

# BASIC CONCEPTS OF CHEMISTRY

**Definition:** It is that branch of basic science which deals with composition, structure and properties of matter.

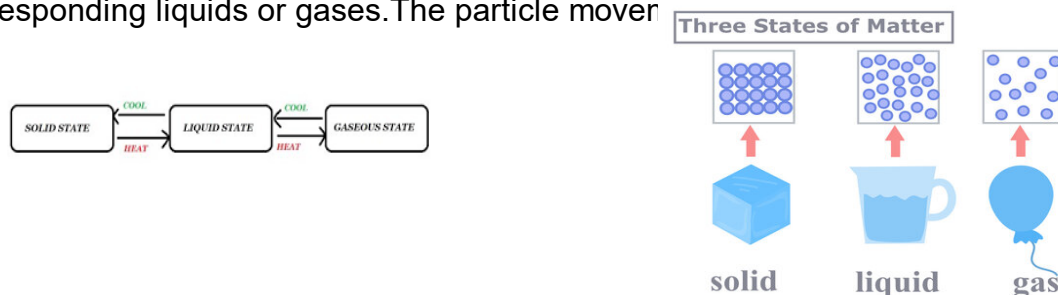
Any thing which has certain mass and it occupies some space is known as matter.

Matter can exist in three physical states, solid, liquid and gas

**Solids:** They have definite volume and definite shape. The particles are very close to each other in an orderly fashion. There is not much freedom of movement of particles about their fixed positions.

**Liquids:** They have definite volume but no definite shape. They assume the shape of the container in which they are kept. The particles are comparatively less close, but the particles of liquid can move around.

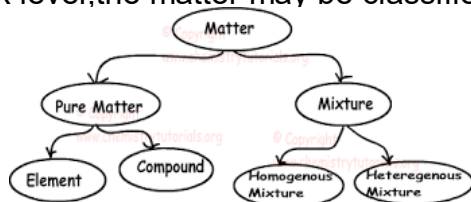
**Gases:** They have neither definite volume nor definite shape. They completely occupy the container in which they are placed. The inter particle distances are far apart in comparison to their corresponding liquids or gases. The particles move



The three states of matter are interconvertible by changing the conditions of temperature and pressure. Usually, on heating the solid it changes to liquid and liquid on further heating is converted to gas. In reverse process, a gas on further cooling liquefies to liquid and the liquid on further cooling freezes to solid state.

**Sublimation:** The conversion between solid and gaseous phases of matter with no intermediate liquid stage. e.g. vapourization of frozen carbon dioxide (dry ice) at normal temperature and pressure.

At macroscopic or bulk level, the matter may be classified as follows:



**Pure Matter:** They have fixed composition. e.g. Copper, Silver, Gold, Water, Glucose etc.

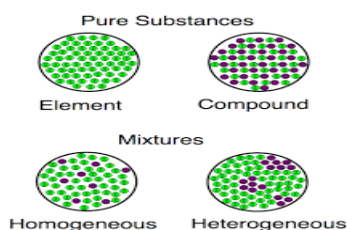
**Elements:** It consists of only one type of particles (atoms/molecules)

**Compounds:** Two or more atoms of different elements chemically combine in fixed ratio to form a molecule of a compound. e.g. water, Carbon dioxide, Methane, Ammonia etc

**Mixture:** It is a combination of two or more substances (called components of the mixture) in any ratio and their composition is variable. e.g. sugar solution in water, air, mixture of oil with water etc.

**Homogenous Mixture:** It is that type of mixture in which components completely mix with each other such that the composition is uniform throughout. e.g. sugar solution, air etc.

**Heterogenous Mixture:** It is that type of mixture in which components intermix with each other in such a manner that the composition is not uniform throughout. e.g. mixture of salt and sugar, mixture of grains and pulses etc



## The Laws of Chemical Combination

There are several laws of chemical combination which are enunciated by different Scientists/Chemists in the last part of nineteenth century which govern the combination of elements to form different compounds.

1. Law of conservation of mass
2. Law of definite proportions
3. Law of multiple Proportion
4. Gaylussac's law of gaseous Volume
5. Avogadro's Law

**1. Law of Conservation of Mass:** This law was put forth by Antoine Lavoisier in 1789.

It states that matter can neither be created nor destroyed.

It was evident from various chemical reactions the sum of masses of reactants is exactly equal to masses of products.

**2. Law of definite proportions:** This law was put forth by a French Chemist Joseph Proust.

It states that a given compound always contains exactly the same proportion of elements by their weights.

Whether a compound is natural or synthetic, the composition of elements present in it was same for both the samples. He collected two samples of cupric carbonate both from natural and synthetic origin and found percentage of composition are fixed for both the samples i.e % of copper-51.35, % of Oxygen 9.74 and % of carbon 38.91.

**3. Law of Multiple Proportions:** It was proposed by John Dalton in 1803. According to this law, if two elements can combine to form more than one compound, the masses of one element that combine the fixed mass of other element are in ratio of small whole numbers. i.e Hydrogen combines with oxygen to form water and hydrogen peroxide. It has been observed that 02 grams of hydrogen combines with 16 grams of oxygen to form 18 grams of water and again same 2 grams of hydrogen combines with 32 grams of oxygen to form 34 grams of hydrogen peroxide. Hence the masses oxygen are 16 grams and 32 grams bears a simple whole ratio,  $16:32=1:2$

**4. Gay Lussac's Law of gaseous volumes:** This was given by Gay Lussac in 1808. As per the law, when gases combine or are produced in a chemical reaction, they do so in a simple ratio by volume provided all the gases are at same temperature and pressure. e.g 100 ml hydrogen combine with 50 ml of oxygen to form 100 ml of water. Thus the volumes of hydrogen and oxygen are in ratio,  $100:50=2:1$

**5. Avogadro's Law:** Avogadro proposed a law in 1811. It states that equal volume of gases at same temperature and pressure should contain equal numbers of molecules.

**DALTON'S ATOMIC THEORY:** In 1808, John Dalton published his famous book, 'A New System in Chemical Philosophy' in which he postulated details on Atomic Theory. as follows,

- i) Matter consists of indivisible particles called atoms
- ii) All the atoms a given element have identical properties including identical masses. Atoms of different elements differ in their masses.
- iii) Compounds are formed when the atoms of different elements combine in a fixed ratio.
- iv) Chemical reactions involve reorganization of atoms. They are neither created nor destroyed in a chemical reaction.

Drawbacks: i) It could not explain the existence of isotopes

ii) It could not explain the structure of atoms

iii) It could not explain the divisibility of atom.

### Atomic and Molecular Masses:

The mass of the atom is very very small. It may be accurately determined by the modern method of mass spectrometry. In nineteenth century, scientists adopted relative mass concept. The mass of the hydrogen being lightest was taken as unit mass. The atomic masses of all other elements are compared with that of the hydrogen. But in 1961, it was agreed upon by the scientists to take atom  $^{12}\text{C}$  isotope as standard of atomic mass and it was assigned as 12 atomic mass units (amu). Accordingly, one atomic mass unit was defined as  $1/12$  part of atom of  $^{12}\text{C}$  isotope.

1 amu =  $1.66056 \times 10^{-24}$  grams

Mass of one atom of hydrogen =  $1.6736 \times 10^{-24}$  grams

In terms of amu, the atomic mass of hydrogen =  $1.6736 \times 10^{-24} \text{g} / 1.66056 \times 10^{-24} \text{g} = 1.0078$  amu or say 1.008 amu

Atomic mass of Oxygen = 15.995 amu

Now a days, amu is replaced by u (unified mass)

**Average Atomic Mass:** Many natural occurring elements exist as more than one isotope. While calculating average atomic mass we take into account all the isotopes of an element and their relative abundance in nature in terms of per cent age. e.g Carbon has three isotopes  $^{12}\text{C}$ ,  $^{13}\text{C}$  and  $^{14}\text{C}$ .

Isotopes	Relative Abundance	Atomic Mass
$^{12}\text{C}$	98.892%	12
$^{13}\text{C}$	1.108%	13.00335
$^{14}\text{C}$	$2 \times 10^{-10}\%$	14.00317

Average atomic Mass of Carbon =  $0.98892 \times 12 + 0.01108 \times 13.00335 + 2 \times 10^{-10} \times 14.00317 = 12.011 \text{u}$

Atomic masses mentioned in modern periodic table are their average atomic masses.

**Molecular Mass:** The molecular mass is the sum of average atomic masses of the elements present in a molecule. It is obtained by multiplying atomic masses of each element by the number of atoms and adding them together. e.g Molecular mass of methane ( $\text{CH}_4$ )

$12.011 + 1.008 \times 4 = 16.043 \text{u}$

**Formula Mass:** The formula mass of the molecule is sum atomic weights of atoms in the empirical formula of the compound.

**Mole Concept and Molar Masses:** One mole is that amount of substance that contains as many particles or entities as there are atoms in exactly 12 grams  $^{12}\text{C}$  isotope

No of Molecules in one mole of a substance =  $12 \text{g of } ^{12}\text{C isotope} / \text{Mass of one atom of } ^{12}\text{C isotope} = 12 \text{g} / 1.992648 \times 10^{-23} \text{g} = 6.0221367 \times 10^{23}$ . This is known as Avogadro's Number

The mass of one mole of a substance in grams is known as the molar mass

**Percentage Composition:** Mass% of an element in a compound =  $\text{mass of element in compound} \times 100 / \text{Molar mass of the compound}$

Let take % composition of Hydrogen and Oxygen in water ( $\text{H}_2\text{O}$ )

Molar mass of water = 18.02 g

Mass % of hydrogen =  $2 \times 1.008 / 18.2 = 11.18$

Mass% of oxygen =  $16 / 18.2 = 88.79$

**Empirical Formula and molecular formula:** An empirical formula represents the simplest whole number ratio of various atoms present in the compound where as molecular formula shows the exact number of atoms present in a molecule of a compound.

**Limiting Reagent:** If in a chemical reaction, if one of the reactants is in lesser amount as required in balanced chemical reaction, then it gets consumed and limits amount product formed is known as Limiting Reagent.