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

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

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

$$Cppm = \frac{Wt.g}{V.mL} \times 10^6$$ For aqueous solution.

$$ppm = 1.0\ mg/L \equiv 1.0\ \mu g/mL$$

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

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:

$$NaCl \rightarrow Na^+ + Cl^-$$

0.1 M 0.1M 0.1 M

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

$$= -\log [0.1] \qquad 0.1 = 10^{-1}$$

$$= 1$$

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.

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

No. = number.

Soln. = Solution.

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

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

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

This law used for ***solid state*** material

mole/L, mmol/mL → Molar

No. of moles = M × $V_{(L)}$

No. of millimoles = M ×$V_{(mL)}$

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

Molarity of ***liquid state*** solution

Dilution Law

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

Conc. Soln.		***dil. Soln,***
no. of moles	=	no. of moles
no. of millimoles	=	no. of millimoles

$$M_1 \, . \, V_1 = M_2 \, . \, V_2$$

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

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.

$$F = \frac{W \times 1000}{F.Wt. \times VL}$$

F= F.w/L, m.Fw./mL → Formal

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

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

$$no.eq. = \frac{Wt.}{eq.Wt.} \quad ....$$

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.

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

$$N = \frac{W \times 1000}{eq.wt. \times VmL}$$

For **solid state** material

N= eq/L, m.eq./mL → Normal

$$N = \frac{Sp.gr. \times \% \times 10}{eq.wt.}$$

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

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

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

$$HCl \rightarrow H^+ + Cl^-$$

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

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

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

$$H_2SO_4 \rightarrow 2H^+ + SO_4^-$$

$$\text{eq.wt. of } H_2SO_4 = \frac{\text{M.wt.}}{\text{no.of proton replacable of base}}$$

$$\text{eq.wt. of } H_2SO_4 = \frac{98}{2} = 49$$

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.

$$N_{\text{of } H2SO4} = M \times 2$$

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

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

C. Of Base

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

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.2. Calculate the equivalent weight of $Mg(OH)_2$? 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

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

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

$$\text{eq.wt. of } Na_2CO_3 = \frac{M.wt.}{2\times(+1)}$$

$$= \frac{106}{2\times(+1)} = 53$$

E. Of material that suffer oxidation reduction

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

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

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

$$\mathbf{MnO_4^- + Fe^{+2} + 8H^+ + 5e^- \rightarrow Mn^{+2} + Fe^{+3} + 4H_2O}$$

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

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

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

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

F. Of Complex Formation Reaction

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

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

$$\mathbf{Ni^{+2} + 2DMG \rightarrow Ni(DMG)_2 \downarrow}$$

DMG:

$CH_3 - CH - N - OH$
$\qquad\quad |$
$CH_3 - CH - N - OH$

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

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

- 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 × M.wt. × 1000***

ppm = N × eq.wt. × 1000