

# ATOM AND MOLECULE

## Maharshi Kanad's Theory

- According to the Indian philosopher **Maharshi Kanad**, if we keep dividing matter into smaller and smaller parts, a stage will eventually be reached where further division is not possible.
- He called these smallest particles "**Parmanu**", which are known today as **atoms**.

Example:

- If we break a piece of chalk repeatedly, it becomes smaller and smaller until we reach a tiny particle that cannot be divided further—this is called an atom.

## Laws of Chemical Combination

When elements combine to form compounds, the process follows two important laws:

1. Law of Conservation of Mass
2. Law of Constant Proportions

### Law of Conservation of Mass

- This law was given by **Antoine Lavoisier (1774)**.
- In any physical or chemical change, the total mass of the reactants is always equal to the total mass of the products.
- This means **mass is neither created nor destroyed**.

Example:

If 10 g of hydrogen reacts with 80 g of oxygen to form water, the total mass of water formed will be 90 g.

### Law of Constant Proportions (Law of Definite Proportions)

- This law was given by **Joseph Proust**.
- A pure chemical compound always contains the same elements combined in the same fixed proportion by mass.

Example:

Water (H<sub>2</sub>O) always contains hydrogen and oxygen in the mass ratio of 1:8, regardless of its source.

## Atoms

An atom is the smallest particle of an element that cannot be further divided and retains all the chemical properties of that element.

Example:

Hydrogen atom (H), Oxygen atom (O)

### **Size of an Atom**

Atoms are extremely small, and their size is measured in terms of radius.

Example:

The hydrogen atom is the smallest atom with a radius of about  $0.37 \times 10^{-10} \text{ m}$  (or 37 pm).

### **Dalton's Atomic Theory**

- Proposed by **John Dalton**, this theory explains the nature of matter.

**Postulates:**

- All matter is made up of tiny particles called atoms.
- Atoms cannot be divided into smaller particles.
- Atoms can neither be created nor destroyed in chemical reactions.
- All atoms of the same element are identical in mass and properties.
- Atoms of different elements are different.
- Atoms combine in simple whole-number ratios to form compounds.

Example:

In water ( $\text{H}_2\text{O}$ ), 2 hydrogen atoms combine with 1 oxygen atom.

### **Drawbacks of Dalton's Atomic Theory**

- Atoms are divisible (they contain electrons, protons, and neutrons).
- Atoms of the same element may differ (isotopes).
- Atoms of different elements may have similar properties (isobars).
- Atoms can be destroyed in nuclear reactions.
- It does not explain how atoms combine to form compounds.

Example:

Carbon-12 and Carbon-14 are isotopes of carbon.

### **Berzelius Atomic Symbols**

In 1813, **J. J. Berzelius** suggested that chemical symbols should be based on Latin or Greek names of elements.

Examples:

- Sodium  $\rightarrow$  Na (from **Natrium**)
- Iron  $\rightarrow$  Fe (from **Ferrum**)

## Atomic Mass

The atomic mass of an element is the mass of its atom expressed in atomic mass units (u), relative to 1/12th the mass of a carbon-12 atom.

Example:

Atomic mass of carbon = 12 u

Atomic Mass Unit (amu or u)

1 atomic mass unit is equal to **1/12th the mass of a carbon-12 atom.**

## Relative Atomic Mass

It is the average mass of the atoms of an element compared to 1/12th the mass of a carbon-12 atom.

## Gram Atomic Mass

When atomic mass is expressed in grams, it is called gram atomic mass.

Example:

Oxygen has atomic mass 16 u → gram atomic mass = 16 g

## Molecules

A molecule is the smallest particle of an element or compound that can exist independently and shows all its properties.

**Types:**

- Molecules of elements: H<sub>2</sub>, O<sub>2</sub>
- Molecules of compounds: H<sub>2</sub>O, CO<sub>2</sub>

## Molecular Mass

The molecular mass is the mass of a molecule compared to 1/12th the mass of a carbon-12 atom.

Example:

Molecular mass of H<sub>2</sub>O = 2(1) + 16 = **18 u**

## Ions

Ions are charged particles formed when atoms lose or gain electrons.

**Types:**

1. **Cations (Positive ions)**

- Formed by loss of electrons
- Examples:  $\text{Na}^+$ ,  $\text{Mg}^{2+}$

## 2. Anions (Negative ions)

- Formed by gain of electrons
- Examples:  $\text{Cl}^-$ ,  $\text{O}^{2-}$

## Chemical Formula of a Compound

A chemical formula is a symbolic representation that shows the elements present in a compound and the number of atoms of each element.

Examples:

- $\text{H}_2\text{O} \rightarrow$  Water
- $\text{CO}_2 \rightarrow$  Carbon dioxide

## Mole Concept

**Mole:**

- A mole is the amount of substance that contains  **$6.022 \times 10^{23}$  particles** (Avogadro number).

Examples:

- 1 mole of atoms =  $6.022 \times 10^{23}$  atoms
- 1 mole of molecules =  $6.022 \times 10^{23}$  molecules

## Molar Mass

The mass of one mole of a substance is called its molar mass.

Examples:

- Molar mass of  $\text{H}_2\text{O}$  = 18 g/mol
- Molar mass of  $\text{CO}_2$  = 44 g/mol