Introduction

- We all know that matter is anything that occupies space and have mass. The idea of divisibility of matter was considered long back in India, around 500 BC. An Indian philosopher Maharishi Kanad, postulated that if we go on dividing matter (padarth), we shall get smaller and smaller particles. Ultimately, a stage is reached when we come across the smallest particles beyond which cannot be divided further. He named these particles Parmanu or atoms.

Laws of Chemical Combination

- By the end of eighteenth-century Antoine L. Lavoisier laid the foundation of chemical sciences by formulating two important laws of chemical combination.
- Lavoisier and Joseph L. Proust established the following two laws after careful experimentation and observation:

1. Law of conservation of mass- This law states that mass can neither be created nor destroyed in a chemical reaction i.e. Total masses of reactants is equal to the sum of masses of products and the masses of unreacted reactants. For instance, the reaction of carbon with oxygen to produce carbon-dioxide involves conservation of mass in the following way.

$$H_2\ (2g) + 1/5\ O_2\ (16g) = H_2O\ (18g)$$

In the above reaction, total mass of the reactants (18 g) is equal to the total mass of the products (18 g). this means that the mass is neither created nor destroyed. It remains the same.

2. Law of constant proportion - This law states that in a chemical substance the elements are always present in a definite proportion by mass. It is also termed as law of definite proportion.

   For instance, in ammonia molecule, nitrogen and hydrogen are always present in the ratio 14:3 by mass, whatever the method or the source from which it is obtained.

Dalton's Atomic theory- John Dalton proposed his famous theory and provided an explanation for the laws of chemical combination. Following are the postulates:

i. All matter is made of very tiny particles called atoms.
ii. Atoms cannot be further divided, they can neither be created nor destroyed in a chemical reaction.
iii. Atoms of a given element are identical in mass and chemical properties.
iv. Atoms of different elements have different masses and chemical properties.
v. Atoms combine in the ratio of small whole numbers to form compounds.
vi. The relative number and kinds of atoms are constant in a given compound.

Atoms

- As per Dalton's atomic theory, atom is defined as the smallest particle of matter.

Characteristics of atoms

- Atoms are very tiny in size and cannot be seen through naked eye.
- Atoms doe not exist in the free- state in nature.
- The properties of matter depend on the properties of its atoms.
- Atoms are the building blocks of all matter.
- In ancient times atoms were regarded as indivisible.

Dalton was the first scientist to use symbols for elements. While using symbol of an element he also meant a definite quantity of that element. Berzelius suggested that symbol of an element should contain one or two letters of the name of the element.

Initially, the name of the elements were derived from the name of the place from they were found. For example, name of the copper was derived from Cyprus. Symbols of elements were the first one or two letters of the element's name in English.

The first letter of a symbol is always written as a capital letter. Now-a-days, IUPAC (International Union of Pure and Applied Chemistry) approves the names of elements, symbols and units.

Some of the symbols contain the first letter of the element name and a letter that appears later in it. For instance, Cl for chlorine, Zn for zinc etc.

Some of the symbols are derived from their names in latin or greek. For instance, Na (natrium) for sodium, Fe (Ferrum) for iron.

MODERN DAY SYMBOLS

Element	Symbol	Element	Symbol
Carbon	C	Silver	Ag
Hydrogen	H	Gold	Au
Sulphur	S	Potassium	K
Nitrogen	N	Sodium	Na
Cobalt	Co	Silicon	Si
Iodine	I	Uranium	U
Copper	Cu	Zinc	Zn
Magnesium	Mg	Lead	Pb

Atomic Mass

- The mass of an atom is called atomic mass. The concept of atomic mass was given by John Dalton.
- For a universally accepted atomic mass unit, Carbon-12 isotope was taken as the standard reference for measuring atomic masses.
- It depicts how many times an atom of an element is heavier than one-twelfth (1/12th) the mass of one atom of carbon-12.
- Atomic mass unit is abbreviated as **amu**. Nowadays amu is replaced by **u**.
- The atomic mass of 1 hydrogen atom = 1u. this means one hydrogen atom is 1 times heavier than $1/12^{th}$ carbon atom.

Molecules

- A molecule is defined as a group of two or more atoms that are chemically bonded together, that means, tightly held together by attractive forces.
- A molecule can be defined as the smallest particle of an element or a compound that is capable of an independent existence and shows all the properties of that substance.
- A molecule is made of either atoms of the same element or of different elements bonded together.

Atomicity

- The number of atoms present in a molecule is known as atomicity.

- For example, molecule of Oxygen contains 2 atoms, hence it is called Diatomic. Molecules of Argon, Helium etc contains only one atom, hence called Monoatomic.
- Similarly, when a molecule is composed of 3 atoms it is called Triatomic.
- When a molecule contains more than 3 atoms it is called Polyatomic.

Compounds of molecules

- Atoms of different elements join together in definite proportions to form molecules of compounds.
- For example, in water molecule Hydrogen and Oxygen combine in 1:8 ratio.
- In ammonia molecule, Nitrogen and Hydrogen combine in 14:3 ratio.

Ion

- Atoms of many elements exist as charged species called ion. Atoms or molecules with negative or positive charge are called ions.
- An ion can be negatively or positively charged. Negatively charged ion is called an Anion and positively charged ion is called a Cation.
- For example, NaCl molecule is composed of positively charged sodium ion (Na^+) and negatively charged chloride ion (Cl^-).
- A group of atoms carrying a charge is called a polyatomic ion.

Valency

- The capacity of an atom to gain or loose electron to achieve the nearest noble gas configuration.
- It is defined as the ability of an element to combine with other elements.
- It can be obtained by determining the number of electrons available for bonding in the outermost shell of each atom of an element.
- For example, the atomic number of potassium is 12. Thus, electronic configuration will be 2, 8, 8, 1. There is only one electron in the outermost shell and requires to loose this electron to gain nearest noble gas configuration. This means the valency of K is 1
- On the other hand, Cl with atomic number 17 requires only one electron to achieve noble gas configuration. The valency of Cl is also 1.
- During the formation of KCl molecule Potassium loses on electron which is gained by Chlorine and both acquire noble gas configuration.

Writing a Chemical formula

- The chemical formula of a compound is the symbolic representation of its composition. The rules to be followed while writing a chemical formula are:

Rule 1

Cross multiply the valencies of the element to write the formula of the compound.

Mg	**Cl**
2	**1**

Rule 2

If the compound contains both a metallic as well as a non-metallic element then, the symbol of the metal is written first.

Mg	**Cl**
2	**1**

Since Mg is a metal thus its symbol will be written first.

Rule 3

In case compounds are formed from polyatomic ions then the ion is enclosed in a bracket and then the number is written to indicate the ratio. But in case the number of polyatomic ion is one then there is no need for bracket.

For example: $Mg(OH)_2$

Na	**OH**
1+	**1-**

NaOH

Mg	**OH**
2+	1-

$Mg(OH)_2$

Molecular Mass

- The molecular mass of a substance is the sum of the atomic masses of all the atoms present in a molecule of the substance. Thus, it is the relative mass of a molecule expressed in atomic mass units (u).
- For example, the molecular mass of a water molecule can be calculated as follows:

Atomic Mass of H = 1u

Atomic Mass of O = 16 u

So the molecular mass of H_2O will be = 2 × 1 + 16 × 1

= 18 u

Formula Mass Unit

- The formula unit mass of a substance is a sum of the atomic masses of all atoms in a formula unit of a compound.
- It is calculated in the same way as molecular formula; the only difference is that we use the word formula unit for those substances whose constituent particles are ions.
- For example, the formula unit mass of $CaCl_2$ can be calculated as follows:

Atomic Mass of Ca = 40 u

Atomic Mass of Cl = 16 u

So the molecular mass of $CaCl_2$ will be = 40 + 2 × 35.5

= 111u

Mole Concept

- The word “mole” was introduced around 1896 by Wilhelm Ostwald
- Mole is the SI unit used to express the quantity of a substance.
- One mole contains exactly $6.02214076 \times 10^{23}$. This number is the numerical value of Avogadro’s constant. When expressed in the unit mol^{-1}it is called Avogadro Number.
- Let us calculate the number of moles in 26g of S. For this, we will follow below given steps

Atomic mass of S =32u
Molar mass of S = 26 g

Therefore,

number of moles (n) = given mass (m) / molar mass (M)

n = 26/32 = 0.81

Molar Mass

- The molar mass of a chemical compound is defined as the mass of a sample of that compound divided by the amount of substance measured in moles.
- To get the mass of 1 mole that is, molar mass of an element, we have to take the same numerical value but change the units from ‘u’ to ‘g’.
- For example, atomic mass of hydrogen= 1u. So, gram atomic mass of hydrogen = 1 g.1 u hydrogen has only 1 atom of hydrogen and 1 g hydrogen has 1 mole atoms, that is,6.022 × 1023 atoms of hydrogen.
  Similarly,
  16 u oxygen has only 1 atom of oxygen, ands
  16 g oxygen has 1 mole atoms, that is,
  6.022 × 1023 atoms of oxygen.