VMC Vidyamandir Classes SINCE 1986

IIT JEE | MEDICAL | FOUNDATION

Stoichiometry-1

SAP-4

Problems based on % Purity →

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

Sol^n →

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

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

2000 gm

x% Pure

⇓

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

⇓

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

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

$$x = 50$$

$\Rightarrow$ 50% Pure

Problems based on Sequential reactions →

$$2A \longrightarrow 3B$$

1 mole — 1.5 mole

$$B \longrightarrow 4C$$

1.5 mole — 6 mole

$2C \longrightarrow 5D$

mole = ?

6 mole

$\frac{5}{2} \times 6 = 15$ mole

NX is produced by the following step of reactions

$M + X_2 \longrightarrow MX_2$

$3MX_2 + X_2 \longrightarrow M_3X_8$

$M_3X_8 + N_2CO_3 \longrightarrow NX + CO_2 + M_3O_4$

How much M (metal) is consumed to produce 206 g of NX. (Take at wt of M = 56, N=23, X = 80)

Sol^n→

$M + X_2 \longrightarrow MX_2$

$\frac{3}{4}$ mole → $\frac{3}{4}$ mole

$3MX_2 + X_2 \longrightarrow M_3X_8$

$\frac{3}{4}$ mole → $\frac{1}{4}$ mol

$M_3X_8 + 4N_2CO_3 \longrightarrow 8NX + 4CO_2 + M_3O_4$

$\frac{1}{4}$ mol → 2 mole

mass of M = $\frac{3}{4} \times 56 = 42$ gm

Illustration - 23 *NH_3 is formed in the following steps :*

I. $Ca + 2C \longrightarrow CaC_2$ — 50 % yield

II. $CaC_2 + N_2 \longrightarrow CaCN_2 + C$ — 100 % yield

III. $CaCN_2 + 3H_2O \longrightarrow 2NH_3 + CaCO_3$ — 50 % yield

Find the moles of calcium needed to produce 2 moles of ammonia.

$\%\ \text{yield} = \frac{2}{\text{theo. moles}} \times 100 = 50$

$Ca + 2C \xrightarrow{50\%} CaC_2$

4 mole

2 mole actual
4 mole theo.

$CaC_2 + N_2 \xrightarrow{100\%} CaCN_2 + C$

2 mole

2 mole

$CaCN_2 + 3H_2O \xrightarrow{50\%} 2NH_3 + CaCO_3$

2 mole

4 mole

Problems based on Parallel reactions →

Ex. $2A \longrightarrow 3B$

$4A \longrightarrow 5C$

If 6 moles of A, Produce 1.5 moles of B then find moles of C formed.

Sol^n →

$2A \longrightarrow 3B$

1 mol 1.5 mol

$4A \longrightarrow 5C$

5 mol $\frac{5}{4} \times 5 = \frac{25}{4}$ mol

$KClO_3$ decomposes by two parallel reaction

(i) $2KClO_3 \xrightarrow{\Delta} 2KCl + 3O_2$ (ii) $4KClO_3 \xrightarrow{\Delta} 3KClO_4 + KCl$

If 3 moles of O_2 and 1 mol of $KClO_4$ is produced along with other products then determine initial moles of $KClO_3$.

Soln →

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

2 mol — 3 mol

$4\,KClO_3 \xrightarrow{\Delta} 3\,KClO_4 + KCl$

$\frac{4}{3}$ mol — 1 mol

Initial moles of $KClO_3 = 2 + \frac{4}{3} = \frac{10}{3}$ mole

Principle of atom conservation →

Q. If all the carbon atoms present in $K_2Zn_3[Fe(CN)_6]_2$ are converted into CO_2. then mass of CO_2 obtained by reaction of 6.97 gm $K_2Zn_3[Fe(CN)_6]_2$?

[Zn = 65, Fe = 56, K = 39]

Soln →

$K_2Zn_3[Fe(CN)_6]_2 \longrightarrow 12\,CO_2$

6.97 gm — 0.01 mol — 0.12 mol

⇓

0.12×44

$= 5.28$ gm

In a gravimetric determination of P , an aqueous solution of dihydrogen phosphate ion $H_2PO_4^-$ is treated with a mixture of ammonium and magnesium ions to precipitate magnesium ammonium phosphate, $Mg(NH_4)PO_4.6H_2O$. This is heated and decomposed to magnesium pyrophosphate, $Mg_2P_2O_7$, which is weighed. A solution of $H_2PO_4^-$ yielded 1.054 g of $Mg_2P_2O_7$. What weight of NaH_2PO_4 was present originally ?

$NaH_2PO_4 + NH_4^+ + Mg^{2+} \longrightarrow Mg(NH_4)PO_4 \cdot 6H_2O$

gm = ?

$\downarrow \Delta$

$Mg_2P_2O_7$

1.054 gm

$2\,NaH_2PO_4 \longrightarrow Mg_2P_2O_7$

9.5×10^{-3} mol $\qquad$ 4.75×10^{-3} mol

$\Downarrow$

$9.5 \times 10^{-3} \times 120$ gm

= 1.14 gm

Problems related with mixture →

2. A 10.0 gm sample of a mixture of calcium and sodium chloride is treated with Na_2CO_3 to precipitate the calcium as calcium carbonate. This $CaCO_3$ is heated to convert all the calcium to CaO and the final mass of CaO is 1.62 gms. The % by mass of $CaCl_2$ in the original mixture is :

(A) 15.2% (B) 32.1%

(C) 21.8% (D) 11.7%

Soln →

$CaCl_2 + NaCl$

10 gm

$NaCl + Na_2CO_3 \longrightarrow xxx$

$CaCl_2 + Na_2CO_3 \longrightarrow CaCO_3 + 2NaCl$

0·029 mol

$\downarrow \Delta$

$CaO + CO_2$

1·62 gm

0·029 mol

$$w_{CaCl_2} = 0.029 \times 111 = 3.219 \text{ gm}$$

$$\% CaCl_2 = \frac{3.219}{10} \times 100 = 32.19\%$$

20. A 2.0 g mixture of Na_2CO_3 and $NaHCO_3$ loses 0.248 g when heated to 300°C, the temperature at which $NaHCO_3$ decomposes to Na_2CO_3, CO_2 and H_2O. The % Na_2CO_3 in mixture is :

(A) 33.33% **(B)** 66.6%

(C) 25% **(D)** 50%

Soln → $Na_2CO_3 + NaHCO_3 \longrightarrow x$ mol.

2 gm

$Na_2CO_3 \xrightarrow{\Delta} xxx$

$2NaHCO_{3(s)} \xrightarrow{\Delta} Na_2CO_{3(s)} + H_2O_{(g)} + CO_{2(g)}$

x mol $\quad \frac{x}{2}$ mol $\quad \frac{x}{2}$ mol

Total mass of gases $= \left(\frac{x}{2} \times 18\right) + \left(\frac{x}{2} \times 44\right)$

$= (9x + 22x) = 31x$ gm

$= 0.248$

$x = \frac{0.248}{31} = 8 \times 10^{-3}$

$W_{NaHCO_3} = (8 \times 10^{-3} \times 84) = 0.672$ gm

$W_{Na_2CO_3} = 2 - 0.672 = 1.328$ gm

$\%\ Na_2CO_3 = \frac{1.328}{2} \times 100 = 66.4\ \%$

Illustration - 30 *A mixture of 5.85 gm of NaCl and 12.25 gm of $KClO_3$ is heated strongly to produce $KClO_4$ and KCl. The residue is dissolved in excess of $AgNO_3$. The mass of white precipitate formed is :*

[Molecular mass of AgCl = 143.5 and $KClO_3$ = 122.5]

(A) 28.7 gm (B) 1.793 gm (C) 17.93 gm (D) 7.175 gm

Soln →

$NaCl + KClO_3$

0.1 mol 0.1 mol

$NaCl \xrightarrow{\Delta} x\ x\ x$

$4KClO_3 \xrightarrow{\Delta} 3KClO_4 + KCl$

0.1 mol $\frac{0.3}{4}$ mol $\frac{0.1}{4}$ mol

Residue $\Rightarrow$ $\underbrace{NaCl + KClO_4 + KCl}$

$\downarrow AgNO_3$

$AgCl \downarrow$

white ppt

$NaCl + AgNO_3 \longrightarrow AgCl\downarrow + NaNO_3$

0.1 mol 0.1 mol

$KCl + AgNO_3 \longrightarrow AgCl\downarrow + KNO_3$

$\frac{0.1}{4}$ mol $\frac{0.1}{4}$ mol

$KClO_4 + AgNO_3 \not\longrightarrow AgCl\downarrow$

$$n_{AgCl} = 0.1 + \frac{0.1}{4} = \frac{0.5}{4} \text{ mol}$$

$$W_{AgCl} = \frac{0.5}{4} \times 143.5 = 17.94 \text{ gm}$$

Stochiometric analysis $\longrightarrow$ It is quantitative analysis of chemical substance.

Two types $\rightarrow$

(i) Gravimetric analysis $\longrightarrow$ based on measurement of mass and vol. of chemical substance.

(ii) Volumetric analysis (Titrimetric analysis) $\rightarrow$

based on measurement of vol. of chemical substance.

stoichiometric analysis tools

Mole concept

- Generally used for gravimetric analysis
- Can be applied for all type of reactions

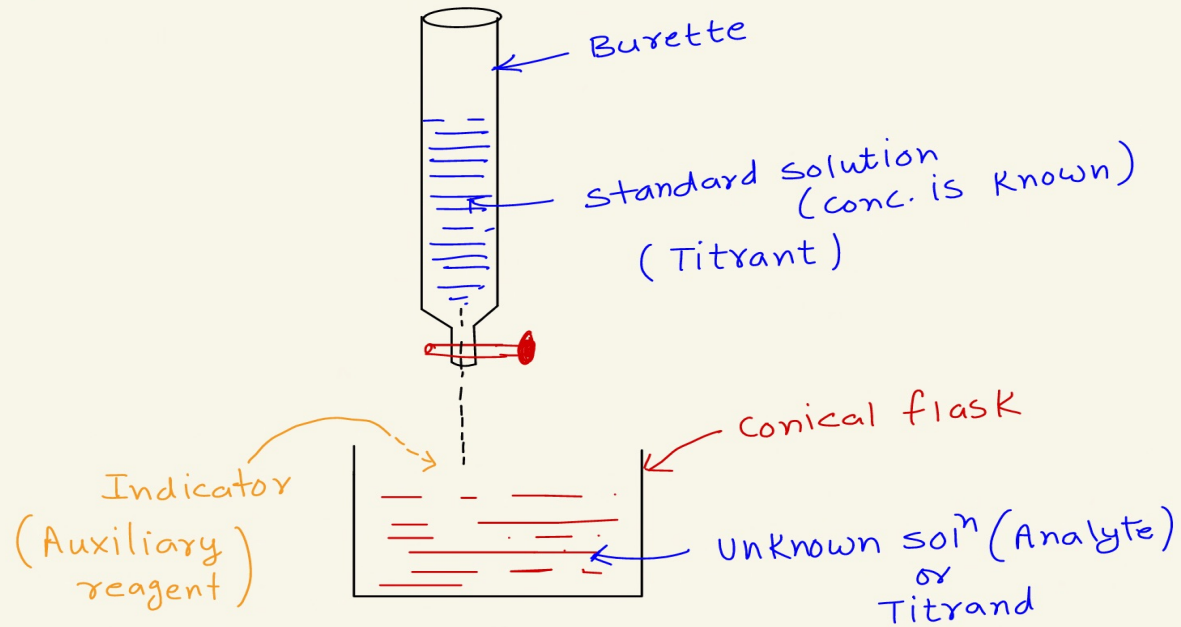
Concept of gm equivalents or Law of equivalence

⇓

used for volumetric analysis.

- Acid base neutralisation
- Redox Rxⁿ

Acid base titration →



End Point → It is determined Practically or experimentally.

At end Point, indicator shows change in colour.

Equivalence Point → It is calculated theoretically.

At equivalence point, Σ(No. of eq. of acid used) = Σ(No. of eq. of base used)

$\frac{\text{given mass}}{\text{Ewt}}$, mol × nf, $N \times V_L$

Law of equivalence →

$$xA + yB \longrightarrow zC$$

x mol Use	y mol Use	Z mol form
P eq Use	P eq use	P eq form

Types of Acid- base titration →

(1) Simple titration (2) Back titration

(3) Double indicator titration

Problems based on simple titration →

How many mL of 0.5 N HCl acid will be required to completely neutralise 500 ml of a 0.1 N NaOH solution?

Soln →

HCl	NaOH
0.5N	0.1 N
$V_{ml} = ?$	500 ml

$$(eq)_{HCl} = (eq)_{NaOH}$$

$$(0.5 \times V) = (0.1 \times 500)$$

$$V = 100 \text{ ml}$$

Illustration - 15 *What volume of a $\frac{M}{6}$ H_3PO_4 solution will completely react with 200 ml of a solution of $\frac{M}{2}$ aluminium carbonate ?*

(A) 600 mL (B) 900 mL (C) 1200 mL (D) 1800 mL

Soln →

H_3PO_4	$Al_2(CO_3)_3$
$\frac{1}{6}$ M	$\frac{1}{2}$ M
$V_{ml} = ?$	200 ml

$$(eq)_{H_3PO_4} = (eq)_{Al_2(CO_3)_3}$$

$$\left(\frac{1}{6} \times 3\right) \times V_{ml} = \left(\frac{1}{2} \times 6\right) \times 200$$

$$V_{ml} = 1200 \text{ ml}$$

If 25 mL of a H_2SO_4 solution reacts completely with 1.06 g of pure Na_2CO_3, what is the normality of this acid solution :

(A) 1 N (B) 0.5 N (C) 1.8 N (D) 0.8 N

Soln →

$$(eq)_{H_2SO_4} = (eq)_{Na_2CO_3}$$

$$N \times \frac{25}{1000} = \frac{1.06}{106} \times 2$$

$$N = 0.8 \text{ eq/lit.}$$

0.5 gm of fuming H_2SO_4 (oleum) is dilute with water. This solution is completely neutralised by 30.0 mL of 0.4 N NaOH. Find the % age of free SO_3 in the sample.

Soln →

H_2SO_4 + SO_3

$(0.5-x)$ gm x gm

$$(eq)_{H_2SO_4} + (eq)_{SO_3} = (eq)_{NaOH}$$

$$\left(\frac{0.5-x}{98} \times 2\right) + \left(\frac{x}{80} \times 2\right) = \frac{0.4 \times 30}{1000}$$

$$x = 0.4 \text{ gm}$$

$$\% \text{ of } SO_3 = \frac{0.4}{0.5} \times 100 = 80\%$$

Illustration - 16 100 mL of mixture of NaOH and Na_2SO_4 is neutralised by 10 mL of 0.5 M H_2SO_4. Hence, mass of NaOH in 100 mL solution is :

(A) 0.2 g (B) 0.4 g (C) 0.6 g (D) None of these

NaOH Na_2SO_4 H_2SO_4

base Neutral Acid

x gm Salt

$$(eq)_{NaOH} = (eq)_{H_2SO_4}$$

$$\left(\frac{x}{40} \times 1\right) = (0.5 \times 2) \times \frac{10}{1000}$$

$$x = 0.4 \text{ gm}$$

Illustration - 20 5 mL of 8 N HNO_3, 4.8 mL of 5 N HCl and a certain volume of 17 M H_2SO_4 are mixed together and made upto 2 L. 30 mL of the acid mixture exactly neutralises 42.9 mL of Na_2CO_3 solution containing 0.1 gm of $Na_2CO_3.10H_2O$ in 10 mL of water. Calculate : (a) the volume of H_2SO_4 added to the mixture. (b) the amount (in gm) of the sulphate ions in the solution.

Soln →

No. of eq. of HNO_3 $= \frac{8 \times 5}{1000} = \frac{40}{1000}$

H_2SO_4 : V ml

No. of eq. of HCl $= \frac{4.8 \times 5}{1000} = \frac{24}{1000}$

No. of eq. of H_2SO_4 $= \frac{17 \times 2 \times V}{1000} = \frac{34V}{1000}$

In 2 lit. soln, total eq. of acids $= \frac{40}{1000} + \frac{24}{1000} + \frac{34V}{1000}$

$$= \frac{64 + 34V}{1000}$$

In 30 ml soln, total eq. of acids $= \left(\frac{64+34V}{1000}\right) \times \frac{30}{2000}$

$$\Sigma (eq)_{acids} = (eq)_{Na_2CO_3}$$

$$\left(\frac{64+34V}{1000}\right) \times \frac{30}{2000} = \left(\frac{0.1 \times 1000}{286 \times 10}\right) \times 2 \times \frac{42.9}{1000}$$

$$V = 4 \text{ ml}$$

$H_2SO_4 \longrightarrow 2H^+ + SO_4^{2-}$

17 M

4 ml

$\Downarrow$

$\frac{68}{1000}$ mol

$\Downarrow$

$\frac{68}{1000}$ mol

$\Downarrow$

$\frac{68}{1000} \times 96$ gm

$= 6.528$ gm

Homework

DTS- 1 to 11
Q.28,35,40-42,90,91,93,97,101,102,121,126,128,132,133,136

JEE main archive:
Q.8-12,16-20,23-31,33,34,37-42

JEE advanced archive:
Q.1-9,11-30