

**Class XI**  
**Some basic concepts of chemistry**

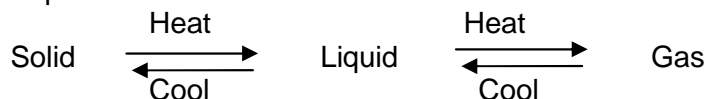
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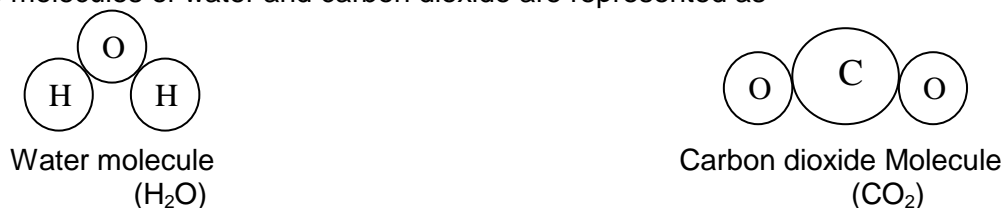
- Chemistry deals with the composition, structure and properties of matter. These aspects can be best described and understood in terms of basic constituents of matter, that's why chemistry is called the science of atoms and molecules. Chemistry plays a central role in science and is often intertwined with other branches of science like physics, biology, geology etc.

### Nature of matter

- Matter is anything which has mass and occupies space e.g., solid, liquid and gaseous states are three different states of matter.
  1. **Solid** have definite volume and definite shape. In solids, particles are held very close to each other in an orderly fashion.
  2. In **liquids**, the particles are closed to each other but they can move around. Its have definite volume but not definite shape. They take the shape of container in which they are placed.
  3. In **gases**, particles are far apart as compared to those present in solids and liquids state and their movement is easy and fast. Gases have neither definite volume nor definite shape. They completely occupy the container in which they are placed.
- These three states of matter are interconvertible by changing the conditions of temperature and pressure.



- Homogeneous mixture is a mixture which has the same composition through out. The components are indistinguishable, e.g. sugar solution.
- Heterogeneous mixture has distinguishable components, it does not have same composition throughout, e.g. mixture of salt and sugar.
- Pure substances are either elements or compounds. Elements consist of only one kind of atoms and can not be decomposed in to simple substances.
- When two or more atom of different elements combine, the molecule of a compound is obtained.
- The molecules of water and carbon dioxide are represented as –



**Fig – 1**

### A depiction of molecules of water and carbon dioxide

- The international system of units (SI) has seven units i.e. mass (kg), length (m), time (s), temperature (K), electric current (A), luminous intensity (cd), amount of substance (mol). The units for various physical quantities are derived using the base SI units. These units are called derived units.
- A mole is the amount of substance that contains as many entities (atoms, molecules or other particles) as there are atoms in exactly (12g) of the C -12 isotope. The mole of a substance always contains the same number of entities, no matter what the substance may be. A mole has  $6.022 \times 10^{23}$  entities (atoms, molecules, or ions etc.)

**Note:**

The number of entities in 1 mol is given the separate name and symbol, known as Avogadro number.  $N_A$

$$N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$$

### Laws of chemical combination

- The combination of elements to form compounds is governed by the following five basic laws –
  1. Law of conservation of mass (Lavoisier) states that “matter can neither be created nor destroyed in a chemical reaction.
  2. Law of definite proportion (J. Proust) states that “a given compound always contains exactly the same proportion of elements by weight.”
  3. Law of multiple proportion (Dalton) states that “for a fixed mass of an element, the masses of other elements in two or more compounds are in the ratio of small integers.
  4. Gay – Lussac’s law of gaseous volumes states that when gases combine or are produced in a chemical reaction they do so in a simple ratio by volume provided all gases are at same temperature and pressure.
  5. Avogadro’s law states that the volume of a gas (at fixed temperature and pressure) is proportional to the number of moles (or molecules of gas present).

$$V \propto n$$

- One mole of any gas at STP (273k and 1atm) occupies 22.4l volume.

### Dalton’s atomic theory of matter-

1. Matter consists of indivisible atoms.
2. Atoms of the given element are identical in size, shape and mass, however atoms of different element have different masses, shape and different chemical properties.
3. The combination of different atoms in the small whole number ratio gives compounds.
4. Chemical reactions involve only combination, separation and rearrangement of atom.
5. Chemical reactions involve reorganization of atoms. These are neither created nor destroyed in a chemical reaction.

### Atomic masses and molecular masses

- The atomic mass or the mass of an atom is actually very – very small because atoms are extremely small. The relative atomic masses are referred to as the atomic weight and C-12 isotope is used as standard to measure the relative atomic masses. One atomic mass unit (1 amu) is the unit equal to exactly one twelfth the mass of C-12 atom.
- The particular element may consist of several isotopes with different atomic masses. The atomic mass depends upon the isotopic composition of that particular element. Suppose an element A consists of x% of first isotope of A and y% of second isotope of A, then the atomic mass of A will be –

$$\frac{Xx(\text{massnumberofA}) + Yx(\text{massnumberofA})}{100}$$

100

- Molecular mass is the sum of atomic masses of all atoms in a formula unit of a compound. E.g. formula mass of NaCl = 23+ 35.5 = 58.8 amu
- Empirical formula of a compound is a chemical formula showing the simplest whole number ratio of various atoms present in a compound

whereas the molecular formula shows the exact number of different types of atoms present in a molecule of a compound.

- If the mass percent of various elements present in a compound is known, its empirical formula can be determined. Molecular formula can further be obtained if the molar mass is known.
- The molecular formula conveys two important information
  - a. The relative number of each type of atoms in a molecule.
  - b. The total number of atoms of each elements in the molecule.
- The reactant which is consumed completely when a reaction goes to completion is called the **limiting reactant** or **limiting reagent**. The reactant which is not completely consumed is referred to as the excess reactant or reagent.

#### Concentration in solutions –

- The concentration of a solution or the amount of substance present in its given volume can be expressed in any of the following ways —
  - a. Mass percent or weight percent
  - b. Mole fraction
  - c. Molarity
  - d. Molality
- Mass percent – It is obtained by using the following relation-

$$\text{Mass per cent} = \frac{\text{Mass of solute}}{\text{Mass of solution}} \times 100$$

#### Mole fraction –

- The ratio of the number of moles of one moles of one component to the total number of moles of all the component present in the solution. It is expressed as X e.g. for a binary solution of two component A and B.

$$X_A = \frac{n_A}{n_A + n_B}, X_B = \frac{n_B}{n_A + n_B}$$

$$X_A + X_B = 1$$

- Molarity (M) is defined as the number of moles of solute dissolve per litre (dm<sup>3</sup>) of the solution.

$$M = n/v \quad \begin{array}{l} n = \text{moles of solute} \\ V = \text{volume of solution} \end{array}$$

Or 
$$\frac{10 \times x \times d}{M_{(\text{solute})}}$$

Where x = percentage by mass of solution  
d = density of the solution in g/cm<sup>3</sup>

M<sub>(solute)</sub> = molar mass of solute

- Molality (m) – The number of moles of solute dissolved per 1000g (1 kg) of the solvent.

$$m = n/w$$

Where n = number of moles of solute  
W = weight of solvent in kg

Or 
$$m = nx1000/ w \text{ (in grams)}$$

- Molality and molarity are related by the equation

$$\frac{D}{M} = \frac{1}{m} + \frac{M_{(solute)}}{1000}$$

- Molarity and normality both changes with change in temperature but molality is independent of temperature.

## STOICHIOMETRY

The elemental analysis in accordance with chemical equations is known as Stoichiometry and can be classified into two parts:

1. Volumetric Analysis
2. Gravimetric Analysis

**1. Volumetric Analysis:** as the name suggest it is the volume based analyiis of elements.

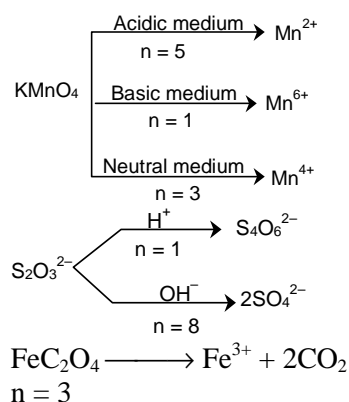
- **Equivalent Weight:** It is the weight of a substance which accepts or donates one mole of electrons.

$$\text{Equivalent weight} = \frac{\text{Molecular weight (or) Atomic weight (or) Ionic weight}}{\text{n factor}}$$

### Calculation of 'n' Factor for Different Class of Compounds

1. **Acids:** n = basicity  
 $\text{H}_3\text{PO}_4$  n = 3  
 $\text{H}_3\text{PO}_3$  n = 2  
 $\text{H}_3\text{PO}_2$  n = 1
2. **Bases:** n = acidity  
 eg. Ammonia and all amines are monoacidic bases
3. **Salt:** (Which does not undergo redox reactions)  
 n factor = Total cationic or anionic charge
4. **Oxidizing Agents or Reducing Agents :** 'n' factor = change in oxidation number Or number of electron lost or gained from one mole of the compound.

#### Examples:



**Note:** In a balanced equation n factor ratio of two compounds is reverse of their molar ratio.

**Interconversion of Molarity and Normality:** Normality = n factor × Molarity

**Law of Chemical Equivalents:** In a chemical reaction the equivalents of all the species (reactants or products) are equal to each other provided none of these compound is in excess.

$N_1V_1 = N_2V_2$  ( when normalities and volumes are given)

$$\frac{W}{E} = \frac{NV}{1000} \text{ (When weight of one substance in given)}$$

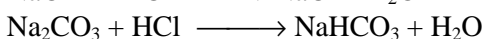
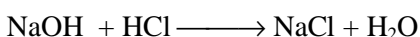
Relation between percentage weight by weight (a), sp. gravity (d) and strength in gm / litre (s)  
**S = 10 ad**

### Back Titration:

This is a method in which a substance is taken in excess and some part of it has to react with another substance and the remaining part has to be titrated against standard reagent.

**Double Titration:** This is a titration of specific compound using different indicators. Let us consider a solid mixture of NaOH,  $\text{Na}_2\text{CO}_3$  and inert impurities.

When the solution containing NaOH and  $\text{Na}_2\text{CO}_3$  is titrated using phenolphthalein indicator following reaction takes place at the phenolphthalein end point –



Here, eq. of NaOH +  $\frac{1}{2}$  eq. of  $\text{Na}_2\text{CO}_3$  = eq. of HCl  
(n=2)

When methyl orange is used,  $\text{Na}_2\text{CO}_3$  is converted into  $\text{NaCl} + \text{CO}_2 + \text{H}_2\text{O}$ .

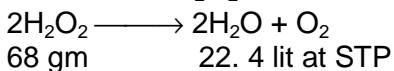
Hence, eq. of NaOH + eq. of  $\text{Na}_2\text{CO}_3$  = eq. of HCl  
(n=2)

Above titration can be carried out using phenolphthalein and methyl orange in continuation as well as separately. Accordingly we apply law of equivalents to calculate percentage composition of the mixture.

**Note:** Phenolphthalein indicates end point when  $\text{Na}_2\text{CO}_3$  is converted into  $\text{NaHCO}_3$

### Volume Strength of $\text{H}_2\text{O}_2$

x volume of  $\text{H}_2\text{O}_2$  means x litre of  $\text{O}_2$  is liberated by 1 volume of  $\text{H}_2\text{O}_2$  on decomposition



$$x \text{ litre of } \text{O}_2 \text{ is released from } \frac{68x}{22.4} \text{ gm of } \text{H}_2\text{O}_2 = \frac{17x}{5.6}$$

$$\text{Strength, S} = \frac{17x}{5.6}$$

$$\text{Normality} = \frac{S}{E} = \frac{17x}{5.6 \times 17} = \frac{x}{5.6}$$

$$\text{Molarity} = \frac{1}{2} \text{ Normality} = \frac{x}{11.2}$$

### Gravimetric Analysis:

In gravimetric analysis we deal with different types of relations like weight - weight, weight - volume, or volume - volume relationship between reactants or products of the reaction.