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# CHEMISTRY

TARGET : JEE Advanced - 2022

# CAPS-1

## MOLE CONCEPT
## EQUIVALENT CONCEPT

**1.** A sample of $Fe_2(SO_4)_3$ and $FeC_2O_4$ was dissolved in dilute $H_2SO_4$. The complete oxidation of reaction mixture required 40 mL of N/16 $KMnO_4$ solution. After the oxidation, the reaction mixture was reduced by Zn and dilute $H_2SO_4$. On again oxidation by same $KMnO_4$, 60 mL were required. Calculate the ratio of milli moles of $Fe_2(SO_4)_3$ & $FeC_2O_4$.

(A) 7 : 4 (B) 4 : 7 (C) 3 : 7 (D) 7 : 3

**Ans.** **(A)**

**Sol.** Let m.moles of $Fe_2(SO_4)_3$ and $FeC_2O_4$ are x and y. In first reaction, only $FeC_2O_4$ react with $KMnO_4$ as :

$$FeC_2O_4 + KMnO_4 \longrightarrow Fe^{+3} + CO_2 + Mn^{+2}$$

v.f. = 3 v.f. = 5

m.eq. of $FeC_2O_4$ = m. eq. of $KMnO_4$

$$y \times 3 = 40 \times \frac{1}{16}$$

$$y = \frac{40}{48} \qquad \text{......... (1)}$$

In IInd reaction, all $Fe^{+3}$ is convert into $Fe^{+2}$ :

$$\begin{array}{llll} & Fe^{+3} \text{ from } FeC_2O_4 & + \; Fe^{+3} \text{ from } Fe_2(SO_4)_3 & \xrightarrow{Zn/H^+} \; Fe^{+2} \\ t = 0 & y & 2x & 0 \\ t = t & 0 & 0 & (y + 2x) \end{array}$$

In IIIrd reaction all $Fe^{+2}$ again react with $KMnO_4$ as :

$$Fe^{+2} + KMnO_4 \longrightarrow Fe^{+3} + Mn^{+2}$$

v.f. = 1 v.f. = 5

m.eq. of $Fe^{+2}$ = $m_{eq}$ of $KMnO_4$

$$y + 2x = 60 \times \frac{1}{16}$$

Putting the value of y from equation 1st ,

$$2x = \frac{60}{16} - \frac{40}{48}$$

$$2x = \frac{140}{48}$$

$$x = \frac{70}{48} \qquad \text{......... (2)}$$

From eq. (1) and (2),

$$\frac{x}{y} = \frac{7}{4} \quad \textbf{Ans.}$$

**2.** 0.7 g of $(NH_4)_2 SO_4$ sample was boiled with 100 mL of 0.2 N NaOH solution till all the $NH_3$ gas is evolved. The resulting solution was diluted to 250 mL. 25 mL of this solution was neutralized using 10 mL of a 0.1 N $H_2SO_4$ solution. The percentage purity of the $(NH_4)_2SO_4$ sample is :

(A) 94.3 (B) 50.8 (C) 47.4 (D) 79.8

**Ans.** **(A)**

**Sol.** m.eq of $(NH_4)_2SO_4$ + m.eq of $H_2SO_4$ = m.eq of NaOH

$(\text{m.moles} \times 2) + (0.1 \times 10 \times \frac{250}{25}) = 0.2 \times 100$

$\therefore$ m.mole of $(NH_4)_2SO_4 = 5$

wt. of $(NH_4)_2SO_4 = \frac{5}{1000} \times 132 = 0.66$ g

$\therefore$ % of $(NH_4)_2SO_4 = \frac{0.66}{0.7} \times 100 = 94.28\ \% \approx 94.3\ \%$

**3.** Which of the following statements is incorrect :

(A) 0.2 moles of $KMnO_4$ will oxidise one mole of ferrous ions to ferric ions in acidic medium.

(B) 1.5 moles of $KMnO_4$ will oxidise 1 mole of ferrous oxalate to one mole of ferric ion and carbon dioxide in acidic medium in acidic medium.

(C) 0.6 moles of $KMnO_4$ will oxidise 1 mole of ferrous oxalate to one mole of ferric ion and carbon dioxide in acidic medium.

(D) 1 mole of $K_2Cr_2O_7$ will oxidise 2 moles of ferrous oxalate to ferric ions and carbon dioxide in acidic medium.

**Ans.** **(B)**

**Sol.** $MnO_4^- + 5e^- + 8H^+ \longrightarrow Mn^{2+} + 4H_2O$

$\Rightarrow$ 1 mole of $MnO_4^-$ accepts 5 mole of $e^-$

1/5 mole of $MnO_4^-$ accepts 1 mole of $e^-$

$\Rightarrow$ 0.2 mole of $MnO_4^-$ accepts 1 mole of $e^-$

$\Rightarrow$ 0.6 mole of $MnO_4^-$ accepts 3 mole of $e^-$

$Fe^{2+} \longrightarrow Fe^{3+} + e^-$

$\Rightarrow$ 1 mole of $Fe^{2+}$ will liberate 1 mole of $e^-$

$Cr_2O_7^{2-} + 6e^- + 14H^+ \longrightarrow 2Cr^{+3} + 7H_2O$

$\Rightarrow$ 1 mole of $Cr_2O_7^{2-}$ will accept 6 moles of $e^-$

1 mole of $FeC_2O_4 \longrightarrow Fe^{3+} + CO_2 + 3e^-$

$\Rightarrow$ 1 moles of ferrous oxalate gives 3 moles of $e^-$

$\Rightarrow$ 0.2 moles of $KMnO_4$ = 1/5 moles of $KMnO_4$ oxidises 1 mole of $Fe^{2+}$ ion. (Tallies with statement A)

0.6 moles of $KMnO_4$ = 3/5 moles of $KMnO_4$ will oxidise 1 mole of ferrous oxalate (Tallies with statement C)

1 mole of $K_2Cr_2O_7$ will oxidise 2 moles of ferrous oxalate. (Tallies with statement D)

Hence ,(A) , (C) , (D) are correct while (B) is incorrect.

**4.** A 10.0 g sample of a mixture of calcium chloride and sodium chloride is treated with $Na_2CO_3$ solution. This calcium carbonate is heated to convert all the calcium to calcium oxide and the final mass of calcium oxide is 1.62 gm. The percentage by mass of calcium chloride in the original mixture is :

(A) 15.2% (B) 32.1% (C) 21.8% (D) 11.07%

**Ans.** **(B)**

**Sol.** $CaCl_2 + Na_2CO_3 \longrightarrow CaCO_3 + 2NaCl$

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

Mole of $CaCl_2$ = mole of $CaCO_3$ = mole of CaO = $\left(\frac{1.62}{56}\right)$

Mass of $CaCl_2$ = $\left(\frac{1.62}{56}\right)$ Molar mass of $CaCl_2$

$= \left(\frac{1.62}{56}\right) \times 111$ gm.

% of $CaCl_2 = \frac{3.21}{10} \times 100 = 32.1\ \%.$

**5.** Consider the following statements :

1. If all the reactants are not taken in their stoichiometric ratio, then at least one reactant will be left behind.
2. 2 moles of $H_2(g)$ and 3 moles of $O_2(g)$ produce 2 moles of water.
3. equal wt. of carbon and oxygen are taken to produce $CO_2$ then $O_2$ is limiting reagent.

The above statements 1, 2, 3 respectively are (T = True, F = False)

(A) T T T (B) F T F (C) F F F (D) T F T

**Ans.** **(A)**

**Sol.** (1) It is a fact.

(2) $2H_2 + O_2 \longrightarrow 2H_2O$

| | $2H_2$ | $O_2$ | $2H_2O$ |
|---|---|---|---|
| Initial mole | 2 | 3 | 0 |
| final mole | 0 | 3-1 =2 | 2 |

(3) $C + O_2 \longrightarrow CO_2$

$\frac{w}{12}$ $\frac{w}{32}$

Here C is limiting reagent.

**6.** During the disproportionation of Iodine to iodide and iodate ions, the ratio of iodate and iodide ions formed in alkaline medium is :

(A) 1 : 5 (B) 5 : 1 (C) 3 : 1 (D) 1 : 3

**Ans.** **(A)**

**Sol.** $3I_2 + OH^- \longrightarrow IO_3^- + 5I^-$ (balance reaction)

So, ratio is 1 : 5.

**7.** A 5.0 $cm^3$ solution of $H_2O_2$ liberates 0.508 g of $I_2$ from an acidified KI solution.

The strength of $H_2O_2$ solution in terms of volume strength at STP is

(A) 2.24 vol (B) 8.96 vol (C) 1.12 vol (D) 4.48 vol

**Ans.** **(D)**

**Sol.**

$$\overset{-1}{H_2O_2} + \overset{-1}{K\,I} \rightarrow \overset{-2}{KOH} + \overset{0}{I_2}$$

n-fac $I_2$ = 2, n-fac $H_2O_2$ = 2

Eq. of $I_2$ = Eq. of $H_2O_2$

$$\frac{0.508}{254} \times 2 = M_{H_2O_2} \times 5 \times 10^{-13} \times 2$$

$$M_{H_2O_2} = 0.4\ M$$

Vol. strength = M × 11.2

= 0.4 × 11.2

= 4.48

∴ Vol. strength of $H_2O_2$ = 4.48

**8.** A 0.6 g sample of only $CaC_2O_4$ and $MgC_2O_4$ is heated at 500oC converting them to $CaCO_3$ and $MgCO_3$ weighing 0.465 g. If the sample was heated to 900oC where the products are CaO and MgO, what will be the weight of mixture of oxides

(A) 0.12 g (B) 0.21 g (C) 0.25 g (D) 0.3 g

**Ans.** **(C)**

**Sol.** $\underset{(0.6gm)}{CaC_2O_4 + MgC_2O_4} \xrightarrow{\Delta} \underbrace{CaCO_3 + MgCO_3}_{0.465g}$

$CaC_2O_4 \xrightarrow{\Delta} CaCO_3 + CO$

$MgC_2O_4 \xrightarrow{\Delta} MgCO_3CO$

Molecular Weight $CaC_2O_4$ = 128 gm

Molecular Weight $MgC_2O_4$ = 112 gm

$CaC_2O_4 \rightarrow$ xgm, $CaCO_3 \rightarrow$ ygm

$$\begin{tikzcd} 128\text{gm} \arrow[r] \arrow[dr, dash] & 100\text{gm } CaCO_3 \arrow[dl, dash] \\ x\text{ gm} \arrow[r] & y \end{tikzcd}$$

$100x = 128y \Rightarrow x = 1.28y$

$MgC_2O_4 \rightarrow 0.6 - x$, $MgCO_3 \rightarrow 0.465 - y$

$$\begin{tikzcd} 118\text{gm} \arrow[r] \arrow[dr, dash] & 84\text{gm } MgCO_3 \arrow[dl, dash] \\ 0.6 - x \arrow[r] & 0.465 - y\text{gm} \end{tikzcd}$$

$\Rightarrow 112\text{gm } (0.465 - y) = 84\ (0.6 - x)$

$\Rightarrow 112\ (0.465 - y) = 84\ (0.6 - 1.28y)$

$\Rightarrow 52.08 - 112y = 50.4 - 107.52y$

$\Rightarrow 1.68 = 4.48y$

$\Rightarrow y = 0.375$

$\Rightarrow x = 0.48$

$\therefore$ Amount of $CaCO_3$ = 0.375

Amount of $MgCO_3$ = 0.09

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

$MgCO_3 \xrightarrow{\Delta} Mg0 + CO_2$

100 gm $CaCO_3 \rightarrow$ 56 gm CaO

0.375 gm $\rightarrow$ ? = 0.21 gm CaO

84 gm $MgCO_3 \rightarrow$ 40 gm MgO

0.09 gm $\rightarrow$ ? = 0.042 gm MgO

$\therefore$ Total oxide formed = 0.21 + 0.04 $\simeq$ 0.25 gm

**9.** $K_2Cr_2O_7$ can supply "oxygen" to oxidise pollutants in a water sample. If one kilogram of such water sample requires 20 ml of 0.1 M $K_2Cr_2O_7/H^+$, what is the oxygen requirement of that water in ppm units?

(A) 96 ppm (B) 48 ppm (C) 24 ppm (D) 32 ppm

**Ans.** **(A)**

**Sol.** $K_2\overset{+6}{Cr_2}O_4 + H_3\overset{+2}{S}O_4 \rightarrow K_3SO_4 + \overset{+3}{Cr_2}(SO_4)_3 + H_2O + \overset{0}{O_2}$

$Cr_2O_7^{2-}$, n-factor = 6 Eq of $K_2Cr_2O_7$ = Eq. of $O_2$

$O_2$, n-factor = 4 $\quad$ $6 \times 0.1 \times 20 \times 10^{-3} = \text{moles} \times 4$

Moles = $3 \times 10^{-3}$

Wt. of $O_2 = 3 \times 10^{-3} \times 32$ gm

= $96 \times 10^{-3}$ gm

$$\text{Ppm of } O_2 = \frac{96 \times 10^{-3}}{10^3} \times 10^6$$

= 96 ppm

NOTE; Given 1 kg water – $10^3$ g

**10.** $Cl_2$ disproportionate into $Cl^-$ ions and $ClO_3^-$ ions in hot alkali. Which statement is wrong about this reaction?

(A) Equivalent weight of $Cl_2$ is 60 % that of molecular weight.

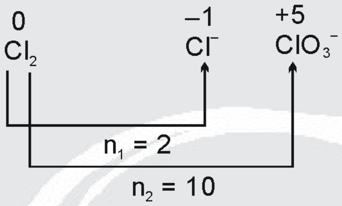
(B) Equivalent weight of oxidised chlorine is 7.1.

(C) $\frac{5}{6}$ th fraction of total chlorine is reduced.

(D) $\frac{5}{6}$ th fraction of total chlorine is oxidized.

**Ans.** **(D)**

**Sol.**

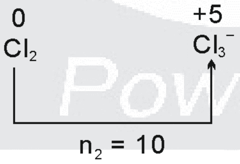


(a) $\quad$ $\text{n factor of } Cl_2 = \frac{10 \times 2}{12} = \frac{5}{3}$

$\Rightarrow$ $\quad$ $\text{Eq. wt.} = \frac{71 \times 3}{5} = 42.6$

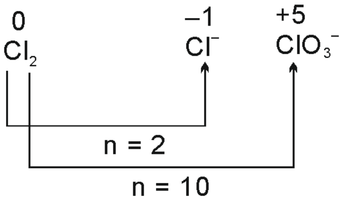
= 60% of mol wt.

(b) $\quad$ Eq. wt. of Cl2 oxidized



$\text{Eq. wt.} = \frac{71 \times 0}{10} = 7.1$

(c)



For balancing: $12Cl_2 \rightarrow 10Cl^- + 2ClO_3^-$

$\therefore$ Fraction of $Cl_2$ reduced = $\frac{10}{12} = \frac{5}{6}$

(d) Fraction of $Cl_2$ oxidized $\frac{2}{12} = \frac{1}{6}$

Therefore (d) is wrong statement.

**11.** A mixture of $H_2SO_4$ and $H_2C_2O_4$ (oxalic acid) and some inert impurity weighing 3.185 g was dissolved in water and the solution made up to 1 litre, 10 mL of this solution required 3 mL of 0.1 N NaOH for complete neutralization. In another experiment 100 mL of the same solution in hot condition required 4 mL of 0.02M $KMnO_4$ solution for complete reaction. The wt. % of $H_2SO_4$ in the mixture was:

(A) 40 (B) 50 (C) 60 (D) 80

**Ans.** **(A)**

**Sol.** Mixture: $H_2SO_4 + H_2C_2O_4$.

Titration: 1 → 10 ml mixture with NaOH

Titration: 2 → 100 ml mixture with 4 ml, 0.02 M $KMnO_4$

From titration 2 $\Rightarrow K\overset{+7}{Mn}O_4 + H_2\overset{+3}{C_2}O_4 \rightarrow Mn^{2+} + \overset{+4}{C}O_2$

n-fac $KMnO_4$ = 5

n-fac $H_2C_2O_4$ = 2

$\overset{2}{\cancel{4}} \times 0.02 \times 5 = \cancel{2} \times$ moles of $H_2C_2O_4$

Moles of $H_2C_2O_4$ = 0.2 m mol

0.2 mmol $H_2C_2O_4$ in 100 ml

$\Rightarrow$ 2 mmol $H_2C_2O_4$ in 1 lit

From titration: 1 $\Rightarrow$ NaOH + $H_2SO_4 \rightarrow Na_2SO_4$

NaOH + $H_2C_2O_4 \rightarrow Na_2C_2O_4$

Eq. of NaOH = eq. of $H_2SO_4$ + eq. of $H_2C_2O_4$

NOTE: In 10 ml, 0.02 mmol $H_2C_2O_4$ is present

$\Rightarrow$ $0.1 \times 3 = 2 \times$ moles $H_2SO_4 + 2 \times 0.02$

$\Rightarrow$ moles $H_2SO_4$ = 0.13 mmol in 10 ml mixture

= $13 \times 98 \times 10^{-3}$ gm $H_2SO_4$ in 1 lit mixture

= 1.274 gm $H_2SO_4$

$\therefore$ % $H_2SO_4$ in mixture = 40%

**12.** Oxalic acid ($H_2C_2O_4$) is a dibasic acid as well as a good reducing agent while $KHC_2O_4$ is an amphoteric salt in addition to being a good reducing agent. A 3.0 g sample containing $KHC_2O_4$, oxalic acid dihydrate ($H_2C_2O_4.2H_2O$) and some inert impurity was dissolved in water and diluted to 100 mL and finally analyzed. 0.228 g $CaC_2O_4$ is precipitated by 10 mL of the solution with $CaCl_2$ in $NH_4OH$. Answer the following question based on the information provided (Molar mass K = 39, C = 12 and O = 16) – A 10 mL portion of the above solution required 7.8 mL of a 0.05 M $H_2SO_4$ solution to reach the end point. What is the mass percentage of $KHC_2O_4$ in the original sample?

(A) 28% (B) 33% (C) 48% (D) 60%

**Ans.** **(B)**

**Sol.** When titrated against $H_2SO_4$, from the sample of $H_2C_2O_4.2H_2O$, $KHC_2O_4$, only $KHC_2O_4$ would react.

$\therefore$ m. eq. of $H_2SO_4$ = m. eq. of $KHC_2O_4$

$\Rightarrow$ $7.8\times0.05\times2 = (\text{moles})_{KHC_2O_4}\times1$

$\Rightarrow$ $(\text{moles})_{KHC_2O_4} = 0.78$ m moles

$\Rightarrow$ wt. of $KHC_2O_4$ = 99.84 mg (in 10 ml)

In 100 ml, wt. of KHC2O4 ≈ 1000 mg.

Mass % of $KHC_2O_4$ = $\frac{1}{3}\times100 = 33.3\%$

Mass % of $KHCO_4$ = 33%

**13.** Match the column

**Column-I**

| | |
|---|---|
| (A) $\underset{3.5\text{mole}}{Sn^{+2}}+\underset{1.2\text{mole}}{MnO_4^-}$(acidic) | (p) Amount of oxidant available decides the number of electrons transfer |
| (B) $\underset{8.4\text{mole}}{H_2C_2O_4}+\underset{3.6\text{mole}}{MnO_4^-}$(acidic) | (q) Amount of reductant available decides the number of electrons transfer |
| (C) $\underset{7.2\text{mole}}{S_2O_3^{-2}}+\underset{3.6\text{mole}}{I_2}$ | (r) Number of electrons involved per mole of oxidant > Number of electrons involved per mole of reductant |
| (D) $\underset{9.2\text{mole}}{Fe^{+2}}+\underset{1.6\text{mole}}{Cr_2O_7^{-2}}$(acidic) | (s) Number of electrons involved per mole of oxidant < Number of electrons involved per mole of reductant. |

**Ans.** **((A) – p, r; (B) – q, r; (C) – p, q, r; (D) – q, r)**

**Sol.** Consider option D:

Balancing

$6Fe^{2+} + Cr_2O_7^{2-} + 14H^+ \rightarrow 6Fe^{3+} + 2Cr^{3+} + 7H_2O$

Given 9.2 mol $Fe^{2+}$, 1.6 mol $Cr_2O_7^{2-}$ (6 mol $Fe^{2+}$ requires 1 mol $Cr_2O_7^{2-}$)

LR = $Fe^{2+}$

$\therefore$ No of $e^-$ transfer is decided by $Fe^{2+}$, i.e., reductant

Also, n-fac of $Cr_2O_7^{2-}$ > n-fac of Fe2+

$\therefore$ No of $e^-$ involved per mol of $Cr_2O_7^{2-}$ (oxidant) is greater than $Fe^{2+}$ (reductant)

**14.** Given two mixtures:

I) $NaOH + Na_2CO_3$

II) $NaHCO_3 + Na_2CO_3$

100 ml of mixture I required ‘W’ and ‘X’ ml of 1 M HCl in separate titrations using phenolphthalein and Methyl orange indicators. While 100 ml of mixture II required ‘Y’ and ‘Z’ ml of same HCl solution in separate titration using same indicators.

| **Column I (Substance)** | **Column II (Molarity in solution)** |
|---|---|
| (A) $Na_2CO_3$ in mixture I | (P) $(2w – x) \times 10^{-2}$ |

| | | | |
|---|---|---|---|
| (B) | $Na_2CO_3$ in mixture II | (Q) | $(z - 2y) \times 10^{-2}$ |
| (C) | NaOH in mixture I | (R) | $y \times 10^{-2}$ |
| (D) | $NaHCO_3$ in mixture II | (S) | $(x - w) \times 10^{-2}$ |

**Ans.** **A - S; B - R; C - P; D - Q**

**Sol.** Mixture I: NaOH + $Na_2CO_3$

Titration-I: end pt. using phenolphthalein

w ml HCl used

Reactions:

$NaOH + HCl \rightarrow NaCl + H_2O$

$Na_2CO_3 + HCl \rightarrow NaCl + NaHCO_3$

pH > 7

Titration-II: End point using methyl orange

x ml HCl used

Reactions:

$NaOH + HCl \rightarrow NaCl + H_2O$

$Na_2CO_3 + HCl \rightarrow NaCl + NaHCO_3$

$NaHCO_3 + HCl \rightarrow NaCl + CO_2 + H_2O$

$\therefore$ (x – w) ml HCl used to neutralize $NaHCO_3$.

= Eq of HCl = Eq of $NaHCO_3$ = Eq of $Na_2CO_3$

$\Rightarrow$ $(x - w) \times 1 \times 1 = M_{NaHCO_3} \times 100 = M_{Na_2CO_3} \times 100$

$$\Rightarrow \quad M_{Na_2CO_3} = \frac{x - w}{100}$$

Volume of HCl for neutralization of NaOH

= w – (x – w)

= (2w – x) ml

Eq of HCl = Eq of NaOH

$1 \times (2w - x) = 100 \times MNaOH$

$$M_{NaOH} = \frac{2w - x}{100}$$

Mixture-II: $NaHCO_3 + Na_2CO_3$

Titration-I y ml HCl used (phenolphthalein)

$Na_2CO_3 + HCl \rightarrow NaHCO_3 + NaCl$

Titration-II: z ml HCl used (methyl orange)

$NaHCO_3 + HCl \rightarrow NaCl + CO_2 + H_2O$

From titration-1

Eq of $Na_2CO_3$ = Eq of HCl

$$\Rightarrow \quad M_{Na_2CO_3} \times 100 = y \times 1$$

$$M_{Na_2CO_3} = \frac{y}{100}$$

From titration-2

Amount of HCl required for neutralization of $NaHCO_3$ in mixture II} = z – 2y

Eq of HCl = Eq of $NaHCO_3$

$\Rightarrow \quad z - 2y \times 1 = M_{NaHCO_3} \times 100$

$\Rightarrow \quad M_{NaHCO_3} = z - 2y/100$

**15.** Match the following

| | **Column I** | | **Column II** |
|---|---|---|---|
| (A) | $\underline{P_2H_4} \rightarrow PH_3 + P_4H_2$ | (P) | $E = \frac{3M}{4}$ |
| (B) | $\underline{I_2} \rightarrow I^- + IO_3^-$ | (Q) | $E = \frac{3M}{5}$ |
| (C) | $MnO_4^- + Mn^{2+} + H_2O \rightarrow Mn_3O_4 + H^+$ | (R) | $E = \frac{15M}{26}$ |
| (D) | $\underline{H_3PO_2} \rightarrow PH_3 + H_3PO_3$ | (S) | $E = \frac{5M}{6}$ |

**Ans.** **A - S; B - Q; C - R; D - P**

**Sol.** 1

## MULTIPLE CHOICE QUESTIONS

**16.** To a 25 ml $H_2O_2$ solution excess acidified solution of KI was added. The iodine liberated 20 ml of 0.3 N sodium thiosulphate solution. Use these data to choose the correct statements from the following :

(A) The weight of $H_2O_2$ present in 25 ml solution is 0.102 g

(B) The molarity of $H_2O_2$ solution is 0.12 M

(C) The weight of $H_2O_2$ present in 1 L of the solution is 0.816 g

(D) The volume strength of $H_2O_2$ is 1.344 L

**Ans.** **(ABD)**

**Sol.** No. of equivalents of $S_2O_3^{2-} = 20 \times 0.3 \times 10^{-3}$
$= 6 \times 10^{-3}$ eq.
No. of equivalents of $I_2$ produced = $6 \times 10^{-3}$ eq.
No. of equivalents of $H_2O_2$ = $6 \times 10^{-3}$ eq.
Wt of $H_2O_2$ present in 25 ml of solution = $6 \times 10^{-3} \times 17$
($\because$ Eq. wt $H_2O_2$ = 17) = 0.102 g
Statement (A) is correct.

Wt of $H_2O_2$ in 1L of the solution = $\frac{0.102 \times 1000}{25}$
= 4.08 g
Statement (C) is wrong.

$\therefore$ molarity of $H_2O_2$ solution = $\frac{4.08}{34}$ = 0.12 M

Statement (B) is correct.

$2H_2O_2 \longrightarrow 2H_2O + O_2$

2 mol 1 mol

0.2 mol 0.06 mol

Volume of $O_2$ at NTP = 0.06 × 22.4 lit
= 1.344 lit

**17.** Given following series of reactions:

(I) $NH_3 + O_2 \rightarrow NO + H_2O$

(II) $NO + O_2 \rightarrow NO_2$

(III) $NO_2 + H_2O \rightarrow HNO_3 + HNO_2$

(IV) $HNO_2 \rightarrow HNO_3 + NO + H_2O$

Select the correct option(s):

(A) Moles of $HNO_3$ obtained is half of moles of Ammonia used if $HNO_2$ is not used to produce $HNO_3$ by reaction (IV)

(B) $\frac{100}{6}$% more $HNO_3$ will be produced if $HNO_2$ is used to produce $HNO_3$ by reaction (IV) than if $HNO_2$ is not used to produce $HNO_3$ by reaction (IV)

(C) If $HNO_2$ is used to produce $HNO_3$ then $\frac{1}{4}$th of total $HNO_3$ is produced by reaction (IV)

(D) Moles of NO produced in reaction (IV) is 50% of moles of total $HNO_3$ produced.

**Ans.** **(ACD)**

**Sol.** (a) $2NH_3 + \frac{7}{2}O_2 \rightarrow HNO_3 + HNO_2 + 2H_2O$ (up to reaction III)

Moles of HNO3 obtained is half of moles of Ammonia used.

(b) $3HNO_2 \rightarrow HNO_3 + 2NO + H_2O$

Suppose 1 mole of $NH_3$ is taken initially.

It makes $\frac{1}{2}HNO_3$ & $\frac{1}{2}$ $HNO_2$ till reaction III.

But now $\frac{1}{2}$ $HNO_2$ makes of $\frac{1}{6}$ $HNO_3$ in reaction IV.

So, $HNO_3$ formed is $\frac{1}{2}+\frac{1}{6}=\frac{2}{3}$mole

% increase = $\frac{\frac{1}{6}}{\frac{1}{2}}\times 100 = \frac{100}{3}$%

(c) is correct

(d) Moles of NO produced = $\frac{1}{2}\times\frac{2}{3}=\frac{1}{3}$moles

$$\% = \frac{\frac{1}{3}}{\frac{2}{3}}\times 100 = 50\%$$

**18.** One gram of carbonate of Alkaline Earth metal was dissolved in 25 ml of Normal HCl. The resulting liquid required 50 ml of $\frac{N}{10}$ caustic soda solution to neutralize it completely. Then which of the following are correct?

(A) Eq. wt of Metallic carbonate = 50 (B) Eq. wt of Metal = 20

(C) Eq. wt of Metal = 3 (D) Eq. wt of Metallic carbonate = 40

**Ans.** **(AB)**

**Sol.** $MCO_3 + 2HCl \rightarrow MCl_2 + CO_2 + H_2O$

1 gm 1 N, 25 ml

Excess HCl (left out) reacted with 50 ml, $\frac{N}{10}$ caustic soda (NaOH)

Eq. of HCl left = Eq. of NaOH

$1 \times x = 50 \times \frac{N}{10} \Rightarrow x = 5ml$

Amount of HCl reacting with $MCO_3$ = 20 ml

Eq. of $MCO_3$ = Eq. of HCl

$\frac{wt}{eq\ wt}(\text{of } MCO_3) = 20 \times 10^{-3} \times 1$

$\Rightarrow \quad \frac{1gm}{Eq.\ wt} = \frac{20}{1000}$

$\Rightarrow \quad$ Eq. wt of $MCO_3 = \frac{1000}{20} = 50$

n-factor of $MCO_3$ = 2

mol. wt. of $MCO_3$ = 100

$\Rightarrow$ atomic wt. of M + 12 + 3(16) = 100

$\Rightarrow$ atomic wt. of metal = 40 gm

$\Rightarrow$ Eq. wt. of metal = $\frac{40}{2} = 20$ (n factor of metal = 2)

**19.** Identify intramolecular redox reactions but not disproportionation reactions

(A) $(NH_4)_2 Cr_2 O \rightarrow N_2 + Cr_2 O_3 + H_2O$

(B) $NH_4NO_3 \rightarrow N_2O + 2H_2O$

(C) $2KClO_3 \rightarrow 2KCl + 3O_2$

(D) $PCl_5 \xrightarrow{\Delta} PCl_3 + Cl_2$

**Ans.** **(ABCD)**

**Sol.** (a) $(\overset{+3}{N}H_4)_2 \overset{+6}{Cr_2}O_7 \rightarrow \overset{0}{N_2} + \overset{+3}{Cr_2}O_3 + H_2O$

Nitrogen → reduced

Cr → oxidised

Intramolecular redox.

(b) $\overset{-3}{N}H_4 \overset{+5}{N}O_3 \rightarrow \overset{+1}{N_2}O + 2H_2O$

One N is oxidized

One N is reduced

Not disproportionation but redox.

(c) $2K\overset{+5}{Cl}\overset{-2}{O_3} \rightarrow 2K\overset{-1}{Cl} + \overset{0}{O_2}$

C $\rightarrow$ reduced

O $\rightarrow$ oxidised

$\therefore$ Intramolecular redox

(d) $\overset{+5}{P}\overset{-1}{Cl_5} \rightarrow \overset{+3}{P}Cl_3 + \overset{0}{Cl_2}$

P $\rightarrow$ reduced

C $\rightarrow$ oxidised

$\therefore$ Intramolecular redox

**20.** A 150 ml mixture of CO and $CO_2$ is passed through a tube containing excess of red-hot charcoal. The volume become 200 ml due to reaction $CO_2$ (g) + C (s) $\rightarrow$ 2CO(g)

(a) Mole percent of $CO_2$ in the original mixture is 50.

(b) Mole fraction of CO in the original mixture is 0.66.

(c) The original mixture contains 50 ml of $CO_2$.

(d) The original mixture contains 50 ml of CO.

**Ans.** **(BC)**

**Sol.** 150 ml CO and $CO_2$ mixture

Say $CO_2 \rightarrow$ x ml

CO $\rightarrow$ (150 – x) ml

CO2 + C $\rightarrow$ 2CO

x ml $CO_2 \rightarrow$ 2x ml CO

Total volume after reaction = 200 ml (given)

$\therefore$ 200 = 150 – x + 2x

$\Rightarrow$ x = 50 ml

$\therefore$ $CO_2 \rightarrow 50$ ml, $\frac{0.05}{22.4}$mol

CO 100 $\rightarrow$ ml, $\frac{0.1}{22.4}$mol

$$\text{Mole fraction of CO} = \frac{\frac{0.1}{22.4}}{\frac{0.05}{22.4} + \frac{0.1}{22.4}} = \frac{0.1}{0.15} \simeq 0.667$$

**NUMERIC ANSWER TYPE**

**21.** To 100 ml of 5 M NaOH solution (density 1.2 g/ml) were added 200 ml of another NaOH solution which has a density of 1.5 g/ml and contains 20 mass percent of NaOH. What will be the volume of the gas (at STP) in litres liberated when aluminium reacts with this (final) solution. The reaction is Al + NaOH + $H_2O \rightarrow NaAlO_2 + H_2$ (At. wt. Na = 23, 0 = 16, H = 1)

**Ans.** **(67.2)**

**Sol.** 100 ml of 5 M NaOH soln

Moles $\Rightarrow$ M × V = $\frac{100 \times 5}{1000}$ = 0.5 moles from solution 1

From second solution

mass = mass%*density × volume

Mass = 20% of density × volume

$$\text{moles} = \frac{20}{100} \times \frac{200 \times 1.5}{40} = 1.5 \text{ moles}$$

Total moles of NaOH = 2 moles

According to the balanced equation

$$Al + NaOH + H_2O \rightarrow NaAlO_2 + \frac{3}{2}H_2$$

1 moles NaOH $\rightarrow \frac{3}{2}H_2$ moles

∴ 2 moles → 3 moles of $H_2$

∴ Volume at STP = 3 × 22.4 = 67.2 L

**22.** 10 g sample of bleaching powder was dissolved in water to make one litre solution. To this solution, 35 mL of 1.0 M Mohr salt solution was added containing enough $H_2SO_4$. After the reaction was complete, the excess Mohr salt required 30 mL of 0.1 M $KMnO_4$ for oxidation. Find the approximate % of available $Cl_2$.

**Ans.** **(7.1%)**

**Sol.** M eq of Mohr salt = 35 × 1 × 1 = 35

M eq of $KMnO_4$ = M eq of excess Mohr's salt = 30 × 0.1 × 5 = 15

M eq of Mohr's salt reacted with bleaching powder = 35-15 = 20

M eq of $Cl_2$ = 20

Wt. of $Cl_2$ = $20 \times 10^{-3} \times \frac{71}{2} = 0.71\,g$

% of Cl2 = 7.1%

**23.** 1 gm of a metal ion $M^{x+}$ (atomic mass = 100) was treated with 3.00 gm of $N_2H_4.H_2O$ and $CO_2(g)$ was passed through the mixture when entire metal got precipitated as a complex of formula $(N_2H_5)_m[M(N_2H_3COO)_n]$. One tenth of the volume of the filtrate after filtering off the precipitate required 20 ml of 0.1M $KIO_3$ solution in 6 M HCl.

$$IO_3^- + N_2H_4 + 2H^+ + Cl^- \longrightarrow ICl + 3H_2O + N_2$$

Find the value of (m + n).

**Ans.** **(4.00)**

**Sol.** $$\underset{1\,gm}{M^{x+}} + \underset{3\,gm}{N_2H_4.H_2O} \xrightarrow{CO_2} (N_2H_5)_m[M(N_2H_3COO)_n]\downarrow$$

After filtrate is removed, left out $N_2H_4.H_2O$ is titrated against $KIO_3$

Thus

Total moles of $N_2H_4$ taken = Moles reacted with $M^{x+}$ + Moles reacted with $KIO_3$

Total moles of $N_2H_4.H_2O$ taken = $\frac{wt}{mol\ wt} = \frac{3}{50} = 0.06$

Moles reacted with $KIO_3$

Eq of $KIO_3$ = Eq of $N_2H_2.H_2O$

$$\overset{+5}{1}0_3^- + \overset{-2}{N_2}H_4 + 2H^+ + Cl^- \rightarrow \overset{+1}{I}Cl + 3H_2O + \overset{0}{N_2}$$

⇒ $4 \times 0.1 \times 20 \times 10^{-3}$ = moles × 4

⇒ moles = 0.002

But for titration only 1/10th volume is used

Thus V/10 volume is used.

Thus V/10 volume has 0.002 mol N2H2.H2O

⇒ V volume has = 0.002 × 10 = 0.02 mol

$\therefore$ 0.06 = moles reacted with $M^{x+}$ + 0.02

$\Rightarrow$ Moles reacted with $M^{x+}$ = 0.04

$M^{x+} + N_2H_4.H_2O \xrightarrow{CO_2} (N_2H_5)_m[M(N_2H_3COO)_n]\downarrow$

Balancing: $M^{x+} + (m+n)N_2H_4 \xrightarrow{CO_2} (N_2H_5)_m[M(N_2H_3COO)_n]$

1 mol $M^{x+} \rightarrow$ (m + n) mol $N_2H_4$

$\frac{1}{100}$ mol $\rightarrow$ 0.04 mol

$\Rightarrow$ $0.04 = \frac{m+n}{100} \Rightarrow m+n = 4$

**24.** $pCu_2O + qMnO_4^- + rH_2O \rightarrow sMnO_2 + t\,Cu\,(OH)_2\ u\,OH^-$. The value of (p + q + r) −(s + t + u) is

**Ans.** **(2.00)**

**Sol.** $pCu_2O + qMnO_4^- + rH_2O \rightarrow sMnO_2 + tCu(OH)_2 + uOH^-$

Balancing

$3Cu_2O + 2MnO_4^- + 7H_2O \rightarrow 2MnO_2 + 6Cu(OH)_2 + 2OH^-$

(p + q + r) – (s + t + ν) = (3 + 2 + 7) – (2 + 6 + 2) = 2

## SUBJECTIVE ANSWER TYPE

25. The density of a pure liquid ($X_2$) having molecular mass 70 is 3.5 gm/ml. If 2 ml of liquid contain 35 drops, then the number of mole atoms in 2 litre of liquid will be

Sol. Mass of 2 litre liquid = 2000 × 3.5 = 7000 gm
Number of moles =  = 100 mole molecule = 200 gm atoms.

26. What volume of liquid **'A'** has same number of moles of **'A'** as there are number of moles of **'B'** in 80cm$^3$ of liquid **'B'**.
**Given :**[Density of A = $1.0 \times 10^{-3}$ gm/mL ; Density of B = $1.0 \times 10^{-3}$ gm/mL
Molecular mass of A and B liquids are 40 & 20 respectively]

Sol. $d = \frac{M}{V} \quad \therefore \quad \frac{1.0\times10^{-3}\times V_A}{40} = \frac{80\times1.0\times10^{-3}}{20}$

$V_A$ = 160

**27.** At room temperature, the density of water is 1.0 g/ml and the density of ethanol is 0.789 g/ml. What volume of ethanol contains the same number of molecules as are present in 175 ml of water ?

**Ans.** 566.82 ml.

**Sol.** Let the volume of ethanol containing the same number of molecules as are present in 175 ml of $H_2O$ be V ml. As given ,

moles of $C_2H_5OH$ in V ml = moles of $H_2O$ in 175 ml

Now , $\frac{\text{wt.of } C_2H_5OH}{\text{mol.wt.of } C_2H_5OH} = \frac{\text{wt.of } H_2O}{\text{mol.wt.of } H_2O}$

or , $\frac{0.789\times V}{46} = \frac{1.0\times175}{18}$

$\therefore$ V = 566.82 ml.

**28.** A fluorine disposal plant was constructed to carryout the reactions :

$$F_2 + 2NaOH \longrightarrow O_2 + 2NaF + H_2O$$

$2NaF + CaO + H_2O \longrightarrow CaF_2 + 2NaOH$

As the plant operated, excess lime was added to bring about complete precipitation of the fluoride as $CaF_2$. Over a period of operation, 1900 kg of fluorine was fed into a plant and 10,000 kg of lime was required. What was the percentage utilisation of lime ? [ At mass F = 19 ], [Lime : CaO]

**Ans.** 28 %

**Sol.** $F_2 + 2NaOH \longrightarrow \frac{1}{2}O_2 + 2NaF + H_2O$

Mole $50 \times 10^3$   $2[50 \times 10^3]$

$2NaF + CaO + H_2O \longrightarrow CaF_2 + 2\,NaOH$

$2\times[50 \times 10^3]$   $50 \times 10^3$ Mole

Weight of lime (CaO) = $50 \times 10^3 \times 56$
= 2800 kg.

Feed amount of lime = 10,000

% Utilisation = $\frac{2800}{10,000} \times 100 = 28\%$

**29.** Two beakers A and B contain distilled water each. In beaker A, 100 g of $NaNO_3$ is dissolved and in B, 100 g of $NH_2CO\,NH_2$ is dissolved, so that the total volume in each of the beakers now becomes 500 ml respectively. What will be the molarity with respect to $NaNO_3$ and $NH_2CONH_2$ each when the two solutions are mixed. (Given At. mass Na = 23) (Assume no reaction between $NaNO_3$ and $NH_2CONH_2$).

**Ans.** **= 1.175 M, = 1.66 M**

**Sol.** mol mass of $NaNO_3$ = 85 g, mol mass $NH_2CONH_2$ = 60 g
molarity of $NaNO_3$ in Beaker A = 2.35 M and
molarity of $NH_2CO\,NH_2$ in Beaker B = 3.33 M

When mixed final molarity $M_{final} = \frac{M_1V_1 + M_2V_2}{V_1 + V_2}$

Hence $M_{final}$ of $NaNO_3 = \frac{2.35 \times 500 + 0}{500 + 500} = 1.176$ M

$M_{final}$ of $NH_2CO\,NH_2 = \frac{3.33 \times 500 + 0}{500 + 500} = 1.66$ M

**or**

$M_{NaNO_3} = \frac{\text{Total moles}}{\text{volume in litres}} = \frac{100/85}{1} = 1.176$ M

$M_{NH_2CONH_2} = \frac{100/60}{1} = 1.67$ M.

**30.** $A_2 + 2B_2 \rightarrow A_2B_4; \frac{3}{2}A_2 + 2B_2 \rightarrow A_3B_4.$

Two substance $A_2$ & $B_2$ react in the above manner. When $A_2$ is limited it gives $A_2B_4$ in xcess gives $A_3B_4$. $A_2B_4$ can be converted to $A_3B_4$ when reacted with $A_2$. Using this information calculate the composition of the final mixture when the mentioned amount of $A_2$ & $B_2$ are taken

(a) 4 moles $A_2$ & 4 moles $B_2$   (b) 1/2 moles $A_2$ & 2 moles $B_2$
(c) 1.25 moles $A_2$ & 2 moles $B_2$

**Ans.** **(a) $A_3B_4$ = 2 & $A_2$ = 1**   **(b) $A_2B_4$ = 0.5 & $B_2$ = 1**   **(c) $A_2B_4$ = 0.5 & $A_3B_4$ = 0.5**

**Sol.** (a) $A_3B_4$ = 2 & $A_2$ = 1;   (b) $A_2B_4$ = 0.5 & $B_2$ = 1;   (c) $A_2B_4$ = 0.5 & $A_3B_4$ = 0.5

$A_2 + 2B_2 \rightarrow A_2B4$ .....(i)

$\frac{3}{2}A_2 + 3B_2 \rightarrow A_3B_4$ .....(ii)

Also, $A_3B_4$ can be produced if $A_2B_4$ is reacted with $A_2$.

i.e., $\frac{1}{2}A_2 + A_2B_4 \rightarrow A_3B_4$ .....(iii)

(a) 4 moles of A2 & 4 moles of B2.

Reaction 1 says $2B_2$ requires $1A_2$,

$\therefore$ $4B_2$ would require $2A_2$ to produce $2A_2B_4$ & $2A_2$ would leave out.

Now in reaction 3, $2A_2B_4$ would react with $1A_2$ to produce 2 of $A_3B_4$ and 1 mole of $A_2$ would leave out.

(b) 0.5 moles of $A_2$ & 2 moles of $B_2$.

Reaction 1 says 2 $B_2$ required 1 $A_2$,

$\therefore$ 0.5 $A_2B_4$ would be generated and 1 $B_2$ would leave out.

Since $A_2$ is completely consumed no further reaction will occur.

(c) $\frac{5}{4}$ moles of $A_2$ & 2 moles of $B_2$. $\left(\frac{5}{4} \Rightarrow 1.25\right)$

Reaction 1 says $2B_2$ requires $1A_2$,

$\therefore$ 1 of $A_2B_4$ will form and 0.25 or $\frac{1}{4}$ of $A_2$ will be left out.

Now in reaction 3, 0.5 $A_2B_4$ would react with $\frac{1}{4}A_2$ to produce 0.5 of $A_3B_4$ and 0.5 moles of $A_2B_3$ would leave out.

**31.** Uranium is isolated from its ore by dissolving it as $UO_2(NO_3)_2$ and separating it as solid $UO_2(C_2O_4).xH_2O$. A 1.0 g sample of ore on treatment with nitric acid yielded 1.48 g $UO_2(NO_3)_2$ which on further treatment with 0.4 g $Na_2C_2O_4$ yielded 1.23 g $UO_2(C_2O_4).xH_2O$. Determine weight percentage of uranium in the original sample and x.

**Ans.** **(89.4, 3)**

**Sol.** Mass of U in sample = $\frac{1.48 \times 238}{394} = 0.894\,g$

Mass of % of U = 89.4%

| | | | | |
|---|---|---|---|---|
| $UO_2(NO_3)_2$ | + | $Na_2C_2O_4$ | + | $xH_2O \rightarrow UO_2(C_2O_4).xH_2O$ |
| 3.756 mmol | | 2.985 mmol | | 2.985 mmol |
| | | Limiting reagent | | |

Molecular weight of the pdt = $\frac{1.239}{2.985} \times 1000 = 412\,g\,mol^{-1}$

In $UO_2(C_2O_4).xH_2O$ = 412 mol. Wt., it must have x = 3

**32.** A sample of fuming sulphuric acid containing $H_2SO_4$, $SO_3$ and $SO_2$ weighing 1.00 g is found to require 23.47 mL of 1.00 M alkali (NaOH) for neutralization. A separate sample shows the presence of 1.50% $SO_2$. Find the percentage of "free" $SO_3$, $H_2SO_4$ and "combined" $SO_3$ in the sample.

(A) 1 (B) 1 (C) 1 (D) 1

**Ans.** **($H_2SO_4$ = 35.38%, Free $SO_3$ = 63.1%, combined $SO_3$ = 28.89%)**

**Sol.** Let $H_2SO_4 = a$, $SO_3 = b$. $SO_2 = c$ (in grams)

a + b + c = 1 g(given)

Also, SO2 = 1.5% i.e., 0.015 g

∴ a + b = 0.985g

$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4$

$\frac{a}{98}$moles

$SO_2 + 2NaOH \rightarrow Na_2SO_4 + H_2O$

$\frac{b}{80}$

$SO_2 + 2NaOH \rightarrow Na_2SO_3 + H_2O$

$\frac{0.015}{64}$

Since molarity is given, i.e., moles are given

∴ $\frac{a}{98}+\frac{b}{80}+\frac{0.015}{64}=23.47\times10^{-3}$

a + b = 0.985 After solving

$a(H_2SO_4) = 0.35\text{ g} \Rightarrow 35\%$

$b(SO_3) = 0.633\text{g} \Rightarrow 63\%$

Total $SO_3 = \frac{0.3514}{98}\times 80 = 0.2868\text{g}$

⇒ 28% combined