FIRST TERM SS1 CHEMISTRY LESSON NOTE

SS1 CHEMISTRY SCHEME OF WORK

WEEK	TOPIC	SPECIFIC TOPIC
1	Introduction	• Science and scientific method • Meaning of Chemistry • Careers in Chemistry • Areas of Application.
2	Chemical Industries	• Definition of chemical industry • Types of chemical industry. • Adverse effects of chemicals.
3	Standard Separation Techniques	• Sieving • Magnetic separation • Filtration, decantation and Centrifugation. • Evaporation to dryness. • Crystallization and Fractional Crystallization. • Precipitation.
4	Standard Separation Techniques	• Distillation and Fractional distillation. • Separating Funnel Method. • Sublimation. • Pure and Impure Substances.
5	Particulate Nature of Matter	• Definition of Matter as well as examples. • Classification of Matter. • Physical and Chemical Changes.
6	Particulate Nature of Matter	• Protons, Neutrons and Electrons. • Arrangement of electrons around the nucleus.
7	Particulate Nature of Matter	• Atomic/Proton Number(Z). • Mass Number (A). • Relative Atomic Mass(RAM) and Relative Molecular Mass(RMM): Definitions as well as Calculations.
8	Practical	• Laboratory Apparatuses and Uses. • Safety Guidelines in the Laboratory.

9	Revision	
10−12	Examination/ vacation	

WEEK ONE

INTRODUCTION TO CHEMISTRY

DEFINITION OF SCIENCE:

The word **"*science*"** has been derived from a Latin word **"*scientia*"** which means knowledge**. Science → Scientia → Knowledge**

Science is defined as the knowledge of physical and natural world gained through observations and experimentations. It is a systematic way of observing the world first and then doing experiments to understand its structure and behaviour.

DEFINITION OF CHEMISTRY:

Chemistry is defined as branch of pure science which deals with the study of matter: its composition, properties, structures, uses and changes that it undergoes. Matter is defined as anything that has mass and occupies space. It is built up of three elementary particles namely: ***atoms***, ***molecules*** and ***ions***. *The mass of an object is the quantity of matter that it contains and it is same everywhere*. The S.I. unit of measurement of mass is ***kilogram***.

Examples of matter include: ***school chalk***, ***school bag***, ***exercise book***, ***mobile phone***, ***television set*** and ***pencil*** etc.

WHY STUDY CHEMISTRY?

A study of chemistry enables those who study it to acquire certain scientific skills such as handling of laboratory apparatus, performing experiments with ease, and thinking scientifically. *The application of knowledge and skills gathered through the study of science* is called **TECHNOLOGY. Scientists** *in the field of chemistry are called* **CHEMISTS.** A qualified chemist is called **ANALYTICAL CHEMIST. Analytical chemists** *examine the composition, structure and identify the various elements and compounds that make up a substance, as well as the changes that they undergo.*

BRANCHES OF CHEMISTRY

There are basically **FIVE** major branches of chemistry namely:

1. **ORGANIC CHEMISTRY;**

This deals with the study of molecules that contain ***carbon*** and ***hydrogen*** and also sometimes oxygen, nitrogen and other elements.

2. **INORGANIC CHEMISTRY;**

This deals with the study of compounds that do not contain ***hydrocarbons***; the study of elements in the Periodic Table and their compounds.

3. **PHYSICAL CHEMISTRY;**

This deals with the study of physical properties of chemical substances, often from a theoretical point of view.

4. **ANALYTICAL CHEMISTRY;**

This deals with the study of techniques to analyse elements and substances.

5. **BIOCHEMISTRY.**

This deals with the study of processes in living organism.

CAREERS IN CHEMISTRY

1. **HEALTH SERVICES:**
   - Pharmacists;
   - Doctors;
   - Nurses;
   - Medical assistants;
   - Dispensers.
2. **FOOD PROCESSING;**
   - Food technologists and
   - Research chemist.
3. **AGRICULTURE;**
   - Agricultural scientists;
   - Biochemists and physiologists engage in research to improve the quality and yield of crops and livestocks.
4. **TEACHING SERVICES**.

- Chemistry Teachers and Lecturers in Secondary Schools, Polytechnics, College of Education and Universities.
- Laboratory assistance in Schools and Universities.

APPLICATIONS/USES OF CHEMISTRY

1. **FOOD PRODUCTION:** *Chemistry is applied in;*
   - *The production of fertilizers;*
   - *The production of pesticides;*
   - *The production of herbicides;*
   - *Food preservation techniques (Pasteurization and canning);*
   - *The production of food additives.*
   - *The analysis of food products;*
   - *Food sensory analysis;*
   - *Food biotechnology (Biotechnology involves the use of living organism to produce food products or modify food products).*

2. **CLOTHING:** *Chemistry plays a role in the Textile industry at every stage. It plays a crucial role in:*
   - *the manufacture of synthetic fibres;*
   - *the production of dyes and printing inks;*
   - *the treatment of the fabrics;*
   - *resizing (resizing chemicals strengthen or "set" a fabric fibers).*

3. **MEDICINE:** *Chemistry plays a crucial role in medicine. It contributes to:*
   - *Drug discovery/production;*
   - *The diagnosis of diseases;*
   - *Drug delivery;*
   - *The preparation and use of surgical materials such as sutures, artificial skin and sterile materials.*

4. **TRANSPORTATION:** Modern transportation is an essential feature of today's world. This rapid development from carts pulled by animals to the latest aircraft was made possible by chemists producing suitable fuels and structural materials like alloys which are light, strong and heat-resistant.

5. **HOUSING:** *Chemistry plays a significant role in shaping the Modern world, particularly in the field of building and construction. It plays a crucial role in:*

- *Concrete production;*
- *Cement production;*
- *Production of steel rods;*
- *Production of tiles;*
- *Production of paints;*
- *Corrosion protection;*
- *Adhesive bonding;*
- *Fire protection (involves the production of fire-resistant materials used to enhance safety);*
- *Waterproofing.*

6. **MILLITARY:** *Arms and ammunitions, Camouflages; bullet-proof wears; Helmets.*
7. **SPACE SCIENCE:** *Production of structural materials for the constructions of rockets; rockets fuels.*

ADVERSE EFFECTS OF CHEMICALS

ENVIROMENTAL POLLUTION: *Pollution is the introduction of harmful materials/substances into the environment.* These harmful materials are called ***pollutants*. Pollution is caused by the following;**

- Vehicle exhaust emit ***hazardous gases*** (Carbon (II) oxide; CO), Sulphur(IV) oxide, SO_2 into the atmosphere, thereby, causing air pollution.
- ***Crude oil spillage*** causes water and ***soil pollution***.
- Plastic containers litter the surrounding; they are non-biodegradable (not decomposed by bacteria).

DRUG ABUSE: ***'Drug abuse'*** also called ***'substance abuse'*** is an illness that is characterized by a destructive patterned use of illegal or legal drug or medication.
Some of the commonly used drugs are:

- Alcohol
- Cocaine
- Aspirin
- Morphine
- Tramadol.

SCIENTIFIC METHOD

DEFINITION OF TERMS USED IN SCIENTIFIC METHOD

These are series of steps followed by scientific investigators to answer specific questions about the natural world.

HYPOTHESIS: ***A hypothesis is defined as an assumption taken to be true for the purpose of argument or investigation***.

SCIENTIFIC THEORY/THEORY: ***"A scientific theory is an idea put forward to explain the existence of one or more laws". "It can also be defined as a scientific idea which was thought of by somebody, suggested by him in a scientific book or journal and accepted by other scientists after due consideration". A theory must be testable***. When an idea is first put forward, and is still in the 'argument-and-objection' stage, it is called a **HYPOTHESIS**. Later, if generally accepted, a **THEORY**.

SCIENTIFIC LAW/LAW: ***A scientific law is simply a generalized statement of observed facts***. *For example, in all cases examined, it has been found that the total mass of the products of a chemical reaction is equal to the total mass of the original reagents*. This result is assumed to apply in all such cases and is generalize as the Law of Conservation of Mass.

A scientific law is subject to **TWO** possibilities of error namely: ***first, it is not possible to examine every last case of the operation of the law***. ***Secondly, the law can be accurate only to the limit of experimental error.***

RELATIONSHIP BETWEEN SCIENTIFIC LAW AND THEORY: *Once a scientific law has been definitely established it will usually stand for any relevant time, being well grounded in fact whereas a theory put forward to explain the law may, however, be replaced from time to time as the knowledge increases.*

STEPS INVOLVED IN SCIENTIFIC METHOD

- *Make observation*
- *Ask a question?*
- *Form a hypothesis*
- *Conduct an Experiment*
- *Analyze the results*
- *Draw conclusion*

- *Share results*

STUDY QUESTIONS

1. *Define clearly the term "Chemistry"*
2. *Define clearly the term "Science"*
3. *Mention five major branches of chemistry.*
4. *Distinguish between hypothesis and scientific law.*
5. *Distinguish between Scientific theory and scientific law.*
6. *Lists the steps involved in scientific methods.*
7. *List three physical classification of matter.*
8. *Mention three chemical classification of matter.*

WEEK 2

THE CHEMICAL INDUSTRY

DEFINITION OF TERMS

CHEMICAL INDUSTRY: ***A chemical industry is a place where chemicals and chemical products are manufactured on a large scale.***

FINISHED PRODUCT: ***A finished product is a completely processed material from a particular raw material.***

PRIMARY/MAIN-PRODUCT: ***A primary or main product is the finished product expected from a particular raw material.*** For example: Haber Process is designed to produce ammonia.

BY-PRODUCT/SECONDARY PRODUCT: ***A by-product/secondary product is obtained along with the primary product from a chemical reaction*****.** Example: in the production of ethanol from sugar cane juice, ethanol is the primary product, while CO_2 is secondary.

WASTE PRODUCT: ***A waste product is an unwanted or harmful substances produced during an industrial process*****.** Example: In the blast furnace, pig iron is the primary product while slag is the waste product.

INDUSTRIAL RAW MATERIALS

AIR

Air is the chief source of oxygen and nitrogen. The latter is used in the manufacture of ammonia by the Haber process.

COMMON SALT/SODIUM CHLORIDE/NaCl

Sodium chloride, NaCl, known simply as common salt, is found in sea water to the extent of about 3% by mass. It is also an essential part of our diet.

USES OF SODIUM CHLORIDE/COMMON SALT

1. Common salt is used to manufacture Na, NaOH, Chlorine, Na_2CO_3 and $NaClO_3$.
2. It is also used in glazing earthenware, regenerating water softeners and salting out.
3. It is commonly used as a food preservative.

COAL

Coal: *Coal is formed by the gradual decay of plants vegetation, buried deep down the earth's crust*. On subjecting to high temperature and pressure in the absence of air and moisture, the vegetation undergoes various changes, passing through the following stages: **Wood → Peat → Lignite → Bituminous coal →Anthracite.** The above process is called ***Carbonization***.

Carbonization of Vegetable Materials yields the following:

- Peat.
- Lignite/Brown Coal.
- Bituminous/Soft Coal.
- Anthracite/Hard Coal.

USES OF COAL

1. Coal is used mainly as a fuel to generate power for steam engines, factories and electric plants.
2. It is also used for making various chemicals.

NATURAL GAS

Natural gas (also called fossil gas or methane gas) is a naturally occurring mixture of gaseous hydrocarbons consisting primarily of methane. In addition to various smaller amounts of other higher alkanes. Traces of CO_2, Nitrogen, H_2S and helium are also usually present**.**

USES OF NATURAL GAS

1. Natural gas can be burned for heating, cooking and electricity generation.
2. It is also used as a chemical feedstock (or raw material) in the manufacture of plastics and other commercially important organic chemicals.

PETROLEUM/CRUDE OIL/LIQUID MINERAL

Petroleum/crude oil is one of the most valuable naturally occurring industrial raw materials, which is used to in the production of gaseous and liquid fuels.

Petroleum products are the main sources of petrochemicals, which are used in the production of a wide range of products- such as dyes, drugs, plastics, fertilizers, detergents and paints.

LIMESTONE/ $CaCO_3$/CALCIUM TRIXOCARBONATE(IV)

Limestone also called calcium trioxocarbonate(IV), $CaCO_3$ is a major raw material in chemical industry.

USES OF LIMESTONE

1. Limestone is used in making Na_2CO_3, glass, quicklime and steel.
2. It is also used for the production of cement.
3. In the extraction of iron, limestone provides the CaO which is used to remove impurities as slag.
4. Finely ground limestone is used to neutralize excess acid in the acidic soils.
5. Chalk mixed with ammonium trioxonitrate(V)/NH_4NO_3, known as *nitrochalk*, is widely used as a fertilizer.

SULPHUR

Sulphur is an important raw material in the chemical industry.

USES OF SULPHUR

1. Sulphur is used to produce SO_2 for manufacturing H_2SO_4.
2. It is used in the vulcanization of rubber.
3. It is used to manufacture the bleaching agent used in the pulp and paper industry.
4. Sulphur is used for the production of skin ointments and dyes.
5. It is used for the production of matches, fireworks and gunpowder.

TYPES OF CHEMICAL INDUSTRIES

1. **FERTILIZER INDUSTRY**: Fertilizers increases the yield of soil and are of great help to farmers.

TYPES OF FERTILIZERS

(i). Liquid ammonia, NH_3 (injected into the ground using special equipment).

(ii). Ammonium trioxonitrate(V), NH_4NO_3.
(iii). Ammonium tetraoxosulphate(VI), $(NH_4)_2SO_4$.

(iv). Urea, $CO(NH_2)_2$.

The three elements that are commonly used are nitrogen(N), Phosphorus(P) and Potassium(K).

2. **PHARMACEUTICAL INDUSTRY**: *Pharmaceuticals are concerned with the production of drugs*. Drugs can be put in groups: anti-malarias, analgesics, sedative, antibiotics and chloroquine. Most drugs are organic compounds.

3. **SOAP AND DETERGENT INDUSTRY**: *Hydrolysis of fats and oils with caustic alkali*(NaOH/KOH) *yields propane-1,2,3-triol and the corresponding sodium and potassium salts of the component fatty acids*. These salts are the principal constituents of soap. This process is called **SAPONIFICATION**. **Fat/oil + caustic alkali → soaps + propane-1,2,3-triol**

Detergent means any substance which has the ability to clean an object. This includes soaps, soap powders and dish washing liquids as well as water.

TYPES OF DETERGENTS

There are basically two types of detergents namely;

1. Soapy detergents and
2. Soapless detergents.

4. **CEMENT INDUSTRY**: *Limestone is used for making cement which is a mixture of calcium trioxosilicate*(IV), **$CaSiO_3$**, and *calcium aluminate,* **$CaAl_2O_4$**. *Cement is formed by heating limestone and clay to 1500*℃ *in a rotary kiln*. When water is added to the cement complex chemical changes occur and it sets into a hard mass. Cement is mixed with sand or gravel to form *concrete*, which sets hard when water is added. Concrete with steel rods embedded inside is called *reinforced concrete*.

5. **METALLURGICAL INDUSTRY**: This is the industry concerned with the extraction, refining, alloying and fabrication of metals. *The metallurgical industry can be broadly divided into primary and secondary metal production operations. Primary refers to the production of metal from ore. Secondary refers to production of alloys from ingots and to recovery of metal from scrap and salvage*.

FACTORS THAT INFLUENCE THE SITING OF A CHEMICAL INDUSTRY

1. Nearness to the source of Raw Materials.
2. Energy (Power and Fuel) supply.
3. Human Resources (Labour Force).

4. Transport Cost.
5. Nearness to the Market.
6. Nearness to a Source of Water.
7. Conducive Climate.

EFFECTS OF AN INDUSTRY ON THE COMMUNITY

1. There are employment opportunities/provision of employment.
2. Improvement in the standard of living of the people as a result greater purchasing power/improvement in the standard of living.
3. Improvement in the social well-being of the people within the community.

HEAVY CHEMICALS AND FINE CHEMICALS

HEAVY CHEMICALS: ***Heavy chemicals are chemicals used extensively in industries and are produced in very large quantities.***

EXAMPLES OF HEAVY CHMICALS

1. Tetraoxosulphate(VI) acid, H_2SO_4.
2. Sodium hydroxide, NaOH.
3. Ammonia, NH_3.
4. Calcium trioxocarbonate(IV), $CaCO_3$.
5. Trioxonitrate(V), acid HNO_3.
6. Hydrochloric acid, HCl.
7. Sodium trioxocarbonate(IV), Na_2CO_3.
8. Bleaching powder/Calcium hypochlorite, $CaOCl_2$.
9. Metals (Fe, Sn, Al, Cu, Zn).

FINE CHEMICALS*: Fine chemicals are chemicals produced in small quantities for specific purposes and to a very degree of purity.*

EXAMPLES OF FINE CHEMICALS

1. Laboratory/Analytical Reagents.
2. Drugs.
3. Dyes.
4. Perfumes.
5. Photographic reagents.
6. Cosmetics.
7. Additives.

BIOTECHNOLOGY

DEFINITION OF TERMS

BIOTECHNOLOGY: *This is the regarded as any technique that uses living organisms or biological processes to make or modify a product, in order to improve plants or animals, or to develop micro-organisms for specific purposes. Or*

Biotechnology can be defined as the use of biological processes/living organisms to make products for human use.

BIOGAS: *Biogas is a fuel obtained from the anaerobic decomposition of organic wastes, into a mixture of methane and carbon(IV) oxide.*

BIOREMEDIATION: *This is a waste management technique that involves the use of organisms to remove pollutants from a contaminated area.*

GENETIC ENGINEERING: *This is a technique used in biotechnology.*

APPLICATIONS OF BIOTECHNOLOGY

Biotechnology can be applied in the following:

1. Production of drugs(medical)
2. Production of fertilizer
3. In pest control;
4. In waste management;
5. Production of local foods and beverages (*kenkey*, *fufu*, *garri* and *burukutu* e.t.c.).
6. In energy supply for domestic purposes, from organic wastes (In biogas production).

WEEK 3

STANDARD SEPARATION TECHNIQUES

INTRODUCTION

Separation techniques are the physical methods used for separating the constituents of various mixtures.

The principle of separation is based on the ***differences in the physical properties of the constituents of the mixtures***. Such properties include: physical state (solid, liquid and gas), *particle size*, *colour*, *density*, *melting point*, *boiling point*, *solubility in common solvents*, *magnetic property*, *polarity* and *degree of adsorption.*

TECHNIQUES FOR SEPARATING MIXTURES

S/n	Techniques	Mixtures to be separated
1.	Sieving	Solid particles of different sizes
2.	Magnetic separation	Magnetic solids from non-magnetic ones.
3.	Sublimation	Solids which sublime from others solids
4.	Decantation	Insoluble solid from a liquid
5.	Centrifugation	Insoluble solid from a liquid
6.	Evaporation	Soluble solid from a solution
7.	Crystallization	Soluble solid from a solution
8.	Fractional crystallization	Soluble solid from a solution
9.	Precipitation	Soluble solid from a solution
10.	Simple distillation	Solvent from its solution
11.	Fractional distillation	Miscible liquids
12.	Separating funnel method	Immiscible liquids
13.	Chromatography	Solutes from a solution

TYPES OF SEPARATION TECHNIQUES

SIEVING: ***This is a separation technique used to separate solid particles of different sizes***. It is based on the *difference in the particle sizes of the constituents* of the mixture.

Application of sieving:

- It is used in the mining industry to sieve out various sizes of diamond or gold.
- It is used in *pap processing industry*.

- It is also used in *Gari processing industry*.

MAGNETIZATION: ***This is a technique used to separate magnetic substances from non-magnetic ones***. Iron fillings is a magnetic substance. A mixture of ***iron fillings*** and ***yellow Sulphur powder***.

***Application of Magnetic Separation*:**

It can be used for the separation of iron ores from impurities.

FILTRATION: ***Filtration method is used to separate a mixture of a solid in contact with a liquid in which it is insoluble***. The liquid part that passes through the filter paper is called ***filtrate*** and the solid part that remains after filtration is called the ***residue***. The method is based on *the differences in the physical state* and the insolubility of one component of the mixture in the other. ***The by-product of filtration is filtrate***.

Suitable mixtures:

- $NaCl_{(s)}$ and $Zn_{(s)}$
- $FeSO_{4(s)}$ and $CuO_{(s)}$
- $NaCl_{(s)}$ and $CaCO_{3(s)}$
- $Na_2CO_{3(s)}$ and $MgCO_{3(s)}$

DECANTATION: ***This is a separation technique which involves pouring off a liquid from above insoluble particles that have settled at the bottom of a mixture.*** It is a quick but inaccurate method of separating a mixture.

CENTRIFUGATION (or CENTRIFUGING): ***A centrifuge is a device used to separate fine solid particles in a colloidal solution.*** *Such a mixture is difficult to separate*. E.g. blood.

Centrifuging is based on the *difference in the rates of sedimentation of different particles in a centrifugal field*. **One disadvantage of *centrifuging is that the liquid cannot be completely separated from the sediments* due to the fine nature of the particles.**

Application of Centrifugation

- It is used in the hospital laboratory to separate the blood cells from plasma.
- Dairies use a centrifuge to separate butter from cream.

SUBLIMATION: ***This is a separation technique used to separate solid substances that sublime from others that do not sublime***. *An important feature of this separation technique, however, is that the change from solid to vapour is easily reversible.* Sublimation is a phenomenon whereby certain solids change directly from solid state into gaseous state when heated. Examples of solid substances which sublime when heated are: *anhydrous aluminum chloride(***$AlCl_3$***)*, *anhydrous iron(III) chloride(*$FeCl_3$*)*, *benzoic acid(***C_6H_5COOH***)*, *iodine crystals*, *Sulphur*, *Naphthalene*, *Camphor* and *Ammonium chloride*(**NH_4Cl**).

***Suitable mixtures of salts*:**

- $NH_4Cl_{(s)}$ and $NaCl_{(s)}$.
- $Naphthalene_{(s)}$ and $NaCl_{(s)}$
- Iodine $crystal_{(s)}$ and $KCl_{(s)}$

EVAPORATION TO DRYNESS: ***This technique is used to recover a solid from a liquid solvent in which it is soluble to give a solution***. The method is suitable, if the solid has a high melting point, i.e *cannot be decomposed by heating. Here, the solvent is usually sacrificed*. *A solution which has water as its solvent is called an* ***aqueous solution***.

Evaporation is based on the large difference between ***the melting point of the solid*** and ***the boiling point of the solvent***.

***Suitable solutions*:**

- $NaCl_{(aq)}$.: Aqueous solution of sodium chloride.
- $KCl_{(aq)}$: Aqueous solution of potassium chloride.
- $K_2CO_{3(aq)}$: Aqueous solution of potassium trioxocarbonate(IV).
- $Na_2CO_{3(aq)}$: Aqueous solution of sodium trioxocarbonate(IV).

CRYSTALLIZATION: ***Crystallization is the process of obtaining crystals of a solid from its saturated solution, without evaporating the solvent completely***.

Crystallization method is better used for recovering solids that ***decompose or melt easily when heated directly.*** The salt crystals obtained in this way are pure and usually contain water of crystallization. Examples:

1. Copper(II) tetroxosulphate(VI) pentahydrate, $CuSO_4.5H_2O$;
2. Copper(II) trioxonitrate(V) trihydrate, $Cu(NO_3)_2.3H_2O$;
3. Iron(II) tetraoxosulphate(VI) heptahydrate, $FeSO_4.7H_2O$.

CRYSTALIZATION VERSUS EVAPORATION TO DRYNESS

- Crystallization process is slower than evaporation to dryness.
- Product of crystallization is purer, because the impurity remains in the solution, unlike evaporation to dryness.

Application of Crystallization

Where a high degree of purity of the product is greatly desired, crystallization is used example in:

- *Pharmaceutical industries for drug production*
- *Sugar production.*

RECRYSTALLIZATION: When the crystallization process is repeated on a given solid sample using a fresh solvent, it is called ***recrystallization*.** The purpose is to obtain purer crystals.

FRACTIONAL CRYSTALLIZATION: ***Fractional crystallization is the process whereby a mixture of two or more solid substances are crystallized, one after the other, from the same solution.*** It is based in the *difference of the solids in the same liquid solvent.*

DISTILLATION/SIMPLE DISTILLATION: ***This is a separation technique used to separate a mixture containing two miscible or mixable liquids which have wide differences in their boiling points***. The liquids collected via the process is called ***distillates***. ***Anti-bumping granules*** **(also known as boiling stones or boiling chips)** are often added to the liquid being distilled to prevent the formation of large bubbles in the liquid during boiling.

Suitable mixtures of liquids

- Water(b.p.100℃) and ethanol(b.p.78℃).
- Methyl benzene(b.p. 110℃) and benzene(b.p. 80℃).

Application of simple distillation

- *It is used in gin distilleries and water distilleries for the manufacture of gin and distilled water respectively.*
- *It is also used to obtain drinking water from salt water on a large scale (desalination).*

FRACTIONAL DISTILLATION: ***This is a separation technique used to separate a mixture containing two or more miscible or mixable liquids which have close differences in their boiling points***.

Application of fractional distillation

- *It is used in petroleum (crude oil) industry to separate petroleum into its components or parts.*
- *It can also be used to separate liquid air into its gaseous components.*

CHROMATOGRAPHY: *Chromatography is derived from the Greek word 'chromos' (meaning colour) because it was first observed in connection with the separation of the various coloured pigments present in leaves*. ***Chromatography is a means of separating the constituents of a mixture by taking advantage of their different rates of movement (in a solvent) over an adsorbent medium***. The adsorbent medium is the filter paper and the solvent is ***propanone*** or ***ethanol***. There are basically two phases in a chromatographic separation namely: stationary phase (i.e. *a piece of chromatography paper*) and mobile phase (i.e. *mixture dissolved in a particular solvent*).

Chromatography can be used for mixtures *other than those which are coloured, provided that the separated substances are capable of being identified in some conventional manner.*

TYPES OF CHROMATOGRAPHY

- *Gas-liquid chromatography*(GLC).
- *Ion exchange chromatography.*
- *Column chromatography.*
- *Paper chromatography.*
- *High pressure liquid chromatography*(HPLC).
- *Thin layer chromatography*(TLC).

ADVANTAGES OF CHROMATOGRAPHIC SEPARATION

- It can be performed with very small masses of material.
- The substances are not destroyed in the process.

CHROMATOGRAPHY IN INDUSTRY

- *Forensic scientists use gas chromatography to detect traces of illegal drug compounds and alcohol in urine and blood.*

- *It can be used to identify pesticides and harmful chemicals that have entered food from contaminated water resources.*
- *Food scientists use chromatography to analyse food sample to detect the presence of additives like vitamins and preservatives.*

PRECIPITATION: Precipitation method is based on the principle of solubility of a solid in two miscible liquids**. Precipitation is the formation of a solid in a solution during a chemical reaction.** ***In precipitation method, two solids that are soluble in the same solvent are separated by the addition of another solvent in which one of the solids is insoluble***.

Suitable mixture**:** *A solution containing lead (II) ions,* Pb^{2+} *and Calcium ions,* Ca^{2+} [*a mixture of* $Pb(NO_3)_2$ and $Ca(NO_3)_2$] *is separated using precipitation*.

FROTH FLOTATION(FROSTATION): ***This method is specifically used to separate an ore of a metal from earthly impurities.***

SOLVENT EXTRACTION: ***Solvent extraction is a physical method used to separate solids based on their relative solubilities in two different immiscible liquids, usually water and an organic solvent.*** The method involves an extraction of a solid from one liquid phase into another liquid phase using a separating funnel.

*Solvent extraction is used in the production of fine organic compounds, processing of perfumes and production of vegetable oils***.**

SEPARATING FUNNEL METHOD: ***A separating funnel is used to separate two liquids, which do not mix*** (***immiscible liquids***). *The use of separating funnel is based on the difference in the polarities of the liquids.*

Suitable mixtures:

- Water and Kerosene.
- Water and Palm Oil.
- Water and Petrol.

PURE AND IMPURE SUBSTANCES

Since under the same conditions of temperature, pressure and surroundings a pure substance always possesses a set of properties which are unique to that particular substance and which may be reproduced at any time, certain characteristics of the

substance are chosen by which the degree of purity of the sample may be determined. A pure substance must have a

1. ***Sharp/definite melting point(solids)***
2. ***Sharp/definite boiling point (for liquids).***
3. ***Definite refractive index***.
4. ***Definite density***.

DETERMINATION OF THE MELTING POINT OF BENZOIC ACID

1. Place a small quantity of the powdered benzoic acid into a capillary tube sealed at one end.
2. Tie it to the thermometer such that the bulb of the thermometer is completely immersed in the beaker, that is half-filled with liquid paraffin and placed on a tripod stand with wire gauze.
3. Heat the content of the beaker gently with constant stirring of the liquid paraffin.
4. Note the temperature at which the benzoic acid melts.
5. Repeat the process using a fresh/new benzoic acid until the readings agree within 2.0℃.

WEEK 4

PARTICULATE NATURE OF MATTER

- **Definition of matter with examples;**
- **Classification of Matter;**
- **Physical and Chemical Changes as well as their differences;**
- **Atoms, Molecules and Ions.**

Matter is defined as anything that has mass and occupies space. Examples of matter are: school chalk. School bag, mobile phones, drinking cup, and bread. ***Virtually everything on earth is matter***.

Matter is divided into two categories; It occurs in nature as **mixtures** and **pure substances.** ***A pure substance is any matter that has fixed chemical composition and distinct composition. Examples of include: element and compound.***

CLASSIFICATION OF MATTER

PHYSICAL CLASSIFICATION OF MATTER

On this basis, matter can be classified as: Solid, Liquid and Gas. *The fundamental difference between the three states of matter (i.e. solid state, liquid state and gaseous state) is the degree of movement of their particles.*

1. **Solid State of Matter:**

- *Solids have definite shape/form*
- *They have fixed mass.*
- *They are incompressible*
- *They have definite volume*
- *Solids are very dense*.

2. **Liquid State of Matter:**

- *Liquids have no definite shape/form.*
- *They are incompressible.*
- *They have definite volume.*
- *They have definite mass.*
- *Liquids are less dense than solids*.

3. **Gaseous State of Matter:**

- *Gases have no definite shape/form*
- *They are compressible.*

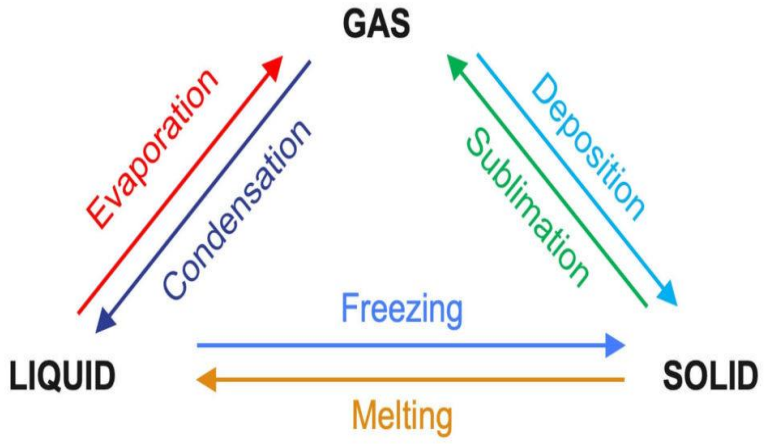
- *They have definite mass.*
- *They have no definite/fixed volume*
- *Gases are the least dense when compared to solids and liquids respectively*.

COMPARISMS OF THE DIFFERENCES BETWEEN SOLIDS, LIQUIDS AND GASES.

SOLIDS	LIQUIDS	GASES
Have fixed shape/form	*Have no fixed shape/form*	*Have no fixed shape/form*
Have fixed volume	*Have fixed volume*	*Have no fixed volume*
Are incompressible	*Are incompressible*	*Are compressible*
Are very dense	*Are less dense*	*Are the least dense*

CHANGE OF STATE OF MATTER

A change of state is brought about by a change in temperature (***Either heating or cooling***). A solid matter can be transformed into a liquid state and vice versa. This transformation is known as a change of state.



EVAPORATION: *This is the process that changes a substance from a liquid state into a gas or vapour.*

FACTORS THAT AFFECT THE RATE OF EVAPORATION

- Temperature.
- Pressure.
- Wind and dryness of the air.
- Area of liquid exposed.

- Nature of the liquid.

SUBLIMATION: *This is the transition of a substance from the solid phase to the gaseous phase without changing into the liquid phase.*

EXAMPLES OF SOLID SUBSTANCES THAT UNDERGO SUBLIMATION

- Anhydrous aluminum chloride($AlCl_3$)
- Anhydrous iron(III) chloride($FeCl_3$)
- Benzoic acid(C_6H_5COOH)
- Ammonium chloride(NH_4Cl)
- Naphthalene
- Camphor
- Iodine Crystals
- Sulphur

CONDENSATION: *Condensation is a process whereby a vapour loses some of its kinetic energy to a colder body and changes into the liquid state.*

MELTING/FUSION: *This is the process whereby a solid change into a liquid when heat is applied.*

DESUBLIMATION/DEPOSITION: *This is the transition of a substance directly from the gas to the solid state on cooling, without passing through the liquid state.*

CHEMICAL CLASSIFICATION OF MATTER

On this basis, matter is classified as: Elements, Compounds and Mixtures.

ELEMENTS

***An element is a substance which cannot be split into simpler units by an ordinary chemical process*.**

TYPES OF ELEMENTS

There are basically Six (6) types of elements namely:

1. Reactive elements.
2. Pure metals.
3. Lanthanides and actinides.
4. Non-metals.
5. Transition elements.
6. Noble/rare gases.

CLASSIFICATION OF ELEMENTS

Elements can be classified as Metals, Non-metals and Semi-metals/Metalloids.

METALS

A metal is an element whose atoms ionize by electron loss. Metals are electron donors. Examples of metals: Sodium, Potassium, Calcium, Magnesium, Aluminum, Zinc, Vanadium, Titanium, Chromium, Manganese and Copper etc.

NON-METALS

A non-metal is an element whose atoms ionize by electron gain. Non-metals are electron acceptors. Examples of non-metals: Phosphorus, Sulphur, Carbon, Nitrogen, Oxygen, halogens (Fluorine, Chlorine, Bromine and Iodine) and hydrogen etc.

SEMI-METALS/METALLOIDS

***A semi-metal/metalloid is an element which has both metallic and non-metallic properties*.** Example: Silicon, Boron and Germanium**.**

CHEMICAL SYMBOLS OF ELEMENTS

The names of elements were represented by ***chemical symbols*.** A Swedish chemist, ***Jons Berzelius*** (1818), suggested the use of the letters of the alphabets as *the chemical symbols of elements.*

Element	Symbol	Atomic Number/ Proton Number	Nature of Element
Hydrogen	H	1	Non-metal
Helium	He	2	Noble/ Rare gas
Lithium	Li	3	Metal
Beryllium	Be	4	Metal
Boron	B	5	Metalloid
Carbon	C	6	Non-metal
Nitrogen	N	7	Non-metal
Oxygen	O	8	Non-metal
Fluorine	F	9	Non-metal
Neon	Ne	10	Noble/ Rare gas
Sodium	Na	11	Metal
Magnesium	Mg	12	Metal

Aluminum	Al	13	Metal
Silicon	Si	14	Metalloid
Phosphorus	P	15	Non-metal
Sulphur	S	16	Non-metal
Chlorine	Cl	17	Non-metal
Argon	Ar	18	Noble/Rare gas
Potassium	K	19	Metal
Calcium	Ca	20	Metal
Scandium	Sc	21	Transition metal
Titanium	Ti	22	Transition metal
Vanadium	V	23	Transition metal
Chromium	Cr	24	Transition metal
Manganese	Mn	25	Transition metal
Iron	Fe	26	Transition metal
Cobalt	Co	27	Transition metal
Nickel	Ni	28	Transition metal
Copper	Cu	29	Transition metal
Zinc	Zn	30	Transition metal

COMPOUNDS

A compound is a substance which contains two or more elements chemically combined together. The atoms of elements in a compound are joined together by *chemical bonds**.** A chemical bond is a strong attractive force that makes it difficult to separate the elements in a compound.*

EXAMPLES OF SOME COMPOUNDS

Compounds	Formula	Elements contained
Water	H_2O	Hydrogen, Oxygen
Glucose	$C_6H_{12}O_6$	Carbon, Hydrogen, Oxygen
Fructose	$C_6H_{12}O_6$	Carbon, Hydrogen, Oxygen
Galactose	$C_6H_{12}O_6$	Carbon, Hydrogen, Oxygen
Sucrose	$C_{12}H_{22}O_{11}$	Carbon, Hydrogen, Oxygen.
Maltose	$C_{12}H_{22}O_{11}$	Carbon, Hydrogen, Oxygen

Lactose	$C_{12}H_{22}O_{11}$	Carbon, Hydrogen, Oxygen
Limestone	$CaCO_3$	Calcium, Carbon, Oxygen
Sodium Chloride	NaCl	Sodium, Chlorine
Trioxonitrate(V) acid	HNO_3	Hydrogen, Nitrogen and Oxygen.

CLASSIFICATION OF COMPOUNDS

Based on their sources, compounds are broadly classified into inorganic and organic compounds.

1. **Organic compounds:** *Organic compounds are those compounds found in plants (as carbohydrates, fats and oils); in animals (as proteins, fats and oils) and in liquid minerals (crude oil).*
2. **Inorganic compounds:** *Inorganic compounds are those that occur in the form of mineral ores and found in the earth's crust e.g. sand, limestone and rock salt.*

MIXTURES

A mixture contains two or more constituents which can easily be separated by physical methods

TYPES OF MIXTURES

There are basically two types of mixtures namely:

HOMOGENEOUS MIXTURES

A homogeneous mixture is one whose constituents has uniform composition throughout its mass. *Examples: air, alloy, sugar dissolved in water, alcohol dissolved in water. A homogeneous mixture can also be called a* ***solution****.*

HETEROGENEOUS MIXTURES

A heterogeneous mixture is one whose constituents do not have uniform composition throughout its mass. *Examples: Blood, Palm wine. A heterogeneous mixture can be called a* ***suspension****.*

DIFFERENCES BETWEEN COMPOUNDS AND MIXTURES

	Mixtures	Compounds
a.	The constituents can be mixed in all proportion.	The constituent are present in a fixed amount by mass.
b.	No chemical bonds between constituents.	Constituents are joined by chemical bonds.
c.	The properties of a mixture are the sum of the properties of the constituents of the mixture.	The properties of a compound are peculiar to itself and are usually quite different from those of its constituent elements.
d.	Constituents cannot be represented by a chemical formula.	Constituents can be represented by a chemical formula.

DIFFERENCES BETWEEN ELEMENTS, COMPOUNDS AND MIXTURES

Element	Compound	Mixture
Consists of one kind of atom	Composition is constant	Composition can vary and consists of two or more elements or compounds.
Properties are unique	Properties differ from those of the constituent elements	Properties are the same as those of constituent substances.
Constituents cannot be separated by chemical or physical methods	Constituents can be separated by chemical methods.	Constituents can be separated by physical methods.

PHYSICAL AND CHEMICAL CHANGES

PHYSICAL CHANGE: ***A physical change is one which is easily reversed and in which no new substances are formed.***

EXAMPLES OF PHYSICAL CHANGE

1. *Changes in the states of matter such as the melting of solids to liquids, the freezing of liquids to solids, the vaporization of liquids to gases and the sublimation of solids to vapours;*
2. *The magnetization and demagnetization of iron rods;*

3. *The separation of mixtures by evaporation, distillation, fractional distillation, sublimation and crystallization;*
4. *Removing a paint-stain or grease with kerosene;*
5. *Boiling of water.*

CHEMICAL CHANGE: *A chemical change is one which is not easily reversed and in which new substances are formed.*

EXAMPLES OF CHEMICAL CHANGES:

1. *The dissolution of metals and limestone in acids;*
2. *The rusting of iron;*
3. *The addition of water to quicklime i.e. the slaking of lime;*
4. *Fermentation and decay of substances;*
5. *The changes in the electrochemical cell;*
6. *Any process in which a gas is liberated;*
7. *Smouldering (to burn slowly with smoke but without flames) of phosphorus in air;*
8. *Chemical decomposition−like digestion of food;*
9. *All combustion processes−like burning of coal.*

DIFFERENCES BETWEEN PHYSICAL AND CHEMICAL CHANGES

S/N	**Physical Change**	**Chemical Change**
1.	Mixture is formed.	Compound is formed.
2.	Easily reversible.	Not easily reversible.
3.	No new substance is formed.	New substance is formed.
4.	No change in mass.	There is a noticeable change in mass.
5.	Not accompanied by heat change.	Usually accompanied by heat change.

CONCEPTS OF ATOMS, MOLECULES AND IONS

ATOMS: *An atom is the smallest particle of an element which take part in any chemical reaction*. Atom of different elements have various shapes**. Examples of atoms include:** Na, K, Mg, Ca, Al and S atoms respectively.

MOLECULES: *A molecule is the smallest particle of a substance that can exist alone and still retains the chemical properties of that substance, be it an element*

or a compound. *A molecule is formed when two or more atoms combine together chemically.*

Examples:

1. $O_{(g)} + O_{(g)} \rightarrow O_{2(g)}$
2. $N_{(g)} + N_{(g)} \rightarrow N_{2(g)}$
3. $Cl_{(g)} + Cl_{(g)} \rightarrow Cl_{2(g)}$
4. $H_{(g)} + H_{(g)} \rightarrow H_{2(g)}$
5. $O_{(g)} + O_{(g)} + O_{(g)} \rightarrow O_{3(g)}$
6. $H_{(g)} + Cl_{(g)} \rightarrow HCl_{(g)}$
7. $2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(l)}$

ATOMICITY

The atomicity of an element is the number of atoms contained in each molecule of it.

ATOMICITY OF SOME ELEMENTS

Element	Formula of molecule	Atomicity
Neon	Ne	1
Argon	Ar	1
Hydrogen	H_2	2
Nitrogen	N_2	2
Oxygen	O_2	2
Chlorine	Cl_2	2
Ozone	O_3	3
Phosphorus	P_4	4
Sulphur	S_8	8

IONS

An ion is any atom or group of atoms that possesses an electric charge.

TYPES OF IONS

There are basically TWO types of ions in Chemistry namely:

- *Positively charged ions also called Cations and*
- *Negatively Charged ions also called Anions.*

Ions are produced when atoms loss or gain electrons.

$Na \rightarrow Na^{+} + e^{-}$
$Ca \rightarrow Ca^{2+} + 2e^{-}$
$Cl + e^{-} \rightarrow Cl^{-}$
$S + 2e^{-} \rightarrow S^{2-}$

SOME EXAMPLES OF IONS

S/N	IUPAC NAME	SYMBOL	TYPE
1.	Sodium ion	Na^{+}	Cation
2.	Potassium ion	K^{+}	Cation
3.	Calcium ion	Ca^{2+}	Cation
4.	Magnesium ion	Mg^{2+}	Cation
5.	Aluminum ion	Al^{3+}	Cation
6.	Chloride ion	Cl^{-}	Anion
7.	Oxide ion	O^{2-}	Anion
8.	Sulphide ion	S^{2-}	Anion
9.	Nitride ion	N^{3-}	Anion
10.	Ammonium ion	NH_4^{+}	Cation
11.	Trioxosulphate(IV) ion	SO_3^{2-}	Anion

ATOMIC STRUCTURE

Atoms are made up of three fundamental sub-particles namely: ***protons***, ***neutrons*** and ***electrons***.

An atomic nucleus consists of protons and neutrons except for the simplest hydrogen nucleus, which is a single proton. The electrons are found on the orbit or shell.

VALUES OF THE CHARGE AND MASS OF PROTONS, NEUTRONS AND ELECTRONS

Sub-particle	Charge	Mass ($^{12}_{6}C$=12.000)	Location
Proton	+1	1	Nucleus
Electron	−1	$\frac{1}{1840}$	Shell/orbital
Neutron	Nil	1	Nucleus

PROTONS (Discovered by Ernest Rutherford 1917)

- *Protons are the positively charged particle in an atom.*
- *A proton has a relative mass of one.*
- *Protons were discovered by Ernest Rutherford in 1917.*

- *They are located inside the nucleus of an atom*.

NEUTRONS (Discovered by James Chadwick in 1932)

- *Neutrons are the neutral particles in an atom.*
- *A neutron has a relative mass of one.*
- *Neutrons were discovered by James Chadwick in 1932 when he bombarded beryllium-9 with alpha particle.*
- *They are located inside the nucleus of an atom*.

ELECTRONS (Discovered by Joseph John Thompson in 1897)

- *Electrons are the negatively charged particle in an atom.*
- *An electron has a relative mass of approximately 0.0005.*
- *Electrons were discovered by Joseph John Thompson in 1897 via his cathode ray experiment.*
- *They revolve around the nucleus*.

ARRANGEMENT OF ELECTRONS AROUND THE NUCLEUS

Electronic configuration is basically the arrangement s of electrons around the nucleus. According to **Niels Bohr**, electrons revolve around the nucleus in circular paths called *orbitals* or *shells* positioned at some distance from the nucleus.

Note the following:

1. The shells are denoted by letters: K, L, M, N, O, P and Q which increases from the nucleus. These correspond to the numbering:1, 2, 3, 4, 5, 6 and 7.

Shell	**K**	**L**	**M**	**N**	**O**	**P**	**Q**
Energy level, n	1	2	3	4	5	6	7

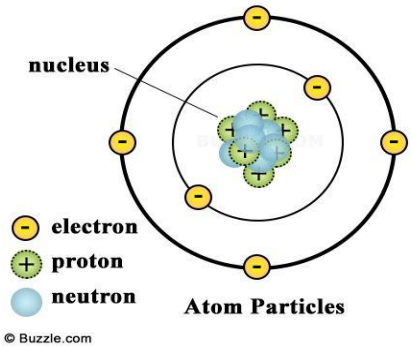
2. The maximum possible number of electrons in a shell numbered n is $2n^2$.

Shell	Value of n	Maximum possible number of electrons
K	1	$2(1)^2 = 2$ electrons
L	2	$2(2)^2 = 8$ electrons
M	3	$2(3)^2 = 18$ electrons
N	4	$2(4)^2 = 32$ electrons

3. The maximum number of electrons that can fill each shell is:

- *Two in the first shell,*
- *Eight in the second shell,*
- *Eight in the third shell.*

4. Calcium, in 20th element has two further electrons that go in the fourth shell.



DALTON'S ATOMIC THEORY (JOHN DALTON 1808)

1. *All elements are made of small indivisible particles called atom.*
2. *Atoms can neither be created nor destroyed.*
3. *Atoms of the same element are alike and differs from atoms of all other elements.*
4. *When atoms combine with other atoms, they do so in simple ratios.*
5. *All chemical changes result from the combination or the separation of atoms*.

MODIFICATION OF THE THEORY

1. *All elements are made up of small indivisible particles called atoms.*
   Modification—due to the discovery of protons, neutrons and electrons.
- ***Matter is made up of small particles called atoms are composed of protons, neutrons and electrons***.
2. *The atom can neither be created nor destroyed. During a nuclear fission of Uranium-235, some atoms were destroyed.* [This is true of chemical reactions]
   Modification—due to nuclear reactions.
- ***In nuclear reactions, atoms are of one element are converted into atoms of other elements***.
3. *The atoms of the element are alike in every aspect and differ from atoms all other elements.*
   Modification—due to the concept of isotopy.
- ***Atoms of the same element may have different masses***.
4. *When atoms combine with one another, they do so in small whole number ratio.* [This is not true of inorganic compounds and reactions].
   Modification—due to polymerization of molecules or organic compounds.

- ***When atoms combine with one another, they do so in small and in large whole number ratios.***

WEEK 5

PARTICULATE NATURE OF MATTER

- **Atomic/Proton number(Z).**
- **Mass number(A).**
- **Relative Atomic Mass(RAM): Definition and Calculations.**
- **Relative Molecular Mass(RMM): Definition and Calculations.**

Atomic/Proton number(Z): ***The atomic number, Z, of an element is the number of protons in one atom of that element.*** *It is equal to the number of electrons around the nucleus of the atom.*

Mass number/Nucleon number(A): ***The mass number, A, of an atom of an element is the sum of protons and neutrons in it.*** **Example:**

A = Z + N ---------- (1)

N= A−Z ----------(2)

Where **N** = number of neutrons, **Z** = Atomic number/Proton number and **A** = mass number/nucleon number.

Mass Number (A) →
Atomic number (Z)→ X ←Symbol of an atom of an element

Note the following:

1. *In a neutral atom, there is an equal number of protons and electrons.*
2. *If a neutral atom loses an electron(s), it becomes a positively charged ion or cation.*
3. *If a neutral atom gains an electron(s), it becomes a negatively charged ion or anion.*
4. *The net charge in a given ion shows the number of electrons lost or gained.*

Ion	Electron lost or gained
$^{23}_{11}Na^{+}$	(lost 1)
$^{27}_{13}Al^{3+}$	(lost 3)
$^{40}_{20}Ca^{2+}$	(lost 2)
$^{24}_{12}Mg^{2+}$	(lost 2)
$^{39}_{19}K^{+}$	(lost 1)
$^{16}_{8}O^{2-}$	(gained 2)

EXAMPLE 1

Calculate the number of protons, neutrons and electrons contained in the following atoms/ions:

1. $^{23}_{11}Na$
2. $^{27}_{13}Al^{3+}$
3. $^{27}_{13}Al$
4. $^{23}_{11}Na^{+}$

Solution:

1. $^{23}_{11}Na$, A=23, Z=11, N=A−Z= 23−11= 12 Neutrons, 11 Electrons and 11 Protons.
2. $^{27}_{13}Al^{3+}$ = A=27, Z=13, N=A−Z= 27−13= 14 Neutrons, 10 Electrons and 13 Protons.
3. $^{27}_{13}Al$ = A=27, Z=13, N=A−Z= 27−13= 14 Neutrons, 13 Electrons and 13 Protons.
4. $^{23}_{11}Na^{+}$ = A=23, Z=11, N=A−Z= 23−11= 12 Neutrons, 10 Electrons and 11 Protons.

ISOTOPES AND ISOTOPY

ISOTOPY: ***This is a phenomenon whereby atoms of an element exhibit different mass numbers but have the same atomic number.***

ISOTOPES: ***Isotopes are atoms of the same element with the same atomic number but different mass numbers.***

ELEMENTS AND THEIR ISOTOPES

Element	Isotopes
Hydrogen	$^{1}_{1}H$, $^{2}_{1}H$ and $^{3}_{1}H$
Oxygen	$^{16}_{8}O$, $^{17}_{8}O$ and $^{18}_{8}O$
Chlorine	$^{35}_{17}Cl$ and $^{37}_{17}Cl$
Copper	$^{63}_{29}Cu$ and $^{65}_{29}Cu$

CALCULATONS ON ISOTOPY

Example 1

The relative atomic mass of an element is 21.5. the two isotopes of the element are ${}^{20}_{10}X$ occurring 25% in nature and ${}^{x}_{10}X$ occurring 75% in nature. Calculate x.

Solution

Average Atomic Mass = $\frac{\sum \%\ \text{Abundance} \times \text{Mass number}}{100}$

$= \frac{25 \times 20}{100} + \frac{75 \times x}{100} = 21.5$

$= 5 + 0.75x = 21.5$

Collect like terms

$0.75x = 21.5 - 5 = 16.5$

Divide both sides by 0.75

$\frac{0.75x}{0.75} = \frac{16.5}{0.75} = 22$

SEE CHAPTER ONE (page 13) OF THE REVISED SECOND EDITION OF PRINCIPLES OF MODERN CHEMISTRY CALCULATIONS FOR FURTHER EXAMPLES AND STUDY QUESTIONS (page 17). KEEP SOLVING AND KEEP LEARNING.

RELATIVE ATOMIC MASS(RAM)

The relative atomic mass of an element is the number of times the average mass of that element is heavier than one-twelfth the mass of one atom of C-12. Relative atomic mass of elements is used to calculate the relative molecular mass of a compound. ***It has no unit***.

RELATIVE MOLECULAR MASS(RMM)

The relative molecular mass of an element or a compound is the number of times the average mass of one molecule of it is heavier than one-twelfth the mass of one atom of C-12. It has no unit.

CALCULATIONS ON THE RELATIVE MOLECULAR MASS(RMM)

Example 1

Calculate the Relative Molecular Mass of the following compounds:

1. $CaCO_3$

2. $Na_2CO_3.10H_2O$.

[Ca=40, C=12, H=12, O=16, Na=23]

Solution:

1. Ca + C + O_3 = 40 + 12 + (3 x 16) = 40 + 12 + 48 = 100 (No unit).
2. Na_2 + C + O_3. + $10H_2O$ = (23 x 2) + 12 + (3 x 16) + (10 x 18)
   = 46 + 12 + 48 + 180 = 286 (No unit).

SEE CHAPTER TWO (page 20) OF THE REVISED SECOND EDITION OF PRINCIPLES OF MODERN CHEMISTRY CALCULATIONS FOR FURTHER EXAMPLES AND STUDY QUESTIONS (page 29). KEEP SOLVING AND KEEP LEARNING.

CALCULATING THE PERCENTAGE BY MASS OF EACH ELEMENT IN A COMPOUND

1. Calcualte the percentage by mass of each element in the following compounds:
   (a). $CaCO_3$
   (b). $MgSO_4$
   [Ca=40, C=12, O=16, Mg=24]
   Solution:
   (a). Ca + C + O_3 = 40 + 12 + (3 x 16) = 40 + 12 + 48 = 100
   % by mass of Ca in $CaCO_3$ = $\frac{40}{100} \times \frac{100}{1}$ = 40%
   % by mass of C in $CaCO_3$ = $\frac{12}{100} \times \frac{100}{1}$ = 12%
   % by mass of O in $CaCO_3$ = $\frac{48}{100} \times \frac{100}{1}$ = 48%
   (b). Mg + S + O_4 = 24 + 32 + (4 x 16) = 24 + 32 + 64 = 120
   % by mass of Mg in $MgSO_4$ = $\frac{24}{120} \times \frac{100}{1}$ = 20%
   % by mass of S in $MgSO_4$ = $\frac{32}{120} \times \frac{100}{1}$ = 27%
   % by mass of O in $MgSO_4$ = $\frac{64}{120} \times \frac{100}{1}$ = 53%

SEE CHAPTER TWO (page 23) OF THE REVISED SECOND EDITION OF PRINCIPLES OF MODERN CHEMISTRY CALCULATIONS FOR FURTHER EXAMPLES AND STUDY QUESTIONS (page 29). KEEP SOLVING AND KEEP LEARNING.