

## ***II. Parts per thousand, Parts per million and Parts per billion:***

$$C_{ppt} = \frac{Wt.g}{V.mL} \times 10^3 \quad (\text{which used specially in oceanography}).$$

For very dilute solution part per million (ppm) is a convenient way to express concentration.

$$C_{ppm} = \frac{Wt.g}{V.mL} \times 10^6 \quad \text{For aqueous solution.}$$

$$ppm = 1.0 \text{ mg/L} \quad \equiv \quad 1.0 \mu\text{g} / \text{mL}$$

$$C_{ppb} = \frac{Wt.g}{V.mL} \times 10^9$$

### ***Example:***

Calculate the number of grams of KCl to prepare solution in volume 500mL, the concentration of KCl in the solution is 250 ppm?

### III. P- Function:

Sometimes it's suitable to expressing concentration of ion by logarithm.

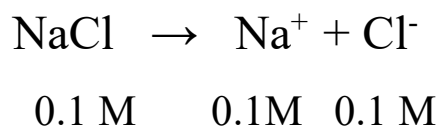
The most well known p-function is pH which it is negative logarithm of  $[H^+]$ . ( $H^+$  concentration).

$$pH = - \log [H^+]$$

$$pOH = - \log [OH^-]$$

$$pX = - \log [X^-]$$

**Example:**



$$pNa^+ = - \log [Na^+]$$

$$= -\log [0.1]$$

$$= 1$$

$$0.1 = 10^{-1}$$

## ***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.

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

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

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

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

## ***Dilution Law***

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

**Conc. Soln.**

no. of moles

=

**dil. Soln,**

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  $\text{CaCO}_3$  in 2 litter?

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

**Ex.2.** Calculate the volume of  $\text{NH}_3$  conc. which used to prepare 500 mL of 0.1 M  $\text{NH}_3$ , 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.

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

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

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

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

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.

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

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

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

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

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

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

n = active unite.

n = H<sup>+</sup> (acids).

n = OH<sup>-</sup> (bases).

n = charge × number of ions (salt).

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

**Calculate the equivalent weight:**

**A. Of Element**

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

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

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

**B. Of Acid**

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

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



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

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

**Ex.2.** Calculate the equivalent weight of  $\text{H}_2\text{SO}_4$ ? 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,  $\text{H}_2\text{SO}_4$  has two reacting units of proton ; there are two equivalents of proton in each mole. While  $\text{HCl}$  has one reacting unit of proton, there is one equivalent of proton in each mole. So the normality of  $\text{H}_2\text{SO}_4$  solution is twice its molarity.

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

To convert Molarity (M) to Normality (N) use the following law

$$N = M \times n \text{ Factor}$$

### C. Of Base

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

**Ex.1.** Calculate the equivalent weight of  $\text{NaOH}$ ? 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.2.** Calculate the equivalent weight of  $\text{Mg(OH)}_2$ ? M.wt.58

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

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

### D. Of Salt

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

**Ex.:** Calculate the eq.wt. of  $\text{Na}_2\text{CO}_3$ ? M.wt. = 106

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

### E. Of material that suffer oxidation reduction

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

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

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



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

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

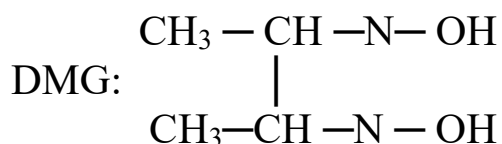
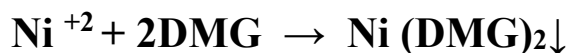
$$\text{eq.wt. of Fe}^{+3} = \frac{\text{A.wt.}}{\text{number of loss electrons}}$$

$$\text{eq.wt. of Fe}^{+3} = \frac{\text{A.wt.}}{1}$$

## F. Of Complex Formation Reaction

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

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



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

$$eq.wt. Ni = \frac{At.wt.}{2}$$

- 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  $10^6$

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

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

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

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

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