Principal of atom conservation (POAC):

- POAC method is applicable to find out product quantity in unbalanced reaction.

- generally, this method is used for complex reaction (multi-step reaction).

for eg: (i) $KClO_3 \longrightarrow KCl + O_2$

⟹ Apply POAC on 'K' atom.

$1 \times$ mole of $KClO_3 = 1 \times$ mole of KCl.

Apply POAC on 'Cl' atom.

$1 \times$ mole of $KClO_3 = 1 \times$ mole of KCl.

Apply POAC on 'O' atom.

$3 \times$ mole of $KClO_3 = 2 \times$ mole of O_2

(ii) $N_2 + H_2 \longrightarrow NH_3$

⟹ Apply POAC on 'N' atom.

$2 \times$ mole of $N_2 = 1 \times$ mole of NH_3

Apply POAC on 'H' atom

$2 \times$ mole of $H_2 = 3 \times$ mole of NH_3

Q: How much quantity of ammonia should be formed in haber process if 28gm of Nitrogen gas hydrogenated.

⟹ $N_2 + H_2 \longrightarrow NH_3$

give mass / molec. mass = mole

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Apply POAC on 'N' atom

2 × mole of N_2 = 1 × mole of NH_3

$\Longrightarrow 2 \times \frac{28}{28} = 1 \times \frac{x}{17}$

$2 \times 17 = x$

∴ 34gm (2 moles)

Q: 27.6gm K_2CO_3 was treated by series of reagents so as to convert all of its carbon to K_2Zn_3, ~~but we know~~ $[Fe(CN)_6]_2$. Calculate weight of product. (mol. wt. K_2CO_3 = 138, mol. wt. $K_2Zn_3[Fe(CN)_6]_2$ = 698)

$\Longrightarrow K_2CO_3 \longrightarrow K_2Zn_3(Fe(CN)_6)_2$

→ Apply POAC on 'C' atom.

1 × mole K_2CO_3 = 12 × mole of $K_2Zn_3[Fe(CN)_6]_2$

$1 \times \frac{\text{wt of } K_2CO_3}{\text{mol. wt of } K_2CO_3} = 12 \times \frac{\text{wt. of prod}}{\text{mol. wt. of prod.}}$

$\frac{27.6}{138} \times \frac{698}{12} \longrightarrow$ 11.63gm

Q: Apply POAC on carbon atom in following chemical rxn:

(a) $C_6H_{12}O_6 + O_2 \longrightarrow CO_2 + H_2O$

acetylene gas (b) $CH \equiv CH + O_2 \longrightarrow CO_2 + H_2O$

(c) $C_2H_5OH + O_2 \longrightarrow CO_2 + H_2O$

Apply POAC on 'C' atom.

$\Longrightarrow$ (a) 6 × mole of $C_6H_{12}O_6$ = 1 × mole of CO_2.

(b) 2 × mole of $CH \equiv CH$ = 1 × mole of CO_2

(c) 2 × mole of C_2H_5OH (ethanol) = 1 × mole of CO_2.

Q: How much volume of CO_2 at STP should be formed if 100gm of glucose completely combuste

⟹ $C_6H_{12}O_6 + O_2 \longrightarrow CO_2 + H_2O$

mole = $\frac{100}{180}$ ⟹ $6 \times \frac{100}{180} = 1 \times CO_2$

vol = $\frac{\text{vol. of } CO_2}{22.4}$ ⟹ $\frac{10}{3} = 1 \times CO_2$

⟹ $\frac{10}{3} \times 22.4 = CO_2$

⟶ $\frac{224}{3} = CO_2$

Q: In a determination of 'P' an aqueous solution of (NaH_2PO_4) is treated with a mixture of Ammonium & Magnesium ions to precipitate magnesium-ammonium phosphate [$Mg(NH_4)PO_4 \cdot 6H_2O$].

- This compound is heated and decomposed into magnesium pyrophosphate ($Mg_2P_2O_7$) which is weighted.

- A solution of (NaH_2PO_4) yielded about 3.33gm of ($Mg_2P_2O_7$). What weight of NaH_2PO_4 was present originally?

⟹ $NaH_2PO_4 \longrightarrow Mg(NH_4)PO_4 \cdot 6H_2O \longrightarrow Mg_2P_2O_7$

applied POAC on 'P' atom:

$1 \times$ mole of NaH_2PO_4 = $2 \times$ mole of $Mg_2P_2O_7$

mole = $\frac{\text{given mass}}{\text{molar mass}}$

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($\because$ NaH_2PO_4 = 120 $Mg_2P_2O_7$ = 222)

$$\Rightarrow 1 \times \frac{x}{120} = 2 \times \frac{\overset{0.03}{\cancel{3.33}}}{\underset{111}{\cancel{222}}}$$

$$\therefore x = 0.03 \times 120 \quad \left(\frac{3}{10\cancel{0}} \times 12\cancel{0}\right)$$

$$= 3.6$$

Concentration of solution:

- Solution = Solute × solvent.

  Qty : solvent > solute.

Solution

- Homogeneous (true solution)
- Heterogeneous (pseudo solution)
  - colloidal
  - suspended.

Concentration

- → % w/w weight/weight
- → % w/v weight/volume
- → % v/v volume/volume
- → ppm part per million.
- → ppb part per billion.

- → mole fraction (X)
- → molarity (M)
- → formality (F)
- → molality (m)
- → normality (N)
- → demal (D)

% w/w (weight/weight) solution:-

- 5% w/w of NaOH solution: means 5gm of NaOH available in 100 gm of solution.

$$\text{solution} = \text{solute} + \text{solvent}$$

$$NaOH \Rightarrow 100gm = 5gm + 95gm$$

$$\%\,w/w\ NaOH = \frac{\text{wt of solute (gm)}}{\text{wt of solution (gm)}} \times 100.$$

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Q: Find out the (% w/w) of NaCl if it dissolves in 1.5 gm in 35 gm of water.

⟹ $(\% \ w/w) \ NaCl = \frac{1.5}{35} \times 100$

$= \frac{300}{7} \longrightarrow \boxed{4.28\%}$

⇛ % w/v (weight / volume) solution :- (यहाँ volume = Liq.)

- $\frac{\text{weight of solute (gm)}}{\text{volume of solution (ml)}} \times 100\%$

- 5% w/v of aqueous NaOH solution : means 5gm of NaOH available in 100ml of solution

⇛ % v/v (volume / volume) solution :-

- $\frac{\text{volume of solute (ml)}}{\text{volume of solution (ml)}} \times 100\%$

- 5% v/v of aqueous ethanol solution : means 5ml of ethanol available in 100ml of solution.

here; vol. of ethanol = 5ml (solute)
vol. of H_2O = 100 - 5 = 95ml ✗

⇒ **ppm (parts per million) :-** (1 mill = 10,00,000)

- $ppm = \frac{\text{weight of solute (gm)}}{\text{volume of solution (ml)}} \times 10^6$

ppm → w/w, w/v, v/v
- used for diluted solution.

- 5 ppm (w/v) NaOH solution : means 5gm of NaOH available in 1 million ~~litre~~ ml solution.

⇒ **ppb (parts per billion) :-** (1 bill = 1000000000)

- $ppb = \frac{\text{weight of solute (gm)}}{\text{volume of solution (ml)}} \times 10^9$

ppb → w/w, w/v, v/v

⇒ **mole fraction :- (x)**

- for a binary solution, mole fraction of component 'A' and 'B' can be written as:

$$X_A = \frac{n_A}{n_A + n_B}$$

n_A = mole A
n_B = mole B

- $$X_A = \frac{wt_A / m_A}{wt_A/m_A + wt_B/m_B}$$

wt = weight
m = molecular weight

- similarly, mole fraction of component B

$$X_B = \frac{n_B}{n_A + n_B}$$

- the total of whole (all) component mole fraction should be always one (1).

$$X_A + X_B + \ldots\ldots = 1$$

- mole fraction is unit-less.

⇒ **molarity :- (M)**

☆ • number of mole of solute available in one litre (1 l) of solution.

$$M = \frac{\text{mole of solute}}{\text{volume of solution (l)}}$$

$$\Rightarrow M = \frac{\text{wt of solute (gm)}}{\text{molecular wt of solute} \times \text{vol. of sol}^n \text{ (litre)}}$$

$$\frac{\frac{x}{y}}{A} \rightarrow \frac{x}{y \times A}$$

$$\Rightarrow M = \frac{\text{wt of solute (gm)} \times 1000}{\text{m.wt of solute} \times \text{vol. of sol}^n \text{ (ml)}}$$

concentration term

- Molarity is temperature dependent.

{ Temp ↑ Volume ↑ ⟶ Molarity ↓
  Temp ↓ Volume ↓ ⟶ Molarity ↑ }

Q: Find molarity of 10% (w/w) NaOH solution.

⟹ 10% w/v = 10 gm NaOH
volume = 100 ml. mol. wt of NaOH = 40.

$$\text{Molarity} = \frac{\frac{10}{40}}{\frac{100}{1000}}$$

10 — wt.
40 — molecular wt.
100 — vol.
1000 — ÷1000 for litre conversion

$$M = \frac{10 \times 1000}{40 \times 100} = \frac{10}{4} \longrightarrow \boxed{2.5 \text{ mol/lit}}$$

Q: Find mole fraction of NaOH in 4% of (w/w) aqueous solution.

⟹ 4% w/w = 4 gm NaOH NaOH = 40
Solution = 100 gm H_2O = 18.
H_2O = 96 gm.

$$\text{mole of NaOH} = \frac{4}{40} \quad 0.1 \text{ mol.}$$

$$\text{mole of } H_2O = \frac{96}{18} \quad \frac{16}{3} \text{ mol.} \longrightarrow 5.3$$

$$X_{NaOH} = \frac{n_{NaOH}}{n_{NaOH} + n_{H_2O}}$$

$$= \frac{0.1}{0.1 + \frac{16}{3}} = \frac{0.1}{0.1 + 5.3} = \frac{0.1}{5.4}$$

$$\Longrightarrow \frac{1}{54}$$

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Q: In above question; find mole fraction of water.

⟹ as $X_{NaOH} + X_{H_2O} = 1$.

$\therefore \frac{1}{54} - 1 = H_2O$

$\rightarrow \frac{54-1}{54} \rightarrow \boxed{\frac{53}{54}}$

Q: Find out mass fraction of NaCl 2.5% (w/w) NaCl-solution

⟹ NaCl (2.5%) = 2.5 gm NaCl = 23+35.5

H_2O = 97.5 gm mass = 100 = 58.5

⟹ mass fraction = $\frac{2.5}{100} \rightarrow \boxed{0.025}$

$\frac{25}{1000} \rightarrow \boxed{\frac{1}{40}}$

Q: How much quantity of KOH (potassium hydroxide) is required to prepare 200 ml of 2.5 molar (2.5 M) aqeous solution.

⟹ KOH = 39+16+1 ⟶ 56.

$\therefore M = \frac{\text{quantity KOH}}{\text{vol. of sol}^n}$

$2.5 = \frac{KOH}{0.2} \Rightarrow \boxed{0.5 \text{ mol.}}$

$\therefore \text{mole} = \frac{\text{at. wt.}}{\text{mol. wt.}}$

$0.5 = \frac{KOH}{56} \longrightarrow \boxed{KOH = 28 \text{ gm}}$