INTRODUCTION



CHEMISTRY

- **Chemistry:** is one of the three main branches of pure science, the other being biology and physics. Chemistry deals with the composition, properties and use of matter. It probes into the principles governing the changes that matter undergoes.
- **Uses of Chemistry:**
  - Food
  - Clothing
  - Military and Space Science
  - Medicine etc.

NATURE OF MATTER SEPARATION TECHNIQUES

MATTER

- **Matter: is anything that has mass and occupies space.**
- **Properties of Matter:** substances can be identified by the characteristics they possess. These characteristics are called *properties.*
  - **Physical properties:** are properties associated with physical changes. Common physical properties of substance include its boiling point, melting point, hardness, density etc. as well as properties which may be detected by the senses such as color, odor, and taste.
  - **Chemical properties:** are those properties which are involved when matter undergoes a change to form new substances. The rusting of iron is a chemical property of iron since a new substance, iron rust, is formed.
  - **Physical changes:** is one which is easily reversed and in which no new substance is formed. Example; melting of solids to liquids, freezing of liquid to solids, vaporization of liquids to gases.
  - **Chemical changes:** is one which is not easily reversed and in which new substances are formed. Example; burning of firewood, rusting of iron, fermentation and decay of substances etc.

Elements, Compound, and Mixture

- **Element:** an element is a substance which cannot be split into simpler units by an ordinary chemical process.
  - Elements are classified as metals, metalloids and non–metals.
  - Metals are those elements, which ionize by electron loss, example; *Calcium, Magnesium, Iron* etc.
  - Non–Metals are those elements which ionize by electron gain, example; *Chlorine, Oxygen, Nitrogen, Iodine* etc.
- **Compound:** is a substance which contains two or more elements chemically combined together. A compound is formed as a result of a chemical change. It is a new substance with entirely different properties from those of
  - The substance from which it was formed or its component elements.
  - Its component elements.
- **Mixture:** a mixture contains two or more constituents which can easily be separated by physical methods. The constituents of mixture can be elements or compounds, or both.

SEPARATION TECHNIQUES

- A mixture contains two or more different substances. Each constituent of a mixture still retains its individual properties. We can take advantage of this characteristic to separate mixture. Thus, the techniques employed in separating mixtures make use of the physical properties of their constituents.
- **Separation techniques** are methods used to separate mixtures into their individual components based on their physical or chemical properties. These techniques are essential in both laboratories and industries. Below is an overview of common separation techniques:

- **Sieving**
  - **Description**: Used to separate particles of different sizes.
  - **Process**: A sieve (mesh) with specific-sized holes allows smaller particles to pass through while retaining larger ones.
  - **Example**: Separation of sand and gravel.
- **Magnetic Separation**
  - **Description**: Used to separate magnetic materials from non-magnetic materials.
  - **Process**: A magnet is used to attract magnetic substances like iron filings, leaving non-magnetic components behind.
  - **Example**: Separating iron from a mixture of iron and sulfur.
- **Sublimation**
  - **Description**: Separates substances that sublime (change from solid to gas without becoming liquid) from those that do not.
  - **Process**: Heat the mixture; the sublimable component turns into vapor, which can be condensed back into a solid.
  - **Example**: Separation of iodine or ammonium chloride from a mixture.

- **Decantation**
  - **Description**: Used to separate a liquid from a solid or two immiscible liquids.
  - **Process**: The liquid is carefully poured off, leaving the sediment or denser liquid behind.
  - **Example**: Separating sand from water.

- **Filtration**
  - **Description**: Separates insoluble solids from liquids.
  - **Process**: The mixture is passed through a filter paper, which traps the solid (residue) while the liquid (filtrate) passes through.
  - **Example**: Separation of chalk powder from water.
- **Centrifugation**
  - **Description**: Separates substances of different densities using a centrifuge.
  - **Process**: The mixture is spun rapidly, causing denser components to settle at the bottom and lighter components to remain on top.
  - **Example**: Separation of cream from milk.
- **Floatation**
  - **Description**: Separates substances based on differences in density.
  - **Process**: Lighter components float on the liquid surface, while heavier ones sink.
  - **Example**: Separation of wood chips from water.
- **Evaporation to Dryness**
  - **Description**: Used to separate a soluble solid from its solvent.
  - **Process**: The mixture is heated until the solvent evaporates, leaving the solid behind.
  - **Example**: Obtaining salt from seawater.
- **Crystallization**
  - **Description**: Separates a solid dissolved in a liquid by forming crystals.
  - **Process**: The solution is heated to concentrate it and then cooled, allowing crystals to form.
  - **Example**: Purifying sugar.
- **Fractional Crystallization**
  - **Description**: Separates two or more dissolved solids based on their solubility.
  - **Process**: Crystals of one solid form first as the solution cools, leaving the other solid in the solution.
  - **Example**: Separation of potassium nitrate and sodium chloride.
- **Precipitation**
  - **Description**: Used to separate a solid (precipitate) formed during a chemical reaction in a solution.
  - **Process**: A reagent is added to form an insoluble compound that can be filtered or decanted.
  - **Example**: Formation of barium sulfate from barium chloride and sulfuric acid.

- **Distillation**
  - **Description**: Separates a liquid from a solution or a mixture based on boiling points.
  - **Process**: The mixture is heated; the liquid with the lower boiling point evaporates, and then condenses into a separate container.
  - **Example**: Purifying water from a salt solution.

- **Fractional Distillation**
  - **Description**: Separates a mixture of liquids with different boiling points.
  - **Process**: The mixture is heated in a fractionating column, allowing liquids to evaporate and condense at their specific boiling points.
  - **Example**: Separation of crude oil into petrol, diesel, and kerosene.
- **Separating Funnel Method**
  - **Description**: Used to separate immiscible liquids (liquids that do not mix).
  - **Process**: The mixture is poured into a separating funnel; the denser liquid settles at the bottom and is drained off.
  - **Example**: Separation of oil and water.
- **Chromatography**
  - **Description**: Separates components of a mixture based on their movement through a medium.
  - **Process**: A mixture is applied to a stationary phase (e.g., paper) and a solvent (mobile phase) moves through it, separating components by solubility.
  - **Example**: Separation of pigments in ink or plant dyes.

❖ **Conclusion**

Separation techniques are vital for purifying substances and analyzing mixtures. Each technique is chosen based on the properties of the components, such as size, solubility, boiling point, or magnetic properties. Understanding these methods is crucial for practical applications in chemistry.

 Pure and Impure Substance

- **Pure Substances**
  - A pure substance consists of only one type of particle, either an element or a compound. It has a fixed composition and definite physical and chemical properties.
  - **Characteristics of Pure Substances:**
    - Uniform composition throughout.
    - Fixed melting and boiling points.
    - Cannot be separated into simpler substances by physical means.
  - **Examples of Pure Substances:**
    - **Element**: Oxygen (O_2), Gold (Au).
    - **Compound**: Water (H_2O), Carbon Dioxide (CO_2).

- **Impure Substances (Mixtures)**
  - Impure substances consist of two or more different particles physically combined. They do not have fixed compositions or properties.
  - **Characteristics of Impure Substances:**
    - Non-uniform composition.
    - Variable melting and boiling points.
    - Can be separated into components using physical methods like filtration or distillation.

- **Types of Mixtures:**
  - **Homogeneous Mixture**: Components are uniformly distributed (e.g., saltwater, air).
  - **Heterogeneous Mixture**: Components are not uniformly distributed (e.g., sand and iron filings).
- **Tests for Purity**
  - Purity of a substance is determined by checking its physical and chemical properties.
- **Physical Methods for Testing Purity:**
  - **Melting Point Test**: A pure substance has a sharp and fixed melting point. Impurities lower the melting point and broaden the range.
    - **Example**: Pure ice melts at exactly 0°C under standard conditions.
  - **Boiling Point Test**: A pure liquid boils at a fixed temperature. Impurities raise the boiling point and cause irregular boiling.
    - **Example**: Pure water boils at exactly 100°C under standard atmospheric pressure.
- **Chemical Methods for Testing Purity**:
  - Reacting the substance with a known reagent to observe if it behaves as expected.

❖ **Melting Point**

- **Definition**: The temperature at which a solid turns into a liquid at atmospheric pressure.
- **Key Features:**
  - Fixed for pure substances.
  - Impurities lower the melting point and make it less distinct.
- **Applications**:
  - Identifying substances.
  - Testing the purity of solids like metals, ice, or organic compounds.

❖ **Boiling Point**

- **Definition**: The temperature at which a liquid turns into vapor at atmospheric pressure.
- **Key Features:**
  - Fixed for pure liquids.
  - Impurities increase the boiling point and make boiling less distinct.

- **Applications**:
    - Identifying liquids.
    - Testing the purity of substances like water, alcohol, or organic solvents.

ATOM, MOLES, FORMULAE, EQUATIONS

PARTICULATE NATURE OF MATTER

- **Matter** is made up of discrete particles, the main ones being atom, molecules, and ions.
- **Atom:**
    - An atom is the smallest particle of an element which can take part in a chemical reaction.
    - An atom is the smallest part of an element that can ever exist and still possess the chemical properties of that element.
    - The atom have three fundamental sub – particles; the **electrons**, the **protons**, and the **neutrons**.
    - The proton is **positively charged**, the neutron have **no charge** and they are both located in the **nucleus** of the atom. The electron is **negatively charged** and located **outside the nucleus**; **on shells**.
- **Molecule:**
    - A molecule is the smallest particle of a substance that can normally exist alone and still retain the chemically properties of that substance, be it an element or a compound.
- **An ion** is any atom or group of atoms which possesses an electric charge.
- **Atomic number Z** of an atom of an element is the number of protons in one atom of that element. The atomic number is written as a subscript to the symbol of the element.
- **The mass number A** of an atom of an element is the sum of the protons and neutrons in it. It is written as a superscript to the symbol of the element.
- **Isotopy** is a phenomenon whereby atoms of an element exhibit different mass numbers but have the same atomic number. This is due to differences in the number of neutrons present in these atoms. Such atoms are known as isotopes.
- **Isotopes** are atoms of the same elements with the same atomic number but different mass numbers. Isotopes of an element have slightly different physical properties but exhibit the same chemical properties. This is because neutrons contribute only to the mass of an atom, not its chemical behavior.

DALTON'S ATOMIC THEORY

- In 1808, John Dalton proposed the *Atomic theory* which can be summarized as follows:
  - All elements are made up of small, indivisible particles called *atoms.*
  - *Atoms* can neither be created nor be destroyed.
  - Atoms of the same element are alike in every aspect, and differ from atoms of all other elements.
  - When atoms combine with other atoms, they do so in simple ratios.
  - All chemicals changes result from the combination or the separation of atoms.

RELATIVE ATOMIC MASS

- **Relative atomic mass**, $\mathbf{A_r}$ of an element is the number of times the average mass of one atom of that element is heavier than one–twelfth the mass of one atom of carbon – 12.
- **Mass Spectrometer:** measures the masses of isotopes, molecules and compounds. It is the most accurate instrument for getting the mass of compounds and can also differentiate between isotopes of the same element.
- The term *atomic mass unit (amu)* is sometimes used, where *1 amu is an amount of matter that has a mass one – twelfth that of carbon – 12.* From this definition, one carbon atom has a mass of 12amu, one oxygen atom, a mass of 16 amu and one hydrogen atom, a mass of 1 amu.
- **Relative molecular mass, $\mathbf{M_r}$**
  - 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 carbon – 12.
  - The relative molecular mass of an element or a compound is the sum of the relative atomic masses of all the atoms in one molecule of that substance. It is also referred to as the **formula mass**, which is more general term.
  - **Example:** Calculate the relative molecular mass of limestone, $CaCO_3$ (Ca = 40, C = 12, O = 16)

    One molecule of $CaCO_3$ has 1 Ca, 1 C and 3 O atoms. Therefore relative molecular mass of $CaCO_3$.

    $= 1 \times A_r$ of Ca + $1 \times A_r$ of C + $3 \times A_r$ of O

    $= (1 \times 40 + 1 \times 12 + 3 \times 16)$

    $= 100$

- **Mole**
  - One mole of a substance is the amount containing as many elementary entities as the number of atoms in exactly 12 grams of carbon – 12.
  - Through experimental work, it was found that 1 mole or 12 grams of carbon – 12 contain 6.02×10^{23} atoms. This number is known as the *Avogadro number.*

    Avogadro number = 6.02×10^{23}
  - Therefore, 1 mole of oxygen atoms contains 6.02×10^{23} oxygen atoms just as 1 dozen eggs means 12 eggs.
  - The definition of mole also give us the following relationships:

    $$\text{Number of moles of a substance} = \frac{\text{Number of particles}}{6.02 \times 10^{23}}$$
- **Molar mass** of any substance is the mass of one mole of that substance expressed in grams. Its unit is grams per mole ($g\ mol^{-1}$).

LAWS OF CHEMICAL COMBINATION

- There are four laws of chemical combination which describe the general features of a chemical change. Although research has shown that these laws are only approximately correct, they still form the basis of chemistry.

- **The Law of Conservation of Mass** states that matter is neither created nor destroyed during chemical reaction but change from one form to another.
- **The Law of Definite Proportions** states that all pure samples of a particular chemical compound contain similar elements combined in the same proportion by mass.
- **The Law of Multiple Proportion** states that if two elements, A and B, combine to form more than one chemical compound, then the various masses of one element, A, which combine separately with a fixed mass of the other element, B, are in simple multiple ratio.
- **The Law of Reciprocal Proportion** states that the masses of several elements, A, B, C, which combines separately with a fixed mass of another element, D, are same as, or simple multiples of, the masses in which A, B, C, themselves combine with one another.
- **Valency:** is the combining power of an element. The number of moles of hydrogen atoms that will combine with one mole of an element gives the **valency** of that element.