Concentration:

- The quantity of the solute present in a definite quantity of the solution relative to the solvent is known as the **concentration of the solution** (or) **strength of the solution .**
  Note: A solution whose concentration is known is called as standard solution. The container used to prepare a standard solution is known as standard flask.
- A solution which contains less quantity of the solute compared to the solvent is known as 'dilute solution' i.e., the strength of a dilute solution is 'very low'.
- A solution which contains excess solute, in a definite quantity of the solution is known as a 'concentrated solution' i.e., the strength of a concentrated solution is 'very high'.
- Weight of the solution
  = Volume of the solution × density of the solution
  $W = V \times d$
- The weight of one milli litre of a solution in grams is known as the density of the solution.
  The density of the solution depends on temperature of the solution.
  The units for the density of solution are gram/ml. The ratio between the density of solution and the density of water, both measured at the same temperature is known as relative density of the solution (or) specific gravity of the solution.

- The specific gravity of solution has no units.
  Various terms used in concentration:
  Weight percent:
  Weight fraction = $\frac{weight of solute}{weight of solution}$
  Weight percent = $\frac{weight of solute}{weight of solution} \times 100$
  Volume percent :
  Volume fraction = $\frac{volume of solute}{volume of solution}$
  Volume fraction = $\frac{volume of solute}{volume of solution} \times 100$

- It is applicable for solution containing both solute and solvent as liquids.
  Solubility : It is the weight of solute dissolved in 100 grams of solvent to form saturated solution.
  Solubility = $\frac{weight of solute}{weight of solvent} \times 100$
  Molarity : The number of gram moles of the dissolved solute per litre of solution is known as the molarity of the solution. It is represented by 'M'.
  $= \frac{number of moles of the solute}{volume of the solution in litres}$
- Units for molarity are moles/litre.
- The molarity is the most convenient and commonly used method of expressing the concentration of solution.
- The molarity of a solution slightly decreases with increase in temperature of the solution, due to increase in volume.

$M = \frac{n}{v}$; $M = \frac{no.of millimoles of solute}{volume of solution in m\ell}$

No.of moles of solute = M × V (lit)

No.of milli moles of solute = M × V (mℓ)

$M = \frac{weight of solute in grams}{G.M.W of solute} \times \frac{1}{V_{(lit)}}$

$M = \frac{w}{M.W} \times \frac{1000}{V_{(ml)}}$

$w = M \times M.W. \times V_{(lit)}$

$M = \frac{\% \times 10}{G.M.W} \left(\% \frac{W}{V}\right)$

$M = \frac{density \times 10 \times \%}{G.M.W} \left(\% \frac{W}{W}\right)$

- If a solution is diluted

  $M_1V_1 = M_2V_2$

  M_1 = Molarity before dilution

  M_2 = Molarity after dilution

  V_1 = Initial volume; V_2 = Final volume

  $V_2 = V_1$ + volume of water added

- When two solutions having same solute are mixed.

  The molarity of resultant mixture

  $= \frac{M_1V_1 + M_2V_2 + ...}{V}$

- In case of complete neutralizations or complete reaction between two solutions, the molarity in the resultant mixture is

$$\frac{M_1V_1}{n_1} = \frac{M_2V_2}{n_2}$$

- In case of incomplete reaction or incomplete neutralisation , then the molarity in the resultant mixture,

  $M = \frac{M_aV_a - M_bV_b}{V}$ ($M_aV_a > M_bV_b$)

  $M = \frac{M_bV_b - M_aV_a}{V}$ ($M_bV_b > M_aV_a$)

Equivalent weight (E):

- The weight of the substance which combines with 1 gram of hydrogen or 8 grams of oxygen is called equivalent weight.
- Equivalent weight is the weight of the substance which loses or gains 1 mole of electrons

  No.of equivalents = $\frac{weight of the subs\tan ce(g)}{equivalent weight}$

  No.of milli equivalents = $\frac{weight of the subs\tan ce(mg)}{equivalent weight}$

  $E_{element} = \frac{Atomic weight}{valency}$

  $E_{acid} = \frac{molecular weight}{number of replaceble hydrogens}$

  Ex: $E_{HCl} = \frac{molecular weight}{1}$

- $E_{HNO_3} = \frac{molecular weight}{1}$

$$E_{H_2SO_4} = \frac{molecularweight}{2}$$
$$E_{H_3PO_4} = \frac{molecularweight}{3}$$
$$E_{H_3PO_3} = \frac{molecularweight}{2}$$
$$E_{H_3PO_2} = \frac{molecularweight}{1}$$
$$E_{H_2C_2O_4} = \frac{molecularweight}{2}$$

Equivalent weight of base $=\frac{molecularweight}{numberofreplacebleOH^{-}ions}$

Ex : $E_{NaOH} = \frac{molecularweight}{1}$

$E_{Ca(OH)_2} = \frac{molecularweight}{2}$

$E_{NH_3} = \frac{molecularweight}{1}$

- **Equivalent weight of salt:** $=\frac{\boldsymbol{molecularweight}}{\boldsymbol{totalch\arg e(postiveornegative)}}$

Ex: $E_{NaCl} = \frac{molecularweight}{1}$

$$E_{MgCl_2} = \frac{molecularweight}{2}$$
$$E_{AlCl_3} = \frac{molecularweight}{3}$$
$$E_{Al_2(SO_4)_3} = \frac{molecularweight}{6}$$

- **Equivalent weight of oxidising or reducing agent**

$=\frac{molecularweight}{changeinoxidationstate}$

Ex: $E_{KMnO_4} = \frac{molecularweight}{5}$

($MnO_4^- \rightarrow Mn^{2+}$ in acid medium)

$E_{KMnO_4} = \frac{molecularweight}{1}$

($MnO_4^- \rightarrow MnO_4^{2-}$ in basic medium)

$$E_{KMnO_4} = \frac{molecularweight}{3}$$

($MnO_4^- \rightarrow MnO_2$in neutral medium)

$E_{K_2Cr_2O_7} = \frac{molecularweight}{6}$

($Cr_2O_7^{2-} \rightarrow Cr^{3+}$ in acid and basic medium)

Normality (N):

- The number of gram equivalents of the solute dissolved in one litre of solution is known as its normality.
- Units for normality are gram equivalents/ litre.
- The normality of a solution decreases with increase in temperature of the solution.

  N = $\frac{No.of gram equivalent of the solute}{volume of the solution in litres}$

  N = $\frac{number of milliequivalents of solute}{volume of solution (m\ell)}$
- Number of equivalent weight of solute = N $\times$ $V_{(lit)}$
- Number of milli equivalents of solute = N $\times$ $V_{(ml)}$

  N =$\frac{weight of solute \rightleftarrows in grams}{gram equivalent weight of solute} \times \frac{1}{V_{(litres)}}$

  N =$\frac{W}{G.E.W} \times \frac{1000}{V_{(ml)}}$

  W = N $\times$ G.E.W $\times$ $V_{(lit)}$

  N = $\frac{10\times\%}{G.E.W}$ $\left(\% = \frac{w}{v}\right)$

  N = $\frac{density of solution \times 10 \times \%}{G.E.W}$ $\left(\% \frac{W}{W}\right)$
- If a solution is diluted

  $N_1V_1 = N_2V_2$
- If two solutions having same solute are mixed, normality of the resultant mixture

  N = $\frac{N_1V_1+N_2V_2+.......}{V}$
- When two solutions react completely :

  $N_1V_1 = N_2V_2$
- When a solid reacts with a solution :

$$\frac{W}{G.E.W = NV_{(lit)}}$$

- Normality $\times$ Equivalent weight

  = molarity $\times$ molecular weight

  For any given solute , Mol.weight $\geq$ equivalent weight.

  For any given solution . M $\leq$ N

Formality (F):

- Fomality is the number of formula weights of solute per litre of solution.
- Ionic compounds and polymers do not contain molecules and molecular weights.

  Instead of molecular weight, the formula weight to be taken and instead of molarity the formality to be considered.
- For any given solution, molarity and formality are same.

  Formality=$\frac{weight of solute}{formula weight} \times \frac{1000}{volume of solution (m\ell)}$

- **Molality** : The number of gram moles of the solute dissolved in one kilogram of the solvent is known as the molality of the solution. It is represented by ‘m’.
- The units for molality are mole / kg.
- Molality is independent of temperature.
- Molality is the most inconvenient method of expressing concentration of a solution because it involves determining the weights of liquids.

$$m = \frac{number of gram moles of the solute}{weight of solvent in kilograms}$$

$$m = \frac{weight of solute in grams}{G.M.W of solute} \times \frac{1000}{weight of solvent in grams}$$

- The molality of a saturated solution is given by

$$m = \frac{10 \times solubility}{G.M.W. of solute}$$

If molarity is given :

$$m = \frac{1000 \times M}{(1000 \times d) - (M \times Mol.weight)}$$

Mole fraction :

- The ratio between the number of moles of solute and the total number of moles of solute and solvent in the solution is known as the mole fraction of the solute. It is represented by X_1.

$X_1 = \frac{n}{n+N}$ n = No.of moles of solute

N = No.of moles of solvent

- The ratio between the number of moles of solvent and the total number of solute and the solvent in the solution is known as the mole fraction of the solvent. It is represented by X_2.

$X_2 = \frac{N}{n+N}$ N = No.of moles of solvent

n = No.of moles of solute

- Mole fraction can be expressed with reference to any component of the solution.
- If molality of aqueous solutions is known, then

$$X_1 = \frac{m}{m+55.55}$$

- Mole fraction of solute has no units. The sum of mole fractions of all components in a solution = 1.
- Mole fraction is independent of temperature.

Mole percent :

- The number of moles of solute present in 100 moles of a homogenous mixture of solute and solvent is known as the mole percent of the solute.

Mole percent of solute=Mole fraction of solute×100

Mole percent of solvent=Mole fraction of solvent×100