) Some quantity of water of mass 3.0kg is heated from $260^{o}C$ to $760^{o}C$. If the specific heat capacity of water is $4200J/kg0^{o}C$, calculate the amount of heat used.

2006 Questions

9. (i) Draw and label a diagram of a vacuum flask.

(ii) Describe briefly how heat gain and heat loss are minimised due to the construction of the vacuum flask.

2007 Questions

10. (a) (i) What is a thermostat?

(ii) Name two appliances which use thermostat.

(b) (i) Water of mass 1.5kg is heated from 20oC to 70oC. Calculate the amount of heat absorbed (specific heat capacity of water = 4200Jkg^{-1}K^{-1}).

(c) A glass bottle filled with water to the brim, corked and placed in a freezer cracks after freezing. Explain this observation.

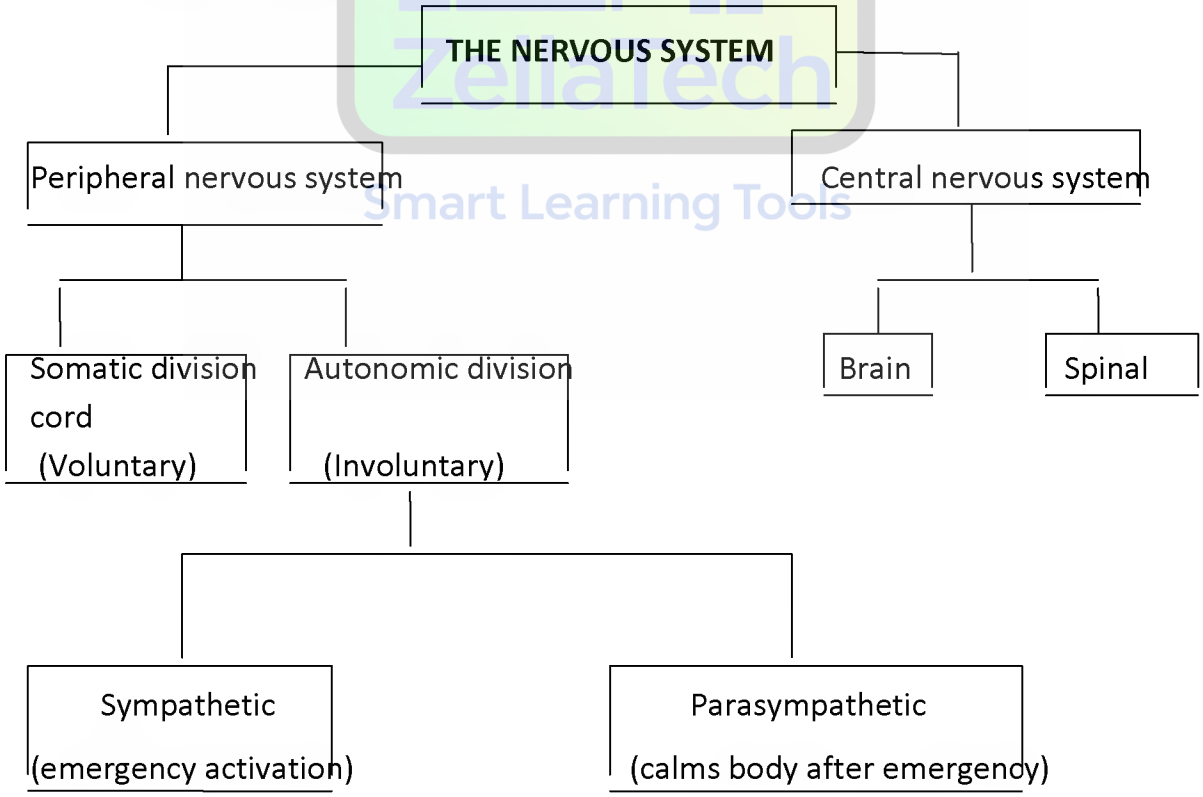
5.2 CO-ORDINATION OF LIFE PROCESSES

Co-ordination is the ability to receive stimulus and respond appropriately to maintain a steady balance, ensuring survival of the organism.

Two main parts of co-ordination are:

- Nervous system
- Endocrine system

THE NERVOUS SYSTEM



Breakdown of the nervous system

BRAIN: Parts and function

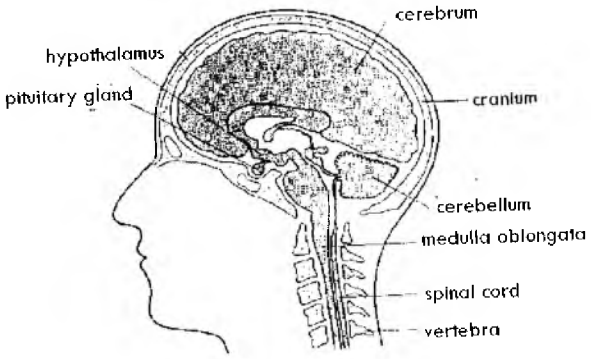
The brain is enclosed in the skull. It is wrapped in protective membrane called **Meninges**. The space between the meninges is filled with fluid called **Cerebrospinal fluid** which acts as cushion and provides cells with food and oxygen. The fluid is also contained in the ventricles of the brain and the central canal of the spinal cord.

The brain consists of:

Cerebrum: is the largest part of the brain made up of two cerebral hemispheres. The inner layer of white matter is very thick. While the outer layer (cerebral cortex) of gray matter is thin, and responsible for such activities as vision, emotion, memory, touch and taste. Also controls higher thought processes such as learning, speech, reasoning, hearing and language.

Cerebellum: is a highly folded mass of nervous tissue found just below the cerebrum. It is responsible for muscle co-ordination and balance; It maintains normal muscle tone, posture and balance and also ensures that all of the skeletal muscles work together to produce smooth and co-ordinate motions and also reflex centers' for vomiting, coughing, sneezing, hiccupping and swallowing.

Medulla Oblongata: the lower half of brain stem and controls many life activities that one does not think about such as breathing, yawning, sneezing, regulating heartbeat, blood pressure etc.



The brain is made up of 100-200 billions of nerve cells called neurons. These neurons allow messages to travel from one part of the body to another. Like all cells in the body, neurons have a cell body, containing a nucleus, which incorporates the inherited material that establishes how the cell will function. The messages that travel through the neuron are purely electrical in nature.

Types of neurons:

- Sensory Neurons (Afferent Neuron) transmit information from the sensory receptors (Sensory organs) to the spinal cord.
- Motor Neurons (Efferent Neuron) transmits information from the spinal cord to the effector organ e.g. muscles, glands.
- Relay Neurons (Intermediate Neuron) transmits impulses between sensory and motor neurons. It is found in the CNS.

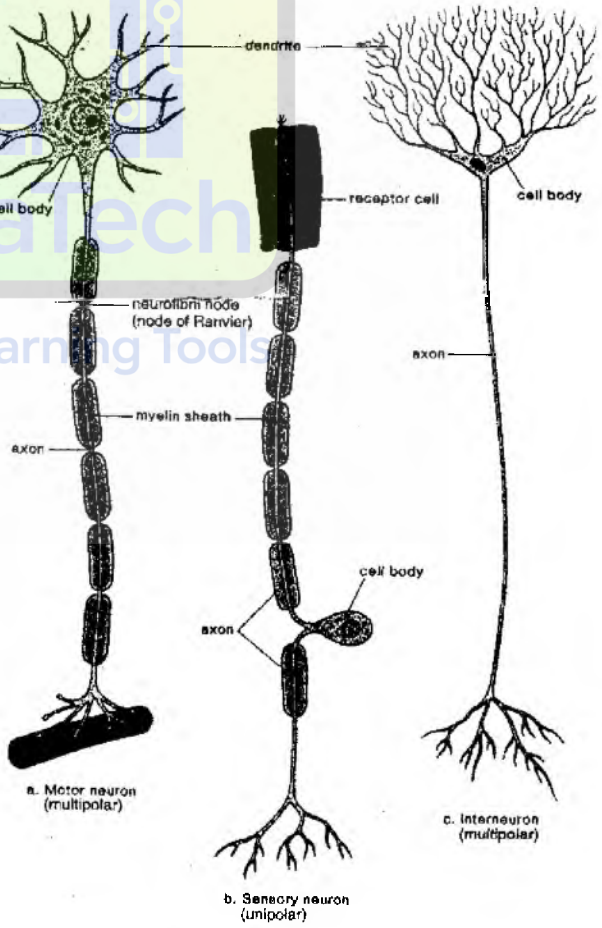


Diagram of Motor Neurone and other Neurones

STRUCTURE OF A NEURONE:

- There are two main parts of a Neuron; the <u>cell body</u> and the <u>Axon</u>
- Cell body contains the nucleus and other

organelles, and nucleus embedded in dense granular cytoplasm

- Short cytoplasmic strands called Dendron rise from the cell body and branches into thread-like process called Dendrites.
- The cytoplasm of the cell body continues into a long process called the axis cylinder; the Axon
- Layer of fatty sheath called Myelin Sheath encloses the Axon
- Myelin sheath protect the Axon and speed up impulse transmission
- Myelin sheath is not continuous with gaps in it called nodes of Ranvier
- Dendrites of one cell body are in close proximity to the terminal dendrite of other neurons, but are not in direct contact.
- A tiny gap known as synapse is left between them.

Function of neurons:

Dendrites (many fibres) detect and pick up information from the receptors (other neurons). The information is carried in the form of an electrical signal to the nerve cell body. The cell body contains the nucleus and other cell structures which keep the cell alive.

The electrical signal continues along the cell body to a single, long fibre called the axon. Of special importance is the small gap between the axon of one cell and the dendrite of another, the synapse. When an electrical signal reaches the tip of an axon, a chemical at the tip of the axon spills into the synapse to receive and carry the electrical signal to the dendrite of the next cell.

The relay process from one cell to the next can take place at the speed of one hundred metres per second.

SPINAL CORD: It extends down from the medulla.

It is located in the neural canal of the vertebra which encloses this rope of nervous tissue and protects it from injury.

It has a central canal containing cerebrospinal fluid; gray matter is centrally located and shaped like letter **H** and an outer white matter.

Gray matter contains cell bodies and short non-myelinated fibres.

White matter contains myelinated axons.

Dorsal root of a spinal nerve contains sensory nerve fibres which enter the gray matter.

Ventral root of a spinal nerve contains motor fibres exiting the gray matter.

Function of spinal cord:

It is the centre for reflex action.

It also serves as a means of communicating between the brain and much of the body.

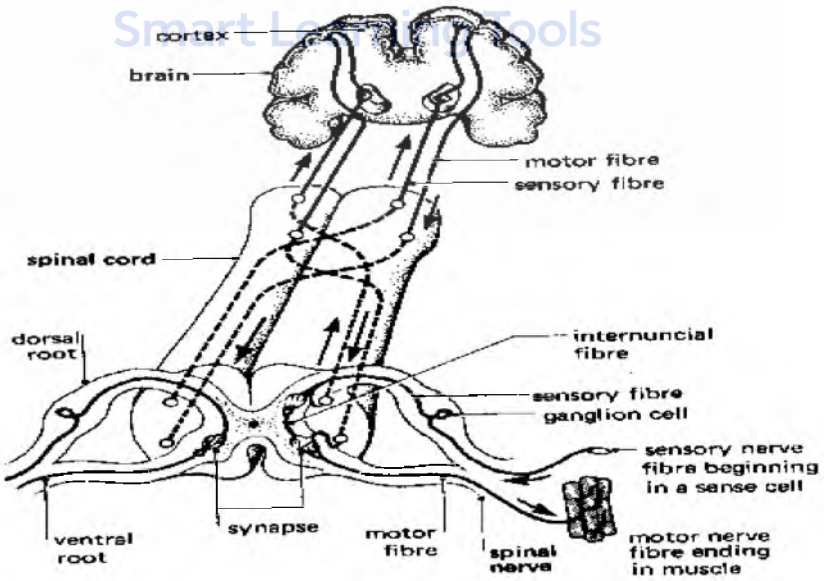
Reflex Action: a fast automatic response to stimulus and controlled by the spinal cord without input from the brain. Reflex action enables us to quickly escape from danger thus protecting the life of the individual.

Reflex Arc: the pathway through which reflex action takes place. The neurons involved are Sensory, Relay and Motor neuron.

A girl accidentally touches a hot plate and quickly withdraws her hand; the mechanism involved in this action is as follows:

The temperature receptors are stimulated and

- message is passed along the sensory neuron to
- the spinal cord through the dorsal root
- Impulse/the message moves over a synapse and
- stimulates a relay and motor neuron
- the impulse leaves the spinal cord through the ventral root to the muscle
- this contracts and pulls the hand away.



Reflex arc involved in withdrawal from an unpleasant stimulus

Analysis of reflex action:

Impulse travelling down a neuron is thought to be due to changes in electrical charge on the inside and outside of the nerve cell (axon).

Reflexes involves the spinal cord thus not under a person's control. Nevertheless, when it happens a further impulse is sent along the spinal cord to inform the brain, and we are made aware of it. Because they are not initiated consciously it cannot be suppressed.

They are exceptionally quick in milliseconds, for instance it takes 100ms for a damage report to reach the brain and a signal sent to the vocal cords.

Vapour arising from a cut onion passes into a nose causing the olfactory sense cells to react thus dissolving the moisture of the eyes. The eyes react by discharging fluid from the tear glands to dilute the dissolved vapour.

Carriers of electrical impulses:

- Olfactory sense cells carry impulses from the nose to the brain.
- Optic nerve cells carry impulses from eye to the brain.
- Auditory nerve cells carry impulses from the ear to the brain.
- Spinal cord carries impulses from the rest of the body to the brain.

THE PERIPHERAL NERVOUS SYSTEM (PNS)

They are nerves which are bundles of axons and lie outside the (CNS) Central nervous system (brain and spinal cord).

- They transmit impulse away from the CNS or into the CNS.
- The cell bodies of neurons are found in CNS or in Ganglia.
- Ganglia(Sing: Ganglion) are collections of cell bodies within the PNS
- Humans have 12 pairs of cranial nerves (nerves from the brain) and 31 pairs of spinal nerves (nerves from the spinal cord).
- The paired spinal nerves emerge from the spinal cord by two short branches called roots.
- The dorsal root contains Axons of Sensory Neuron which conducts impulses to the spinal cord from sensory receptors.

- The ventral root contains Axons of Motor Neurons that conduct impulses from the spinal cord to the effectors (muscles, glands).

VOLUNTARY & INVOLUNTARY ACTIONS

For voluntary actions previous experience is involved where a conscious choice is made to run or sing.

SOMATIC DIVISION: These nerves carry messages to and from the sense organs and skeletal muscles under voluntary control for example, the hand to turn a page and motion of eyes to read a sentence as well as communication of information to and from the sense organs.

AUTONOMIC DIVISION: - They are mostly efferent nerves supplying the involuntary muscles of the walls of organs like stomach, intestines, bladder, heart, blood vessels and secretary organs. They control involuntary movements' such as, the action of digestion, pushing of lungs in and out, and pumping of blood through your body. The autonomic division branches into the sympathetic and the parasympathetic nerves. Both branches are related to emotional responses like crying, sweating, heart rate and other involuntary behaviours.

The sympathetic nerve branch is an emergency system that prepares the body for fight, flight or freeze during times of danger or emotion. In short it arouses the body for action.

The parasympathetic nerve is most active soon after a stressful or emotional event. Its role is to calm the body and return it to lower level arousal. Both branches are active at all times and their activities combine to determine if the body is aroused or quieted.

Summary of activities controlled by autonomic nervous system

SYMPATHETIC SYSTEM	PARASYMPATHETIC SYSTEM
Speeds up heartbeat	Slows down heartbeat
Constricts arteries	Dilates arteries
Dilates pupils	Constricts pupils
Decreases saliva flow	Increases saliva flow

Slows down peristalsis	Speeds up peristalsis

CAUSES OF DAMAGE TO THE BRAIN AND SPINAL CORD:

Accidents on roads, workplace, the air, homes etc may cause a permanent and irreversible damage to the brain and spinal cord since damage nerve cells never heal. However, partial recovery occurs when other parts of the brain take over some of the life activities of the damaged part.

Diseases can cause impaired body function and changes in behavior. Such are biochemical changes in the brain cells, infections like meningitis and organic illness like brain tumours.

Depression is a mental disorder in which one feels extremely unhappy and has no enthusiasm for anything.

- It may be endogenous i.e. of internal origin or
- It may be reactive i.e. response to environment.

Endogenous depression occurs when there is a change in balance of chemicals produced at the synapses of nerve cells.

Reactive depression occurs as a result of stress due to the death of a loved one, a deep disappointment or frustration, being an exaggerated reaction to the situation, which causes it.

Drug Abuse is the improper use of drugs.

Classes of drugs:

Stimulants: - speed up the central nervous system examples are *caffeine* and *nicotine* in tobacco. *Caffeine* speeds up the nervous system, so that people feel active and awake. However, people who drink 5 or more cups of caffeine-containing beverages a day can show signs of loss of appetite, sleeplessness and irritability.

When tobacco smoke is inhaled *nicotine* and the poisonous gas carbon monoxide enter the bloodstream. These chemicals can cause the heart to work harder and the blood pressure to rise. Tobacco smoke also contains many tiny particles which when cooled, form a sticky, brown material called *tar*. Many of the particles in tar are shown to be carcinogens, which mean they can cause cancer.

Depressants: - slow down the nervous system example are *barbiturates* and *alcohols.* Barbiturates can cause slow reaction time, confusion, drowsiness, and even death. Barbiturates are extremely dangerous when they are mixed with alcohol.

When alcohol is swallowed it is absorbed from the stomach and small intestines into the bloodstream and soon reaches the brain. When taken in larger quantities the controls that govern a person's behaviour are weakened. People can become obnoxious and noisy, others withdrawn, sleepy and depressed. The ability to make judgments lessens. Reflexes slow down, vision becomes blurred, hearing can be less acute and people can have difficulty in speaking and walking. The abilities to reason, to concentrate, to remember, and to make decisions are also impaired. Alcohol can also damage the drinker's liver. It causes the liver to shrink and to harden, cirrhosis. Blood cannot be filtered through a hardened liver.

Hallucinogens: - distorts our senses. They are drugs that cause people to see, hear, and feel things that exist only in a person's imagination. Moods can switch from complete joy to absolute terror. Hallucinogens can make people take chances with their lives. The most common is (LSD) *lysergic acid diethylamide*, may affect the brain cells, distort one's perception and cause hallucinations. It may affect one's judgment in dangerous situations as to ignore traffic dangers or jump from a high window believing they can fly. Marijuana is a drug that produces hallucinogenic effects. It seems that a person's reaction time is slowed and the ability to make interpretations takes longer than usual when an individual uses marijuana.

Psychological dependence occurs when one becomes used to taking the drug and feels the need to have it.
Physiological dependence or addiction occurs when the body develops tolerance for the drug and can cope with large quantities. In this case changes are brought about in the way one or more organs function.
An addicted fellow becomes very ill and suffers withdrawal symptoms.
Delirium tremens (frightening hallucinations, tremors and over-activity of internal body organs) is withdrawal symptoms in an alcoholic.

The effect of brain & spinal cord damage on the individual, family and society is abnormal behavior and such a person will be unable to:

1. Look after his/her personal welfare including feeding and personal hygiene.
2. Make rational decisions and plan for the future.
3. Form and sustain relationships with other people.
4. Tolerate behavior patterns different from his/hers.
5. Adjust to stress resulting from weather changes and changes in attitudes and behavior in other people.

THE ENDOCRINE SYSTEM

Endocrine glands make up the endocrine system. An endocrine gland is ductless gland whose secretions do not pass through any duct before reaching any of its target organs.

1. Name of gland : Pituitary gland
   Position : base of the brain
   Hormone secreted : growth, follicle stimulating anti diuretic hormones.

Functions of hormone:

- Controls growth
- Stimulates production of follicles in female and testis in males
- Stimulates production of other hormones

Under-production of hormones causes dwarfism and overproduction causes giantism. Pituitary secretes hormones which controls other endocrine glands of the endocrine system it is therefore, called the master gland.

2. Name of gland : Thyroid
   Position : Neck
   Producing hormone : Thyroxin

Normal functions of hormones:

- Controls speed at which energy is released in your body.

- It keeps the body temperature at approximately 37°C.
- Helps the body maintain a proper weight (controls growth rate)
- Controls brain development
- Controls basic metabolic activities.
- Controls rate of chemical activities e.g. respiration.

Effect of under production:

- Cretinism in children (stunted mental and physical growth)
- Decreased rate of heartbeat
- Low body temperature
- Decreased metabolism rate
- Obesity
- Slow reactions.
- Thick skin
- Premature ageing in adults.

Effect of over production:

- Enlarged thyroid gland
- Restlessness and sleeplessness.
- Increased rate of heartbeat
- Large appetite development
- Increased rate of metabolism
- Causes underweight in adults.

3. Name of gland : Parathyroid
   Position : neck (behind the thyroid gland)
   Hormone secreted : Parathormone

Functions:

- It increases the release of calcium ions from the bone tissue and as such the amount of calcium circulating in the blood.

Overproduction:

- It leads to excessive removal of calcium from bones leaving them brittle and liable to fractures.

Underproduction:

- It leads to low calcium levels leading to nervous disorders and uncontrollable contraction of muscles called Tetany.

4. Name of gland : Adrenal gland
   Position : attached to the kidneys
   Producing hormone : Adrenaline

Normal function of hormone:

- Prepares the body for action in an emergency by raising blood pressure (flight or fight).
- Increases heartbeat
- Increases breathing rate
- Increases blood sugar level.
- Dilates pupils increase supply of blood to the muscles
- Decreases blood supply to the gut.

5. Name of gland : Islets of langerhans
   Position : In the pancreas
   Producing hormone : Insulin

Normal function of the hormone:

- Lowers the level of glucose in the bloodstream by causing the liver to store more as glycogen.
- Promotes uptake of glucose from body muscle cells
- Increases protein synthesis in some cell

Effect of under production:

- Causes diabetes (excess glucose in the bloodstream).

6. Name of gland : Ovary
   Position : Dorsal abdominal wall
   Hormone : Oestrogen and Progesterone

Function of oestrogen:

- Stimulates the development of secondary sexual characteristics in females' e.g. monthly menstruation.

Function of progesterone:

- Prepares the uterus for pregnancy and stimulates the development of breasts.
- Maintains the lining of the womb during pregnancy.

Underproduction of progesterone the oestrogen acts alone to:

- Increase in body fat
- Increase in water and salt retention
- Increased risk of overgrowth of lining of uterus.

Effects of over production:

- Increased risk of overgrowth of breast tissues.

7. Name of gland : Testes
   Position : scrotum
   Hormone : testosterone

Function of hormones:

- Stimulates development of secondary sexual characteristics in males and a growth spurt at puberty.

Under production:

- Decreased energy
- Reduced muscle mass and strength
- Decreased cognitive function
- Reduces sexual interest and potency
- Depression

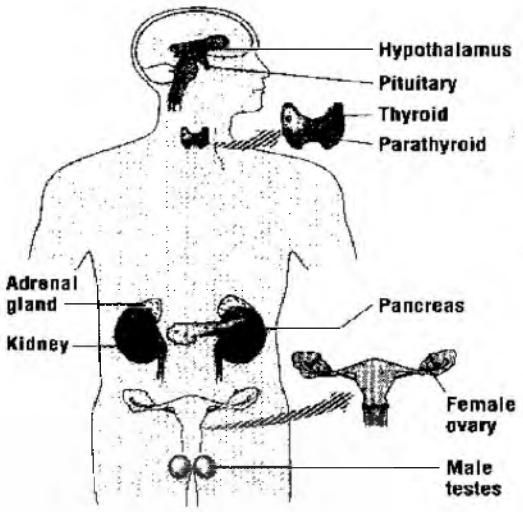
Overproduction:

- Increased facial hair
- Growth of breast tissue in men
- Higher cholesterol levels

Other glands and their functions:

- Prolactin: - stimulation of breast milk.
- Oxytocin: - induces birth (muscular contraction of uterine walls).
- Glucagon: - converts glycogen to glucose

- Vasopression: - controls muscle tone.



Co-ordination of life processes in plants:

Although plants do not have nervous and endocrine systems there is a mechanism by which photosynthesis and respiration are linked and co-ordinate in plants for instance, the products of photosynthesis are the raw materials for respiration and the vice versa, that is, carbohydrate and oxygen produced in photosynthesis are the raw materials used in respiration by plants to release energy.

REVISION QUESTIONS:

1997 Questions

1. (i) What is an endocrine gland?
   (ii) Give two normal functions of thyroxin.
   (iii) State three effects of each of the following in humans
   (α) Over-secretion of thyroxin
   (β) Under-secretion of thyroxin
   (iv) List the senses and their associated organs.

1998 Questions

2. (i) Differentiate between voluntary and involuntary actions.
   (ii) A boy accidentally touches a hot object and quickly withdraws his hand. Explain the mechanism involved in this action.

2000 Questions:

3. State two functions of each of the following hormones in the body

   (i) Thyroxin (ii) Adrenaline (iii) Insulin

2002 Questions:

4. (i) Draw and label a motor neuron

   (ii) Name two other types of neurons

2004 Nov Questions:

5. (i) What is a hormone?

   (ii) Name three mammalian hormones and state one function of each.

2008 G.B.C.E Questions

6. State one function each of the following parts of the nervous system:

   (i) Sensory neuron;

   (ii) Motor neuron;

   (iii) Cerebrum.

BIBLIOGRAPHY

Abbey T.K et.al (2001) *G.A.S.T Integrated Science for Senior Secondary Schools.* Unimax Macmillan Ltd.

Abbey T.K et. al (1989) *G.A.S.T Physics for Senior Secondary Schools.* Macmillan Press Ltd