

Analytical Chemistry

1st Class

Second: Chemical Methods for Expressing concentration

I. Molarity (M): Is the total number of moles of a solute in 1L of solution. Or the total number of millimoles in 1 mL.

$$M = \frac{\text{no.moles (solute)}}{V. \text{ Soln.L}}$$

No. = number.

Soln. = Solution.

$$\text{Moles} = \frac{W}{M.wt.}$$

$$M = \frac{\frac{W}{M.Wt.}}{V} \leftrightarrow \frac{W}{M.wt. \times V.L}$$

$$M = \frac{W \times 1000}{M.Wt. \times V_{mL}}$$

This law used for solid state material

mole/L, mmol/mL → Molar

No. of moles = $M \times V_{(L)}$

No. of millimoles = $M \times V_{(mL)}$

$$M = \frac{Sp.gr. \times \% \times 10}{M.Wt.}$$

Molarity of liquid state solution

$$\text{Specific gravity : } Sp.gr. = \frac{\text{Density of Substance}}{\text{density of Water}}$$

\therefore Density of water (H_2O) $d(H_2O) = 1$ \therefore Sp.gr. = d

Dilution Law

Number of moles of concentration solution = number of moles of dilution solution.

Conc. Soln.

dil. Soln.

no. of moles = no. of moles

no. of millimoles = no. of millimoles

$$M_1 \cdot V_1 = M_2 \cdot V_2$$

Ex.1. Prepare 0.1M of calcium carbonate $CaCO_3$ in 2 liter?

A.wt. : Ca = 40, C = 12, O = 16

Ex.2. Calculate the volume of NH_3 conc. which used to prepare 500 mL of 0.1 M NH_3 , sp.gr. of concentrated solution = 0.9 and the percentage = 28%, M.wt. = 17.?

II. Formality (F): It is number of formula weight of solute in liter of solution.

$$F = \frac{W \times 1000}{F.Wt. \times VL} \qquad F = F.w/L, m.Fw./mL \rightarrow \text{Formal}$$

III. Normality (N): It is the number of equivalents of solute in liter of solution.

$$N = \frac{\text{no.of equivalent}}{\text{Vol.of solution (L)}}$$

$$\text{no.eq.} = \frac{Wt.}{\text{eq.Wt.}} \dots$$

The equivalent weight (eq.wt.) of a substance is not a constant quantity, but it's value depend upon the reaction, in which it is taken part.

$$\text{Since; Eq.wt} = \frac{Mwt.}{n} \qquad n : \text{the reacting units}$$

$$N = \frac{W \times 1000}{\text{eq.wt.} \times VmL} \qquad \text{For solid state material}$$

$$N = \text{eq/L, m.eq./mL} \rightarrow \text{Normal}$$

$$N = \frac{Sp.gr. \times \% \times 10}{\text{eq.wt.}} \qquad \text{For liquid state solution}$$

To calculate the equivalent weight (eq.wt.):

$$eq.wt. = \frac{M.wt.}{n}$$

n = active unite.

n = H⁺ (acids).

n = OH⁻ (bases).

n = charge × number of ions (salt).

n = no.of electrons lost or gained (oxidation –reduction).

Calculate the equivalent weight:

A. Of Element

$$eq.wt. = \frac{A.wt.}{no.of oxidant}$$

Ex. 1. What is the eq.wt. of Mg? A.wt. = 24

$$Eq.wt. = \frac{A.wt.}{no.of oxidant} = \frac{24}{2} = 12$$

B. Of Acid

$$eq.wt. = \frac{A.wt.}{no.of hydrogen atoms interacting}$$

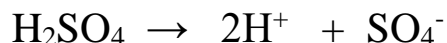
Ex.1. Calculate the equivalent weight of HCl? M.wt. = 36.5



$$eq.wt. of HCl = \frac{M.wt.}{no.of proton replacable of base}$$

$$eq.wt. of HCl = \frac{36.5}{1} = 36.5$$

Ex.2. Calculate the equivalent weight of H_2SO_4 ? M.wt. = 98.



$$\text{eq.wt. of H}_2\text{SO}_4 = \frac{\text{M.wt.}}{\text{no.of proton replacable of base}}$$

$$\text{eq.wt. of H}_2\text{SO}_4 = \frac{98}{2} = 49$$

So, H_2SO_4 has two reacting units of proton ; there are two equivalents of proton in each mole. While HCl has one reacting unit of proton, there is one equivalent of proton in each mole. So the normality of H_2SO_4 solution is twice its molarity.

$$\text{N of H}_2\text{SO}_4 = \text{M} \times 2$$

C. Of Base

$$\text{eq.wt.} = \frac{\text{M.wt.}}{\text{no.of reactivehydroxil groups}}$$

Ex.1. Calculate the equivalent weight of NaOH ? M.wt. = 40

$$\text{eq.wt. of NaOH} = \frac{\text{M.wt.}}{\text{no.of reactivehydroxil groups}}$$

$$\text{eq.wt. of NaOH} = \frac{40}{1} = 40$$

Ex.1. Calculate the equivalent weight of $\text{Mg}(\text{OH})_2$? M.wt.58

$$\text{eq.wt. of Mg}(\text{OH})_2 = \frac{\text{M.wt.}}{\text{no.of reactivehydroxil groups}}$$

$$\text{eq.wt. of Mg}(\text{OH})_2 = \frac{58}{2} = 29$$

D. Of Salt

$$eq.wt. = \frac{M.wt.}{\text{number of metal atoms} \times \text{no.of charge or no.of oxidant}}$$

Ex.: Calculate the eq.wt. of Na_2CO_3 ? M.wt. = 106

$$\begin{aligned} eq.wt. \text{ of } \text{Na}_2\text{CO}_3 &= \frac{M.wt.}{2 \times (+1)} \\ &= \frac{106}{2 \times (+1)} = 53 \end{aligned}$$

E. Of material that suffer oxidation reduction

$$eq.wt. \text{ of oxidation} = \frac{M.wt.}{\text{number of loss electrons}}$$

$$eq.wt. \text{ of reduction} = \frac{M.wt.}{\text{number of gain electrons}}$$

Ex.: Calculate the eq.wt. of manganese Mn^{+2} and ferrous Fe^{+2} in the equation below?



$$eq.wt. \text{ of } \text{Mn}^{+2} = \frac{M.wt.}{\text{number of loss electrons}}$$

$$eq.wt. \text{ of } \text{Mn}^{+2} = \frac{M.wt.}{5}$$

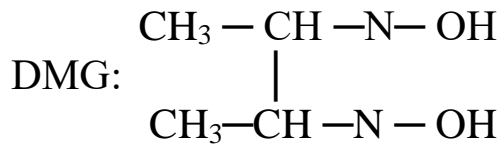
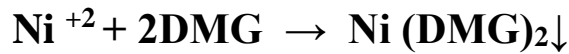
$$eq.wt. \text{ of } \text{Fe}^{+2} = \frac{M.wt.}{\text{number of gain electrons}}$$

$$eq.wt. \text{ of } \text{Fe}^{+2} = \frac{M.wt.}{1}$$

F. Of Complex Formation Reaction

$$eq.wt. = \frac{M.wt.}{no.of\ oxidant\ of\ ion\ which\ contact\ with\ ligand}$$

Ex.: Calculate the eq.wt. of Nickle Ni^{+2} in the equation below?



$$eq.wt. = \frac{M.wt.}{no.of\ oxidant\ of\ ion\ which\ contact\ with\ ligand}$$

$$eq.wt. = \frac{M.wt.}{2}$$

- What is the relationship between Molarity or Normality with part per million ppm?

$$C\ ppm = \frac{Wt.g}{V.mL} \times 10^6$$

$$M = \frac{W \times 1000}{M.Wt. \times VmL}$$

Multiple denominator and numerator by 10^6

$$M = \frac{W \times 1000}{M.Wt. \times VmL}$$

$$M = \frac{ppm \times 1000}{M.Wt. \times 10^6}$$

$$M = \frac{ppm}{M.Wt. \times 1000}$$

$$\therefore ppm = M \times M.wt. \times 1000$$

$$ppm = N \times eq.wt. \times 1000$$