# 3. Atoms and molecules

- According to *law of constant proportions*, a sample of a pure substance always consists of the same elements combined in the same proportion by mass.

- When an element combines with another element and forms more than one compound, then different masses of the one element that combine with the fixed mass of another element are in the ratio of simple whole number or integer. This is the *law of multiple proportions*.

- A molecule is the smallest particle of an element or of a compound which shows all properties of that substance and can exist freely under ordinary conditions.

- A molecule can be represented in the form of a chemical formula using symbols of elements that constitute it.

- Atom of the isotope C-12 is assigned atomic mass unit of 12 and the relative atomic masses of all other atoms of elements are obtained by comparing them with it.

- **The mole is the amount of a substance which contains the same number of particles (atoms, ions or molecule)** as there are atoms in exactly 0.012 kg of carbon-12.

- Avogadro's number is defined as the number of atoms in exactly 0.012 kg (or 12 g) of C-12 and is equal to $6.02 \times 10^{23}$. Avogadro's constant is written as $6.02 \times 10^{23}$ $mol^{-1}$.

- Mass of one mole atoms or one mole molecules or one mole of formula unit of a substance is its **molar mass**.

- The composition of any compound can be represented by its formula. For writing the formula of a compound, valence or valency of an element is used. This is normally done in case of covalent compounds.

- Valency is the combining capacity of an element.

## Build Your Understanding

### Atoms and Molecules

An atom is the smallest particle of an element that retains the chemical properties of the element. An atom of one element is different in size and mass from the atoms of the other elements.

### Atomic Mass

The masses of atoms are obtained by comparison with C-12 isotope which has been arbitrarily assigned a mass of exactly 12 atomic mass units.

### Atomic Number

The number of protons in the nucleus is called atomic number and is denoted by Z.

Total number of protons and neutrons is called mass number and is denoted by A. An element X with atomic number Z and mass number A is denoted as $^{A}_{Z}X$.

### Isotope

Atoms of an element that have the same atomic number (Z) but different mass number (A). For example: $^{16}_{8}O$, $^{17}_{8}O$ and $^{18}_{8}O$.

### Molecule

A molecule is an aggregate of two or more than two atoms of the same or different elements in a definite arrangement. A molecule of a substance shows all chemical properties of that substance. Examples : $H_2O$, $NH_3$, $C_2H_5OH$.

### Molecular formula

A molecule is represented in the form of a formula known as molecular formula. For example $CO_2$, $H_2O$, $CH_4$ etc.

Molecular mass

It is the sum of atomic masses of all the atoms present in that molecule.

### Mole Concept

A mole is the amount of a substance that contains as many elementary entities (atoms, molecules, formula units or other fundamental particles) as there are atoms in exactly 0.012 kg (12 grams) of carbon-12 isotope.

The number of atoms in 12 gram of C-12 is $6.022 \times 10^{23}$. This number is called Avogadro's number.

### Molar Mass

Mass of one mole of a substance is called its molar mass. It is expressed in the unit of $g\ mol^{-1}$.

## Laws of chemical combination

### 1. Law of conservation of mass

In every chemical reaction, total masses of all the reactants is equal to the masses of all the products.

### 2. Law of definite or constant proportion

In a given chemical compound, the proportions by mass of the elements that compose it are fixed.

### 3. Law of multiple proportions

When two elements form more than one compound, the masses of one element in these compound for a fixed mass of the other element are in the ratio of small whole numbers.

## Chemical Formula of Compounds

A compound is represented by a shorthand notation known as chemical formula. In this, the atoms of elements constituting a compound are indicated by their symbols and their number is indicated as a subscript on the right hand bottom of the symbol.

### Valency and Formulation

The combining capacity of an element is called its valency.

### Chemical Formula

For writing chemical formula, we have to write valencies on the symbol of the element and then cross over the valencies of the combining atoms. For example, $CCl_4$, $H_2O$, $HCl$.

| Element | C | Cl | H | O | H | Cl |
|---------|---|----|----|----|----|----|
| Valency | 4 | 1 | 1 | 2 | 1 | 1 |
| Formula | $CCl_4$ | | $H_2O$ | | $HCl$ | |

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### ★ Stretch Yourself

1. Define atom and molecule.
2. Write down the postulates of Dalton's atomic theory
3. If valency of an element 'X' is 2 and another element 'Y' is 3, then what is the formula of compound formed by combination of X and Y?

### ? Test Yourself

1. The atomic number of an element is 20 and its atomic mass is 40. Calculate number of electrons, protons and neutrons in it.
2. What is an isotope? Chlorine is obtained as a mixture of two isotopes $^{35}_{17}Cl$ and $^{37}_{17}Cl$. These isotopes are present in the ratio of 3 : 1. What will be the average atomic mass of chlorine?
3. Calculate the molecular mass of calcium chloride.
4. Define mole and find out the molar mass of the molecule $S_8$ and $O_3$.