**CHEMISTRY SS 1**

**FIRST TERM**

**SCHEME OF WORK**

**WEEKS TOPIC**S

1. INTRODUCTION TO CHEMISTRY
2. LABORATORY FAMILIARIZATION
3. NATURE OF MATTER
4. ELEMENTS & SYMBOLS, VALENCY
5. COMPOUNDS AND MIXTURES
6. STANDARD SEPARATION TECHNIQUES FOR MIXTURES
7. PARTICULATE NATURE OF MATTER
8. IUPAC NOMENCLATURE OF CHEMICAL COMPOUNDS
9. ATOMIC NUMBER, MASS NUMBER, ISOTOPES AND CALCULATIONS
10. STRUCTURE OF THE ATOM: ORBITALS AND ELECTRONICSTRUCTURE OF THE ATOM
11. REVISION
12. EXAMINATION

**WEEK ONE**

# TOPIC: INTRODUCTION TO CHEMISTRY

**CONTENT**

CHEMISTRY AS A SCIENCE SUBJECT

BRANCHES OF CHEMISTRY

SOME LABORATORY APPARATUSES AND THEIR USES

## CHEMISTRY AS A SCIENCE SUBJECT

Chemistry is the systematic study of matter, encompassing its nature, structure, composition, properties, and applications, as well as the transformations it undergoes. It is a science that relies on systematic experimentation and philosophical observation to accumulate and organize knowledge.

Branches of Chemistry

The field of chemistry is divided into three primary branches:

1. Physical Chemistry: This branch delves into the physical aspects of chemistry, exploring topics like quantum theory, heat, and electricity.

2. Organic Chemistry: Organic chemistry focuses on the study of carbon and its various compounds, which form the basis of life.

3. Inorganic Chemistry: Inorganic chemistry is concerned with the study of elements, their properties, and applications, excluding carbon compounds.

Scientific Methods of Discovery

Scientific discoveries are typically made through a systematic process that includes the following stages:

1. Observation: This initial step involves noting and identifying a phenomenon or issue.

2. Pattern: Observations may reveal patterns or regularities, which suggest the existence of a problem.

3. Problem: Once a pattern is identified, it signifies a problem that requires investigation.

4. Hypothesis: A hypothesis is a prediction or educated guess that aims to explain the observed problem.

5. Experiments: Experiments are conducted to test the validity of the hypothesis.

6. Theory: When a hypothesis is confirmed through testing and aligns with available evidence, it becomes a theory.

7. Law: A theory that has been extensively tested, proven correct without exceptions, and is accepted as a fundamental principle becomes a scientific law.

Evaluation

1. Define chemistry and elucidate its primary branches.

2. Identify and describe the stages involved in scientific discoveries.

3. Explain the conditions under which a theory evolves into a scientific law.

Applications of Chemistry

Chemistry plays a pivotal role in our daily lives, influencing various aspects of the environment, and our everyday activities. It impacts cooking, cleaning, digestion, pharmaceuticals, transportation, health care, housing, and clothing, among others.

Career Prospects in Chemistry

A background in chemistry opens the door to a multitude of career opportunities, both inside and outside the laboratory. Some career paths include:

1. Pharmaceutical and drug development

2. Science education

3. Chemical engineering

4. Mining and metallurgy

5. Pure and applied chemistry

6. Petroleum and petrochemical engineering

7. Quality control

8. Medicine and surgery

9. Chemical analysis and forensic science

10. Environmental chemistry

11. Science laboratory technology

12. Biochemistry

Evaluation

1. Enumerate five practical applications of chemistry in our daily lives.

2. Identify five adverse effects of chemicals and describe methods for their control.

General Evaluation

1. List ten potential career opportunities within the field of chemistry.

2. Provide a brief overview of the main branches of chemistry.

**WEEKEND ASSIGNMENT**

1. The aspect of chemistry that deals with the study of carbon and its compound is called (a) physical chemistry (b) Organic chemistry (c) Inorganic chemistry (d) Analytical chemistry
2. Which of the following is not an adverse effect of chemistry? (a) pollution (b) poisoning (c) emulsion (d) corrosion
3. A stage in scientific method of discoveries is (a) Evaporating (b) Hypothesis (c) Dehydrating (d) dissolving
4. A theory which has been extensively tested and proven correct without any exception becomes (a) scientific law (b) hypothesis (c) experiment (d) pattern
5. Career prospects in chemistry includes all the following **EXCEPT** (a) Biochemistry (b) Quality control (c) Accounting (d) Metallurgy

**THEORY**

1. State five applications of chemistry in our daily life
2. Mention five laboratory apparatus and their uses

**WEEK TWO**

# TOPIC: LABORATORY FAMILIARIZATION

**CONTENT**

DEFINITION OF LABORATORY

LABORATORY APPARATUS; MEANING, USES AND IDENTIFICATION

LABORATORY SAFETY RULES

## DEFINITION OF LABORATORY

A laboratory serves as a dedicated space designed for scientific experimentation and research. Within its walls, scientists employ various apparatus and equipment to explore the fascinating world of science.

Laboratory Apparatus

Laboratory apparatus comprises an array of tools and equipment used by scientists to conduct experiments and research. Commonly used apparatus includes:

1. Test Tube: Cylindrical glass tubes for holding and heating small quantities of liquids or substances.

2. Beaker: Graduated glass or plastic containers with a lip, used to measure or hold solutions.

3. Aspirator Bottle: Plastic or glass containers with screw caps, designed for storing distilled water.

4. Crucible: Porcelain containers with lids, capable of withstanding high temperatures; used for igniting substances.

5. Woulff's Bottle: Glass bottles used for holding liquids or solutions employed as drying agents or to absorb unwanted gases.

6. Conical Flask: Graduated flasks frequently used in titration experiments to estimate solution volumes.

7. Flat and Round Bottom Flasks: Glass flasks primarily used for boiling, especially during distillation.

8. Standard Volumetric Flask: Pear-shaped containers with narrow necks, ideal for preparing standard solutions of specific volumes.

9. Fume Cupboard: Wooden cupboards with movable glass fronts, employed to handle poisonous gases safely.

10. Distillation Flask: Glass flasks with slanting long side arms, used in distillation processes.

11. Bell Jar: Thick cylindrical glass containers with knobs at the top, used in combustion experiments.

12. Gas Jar: Tall, cylindrical glass containers sealed at the bottom, used for collecting gases over water or dry gas.

13. Dropping Bottle or Pipette: Used for dispensing solutions or reagents in precise drops.

14. Spatula: Spoon-like iron instrument for transferring small amounts of solids to test tubes.

15. Burette: Essential for titration experiments and transferring small solution volumes.

16. Retort Stand with Clamp: Provides support during experiments.

17. Desiccator: Used for storing and drying solids in a dry, dust-free atmosphere.

18. Measuring Cylinder: Designed for accurately measuring solution volumes.

19. Kipps Apparatus: Facilitates the intermittent supply of gases.

20. Wire Gauze: Provides support for flasks during heating processes.

21. Filter Funnel: Used to fill burettes and support filter paper during filtration.

22. Condenser (Liebig): Used to cool or condense vapors into liquids during distillation or refluxing.

23. Centrifuge: Utilized for separating fine solid particles from liquids.

24. Test Tube: These are employed for holding reactants during qualitative analyses.

25. Separating Funnel: Used to separate immiscible liquids.

Laboratory Safety Rules

1. Dress appropriately for the laboratory: Wear a lab coat, safety goggles, suitable footwear, and secure long hair to avoid accidents

2. Keep pathways clear by storing items like books and bags on shelves or beneath work tables.

3. Never taste or smell chemicals.

4. Do not attempt unauthorized experiments or procedures.

5. Pay close attention to any cautions mentioned in laboratory exercises.

6. Do not leave your designated laboratory station without the teacher's permission.

7. Do not lean on, hang over, or sit on laboratory tables.

8. Avoid horseplay or fooling around; it is strictly prohibited in the laboratory.

9. Familiarize yourself with the location of safety equipment such as fire extinguishers, eye wash stations, first-aid kits, and safety showers.

10. Report all accidents, injuries, and broken glass or equipment to your instructor.

11. Always follow the instructions provided by your teachers.

12. Eating and drinking are strictly prohibited in the laboratory.

13. Leave your work station clean and organized before departing from the laboratory.

General Evaluation

1. List ten crucial safety measures in a laboratory setting.

2. Enumerate the uses of: (a) Evaporating dish, (b) Pipette, (c) Retort stand, (d) Measuring cylinder, and (e) Conical flask.

**WEEKEND ASSIGNMENT**

1. An apparatus in the laboratory in which the preparation of poisonous gases is done is called (a) distillation tank (b) Aspirator bottle (c) fume cupboard (d) bell jar
2. In the laboratory \_\_\_\_\_\_\_ is used for the collection of a gas over water (a) gas jar (b) Woulff’s bottle (c) reagent bottle (d)burette
3. Two liquids which are immiscible with each other can be separated using (a) bell jar

(b) gas jar (c) wash bottle (d) separating funnel

1. An apparatus used to hold drying agents during the preparation of dry gases is (a) conical flask (b) gas jar (c) Woulff’s bottle (d) flat bottom flask
2. Coloured reagent bottles are used to store reagents which are capable of \_\_\_\_\_ easily by sunlight (a) evaporating (b) decomposing (c) dehydrating (d) dissolving

**THEORY**

1. a. Define Laboratory

b. List five safety measures that must be taken when in the laboratory

State the use of the following apparatuses

Separating funnel Condenser

**WEEK THREE**

**TOPIC: NATURE OF MATTER**

**CONTENT**

NATURE OF MATTER

COMPARISON BETWEEN SOLID, LIQUID AND GAS TYPES OF CHANGE

**NATURE OF MATTER**

Matter is anything that has weight and occupies space. It exists in three states namely: solid, liquid and gas.

The fundamental difference between the three states of matter depends on the degree of movement of the particles they are made of.

**SOLID STATE**

The particles of a solid are tightly packed and held together by a strong electrostatic force.

The particles only vibrate to and fro about an equilibrium or a fixed position. They have a definite shape and volume and very difficult to compress.

**LIQUID STATE**

The forces of attraction between molecules of liquids are weak compared to that of solids. Hence they have slight movements. This is why liquids can flow. They have definite volume but not definite shape.

**GASEOUS STATE**

As a result of the distance between the molecules of gases, the cohesive forces between them are very negligible and so they move randomly. Gases have no definite shape and volume. They assume the shape of the containing vessel.

**EVALUATION**

1. What is matter?
2. List and explain the three states of matter.

**COMPARISON BETWEEN SOLID, LIQUID AND GAS**

**SOLID LIQUID GAS**

1. Fixed mass Fixed mass Fixed mass
2. Very dense Less dense Least dense
3. Definite shape Shapeless Shapeless
4. Definite volume Definite volume No volume
5. Incompressible Incompressible Compressible
6. Particles vibrate Particles vibrate, Particles move and move about rotate and move about constantly a fixed position about a restricted space at a fixed speed.

**EVALUATION**

* 1. Define matter
  2. Compare the three states of matter in terms of (a) density (b) compressibility **TYPES OF CHANGES**

Whenever a given substance is heated, its state changes. There are two types of changes: physical and chemical.

**PHYSICAL CHANGE:**

A physical change is a change which is easily reversible and in which no new substances are formed. Examples are:

1. Dissolution of common salt
2. Changes in states of matter such as melting of solids, freezing of liquids, evaporation of liquids, liquefaction of gases to solids, sublimation of solids.
3. Magnetization and demagnetization of iron nails.
4. Separation of mixture by evaporation, distillation, fractional distillation etc.

**EVALUATION**

1. What is a physical change?
2. Give two examples of a physical change.

**CHEMICAL CHANGE:**

A chemical change is a change which is not easily reversible and in which new substances are formed.

Examples of chemical change

1. Rusting of iron/metals.
2. Dissolution of metals and limestone in acids.
3. Fermentation and decay of substances.
4. Changes in electrochemical cells.
5. The addition of water to quick lime.
6. Burning of materials.

**COMPARISON BETWEEN PHYSICAL AND CHEMICAL CHANGES**

**Physical Change Chemical Change**

1. Easy to reverse Difficult to reverse
2. No new substances are New substances are always

formed formed

1. Very little energy changes There are often large heat take place change.
2. No change in mass The new substances formed havedifferent masses but the total mass is unchanged.

**GENERAL EVALUATION/REVISION**

* 1. What is a chemical change?
  2. Give two examples of a chemical change.
  3. State three differences between physical and chemical changes.
  4. State the function of the following laboratory apparatuses: a) Fume cupboard b) Burette(c) Bunsen burner

**WEEKEND ASSIGNMENT**

* 1. Which of the following changes is a chemical change? (a) melting of ice (b) liquefaction of air (c) slaking of lime (d) evaporation of a liquid
  2. Which of the following substances will occupy a wider space? (a)carbon (iv) oxide (b) liquid milk (c) pieces of chalk (d) water
  3. When a solid changes to gas directly, this process is called (a) freezing (b) sublimation

(c) vaporization (d) evaporation

Which of the following changes produces a new substance ?(a) reaction of water with sodium chloride (b) addition of acid to base (c) turning of margarine to oil (d) evaporation of water

Which one of the following has a fixed shape and volume?

(a) a cube of sugar (b) liquid wax (c) smoke (d) kerosene

**THEORY**

* 1. Give two differences between physical and chemical changes.
  2. Give three processes, which involve a physical change

**WEEK FOUR**

**TOPIC: ELEMENTS, SYMBOLS & VALENCY**

**CONTENT**

ELEMENTS AND SYMBOLS

CLASSIFICATION OF ELEMENTS

VALENCY

**ELEMENTS AND SYMBOLS**

An element is a substance which cannot be split into simpler units by ordinary chemical process. There are over one hundred known elements.

**SYMBOLS OF ELEMENTS**

There are three ways in which symbols of elements are derived.

1. From the first letter of the name of the element

Element Symbols

Hydrogen H

Oxygen O

Iodine I

Fluorine F

Nitrogen N

Sulphur S

Carbon C

Phosphorus P

The first letter written in capital letter and one other letter from its name written in small letter.

Element Symbol

Chlorine Cl

Bramine Br

Calcium Ca

Aluminium Al

Magnesium Mg

Berylium Be

Helium He

Neon Ne

Lithium L

The symbols of some elements were derived from their Latin names.

Elements Latin name Symbols

Mercury Hydragyrium Hg

Sodium Natrium Na

Iron Ferrum Fe

Copper Cuprum Cu

Silver Argentum Ag

Tin Stannum Sn

Gold Aurum Au Potassium Kalium K

Lead Plumbum Pb

**EVALUATION**

1. How many elements are discovered now?
2. Write the symbols for the following elements: silicon, iodine, fluorine, sulphur, silver, Iron, copper, potassium and sodium.

**CLASSIFICATION OF ELEMENTS**

Elements can be classified into metals and non-metals.

Examples of metals include iron, zinc, tin, aluminium, copper etc.

Examples of non-metals are: Chlorine, oxygen, sulphur, fluorine, hydrogen etc.

Some elements however possess the properties of metals as well as non-metals. They are called metalloids, examples are silicon and germanium.

**THE DIFFERENCES BETWEEN METALS AND NON-METALS**

Metal Non – metals

1. They are solids (except mercury) They are solids, liquids and gases
2. Good conductors of heat Poor conductors of heat and electricityand electricity (except graphite which conduct electricity)
3. Malleable Brittle
4. Ductile Not ductile
5. Shiny Not shiny

Often very dense Usually less dense(low density)

(high density)

**EVALUATION**

* 1. What are metalloids?
  2. State two differences between metals and non-metals.

**VALENCY**

Valency is the combining power of an element. It can also be defined as the number of hydrogen atoms that can combine with or replace one atom of that element.

Valency of an element depends on the structure of that element. At times it corresponds to the number of electrons in the outermost shells called valence electrons.

Below are the valencies of some elements:

**Element Symbol Valency**

Aluminium Al +3

Argon Ar Nil

Calcium Ca +2

Chlorine Cl -1

Sulphur S -2, -4 or -6

Sodium Na +1

Magnesium Mg +2

Copper Cu +1 or +2

Carbon C -2 or -4

Barium Ba +2

Silver Ag +1

Iron Fe +2 or +3

Valencies have either positive or negative values showing whether electrons are gained or lost. If an element gains electrons, its value is negative but positive when it loses electrons.

Generally, metals exhibit positive valencies while non – metal tend to have negative valencies. Some element exhibit more than one valency. Valency can also be called oxidation number or state.

**RADICALS**

A radical is a group of atoms having an electric charge either positive or negative which keeps its identity and react as a single unit. Any small group of atoms carrying a negative charge is called an acid radical. Examples of acid radicals include S042-, C032-, N03– The valency of a radical corresponds to the charge it carries.

Radical Formula Valency

Ammonium NH4+ +1

Hydroxide 0H– -1 Trioxonitrate(V) N03– -1

Dioxonitrate(III) N02– -1 Trioxocarbonate(IV) C032-  -2

Tetraoxosulphate(VI) S042- -2

Hydrogen trioxocarbonate HC03– -1

**GENERAL EVALUATION/REVISION**

1. Define (i) valency (ii) Radical
2. Write the valency of: a) Oxygen (b) Potassium c) Sulphur d) S042- e) NH4+
3. Classify the following into physical or chemical changes: a) Rusting of iron b) Fermentation of palm wine c) Evaporation of a salt solution d) Melting of ice

**WEEKEND ASSIGNMENT**

1. The combining power of oxygen is (a)+2 (b)-2 (c)-1 (d)+1
2. Which of the following is a metalloid? (a) sulphur (b) iron (c) silicon (d) carbon
3. The symbol Au represents (a) silver (b) lead (c) copper (d) gold
4. Which of the following elements is used as a standard in defining valency?

(a) oxygen (b) copper (c) carbon (d) hydrogen

Which of the following metals is a liquid at room temperature?

iron (b) gold (c) tin (d) mercury

**THEORY**

1. a. Define an element.

Write the symbols of the following elements (i) Manganese (ii) Caesium (iii) Cobalt

1. a. What are metalloids?

Give two differences between metals and non-metal

**WEEK FIVE**

**TOPIC: COMPOUNDS AND MIXTURES**

**CONTENT**

COMPOUND

FORMULAE OF COMPOUNDS

MIXTURES

DIFFERENCES BETWEEN COMPOUNDS AND MIXTURES

**COMPOUND**

A Compound is a substance which contains two or more elements chemically combined together. A compound is formed as a result of chemical change.

Examples of compounds are

Compound Constituent Elements

Water Hydrogen, oxygen

Sand silicon, oxygen

Limestone calcium, carbon, oxygen

Common salt sodium, chlorine

Ethanol carbon, hydrogen, oxygen

**PROPERTIES OF A COMPOUND**

1. It has properties different from those of its component elements.
2. Its formation often requires large amount of heat.
3. It cannot be separated by physical means.
4. The components of a compound have a fixed ratio by mass.
5. Compounds are homogenous.

**EVALUATION**

1. Define a compound.
2. Give three examples of a compound.

**FORMULAE OF COMPOUNDS**

When an element exists as a molecule, a number is written as a subscript after the symbol of that element. For example, hydrogen is written as H2 and oxygen as 02.

A compound contains whole numbers of atoms of the component elements. Its molecular formula is written as follows.

1. The symbols of all the component elements are written close together as a group.
2. The number of atoms of each component element is written as a subscript after the symbol of that element.

Examples

**Compound Formula**

Hydrochloric acid HCl

Water H20

Ammonia NH3

Carbon(IV)oxide C02

Lead II chloride PbCl2

Calcium trioxonitrate(V) Ca(NO3)2

**WRITING FORMULA FROM VALENCIES**

Formulae of compounds can be deduced from the valencies of the component elements or radicals, following the rules below.

1. Write the symbols of the element or radicals in a compound
2. Write their valencies below the symbols of elements/radicals
3. Exchange their valencies.
4. Now write the formula of the compound bringing the symbols of the element or radicals together

**Examples**

1. Write the formula of sodium tetraoxosulphate(VI)

Rule 1 Na S04

Rule 2 & 3 1 2

Rule 4 Na2S04

Write the formula of calcium chloride

Rule 1 Ca Cl

Rule 2 & 3 2 1

Rule 4 CaCl2

**EVALUATION**

1. Write the formulae of; (i) tetraoxosulphate(vi) acid (ii) Magnesium Chloride
2. State three properties of a compound

**MIXTURES**

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

Examples of mixtures with their constituents are outlined below:

Mixture Constituents

Air Oxygen, Carbon (iv)oxide, nitrogen, rare gases, dust, moisture

Soil Sand, clay, humus, water, air, mineral salts

Urine urea, water, mineral salt

Palm wine water, sugar, alkanol, mineral salts, vitamins, yeast, protein, fat

Coca-cola water, sugar, cola, CO2

Milk water, sugar, fat, protein, mineral salts, vitamin

Sea water water, mineral salts, bacteria, remains of organic matter

Brass copper and zinc

**DIFFERENCES BETWEEN MIXTURES AND COMPOUNDS**

Mixture Compound

1. It may be homogenous It is always homogenous.

or heterogeneous.

1. It can be separated into It cannot be separated into its its constituents by physical components by physical means. means
2. The constituents can be The components are present in a added in any ratio by mass fixed ratio by mass. Hence a Hence a mixture cannot be compound can always be repre represented by a chemical sented by a chemical formula.

Formula.

1. The properties of a mixture The properties of a compound are the sum of those of its are entirely different from those individual constituents. of its components.

**EVALUATION**

* 1. List five (5) compounds and their formulae
  2. What is a mixture?
  3. State four differences between compound and mixture

**GENERAL EVALUATION/REVISION**

* 1. State the valency of the following elements and radicals: Na, K, S, O, SO42-, NO3–,

CO32-

* 1. Write the formula of: a) Lead (ii) tetraoxosulphate (vi) b) Hydrochloric acid c) Sodium trioxocarbonate (iv) d) Calcium hydroxide

**WEEKEND ASSIGNMENT**

* 1. Which of the following is a mixture? (a) water(b) sugar(c) milk (d) starch
  2. Which of the following is a compound? (a) water (b) soil (c) diamond (d) graphite
  3. Which of these formulae represents ammonia? (a) NH3 (b) NH4+ (c) NH2 (d) CH4
  4. The formula for sand is (a) C02 (b) SO2 (c) NO2 (d) SiO2
  5. Compounds are always (a) heterogeneous (b) homogeneous (c) homogeneous or heterogeneous (d) chemogeneous

**THEORY**

1. a. Define (i) Compound (ii) Mixture

b. Give two examples each of compound and Mixtures 2. a. State four differences between compound and mixture

b. What is the formula of

i) tetraoxosulphate (vi) acid ii) Ammonium sulphide iii) Sodium tetraoxophosphate

**WEEK SIX**

TOPIC: STANDARD SEPARATION TECHNIQUES

**CONTENT**

STANDARD SEPARATION TECHNIQUES

**STANDARD SEPARATION TECHNIQUES**

The importance of separating a mixture into its constituents cannot be over emphasized since most substances are needed in their pure form. There are many standard separation techniques. Some of these separating techniques are filtration, centrifugation and decantation. Others include sieving, magnetic separation and sublimation, evaporation, crystallization, fractional precipitation, distillation, fractional distillation, using separating funnel and chromatography.

**FILTRATION**

Filtration is a separation technique that involves separating an insoluble solid from liquid using a filter. For example, a mixture of chalk particles in water can be separated using filtration technique. Filtration is used in industries such as water purification plants and breweries.

**CENTRIFUGATION**

**A CENTRIFUGE MACHINE**

Centrifugation is a standard separation technique used to separate a mixture of insoluble solid from liquid by using a centrifuge. A centrifuge is a machine which can spin test tubes containing suspensions at high speed. Centrifugation is often used when there is only a small amount of material. In hospitals, blood samples are centrifuged to separate the blood cells from the plasma.

**DECANTATION**

Decantation is a separation technique used to separate a mixture containing insoluble solid from a liquid. This is done when the mixture is allowed to settle down with the upper clear liquid carefully poured or decanted into a clean container thereby leaving the lower solid in the container originally containing the mixture. This is a quick but inaccurate method of separating the components of a mixture.

**EVAPORATION**

Evaporation is a separation technique used to recover soluble solute from its solvent. For example salt can be separated from salt solution by evaporation.

**A Salt Evaporation Pond**

Salt is produced in the San Francisco area mainly by solar evaporation, where seawater is fed into large ponds that are gradually evaporated by the sun and the wind. After the water is evaporated, the salt is collected.

Evaporation is used in salt –making industries.

**CRYSTALLIZATION**

Crystallization is used to obtain pure crystals of salts which decompose easily on heating from its solution. The solution is concentrated by heating. It is allowed to cool down and crystals start to form. To induce crystal formation:

add crystals of the salt (seedling)

scratch the inside of the container with a glass rod

Crystallization is used in industries where purity of the product is important, such as in drug industries and sugar industries.

**FRACTIONAL CRYSTALLIZATION**

It is used to separate two or more solutes (solids) which are present in the same solution. The solutes to be separated must have different solubilities at different temperatures. Starting from a particular temperature, as cooling of the solution of those solutes takes place, the crystals of the relevant solutes appear leaving the other solutes in the solution.

**EVALUATION**

1. Explain briefly the following methods of separation of mixtures: (a) Filtration (b) Decantation (c) Centrifugation
2. Explain how a pure sample of copper (II) tetraoxosulphate (VI) crystals can be obtained from its solution in the laboratory.

How would you separate a mixture of PbCl2 and NaCl

**PRECIPITATION**

In precipitation, a difference in the solubility of a solid in two different miscible liquids is used. For example, FeS04 is soluble in water but not on ethanol. If ethanol is added to a solution of FeS04 in water, the FeS04 will be precipitated out of the solution and filtered out.

**SUBLIMATION**

Sublimation is the change of state from solid to gas directly on application of heat. Examples of substances that sublime are iodine and ammonium chloride. Sublimation can be used to separate these substances. The pure crystal recovered is the sublimate.

**DISTILLATION**

This is used to recover a solvent from a solution. It involves vapourising a liquid and then condensing the vapour into a liquid called distillate. The solute and other impurities remain in the distillation flask. It is used in gin and water distilleries to manufacture gin and distilled water.

**FRACTIONAL DISTILLATION**

This is used to separate a mixture of two or more miscible liquids based on their boiling points. When two liquids have boiling points that are very close (less than 100oC the use of simple distillation becomes difficult. A fractionating column is inserted into the distillation flask. It is used to separate crude oil into fractions, separation of liquid air into oxygen and nitrogen, manufacture of spirits and to separate benzene and methyl benzene mixture.

**EVALUATION**

1. State the major difference between distillation and fractional distillation in terms of (a)

Features of the apparatus (b) Mixtures to be separated

1. Explain the following separation techniques

Precipitation Sublimation

**SEPARATING FUNNEL**

This is used to separate immiscible liquids. It depends on the densities of the two liquids. The less dense will be on top and the denser below. It is used to separate water and kerosene **SIEVING**

This is used to separate solid particles of different sizes. Particles smaller than the size of the sieve (mesh) pass through leaving behind particles of larger sizes. It is used in gold and diamond mines and in garri industries.

**MAGNETIC SEPARATION**

This is used to separate magnetic substances from non-magnetic particles. It is used in mining and steel industries. It can be used to remove magnetic impurities from tin ores. It can be used to separate iron filings from sulphur powder.

**CHROMATOGRAPHY**

This method uses a solvent moving over an adsorbent medium (paper) which is porous to separate mixtures of solutes.

A chemist uses liquid chromatography to analyze a complex mixture of substances. The chromatograph utilizes an adsorptive medium, which when placed in contact with a sample, adsorbs the various constituents of the sample at different rates. In this manner, the components of a mixture are separated. Chromatography has many valuable applications, such as determining the level of pollutants in air, analyzing drugs, and testing blood and urine samples.

**Types**

1. Paper chromatography
2. Thin layer chromatography
3. Gas chromatography
4. Column chromatography

In paper chromatography, a solution, such as ink, is spotted into the paper near one end. The paper is dipped into an appropriate solvent such as water or ethanol in a closed airtight jar. The solvent moves up the paper. The paper is removed and dried. The different spots on the paper show the different substances the solution (ink or dye) contains.

It is used in medicine to analyze blood. In industry, it is used to identify petroleum fractions. It is also used in scientific research.

**CRITERIA FOR PURITY**

1. The melting point and boiling point of a pure substance are fixed but change in the presence of impurities. Impurities lower the melting point of a substance and increase its boiling point
2. A pure substance gives one spot on a paper chromatogram.

**GENERAL EVALUATION**

1. Explain the following separation techniques. Magnetic separation, paper chromatography and sieving
2. Describe how you would separate a mixture of NaCl, PbCl2 and NH4Cl

What method can be applied to separate a mixture of iron filings and sulphur

4. Mention two criteria for purity of a substance.

**WEEKEND ASSIGNMENT**

1. A mixture of oil and water can be separated by (a) sublimation (b) evaporation to dryness

1. using a separating funnel (d) fractional distillation

Fractional distillation is used to separate (a) an insoluble substance from a soluble volatile substance (b) liquids with differing boiling points (c) gas, liquid or solid impurities from a mixture (d) liquid with close boiling points

Which of the following separating techniques can be used to separate a mixture of iodine and sodium chloride? (a) distillation (b) evaporation (c) sublimation (d) decantation

Which of the following is not a type of chromatography ?(a) thin layer (b) gas (c) paper

1. glass

Which of the following is a quick but inaccurate way of separating mixture? (a) decantation (b) evaporation (c) filtration (d) distillation

**THEORY**

* 1. Explain briefly the following separation techniques (a) evaporation (b) filtration (c) fractional distillation
  2. Mention two criteria for purity of a substance.

**WEEK SEVEN**

**TOPIC: PARTICULATE NATURE OF MATTER**

**CONTENT**

ATOMS AND MOLECULES

IONS

DALTON’S ATOMIC THEORY

MODIFICATIONS OF DALTONS ATOMIC THEORY

**ATOMS AND MOLECULES**

Matter is made up of discrete particles. The main ones are atoms, molecules, and ions.

An atom is the smallest part of an element which can take part in a chemical reaction.

A molecule is the smallest particle of a substance that can exist alone and still retains the chemical properties of that substance. Molecules are made up of atoms.

Atomicity of an element is the number of atoms in one molecule of the element.

We have monatomic, diatomic and triatomic for those elements that contain one atom, two atoms and three atoms respectively in their molecules.

**Examples:**

**Element Atomicity** Hydrogen Diatomic

Oxygen Diatomic

Nitrogen Diatomic

Neon Monoatomic

Helium Monoatomic

Argon Monoatomic

**EVALUATION**

1. Define an atom.
2. Give two examples of diatomic molecules.

**IONS**

An ion is an atom or group of atoms which carries an electric charge. Such groups of atoms that carry either a positive or negative charge are called RADICALS.

An acid radical is thus a small group of atoms carrying a negative charge that keeps its identity. Examples include S042-, N03– e.t.c.

Generally ions are grouped as cations and anions. Cations are positively charged ions e.g Ca2+, Na+, NH4+ e.t.c.

Anions are negatively charged ions e.g.. C032-, S042-, Cl–, OH–, etc.

**EVALUATION**

1. What are ions?
2. State the cation and anion present in (I) H2S04 (ii) NaCl (iii) FeS04

**DALTON’S ATOMIC THEORY**

John Dalton, British Physicist and Chemist (1808) proposed the atomic theory thus:

1. All elements are made up of small indivisible particles called atoms.
2. Atoms can neither be created nor destroyed in any chemical reaction.

Atoms of the same elements are exactly alike in aspect and are different from atoms of all other elements.

1. Atoms of different elements can combine in simple whole number ratios to form compounds.
2. All chemical changes result from the combination or separation of atoms

**MODIFICATIONS OF DALTON’S ATOMIC THEORY**

Due to new discoveries in the twentieth century, Dalton’s atomic theory cannot hold in its entirety. There is need for its modification.

1. The first statement has been proved wrong by Rutherford’s discovery of protons, electron and neutrons as constituents of the atom. An atom is not an indivisible solid piece.
2. The second statement still holds good for ordinary chemical reactions. During nuclear reactions, however, the nucleus can be broken into simpler atoms giving out large amount of heat (nuclear fission). This destroys the atoms involved.
3. The discovery of isotopes makes the third statement unacceptable. Chlorine for example has two atoms with different nucleus content and hence different relative atomic masses although the same proton numbers.
4. The fourth statement is true only for inorganic compounds which contain a few atoms per molecule. Carbon forms very large organic molecules such as proteins, starch and fats which contain thousands of atoms.

**GENERAL EVALUATION/REVISION**

1. State the modifications of the Dalton’s atomic theory.
2. A mixture contains propanone, ethanol and water with boiling point of 560C, 780C and 1000C respectively.
3. What method will be used to separate the liquids
4. Name the first liquid that will distil over. Explain your answer
5. Name an industrial process that uses fractional distillation

**WEEKEND ASSIGNMENT**

1. Which of the following is not a constituent of the atom (a) proton (b) electron (c) neutron

(d) isotope

Which of the following statement about an atom is not correct? (a) it is indivisible (b) it is destructible in some cases (c) it is the smallest part of a substance that takes part in a reaction (d) it is made up of protons, neutrons and electrons

Which of the following is a liquid at room temperature? (a) copper (b) gold (c) mercury

(d) silver

How can you separate a mixture of iron filings and sulphur powder? (a) distillation

(b) chromatography (c) magnetization (d) evaporation

What is the atomicity of neon? (a) monoatomic (b) diatomic (c) triatomic (d) polyatomic

**THEORY**

1. Give any two postulates of the Dalton’s atomic theory.
2. (a) Differentiate an atom from a molecule.

(b) How will an atom become an ion?

WEEK EIGHT

IUPAC NOMENCLATURE OF CHEMICAL COMPOUNDS

CONTENT

**Naming of:**

**—- binary compounds**

**—- radials and compounds having elements with variable oxidation numbers.**

**—- tertiary and quartenary compounds.**

**—- compounds with cations replaced with hydrogen.**

**NAMING OF BINARY COMPOUNDS**

Nomenclature: This is the system of naming chemical compounds. The system is called IUPAC (International union of pure and applied chemistry). The naming is determined by the constituent elements in the compound and the oxidation number if necessary.

In naming binary compounds (compounds with only two elements), electropositive elements (cations) are usually named first while the electronegative elements (anions) come last with a modification of the name end with – ide.

Examples:

Formula IUPAC name

MgO Magnesium oxide

H2S Hydrogen sulphide

NH4Cl Ammonium chloride

NaH Sodium hydride

But in cases where the two elements involved are non-metals, the above rule is not followed. For example, H2O (water) NH3 (ammonia) and PH3 (phosphine)

**EVALUATION**

Name the following compounds: (a) NaCl (b) CaO (c) H2O2.

NAMING OF RADICALS AND COMPOUNDS HAVING ELEMENTS WITH VARIABLE

OXIDATION NUMERS

Radicals (group of atoms of element carrying electrical charge) are treated as a single element when naming their compounds.

Examples of radicals with their names are as follows:

Radical IUPAC NAME

NH4+ Ammonium ion

OH‑ Hydroxyl ion

But in naming acid radicals, the oxidation number of elements is indicated by Roman numbers in bracket.

Example:

Formula IUPAC

NO2‑ Dioxonitratei(iii) ion NO3– Trioxonitrate(v) ion

CO32- Trioxocarbonate(iv) ion.

Also the compounds having elements with Roman numbers in bracket indicating their oxidation numbers in that compound

Examples

Formula IUPAC

FeO Iron (ii) oxide

Cu2O Copper (i) oxide

MgCO3  Magnesium trioxocarbonate (iv)

**EVALUATION**

1. Name the following compounds (a) Fe2O3 (b) CuO

1. What are the oxidation numbers of Fe and Cu in (1) above?

**NAMING TERTIARY COMPOUNDS AND QUARTENARY COMPOUNDS**.

These are compounds containing more than two elements.

Examples are oxo-acids, normal salts, and acid salts.

Acid IUPAC

HNO3  Trioxonitrate(v) acid

H2SO4  Tetraoxosulphate (vi) acid

H3PO4 Tetraoxophospate (v) acid

**Examples of Normal Salts.**

Normal salts IUPAC

KNO3 Potassium trioxonitrate (iv)

NaSO4  Sodiumtetraoxosulphate (vi)

CuCO3 Copper (ii) trioxocarbonate (iv)

**EVALUATION**

1. Determine the oxidation number of: a) C in H2CO3 b) Mn in KMnO4 c) Cu in CuSO4 2. Name the compounds in 1 above

NAMING OF COMPOUNDS WHOSE CATIONS HAS BEEN PARTIALLY REPLACED WITH HYDROGEN IONS.

In naming compounds whose cations have been partially replaced with hydrogen ion, the cations is named first followed by hydrogen, then the radicals present indicating the roman number standing for the oxidation number of the element that is combined with oxygen to form the radical.

E.g Formula IUPAC

NaHSO4 Sodium hydrogen tetraoxosulphate (vi)

KHSO3 Potassium hydrogen trioxosulphate (iv)

**GENERAL EVALUATION/REVISION:**

1. Determine the following oxidation number of a) C in LiHCO3 b) S in KHSO4 and name the compounds
2. Write the chemical formula of the following compounds a) Oxochlorate (I) acid b) Iron (ii) tetraoxosulphate (VI) pentahydrate
3. State the uses of the following laboratory apparatuses a) Condenser b) Kipp’s apparatus c)Tripod stand

**WEEKEND ASSIGNMENT**

1. The compound Na2S is called \_\_\_\_ (a) Sodium (ii) sulphate (b) Sodium sulphur (c) Sodium sulphide (d) Sodium sulphite.
2. The formula of sulphur (iv) oxide is (a) SO4 (b) SO2 (c) S2O4 (d) S4O2
3. Ammonium chloride can be written as (a) NH4Cl (b) NH3Cl2 (c) NH4HCl

(d) NH4OH

1. The IUPAC name of NaHSO4 is (a) Sodium bicarbonate (b) Sodium tetraoxosulphate (vi) acid (c) Sodium sulphate (c) Sodium hydrogen tetraoxosulphate (vi)
2. Which of the following compounds have cation with variable oxidation state. (a) FeO3 (b) ZnCO3 (c) CuO (d) KU

**THEORY**

1. Name the following compounds (a) Fe2O3 (b) KMnO4 (c) KClO3
2. Calculate the oxidation number of (a) Sulphur in H2SO4 (b) Carbon in CuCO3

**WEEK NINE**

**ATOMIC NUMBER, RELATIVE ATOMIC MASSES, ISOTOPES AND CALCULATIONS**

**CONTENT**

ATOMIC NUMBER AND MASS NUMBER

ISOTOPES

CALCULATIONS OF RELATIVE ATOMIC MASS

**CONSTITUENTS OF AN ATOM**

Atoms are made up of sub-particles. Protons, electrons and neutrons. Proton has a positive charge, electron has a negative charge and neutron has no charge.

**Atomic number and mass number**

The atomic number of an element is the number of protons in the nucleus of its atom.

Mass number or atomic mass of an element is the sum of the number of protons and neutrons in the nucleus of its atom.

Mass Number = Number of proton + Number of neutron

An element X can be represented as

ZXA

where A= Atomic mass or mass number

Z= Atomic number

e.g. 40 mass no = 40

Ca

atomic no = 20

**EVALUATION**

1. State the constituents of an atom.
2. What is the number of proton in the following elements?

(a) 11B (b) 12C

6

**ISOTOPES**

Isotopy is the occurrence of atoms of elements having the same atomic number but different mass numbers. This is due to the difference in the number of neutrons present in the atoms. The atoms that exhibit isotopy are called ISOTOPES.

Examples of atoms that exhibit isotopy are chlorine 35Cl and 37 Cl

Carbon- 12 C, 13 C and 14 C

Potassium – 39K19  and 41K19

Oxygen – 16O16  and 18O16

**EVALUATION**

1. Define isotopy.
2. Write the isotopes of chlorine.

**CALCULATION OF RELATIVE ATOMIC MASS**

The following is an example of calculation of relative atomic mass of an element from percentage abundance of its isotopes.

1. X is an element which exists as an isotopic mixture containing 90% of 39X19 and 10% of 41X19

* + 1. How many neutrons are present in the isotope

41X

* + 1. Calculate the mean relative atomic mass of X

Solution

* + 1. Neutrons in 41X19

= 41-19 = 22

* + 1. R.A.M = 90 x 39 + 10 x 41

1. 100

= 90 x 39 + 41 x 10

100

= 3920 = 39.20

100

**EVALUATION**

* + 1. How many neutrons are present in the isotope 37Cl17 ?
    2. A given quantity of chlorine contains 75% 35Cl17, and 25% 37Cl17, determine the relative atomic mass of chlorine.

**CALCULATIONS**

* + 1. The following are more examples of calculations of relative atomic masses of elements.
    2. An element Y exist in two isotopic forms 39Y18 and 40Y18 in the ratio 3:2 respectively.

What is the relative atomic mass of the element?

**SOLUTION**

R.A.M of Y = 3 x 39 + 2 x 40 5 1 5 1

= 0.6 x 39 + 0.4 x 40

= 23.4 + 16

= 39.4

An element with relative atomic mass 16.2 contains two isotopes 16P8 with relative abundance 90% and mP8 with relative abundance 10%. What is the value of m?

**SOLUTION**

16.2 = 90 x 16 + 10 x m

100

16.2 = 9 x 16 + m

10 10

16.2 = 144 + m

10 10

16.2 = 144 + m

10

16.2 x 10 = 144 + m

162 = 144 + m

162 – 144 = m

18 = m

The value of m is 18

**GENERAL EVALUATION/REVISION**

1. Consider the atoms represented below:

q rX

X

p p

1. State the relationship between the two atoms.
2. What is the difference between them?
3. Give two examples of other elements which exhibit the phenomenon illustrated.
4. State the number of electrons, protons and neutrons present in the following atoms/ions
5. Ca b) S2- c) Al3+ d) P
6. If an element R has isotopes 60% 12R6 and 40% xR6 and the relative atomic mass

of R is 12.4, find x.

**WEEKEND ASSIGNMENT**

1. The atomic number of an element is precisely

(a) the number of protons in the atom (b) the number of electrons in the atom (c) the number of neutrons in the atom

An atom can be defined more accurately as (a) the smallest indivisible parts of an element that can take part in a chemical reaction (b) the smallest part of an element that can take part in a chemical reaction (c) a combination of protons, neutrons The mass number is (a) proton number + neutron number (b) electron number + proton number (c) neutron number + electron number

Calculate the relative atomic mass of an element having two isotopes 107 Ag and

109Ag in the ratio 1:1 (a)106 (b)107 (c)108

An element X has two isotopes 18.8X and 15.8X in the proportion of 1:9 respectively. Find the relative atomic mass of X (a)16.1 (b)13.6 (c)16.8

**THEORY**

1. (a) Define the term isotopy.

(b) Determine the number of electrons, protons and neutrons in each of the following:

39K19, 63.5Cu29

2. If an element R has isotopes 60% of 12R6 and 40%  xR6 and the relative atomic mass is 12.4, find x.

WEEK TEN

**TOPIC: STRUCTURE OF THE ATOM**

**CONTENT**

Orbitals of The Atom

Electronic Structure Of the Atom

Filling Of Electrons in to Orbitals

Quantum Numbers

**ORBITALS OF THE ATOM**

The region in space within which there is maximum possibility of finding an electron in an atom is called an ATOMIC ORBITAL. We have s, p, d, and f orbitals.

Shapes of s and p orbitals are as follows

**: s-orbital**

**px orbital**

**py orbital pz orbital**

**EVALUATION**

1. Define atomic orbital

1. State the shape of (i) S-orbital (ii) P-orbital.

**ELECTRONIC STRUCTURE OF THE ATOM**

With the knowledge of atomic orbital the spectra of more complex atoms than hydrogen atom can be explained as follows:

a) that within a given principal quantum number or energy level, there are sub energy levels, i.e. energy levels otherwise called K,L,M,N,O,P AND Q shells have sub-energy levels otherwise called s,p,d and f orbitals

(b) The total number of sub-shells within a shell is given by n2

while the total maximum number of electrons is given by 2n2 where n is the number of enregy level.

Energy Level Number of orbitals Maximum No of electrons

n = 1(K- shell) 12 =1 2´12 =2

n =2 (L- shell) 22 = 4 2´22 = 8  n = 3 (M- shell) 32 = 9 2´32 = 18 n = 4 (N- shell) 42 =16 2´ 42 = 32 n = 5 (O- shell) 52 = 25 2´ 52 =50 n = 6 (P-shell) 62 = 36 2´62 =72 n = 7 (Q – shell) 72 = 49 2´72 = 98

1. In a given orbital there could be a maximum of only two electrons and electron in allorbitals of the same type within a principal quantum number possess equal energies.
2. The electrons in the different sub- shells or orbitals within a principal quantum numberdo not all have equal energies.

The gradation of energies of orbitals is as follows:

1s< 2s<2p<3s<3p<3d<4s<4p<4d—

**EVALUATION**

* 1. State the first five energy levels.
  2. Calculate the total no of electrons when n is equal to (i) 2 (ii) 4.

**FILLING OF ELECTRONS IN ORBITALS**

In filling electrons into the atoms of elements, considerations are given to the conditions laid down by Aufbau Principle, Pauli exclusion principle and Hund’s rule of maximum multiplicity.

AUFBAU PRINCIPLE states that electrons go in to fill orbitals of lower energy first before filling orbitals of higher energy and each orbital may hold up to two electrons.

PAULI EXCLUSION PRINCIPLE states that no two electrons have identical sets of the four quantum numbers {n, l, m and s in an atom}.

HUND’S RULE OF MAXIMUM MULTIPLICITY state that in filling degenerate orbitals with electrons, electrons go in singly first before pairing up occurs.

**EVALUATION**

State the following principle

{a} Aufbau Principle {b} Hund’s rule.

**QUANTUM NUMBERS**

Studies show that the energy of an electron may be characterized by four quantum numbers. These are

{1}The principal quantum number represented by n with integral values of 1,2,3,4 e.t.c. {2}The subsidiary or Azimuthal quantum number represented by l with integral values ranging from O to (n-1).

(3) The magnetic quantum number represented by m with integral values ranging

from –l to +l.

4. The spin quantum number represented by s with integral values – 1/2 and = 1/2.

**Element Atomic Number Electronic configuration.**

H 1 1S1 He 2 1S2

Li 3 1S2 2S1

Be 4 1S2 2S2

1. 5 1S2 2S2 2P1
2. 6 1S2 2S2 2P2
3. 7 1S2 2S2 2P3
4. 8 1S2 2S2 2P4

F 9 1S2 2S2 2P5

Ne 10 1S2 2S2 2P6

Na 11 1S2 2S2 2P6 3S1

Mg 12 1S2 2S2 2P6 3S2

Al 13 1S2 2S2 2P6 3S2 3P1

Si 14 1S2 2S2 2P6 3S2 3P2

P 15 1S2 2S2 2P63S233P3 S 16 1S2 2S2 2P63S2 3P4

Cl 17 1S2 2S2 2P6 3S2 3P5

Ar 18 1S2 2S2 2P6 3S23P6

K 19 1S2 2S2 2P6 3S23P6 4S1

Ca 20 1S2 2S2 2P6 3S23P6 4S2

**GENERAL EVALUATION**

1. State the four quantum numbers.
2. Write the electronic configuration of the following a) Mg b) S2- c) Ca2+ d) Si

**WEEKEND ASSIGNMENT**

1. Which of the following orbitals is spherical in shape?

s (b) p (c) d (d) f

1. Which of the following shells have a maximum of eight electrons ?

k (b) l (c) m (d) n

1. 1s2 2s2 2p6 3p1 is the electronic configuration of potassium (b) calcium (c) sodium (d) aluminum.
2. “No two electrons have identical sets of four quantum numbers”. This statement is

Aufbau principle (b) Pauli exclusion (c) Hund’s rule (d) Rutherford’s model.

1. Which of the quantum number is represented by L?

principal quantum no (b) subsidiary quantum no (c) magnetic quantum

(d) spin quantum.

**THEORY**

1. State the following principle (a) Pauli exclusion principle. (b) Aufbau principle.
2. Write the electronic configuration of
3. Oxygen
4. Calcium (c) Chloride ion (Cl–) (d) Aluminum ion (Al3+)