VMC Vidyamandir Classes SINCE 1986

IIT JEE | MEDICAL | FOUNDATION

Stoichiometry-1

SAP-4

Q. If 2M, 300ml $CaCl_{2(aq)}$ solⁿ is mixed with 3M, 500ml $CaCl_{2(aq)}$ solⁿ. Then find

(i) molarity of new solⁿ

(ii) Molarity of Ca^{2+} in new solⁿ

(iii) molarity of Cl^- ions in new solⁿ.

Solⁿ →

$$(2 \times 300) + (3 \times 500) = M_f \times 800$$

$$M_f = 2.625 \text{ mol/lit.}$$

$$CaCl_2 \longrightarrow Ca^{2+} + 2Cl^-$$

1M	1M	2M
2.625 M	2.625 M	5.25 M

2M of 100 ml Na_2SO_4 is mixed with 3M of 100 ml NaCl solution and 1M of 200 ml $CaCl_2$ solution. Then the ratio of the concentration of cation and anion.

Solⁿ →

$$[Na^+]_1 V_1 + [Na^+]_2 V_2 + [Na^+]_3 V_3 = [Na^+]_f V_f$$

$$(4 \times 100) + (3 \times 100) + 0 = [Na^+]_f \times 400$$

$$[Na^+]_f = \frac{7}{4} \text{ M}$$

$$[Cl^-]_1 V_1 + [Cl^-]_2 V_2 + [Cl^-]_3 V_3 = [Cl^-]_f V_f$$

$$0 + (3 \times 100) + (2 \times 200) = [Cl^-]_f \times 400$$

$$[Cl^-]_f = \frac{7}{4} M$$

$$[SO_4^{2-}]_1 V_1 + [SO_4^{2-}]_2 V_2 + [SO_4^{2-}]_3 V_3 = [SO_4^{2-}]_f V_f$$

$$(2 \times 100) + 0 + 0 = [SO_4^{2-}]_f \times 400$$

$$[SO_4^{2-}] = \frac{2}{4} M$$

$$[Ca^{2+}]_1 V_1 + [Ca^{2+}]_2 V_2 + [Ca^{2+}]_3 V_3 = [Ca^{2+}]_f V_f$$

$$0 + 0 + (1 \times 200) = [Ca^{2+}]_f \times 400$$

$$[Ca^{2+}] = \frac{2}{4} M$$

$$\frac{[Na^+] + [Ca^{2+}]}{[SO_4^{2-}] + [Cl^-]} = \frac{\frac{7}{4} + \frac{2}{4}}{\frac{2}{4} + \frac{7}{4}} = 1:1$$

94. One litre of 0.15 M HCl and one litre of 0.3 M HCl is given. What is the maximum volume of 0.2 M HCl which one can make from these two solutions. No water is added.

(A) 1.2 L (B) 1.5 L (C) 1.3 L (D) 1.4 L

Sol^n →

0.15 M HCl : V_1 lit.

0.3 M HCl : V_2 lit.

$$(0.15 \times V_1) + (0.3 \times V_2) = 0.2(V_1 + V_2)$$

$$0.05 V_1 = 0.1 V_2$$

$$V_1 = 2 V_2$$

For max. final vol. $\Rightarrow$ $V_1 = 1$ lit., $V_2 = 0.5$ lit

$$V_1 + V_2 = 1 + 0.5 = 1.5 \text{ lit.}$$

Empirical and molecular formula

$\rightarrow$ Molecular formula of a comp. represents actual ratio of the atoms present in the compound.

Empirical formula of a comp. represents simplest ratio of atoms present in the comp.

M.F.	E.F.
C_6H_6	CH
C_2H_6	CH_3
$C_6H_{12}O_6$	CH_2O
N_2O_4	NO_2

C_5H_{10}	CH_2
C_5H_{12}	C_5H_{12}

$$\boxed{\begin{aligned} M.F. &= (E.F.)_n \\ \text{where } n &= +\text{ve integer} \\ &= \frac{\text{Molecular mass}}{\text{Empirical formula mass}} \end{aligned}}$$

Q. A comp. made up of nitrogen and oxygen atoms in 7 : 16 mass ratio.
Find empirical formula of comp.
If molecular mass of comp. is 92 u then
Find molecular formula of comp.

Soln →

	N	O
	$7x$ gm	$16x$ gm
mole →	$\frac{7x}{14}$	$\frac{16x}{16}$
Atoms →	$\frac{7x}{14} \times N_A$	$\frac{16x}{16} \times N_A$

$$\text{Ratio} = \frac{1}{2} : 1 \Rightarrow 1 : 2$$

Empirical formula = NO_2

$$n = \frac{92}{14+32} = 2$$

molecular formula = $(NO_2)_2 = N_2O_4$

Q. A Comp. made up of C and O atoms such that mass percentage of C in the comp. is 50%. find empirical formula. If molecular mass of comp. is 288 u then find molecular formula.

Solⁿ→

	C	O
	50 gm	50 gm
mole →	$\frac{50}{12}$	$\frac{50}{16}$
Ratio →	$\frac{1}{12}$:	$\frac{1}{16}$

$$\frac{4 : 3}{48} \Rightarrow 4 : 3$$

Empirical formula = C_4O_3

$$n = \frac{288}{96} = 3$$

Molecular formula $= (C_4O_3)_3 = C_{12}O_9$

Minimum molecular mass determination $\rightarrow$

Q. % by mass of sulphur in insulin is x%. Find min. molecular mass of insulin?

Sol$^n \rightarrow$ x gm sulphur $\longrightarrow$ 100 gm Insulin

32 gm sulphur $\longrightarrow$ $\frac{100}{x} \times 32$ gm Insulin

min. Molecular mass $= \frac{100 \times 32}{x}$ amu

min. Molar mass $= \frac{100 \times 32}{x}$ gm

20. The sodium salt of an acid dye contains 7% of sodium. What is the minimum molar mass of the dye?

(A) 336.5 (B) 286.5 (C) 300.6 (D) 306.5

7 gm Na $\longrightarrow$ 100 gm Sodium Salt

23 gm Na $\longrightarrow$ $\frac{100}{7} \times 23$ gm Sodium Salt

$= 328.57$ gm Sodium salt

$$\begin{tikzcd} \text{acid} \arrow[r, "-H^+", "+Na^+"'] & \text{sodium salt} \arrow[l, bend left, "+H^+ \; -Na^+"] \end{tikzcd}$$

Min. Molar mass of acid dye $= 328.57 + 1 - 23$

$= 306.57$ gm

% by mass of an atom in a comp. →

Ex. CH_4

$$\% \, C = \frac{12}{16} \times 100 = 75\%$$

$$\% \, H = \frac{4}{16} \times 100 = 25\%$$

19. A hydrate of Na_2SO_3 has 50% water in mass. It is :

(A) $Na_2SO_3 \cdot 5H_2O$ (B) $Na_2SO_3 \cdot 6H_2O$

(C) $Na_2SO_3 \cdot 7H_2O$ (D) $Na_2SO_3 \cdot 2H_2O$

Sol^n →

$Na_2SO_3 \cdot x \, H_2O$

$$\% \, H_2O = \cancel{50} = \frac{18x}{126 + 18x} \times \cancel{100}^{\,2}$$

$$36x = 126 + 18x$$

$$18x = 126$$

$$\Rightarrow x = 7$$

(iv) *The hydrated salt $Na_2SO_4.nH_2O$ undergoes 55.9% loss in weight on heating and becomes anhydrous. The value of n will be :*

(A) 5 (B) 3 (C) 7 (D) 10

Sol^n →

$$\% \, H_2O = 55.9 = \frac{18n}{142 + 18n} \times 100$$

$n = 10$

Basic reaction stoichiometry →

Balanced Chemical eq^n →

$2A \longrightarrow 3B + 6C$

2 mol use	3 mol form	6 mol form
10 mol use	15 mol form	30 mol form
6 mol use	9 mol form	18 mol form
✗ 2 gm use	3 gm form	6 gm form

Ex.

$N_2 + 3H_2 \longrightarrow 2NH_3$

1 mol use	3 mol use	2 mol form
3 mole	9 mol use	6 mol form
28 gm use	6 gm use	34 gm form

What weight of KCl (Potassium Chloride) will be formed on heating 12.25 gm of $KClO_3$? Also calculate weight of O_2 will be liberated.

$(K = 39, Cl = 35.5, O = 16)$

Sol^n →

$2KClO_3 \xrightarrow{\Delta} 2KCl + 3O_2$

12.25 gm   0.1 mol $\frac{3}{2} \times 0.1$

0.1 mol $= 0.15$ mol

$$W_{KCl} = 0.1 \times 74.5 = 7.45 \text{ gm}$$

$$W_{O_2} = 0.15 \times 32 = 4.8 \text{ gm}$$

Action of Heat on Some Important Compounds :

	Alkali Metals	Alkaline Earth Metals
Carbonates	Stable $Na_2CO_3 \xrightarrow{\Delta}$ No Reaction	Unstable $CaCO_3 \xrightarrow{\Delta} CaO + CO_2$
Bicarbonates	Unstable $2NaHCO_3 \xrightarrow{\Delta} Na_2CO_3 + CO_2 + H_2O$	Unstable $Ca(HCO_3)_2 \xrightarrow{\Delta} CaO + H_2O + 2CO_2$
Sulphates	Stable $Na_2SO_4 \xrightarrow{\Delta}$ No Reaction	Stable

Some Basic Chemical Equations :

(i) $2\,KClO_3 \xrightarrow{\Delta} 2\,KCl + 3\,O_2$

(ii) $2\,NaHCO_3 \xrightarrow{\Delta} Na_2CO_3 + CO_2 + H_2O$

(iii) $NaNO_3 \xrightarrow{\Delta} NaNO_2 + \frac{1}{2}\,O_2$

(iv) $2\,Pb(NO_3)_2 \xrightarrow{\Delta} 2\,PbO + 4\,NO_2 + O_2$

(v) $2\,Na_2S_2O_3 + I_2 \longrightarrow Na_2S_4O_6 + 2\,NaI$

(vi) $Na_2C_2O_4 \xrightarrow{\Delta} Na_2CO_3 + CO$

(vii) $2\,FeSO_4 \xrightarrow{\Delta} Fe_2O_3 + SO_2 + SO_3$

(viii) $2AgNO_3 \xrightarrow{\Delta} 2Ag + 2NO_2 + O_2$

(ix) $\left[\begin{array}{l} 2Mg + O_2 \longrightarrow 2MgO \\ 3Mg + N_2 \longrightarrow Mg_3N_2 \end{array}\right.$

(Calcium behaves similarly)

(x) $\left[\begin{array}{l} NH_4NO_3 \xrightarrow{\Delta} N_2O + 2H_2O \\ NH_4NO_2 \xrightarrow{\Delta} N_2 + 2H_2O \end{array}\right.$

Illustration - 7 *A flash bulb used for taking photograph in poor light contains 30 mL of O_2 at 780 mm pressure at 27°C. Suppose that metal wire flashed in the bulb is pure Aluminium (Al) and it is oxidised to Al_2O_3 in the process of flashing, calculate the minimum weight of Al-wire that is to be used for maximum efficiency.*

Sol^n →

$$2Al + \frac{3}{2}O_2 \longrightarrow Al_2O_3$$

30 ml

780 mm

300 K

$$n_{O_2} = \frac{PV}{RT} = \frac{\frac{780}{760} \times \frac{30}{1000}}{0.0821 \times 300}$$

$$= 1.25 \times 10^{-3} \text{ mol}$$

$$n_{Al} = \left(\frac{2}{3} \times 2\right) \times 1.25 \times 10^{-3} \text{ mol}$$

$$= 1.67 \times 10^{-3} \text{ mol}$$

$$w_{Al} = 1.67 \times 10^{-3} \times 27 = 0.045 \text{ gm}$$

Limiting reagent and excess reagent →

Limiting reagent is the reactant which gets consumed first during the Rx^n.

Limiting reagent is the reactant which limits the formation of Product.

Excess reagent is the reactant which is left unreacted during the reaction.

Ex.

$$\underset{2 \text{ mole}}{N_2} + \underset{9 \text{ mole}}{3H_2} \longrightarrow \underset{\text{mole} = ?}{2NH_3}$$

6 mole

4 ~~mole~~

$N_2 \longrightarrow$ Limiting reagent.

$H_2 \longrightarrow$ Excess reagent

3 mol H_2 Use $\longrightarrow$ 2 mol NH_3 form

6 mol H_2 Use $\longrightarrow$ 4 mol NH_3 form

H_2 left $= 9 - 6 = 3$ mol

M2

$$\underset{\text{2 mole}}{\overset{\text{L.R.}}{N_2}} + \underset{\text{9 mole}}{\overset{\text{E.R.}}{3H_2}} \longrightarrow \underset{\text{4 mole}}{2NH_3}$$

$$\frac{2}{1} < \frac{9}{3}$$

Illustration - 12 *Consider the reaction : $2A + 3B \longrightarrow 4C + 5D$*

In the above reaction A and B are reactants and C and D are products. If one mole each of A and B are reacted. Then:

I.	*2.25 mole of of D is formed*	II.	*1.6 mole of D is formed*
III.	*0.33 mole of A are left after complete reaction*	IV.	*1.33 mole of C is formed*

The correct choice is :

(A) I, II ✓(B) II, III, IV (C) I, III, IV (D) I, II, IV

$$\underset{1\text{ mol}}{\overset{\text{E.R.}}{2A}} + \underset{1\text{ mol}}{\overset{\text{L.R.}}{3B}} \longrightarrow \underset{\frac{4}{3}\text{ mol}}{4C} + \underset{\frac{5}{3}\text{ mol}}{5D}$$

$$\frac{1}{2} > \frac{1}{3}$$

2 mol A Use $\longrightarrow$ 3 mol B Use

$\frac{2}{3}$ mol A Use $\longrightarrow$ 1 mol B Use

A left $= 1 - \frac{2}{3} = \frac{1}{3}$ mol

Illustration - 14 *What is the number of moles of $Fe(OH)_3(s)$ that can be produced by allowing 1 mole of Fe_2S_3, 2 moles of H_2O and 3 moles of O_2 to react as : $2Fe_2S_3 + 6H_2O + 3O_2 \longrightarrow 4Fe(OH)_3 + 6S$?*

(A) 1 *mol* (B) 1.84 *mol* (C) 1.34 *mol* (D) 1.29 *mol*

$$2\,Fe_2S_3 + \overset{L.R.}{6\,H_2O} + 3\,O_2 \longrightarrow 4\,Fe(OH)_3 + 6\,S$$

1 mole 2 mole 3 mole

$\frac{1}{2}$ $\frac{2}{6}$ $\frac{3}{3}$

$\frac{4}{6} \times 2$

$= 1.33$ mol

32. 100 mL of 20.8% $BaCl_2$ solution and 50 mL of 9.8% H_2SO_4 solution will form $BaSO_4$ (Ba = 137, Cl = 35.5, S = 32, H = 1, O = 16) Calculate the weight of $BaSO_4$ formed.

$BaCl_2 + H_2SO_4 \longrightarrow BaSO_4 + 2HCl$

(A) 23.3 g **(B)** 11.65 g **(C)** 30.6 g **(D)** None of these

Sol$^n \rightarrow$

$$W_{BaCl_2} = \frac{20.8}{100} \times 100 = 20.8 \text{ gm}$$

$$W_{H_2SO_4} = 50 \times \frac{9.8}{100} = 4.9 \text{ gm}$$

$$\underset{0.1\ mol}{BaCl_2} + \underset{0.05\ mol}{\overset{L.R.}{H_2SO_4}} \longrightarrow \underset{0.05\ mol}{BaSO_4} + 2HCl$$

$$w_{BaSO_4} = 0.05 \times 233$$
$$= 11.65\ gm$$

Problems based on % yield of Product →

$$\%\ yield = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100$$

Illustration - 13 *In the following reaction : $MnO_2 + 4HCl \longrightarrow MnCl_2 + 2H_2O + Cl_2$. When 2 moles of MnO_2 reacted with 4 moles of HCl, 11.2 L Cl_2 was collected at STP. Find the percent yield of Cl_2.*

(A) 25% (B) 50% (C) 100% (D) 75%

$$\underset{2\ mole}{MnO_2} + \underset{4\ mole}{\overset{L.R.}{4HCl}} \longrightarrow MnCl_2 + 2H_2O + \underset{1\ mole}{Cl_2}$$

$$\text{Actual moles of } Cl_2 = \frac{11.2}{22.4} = 0.5\ mole$$

$$\%\ yield\ of\ Cl_2 = \frac{0.5}{1} \times 100$$
$$= 50\%$$

Problems based on % Purity →

Q. 2 kg limestone on heating produce 0.44 kg CO_2. Find % purity of $CaCO_3$ sample.

Sol^n→

$$CaCO_3 \xrightarrow{\Delta} CaO + CO_2$$

2000 gm

x% pure

⇓

$2000 \times \frac{x}{100}$ gm

⇓

$\frac{20x}{100}$ mol

CO_2: $\frac{20x}{100}$ mol

$$\frac{20x}{100} \times 44 = 0.44 \times 1000$$

$$x = 50$$

⇒ 50% pure

Homework

Workbook DTS-1 to 11

Q.19-22,25,28,32-34,36-39,48-52,54-56,61,64,66,67,70, 71,75,78,80,82,84,85,87,88,92,95,96,100,113,129,131