# Volumetric Analysis

- Eq. wt = $\frac{\text{Mol. wt}}{\text{Valency Factor / n-Factor}}$

## ① Calculation of Eq. wt of Acid :-

$$E = \frac{\text{mol. wt}}{\text{Basicity}}$$

↳ no. of replaceable Hydrogen

ⓐ Inorganic acid → no. of H = basicity

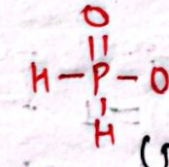
HCl → 1, $H_2SO_4$ → 2, $HNO_3$ → 1

HBr → 1, $H_3PO_4$ → 3 (↳ phosphoric acid), $H_2CO_4$ → 2

$HClO_4$ → 1, $HPO_3$ → 1 (↳ metaphosphoric acid)

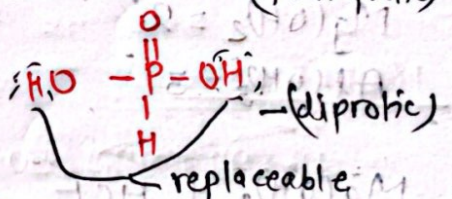
except :-

$H_3PO_2$ → Hypophosphorus acid → 1



(replaceable, monoprotic)

$H_3PO_3$ → phosphorus acid → 2

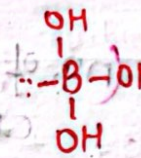


(diprotic, replaceable)

HF → exist in dimer form (because of intermolecular H-bond)

$H_2F_2$ ⇒ 2

$H_3BO_3$ → Boric acid → 1



Aprotic, e⁻ pair accept. So, monobasic (lewis acid).

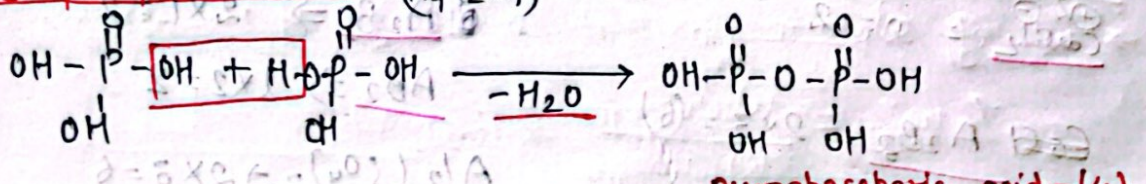
Rxn: $H_3PO_4 + NaOH \longrightarrow Na_2HPO_4 + H_2O$

↳ basicity = 2. $E = \frac{M}{2} = \frac{98}{2} = 49$

$H_3PO_4 + NaOH \longrightarrow NaH_2PO_4 + H_2O$

↳ basicity = 1. $E = \frac{M}{1}$

* Pyrophosphoric acid ($H_4P_2O_7$)



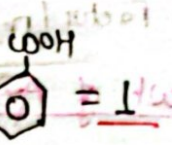
Pyrophosphoric acid = (4)

⑥ Organic acid.

$-COOH$ containing acid.

⇒ No. of $-COOH$ = basicity

(i) $CH_3-COOH = 1$

(ii)  $= 1$

(iii) $\begin{matrix} COOH \\ | \\ COOH \end{matrix} \Rightarrow 2$

(iv) $\begin{matrix} CH_2-COOH \\ | \\ CH-COOH \\ | \\ CH_2-COOH \end{matrix} \Rightarrow 3$

② eq. wt for base

$$E.W = \frac{\text{mol. wt}}{\text{acidity}}$$

↳ no. of replaceable $OH^-$.

↓

no. of replaced $OH^-$ (if rxn is given).

$NaOH = 1$

$Mg(OH)_2 = 2$

$Al(OH)_3 = 3$

$Zn(OH)_2 = 2$ } No exception

$B(OH)_3 = B(H_3BO_3)$
↳ not base
So, no acidity

• $Mg(OH)_2 + HCl \longrightarrow Mg(OH)Cl + H_2O$

↳ acidity = (1) $EW = \frac{\text{mol. wt}}{1}$

③ Radical (no. of charge = Basicity)

$Na^+ = 1$ $Cl^- = 1$

$CO_3^{2-} = 2$ $PO_4^{3-} = 3$ $NH_4^+ = 1$

④ Salt:

n = total no of either +ve charge or −ve charge.

$NaCl$ = n = 1.

$CaCl_2$ = n = 2

$A_2B_3 = 2 \times 3 = (6)$

$A_xB_y \Rightarrow (x \times y = n\text{-Factor})$

$A_2B \Rightarrow 2 \times 1 = 2$

$AB_2 \Rightarrow 1 \times 2 = 2$

· $^{+2}CaO^{-2}$ = 2 → (AB rule) ✗ ← · $^{+3}Al(PO_4)^{-3}$ = 3

· $^{+2}CaSO_4^{-2}$ → 2

· $Ca_3(PO_4)_2 = 3 \times 2 = 6$

· $^{+1}NaHCO_3^{-1}$ = 1

# Equivalent weight of oxidising agent & reducing agent

$$E = \frac{\text{Mol. wt}}{\text{V. factor}}$$

↳ change in O.N per mole or, no. of $e^-$ transfered per mole.

· List of important O.A

① $KMnO_4$ →

· in acidic medium

$$\overset{+7}{K}\overset{+7}{Mn}O_4 \longrightarrow \overset{+2}{Mn}O$$

5 × 1 = 5 ↳ V.f.

$$\text{Eq wt} = \frac{\text{Mol. wt}}{5}$$

· in basic medium

$$\overset{+7}{K}\overset{+7}{Mn}O_4 \longrightarrow K_2\overset{+6}{Mn}O_4$$

1 × 1 = 1 → V.f

$$\text{eq. wt} = \frac{\text{Mol wt}}{1}$$

· in Neutral medium

$$\overset{+7}{K}\overset{+7}{Mn}O_4 \longrightarrow \overset{+4}{Mn}O_2$$

3 × 1 = 3 ↳ V.f

$$\text{eq wt} = \frac{\text{mol. wt}}{3}$$

Q Bi NA ⇒ 135

② $K_2\overset{+6}{Cr_2}O_7$ → rxt only in acidic medium

↳ $Cr^{+3}$

3 × 2 = 6 ↳ V.f

$$\text{eq. wt} = \frac{\text{mol. wt}}{6}$$

$$K_2Cr_2O_7 \xrightarrow[H_2SO_4]{\text{acidic med.}} Cr_2(SO_4)_3$$

③ $H_2O_2$

$\rightarrow H_2\overset{-1}{O_2} \xrightarrow{O.Agent} H_2\overset{-2}{O}$

$1 \times 2 = 2$ ↳ V.F

$Eq.wt = \frac{Mol.wt}{2}$

- List of important Reducing agent

① $H_2\overset{-1}{O_2} \xrightarrow{R.agent} \overset{0}{O_2}$

$1 \times 2 = 2$ ↳ V.F

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

② $K\overset{-1}{I} \longrightarrow \overset{0}{I_2}$

$1 \times 1 = 1$ ↳ V.F

$eq\,wt = \frac{mol\,wt}{1}$

③ $\begin{matrix} COOH \\ | \\ COOH \end{matrix}$ or $H_2\overset{+3}{C_2}O_4 \longrightarrow \overset{+4}{CO_2}$ (oxalic acid)

$1 \times 2 = 2$ ↳ V.F

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

④ Mohr's salt

$\overset{+2}{Fe}SO_4(NH_4)_2SO_4 \cdot 6H_2O \longrightarrow \overset{+3}{Fe}$

$1 \times 1 = 1$ ↳ V.F

$eq\,wt = \frac{Mol\,wt}{1}$

⑤ $Na_2S_2O_3$ (sodium thiosulphate (Hypo))

$1 \times 2 = V.F \Rightarrow eq\,wt = \frac{Mol\,wt}{2}$

$\overset{+2}{Na_2}\overset{2}{S_2}O_3 + \overset{0}{I_2} \longrightarrow Na_2\overset{+2.5}{S_4}O_6 + \overset{-1}{NaI}$

$0.5 \times 2 = 1$ ↳ V.F

sodium tetrathionate

$eq.wt = \frac{Mol.wt}{1}$

⑥ # Concentration Term

① % w/w or % by weight :-

→ wt. of solute in gm that in 100 gm of its solution.

$\%\ w/w = \frac{w_{solute\ (gm)}}{w_{soln\ (gm)}} \times 100\%$

(unitless)

Q. An aqueus solution contains 30% by wt. of urea.

(a) What does it mean?

– 30 gm of urea is present in 100 gm of urea solution.

# 20% w/w of NaOH

wt. of NaOH = 20 gm

wt. of NaOH soln = 100 gm

$\eta_{NaOH} = \frac{20}{40} = \frac{1}{2}$

Weight of solvent = 100 − 20 = 80 gm

$\eta_{solvent} = \frac{80}{100} = 4/5$

# 11% w/w of sucrose

11 gm sucrose

100 gm sucrose solution.

So, 89 gm → water (solvent)

Q. 30% w/w urea solution:– Calculate weight of solute & solvent in 7.5g solution

30 gm urea ⇒ 100 g urea solution

100 g ⇒ 30 g

$7.5g = \frac{30}{100} \times 7.5 = 2.25$ gm urea. ↳ $W_{solute}$

$W_{solvent} = 7.5 - 2.25$

$= 5.25g$.

Q. 0.2 moles glucose are dissolved in 64g of water. Calculate % w/w of glucose in the solution:–

→ $\% W/w = \frac{\text{wt. of solute (g)}}{\text{wt. of soln (g)}} \times 100$

$= \frac{36}{100} \times 100\%$

$= 36\%$

→ wt. of solute = $0.2 \times 180$ (M.W) = 36 gm

→ wt. of solution = 36 + 64 = 100 gm

② % w/v →

→ wt. of solute (gm) present in 100mL of solution.

$$\% \, w/v = \frac{W_{solute}\,(gm)}{V_{soln.}\,(ml)} \times 100$$

Q. An aq. solution contain 30% w/v of urea. what does it mean?

→ 30g of urea present in 100mL of urea soln.

· What wt. of urea will be in 5mL of soln?

~~100gm = 30~~ 100mL = 30gm

$5ml = \frac{30}{100} \times 5 = 1.5gm$ of urea.

Q. 5% w/v sucrose soln:—

5gm sucrose = 100ml soln.
sucrose

Q. 5moles of glucose are dissolved in 1.1kg of water. If density of solution is 1.25g/ml. Then determine % w/v of glucose.

→ wt. of glucose = 5 moles × 180 M.W
= 900gm

wt of solvent = 1100gm

wt. of solution = 1100 + 900
= 2000gm.

$\delta = \frac{m}{V}$

$V = \frac{m}{d}$

$= \frac{2000}{1.25} = 1600ml.$

$\therefore \% \, w/v = \frac{900}{1600} \times 100\%$

$= 56.25\%$

- Relation between % w/w & % w/v

$\therefore \% \, w/v = \frac{W_{solute}}{V_{soln}} \times 100$

$= \frac{W_{solute}}{W_{soln}/d_{soln}} \times 100 = \frac{W_{solute} \times d_{soln}}{W_{soln}} \times 100$

$\therefore$ $\%\ w/v = \%\ \frac{w}{w} \times$ density (sp. gravity also)

③ gm/litre (strength of soln)

→ wt of solute in gm present in 1L of its solution.

$$g/L = \frac{w_{solute\ (gm)}}{V_L}$$

$$g/L = \frac{W_{solute\ (gm)}}{V_{mL}} \times \frac{1000}{100 \times 10}$$

$\%\ w/v$

$$g/L = \%\ \frac{w}{v} \times 10$$

$$g/L = \%\ \frac{w}{w} \times d \times 10$$

Q. 5 g/L NaOH soln:-

→ wt of NaOH = 5gm

→ vol. of soln = 1 litre.

5g NaOH = 1000mL of its soln.

Q. 10% $w/v$ NaOH solution:-

g/L = ?

a) wt. of solute = 10 gm

soln. vol = 100 mL

100 mL → 10 gm

so, 1L → 10×10 = 100g

$g/L = \%\ w/v \times 10 = 10 \times 10 = 100\ g/L$

Q. 20 g/L of KOH solution:-

20g KOH = 1000 mL of KOH solution.

$$\%\ w/v = \frac{20}{1000} \times 100$$

$$= \frac{20}{10} = 2.$$

Q. 15g/L NaOH solution :- %. w/v = ?

$\therefore$ %. $\frac{w}{v} = \frac{15}{1000} \times 100\%$.

$= \frac{15}{10} = 1.5\%$

Q. 19% w/v of urea solution. gm/L = ?

wt. of urea = 19g
wt. of soln = 100ml.

$gm/L = \frac{19}{100} \times 1000$

$= 190\ g/L$.

Q. 25% $\frac{w}{v}$ of NaOH. gm/L = ?

25g NaOH = 100 ml of NaOH soln.

$gm/L = \frac{25}{100} \times 1000$

$= 250\ g/L$

## (4) Molarity (M)

→ no. of moles of solute present in 1 Litre solution.

$$M = \frac{\text{no. of moles of solute}}{\text{vol. of soln in litre}}$$

$M = \frac{n}{V_L}$, $M = \frac{n}{V_{mL}} \times 1000$

$M = \frac{w}{M.w \times V_L}$, $M = \frac{w}{M.w \times V_{mL}} \times 1000$

n → mole.

Q. 5M NaOH solution.

→ ~~5M of~~ 5 moles of NaOH is prest in 1L of NaOH soln.

Q. 2M urea soln :-

2 moles urea = 1L of urea soln.

$$M = \frac{n_{solute}}{V_L}$$

$$\boxed{n_{solute} = M \times V_L}$$

$$\boxed{\text{milimole} = M \times V_{mL}}$$

Q. 30g of urea is dissolved in sufficient water to produce 200ml soln. Calculate:-

① %w/v

$$\%\,w/v = \frac{30}{200} \times 100$$

$$= 15\%$$

(ii) Molarity $\leftarrow n = \frac{30}{60} = \frac{1}{2}$ (M.W)

$$M = \frac{\frac{1}{2}}{200\,ml} \times 1000$$

$$= \frac{10}{4} = 2.5M.$$

- Semi-molar = $M/2$
- Molar = $M$
- Decimolar = $M/10$
- centimolar = $M/100$
- millimolar = $M/1000$

Q. Calculate wt. of $H_2SO_4$ ~~that~~ present in 200ml of decimolar soln.

0.2 litre. $1/10$ M.

$$\rightarrow n = M \times V_L$$

$$= \frac{1}{10} \times 0.2$$

$$= 0.02$$

$$wt = n \times M.W$$

$$= 0.02 \times 98$$

$$= 1.96\ gm.$$

Q. Calculate molarity:-

(i) 18g of glucose in 1L of glucose solution:-

$$n = \frac{18}{180} = \frac{1}{10} \quad M = \frac{n}{V_L} = \frac{0.1}{1} = 0.1.$$

(ii) 2 millimoles in 200ml soln.

$$M = \frac{2\ (\text{millimole})}{200\ (\text{millilitre})} = 0.01M.$$

③ 5 moles in 2000 mL soln:-

$$M = \frac{5}{2000} \times 1000$$

$$= 2.5$$

④ 5 M NaOH soln:-

$n_{NaOH} = 5$

V. of soln = 1 L

$M = \frac{5}{1}$

wt. of NaOH = 5 × 40

= ~~320g~~ 200g

$$\% \, w/v = \frac{200}{1000} \times 100$$

= 20%

⑤ Molality (m)

→ defined as no. of moles of solute present per kg of solvent.

1kg solvent = no. of moles of solute

$$m = \frac{\text{no. of moles of ~~unit~~ solute}}{\text{wt of solvent (kg)}}$$

unit → mole/kg.

Q. 5m NaOH.

$n_{NaOH} = 5$

wt. of $H_2O$ (solvent) = 1 kg.

Q. 360 g of glucose is added in sufficient $H_2O$ to produce 1.36 kg of solution. Calculate molality in solution.

→ $n = \frac{360}{180} = 2.$ (moles)

wt. of solution = 1360 gm.

wt. of solvent = 1360 − 360

= 1000 gm

= 1 kg

$m = \frac{2}{1} = 2$ molal.

Q. 90 g of glucose are dissolved in sufficient water to produce 500 mL of solution. If density of solution is 1.18 g/mL. Calculate. 0.5 L.

(a) Molarity (b) Molality (c) % w/v (d) % w/w

$$n = \frac{90}{180} = 0.5$$

(a) $M = \frac{0.5}{0.5} = 1M$

(b) $d = \frac{m}{V}$

$m = d \times V$

$= 1.18 \times 500$

$= 590$

$\therefore m = \frac{0.5}{0.5} = 1.$

$w_{solvent} = 590 - 90 = 500\,g = 0.5\,kg.$

(c) $\% w/v = \frac{90}{500} \times 100\% = 18\%$

(d) $\% w/w = \frac{\text{wt of solute}}{\text{wt of soln}} \times 100$

$= \frac{90}{590} \times 100$

$= 15.25\%$

Q. Calculate molarity of $H_2SO_4$ solution which contains 98% w/w of $H_2SO_4$ & having density 1.8 gm/ml.

$$M = \frac{98 \times 10 \times 1.8}{98} = 18\,M.$$

Q. 98% w/w of $H_2SO_4$.

wt of $H_2SO_4 = 98\,g$

wt of soln $= 100\,gm$

$d = \frac{m}{V}$

$V = \frac{m}{d} = \frac{100}{1.8} = 55.55\,mL$

$M = \frac{1}{55.55} \times 1000$

$= 18\,M$

Q. An aq. soln contains 28 % w/w KOH. if density of soln is 1.25 gm/mL. Find:-

ⓐ M ; ⓑ m ; ⓒ % w/v

→ 28 % w/w KOH

wt of KOH = 28 g. ; wt of soln = 100 gm

wt of solvent = 100 − 28 = 72 g.

$\therefore M = \frac{\text{wt of KOH}}{V_{ml}} \times 1000$

$= \frac{0.5}{80} \times 1000$

$= 6.25\ M.$

$\because V = \frac{m}{d} = \frac{100}{1.25}$

$= 80\ mL$

$m = \frac{0.5}{72} \times 1000 = 6.94$

$\% w/v = \frac{28}{80} \times 100$

$= 35\ \%$

Q. 36 % w/v KOH solution.

wt of KOH = 36 g.

vol. of soln = 100 mL.

$M = \frac{36/56}{100} \times 1000$

$= \frac{36}{5.6}\ M.$

Q. 2 M NaOH soln, density of solution is 1.18 gm/mL.

ⓐ % w/v ⓑ % w/w ⓒ m

→ 2 M NaOH soln.

$n_{NaOH} = 2$

vol. of soln = 1 L

$\therefore w = 2 \times 40 = 80\ gm$

$\because \% w/v = \frac{80}{1000} \times 100$

$= 8\ \%$

$d = \frac{m}{V}$

$m = d \times V = 1.18 \times 1000 = 1180\ g.$

$\therefore$ wt of solvent $= 1180 - 80$

$= 1100\ gm$

$m = \frac{2}{1.1\ kg}$

$\% w/w = \frac{80}{1180} \times 100\ \%$

# Mole fraction

→ Ratio of moles of substance to total moles.

$$\chi_{substance} = \frac{n_{substance}}{n_{total}}$$

Solution

Solute (A) — Solvent (B)

$$\chi_{solute} = \chi_A = \frac{n_A}{n_A + n_B} \qquad \chi_{solvent} = \chi_B = \frac{n_B}{n_A + n_B}$$

$$\chi_A + \chi_B = 1$$

$$\Sigma \chi = 1 \rightarrow \text{always}$$

Q. 30 g of urea is mixed with 45 g of $H_2O$.

① determine % w/w of urea

② mole fraction of urea.

(i) → $\% w/w = \frac{30}{30+45} \times 100$

$= 40\%$

(ii) $\chi_{urea} = \frac{1/2}{\frac{1}{2} + \frac{45}{18}} = \frac{1}{6}$

$n_{urea} = \frac{30}{60} = \frac{1}{2}$

$n_{water} = \frac{45}{18} = 2.5$

Q. Mole fraction of glucose = 0.05 in aq. solution. % w/w = ?

M.W of glucose = 180

Mole fraction of glucose = 0.05

Mole fraction of water = 1 − 0.05

= 0.95 (Total moles = 1)

$n_{glucose} = 0.05 \times 180 = 9$

$n_{H_2O} = 0.95 \times 18 = 17.1$

$\% w/w = \frac{9}{9+17} \times 100\%$

$= \frac{9}{26} \times 100\%$

$= 34.4\%$

Q. $X_{NaOH} = 0.2$, $d = 1.12 gm/ml$.

(i) % w/w (ii) m (iii) g/L (iv) M (v) % w/v

Moles fraction of NaOH = 0.2.

M.W = 40 Total moles = 1

$n_{NaOH} = 0.2$ $n_{H_2O} = 0.8 = 0.8 \times 18 = 14.4 gm$ ($W_{H_2O}$)

$W_{NaOH} = 0.2 \times 40 = 8 gm$

$W_{soln} = 22.4 gm = (14.4 + 8)$

$V_{soln} = \frac{22.4}{1.12} = 20 mL$.

(i) % w/w $= \frac{8}{22.4} \times 100\% =$

(ii) $m = \frac{0.2}{14.4 - \text{wt of solvent}} \times 1000 =$

(iii) g/L $= \frac{8}{20} \times 1000$

(iv) $M = \frac{0.2}{20} \times 1000$

(v) % w/v $= \frac{8}{20} \times 100\%$

Q. Calculate molality of urea solution in which mole fraction of urea is 0.25.

$X_{urea} = 0.25$

Total moles = 1

$n_{urea} = 0.25$ $W_{urea} = 0.25 \times 60 = 15$

$n_{H_2O} = 0.75$ $W_{H_2O} = 0.75 \times 18 = 13.5$

$m = \frac{0.25}{13.5} \times 1000 = 18.51 m$

$N = \frac{gm\ equi}{V_L}$

$\therefore gm\ eq = N \times V_L$

$$\boxed{gm\ eq = N \times V_L = \frac{w}{E} = mole \times V.F}$$

## # Dilution

$\boxed{M_1, V_1} \xleftarrow{H_2O}$ soln. ↳ initial situation

$M_1 \times V_1 = n_1$ ↳ moles.

$\boxed{M_2 \quad V_2}$ → new soln. $\boxed{V_2 > V_1}$

↳ $M_2 \times V_2 = n_2$ $\boxed{M_1 > M_2}$

$n_1 = n_2$

$\boxed{M_1V_1 = M_2V_2}$ → Dilution formula

Q. $M_1 = 2M$, $V_1 = 200mL$ . 300mL of $H_2O$ added. $M_2 = ?$

$M_1V_1 = M_2V_2$

$2 \times 200 = M_2 \times (200+300)$

$M_2 = 0.8M.$

Q. How much water should be added in 250 mL of semimolar NaOH solution to make it decimolar.

Soln. $V_1 = 250$, $M_1 = \frac{1}{2}$. $M_2 = \frac{1}{10}$, $V_2 = ?$

$V_1M_1 = M_2V_2$

$250 \times \frac{1}{2} = \frac{1}{10} \times V_2$

$V_2 = 1250\ mL.$

$\therefore V_{water\ added} = 1250 - 250$

$= 1000\ mL$

$= 1L.$

Q. 100 mL of 1M $H_2SO_4$ solution is diluted by 400 mL. Findout the final molarity of solution.

→ $M_1 = 100mL$, $M_1 = 1M$.

$V_2 = 100 + 400 = 500 mL$

$M_2 = ?$

$M_1V_1 = M_2V_2$

$1 \times 100 = M_2 \times 500$

$M_2 = 0.2M.$

$N = M \times V.F$

1M $H_2SO_4$ → $N = M \times 2$

$= 2.$

Q. Calculate the volume of $H_2O$ added in 100mL of 1M $H_2SO_4$ so that the final concentration becomes 0.5 N?

$M = \frac{0.5}{2} = 0.25$

→ $M_1V_1 = M_2V_2$

$100 \times 1 = 0.25 \times V_2$

$V_2 = 400mL.$

Added $H_2O = 400 - 100$

$= 300 mL.$

Q. What vol. of $H_2O$ must be added in 200mL of 0.01 M $H_2SO_4$ solution is that its molarity becomes 0.004M.

Sol. $M_1V_1 = M_2V_2$

$0.01 \times 200 = 0.004 \times V_2$

$V_2 = 500 mL.$

added $H_2O = 500 - 200$

$= 300 mL.$

Q. The vol. of $H_2O$ added to 500mL, 0.5M NaOH, so that the strength becomes 10mg NaOH per mL.

$\left(\frac{g/L}{M.\omega} = M\right)$

10 mg/mL NaOH

$g/L = 10\ \frac{mg}{mL}$ $\quad M = \frac{10/L}{40} = \frac{1}{4} = 0.25\ M$

$M_1V_1 = M_2V_2$

$500 \times 0.5 = 0.25 \times V_2$

$V_2 = 1000\ mL$

$H_2O$ added $= 1000 - 500$

$= 500\ mL$

Q. Find out the mass of $H_2SO_4$ that in 1,200mL of a solution of 0.1M ?

→ $M = 0.1$ $\quad M.\omega$ of $H_2SO_4 = 98$.

$N = 0.1 \times 2 = 0.2$ $\quad E. = 49$

$W = \frac{NEV}{1000} = \frac{0.2 \times 49 \times 1200}{1000}$

or, $W = \frac{M \times m.\omega \times V}{1000}$

or, $n = 0.1 \times 1.2L$

$= 0.12$ moles

$W = n \times m.\omega$

$= 0.12 \times 98$

$=$

Q. Calculate the amount of glucose obtain from 250mL of semi molar soln

soln → $n = \frac{250}{1000} V_L \times \left(\frac{1}{2}\right) = M.0$

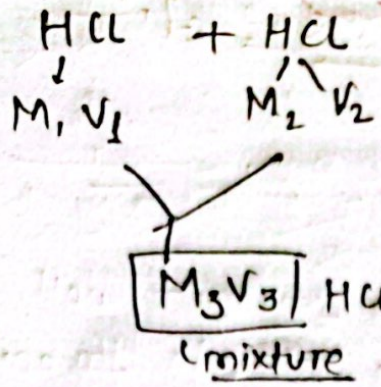
$= \frac{1}{8}$

$W = n \times M.\omega$

$= \frac{1}{8} \times 180 =$

# Molarity of Mixing

• Same substance Mix



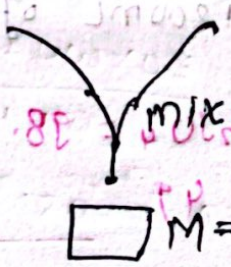

$$n_3 = n_1 + n_2$$

$$M_3V_3 = M_1V_1 + M_2V_2$$

$$\therefore M_3 = \frac{M_1V_1 + M_2V_2}{V_3}$$

Q. HCl 0.1M 200mL $n = 20$ milimole

HCl 0.2M 300M 60 milimole




$$M_{mix} = \frac{\text{Total milimole}}{\text{Total vol. (ml)}} = \frac{80}{500} = \frac{4}{25}\,M.$$

or,

$$M_{Mix} = \frac{M_1V_1 + M_2V_2}{V_{Total}} = \frac{0.1 \times 200 + 0.2 \times 500}{500} = \frac{80}{500} = \frac{4}{25}\,M.$$

Q. 100 mL of 0.2M HCl solution mix with 3.65gm HCl $M_{Final} = ?$

$0.1 \times 0.2 = 0.02$

$n = \frac{3.65}{36.5} = 0.1$

$$M_{Final} = \frac{n_{total}}{V_{total}} = \frac{0.02 + 0.1}{100} \times 1000$$

$= 1.2\,M$ Ans.

Q. $\frac{3M}{1}$, 5L $H_2SO_4$ + $\frac{2M}{1}$, 2L $H_2SO_4$. Final mixture का Molarity ?

→ 15

$$M_{mix} = \frac{15+4}{7} = \frac{19}{7}$$

or,

$$M_{mix} = \frac{3\times5 + 2\times2}{5+2} = \frac{19}{7}$$

# $N = \frac{gmeq}{V_L}$

$$gmeq = \frac{\omega}{\varepsilon} = mole \times V.F = N \times V_L$$

## ① Acid Mixture

$$N_1V_1 + N_2V_2 + \dots = N_RV_R$$

$$N_R = \frac{N_1V_1 + N_2V_2 + \dots}{V_R} = [H^+]$$

## ② Base-Mixture

$$N_R = \frac{N_1V_1 + N_2V_2 + \dots}{V_R} = [OH^-]$$

## ③ Acid-Base Mixture

$$N_RV_R = N_AV_A - N_bV_b$$

(a) If $N_RV_R = 0 \Rightarrow$ Neutral, PH = 7

(b) If $N_RV_R$ = +ve $\Rightarrow$ acidic, PH = less than 7

(c) If $N_RV_R$ = −ve $\Rightarrow$ basic, $N_R = [OH^-]$, PH = more than 7.

Q. 200 mL of 0.1M $H_2SO_4$ is mixed with 300 mL of 0.2M HCl. Calculate the conc. of $[H^+]$ ion :-

Sol:

$$N_R = \frac{200 \times 0.2 + 300 \times 0.2}{500} = 0.2$$

$\therefore$ conc of $[H^+]$ ion = 0.2

Q. How many mL of 0.5M $Ba(OH)_2$ solution should be mixed with 400 mL of 0.3M NaOH solution. Such that final conc. of $OH^-$ is 0.6M.

Sol:-

$N_2 = 0.6M = [OH^-]$

$$\frac{N_1V_1 + N_2V_2}{V_{Total}} = 0.6M$$

$$\text{or, } \frac{1 \times x + 400 \times 0.3}{x + 400} = 0.6$$

$$\text{or, } x + 120 = 0.6x + 240$$

$$\text{or } 0.4x = 120$$

$$x = 300 \text{ mL}.$$

Q. 10mL of 2.5M HCl solution is mixed with 20mL of 1.5N NaOH solution. & The mixture is diluted to 100 mL. The normality & nature of resultant solution is :-

Sol:

$$N_R = \frac{30 - 25}{100} = \frac{5}{100} = \frac{1}{20}$$

basic $(OH^-)$ (base वाली ई)

Q. 300 mL of $\frac{M}{30}$ $H_2SO_4$ is mixed with 500 mL of $\frac{M}{50}$ HCl. Find the $N_R$. & (conc of $H^+$) $\frac{M}{30} \times 2 = \frac{M}{15} = N$.

Sol.

$$N_R = \frac{300 \times \frac{1}{15} + 500 \times \frac{1}{50}}{800} = \frac{30}{800} = \frac{3}{80} N.$$

Q. 400 mL of 0.2N $H_2SO_4$ is mixed with 400 mL of 0.4M NaOH. Find nature and normality of resulting solution?

→

$$N_R = \frac{400 \times 0.2 + 400 \times 0.4}{400 + 400}$$

$$= \frac{80 + 160}{800} = \frac{240}{800} = \frac{3}{10}$$

Nature → Neutral (acid = base)

$$N_R = \frac{400 \times 0.4 - 400 \times 0.2}{800} = \frac{80}{800} = 0.1$$

Nature → basic (base is more).

→ $\boxed{M \times V_L = n}$

→ $\boxed{N \times V_L = gm\ eq}$

→ $\boxed{N \times V_{mL} = mili\ gm\ eq.}$

→ $\boxed{M \times V_{mL} = millimole}$

→ $\boxed{gm\ eq = N \times V_L = \frac{w}{E} = n \times V.f}$

• No. of gm equivalent of a substance is equal to the no. of gram equivalent of another substance — for complete reaction.

Q. x gm of $CaCO_3$ reacts completely with 20mL of 1M HCl. Calculate value of x.

$E = 50$

$(N_1 = N_2)$

$$n = \frac{x}{E} = \frac{N \times V_{mL}}{1000}$$

$$\frac{x}{50} = \frac{1 \times 20}{1000}$$

$$\therefore x = 1g$

Q. x gm of $Na_2CO_3$ ($E = 53$) reacts completely ($N_1 = N_2$) with 50 mL of 2N HCl sol. The value of x is :—

$$\frac{W}{E} = \frac{N \times V_{mL}}{1000}$$

$$\frac{W}{53} = \frac{2 \times 50}{1000}$$

$$W = \frac{53}{10} = 5.3\,g$$

Q. 0.62gm of $Na_2CO_3 \cdot H_2O$ is dissolved in 100cc of 1N $H_2SO_4$ solution. The nature of mixture is :-

Sol:

$$\text{gm eq of } Na_2CO_3 \cdot H_2O = \frac{W}{E}$$

$$E = 62 \qquad = \frac{0.62}{62} = 0.01$$

$$\text{gm eq of } H_2SO_4 = \frac{N \times V_{mL}}{1000} = \frac{1 \times 100}{1000} = 0.1$$

∴, Solution is acidic. ($H_2SO_4 > Na_2CO_3 \cdot H_2O$)

- Normality eqn → when 2 solution rxt completely.

$$N_1V_1 = N_2V_2$$

Q. If 20mL of 0.5N NaOH is mixed with 30mL of 0.3N HCl, is the resulting solution acidic or basic, calculate the normality of final solution?

→ gm eq. of $NaOH = \frac{0.5 \times 20}{1000} = 0.01$

" " $HCl = \frac{0.3 \times 30}{1000} = 0.009$

gm eq (base > acid) ∴ nature → basic

$$N_R = \frac{0.01 - 0.009}{50} \times 1000$$

$$= 0.02\,N \text{ Ans.}$$

Q. What weight of $KMnO_4$ is required to prepare 200mL of its semi normal solution if rxn is to be carried out in acidic medium

Soln:-

$$\frac{W}{E} = \frac{N \times V_{ml}}{1000}$$

$$E = \frac{W}{5}$$

$$W = \frac{N \times E \times V}{1000} = \frac{1}{2} \times \frac{158}{5} \times \frac{200}{1000}$$

$$W = 3.16gm$$

Q. How many gram of dibasic acid (mol.wt 200gm) should be present in 100 mL of its aq. solution to give decinormal

$$W = \frac{N \times E \times V}{1000} = \frac{1}{10} \times \frac{200 \times 100}{1000}$$

$$E = \frac{M}{2}, \quad N = \frac{1}{10}$$

$$= 1g$$

Q. 10 mL of 0.2M $H_2SO_4$ is mixed with 10mL of water. 10mL of mixture can neutralize how many ml of 0.2M NaOH solution?

→ $N_1V_1 = N_2V_2$

$$10 \times 0.2 \times 2 = N_2 \times (10+10)$$

$N_2 = 0.2\,N$ (water)

again,

$N_1V_1 = N_2V_2$

$$10 \times 0.2 = 0.2 \times V_2$$

$$V_2 = 10mL$$

Q. 300 mL of 0.2M NaCl, 500 ml of 0.3M $MgCl_2$, 800mL of 0.3M $AlCl_3$ soln & 2L of water mixed together. determine concn of $Cl^-$ ion in the final solution?

NaCl → $300 \times 0.2 = 60$ milimole $(Cl^-)$

$MgCl_2$ → $500 \times 0.3 = 150$ milimole $\Theta = 300 (Cl^-)$

$AlCl_3$ → 240 milimole $= 720 (Cl^-)$

$\therefore n_{Cl^-} = 1080$

$$N = \frac{1080}{300+500+800+2000}$$

$$= \frac{3}{10} = 0.3N$$

Q.) 100mL of 0.1M $AgNO_3$, 300mL of 0.2M $NaNO_3$ & 600mL of 0.3M $Na_2SO_4$ are mixed together. calculate conc of $[NO_3^-]$ & $[Na^+]$ in soln:-

→

$AgNO_3$

$100 \times 0.1$

$= 10$ milimole

$NaNO_3$

$300 \times 0.2$

$= 60$

$Na_2SO_4$

$600 \times 0.5$

$= 180$

$AgNO_3$ → $Ag^+$ (10), $NO_3^-$ (10)

$NaNO_3$ → $Na^+$ (60), $NO_3^-$ (60)

$Na_2SO_4$ → $2Na^+$ (360), $SO_4^{--}$ (180)

$[NO_3^-] = \frac{10+60}{1000} = \frac{70}{1000} = \frac{7}{100} = 0.07$ mole/L

$[Na^+] = \frac{360}{1000} = \frac{360+60}{1000} = \frac{420}{1000} = 0.42$ mole/liter

$M = \frac{g/L}{m.wt}$

$\therefore g/L = M \times m.wt$

$N = \frac{g/L}{eq.wt}$

$g/L = N \times eq.wt$

↳ strength of sol.

Q. Find out strength of $H_2SO_4$ solution, if we take 0.1N $H_2SO_4$ soln:-

$E = 49$.

$\therefore g/L = N \times eq.wt$

$= 0.1 \times 49$

$= 4.9$ gm.

Q. $V_1 = 100$ml, 0.3N HCl $V_2 = 200$ml, 0.6N $H_2SO_4$.

find Normality of new soln.

$[H^+] = N_R = \frac{N_1V_1 + N_2V_2}{V_R} = \frac{100 \times 0.3 + 200 \times 0.6}{300} = 0.5N$

Q. Determine the volume of water to be added to N/2 HCl to prepare 500 $cm^3$ of N/10 soln:-

Sol:

$N_1V_1 = N_2V_2$

$\frac{1}{2} \times V_1 = \frac{1}{10} \times 500$

$\therefore V_1 = 100\ mL$

$\therefore$ water added = 500 - 100

= 400mL.

Q. $Ca_3(PO_4)_2 = Z$

→ eq. wt = Z/6

Q. What wt. of $K_2Cr_2O_7$ (mol wt = 294) should be added to obtain 1L of 0.1N solution :- ($E = \frac{w}{6}$ always)

→

$W = NEV$

$= 0.1 \times \frac{294}{6} \times 1$

$= 4.9\ g$

Q. A solution containing 0.275 gm of NaOH required 35.4 mL of HCl for neutralization. What was the normality of HCl.

→

$\left(\frac{W}{E}\right)_{NaOH} = \left(\frac{N \times V_{ml}}{1000}\right)_{HCl}$

$\left(\frac{0.275}{40}\right) = \left(\frac{N \times 35.4}{1000}\right)_{HCl}$

$\therefore N = 0.194\ N$ HCl.

Q. What is the normality of 1M solution of $H_3PO_4$ ? ($H_3PO_2 \rightarrow 1$, $H_3PO_3 \rightarrow 2$, $H_3PO_4 \rightarrow 3$)

(a) 0.5N (b) 1.0N (c) 2.0N (d) 3.0N

$N = 3 \times 1 = 3$

Q. Normality of 2M $H_2SO_4$ is :-

(a) 2N (b) 4N (c) N/2 (d) N/4

$N = M \times V.F$

$= 2 \times 2 = 4N$.

Q. The solution of $H_2SO_4$ contains 80% by weight $H_2SO_4$. Sp. grav. of this solution is 1.71. Its normality is about :-

(a) 18.0 (b) 27.9 (c) 1.0 (d) 10.0

$\% \frac{w}{w} = 80\%$

$M = \frac{\% \frac{w}{w} \times d \times 10}{M.wt}$ , $N = \frac{\% \frac{w}{w} \times d \times 10}{Eq.wt}$

$\Downarrow$

$M = \left(\frac{\% \frac{w}{w} \times 10}{M.wt.}\right)$

$= \frac{80 \times 1.71 \times 10}{49}$

$= 27.9\ N$

Q. The eq. wt of $H_3PO_4$ (phosphoric acid) in the rxn :-

$NaOH + H_3PO_4 \longrightarrow NaH_2PO_4 + H_2O$ is :-

(a) 25 (b) 49 (c) 59 (d) 98

$H_3PO_4 \rightarrow 1\ H^+$ rep.

$\Downarrow$ so, V.F = 1.

mwt = 98.

Q. 75 mL of $\frac{N}{5}$ $H_2SO_4$, 10mL of $\frac{N}{2}$ HCl & 30mL of $\frac{N}{10}$ $HNO_3$ are mixed together. The strength of the resulting acid mixture is :-

(a) 0.2N (b) 0.3N (c) 0.4N (d) 0.1N

$N_R = \frac{75 \times \frac{1}{5} + 10 \times \frac{1}{2} \times 30 \times \frac{1}{10}}{115}$ (all acid)

$= 0.2N$

Q. 5mL of N HCl, 20 Ml $\frac{N}{2}$ $H_2SO_4$, & 30 mL of $\frac{N}{3}$ $HNO_3$ are mixed together & volume made to one litre. The normality of mixture is :-

(a) $\frac{N}{5}$ (b) $\frac{N}{10}$ (c) $\frac{N}{20}$ (d) $\frac{N}{40}$

$N_R = \frac{5 \times 1 + 20 \times \frac{1}{2} \times 30 \times \frac{1}{3}}{1000\ ml} = \frac{25}{1000} = \frac{N}{40}$

Q. How many mL of 1M $H_2SO_4$ solution is required to neutralize 10mL of 1M NaOH solution?

(a) 2.5mL (b) 5.0mL (c) 10.0mL (d) 20.0mL

$N_1V_1 = N_2V_2$ $(N_1 = M_1 \times 2)$

$2 \times V_1 = 1 \times 10$

$V_1 = 5\,mL.$

Q. 100 mL of 1.0 M HCl are mixed with 75 mL of 1.0M $Na_2CO_3$. The resulting solution will be:-

(a) acidic (b) basic (c) neutral (d) amphoteric

- HCl $(100 \times 1 = 100$ milligm eq$)$
- $Na_2CO_3 \rightarrow (75 \times 2 \times 1) = 150$ (milligm eq) (Normality का term आ गया)

$N = 2 \times M.$

# PPM (Parts Per Million)

→ $PPM\ (w/v) = \dfrac{\text{wt. of solute in gm}}{V_{soln} \times mL} \times 10^6$

$= \dfrac{\text{wt. of solute in gm}}{V_{soln} \times mL} \times 1000 \times 1000$ (g/L)

$\boxed{ppm = g/L \times 1000}$

$\boxed{ppm = \%\ w/v \times 10 \times 1000}$

$\boxed{ppm = \%\ w/w \times \text{sp. gravity} \times 10 \times 1000}$

Used mainly in:- $Cl^-$ in $H_2O$

$F^-$ in toothpaste

$I_2$ in NaCl

Q. A sample of water contains 0.1 g/L Arsenic. The conc of As in the sample is :-

(a) 100 ppm (b) 1000 ppm (c) 10 ppm (d) 0.1 ppm

Sol. $ppm = g/L \times 1000$

$= 0.1 \times 1000$

$= 100 ppm$

# $ppm\ (w/w) = \frac{\text{wt. of solute in gm}}{\text{wt of solution in gm}} \times 10^6$

Q. 200 gm of toothpaste sample consist 0.2g $F^-$ ion. Find its conc in ppm?

→ $ppm = \frac{w_{solute}}{w_{soln}} \times 10^6$

$= \frac{0.2}{200} \times 10^6 = 1000 ppm.$

# Half Neutralization

Q. 200 mL of 0.2M HCl is neutralized with 0.1 M NaOH. Then during their half neutralization, what will be the molarity of HCl?

(a) 0.1 M (b) 0.5 M (c) 0.05 M (d) 1 M

(200 mL of 0.2M HCl) → half → 100 mL of 0.2M HCl

then, $N_1V_1 = N_2V_2$

$0.2 \times 100 = 0.1 \times V_2$

$V_2 = 200 mL.$

200 mL, 0.1 M NaOH में Half neutralize होते.

then, $N_R = \frac{200 \times 0.2 \text{ (acid)} - 0.1 \times 200 \text{ (base)}}{400}$

$= \frac{1}{20} = 0.05 M/N_{Ans}$

Q. 100mL of 0.1N HCl is neutralized with 0.1N NaOH. Then during half neutralization what will be normality of HCl?

→ half → 50mL

$N_1V_1 = N_2V_2$

$0.1 \times 50 = 0.1 \times V_2$

$V_2 = 50mL.$

Then, $N_2 = \frac{100 \times 0.1 - 50 \times 0.1}{150}$

$= \frac{5}{150} = \frac{1}{30} = 0.03N.$

Q. The volume of water is to be added to 150mL of 0.2N $Na_2CO_3$ solution to make it 0.05N?

(a) 450 mL (b) 600mL (c) 750mL (d) 300mL

$0.2 \times 150 = 0.05 \times V_2$

$V_2 = 600.$

∴ water added = 600 - 150

= 450 mL

Q. 10mL of 1M NaOH solution will be neutralized by the following volume of 1M $H_2SO_4$?

(a) 25mL (b) 20mL (c) 10mL (d) 5mL

$10 \times 1 = 2 \times V_2$

$V_2 = 5mL.$

Q. The volume of 0.1 M NaOH that is needed to completely neutralize 20mL of 0.05 M oxalic acid?

(a) 10 mL (b) 40mL (c) 20mL (d) 80mL

$0.1 \times V_2 = 20 \times 0.05 \times 2$

$V_2 = \frac{20 \times 0.1}{0.1}$

$V_2 = 20mL$

Q. One mole of potassium dichromate completely oxidizes the following no. of moles of ferrous sulphate in acidic medium? $K_2Cr_2O_7$

(a) 1 (b) 3 (c) 5 (d) 6

$n \times V \cdot F = W/E = g/L$.

$1 \times 6 = 1 \times n$

$\therefore n = 6$.

Q. No. of moles of $KMnO_4$ required to oxidize one mole of $Fe(C_2O_4)$ in acidic medium is:-

(a) 0.2 (b) 0.4 (c) 0.6 (d) 0.67

$n \times V \cdot F = n \times V \cdot f$

$n \times 5 = 1 \times 3$

$n = 3/5 = 0.6$

Q. No. of moles of $K_2Cr_2O_7$ reduced by one mole of $Sn^{+2}$ ions is

(a) 1/3 (b) 3 (c) 1/6 (d) 6

$Sn^{+2} \rightarrow Sn^{+4}$ (2)

$n \times 6 = 1 \times 2$

$n = 1/3$