

Solved Examples

JEE Main/Boards

Example 1: Calculate the composition of 109% oleum.

Sol: Let the mass of SO_3 in the sample be 'w' g, then the mass of H_2SO_4 would be (100 - w)g. On dilution,

$$\underset{\substack{\text{SO}_3\\80g}}{\text{SO}_3} + \underset{\substack{\text{H}_2\text{O}}{18g}}{\longrightarrow} H_2\text{SO}_4$$

Moles of SO₃ in oleum = $\frac{W}{80}$ = Moles of H₂SO₄ formed after dilution.

 $\therefore \text{ Mass of H}_2\text{SO}_4 \text{ formed on dilution} = \frac{98\text{w}}{80}$

Total mass of H₂SO₄ present in oleum after dilution

$$=\frac{98w}{80}+(100-w)=109; \quad w=40$$

Thus oleum sample contains 40% SO_3 and 60% H_2SO_4 .

Example 2: 20g of a sample of $Ba(OH)_2$ is dissolved in 10 mL. of 0.5 N HCl sol. The excess of HCl was titrated with 0.2 N NaOH. The volume of NaOH used was 10 cc. Calculate the percentage of $Ba(OH)_2$ in the sample.

Sol: The titration principle is applied wherein milliequivalents of the neutralization reactions is calculated. Solving further, one gets the mass and % of the base.

Milli eq. of HCl initially = $10 \times 0.5 = 5$

Milli eq. of NaOH consumed

- = Milli eq.of HCl in excess = $10 \times 0.2 = 2$
- :. Milli eq. of HCl consumed
- = Milli eq. of $Ba(OH)_2 = 5 2 = 3$
- :. Eq. of Ba(OH)₂ = $3/1000 = 3 \times 10^{-3}$
- Mass of Ba(OH)₂ = 3×10^{-3} (171/2) = 0.2565 g

%
$$Ba(OH)_2 = (0.2565/20) \times 100 = 1.28\%$$

Example 3: One litre of mixture of CO and CO₂ is passed through red hot charcoal in tube. The new volume becomes 1.4 litre. Find out % composition of original mixture by volume. All measurements are made at same P and T.

Sol: Assuming the mixture contents as a and b, the reaction is framed and values are laid down.

Let the mixture contains

$$CO = a \text{ litre;} CO_2 = b \text{ litre}$$

$$\therefore a + b = 1 ...(i)$$

On passing the mixture over charcoal only CO₂ reacts as:

		CO_2	+C	→2CO
Vol. before react	tion	b		0
Vol. after reacti	on	0		2b
∴ a + 2b = 1.4				
By Eqs. (i) and (ii	i)			
a = 0.6 litre	or	ā	a = 60%	
b = 0.4 litre	or	k	o = 40%	

Example 4: 0.5 g sample containing is treated with HCl liberating Cl_2 . The is passed into a Sol. of KI and 30.0 cm³ of 0.1 M are required to titrate the liberated iodine. Calculate the percentage of in sample. (At. wt. of Mn = 55).

Sol: Principle of titration is involved in which equating the neutralization reactions is done and milliequivalents of each species is calculated. Thus, weight is calculated and the purity is found.

$$MnO_{2} \xrightarrow{HCI} CI_{2} \xrightarrow{KI} I_{2}$$

$$\xrightarrow{Na_{2}S_{2}O_{3}} NaI + Na_{2}S_{4}O_{6}$$
Redox change are: $2e^{-} + I_{2}^{0} \longrightarrow 2I$

$$2S_{2}^{2+} \longrightarrow S_{4}^{(5/2)^{+}} + 2e^{-}$$

$$2e^{-} + Mn^{4+} \rightarrow Mn^{2+}$$

The reactions suggest that,

Meq. of MnO_2 = Meq. of Cl_2 formed

= Meq.of I₂ liberated = Meq. of $Na_2S_2O_3$ used

$$\therefore \qquad \frac{W}{M/2} \times 1000 = 0.1 \times 1 \times 30$$

[: $N_{Na_2S_2O_3} = M_{Na_2S_2O_3}$ since valency factor = 1, see redox changes for $Na_2S_2O_3$]

Or
$$w_{MnO_2} = \frac{0.1 \times 1 \times 30 \times M}{2000} = \frac{0.1 \times 1 \times 30 \times 87}{2000}$$

(: $M_{MnO_2} = 87$); $w_{MnO_2} = 0.1305$
: Purity of $MnO_2 = \frac{0.1305}{0.5} \times 100 = 26.1\%$

Example 5: 10 mL mixture of CH_4 , C_2H_4 and C_3H_8 in the ratio 1: 1.5: 2.5 respectively is burnt in excess of air. Calculate the volume of air used and volume of CO_2 formed after combustion. All measurements are made at same P and T.

Sol: Using the given ratios, find the volumes of the hydrocarbons and frame the balanced combustion reactions.

The calculated O_2 level is 1/5th of the air.Hence volume of CO₂ is found.

Volume of
$$CH_4 = \frac{1 \times 10}{5} = 2 \text{ mL}$$

Volume of $C_2H_4 = \frac{1.5 \times 10}{5} = 3 \text{ mL}$
Volume of $C_3H_8 = \frac{2.5 \times 10}{5} = 5 \text{ mL}$
 $CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$
 $C_2H_4 + 3O_2 \longrightarrow 2CO_2 + 2H_2O$
 $C_3H_8 + 5O_2 \longrightarrow 3CO_2 + 4H_2O$
∴ Volume of O_2 needed

= 2 × 2 + 2 × 3 + 3 × 5 = 38 mL

Since, O_2 is 1/5th part of air

$$\therefore \quad V_{air} = \frac{25 \times 100}{20} = 125 \text{ mL}$$

Volume of CO₂ formed

Example 6: Select the species acting as reductant and oxidant in the reaction given below:

(i) $PCI_3 + CI_2 \longrightarrow PCI_5$ (ii) $AICI_3 + 3K \longrightarrow AI + 3KCI$ (iii) $SO_2 + 2H_2S \longrightarrow 3S + H_2O$ (iv) $BaCI_2 + Na_2SO_4 \longrightarrow BaSO_4 + 2NaCI$ (v) $3I_2 + 6NaOH \longrightarrow NaIO_3 + 5NaI + 3H_2O$

Sol: Calculate the oxidation numbers, find the loss/gain of electrons and thus identify the respective oxidants and reductants.

In a conjugate pair oxidant has higher oxidation number.

(i)
$$P^{+3} \longrightarrow P^{+5} + 2e^{-}$$

 $2e^{-} + Cl_2^0 \longrightarrow 2Cl^{-1}$

... PCl₃ is reductant and Cl₂ is oxidant.

: In a conjugate pair of redox, the one having higher ox. no. is oxidant.

(ii) For AICl₃ : Al⁺³ + 3e⁻
$$\longrightarrow$$
 Al⁰;

For $K: K^0 \longrightarrow K^{+1} + e^-$

Oxidant is AICl₃ and reductant is K.

(iii) For
$$SO_3 : S^{+4} + 4e^- \longrightarrow S^0$$
;

For
$$H_2S: S^{-2} \longrightarrow 2e^{-1}$$

 \therefore SO₂ is oxidant and H₂S is reductant.

(iv) No change in ox. no. of either of the conjugate pair.

... None is oxidant or reductant.

(v) For $I_2 : I_2^0 \longrightarrow 2I^{+3}$ and $I_2^0 + 2e^- \longrightarrow 2I^{-1} I_2$ acts as oxidant and reductant both.

Example 7: Balance the following reaction

 $NO_3^- + AI \longrightarrow AI^{3+} + NH_4^+$ in basic medium.

Sol: Here NO_3^- is undergoing reduction and Al is undergoing oxidation.

(i) $NO_3^- \longrightarrow NH_4^+$ (ii) $AI \longrightarrow AI^{3+}$

by balancing each half reaction, we get

(iii)
$$NO_3^- + 7H_2O + 8e^- \longrightarrow NH_4^+ + 10 OH^-$$

(iv) $AI \longrightarrow AI^{3+} + 3e^{-}$

by multiplying equation (iii) by 3 and equation (iv) by 8, we get

(v)
$$3NO_3^- + 7H_2O + 24e^- \longrightarrow 3NH_4^+ + 30 OH^-$$

(vi) $8AI \longrightarrow 8AI^{3+} + 24e^{-}$

by combining these equations, we get

 $8AI + 3NO_3^- + 21H_2O \longrightarrow 8AI^{3+} + 3NH_4^+ + 30 OH^-$

Example 8: The composition of a sample of wurtzite is $Fe_{0.93}O_{1.00}$. What percentage of iron is present in the form of Fe III?

Sol: Oxidation no. of Fe in wustite is $\frac{200}{93} = 2.15$

It is an intermediate value between two oxidation state of Fe as, Fe (II) and (III).

Let percentage of Fe (III) be a, then

$$2 \times (100 - 0) + 3 \times a = 2.15 \times 100$$
 Or $a = 15$

 \therefore Percentage of Fe(III) = 15%

Example 9: A 5.0 cm³ solution of H_2O_2 liberates 0.508g of iodine from an acidified KI solution. Calculate the strength of H_2O_2 solution in term of volume strength at STP.

Sol: Volume strength is the volume of oxygen released from 1 mL of hydrogen peroxide solution.

Meq. of H_2O_2 = Meq. of I_2

$$\frac{\mathsf{w}}{17} \times 1000 = \left\lfloor \frac{0.508}{\frac{254}{2}} \right\rfloor \times 1000$$

$$\therefore w = 0.068 g$$

$$H_2O_2 \longrightarrow H_2O + \frac{1}{2}O_2$$

$$\therefore 34 g H_2O_2 \text{ gives } 11.2 \text{ litre } O_2,$$

$$\therefore 0.068 g \text{ gives } \frac{11.2 \times 0.068}{34} = 0.0224 \text{ litre } = 22.4 \text{ ml } O_2$$

$$\therefore \text{ Volume strength of } H_2O_2 = \frac{22.4}{5} = 4.48\%$$

Example 10: A 1.100 g sample of copper ore is dissolved and the Cu²⁺ is treated with excess KI. The liberated I_2 requires 12.12 mL of 0.10 M Na₂S₂O₃ solution for titration. What is % copper by mass in the ore?

Sol: The titration reaction is framed to identify the loss/ gain of electrons. The milliequivalents of the respective ions are equated and the amount is calculated. % can be found by dividing the whole weight.

$$Cu^{2+} + e^{-} \rightarrow Cu^{+}; 2I^{-} \longrightarrow I_{2} + 2e^{-}$$
$$2S_{2}O_{2}^{2-} \longrightarrow S_{4}O_{6}^{-} + 2e^{-}$$

Meq. of Cu²⁺ = Meq. of liberated I₂ = Meq. of Na₂S₂O₃ = 12.12 × 0.1 × 1 = 1.212

∴
$$\frac{W_{Cu^{2+}}}{63.6/1} \times 1000 = 1.212$$

∴ $W_{Cu^{2+}} = 0.077 \text{ g} = W_{Cu} \text{ (Cu} \xrightarrow{H_2SO_4} \text{ CuSO}_4\text{)}$
∴ % $Cu = \frac{0.077}{1.10} \times 100 = 7\%$

JEE Advanced/Boards

Example 1: Chile salt petre, a source of $NaNO_3$ also contains $NaIO_3$. The $NaIO_3$ can be used as source of iodine, produced in the following reactions.

$$IO_{3}^{-} + 3HSO_{3}^{-} \longrightarrow I^{-} + 3H^{+} + 3SO_{4}^{2-} \qquad \dots (i)$$

$$5I^{-} + IO_{3}^{-} + 6H^{+} \longrightarrow 3I_{2(g)} + 3H_{2}O \qquad \dots (ii)$$

One litre of chile salt petre solution containing 5.80g $NaIO_3$ is treated with stoichiometric quantity of $NaHSO_3$. Now an additional amount of same solution is added to reaction mixture to bring about the second reaction. How many grams of NaHSO₃ are required in step I and what additional volume of chile salt petre must be added in step II to bring in complete conversion of I^- to I_2 ?

Sol: The titration reaction is used to identify the loss/ gain of electrons. The milliequivalents of the respective species are equated and the amount is calculated. Stepwise calculation gives the volume of NaIO₃.

Meq. of NaHSO₃ = Meq. of NaIO₃

$$= N \times V = \frac{5.8}{198 / 6} \times 1000$$

[Et. wt. of NaI = M/6 because $I^{3+} + 6e \longrightarrow I^{-}$]

Meq. of NaHSO₃ = 175.76

 $\therefore \ w_{_{NaHSO_{_{3}}}} = \frac{175.76 \times 104}{2000} = 9.14 \ g$

Also Meq. of formed in I step using valence factor 6 = 175.76

In II step valence factor of IO_{3}^{-} is 1 and valence factor of $% IO_{3}^{-}$ is 5.

Thus, Meq. of formed using valence factor $1 = \frac{175.76}{6}$ Also Meq. of NaIO₃ used in step II = $\frac{175.76}{6}$

$$\therefore N \times V = \frac{175.76}{6}; \Rightarrow \frac{5.8}{198/5} \times V = \frac{175.76}{6}$$
$$\therefore V_{NaIO_2} = 200 \text{ mL}$$

Example 2: What amount of substance containing 60% NaCl, 37% KCl should be weighed out for analysis so that after the action of 25 mL of 0.1 N AgNO₃ solution, excess of Ag⁺ is back titrated with 5 mL of NH₄SCN. Given that 1 mL of NH₄SCN = 1.1 mL of AgNO₃.

Sol: Let a g of the given sample be weighed out for the purpose. The reaction of the chlorides with $AgNO_3$ will give AgCl. The unreacted Ag⁺ ions will get consumed by NH₄SCN to give AgSCN. Proceeding accordingly, equate the milliequivalents and calculate a.

$$\therefore \text{ Wt. of NaCl} = \frac{60}{100} \times a = 0.6 \text{ a g}$$
$$\therefore \text{ Wt. of KCl} = \frac{37}{100} \times a = 0.37 \text{ a g}$$

Now this mixture reacts with $AgNO_3$, the excess of $AgNO_3$ is back titrated with NH_4SCN . Meq. of $AgNO_3$ added to mixture

 $= 25 \times 0.1 = 2.5$

Normality of NH₄SCN can be derived as

Meq. of
$$NH_4SCN =$$
 Meq. of $AgNO_3$
N × 1 = 0.1 × 1.1
N = 0.11

Meq. of $AgNO_3$ left = Meq. of NH_4SCN

= 5 × N

 \therefore Meq. of AgNO₃ left = 5 × 0.11 = 0.55

 \therefore Meq. of AgNO₃ used for mixture = 2.5 – 0.55 = 1.95

Meq. of KCl + Meq. of NaCl is mixture

= 1.95;
$$\frac{0.73a}{74.5} \times 1000 + \frac{0.6a}{58.5} \times 1000 = 1.95$$

∴ a = 0.128 g

Example 3: NaOH and Na₂CO₃ are dissolved in 200 mL aqueous solution In the presence of phenolphthalein indicator, 17.5 mL of 0.1 N HCl are used to titrate this solution. Now methyl orange is added in the same sol. titrated and it requires 2.5 mL of the same HCl. Calculate the normality of NaOH and Na₂CO₃ and their mass present in the solution.

Sol: The titration of a simple acid and a base using an indicator is seen over here. The milliequivalents of the acid is calculated and equated with that of the base. The volume and the mass is thus calculated.

Milli equivalent (a) of HCl used in the presence of phenolphthalein indicator.

 $= N \times V (mL) = 0.1 \times 17.5 = 1.75$

1.75 (a) = milli. eq. of NaOH + 1/2 milli eq. of Na₂CO₃ ... (i)

Milli eq. (b) of HCl used in the presence of methyl orange indicator

= N × V (mL) = 0.1 × 2.5 = 0.25

0.25 (b) = 1/2 milli eq. of Na_2CO_3 ... (ii)

For Na₂CO₃ solution.; from equation (ii)

Milli eq. of acid used by $Na_2CO_3 = 2b = 2 \times 0.25 = 0.5$

Volume of Na_2CO_3 solution = 200 mL

Suppose, Normality of $Na_2CO_3 = N$

Milli equivalents of $= N \times V (mL) = 200 N$

Putting equivalents of acid and Na₂CO₃ equal 200 N = 0.5

Or (Normality of Na₂CO₃ solution) N = $\frac{1}{400}$ Mass of Na₂CO₃ = N × E × V (litre)

(E for Na₂CO₃ = 53) =
$$\frac{1}{400} \times 5 \times 0.2 = 0.0265$$
 gram
For NaOH Sol.; from equation (i) and (ii)

Milli eq. acid used by NaOH = a - b = 1.75 - 0.25 = 1.50

Volume of NaOH solution = 200 mL

Suppose, Normality of NaOH solution = N

Milli eq. of NaOH = $N \times V (mL) = 200 N$

Putting the milli eq. of NaOH and acid used equal 200 N = 1.5

(Normality of NaOH Sol.) N = $\frac{1.5}{200}$ Mass of NaOH = N × E × (V litres) = $\frac{1.5}{200}$ × 40 × 0.2 (E for NaOH = 40) = 0.06 g

Example 4: The molarity and molality of a solution are M and m respectively. If the molecular weight of the solute is M'. Calculate the density of the solution in terms of M, m and M'.

Sol: Let weight of solute be w g and weight of solvent be W g, volume of solution be V mL and density be D. Substitute as follows.

$$\therefore \qquad M = \frac{w \times 1000}{M' \times V} \qquad \dots (i)$$

$$m = \frac{W \times 1000}{M' \times W} \qquad \dots (ii)$$

$$\mathsf{D} = \frac{\mathsf{W} + \mathsf{W}}{\mathsf{V}} \qquad \dots (\mathsf{iii})$$

By Eq. (i)
$$w = \frac{MM^2V}{1000}$$
 ...(iv)

By Eq. (ii) $W - \frac{w \times 1000}{M' \times m}$

By Eq. (iv)
$$W = \frac{MM'V \times 1000}{1000 \times M' \times m} = \frac{MV}{m}$$
 ...(v)

:. By Eq. (iii)
$$D = \frac{\frac{MM'V}{1000} + \frac{MV}{m}}{V}$$
; $D - M \left[\frac{1}{m} + \frac{M'}{1000} \right]$

Example 5: 1.249 g of a sample of pure $BaCO_3$ and impure $CaCO_3$ containing some CaO was treated with dil. HCl and it evolved 168 mL of CO_3 at NTP. From this solution $BaCrO_3$ was precipitated, filtered and washed. The precipitate was dissolved in dilute sulphuric acid and diluted to 100 mL. 10 mL of this solution when treated with KI solution, liberated iodine which required exactly 20 mL of 0.05 N Na₂S₂O₃. Calculate the percentage of CaO in the sample.

Sol: An acid-base titration accompanied with iodine titration gives the following equation.

 $n_{CaCO_3} + n_{BaCO_3} = n_{CO_2}$

Calculating the equivalents of the involved species gives their amount and the %.

$$= \frac{168}{22400} = 7.5 \times 10^{-3} \qquad ...(i)$$

$$2BaCO_{3} \longrightarrow 2BaCrO_{4} \longrightarrow BaCr_{2}O_{7} \qquad ...(i)$$

$$2BaCO_{3} \longrightarrow 2BaCrO_{4} \longrightarrow BaCr_{2}O_{7} \qquad ...(i)$$
Eq. of Na₂S₂O₃ = Eq. of I₂ = Eq. of BaCr₂O₇

$$= \frac{20 \times 10^{-3} \times 0.05 \times 100}{10} = 1 \times 10^{-2}$$
Moles of BaCr₂O₇ = $\frac{1}{6} \times 10^{-2}$,
Moles of BaCrO₄ = $\frac{2}{6}(1 \times 10^{-2})$
Moles of BaCO₃ = $\frac{1}{3} \times 10^{-2} = 3.33 \times 10^{-3} \qquad ...(ii)$
Weight of BaCO₃ = 0.650 gm
From equation (i) and (ii) we get $\Rightarrow n_{CaCO_{3}} = 4.17 \times 10^{-3}$
Weight of CaCO₃ = 100 × 4.17 × 10^{-3} = 0.417 g
Weight of CaO = 1.249 - 0.656 - 0.417 = 0.176

% of CaO =
$$\frac{0.176}{1.249} \times 100 = 14.09$$
 %

Example 6: Find out the percentage of oxalate ion in a given sample of oxalate salt of which 0.3 g dissolved in 100 mL of water required 90 mL of N/20 KMNO₄ for complete oxidation.

Sol: Redox changes are

$$5e^{-} + Mn^{+7} \longrightarrow Mn^{+2}$$
$$C_{2}^{+3} \longrightarrow 2C^{+4} + 2e^{-}$$

 \therefore Meq. of oxalate ion = Meq. of KMNO₄

$$\frac{w}{E} \times 1000 = 90 \times \frac{1}{20}; E_{C_2O_4^{-2}} = \frac{\text{Ionic wt.}}{2} \quad \frac{w}{\frac{88}{2}} \times 1000 = \frac{9}{2}$$

∴ $w_{C_2O_4^{-2}} = 0.198 \text{ g}$
∴ 0.3 g $C_2O_4^{-2}$ sample has oxalate ion = 0.198 g
∴ Percentage of $C_2O_4^{-2}$ in sample = $\frac{0.198 \times 100}{0.3} = 66\%$

Example 7: Balance the following redox equation, $AsO_3^{-3} + MnO_4^{-} \longrightarrow AsO_4^{-3} + MnO_2$ using ion-electron method (alkaline medium)

Sol: (i) Identify the oxidation and reduction halves.

Reduction half reaction: $MnO_{4}^{-} \longrightarrow MnO_{2}$

Oxidation half reaction: $AsO_3^{-3} \longrightarrow AsO^{-3}$

(ii) Atoms of the element undergoing oxidation and reduction are already balanced.

(iii) Balancing O atoms,

Reduction half reactions:

 $2H_2O + MnO_4^- \longrightarrow MnO_2 + 4OH^-$

Oxidation half reactions:

$$2OH^{-} + AsO_{3}^{-3} \longrightarrow AsO_{4}^{-3} + H_{2}O$$

(iv) Balancing H atoms, H atoms are already balanced in both the half reactions.

(v) Balancing charge,

Reduction half reaction:

 $3e^{-} + 2H_2O + MnO_4^{-} \longrightarrow MnO_2 + 4OH^{-}$...(ii)

Oxidation half reaction:

$$2OH^{-} + AsO_{3}^{-3} \longrightarrow AsO_{4}^{-3} + H_{2}O + 2e^{-} \qquad ...(i)$$

(vi) Multiply equation (i) by 3 and equation (ii) by 2 and then add (i) and (ii).

$$3e^{-} + 2H_{2}O + MnO_{4}^{-} \longrightarrow MnO_{3} + 4OH^{-}] \times 2$$

$$2OH^{-} + AsO_{3}^{-3} \longrightarrow AsO_{4}^{-3} + H_{2}O + 2e^{-}] \times 3$$

$$AsO_{3}^{-3} + 2MnO_{4}^{-} + H_{2}O$$

$$\longrightarrow 3AsO_{4}^{-3} + 2MnO_{2} + 2OH^{-}$$

Example 8: 1 g sample of AgNO₃ is dissolved in 50 mL of water. It is titrated with 50 mL of KI solution. The AgI precipitated is filtered off. Excess of KI in filtrate is titrated with M/10 KIO₃ in presence of 6M HCl till all Γ converted into ICl. It requires 50 mL of M/10 KIO₃ solution. 20 mL of the same stock solution of KI requires 30 mL of M/10 KIO₃ under similar conditions. Calculate % of AgNO₃ in sample. The reaction is:

$$KIO_3 + 2KI + 6HCI \longrightarrow 3KCI + 3H_2O$$

Sol: Follow the reaction $AgNO_3 + KI \longrightarrow AgI + KNO_3$

- 1. Ag present in AgNO₃ is removed as AgI by adding 50 mL KI of which 20 mL requires 30 mL of M/10 KIO₃.
- 2. The solution contains KI unused. The unused KI is converted into ICl by KIO₃.
- \therefore Meq. of KI in 20 mL = Meq. of KIO₃

$$4e^{-} + I^{+5} \longrightarrow I^{+1}$$
$$= 30 \times \frac{1}{10} \times 4 \qquad \qquad I^{-} \longrightarrow I^{+1} + 2e^{-1}$$

 \therefore Meq. of KI in 50 mL added to AgNO₃

$$\therefore \text{ Eq. wt. of KI} = \frac{M}{2} = \frac{30 \times 4 \times 50}{10 \times 20} = 30$$

Now, Meq. of KI left unused by $AgNO_3 = 30 - 20$

- : Mole ratio of AgNO₃ and KI
- \therefore Meq. of AgNO₃ = 10

Reaction is 1: 1 and thus if Eq.

$$\therefore \frac{W}{170/2} \times 1000 = 10 \quad \text{Wt. of KI is M / 2,} \\ W = 0.85 \text{ g then Eq. wt. of AgNO}_3 = \text{M/2}$$

... Percentage of purity of AgNO₃ in sample

$$=\frac{0.85\times100}{1}=85\%$$

Example 9: Selenium in a 10.0 gm soil sample is distilled as the tetrabromide, which is collected in an aqueous solution, where it is hydrolysed to SeO_3^{-2} . The SeO_3^{-2} is estimated iodometrically, requiring 4.5 mL of standard $\text{Na}_2\text{S}_2\text{O}_3$ solution for the titration. If 1 mL of $\text{Na}_2\text{S}_2\text{O}_3 = 0.049$ mg of $\text{K}_2\text{Cr}_2\text{O}_7$, what is the concentration of Se in the soil in ppm?

Sol: Follow the reaction
Se → SeBr₄ → SeO₃⁻²
SeO₃⁻² + 4I⁻ + 6H⁺ → Se + 2I₂ + 3H₂O
I₂ + 2Na₂S₂O₃ → Na₂S₄O₆ + 2NaI
1mL Na₂S₂O₃ =
$$\frac{0.049 \times 10^{-3} \times 6}{294}$$
 eq. of K₂Cr₂O₇
= $\frac{0.049 \times 10^{-3} \times 6 \times 10^{3}}{294}$ Meq. of K₂Cr₂O₇
∴ 4.5 mL Na₂S₂O₃
= $\frac{0.049 \times 10^{-3} \times 6 \times 10^{3} \times 4.5}{294}$ Meq. of K₂Cr₂O₇ = 4.5 × 10⁻³

Meq. of
$$K_2Cr_2O_7$$
 or Meq. of $Na_2S_2O_3$

Meq. of Se = Meq. of SeO₃⁻² = Meq. of KI = Meq. of I_2 = Meq. of Na₂S₂O₃

$$\frac{w_{Se}}{79} \times 1000 \times 4 = 4.5 \times 10^{-3}$$

$$\therefore w_{Se} = 8.8875 \times 10^{-5} \text{ g}$$

$$\therefore \text{ ppm} = \frac{8.8875 \times 10^{-5} \times 10^{6}}{10} = 8.8875$$

JEE Main/Boards

Exercise 1

Mole Concept

Q.1 Express the following in S.I. units:

(i) 125 pounds, the average weight of an Indian boy $(1\ell b = 545 \text{ g})$

- (ii) 14 ℓ b/m² (atmospheric pressure)
- (iii) 5'8", the average height of ramp models.

Q.2 The isotropic distribution of potassium is 93.2% 39 K and 6.8% 41 K. How many 41 K atoms are there in 2g-atoms?

Q.3 How many oxygen atoms are present in 6.025 g of Barium phosphate (at. mass of Ba=137.5, P= 31, O = 16 amu)

Q.4 The vapour density of a mixture containing NO_2 and N_2O_4 is 3.83 at 27°C. Calculate the moles of NO_2 in 100 g mixture.

Q.5 Assume that the nucleus of the F atom is a sphere of radius 5×10^{-3} cm. Calculate the density of matter in F nucleus. (At. mass F = 19)

Q.6 20.0 mL of dil. HNO_3 is neutralised completely with 25 mL of 0.08 M NaOH. What is molarity of HNO_3 ?

Q.7 Gastric juice containing 3.0 g of HCl per litre. If a person produces about 2.5 litres of gastric juice a per day, how many antacid tablets each containing 400 mg of $Al(OH)_3$ are needed to neutralise all the HCl produced in one day.

Q.8 10 mL of HCl solution produced 0.1435 g of AgCl when treated with excess of Silver nitrate solution. What is the Molarity of acid solution [At. mass Ag = 100].

Q.9 A certain compound containing only carbon and oxygen. Analysis show it has 36% carbon and 64% oxygen. If its molecular mass is 400 then what is the molecular formula of the compound.

Q.10 0.44 g of a hydrocarbon on complete combustion with oxygen gave 1.8 g water and 0.88 g carbon dixoide. Show that these results are in accordance with the law of conservation of mass.

Q.11 A chloride of phosphate contains 22.57% P. Phosphine contains 8.82% hydrogen and hydrogen chloride gas contain 97.26% chlorine. Show that the data illustrate law of reciprocal proportions.



Q.12 1.375 g of cupric oxide was reduced by heating in a current of hydrogen and the mass of copper that remained was 1.098 g. In another experiment, 1.179 g of copper was dissolved in the nitric acid and the resulting copper nitrate converted into cupric oxide by ignition. The mass of cupric oxide formed was 1.476 g. Show that these results illustrate the law of constant composition.

Q.13 1.020 g of metallic oxide contains 0.540 g of the metal. Calculate the equivalent mass of the metal and hence its atomic mass with the help of Dulong and Petit's law. Taking the symbol for the metal as M, find the molecular formula of the oxide. The specific heat of the metal is 0.216 cal deg⁻¹ g⁻¹.

Q.14 Potassium per magnate is a dark green crystalline substance whose composition is 39.7% K, 29.9% Mn and rest O. Find the empirical formula?

Q.15 Calculate the molarity of pure water at 4°C.

Q.16 (i) What is the mass in grams of one molecule of caffeine $(C_8H_{20}N_4O_2)$?

(ii) Determine the total number of electrons in 0.142 g Cl₂.

Q.17 Calculate the molarity of distilled water if its density is 10³ kg/m³.

Q.18 A plant virus if found to consist of uniform cylindrical particles of 150 Å in diameter and 5000 Å long. The specific volume of virus is 0.75 cm³/g. If the virus is considered to be a simple particle, find the its molecular weight.

Q.19 Calculate the mass of two litre sample of water containing 25% heavy water D_2O in it by volume. Density of H₂O is 1.0 g cm⁻³ whereas that of D₂O is 1.06 g cm⁻³.

Q.20 2.5 moles of sulphuryl chloride were dissolved in water to produce sulphuric acid and hydrochloric acid. How many moles of KOH will be required to completely neutralise the solution?

Q.21 100 g of a sample of common salt containing contamination of NH_4Cl and $MgCl_2$ to the extent of 2% each by mass is dissolved in water. How much volume of 5% by mass of $AgNO_3$ solution (d = 1.04 g cm⁻³) is required to precipitate all chloride ions?

Q.22 A mixture of formic acid and oxalic acid is heated with concentrated H_2SO_4 . The gases produced are collected and on treatment with KOH solution, the volume of the gases decreased by 1.6th. Calculate the molar ratio of the two acids in the original mixture.

Q.23 The mean molecular mass of a mixture of methane (CH_4) and ethene (C_2H_4) in the molar ratio of x: y is found to be 20. What will be the mean molecular mass if the molar ratio of the gases is reversed?

Q.241g sample of KClO₃ was heated under such conditions that a part of it decomposes a $2\text{KClO}_3 \longrightarrow 2\text{KCl} + 3\text{O}_2$ while the remaining part decomposes as

 $4KCIO_3 \longrightarrow 3KCIO_4 + KCI.$

If net oxygen obtained is 146.8 mL at STP.

Calculate the mass of KClO₄ in the residue.

Q.25 A mixture of FeO and Fe_3O_4 was heated in air to constant mass and it was found to gain 5% in its mass. Find the composition of the initial mixture.

Q.26 Equal masses of zinc (at. mass 65) and iodine (at. mass 127) were allowed to react till completion of reaction to form ZnI_2 . Which substance is left unreacted and to what fraction of its original mass?

Q.27 Two gram each of P_4 and O_2 are allowed to react till none of the reactant is left. If the products are P_4O_6 and P_4O_{10} . Calculate the mass of each of the product.

Q.28 A piece of aluminium weighing 2.7 g was heated with 100 mL of H_2SO_4 (25% by mass, d = 1.18 g cm⁻³). After complete dissolution of metal, the solution is diluted by adding water to 500 mL.

What is the molarity of free H_2SO_4 in resulting solution?

Q.29 Chemical reaction between ferrous oxalate and $KMnO_4$ has been given in the form of three partial equations. Write the complete balanced equation and thus find out the volume of 0.5 M $KMnO_4$ required to

completely react with 1.5 mol of FeC_2O_4 . $KMnO_4 + H_2SO_4 \longrightarrow$ $K_2SO_4 + MnSO_4 + H_2O + (O)$ $FeC_2O_4 + H_2SO_4 \longrightarrow FeSO_4 + H_2C_2O_4$ $FeSI_4 + H_2C_2O_4 + H_2SO_4 + O \longrightarrow Fe_2(SO_4)_3 + CO_2 + H_2$

Redox Reactions

Q.1 Indicate the oxidation number of underlined in each case:

(i) $(\underline{N}_2H_5)_2SO_4$	(ii) $\underline{Mg}_{3}N_{2}$
(iii) [<u>Co</u> (NH ₃) ₅ Cl]Cl ₂	(iv) $K_2 \underline{Fe} O_4$
(v) $Ba(H_2\underline{P}O_2)_2$	(vi) $H_2 \underline{S} O_4$
(vii) C <u>S</u> ₂	(viii) \underline{S}^{-2}
(ix) $Na_2 \underline{S}_4 O_6$	(x) \underline{S}_2Cl_6
(xi) RNO ₂	(xii) $\underline{Pb}_{3}O_{4}$
(xiii) $\underline{S}_2 O_8^{-2}$	(xiv) $\underline{C}_{6}H_{12}O_{6}$
(xv) $Mg_2P_2O_7$	(xvi) KCIO,

Q.2 Write complete balanced equation for the following in acidic medium by ion-electron method:

(i) $Br^{-} + BrO_{3}^{-} + H^{+} \longrightarrow Br_{2} + H_{2}O$ (ii) $H_{2}S + Cr_{3}O_{7}^{-2} + H^{+} \longrightarrow Cr_{2}O_{3} + S_{8} + H_{2}O$ (iii) $Au + NO_{3}^{-} + Cl^{-} + H^{+} \rightarrow AuCl_{4}^{-} + NO_{3} + H_{2}O$ (iv) $Cu_{2}O + H^{+} + NO_{3}^{-} \longrightarrow Cu^{+2} + NO + H_{2}O$ (v) $MnO_{4}^{-2} \longrightarrow MnO_{4}^{-1} + MnO_{2}$ (vi) $Cu^{2+} + SO_{2} \longrightarrow Cu^{+} + SO_{4}^{-2}$ (vii) $Cl_{2} + I_{2} \longrightarrow IO_{3}^{-} + Cl^{-}$ (viii) $Fe(CN)_{6}^{-4} + MnO_{4}^{-} \rightarrow Fe^{+3} + CO_{2} + NO_{3}^{-} + Mn^{+2}$ (ix) $Cu_{3}P + Cr_{2}O_{7}^{-2} \longrightarrow Cu^{+2} + H_{3}PO_{4} + Cr^{+3}$

Q.3 Write complete balanced equation for the following in basic medium by ion-electron method:

(i)
$$Cu^{+2} + I^{-} \longrightarrow Cu^{+} + I_{2}$$

(ii) $Fe_{3}O_{4} + MnO_{4}^{-} \longrightarrow Fe_{2}O_{3} + MnO_{2}$
(iii) $C_{2}H_{5}OH + MnO_{4}^{-} \longrightarrow C_{2}H_{3}O^{-} + MnO_{2}(s) + H_{2}O$
(iv) $CrI_{3} + H_{2}O_{2} + OH^{-} \longrightarrow CrO_{4}^{-2} + IO_{4}^{-} + H_{2}O$
(v) $KOH + K_{4}Fe(CN)_{6} + Ce(NO_{3})_{4} \longrightarrow$

 $Fe(OH)_3 + Ce(OH)_3 + K_2CO_3 + KNO_3 + H_2O$

Q.4 Balance the following equations by oxidation method:

(i) $I^- + H_2O_2 \longrightarrow H_2O + I_2$ (Acid medium) (ii) $Cu^{+2} + I^- \longrightarrow Cu^+ + I_2$ (iii) $CuO + NH_3 \longrightarrow Cu + N_2 + H_2O$ (iv) $H_2SO_3 + Cr_2O_7^{-2} \longrightarrow H_2SO_4 + Cr^{+3} + H_2O$ (Acid medium) (v) $Cr_2O_7^{-2} + C_2H_4O + H^+ \longrightarrow C_2H_4O_2 + Cr^{+3}$

 $(V) Cl_2 C_7 + C_2 l_4 C + H \longrightarrow C_2 l_4 C_2 + Cl$ (Acid medium)

(vi) $SbCI_3 + KIO_3 + HCI \longrightarrow SbCI_3 + ICI + H_2O + KCI$ (Acid medium)

Q.5 Define disproportionation? Give one example.

Q.6 Define difference between ion electron method and oxidation method?

Q.7 What is the most essential conditions that must be satisfied in a redox reaction?

Q.8 Does the oxidation number of an element in any molecule or any poly atomic ion represents the actual charge on it?

Q.9 What is redox couple?

Q.10 Calculate the standard e.m.f. of the cells formed by different combinations of the following half cells.

Zn(g) / Zn²⁺(aq) Cu(s) / Cu²⁺(aq) Ni(s) / Ni²⁺(aq) Ag(s) / Ag²⁺(aq)

Q.11 Balance the following equations in acidic medium by both oxidation number and ion electron methods & identify the oxidants and the reductants.

(i) $MnO_4^{-}(aq) + C_2H_2O_4(aq) \longrightarrow Mn^{2+}(aq) + CO_2(g) + H_2O(l)$ (ii) $H_2S(aq) + Cl_2(g) \longrightarrow S(s) + Cl(aq)$

Q.12 Write the half reactions for the following redox reactions:

(i)
$$2Fe^{3+}(aq) + 2I^{-}(aq) \rightarrow 2Fe^{2+} + (aq) + I_2(aq)$$

(ii) $Zn(s) + 2H^{+}(aq) \rightarrow Zn^{2+}(aq) + H_2(g)$
(iii) $AI(s) + 3Ag^{+}(aq) \rightarrow AI^{3+}(aq) + 3Ag(s)$

Q.13 Define oxidation & reduction in term of oxidation number.

Q.14 Discuss the following redox reactions?

- (i) Combination reactions
- (ii) Decomposition reactions
- (iii) Displacement reactions
- (iv) Disproportionation reaction

Q.15 What is the difference between valence and oxidation number?

Q.16 H_2S acts only as reducing agent while SO_2 can act both as a reducing agent and oxidising agent. Explain.

Q.17 What are half reactions? Explain with examples?

Q.18 Explain the term:

(i) Oxidation (ii) Reduction

(iii) Oxidizing agent (iv) Reducing agent

Exercise 2

Mole Concept

Single Correct Choice Type

Q.1 If 'x' gms of an element A reacts with 16 gms of oxygen then the equivalent weight of element A is

(A)
$$\frac{x}{4}$$
 (B) $\frac{x}{2}$ (C) x (D) 2x

Q.2 The mass of CO containing the same amount of oxygen as in 88 gms of CO_2 is

(A) 56 gms (B) 28 gms (C) 112 gms (D) 14 gms

Q.3 When 8 gms of oxygen reacts with magnesium then the amount of MgO formed is

(A) 18 gm (B) 20 gm (C) 24 gm (D) 32 gm

Q.4 One gram of the silver salt of an organic dibasic acid yields, on strong heating 0.5934 g of silver. If the weight percentage of carbon in it 8 times the weight percentage of hydrogen and one half the weight percentage of oxygen, determine the molecular formula of the acid. [Atomic weight of Ag = 108]

(A) $C_4 H_6 O_4$ (B) $C_4 H_6 O_6$ (C) $C_2 H_6 O_2$ (D) $C_5 H_{10} O_5$

Q.5 Mass of sucrose $C_{12}H_{22}O_{11}$ produced by mixing 84 gm of carbon, 12 gm of hydrogen and 56 liter O_2 at 1 atm and 273 K according to given reaction, is

$$C(s) + H_{2}(g) + O_{2}(g) \longrightarrow C_{12}H_{22}O_{11}(s)$$
(A) 138.5 (B) 155.5 (C) 172.5 (D) 199.5

Q.6 40 gm of carbonate of an alkali metal or alkaline earth metal containing some inert impurities was made to react with excess HCl solution. The liberated CO_2 occupied 12.315 lit. at 1 atm and 300 K. The correct option is

(A) Mass of impurity is 1 gm and metal is Be

(B) Mass of impurity is 3 gm and metal is Li

(C) Mass of impurity is 5 gm and metal is Be

(D) Mass of impurity is 2 gm and metal is Mg

Q.7 An hydride of nitrogen decomposes to give nitrogen and hydrogen. It was formed that one volume of the hydride gave one volume of N_2 and 2 volume of H_2 at STP. The hydride of nitrogen is

(A)
$$NH_3$$
 (B) N_2H_6 (C) NH_2 (D) N_2H_4

Q.8 5 volumes of a hydrocarbon on complete consumed 10 volumes of oxygen giving 5 volumes of CO_2 at STP. The hydrocarbon is

(A) C_2H_6 (B) C_2H_4 (C) CH_4 (D) C_2H_4

Q.9 The percentage by mole of NO_2 in a mixture of $NO_2(g)$ and NO(g) having average molecular mass 34 is

Q.10 The minimum mass of mixture of A_2 and B_4 required to produce at least 1 kg of each product is (Given At. mass of 'A' = 10; At. mass of 'B' = 120)

$$5A_2 + 2B_4 \longrightarrow 2AB_2 + 4A_2B$$

Q.11 74 gm of a sample on complete combustion given 132 gm CO_2 and 54 gm of H_2O . The molecular formula of the compound may be

(A)
$$C_5 H_{12}$$
 (B) $C_4 H_{10} O$ (C) $C_3 H_{10} O_2$ (D) $C_3 H_7 O_2$

Q.12 The volume of oxygen used when x gms of Zn is converted to ZnO is

(A) $\frac{2x}{65} \times 5.6$ litres	(B) $\frac{x}{65} \times 5.6$ litres
(C) $\frac{4x}{65} \times 5.6$ litres	(D) None of these

Q.13 A sample of clay was partially dried and then contained 50% silica and 7% water. The original clay contained 12% water. The silica is original sample is

(A) 51.69	(B) 47.31	
(C) 63.31	(D) None of these	

Q.14 The mass of CO_2 produced from 620 mixture of $C_2H_4O_2$ and O_2 , prepared produce maximum energy is (combustion reaction is exothermic)

(A) 413.33 gm	(B) 593.04 gm
(C) 440 gm	(D) 320 gm

Q.15 In the quantitative determination of nitrogen, N_2 gas liberated from 0.42 gm of a sample of organic compound was collected over water. If the volume of N_2 gas collected was 100/11 mL at total pressure 860 mm Hg at 250 K, % by mass of nitrogen in the organic compound is

[Aq. tension at 250 K is 24 mm Hg and R = 0.08 L atm mol⁻¹ K⁻¹]

(A)
$$\frac{10}{3}\%$$
 (B) $\frac{5}{3}\%$ (C) $\frac{20}{3}\%$ (D) $\frac{100}{3}\%$

Q.16 300 mL of 0.1 M HCl and 200 mL of 0.3 M H_2SO_4 are mixed. The normality of the resulting mixture is

Q.17 The volume of water which should be added to 300 mL of 0.5 M NaOH solution so as to get a solution of 0.2 M is

(A) 550 mL (B) 350 mL (C) 750 mL (D) 450 mL

Q.18 The mole fraction of a solution containing 3.0 gms of urea per 250 gms of water would be

(A) 0.00357	(B) 0.99643	
(C) 0.00643	(D) None of these	

Q.19 The mass of P_4O_{10} produced if 440 gm of P_4S_3 is mixed with 384 gm of O_2 is $P_4S_3 + O_2 \longrightarrow P_4O_{10} + SO_2$

(A) 568 gm	(B) 426 gm	
(C) 284 am	(D) 396 am	

Q.20 Calculate percentage change in M_{avg} of the mixture,

if PCl_5 undergo 50% decomposition. $PCl_5 \longrightarrow PCl_3 + Cl_2$			
(A) 50%	(B) 66.66%		
(C) 33.33%	(D) Zero		

Q.21 The mass of Mg_3N_2 produced if 48 gm of Mg metal is reacted with 34 gm NH_3 gas is $Mg + NH_3 \longrightarrow Mg_3N_2 + H_2$

(A)
$$\frac{200}{3}$$
 (B) $\frac{100}{3}$ (C) $\frac{400}{3}$ (D) $\frac{150}{3}$

Q.22 The molarity of a solution of conc. HCl containing 36.5% by weight of HCl would be

(A) 16.75 (B) 17.75 (C) 15.75 (D) 14.75

Q.23 0.35 gms of a sample of $Na_2CO_3.xH_2O$ were dissolved in water and the volume was made to 50 mL

of this solution required 9.9 mL of $\frac{N}{10}$ HCl for complete neutralization. Calculate the value of x.

(A) 1 (B) 2 (C) 3 (D) None of these

Q.24 1.2 gms of a sample of washing soda was dissolved in water and volume was made upto 250 cc. 25 cc of this solution when titrated against N/10 HCl for required 17 mL. The percentage of carbonate is given sample is

(A) Approximately 70% (B) Approximately 66%

(C) Approximately 76% (D) None of these

Q.25 The number of carbon atoms present in a signature, if a signature written by carbon pencil weights 1.2×10^{-3} g is

(A) 12.40 × 10 ²⁰	(B) 6.02×10^{19}
(C) 3.01×10^{19}	(D) 6.02 × 10 ²⁰

Q.26 The average atomic mass of a mixture containing 79 mole % of ²⁴Mg is 24.31. % mole of ²⁶Mg is

(A) 5 (B) 20 (C) 10 (D) 15

Q.27 25 cc of solution containing NaOH and Na₂CO₃ when titrated against N/10 HCl. Using phenolphthalein as indicator required 40 cc. of HCl. The same volume of mixture when titrated against N/10 HCl using methyl orange required 45cc of this HCl. The amount of NaOH and Na₂CO₃ in one mixture is

(A) NaOH = 28 gm/L ; Na₂CO₃ = 10.6 gm/L

(B) NaOH = 10.6 gm/L ; $Na_2CO_3 = 28 \text{ gm/L}$

(C) NaOH = 14 gm/L ; $Na_2CO_3 = 5.3 \text{ gm/L}$

(D) None of these

Q.28 0.5 gms of a mixture of K_2CO_3 and Li_2CO_3 requires 30 mL of 0.25 NHCl solution for neutralization. The percentage composition of mixture would be

(A) K₂CO₃ = 96%; Li₂CO₃ = 4%
(B) K₂CO₃ = 4%; Li₂CO₃ = 96%
(C) K₂CO₃ = 50%; Li₂CO₃ = 25%
(D) K₂CO₃ = 50%; Li₂CO₃ = 74%

Q.29 How many mL of a 0.05 M $KMnO_4$ solution are required to oxidise 2.0 g of $FeSO_4$ in a dilute acid solution?

(A) 5.263	(B) 0.5263	
(C) 52.63	(D) None of these	

Redox Reaction

Single Correct Choice Type

Q.1 The equivalent weight of $FeSO_4$ when it is oxidised by acidified KMnO₄ will be equal to

(A)
$$M_0$$
 of $FeSO_4$ (B) $\frac{M_0FeSO_4}{2}$
(C) $2M_0$ $FeSO_4$ (D) $\frac{M_0FeSO_4}{4}$

Q.2 The equivalent weight of $K_2Cr_2O_7$ when it is converted Cr^{3+} will be equal to

(A)
$$M_{K_2Cr_2O_7}$$
 (B) $\frac{M_{K_2Cr_2O_7}}{3}$

(C)
$$\frac{W_{\kappa_2 Cr_2 O_7}}{4}$$
 (D) $\frac{W_{\kappa_2 Cr_2 O_7}}{6}$

Q.3 The amount of H_2S that can be oxidised to sulfur on oxidation using 1.58 gm of KMnO₄ as oxidising agent in acidic medium will be

(C) 0.425 gms (D) None of these

Q.4 The amount of nitric acid required to oxidise 127 gms of I_2 to I_2O_5 will be _____. Assume that during the reaction HNO₃ gets converted to NO₂.

(A) 12.7	(B) 3.15	(C) 315	(D) 31.5
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Q.5 10 mL of oxalic acid was completely oxidised by 20 mL of 0.02 M KMnO_4 . The normality of oxalic acid solution is

(A) 0.05 N (B) 0.1	N (C) 0.2 N	(D) 0.025 N
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Q.6 0.2 g of a sample of H_2O_2 required 10 mL of 1N KMnO₄ in a titration in the presence of H_2SO_4 . Purity of H_2O_2 is

(A) 25% (B) 65% (C) 85% (D) None of these

Q.7 The number of moles of KMnO₄ that will be needed to react completely with one mole of ferrous oxalate in acidic solution is

(A)
$$\frac{2}{5}$$
 (B) $\frac{3}{5}$ (C) $\frac{4}{5}$ (D) 1

Q.8 A metal oxide is reduced by heating it in a stream of hydrogen. It is found that after complete reduction, 3.15 g of the oxide has yielded 1.05 g of the metal. We may deduce that

(A) The atomic weight of the metal is 8

(B) The atomic weight of the metal is 4

(C) The equivalent weight of the metal is 4

(D) The equivalent weight of the metal is 8

Q.9 Oxidation involves

- (A) Gain of electrons
- (B) Loss of electrons
- (C) Increase in the valency of negative part
- (D) Decrease in the valency of positive part

Q.10 The oxidation number of Cr in K₂Cr₂O₇

(A) +2 (B) -2 (C) +6 (D) -6

Q.11 When $K_2Cr_2O_7$ is converted into $K_2Cr_2O_4$ the change in oxidation number of Cr is

(A) 0 (B) 6 (C) 4 (D) 3

Q.12 White P reacts with caustic soda. The products are PH₃ and NaH₂PO₂. This reaction is an example of

(A) Oxidation	(B) Reduction
(C) Oxidation and reduction	(D) Neutralization

Q.13 The oxidation number of carbon in CH₂O is

(A) -2 (B) +2 (C) 0 (D) +4

Q.14 The oxidation number of C in CH_4 , CH_3Cl , $CH_2Cl_{2'}$ CHCl₃, and CCl_4 are respectively

(A) 0,2,-2,4,-4	(B) -4, -2, 0, +2, +4
(C) 2,4,0,-2,-4	(D) 4,2,0,-2,-4

- Q.15 Which of the following reactions is not redox type
- (A) $2BaO + O_2 \longrightarrow 2BaO_2$
- (B) $4KCIO_3 \longrightarrow 2KCIO_4 + KCI$
- (C) $BaO_2 + H_2SO_4 \longrightarrow BaSO_4 + H_2O_2$
- (D) $SO_2 + 2H_2S \longrightarrow 2H_2O + 3S$

Q.16 In which of the following compounds iron has lowest oxidation state

(A) K ₄ Fe(CN) ₆	(B) K ₂ FeO ₄

(C) Fe_2O (D) $Fe(CO)_5$

Q.17 Select the compound in which chlorine is assigned the oxidation number +5

(A) HCIO (B) $HCIO_2$ (C) $HCIO_3$ (D) $HCIO_4$

Q.18 If three electrons are lost by a metal iron M³⁺ its final oxidation number would be

(A) 0 (B) +2 (C) +5 (D) +6

Q.19 The oxidation number of Mn in MnO_4^- is

(A) +7 (B) -5 (C) -7 (D) +5

Q.20 The oxidation number of carbon in CHCl₃ is

(A) +2 (B) +4 (C) +4 (D) -3

Q.21 Pb²⁺ loses two electrons in a reaction. What will be the oxidation number of lead after the reaction?

(A) +2 (B) 0 (C) +4 (D) -2

Q.22 The oxidation number of carbon in $C_{12}H_{22}O_{11}$ is

(A) 0 (B) -6 (C) +2 (D) +6

Q.23 The oxidation state of sulphur in SO_4^{2-} is

(A) +2 (B) +4 (C) +5 (D) +6

Q.24 If the following reaction 'X' is $MnO_2 + 4H^+ + X \longrightarrow Mn^{2+} + H_2O$

(A) 1e⁻ (B) 2e⁻ (C) 3e⁻ (D) 4e⁻

Q.25 In the following reaction the value of 'X' is $H_2O + SO_3^{-2} \longrightarrow SO_4^{-2} + 2H^+ + X$ (A) $4e^-$ (B) $3e^-$ (C) $2e^-$ (D) $1e^-$ **Q.26** The oxidation state of sulphur is $S_2O_7^{2-}$ is

(A) +6 (B) -6 (C) -2 (D) +2

Q.27 The oxidation number and covalency of sulphur in S_8 are respectively

(A) 0 & 2 (B) 0 & 8 (C) 6 & 8 (D) 6 & 2

Q.28 The oxidation state of nitrogen in N₃H is

(A) 1/3 (B) +3 (C) -1 (D) -1/3

Q.29 The oxidation number of iron in potassium ferricyanide is

(A) +1 (B) +2 (C) +3 (D) +4

Q.30 Oxidation number of hydrogen in MH₂ is

(A) +1 (B) -1 (C) +2 (D) -2

Q.31 The oxidation state of phosphorus varies from

(A) -1 to +1 (B) -3 to +3 (C) -3 to +5 (D) -5 to +1

Q.32 Select the compound in which chlorine is assigned the oxidation number +5

(A) $HCIO_4$ (B) $HCIO_2$ (C) $HCIO_3$ (D) HCI

Previous Years' Questions

Mole Concept

Q.1 If we consider that 1/6, in place of 1/12, mass of carbon atom is taken to be the relative atomic mass unit, the mass of one mole of a substance will **(2002)**

(A) Decrease twice

- (B) Increase two fold
- (C) Remain unchanged

(D) Be a function of the molecular mass of the substance

Q.2 A molar solution is one that contains one mole of a solute in (1986)

(A) 1000 g of the solvent(B) One litre of the solvent(C) One litre of the solution(D) 22.4 litres of the solution

Q.3 In the reaction,

 $2AI(s) + 6HCI(S) \longrightarrow 2AI^{3+}(aq) + 6CI^{-}(aq) + 3H_{2}(g)$ (2007)

(A) 6 l HCl (aq) is consumed for every 3L H₂(g) produced

- (B) $33.6l H_2(g)$ is produced regardless of temperature and pressure for every mole Al that reacts
- (C) 67.2 $l H_2(g)$ at STP is produced for every mole Al that racts
- (D) 11.2 H₂(g) at STP is produced for every mole HCl (aq) consumed

Q.4 How many moles of magnesium phosphate, $Mg_3(PO_4)_2$ will contain 0.25 mole of oxygen atoms (2006)

(A) 0.02	(B) 3.125 × 10 ⁻²
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(C) 1.25×10^{-2} (D) 2.5×10^{-2}

Q.5 If 10^{21} molecules are removed from 200 mg of CO_{2'} then the number of moles of CO₂ left are **(1983)**

(A) 2.85×10^{-3}	(B) 28.8×10^{-3}
(C) 0.288 × 10 ⁻³	(D) 1.68 × 10 ⁻²

Q.6 In standardization of $NA_2S_2O_3$ using $K_2Cr_2O_7$ by iodometry, the equivalent weight of $K_2Cr_2O_7$ is **(2000)**

(A)
$$\frac{MW}{2}$$
 (B) $\frac{MW}{3}$ (C) $\frac{MW}{6}$ (D) $\frac{MW}{1}$

Q.7 The molarity of a solution obtained by mixing 750 mL of 0.5(M) HCl with 250 mL of 2(M) HCl will be: (2013)

(A) 0.875 M (B) 1.00 M (C) 1.75 M (D) 0.975 M

Q.8 A gaseous hydrocarbon gives upon combustion 0.72 g of water and 3.08 g of CO_2 . The empirical formula of the hydrocarbon is: (2013)

(A) C_2H_4 (B) C_3H_4 (C) C_6H_5 (D) C_7H_8

Q.9 Experimentally it was found that a metal oxide has formula $M_{0.98}$ O. Metal M, present as M^{2+} and M^{3+} in its oxide. Fraction of the metal which exists as M^{3+} would be: (2013)

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(A) 7.01 % (B) 4.08 % (C) 6.05 % (D) 5.08 %
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Q.10 The ratio of masses of oxygen and nitrogen in a particular gaseous mixture is 1 : 4. The ratio of number of their molecule is 3 (2014)

(A) 1 : 4 (B) 7 : 32 (C) 1 : 8 (D) 3 : 16

Q.11 The molecular formula of a commercial resin used for exchanging ions in water softening is $C_6H_7SO_3Na$ (Mol. Wt. 206). What would be the maximum uptake of Ca^{2+} ions by the resin when expressed in mole per gram resin? **(2015)**

(A)
$$\frac{1}{103}$$
 (B) $\frac{1}{206}$ (C) $\frac{2}{309}$ (D) $\frac{1}{412}$

Q.12 At 300 K and 1 atm, 15 mL of a gaseous hydrocarbon requires 375 mL air containing 20% O_2 by volume for complete combustion. After combustion the gases occupy 330 mL. Assuming that the water formed is in liquid form and the volumes were measured at the same temperature and pressure, the formula of the hydrocarbon is: (2016)

(A) C_2H_{12} (B) C_4H_8 (C) C_4H_{10} (D) C_3H_6

Redox Reactions

Q.13 Several blocks of magnesium are fixed to the bottom of a ship to (2003)

(A) Keep away the sharks

(B) Make the ship lighter

(C) Prevent action of water and salt

(D) Prevent puncturing by under-sea rocks

Q.14 Which of the following chemical reactions depicts the oxidizing behaviour of H_2SO_4 ? (2006)

- (A) $2HI + H_2SO_4 \rightarrow I_2 + SO_2 + 2H_2O$
- (B) $Ca(OH)_2 + H_2SO_4 \rightarrow CaSO_4 + 2H_2O$
- (C) $NaCl + H_2SO_4 \rightarrow NaHSO_4 + HCl$
- (D) $2PCI_5 + H_2SO_4 \rightarrow 2POCI_3 + 2HCI + SO_2CI_2$

Q.15 The oxidation number of carbon in CH₂O is (1982)

(A) -2 (B) +2 (C) 0 (D) 4

Q.16 The oxidation state of chromium in the final product formed by the reaction between KI and acidified potassium dichromate solution is **(2005)**

(A) +4 (B) +6 (C) +2 (D) +3

Q.17 When $KMnO_4$ acts as an oxidising agent and ultimately forms $[MnO_4]^{-2}$, MnO_2 , Mn_2O_3 , Mn^{+2} then the number of electrons transferred in each case respectively is (2002)

(A) 4, 3, 1, 5	(B) 1, 5, 3, 7
(C) 1, 3, 4, 5	(D) 3, 5, 7, 1

Q.18 Which of the following is a redox reaction (2002)

- (A) $NaCl + KNO_3 \rightarrow NaNO_3 + KCl$
- (B) $CaC_2O_4 + 2HCI \rightarrow CaCl_2 + H_2C_2O_4$
- (C) $Mg(OH)_2 + 2NH_4CI \longrightarrow MgCI_2 + 2NH_4OH$
- (D) $Zn + 2AgCN \rightarrow 2Ag + Zn(CN)_2$

Q.19 The product of oxidation of I^- and MnO_4^- in alkaline medium is (2004)

(A)
$$IO_3^-$$
 (B) I_2 (C) IO^- (D) IO_4^-

Q.20 For H_3PO_3 and H_3PO_4 the correct choice is (2003)

- (A) H_3PO_3 is dibasic and reducing
- (B) H_3PO_3 is dibasic and non-reducing
- (C) H_3PO_4 is tribasic and reducing
- (D) H_3PO_3 is tribasic and non-reducing

Q.21 Consider the following reaction:

$XMnO_4^- + YC_2O_4^{2-} + ZH$	$H^+ \rightarrow xMn^{2+} + 2yCO_2 + \frac{z}{2}H_2O$
The values of X, Y and	Z in the reaction are, respectively: (2013)
(A) 5, 2 and 16	(B) 2, 5 and 8

(C)	2, 5 and 16	(D) 5, 2 and 8

Q.22 In which of the following reaction H₂O₂ acts as a reducing agent? (2014)

(A) $H_2O_2 + 2H^+ + 2e^- \rightarrow 2H_2O$ (B) $H_2O_2 - 2e^- \rightarrow O_2 + 2H^+$ (C) $H_2O_2 - 2e^- \rightarrow 2OH^-$ (D) $H_2O_2 + 2OH^- - 2e^- \rightarrow O_2 + 2H_2O$ (A) (a), (b) (B) (c), (d) (C) (a), (c) (D) (b), (d)

Q.23 The equation which is balanced and represents the correct product(s) is (2014)

(A)
$$\operatorname{Li}_{2}O + 2\operatorname{KCI} \rightarrow 2\operatorname{LiCI} + \operatorname{K}_{2}O$$

(B) $\left[\operatorname{CoCl}(\operatorname{NH}_{3})_{5}\right]^{+} + 5\operatorname{H}^{+} \rightarrow \operatorname{Co}^{2+} + 5\operatorname{NH}_{4}^{+} + \operatorname{CI}^{-}$
(C) $\left[\operatorname{Mg}(\operatorname{H}_{2}O)_{6}\right]^{2+} \left(\operatorname{EDTA}\right)^{4-} \xrightarrow{\operatorname{excess NaOH}} \left[\operatorname{Mg}(\operatorname{EDTA})\right]^{2+} + 6\operatorname{H}_{2}O$
(D) $\operatorname{CuSO}_{4} + 4\operatorname{KCN} \rightarrow \operatorname{K}_{2}\left[\operatorname{Cu}(\operatorname{CN})_{4}\right] + \operatorname{K}_{2}\operatorname{SO}_{4}$

Q.24 From the following statements regarding $H_2O_{2'}$ choose the incorrect statement: (2015)

- (A) It can act only as an oxidizing agent
- (B) It decomposed on exposure to light
- (C) It has to be stored in plastic or wax lined glass bottles in dark
- (D) It has to be kept away from dust

JEE Advanced/Boards

Exercise 1

Mole Concept

Q.1 How many gm of HCl is needed for complete reaction with 69.6 gm MnO₂?

 $HCI + MnO_2 \rightarrow MnCI_2 + H_2O + CI_2$

Q.2 Titanium, which is used to make air plane engines and frames, can be obtained from titanium tetrachloride, which in turn is obtained from titanium oxide by the following process:

 $3\text{TiO}_2(s) + 4\text{C}(s) + 6\text{Cl}_2(g) \rightarrow$

 $3\text{TiCl}_4(g) + 2\text{CO}_2(g) + 2\text{CO}(g)$

A vessel contains 4.32 g TiO_2 5.76 g C and 6.82 g Cl_2 , suppose the reaction goes to completion as written, how many gram of TiCl_4 can be produced? (Ti = 48).

Q.3 Sulphuric acid is produced when sulphur dioxide reacts with oxygen and water in the presence of a catalyst:

 $2SO_2(g) + O_2(g) + 2H_2O(l) \rightarrow 2H_2SO_4.$

If 5.6 mol of SO_2 reacts with 4.8 mole of O_2 and a large excess of water, what is the maximum number of moles of H_2SO_4 that can be obtained?

Q.4 What weight of Na_2CO_3 of 95% purity would be required to neutralize 45.6 mL of 0.235 N acid?

Q.5 How much **BaCl**₂.2H₂O and pure water to be mixed to prepare 50g of 12.0% (by wt.) BaCl₂ solution.

Q.6 To 50 litre of 0.2 N NaOH, 5 litre of 1N HCl and 15 litre of 0.1 N FeCl₃ solution are added. What weight of Fe_2O_3 can be obtained from the precipitate? Also report the normality of NaOH left in the resultant solution.

Q.7 0.5 g fuming H_2SO_4 (oleum) is diluted with water. The solution requires 26.7 mL of 0.4 N NaOH for complete neutralization. Find the percentage of free SO₃ in the sample of oleum.

Q.8 200 mL of a solution of mixture of NaOH and Na₂CO₃ was first titrated with phenolphthalein and N/10 HCl. 17.5 mL of HCl was required for the end point. After this methyl orange was added and 2.5 mL of same HCl

was again required for next end point. Find out amount of NaOH and Na₂CO₃ in mixture.

Q.9 Potassium superoxide, $KO_{2'}$ is used in rebreathing gas masks to generate oxygen:

 $\mathrm{KO}_2(s) + \mathrm{H}_2\mathrm{O}(l) \rightarrow \mathrm{KOH}(s) + \mathrm{O}_2(g)$

If a reaction vessel contains 0.158 mol KO_2 and 0.10 mol H_2O , how many moles of O_2 can be produced?

Q.10 A sample of mixture of $CaCl_2$ and NaCl weighing 4.22 gm was treated to precipitate all the Ca as $CaCO_3$ which was then heated and quantitatively converted to 0.959 gm of CaO. Calculate the percentage of $CaCl_2$ in the mixture.

Q.11 Cyclohexanol is dehyrated to cyclohexene on heating with conc. H_2SO_4 . If the yield of this reaction is 75%, how much cyclohexene will be obtained from 100 g of cyclohexanol? $C_6H_{12}O \xrightarrow{\text{con.}H_2SO_4} C_6H_{10}$

Q.12 How many grams of 90% pure Na_2SO_4 can be produced from 250 gm of 95% pure NaCl?

Q.13 A precipitate of AgCl and AgBr weighs 0.4066 g. On heating in a current of chlorine, the AgBr is converted to AgCl and the mixture loses 0.0725 g in weight. Find the percentage of Cl in original mixture.

Q.14 How many milli-litre of 0.5 M H_2SO_4 are needed to dissolve 0.5 g of copper II carbonate?

Q.15 What is the strength in g per litre of a solution of $H_2SO_{4^{\prime}}$ 12 mL of which neutralized 15 mL of N/10 NaOH solution.

Q.16 n-butane is produced by the monobromination of ethane followed by Wurtz reaction. Calculate the volume of ethane at NTP required to produce 55 g n-butane if the bromination takes place with 90% yield and the Wurtz reaction with 85% yield.

Q.17 0.50 g of a mixture of K_2CO_3 and Li_2CO_3 required 30 mL of 0.25 N HCl solution for neutralization. What is percentage composition of mixture?

Q.18 Sodium chlorate, NaClO₃, can be prepared by the following series of reactions:

 $2KMnO_4 + 16HCI \rightarrow 2KCI + 2MnCI_2 + 8H_2O + 5CI_2$

$$6\text{Cl}_2 + 6\text{Ca(OH)}_2 \rightarrow \text{Ca(ClO}_3)_2 + 5\text{CaCl}_2 + 6\text{H}_2\text{O}$$

 $Ca(CIO_3)_2 + Na_2SO_4 \rightarrow CaSO_4 + 2NaCIO_3$

What mass of $NaClO_3$ can be prepared from 100 mL of concentrated HCl (density 1.18 gm/mL and 36% by mass)? Assume all other substance are present in excess amounts.

Q.19 In a determination of P an aqueous solution of NaH₂PO₄ is treated with a mixture of ammonium and magnesium ions to precipitate magnesium ammonium phosphate Mg(NH₄)PO₄.6H₂O. This is heated and decomposed to magnesium pyrophosphate, Mg₂P₂O₇ which is weighed. A solution of NaH₂PO₄ yielded 1.054g of Mg₂P₂O₇. What weight of NaH₂PO₄ was present originally?

Q.20 5 mL of 8 N HNO₃, 4.8 mL of 5 N HCl and a certain volume of 17 M H_2SO_4 are mixed together and made upto 2 litre. 30 mL of this acid mixture exactly neutralizes 42.9 mL of Na₂CO₃ solution containing 1 g Na₂CO₃.10H₂O in 100 mL of water. Calculate the amount of sulphate ions in g present in solution.

Q.21 A sample of Mg was burnt in air to give a mixture of MgO and Mg₃N₂. The ash was dissolved in 60 Meq of HCl and the resulting solution was back titrated with NaOH. 12 Meq of NaOH were required to reach the end point. As excess of NaOH was then added and the solution distilled. The ammonia released was then trapped in 10 Meq of second acid solution. Back titration of this solution required 6 Meq of the base. Calculate the percentage of Mg burnt to the nitride.

Q.22 A mixture of ethane (C_2H_6) and ethene occupies 40 litre at 1.00 atm and at 400 K. The mixture reacts completely with 130 g of O₂ to produce CO₂ and H₂O. Assuming ideal gas behaviour, calculate the mole fractions of C₂H₄ and C₂H₆ in the mixture.

Q.23 A solid mixture 5 g consists of lead nitrate and sodium nitrate was heated below 600°C until weight of residue was constant. If the loss in weight is 28%, find the amount of lead nitrate and sodium nitrate in mixture.

Q.24 Upon mixing 45.0 mL of 0.25 M lead nitrate solution with 25 mL of 0.10 M chromic sulphate, precipitation of lead sulphate takes place. How many moles of lead sulphate are formed? Also calculate the molar concentration of the species left behind in final solution. Assume that lead sulphate is completely insoluble.

Q.25 A 10 g sample of a mixture of calcium chloride and sodium chloride is treated with Na_2CO_3 to precipitate calcium as calcium carbonate. This $CaCO_3$ is heated to convert all the calcium to CaO and the final mass of CaO is 1.12 gm. Calculate % by mass of NaCl in the original mixture.

Q.26 A mixture of Ferric oxide (Fe_2O_3) and Al is used as solid rocket fuel which reacts to give Al_2O_3 and Fe. No other reactants and products are involved. On complete reaction of 1 mole of $Fe_2O_{3'}$ 200 units of energy is released?

(i) Write a balance reaction representing the above change.

(ii) What should be the ratio of masses of Fe_2O_3 and Al taken so that maximum energy per unit mass of fuel is released.

(iii) What would be energy released if 16 kg of ${\rm Fe_2O_3}$ reacts with 2.7 kg of Al.

Q.27 A mixture of nitrogen and hydrogen. In the ratio of one mole of nitrogen to three moles of hydrogen, was partially converted into so that the final product was a mixture of all these three gases. The mixture was to have a density of 0.497 g per litre at 25°C and 1.00 atm. What would be the mass of gas in 22.4 litres at 1 atm and 273 K? Calculate the % composition of this gaseous mixture by volume.

Q.28 In one process for waterproofing, a fabric is exposed to $(CH_2)_3SiCl_2$ vapour. The vapour reacts with hydroxyl groups on the surface of the fabric or with traces of water to form the waterproofing film [$(CH_3)_2SiO]_2$ by the reaction

$$n(CH_3)_2SiCl_2 + 2nOH^- \rightarrow 2nCl^- + nH_2O + [(CH_3)_2SiO]_n$$

where n stands for a large integer. The waterproofing film is deposited on the fabric layer upon layer. Each layer is 6.0 Å thick [the thickness of the $(CH_3)_2SiO$ group]. How much $(CH_2)_3SiCl_2$ is needed to waterproof one side of a piece of fabric, 1.00 m by 3.00 m, with a film 300 layers thick? The density of the film is 1.0 g/cm³.

Q.29 Two substance P_4 and O_2 are allowed to react completely to form mixture of P_4O_6 and P_4O_{10} leaving none of the reactants. Using this information calculate the composition of final mixture when mentioned amount of P_4 and O_2 are taken.

$$P_{4} + 3O_{2} \longrightarrow P_{4}O_{6}$$

$$P_{4} + 5O_{2} \longrightarrow P_{4}O_{10}$$
(i) If 1 mole P₄ & 4 mole of O₂
(ii) If 3 mole P₄ & 11 mole of O₂
(iii) If 3 mole P₄ & 13 mole of O₂

Q.30 Chloride samples are prepared for analysis by using NaCl, KCl and NH_4Cl seperately or as a mixture. What minimum volume of 5% by weight AgNO₃ solution (sp. gr., 1.04 g mL⁻¹) must be added to a sample of 0.3 g in order to ensure complete precipitation of chloride in every possible case?

Q.31 124 gm of mixture containing NaHCO₃, AlCl₃, and KNO₃ requires 500 mL, 8% w/w NaOH solution $[d_{NaOH} = 1.8 \text{ gm/mL}]$ for complete neutralisation. On heating same amount of mixture, it known loss in weight of 18.6 gm. Calculate % composition of mixture by moles. Weak base formed doesn't interfere in reaction. Assume KNO₃ does not decompose under given conditions.

Q.32 If the yield of chloroform obtainable from acetone and bleaching powder is 75%. What is the weight of acetone required for producing 30 gm of chloroform?

Q.33 A sample of impure Cu_2O contains 66.67% of Cu. What is the percentage of pure Cu_2O in the sample?

Q.34 Equal weights of mercury and iodine are allowed to react completely to form a mixture of mercurous and mercuric iodide leaving none of the reactants. Calculate the ratio by weight of Hg_2I_2 and HgI_2 and formed. (Hg = 200, I = 127)

Redox Reactions

Q.1 Indicate the oxidation state of underlined in each case:

(i) Na <u>N</u> O ₂	(b) <u>H</u> ₂	(c) \underline{Cl}_2O_7
(ii) K <u>Cr</u> O ₃ Cl	(e) <u>Ba</u> Cl ₂	(f) $\underline{I}Cl_3$
(iii) K ₂ <u>Cr</u> 2O ₇	(h) <u>C</u> H ₂ O	(i) <u>Ni</u> (CO) ₄
(iv) <u>N</u> H ₂ OH		

Q.2 Indicate the each reaction which of the reactant is oxidized or reduced if any:

(i) $CuSO_4 + 4KI \longrightarrow 2CuI + I_2 + 2K_2SO_4$

(ii) $2Na_2S + 4HCI + SO_2 \longrightarrow 4NaCI + 3S + 2H_2O$

(iii) $NH_4NO_2 \xrightarrow{\Delta} N_2 + 2H_2O$

Q.3 Calculate the number of electrons lost or gained during the changes:

(i) $3Fe + 4H_2O \longrightarrow Fe_3O_4 + 4H_2$ (ii) $AICI_3 + 3K \longrightarrow AI + 3KCI$

Q.4 Explain, why?

(i) H_2S acts as reductant whereas, SO_2 acts as reductant and oxidant both.

(ii) H_2O_2 acts as reductant and oxidant both.

Q.5 MnO_4^- can oxidize NO_2^- to NO_3^- in basic medium. How many mol of NO_2^- are oxidized by 1 mol of MnO_4^- ?

Q.6 Which is stronger base in each pair?

(i) HSO₄; HSO; (ii) NO₂; NO₃;

(iii) CI^- ; CIO^-

Q.7 Fill in the blanks and balance the following equations:

(i) $Zn + HNO_3 \rightarrow \dots + N_2O + \dots$ (ii) $HI + HNO_3 \rightarrow \dots + NO + H_2O$

Q.8 What volume of 0.20 M H_2SO_4 is required to produce 34.0 g of H_2S by the reaction:

 $8\text{KI} + 5\text{H}_2\text{SO}_4 \longrightarrow 4\text{K}_2\text{SO}_4 + 4\text{I}_2 + \text{H}_2\text{S} + 4\text{H}_2\text{O}$

Q.9 20 mL of 0.2 M MnSO₄ are completely oxidized by 16 mL of KMnO₄ of unknown normality, each forming Mn⁴⁺ oxidation state. Find out the normality and molarity of KMnO₄ solution.

Q.10 KMnO₄ solution is to be standardized by titration against $As_2O_3(s)$. A 0.1097 g sample of As_2O_3 requires 26.10 mL of the KMnO₄ solution for its titration. What are the molarity and normality of the KMnO₄ solution?

Q.11 0.518 g sample of limestone is dissolved and then Ca is precipitated as CaC_2O_4 . After filtering and washing the precipitate, it requires 40 mL of 0.25 N KMnO₄ solution to equivalence point. What is percentage of CaO in limestone?

Q.12 20 mL of a solution containing 0.2 g of impure sample of H_2O_2 reacts with 0.316 g of KMnO₄ (acidic). Calculate:

(i) Purity of $H_2O_{2'}$

(ii) Volume of dry O_2 evolved at 27°C and 750 mm P.

Q.13 5.7 g of bleaching powder was suspended in 500 mL of water. 25 mL of this suspended on treatment with KI and HCI liberated iodine which reacted with 24.35 mL of N/10 Na₂S₂O₃. Calculate percentage of available Cl₂ in bleaching powder.

Q.14 Balance the following equation:

(i)
$$C_2H_5OH + K_2Cr_2O_7 + H_2SO_4 \longrightarrow$$

 $C_2H_4O_2 + Cr_2(SO_4)_3 + K_2SO_4 + H_2O$
(ii) $As_2S_5 + HNO_3 \longrightarrow$
 $NO_2 + H_2O + H_3AsO_4 + H_2SO_4$

(iii)
$$\operatorname{CrI}_3 + \operatorname{Cl}_3 + \operatorname{KOH} \longrightarrow$$

 $\operatorname{KIO}_4 + \operatorname{K}_2\operatorname{CrO}_4 + \operatorname{KCI} + \operatorname{H}_2\operatorname{O}$
(iv) $\operatorname{As}_2\operatorname{S}_3 + \operatorname{HCIO}_3 + \operatorname{H}_2\operatorname{O} \longrightarrow$
 $\operatorname{HCI} + \operatorname{H}_2\operatorname{AsO}_4 + \operatorname{H}_2\operatorname{SO}_4$

Q.15 Balance the following equations:

(i)
$$\operatorname{As}_2 S_3 + \operatorname{OH}^- + \operatorname{H}_2 O_2 \longrightarrow \operatorname{AsO}_4^{2-} + \operatorname{SO}_4^{2-} + \operatorname{H}_2 O$$

(ii) $\operatorname{CrI}_3 + \operatorname{H}_2 O_2 + \operatorname{OH}^- \longrightarrow \operatorname{CrO}_4^{2-} + \operatorname{3IO}_4^- + \operatorname{H}_2 O$
(iii) $\operatorname{P}_4 + \operatorname{OH}^- + \operatorname{H}_2 O_2 \longrightarrow \operatorname{H}_2 \operatorname{PO}_2^- + \operatorname{PH}_3$
(iv) $\operatorname{As}_2 S_3 + \operatorname{NO}_3^- + \operatorname{H}^+ \xrightarrow{\operatorname{+H}_2 O} \operatorname{H}_3 \operatorname{AsO}_4 + \operatorname{NO} + S$

Q.16 Mg can reduce NO_3^- to NH_3 in basic solution: $NO_3^- + Mg(s) + H_2O \longrightarrow$ $Mg(OH)_2(s) + OH^-(aq) + NH_3(g)$

A 25.0 mL sample of NO_3^- solution was treated with Mg. The NH₃(g) was passed into 50 mL of 0.15 N HCl. The excess HCl required 32.10 mL of 0.10 M NaOH for its neutralization. What was the molarity of NO_3^- ions in the original sample?

Q.17 An acid solution of KReO₄ sample containing 26.83 mg of combined rhenium was reduced by passage through a column of granulated zinc. The effluent solution including the washing from the column, was then titrated with 0.05 N KMnO₄. 11.45 mL of the standard KMnO₄ was required for the reoxidation of all the rhenium to the perrhenate ion ReO₄⁻. Assuming that rhenium was the only element reduced, what is the oxidation state to which rhenium was reduced by the zinc column.

Q.18 100 mL solution of FeC_2O_4 and FeSO_4 is completely oxidized by 60 mL of 0.02 M in acid medium. The resulting solution is then reduced by Zn and dil.HCl. The reduced solution is again oxidized completely by 40 mL of 0.02 M KMnO₄. Calculate normality of FeC_2O_4 and FeSO_4 in mixture.

Q.19 1 g of most sample of KCl and KClO₃ was dissolved in water to make 250 mL solution, 25 mL of this solution was treated with SO₂ to reduce chlorate to chloride and excess of SO₂ was removed by boiling. The total chloride was precipitated as silver chloride. The weight of precipitate was 0.1435 g. In another experiment, 25 mL of original solution was heated with 30 mL of 0.2 N ferrous sulphate solution and unreacted ferrous sulphate required 37.5 mL of 0.08 N solution of an oxidant for complete oxidation. Calculate the molar ratio of chlorate to chloride in the given mixture. Fe^{2+} reacts with CIO_3^- according to equation.

$$\mathsf{CIO}_3^- + 6\mathsf{Fe}^{2+} + 6\mathsf{H}^+ \longrightarrow \mathsf{CI}^- + 6\mathsf{Fe}^{3+} + 3\mathsf{H}_2\mathsf{O}$$

Q.20 (i) CuSO₄ reacts with KI in acidic medium to liberate I_2

 $2CuSO_4 + 4KI \longrightarrow Cu_2I_2 + 2K_2SO_4 + I_2$

(ii) Mercuric per iodiate $Hg_5(IO_6)_2$ reacts with a mixture of KI and HCl following the equation:

$$Hg_5(IO_6)_2 + 34KI + 24HCI \longrightarrow$$

$$5K_{2}HgI_{4} + 8I_{2} + 24KCI + 12H_{2}O$$

(iii) The liberated iodine is titrated against Na₂S₂O₃ solution. One mL of which is equivalent to 0.0499 g of CuSO₄.5H₂O. What volume in mL of Na₂S₂O₃ solution will be required to react with I₂ liberated from 0.7245 g of Hg₅(IO₆)₂? M. wt. of Hg₅(IO₆)₂ = 1448.5 and M. wt. of CuSO₄.5H₂O = 249.5.

Q.21 1.249 g of a sample of pure BaCO₃ and impure CaCO₃ containing some CaO was treated with dil. HCl and it evolved 168 mL of CO₂ at NTP. From this solution BaCrO₄ was precipitated, filtered an washed. The dry precipitate was dissolved in dilute H₂SO₄ and dilute to 100 mL. 10 mL of this solution when treated with KI solution liberated iodine which required exactly 20 mL of 0.05 N Na₂S₂O₃. Calculate percentage of CaO in the sample.

Q.22 A 10 g mixture of Cu₂S and CuS was treated with 200 mL of 0.75 M MnO_4^- in acid solution producing SO₂, Cu²⁺ and Mn²⁺. The SO₂ was boiled off and the excess of MnO_4^- was treated with 175 mL of 1 M Fe²⁺ solution. Calculate percentage of CuS in original mixture.

Q.23 For estimating ozone in the air, a certain volume of air is passed through an acidified or neutral KI solution when oxygen is evolved and iodide is oxidised to give iodine. When such a solution is acidified, free iodine is evolved which can be titrated with standard Na₂S₂O₃ solution. In an experiment 10 litre of air at 1 atm and 27°C were passed through an alkaline KI solution, at the end, the iodine entrapped in a solution on titration as above required 1.5 mL of 0.01 N Na₂S₂O₃ solution. Calculate volume percentage of O₃ in sample.

Q.24 30 mL of an acidified solution of 1.5 N $MnO_4^$ ions, 15 mL of 0.5 N oxalic acid and 15 mL of 0.4 N ferrous salt solution are added together. Find the molarities of MnO_4^- and Fe_3^+ ions in the final solution? **Q.25** (i) 25 mL of H_2O_2 solution were added to excess of acidified solution of KI. The iodine so liberated required 20 mL of 0.1 N Na₂S₂O₃ for titration. Calculate the strength of H₂O₂ in terms of normality, percentage and volume.

(ii) To a 25 mL H_2O_2 solution, excess of acidified solution of KI was added. The iodine liberated required 20 mL of 0.3 N sodium thiosulphate solution. Calculate the volume strength of H_2O_2 solution.

Q.26 An aqueous solution containing 0.10 g KIO₃ (formula weight = 214.0) was treated with an excess of KI solution. The solution was acidified with HCl. The liberated I_2 consumed 45 mL of thiosulphate solution to decolorise the blue starch-iodine complex. Calculate the molarity of the sodium thiosulphate solution.

Q.27 A sample of $MnSO_4.4H_2O$ is strongly heated in air. The residue (Mn_3O_4) left was dissolved in 100 mL of 0.1 N FeSO₄ containing dil. H_2SO_4 . This solution was completely reacted with 50 mL of KMnO₄ solution. 25 mL of this KMnO₄ solution was completely reduced by 30 mL of 0.1 N FeSO₄ solution. Calculate the amount of MnSO₄.4H₂O in sample.

Q.28 Write complete balanced equation for the following in acidic medium by ion-electron method:

(i)
$$\operatorname{ClO}_{3}^{-} + \operatorname{Fe}^{2+} \rightarrow \operatorname{Cl}^{-} + \operatorname{Fe}^{+3} + \operatorname{H}_{2}\operatorname{O}$$

(ii) $\operatorname{CuS} + \operatorname{NO}_{3}^{-} \rightarrow \operatorname{Cu}^{+2} + \operatorname{S}_{8} + \operatorname{NO} + \operatorname{H}_{2}\operatorname{O}$
(iii) $\operatorname{S}_{2}\operatorname{O}_{3}^{-2} + \operatorname{Sb}_{2}\operatorname{O}_{3} \rightarrow \operatorname{SbO} + \operatorname{H}_{2}\operatorname{SO}_{3}$
(iv) $\operatorname{HCl} + \operatorname{KMnO}_{4} \longrightarrow \operatorname{Cl}_{2} + \operatorname{KCl} + \operatorname{MnCl}_{2} + \operatorname{H}_{2}\operatorname{O}$
(v) $\operatorname{KClO}_{3} + \operatorname{H}_{2}\operatorname{SO}_{4} \longrightarrow \operatorname{KHSO}_{4} + \operatorname{HClO}_{4} + \operatorname{ClO}_{3} + \operatorname{H}_{2}\operatorname{O}$
(vi) $\operatorname{HNO}_{3} + \operatorname{HBr} \longrightarrow \operatorname{NO} + \operatorname{Br}_{2} + \operatorname{H}_{2}\operatorname{O}$
(vii) $\operatorname{IO}_{4}^{-} + \operatorname{I}^{-} + \operatorname{H}^{+} \longrightarrow \operatorname{I}_{2} + \operatorname{H}_{2}\operatorname{O}$

Q.29 Balance the following equations by oxidation method:

(i)
$$Cu + NO_3^- + \dots - Cu^{+2} + NO_2 + \dots$$

(Acid medium)
(ii) $CI_2 + IO_3^- + OH^- \longrightarrow IO_4^- + \dots + H_2O$
(Basic medium)
(iii) $H_2S + K_2CrO_4 + H_2SO_4 \longrightarrow \dots$
(Acid medium)
(iv) $Fe^{+2} + MnO_4^- \longrightarrow Fe^{+3} + Mn^{+2} + \dots$
(Acid medium)
(v) $KMnO_4 + H_2SO_4 + H_2O_2 \longrightarrow$
 $K_2SO_4 + MnSO_4 + H_2O + \dots$
(Acid medium)

(vi)
$$MnO_2 + H_2O_2 \longrightarrow MnO_4^- + H_2O$$

(Basic medium)

Q.30 Write complete balance equation for the following in basic medium by ion-electron method:

(i)
$$S_2O_4^{-2} + Ag_2O \rightarrow Ag + SO_3^{-2}$$

(ii) $CI_2 + OH^- \rightarrow CI^- + CIO^-$
(iii) $H_2 + ReO_4^- \rightarrow CIO_2^- + Sb(OH)_6^-$
(iv) $I_2 + OH^- \rightarrow I^- + IO_3^-$
(v) $MnO_4^- + Fe^{+2} \rightarrow Mn^{+2} + Fe^{+3}$

Exercise 2

Mole Concept

Single Correct Choice Type

Q.1 'x' gms of an element 'A' on heating in a jar of chlorine give 'y' gms of ACl, the atomic weight of element A is

(A)
$$\left(\frac{x}{y-71}\right) \times \frac{35.5}{2}$$
 (B) $\frac{71x}{y-71}$
(C) $\frac{35.5x}{y-71}$ (D) None of these

Q.2 The amount of H_2SO_4 present in 1200 mL of 0.2 N solution is

(A) 10.76 gms	(B) 11.76 gms
(C) 12.76 gms	(D) 14.76 gms

Q.3 An iodized salt contains 0.5% of NaI. A person consumes 3 gm of salt everyday. The number of iodide ions going into his body everyday is

(A) 10 ⁻⁴	(B) 6.02×10^{-4}
(C) 6.02×10^{19}	(D) $6.02\times10^{\scriptscriptstyle 23}$

Assertion Reasoning Type

(A) If both statement-I and statement-II are true and statement-II is the correct explanation of statement-I, the mark (A).

(B) If both statement-I and statement-II are true and statement-II is not the correct explanation of statement -I, the mark (B).

(C) If statement-I is true but statement-II is false, then mark (C).

(D) If both statement-I and statement-II are false, then mark (D).

Q.4 Statement-I: 0.28 g of N_2 has equal volume as 0.44 g of another gas at same conditions of temperature and pressure.

Statement-II: Molecular mass of another gas is 44 g mol⁻¹.

Q.5 Statement-I: Boron has relative atomic mass 10.81.

Statement-II: Borons two isotopes, ${}^{10}_{5}B$ and ${}^{11}_{5}B$ and their relative abundance is 19% and 81%.

Q.6 Statement-I: The percentage of nitrogen in urea is 46%.

Statement-II: Urea is ionic compound.

Q.7 Statement-I: The oxidation state of central sulfur of $Na_2S_2O_3$ is +6.

Statement-II: Oxidation state of an element should be determined form structure.

Q.8 Statement-I: Molarity of a solution and molality of a solution both change with density.

Statement-II: Density of the solution changes when percentage by mass of solution changes.

Q.9 Statement-I: $2A + 3B \rightarrow C$, 4/3 moles of 'C' are always produced when 3 moles of 'A' and 4 moles of 'B' are added.

Statement-II: 'B' is the liming reactant for the given data.

Multiple Correct Choice Type

Q.10 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 equation (iv)

(B) 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 1/4th of total is produced by reaction (iv)

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

Comprehension Type

Paragraph 1: Normality is number of gram equivalents dissolved per litre of solution. It changes with change in temperature. In case of monobasic acid, normality and molarity are equal but in case of dibasic acid, normality is twice the molarity. In neutralization and redox reactions, number of mill equivalents of reactants as well as products are always equal.

Q.11 On heating a litre of a $\frac{N}{2}$ HCl solution, 2.750 g of

HCl is lost and the volume of solution becomes 750 mL. The normality of resulting solution will be

(A) 0.58 (B) 0.75 (C) 0.057 (D) 5.7

Q.12 The volume of 0.1 M Ca(OH) required to neutralize 10 mL of 0.1 N HCl will be

(A) 10 mL	(B) 20 mL	(C) 5 mL	(D) 40 mL

Q.13 Molarity	/ of 0.5 N Na	$a_2 CO_3$ is	
(A) 0.25	(B) 1.0	(C) 0.5	(D) 0.125

Q.14 6.90 N KOH solution in water contains 30% by weight of KOH. The density of solution will be

(A) 1.288 (B) 2.88 (C) 0.1288 (D) 12.88

Q.15 The amount of ferrous ammonium sulphate required to prepare 250 mL of 0.1 N solution is

(A) 1.96 g (B) 1.8 g (C) 9.8 g (D) 0.196 g

Paragraph 2: A 4.925 g sample of a mixture of $CuCl_2$ and $CuBr_2$ was dissolved in water and mixed thoroughly with a 5.74 g portion of AgCl. After the reaction and solid, a mixture of AgCl and AgBr, was filtered, washed, and dried. Its mass was found to be 6.63 g.

Q.16

(1) % By mass c	of CuBr ₂ in o	riginal mixtur	e is	
(A) 2.24	(B) 74.5	(C) 45.3	(D) None	
(2) % By mass c	of Cu in orig	inal mixture i	S	
(A) 38.68	(B) 19.05	(C) 3.86	(D) None	
(3) % by mole of AgBr in dried precipitate is				
(A) 25	(B) 50	(C) 75	(D) 60	
(4) No. of mole precipitate ion	s of Cl⁻ ion are	present in th	e solution after	
(A) 0.06	(B) 0.02	(C) 0.04	(D) None	

Paragraph 3: Water is added to 3.52 grams of UF_6 . The products are 3.08 grams of a solid [containing only U, O and F] and 0.8 gram of a gas only. The gas [containing fluorine and hydrogen only], contains 95% by mass fluorine.

[Assume that the empirical formula is same as molecular formula.]

Q.17

(1) The empirical formula of the gas is

(A) HF_2 (B) H_2F (C) HF (D) HF_3

(2) The empirical formula of the solid product is

(A) UF_2O_2 (B) UFO_2 (C) UF_2O (D) UFO

(3) The percentage of fluorine of the original compound which is converted into gaseous compound is

(A) 66.66% (B) 33.33% (C) 50% (D) 89.9%

Match the Columns

Q.18 One type of artificial diamond (commonly called YAG for yttrium aluminium garnet) can be represented by the formula $Y_3Al_5O_{12}$. [Y = 89, Al = 27]

Column I	Column II
(A) Y	(p) 22.73%
(B) Al	(q) 32.32%
(C) O	(r) 44.95%

Q.19 The recommended daily does is 17.6 milligrams of vitamin C (ascorbic acid) having formula $C_6H_8O_6$. Match the following. Given: $N_A = 6 \times 10^{23}$

Column I	Column II
(A) O-atoms present	(p) 10 ⁻⁴ mole
(B) Moles of vitamin C in 1 gm of vitamin C	(q) 5.68 × 10 ⁻³
(C) Moles of vitamin C in 1 gm should be consumed daily	(r) 3.6×10^{20}

Q.20 If volume strength of H₂O₂ solution is 'X-V' then its

Column I	Column II
(i) Strength in g/L	(p) X/11.2
(ii) Volume strength X	$(q) \frac{X}{5.6}$
(iii) Molarity	(r) $\frac{17X}{5.6}$
(iv) Normality	(s) 5.6 × N

(A) (i) - r, (ii) - p, (iii) - s, (iv) - q
(B) (i) - s, (ii) - p, (iii) - q, (iv) - p
(C) (i) - r, (ii) - s, (iii) - p, (iv) - q
(D) (i) - r, (ii) - q, (iii) - s, (iv) - p

Q.21 Match the entries in column I with entries in column II and then pick out correct options:

Column I	Column II
(i) M _R on mixing two acidic solutions	(p) $\frac{x \times d \times 10}{M_{solute}}$
(ii) M _R on mixing two basic solutions	(q) n × M × V mL
(iii) M_{R} on mixing two acidic and basic solutions	(r) $\frac{M_1V_1 - M_2V_2}{V_1 + V_2}$
(iv) Milliequivalent	(s) $\frac{M_1V_1}{V_2}$
(v) Molarity	(t) $\frac{M_1V_1 + M_2V_2}{V_1 + V_2}$

(A) (i) - p, (ii) - r, (ii) - p, (iv) - q, (v) - s (B) (i) - t, (ii) - t, (ii) -r, (iv) -q, (v) - p, s (C) (i) - q, (ii) - p, (ii) -q, (iv) - r, (v) - q (D) (i) - p, (ii) - q, (ii) - q, (iv) - r, (v) - r

Redox Reactions

Single Correct Choice Type

Q.1 One mole of N_2H_4 loses ten moles of electrons to form a new compound Y. Assuming that all the nitrogen appears in the new compound, what is the oxidation state of nitrogen in Y? (There is no change in the oxidation state of hydrogen)

(A) –1	(B) –3	(C) +3	(D) +5
	• •	· · /	• •

Q.2 Which is best reducing agent

(A) F [_]	(B) Cl-	(C) Br⁻	(D) I-

Q.3 In the alumino thermite process, aluminium acts as

(A) An oxidizing agent	(B) A flux
(C) Reducing agent	(D) A solder

Q.4 Zinc-copper couple that can be used as a reducing agent is obtained by

(A) Mixing zinc dust and copper gas

- (B) Zinc coated with copper
- (C) Copper coated with zinc
- (D) Zinc and copper wires welded together

Q.5 In the following equations value of X is

 $CIO_3^- + 6H^+ + X \rightarrow CI^- + 3H_2O$

(A) 4e⁻ (B) 5e⁻ (C) 6e⁻ (D) 7e⁻

Q.6 The brown ring complex compound is formulated as $[Fe(H_2O)_5(NO)^+]SO_4$. The oxidation state of iron is (A) 1 (B) 2 (C) 3 (D) 0

Q.7 Oxidation state of oxygen atom in potassium superoxide is

(A) -1/2 (B) -1 (C) -2 (D) 0

Q.8 In the following reaction

 $3Br_2 + 6CO_3^{-2} + 3H_2O \rightarrow 5Br^- + 6HCO_3^- + BrO_3^-$

(A) Bromine is both reduced and oxidised

- (B) Bromine is neither reduced nor oxidised
- (C) Bromine is oxidised and carbonate is reduced
- (D) Bromine is reduced and water is oxidised

Comprehension Type

Paragraph 1: The redox titration involve the chemical reaction between the oxidising agent and reducing agent in aqueous solutions under suitable conditions. Titrations involve the direct use of iodine as oxidising agent are known as iodimetric titrations while those titrations involving indirect use of iodine are known as iodometric titrations. These titrations are used for the estimation of oxidising agents like KMnO₄, K₂Cr₂O₇, CuSO₄ etc.

Q.9 50 mL of an aqueous solution of H_2O_2 was treated with excess of KI solution and the iodine so liberated quantitatively required 20 mL of 0.1 N solution of hypo. This titration is known as:

(A) Iodometric titration	(B) Iodimetric titration
(C) Potassium iodide titration	(D) All of these

Q.10 In the above problem, concentration of H_2O_2 in gm/litre is:

(A) 0.8 (B) 0.08 (C) 0.008 (D) 0.34	(A) 6.8	(B) 0.68	(C) 0.068	(D) 0.34
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Q.11 0.5 gm sample of pyrolusite (MnO₂) is treated with HCl, the Cl₂ gas evolved is treated with KI, the violet vapours evolved are absorbed in 30 mL 0.1 N Na₂S₂O₃ solution percentage purity of pyrolusite sample is

(A) 30% (B) 50% (C) 36% (D) 26.1%

Q.12 Arsenite gets converted into arsenate by using iodine, valency factor for Arsenite and Iodine are respectively

(A) 2 and 2 (B) 2 and 1 (C) 1 and 2 (D) 5 and 2

Paragraph 2: Oxidation and reduction process involves the transaction of electrons. Loss of electrons is oxidation and the gain of electrons is reduction. It is thus obvious that in a redox reaction, the oxidant is reduced by accepting the electrons and the reductant is oxidised by losing electrons. The reactions in which a species disproportionate into two oxidation states (lower and higher) are called disproportionation reactions. In electrochemical cells, redox reaction is involved, i.e., oxidation takes place at anode and reduction at cathode.

Q.13 The reaction: $Cl_2 \rightarrow Cl^- + ClO_3^-$ is

- (A) Oxidation
- (B) Reduction
- (C) Disproportionation
- (D) Neither oxidation nor reduction

Q.14 In the reaction: $I_2 + 2S_2O_3^{-2} \rightarrow 2I^- + S_4O_6^{-2}$

- (A) I₂ is reducing agent
- (B) I_2 is oxidising agent
- (C) $S_2O_3^{-1}$ is reducing agent
- (D) $S_2O_3^{-2}$ is oxidising agent

Q.15 Determine the change in oxidation number of sulphur is H_2S and SO_2 respectively in the following reaction: $2H_2S + SO_2 \rightarrow 2H_2O + 3S$

Multiple Correct Choice Type

Q.16 Which of the following reactions is/are correctly indicated?

Oxidant Reductant

- (A) $HNO_3 + Cu \longrightarrow Cu^{2+} + NO_2$
- (B) $2Zn + O_2 \longrightarrow ZnO$
- (C) $Cl_2 + 2Br^- \longrightarrow 2Cl^- + Br_2$
- (D) $4CI_2 + CH_4 \longrightarrow CCI_4 + 4HCI$

Assertion and Reasoning Type

Each of the questions given below consist of statement-I and statement-II. Use the following Key to choose the appropriate answer.

(A) If both statement-I and statement-II are true, and statement-II is the correct explanation of statement-I.

(B) If both statement-I and statement-II are true, and statement-II is not the correct explanation of statement-I.

(C) If statement-I is true but statement-II is false.

(D) If statement-I is false but statement-II is true.

Q.17 Statement-I: In CrO_{5} oxidation number of Cr is +6.

Statement-II: CrO_5 has butterfly structure in which

peroxide bonds are present.

Q.18 Statement-I: In PbO_4 all Pb has +8/3 oxidation number.

Statement-II: PbO₄ is mixed oxide of PbO and PbO₂

Q.19 Statement-I: HClO₄ is only oxidising agent.

Statement-II: Cl is most electro-negative element in H, Cl and O.

Q.20 Statement-I: In FeS₂ oxidation number of iron is +4. **Statement-II:** In FeS₂ ($S^- - S^-$) linkage is present.

Q.21 Statement-I: In given reaction H_2O_2 is oxidising & reducing agent $H_2O_2 \longrightarrow H_2O + \frac{1}{2}O_2$

Statement-II: In H_2O_2 is a bleaching reagent.

Q.22 Statement-I: In basic medium colour of $K_2Cr_2O_7$ is changed from orange to yellow.

Statement-II: In basic medium $K_2Cr_2O_7$ is changed in chromate ion.

Q.23 Statement-I: $I_2 \longrightarrow IO_3^- + I^-$.

This reaction is disproportionate reaction.

Statement-II: Oxidation number of I can vary from –1 to +7.

Match the Columns

Q.24 Match the entries in column I with entries in column II and then pick out correct options:

Column I	Column II
(A) Increase in oxidation number	(p) Loss of electrons
(B) Decrease in oxidation number	(q) Redox reaction
(C) Oxidising agent	(r) Fractional oxidation number
(D) Reducing agent	(s) Zero oxidation number
(E) $2Cu^+ \rightarrow Cu^{2+}+Cu$	(t) Simple neutralisation reaction
(F) $MnO_2 + 4HCI \rightarrow MnCI_2$	(u) Gain of electrons + Cl_2 + $2H_2O$
(G) <u>Mn</u> ₃ O ₄	(v) Disproportion-ation
(H) <u>C</u> H ₂ Cl ₂	(w) Oxidation
(I) NaOH + HCI \rightarrow NaCl + H ₂ O	(x) Reduction

Q.25 Match the reactions in column I with nature of the reactions/type of the products in Column II.

Column I	Column II
$(A) O_2^- \rightarrow O_2 + O_2^{-2}$	(p) Redox reaction
(B) $\operatorname{CrO}_{4}^{-2} + \operatorname{H}^{+} \rightarrow$	(q) One of the products has trigonal planar structure
(C) $MnO_4^- + NO_2^- + H^+ \rightarrow$	(r) Dimeric bridged tetrahedral metal ion
(D) $NO_3^- + H_2SO_4^- + Fe^{2+} \rightarrow$	(s) Disproportionation

Previous Years' Questions

Mole Concept

Q.1 Naturally occurring boron consists of two isotopes whose atomic weights are 10.01 and 11.01. The atomic weight of natural boron is 10.81. Calculate the percentage of each isotope in natural boron. **(1978)**

Q.2 The vapour density (hydrogen = 1) of a mixture consisting of NO₂ and N₂O₄ is 38.3 at 26.7°C. Calculate the number of moles of NO₂ in 100 g of the mixture. **(1979)**

Q.3 A solid mixture (5.0 g) consisting of lead nitrate and sodium nitrate was heated below 600°C until the weight

of the residue was constant. If the loss in weight is 28.0 percent, find the amount of lead nitrate and sodium nitrate in the mixture. **(1990)**

Q.4 'A' is a binary compound of a univalent metal. 1.422 g of A reacts completely with 0.321 g of sulphur in an evacuated and sealed tube to give 1.743 g of a white crystalline solid B, that forms a hydrated double salt, C with $Al_2(SO_4)_3$ Identify A, B and C. (1994)

Q.5 Calculate the molality of 1.0 L solution of 93% $H_2SO_{4'}$ (weight/volume). The density of the solution is 1.84 g/mL. (1990)

Q.6 20% surface sites have adsorbed N₂. On heating N₂ gas evolved from sites and were collected at 0.001 atm and 298 K in a container of volume is 2.46 cm³. Density of surface sites is 6.023×10^{14} /cm² and surface area is 1000 cm², find out the number of surface sites occupied per molecule of N₂. **(2005)**

Q.7 If 0.50 mole of $BaCl_2$ is mixed with 0.20 mole of Na_3PO_4 the maximum number of moles of $Ba_3(PO_4)_2$ that can be formed is (1981)

(A) 0.70 (B) 0.50 (C) 0.20 (D) 0.10

Q.8 In the standardization of $Na_2S_2O_3$ using $K_2Cr_2O_7$ is (2001)

$$(A) \left(\frac{\text{Molecular Weight}}{2}\right)$$
$$(B) \left(\frac{\text{Molecular Weight}}{6}\right)$$
$$(C) \left(\frac{\text{Molecular Weight}}{3}\right)$$

(D) Same as molecular weight

Q.9 The difference in the oxidation numbers of the two types of sulphur atoms in $Na_2S_4O_6$ is. (2011)

Read the following questions and answer as per the direction given below:

(A) Statement-I is true; statement-II is true; statement-II is the correct explanation of statement-I.

(B) Statement-I is true; statement-II is true; statement-II is not the correct explanation of statement-I.

(C) Statement-I is true; statement-II is false.

(D) Statement-I is false; statement-II is true.

Q.10 Statement-I: In the titration of Na_2CO_3 with HCl using methyl orange indicator, the volume required at the equivalent point is twice that of the acid required using phenolphthalein indicator.

Statement-II: Two moles of HCl are required for the complete neutralization of one mole of Na₂CO₃. **(1991)**

Q.11 2.68 × 10⁻³ moles of a solution containing an ion Aⁿ⁺ require 1.61×10^{-3} moles of MnO_4^- for the oxidation of Aⁿ⁺ to AO_3^- in acidic medium. What is the value of n? **(1984)**

Q.12 A 5.0 cm³ solution of H_2O_2 liberates 0.508 g of iodine from an acidified KI solution. Calculate the strength of H_2O_2 solution in terms of volume strength at STP. **(1995)**

Q.13 A solution of 0.2 g of a compound containing Cu^{2+} and $C_2O_4^{2-}$ ions on titration with 0.02 M KMnO₄ in presence of H_2SO_4 consumes 22.6 mL of the oxidant. The resultant solution is neutralized with NaCO_{3'} acidified with dilute acetic acid and treated with excess KI. The liberated iodine requires 11.3 mL of 0.05 M Na₂S₂O₃ solution for complete reduction. Find out the mole ratio of Cu²⁺ to $C_2O_4^{-2}$ in the compound. Write down the balanced redox reactions involved in the above titrations. **(1991)**

Q.14 A mixture of $H_2C_2O_4$ (oxalic acid) and $NaHC_2O_4$ weighing 2.02 g was dissolved in water and the solution made up to one litre. Ten millilitres of the solution required 3.0 mL of 0.1 N sodium hydroxide solution for complete neutralization. In another experiment, 10.0 mL of the same solution, in hot dilute sulphuric acid medium, required 4.0 mL of 0.1 N potassium permanganate solution for complete reaction. Calculate the amount of $H_2C_2O_4$ and $NaHC_2O_4$ in the mixture. **(1990)**

Q.15 The unbalanced chemical reactions given in list I show missing or condition which are provided in list II. Match list I with list II and select the correct answer using the code given below the lists: **(2013)**

	List I		List II
(i)	$PbO_2 + H_2SO_4 \xrightarrow{?} PbSO_4 + O_2 + other product$	(p)	NO
(ii)	$Na_2S_2O_3 + H_2O \xrightarrow{?} NaHSO_4 + other product$	(q)	I ₂
(iii)	$ \begin{array}{c} N_2H_4 \xrightarrow{?} \\ N_4 + \text{other product} \end{array} $	(r)	Warm
(iv)	$XeF_2 \xrightarrow{?} Xe + other product$	(s)	Cl ₂

Codes:

	(i)	(ii)	(iii)	(iv)
(p)	4	2	3	1
(q)	3	2	1	4
(r)	1	4	2	3
(s)	3	4	2	1

Q.16 For the reaction $I^- + CIO_3^- + H_2SO_4 \rightarrow CI^- + HSO_4^- + I_2$ The correct statement(s) in the balanced equation is/are: (2014)

(A) Stoichiometric coefficient of $\mathsf{HSO}_4^{\scriptscriptstyle-}$ is 6.

(B) Iodide is oxidized.

- (C) Sulphur is reduced.
- (D) H_2O is one of the products

Q.17 Hydrogen peroxide in its reaction with KIO_4 and NH_2OH respectively, is acting as a **(2014)**

(A) Reducing agent, oxidising agent

(B) Reducing agent, reducing agent

- (C) Oxidising agent, oxidising agent
- (D) Oxidising agent, reducing agent

MasterJEE Essential Questions

JEE Main/Boards				JEE Advanced/Boards			
Exercise 1				Exercise 1			
Mole Concept				Mole Concept			
Q.1	Q.3	Q.7		0.3	0.7	0.14	
Q.11	Q.13	Q.18		0.15	0.22	Q.26	
Q.21	Q.29			Q.28		C	
Redox							
	O(1 (F))			Redox			
Q.3 (C)	Q.4 (F)			Q.2	Q.5	Q.13	
Eventian 2				Q.23	Q.17		
Exercise 2							
Mole Concept				Exercise 2			
Q.1	Q.6	Q.10	Q.15	Mole Concept			
Q.19	Q.23	Q.29	Q.33	Q.2	Q.7	Q.13	
Redox				Q.16			
01	0.8	0.15					
Q.1	Q.8	Q.15		Redox			
Q.24	Q.25			Q.1	Q.6	Q.9	
Draviaus Va				Q.16	Q.19	Q.21	
Previous re	ars Questio	ns					
Mole Concept	and Redox			Dravious Va	ars' Questio	nc	

Q.1	Q.5	Q.14

Previous	Years'	Questions
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Mole Concept and Redox

Q.3 Q.14

Answer Key

JEE Main/Boards	Q.15 (i) 55.5 M
Exercise 1	Q.16 (i) 3.24×10^{-22} g/molecule
Mole Concept	(ii) 4.09×10^{22}
0.1 (i) 68.125 Ka (ii) 7.63 Ka/m ² (iii) 1.72 m	Q.17 55.56 moles
Q.2 7.818×10^{22} atoms	Q.18 7.098×10 ⁷ g mol ⁻¹
Q.3 4.82×10^{22} atoms	Q.29 2.03 kg
Q.4 0.437	Q.20 10 mol
Q.5 $6.02 \times 10^{10} \text{ g / cm}^3$	Q.21 260 mL
Q.6 0.1 M HNO ₃	Q.22 $\frac{x}{y} = 5$
Q.7 14.0 tablets	Q.23 24
Q.8 0.1 M	Q.24 0.394 g
Q.9 $(C_3O_4) = C_{12}O_{16}$	Q.25 79.714 gm
Q.10 0.44 g	Q.26 0.744
Q.11 35.5: 1, 35.5: 1, 1: 1	Q.27 1.125, 1.99, 2.00
Q.12 0.7985, 0.798	Q.28 0.302 M
Q.13 M ₂ O ₃	Q.29 1800 mL
Q.14 K ₂ MnO ₄	

Redox Reaction

Q.1	(i) 5/2	(ii) +2	(iii) +3	(iv) +6	(v) +2	(vi) +6
	(vii) +2	(viii) –2	(ix) +5/2	(x) +1	(xi) +3	(xii) +8/3
	(xiii) +7	(xiv) 0	(xv) +5	(xvi) +5		

Q.2 (i) $5Br^{-} + BrO_{3}^{-} + 6H^{+} \longrightarrow 3Br_{2}^{-} + 3H_{2}O$,	(ii) $8Cr_2O_7^{2-} + 24H_2S + 16H^+ \longrightarrow 8Cr_2O_3 + 3S_* + 32H_2O_3$					
(iii) $Au + 2NO_3^- + 4CI^- + 4H^+ \longrightarrow AuCI_4^- + 2NO_2^- + 2H_2O$	(iv) $3Cu_2O + 14H^+ + 2NO_3^- \longrightarrow 6Cu^{+2} + 2NO + 7H_2O$					
(v) $3MnO_4^- + 4H^+ \longrightarrow 2MnO_4^{-1} + MnO_2 + 2H_2O$	(vi) $2Cu^{+2} + SO_2 + 2H_2O \longrightarrow 2Cu^+ + 4H^+ + SO_4^{-2}$					
(vii) $5CI_2 + I_2 + 3H_2O \longrightarrow 2IO_3^- + 10CI^- + 6H^+$						
(viii) $5Fe(CN)_6^{-4} + 188H^+ + 61MnO_4^- \longrightarrow 5Fe^{3+} + 30CO_2 + 30NO_3^- + 61Mn^{+2} + 94H_2O_3^{-1} + $						
(ix) $6Cu_{3}P + 124H^{+} + 11Cr_{2}O_{7}^{-2} \longrightarrow 18Cu^{+2} + 6H_{3}PO_{4} + 22Cr^{+3} + 53H_{2}O$						

 $\begin{array}{l} \textbf{Q.3} (a) \ 2Cu^{+2} + 2I^{-} \longrightarrow 2Cu^{+} + I_{2} \\ (i) \ 6Fe_{3}O_{4} + 2MnO_{4}^{-1} + 8H_{2}O \longrightarrow 9Fe_{2}O_{3} + 2MnO_{3} + 16OH^{-} \\ (ii) \ 3C_{2}H_{5}OH + 2MnO_{4}^{-} + OH^{-} \longrightarrow 3C_{2}H_{3}O^{-} + 2MnO_{2}(s) + 5H_{2}O \\ (iii) \ 2CrI_{3} + 27H_{2}O_{2} + 10OH^{-} \longrightarrow 2CrO_{4}^{-2} + 6IO_{4}^{-} + 32H_{2}O \\ (iv) \ 258KOH + K_{4}Fe(CN)_{6} + 61Ce(NO_{3})_{4} \longrightarrow 61Ce(OH)_{3} + Fe(OH)_{3} + 36H_{2}O + 6K_{2}CO_{3} + 250KNO_{3} \end{array}$

Q.4 (i)
$$H_2O_2 + 2I^- + 2H^+ \longrightarrow 2H_2O + I_2$$

(ii) $2Cu^{+2} + 2HI \longrightarrow 2Cu^+ + I_2 + H_2O$
(iii) $3CuO + 2NH_3 \longrightarrow 3Cu + N_2 + 3H_2O$
(iv) $3H_2SO_3 + Cr_2O_7^{-2} + 8H^+ \longrightarrow 3H_2SO_4 + 2Cr^{+3} + 4H_2O$
(v) $\therefore 2Cr_2O_7^{2-} + 9C_2H_4O + 16H^{\oplus} \longrightarrow 9C_2H_4O_2 + 4Cr^{+3} + 8H_2O$
(vi) $2SbCI_3 + KIO_3 + 6HCI \longrightarrow 2SbCI_5 + ICI + 3H_2O + KCI$
(vii) $As_2S_5 + 2HNO_3 \longrightarrow 5H_2SO_4 + 40NO_3 + 2H_5AsO_4 + 12H_2O$

Exercise 2

Mole Concept

Single Correct Choice Type

Q.1 B	Q.2 C	Q.3 B	Q.4 B	Q.5 B	Q.6 B	Q.7 D
Q.8 C	Q.9 A	Q.10 A	Q.11 C	Q.12 A	Q.13 B	Q.14 C
Q.15 A	Q.16 C	Q.17 D	Q.18 A	Q.19 B	Q.20 C	Q.21 A
Q.22 C	Q.23 B	Q.24 C	Q.25 B	Q.26 C	Q.27 D	Q.28 A
Q.29 C						

Redox Reaction

Single Correct Choice Type

Q.1 A	Q.2 D	Q.3 A	Q.4 C	Q.5 C	Q.6 C	Q.7 B
Q.8 C	Q.9 B	Q.10 C	Q.11 D	Q.12 C	Q.13 C	Q.14 B
Q.15 C	Q.16 D	Q.17 C	Q.18 D	Q.19 A	Q.20 A	Q.21 C
Q.22 A	Q.23 D	Q.24 B	Q.25 C	Q.26 A	Q.27 A	Q.28 D
Q.29 C	Q.30 D	Q.31 C	Q.32 C			

Previous Year's Questions

Q.1 A	Q.2 C	Q.3 D	Q.4 B	Q.5 A	Q.6 C	Q.7 A
Q.8 D	Q.9 B	Q.10 B	Q.11 D	Q.12 A	Q.13 C	Q.14 A
Q.15 C	Q.16 D	Q.17 C	Q.18 D	Q.19 A	Q.20 A	Q21. C
Q.22 D	Q.23 B	Q.24 A				

JEE Advanced/Boards

Exercise 1

Mole Concept

Q.1	116.8 gm	Q.2 9.12	Q.3 5.6	Q.4 0.597 g			
Q.5	$BaCl_2.2H_2O = 7.038 \text{ g}, H_2O =$	42.962 g	Q.6 120 g	Q.7 20.78%			
Q .8	NaOH = 0.06 g per 200 mL,	$Na_2CO_3 = 0.0265 \text{ g per } 2$	200 mL				
Q.9	0.1185	Q.10 45%	Q.11 61.5 gm	Q.12 320.3 gm			
Q.13	6%	Q.14 8.097 mL	Q.15 6.125 g/litre	Q.16 55.53 litre			
Q.17	$K_2CO_3 = 96\%, Li_2CO_3 = 4\%$		Q.18 12.9 gm	Q.19 1.14 gm			
Q.20	SO_4^{-2} ion concentration =	6.528	Q.21 27.27%	Q.22 $C_2H_6 = 0.66, C_2H_4 = 0.34$			
Q.23	23 $Pb(NO_3)_2 = 3.32 \text{ g}, \text{ NaNO}_3 = 1.68 \text{ g}$						
Q .24	4 0.0075, $[Pb^{2+}] = 0.0536 \text{ M}$, $[NO_3^{-}] = 0.32 \text{ M}$, $[Cr^{3+}] = 0.0714 \text{ M}$ Q.25 %NaCl = 77.8%						
Q .26	26 (i) $Fe_2O_3 + 2AI \longrightarrow AI_2O_3 + 2Fe$; (ii) 80: 27; (iii) 10,000 units						
Q .27	7 12.15 gm, N ₂ = 14.28%, H ₂ = 42.86%, NH ₃ = 42.86%						
Q .28	0.9413 gram	Q.29 (i) 0.5, 0.5; (ii) 0.66	, 0.33; (iii) 1, 2	Q.30 13.4 mL			
Q.31	1 AICl ₃ = 33.33%; NaHCO ₃ = 50; KNO ₃ = 16.67						
Q.32	9.4 gm	Q.33 75%	Q.34 0.532: 1.00				

Redox Reaction

- $\textbf{Q.2} \ \text{Oxidized: KI, Na}_2\text{S, NH}_4^+\text{; Reduced: CuSO}_{4'} \text{SO}_{2'} \ \text{NO}_2^-$
- Q.3 (i) 8 electrons, (ii) electrons
- **Q.4** (i) Oxidation number of sulphur in H_2S and SO_2 are respectively -2 and +4.
- **Q.5** NO_2^- is oxidized to NO_3^- by MnO_4^- (in basic medium) which is reduced to MnO_2^- .



Thus, $MnO_4^- \longrightarrow MnO_3$ oxidation number decreases by 3-units

 $NO_2^- \longrightarrow NO_3^-$ oxidation number increases by 2 units

Thus, $2MnO_4^- \equiv 3NO_2^ MnO_4^- \equiv \frac{3}{2}NO_2^- = 1.5 \text{ mol } NO_2^-$

Q.6 (i) HSO_3^- ; (ii) NO_2^- ; (ii) CI^-

Q.7 (i) $4Zn + 10HNO_3 \longrightarrow 4Zn(NO_3)_2 + N_2O + 5H_2O$ (ii) $6HI + 2HNO_3 \longrightarrow 3I_2 + 2NO + 4H_2O$ Q.8 25 litre **Q.9** 0.5 N, 0.167 M Q.10 0.085 M, 0.042 N **Q.12** (i) 85%; (ii) 124.79 mL **Q.11** 54% **Q.13** 30.33% **Q.14** (i) 3 2 8 3 1 2 11 (ii) 1 40 40 12 2 5 (iii) 2 27 64 6 2 54 32 (iv) 3 14 14 6 9 18 **Q.15** (i) $As_2S_3 + 12OH^- + 14H_2O \longrightarrow 2As^{3-}O_4 + 3S^{2-}O_4 + 20H_2O$ (ii) $2CrI_3 + 10OH^- + 27H_2O_2 \longrightarrow 2Cr^{2-}O_4 + 6IO_4^- + 32H_2O_2$ (iii) $P_4 + 3OH^- + 3H_2O \longrightarrow 3H_2PO_2^- + PH_3$ (iv) $3As_2S_3 + 4H_2O + 10NO_3^- + 10^+ \longrightarrow 6H_3AsO_4 + 9S + 10NO_3^-$ **Q.16** 0.1716 **Q.17** +3 **Q.18** FeC₂O₄ = 0.03 N, FeSO₄ = 0.03 N **Q.19** Molar ratio = 1: 1 **Q.20** 40 mL **Q.21** 14% **Q.22** 57.4% **Q.24** $[Fe^{3+}] = 0.1M$, $[MnO_4^{-}] = 0.105M$ **Q.23** $1.847 \times 10^{-3}\%$ **Q.25** (i) 0.08 N, 0.136%, 0.448 volume; (ii) 1.344 **Q.26** 0.062 M Q.27 1.338 g **Q.28** (i) $6H^+ + CIO_2^- + 5Fe^{+2} \longrightarrow CI^- + 5Fe^{+3} + 3H_2O$ (ii) $24CuS + 16NO_3^- + 64H^+ \longrightarrow 24Cu^{+2} + 3S_8 + 16NO + 32H_2O$ (iii) $S_2O_3^{-2} + Sb_2O_5 + 4H^+ \longrightarrow 2SbO + 2H_2SO_3$ (iv) $16HCI + 2KMnO_4 \longrightarrow 5CI_2 + 2KCI + 2MnCI_2 + 8H_2O$ (v) $3KCIO_3 + 3H_2SO_4 \longrightarrow 3KHSO_4 + HCIO_4 + 2CIO_2 + H_2O_4$ (vi) $2HNO_3 + 6HBr \longrightarrow 2NO + 3Br_2 + 4H_2O$ (vii) $IO_4^- + 7I^- + 8H^+ \longrightarrow 4I_2 + 4H_2O$ **Q.29** (i) $Cu + 4H^+ + 2NO_3^- \longrightarrow Cu^{+2} + 2NO_2 + 2H_2O$ (ii) $CI_2 + IO_3^- + 2OH \longrightarrow IO_4^- + 2CI^- + 2H_2O$ (iii) $3H_2S + 2K_2CrO_4 + 5H_2SO_4 \longrightarrow Cr_2(SO_4)_3 + 2K_2SO_4 + 8H_2O + 3S$ (iv) $5Fe^{2+} + MnO_4^- + 8H^+ \longrightarrow 5Fe^{+3} + Mn^{+2} + 4H_2O$ (v) $2KMnO_4 + 3H_2SO_4 + 5H_2O_2 \longrightarrow K_2SO_4 + 2MnSO_4 + 8H_2O + 5O_2$ (vi) $2H_2O_2 + 2MnO_2 + 2OH^- \longrightarrow 2MnO_4^- + 4H_2O$

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Q.30 (i) $S_2O_4^{-2} + Ag_2O + 2OH^- \longrightarrow 2Ag + 2SO_3^{-2} + H_2O$ (ii) $CI_2 + 2OH^- \longrightarrow CI^- + CIO^- + H_2O$ (iii) $3H_2 + 2ReO_4^- \longrightarrow 2ReO_2 + 2H_2O + 2OH^-$ (iv) $2CIO_2 + SbO_2^- + 2OH^- + 2H_2O \longrightarrow 2CIO_2^- + Sb(OH)_6^{-1}$ (v) $6I_2 + 12OH^- \longrightarrow 10I^- + 2IO_2^- + 6H_2O$ (vi) $MnO_4^- + 5Fe^{+2} + 4H_2O \longrightarrow Mn^{+2} + 5Fe^{+3} + 8OH^-$

Exercise 2

Mole Concep	ot					
Single Correct	Choice Type					
Q.1 D	Q.2 B	Q.3 C				
Assertion Rea	soning Type					
Q.4 B	Q.5 A	Q.6 C	Q.7 B	Q.8 A	Q.9 C	
Multiple Corre	ect Choice Type	e				
Q.10 A, C, D						
Comprehensic	on Type					
Paragraph 1:	Q.11 A	Q.12 C	Q.13 A	Q.14 A	Q.15 C	
Paragraph 2:	Q.16 (1) C; (2)	A; (3) B; (4) A				
Paragraph 3:	Q.17 (1) C; (2)	A; (3) A				
Match the Col	umns					
Q.18 A → r; B -	\rightarrow p; C \rightarrow q	Q.19 A → r; B	\rightarrow q; C \rightarrow p	Q.20 C	Q.21 B	
Redox React	ion					
Single Correct	Choice Type					
Q.1 C Q.8 B	Q.2 D	Q.3 C	Q.4 D	Q.5 C	Q.6 A	q.7 A
Comprehensic	on Type					
Paragraph 1:	Q.9 D	Q.10 D	Q.11 D	Q.12 D		
Paragraph 2:	Q.13 C	Q.14 B, C	Q.15 B	Q.16 A, B, D		

1.56 Stoic	hiometry and R	edox Reactions						
Assertion Reasoning Type								
Q.17 A	Q.18 D	Q.19 C	Q.20 D	Q.21 B	Q.22 A	Q.23 B		
Match the C	olumns							
Q.24 $A \rightarrow W$;	$B \rightarrow x; C \rightarrow u; D$	$p \rightarrow p; E \rightarrow v; F \rightarrow v; $	\Rightarrow q; G \rightarrow r; H \rightarrow s;	$I \rightarrow t$				
Q.25 A \rightarrow p, s; B \rightarrow r; C \rightarrow p, q; D \rightarrow p								
Previous	Year's Quest	ions						
Q.1 20%	Q.2 0.437	Q.3 1.7 g	Q.4 A = KO ₂	Q.5 10.43	Q.6 2	Q.7 D		
Q.8 B	Q.9 5	Q.10 B	Q.11 2	Q.12 4.48 V				
Q.13 Moles of Cu ²⁺ ; Moles of $C_2O_4^{-2} = 1:2$			Q.14 0.9 g, 1.1	L2 g	Q.15 D	Q.16 A, B, D		

Solutions

JEE Main/Boards

Exercise 1

Q.17 A

Mole Concept

Sol 1: (i) 125 pound 1 pound = lb = 545 gm 125 pound = 125 × 545 gm = 125 × 545 × 10⁻³ kg = 68. 125 kg (ii) 14 lb/m² 1lb = 545 gm In SI units = $14 \times 545 \times 10^{-3} \text{ kg/m}^2$ = 7. 63 kg/m² (iii) 5'8" (1' = 12") 5'8" = (12" × 5) + 8" = 68" = 68 × 2. 54 cm = 1. 72 m

Sol 2: M_{avg.} = (0. 932) 39 + (0. 068)41 = 39. 136 Mass of 2g-atoms = 2 × 39. 136 gm Mass of "41K" in 2g-atoms = 2 × 39. 136 × (0. 068) Number of atoms = $\frac{2 \times 39.136}{41} \times (0.068) \times 6.023 \times 10^{23}$ = 7.818 × 10²²

Sol 3: Barium phosphate = $Ba_3(PO_4)_2$ No. of oxygen atoms = $\frac{6.025}{602.5} \times 8 \times 6.023 \times 10^{23}$ = 4.82×10^{22} atoms

Sol 4: Molecular weight = Vapour density × 2 = 76. 6 Let's suppose x % mole of NO₂ is there 76. 6 = x (46) + (1 - x) 92 46x = 15. 4 x = 0.3347=33. 47% = mole fraction of NO₂ Total mole = $\frac{100}{76.6}$ = 1. 305 mole Mole of NO₂ = (0. 3347) × (1. 305) = 0.437 mole. Sol 5: Correction: radius of fluorine $= 5 \times 10^{-3} \text{ Å}$

Mass of nucleous = $19 \times 1.67 \times 10^{-27}$ kg Volume of nucleous

$$=\frac{4}{3} \times \pi \times (5 \times 10 - 3)^3 \text{ cm}^3$$

Density

 $= \frac{3 \times 19 \times 1.67 \times 10^{-27} \times 10^{3}}{4 \times \pi \times (5 \times 10^{-3})^{3} \times (10^{-10})^{3}} \frac{gm}{cm^{3}}$ $= \frac{95.19 \times 10^{-27} \times 10^{30}}{1570.79 \times 10^{-9}} \text{ gm/cm}^3$

 $= 6.02 \times 10^{13} \text{ gm/cm}^{3}$

Sol 6: mole = M_1V_1 For neutralisation $H_{HNO} = H_{NaOH}$ $M_1V_1 = M_2V_2$ $20 \times M_1 = 0.08M \times 25$ $M_1 = \frac{0.08 \times 25}{20} = 0.1M$

Sol 7: HCl produced perday

= 3.0 gm × 2.5 = 7.5 gm = $\frac{7.5}{36.5}$ mole Moles of Al(OH)₃ in an antacid tablet $=\frac{400\times10^{-3}}{(27+51)}=\frac{0.4}{78}$ mole $3 \times \text{mole of Al(OH)}_3 = \text{moles of HCl}$ $3 \times n \times \frac{0.4}{78} = \frac{7.5}{36.5}$ n ≈ 14 **Sol 8:** HCl + AgNO₃ \rightarrow AgCl + HNO₃ $M \times 10 \times 10^{-3} = \frac{0.1435}{108 + 35.5}$ M = 0.1 M.Sol 9: Lets it is C_xO_y x(12) + y(16) = 400 $\frac{x(12)}{400} = 0.36$ x = 12; y = 16

the formula is $C_{12}O_{16} = (C_3O_a)_a$

Sol 10: $C_xH_y + O_2 \rightarrow H_2O + CO_2$ 0.1 mole 0.2 mole Mole of $H_2O = \frac{0.18}{18} = 0.1$ mole Mole of $CO_2 = 0.02$ mole Mole of O₂ required = $\frac{1}{2}(0.1) + 0.02 = 0.07$ mole y = Mole of H = (0. 1)2 = 0.2 molex = Mole of C = 0.02 moleMass of hydro is = (0.02)12 + (0.2)1= 0.24 + 0.2 = 0.44 gm.

Sol 11: PCI, and PH, 2257% 91.18% Mass of Cl in PCl₂ = 3 × 35. 5 = 106. 5 Mass of H in $PH_3 = 3 \times 1 = 3$ ratio = $\frac{106.5}{3}$ = 35.5 Ratio of CI: H = 35.5

Hence prove.

Sol 12: Exp. (I) $CuO \rightarrow Cu + X$ Ratio of mass of Cu : CuO = $\frac{1.098}{1.375} = 0.7985$ Exp. (II) $\underset{1.179 \text{ gm}}{\text{Cu}} \xrightarrow{\text{HNO}_3} \text{Cu(NO}_3)_2 \xrightarrow{\text{CuO}} \underset{1.476 \text{ gm}}{\text{CuO}}$ Ratio of mass of Cu : CuO = $\frac{1.179}{1.479} = 0.798$ both ratio are same. Hence prove.

Sol 13: M_vO_v

 $x \times atomic mass of M = 0.540$ (i) $y \times 16 = 1.020 - 0.540$ y = 0.03Dulong-Petit law (atomic mass of M) × 0. 216 = 5. 83 Atomic mass of $M \cong 27$ (ii) Petit $x \times (27) = 0.540$ x = 0.02Formula of metal oxide = M_2O_3 .

Sol 14: Let's say substance is 100 gm

Moles of K = $\frac{39.7}{39}$ = 1.017 Moles of Mn = $\frac{29.9}{55}$ = 0.5436 Moles of O = $\frac{100 - 39.7 - 29.9}{16}$ = 1.9 so by seeing on ratio of K : Mn : O empirical formula is K₂MnO₄.

Sol 15: Molarity = $\frac{\text{no. of moles}}{\text{volume (in litre)}}$

No. of moles = $\frac{\text{mass}}{18} = \frac{1000 \times 0.997}{18}$ per litre.

Molarity = 55. 38 M

Sol 16: (a) Mass = $(8 \times 12) + (10 \times 1) + (4 \times 14) + (2 \times 16)$ = 96 + 10 + 56 + 32 Mass = 194 amu = 194 × 1. 66 × 10⁻²⁴ gm/molecule = 3. 24 × 10⁻²² gm/molecule

(b) Molecular mass of $Cl_2 = 71$ Total no. of electrons in one molecule of $Cl_2 = 34$

So no. of electrons = $\frac{0.142}{71} \times 34 \times 6.023 \times 10^{23}$ = 4.029 × 10²²

Sol 17: Molarity = moles per litre

 $= \frac{\text{Mass}}{18 \times \text{V}} = \frac{\text{Density} \times \text{Volume}}{18 \times \text{Volume}} = \frac{1000}{18} = 55.55 \text{M}$

Sol 18: Volume of plant virus = $(\pi r^2 h)$ = $\pi \times (75 \times 10^{-10})^2 \times (5000 \times 10^{-10})$ = $8.835 \times 10^{-23} m^3$ = $8.835 \times 10^{-23} \times (10^{+2})^3 cm^3$ = $8.835 \times 10^{-17} cm^3$ Mass = $\frac{8.835 \times 10^{-17}}{0.75}$ gm = 11.78×10^{-17} gm = $11.78 \times 6.023 \times 10^{+23} \times 10^{-17}$ = 7.098×10^7 g mol⁻¹ Sol 19: 25% of heavy water = 0.5 litre. Mass of heavy water = $0.5 \times 10^3 \times 1.06 \text{ gm/cm}^3 = 530 \text{ gm}$ Mass of normal water = $1.5 \times 10^3 \times 1 \text{ gm/cm}^3 = 1500 \text{ gm}$ Total mass = 2030 gm = 2. 030 kg

Sol 20 $SO_2Cl_2 + 2H_2O \rightarrow H_2SO_4 + 2HCl$ Initially 2.5 0 0 after 0 2.5 5 For 2.5 moles of H_2SO_4 , KOH = 5 mole For 5 mole of HCl, KOH = 5 mole Total KOH = 5 + 5 = 10 mole

Sol 21: $\underbrace{NH_4Cl + MgCl_2}_{2 \% \text{ by mass}} + \underbrace{AgNO_3}_{5\% \text{ by mass}} \rightarrow$

AgCl + NH₄NO₃ + Mg(NO₃)₂ d = 1040 gm/lit. Moles of Cl⁻ in NH₄Cl = $\frac{2}{(14 + 4 + 35.5)}$ = 0. 0373 mole Moles of Cl⁻ in MgCl₂ = 2 × $\frac{2}{(24 + 71)}$ = 0. 0421 mole Total mole of Cl⁻ = Total mole of AgNO₃ required = 0.0421 + 0.0373 = 0.07940 mole Mass of AgNO₃ = 0.07940 × 170 = 13.49 gm Mass of solution of AgNO₃ × 13. 49 × $\frac{100}{5}$ = 269.97 gm Volume required = $\frac{269.97}{1.04}$ cm³ = 259. 59 cm³ **Sol 22:** Oxalic acid = H₂C₂O₄ Formic acid = HCOOH

 $H_{2}C_{2}O_{4} + H_{2}SO_{4} \rightarrow SO_{4}^{2-} + H_{4}C_{2}O_{4}^{2+}$ $HCOOH + H_{2}SO_{4} \xrightarrow{\Delta} SO_{4}^{2-} + 2H^{+} + HCOOH$ $H_{4}C_{2}O_{4}^{2+} + KOH \rightarrow C_{2}O_{4}^{2-}$

Sol 23: $CH_4 \rightarrow x \mod x \mod x$ Molecular weight = 16 $(C_2H_4) \rightarrow y \mod x$ Molecular weight = 28 Mean molecular weight

$$= 20 = \frac{x(16) + y(28)}{x + y}$$

$$20 = 16 + \frac{12y}{x + y}$$

$$0.33 = \frac{y}{x + y}$$

$$\frac{x}{x + y} = 0.66$$

$$x : y = 2 : 1$$

If $x : y = 1 : 2$
Then, mean molecular weight = $\frac{1(16) + 2(28)}{3} = 24$

Sol 24:

 $2\text{KCIO}_{3} \rightarrow 2\text{KCI} + 3\text{O}_{2}$ $4.369 \times 10^{-3} \qquad 6.55 \times 10^{-3}$ $4\text{KCIO}_{3} \rightarrow 3\text{KCIO}_{4} + \text{KCI}$ $3.794 \times 10^{-3} \qquad 2.845 \times 10^{-3}$ Moles of oxygen produced

$$= \frac{146.8 \times 10^{-3}}{22.4} = 6.55 \times 10^{-3} \text{ mole}$$

Total mole of KClO₃ = $\frac{1}{39 + 35.5 + 48}$

= 8.163 × 10⁻³ mole

Moles of KClO₃ in IInd reaction = 3.794×10^{-3} moles Moles of KClO₄ produced in IInd reaction = 2.8496×10^{-3} mole Mass of KClO₄ = $2.8456 \times 10^{-3} \times (39 + 35.5 + 64)$ = 0.394 gm

Sol 25: Let's say we have 100 gm mix. Fe₃O₄ = FeO.Fe₂O₃ \rightarrow FeO + Fe₂O₃ x gram 0.310 gram 0.680x gram Initially FeO \rightarrow (100 - x) gram Total (FeO) \rightarrow (100 - x + 0.310 x) gm = (100 - 0.690 x) gm 2FeO + $\frac{1}{2}O_2 \rightarrow$ Fe₂O₃

(105 - 0. 690x)gm $2 \times \left(\frac{100 - 0.690 x}{72}\right) = \frac{(105 - 0.690 x)}{160}$ $(100 \times 0.690x) \times \frac{160}{36} = 105 - 0.690x$ 4000 - 27.6 x = 945 - 6.21 x 3055 = 21.39 x x = oxygen external = 5gm = $\frac{5}{32}$ mole So moles of FeO that was present $\frac{(100 - 0.690x)}{56 + 16} = \frac{4 \times 5}{32}$ $Fe_3O_4 + x = 79.71 \text{ gm}$ FeO = 100 - x = 20.29 gm**Sol 26:** $Zn + 2I \rightarrow ZnI_2$ m m 2x moles of Zn = moles of I (to complete reaction) $2 \times \frac{m}{65} = 2x$ moles of Zn $\frac{111}{127}$ = moles of I Since moles of I < 2x moles of Zn So Zn will be left unreacted Zn unreacted = $\frac{m}{65} - \frac{m}{127 \times 2}$ mole Mass Zn unreacted = $m - \frac{65}{254}m = 0.744 m$ **Sol 27:** Mole of $P_4 = \frac{2}{4 \times 31} = \frac{1}{62}$ mole Moles of $O_2 = \frac{2}{2 \times 16} = \frac{1}{16}$ mole $\begin{array}{rrrr} \mathsf{P}_4 & + & 3\mathsf{O}_2 & \rightarrow & \mathsf{P}_4\mathsf{O}_6 \\ \mathsf{x} & & 3\mathsf{x} & & \mathsf{O} \end{array}$ Initial 0 0 After $P_4 + 5O_2 \rightarrow P_4O_{10}$ 5y 0 у Initial 0 0 У After $x + y = \frac{1}{62} = 0.0161$ 3x + 5y = $\frac{1}{16} = 0.0625$ by solving

y = 7.056 × 10⁻³
x = 9.0435 × 10⁻³
Mass of P₄O₆ = 9.0435 × 10⁻³
[(4 × 31) + (6 × 16)] = 1.9895 gm
Mass of P₄O10 = 7.056 × 10⁻³
[(4 × 31) + (10 × 16)] = 2.003 gm
Sol 28: Moles of aluminium =
$$\frac{2.7}{27}$$
 = 0.1 mole
Moles of H₅O₄ in solution
= $\frac{(1.18 \times 100) \times 0.25}{98}$ = 0. 3010 mole
 $(C) [Co(NH_3)_5 C]^{1/2} + 2CF$
Moles of H₅O₄ in solution
= $\frac{(1.18 \times 100) \times 0.25}{98}$ = 0. 3010 mole
 $(C) [Co(NH_3)_5 C]^{-1/2} + 2CF$
For consumption of Al, required mole of
H₅SO₄ = (0.10) × $\frac{3}{2}$ = 0.15 mole
Molarity = $\frac{0.151}{500} \times 1000 = 0.302M$
Sol 29: KMnO₄ + H₅SO₄ → K₂SO₄ + MnSO₄
+ H₂O + (O)(1)
FeC₅O₄ + H₂SO₄ → C₅O₄ + H₅C₉
 $(C) \frac{2H^{+} + Px^{+} + 2O^{2-}}{2}$
FeSI₄ + H₂C₂O₄ + H₂SO₄ + O →
Fe₅(SO₂)₃ + CO₂ + H₂(3)
Sol 29: KMnO₄ + SFeC₂O₄ + O →
Fe₅(SO₂)₃ + CO₂ + H₂(3)
 $2(N^{+}PS^{+} + 2CO_{2} + H_{2} -(2)$
FeSI₄ + H₂C₂O₄ + H₂SO₄ + O →
Fe₅(SO₂)₃ + CO₂ + H₂(3)
 $2(N_2H_5)^{+} + SO_{4}^{-1}$
 $(0. 5)V = \frac{(1.5)}{5} \times 3$
 $V = 1.8$ lit = 1800 mL
Sol 1: (a) (N₂H₅)₂ SO₄
 $2(N^{+}+ + SH^{+})$
 $(i) S2Cl2
 $2(N^{-}+ + 5H^{+})$
 $(j) S5Cl2
 $2(N_2H_5)^{+} + SO_{4}^{-1}$
 $2(N_2H_5)^{+} + SO_{4}^{-1}$
 $2(N_2H_5)^{+} + SO_{4}^{-1}$
 $(i) Signe = 100 + 100$$$

(k) RNO₂ +1 + x - 4 = 0; x = 3N+3 (I) Pb_3O_4 +3x - 8 = 0 $x = + \frac{8}{3}$ Pb^{+8/3} (m) $S_2O_8^{2-}$ 2x - 16 = -22x = 14; x = +7 S⁺⁷ (n) $C_6 H_{12} O_6$ +6x + 12 - 12 = 0; x = 0 C^0 (o) $Mg_{2}P_{2}O_{7}$ +2(2) + 2x - 14 = 0x = +5P+5 (p) KCIO₃ +1 + x - 6 = 0; x = +5CI+5

$$8Cr_{2}O_{7}^{2-} + 24H_{2}S + 16H^{+} \rightarrow 8Cr_{2}O_{3} + 3S_{8} + 32H_{2}O$$
(c) Au + 4Cl⁻ \rightarrow AuCl⁻₄ + 3e⁻(1)
NO_{3}^{-} + e⁻ + 2H^{+} \rightarrow NO₂ + H₂O(2)
(1) + (2 × (2))
Au + 4Cl⁻ + 2NO_{3}^{-} + 4H^{+} \rightarrow AuCl⁻₄ + 2NO₂ + 2H₂O
(d) Cu₂O + 2H⁺ \rightarrow 2Cu⁺² + 2e⁻ + H₂O(1)
H⁺ + NO_{3}^{-} + 3e⁻ \rightarrow NO + 2H₂O(2)
(3 × (1)) + (2 × (2))
3Cu₂O + 6H⁺ + 8H⁺ + 2NO_{3}^{-} \rightarrow 6Cu²⁺ + 3H₂O + 2NO +
4H₂O
3Cu₂O + 2NO_{3}^{-} + 14H⁺ \rightarrow 6Cu²⁺ + 2NO + 7H₂O
(e) MnO_{4}^{2-} \longrightarrow MnO_{4}^{-} + e⁻(2) × 2
3MnO_{4}^{2-} \longrightarrow MnO₂ + 2H₂O(1)
MnO_{4}^{2-} \longrightarrow MnO₂ + 2MnO_{4}^{-} + 2H₂O
(f) Cu²⁺ + SO₂ \rightarrow Cu⁺ + SO₄²⁻
Cu²⁺ + e⁻ \rightarrow Cu⁺ × (2)
H₂O + SO₂ \rightarrow SO₄²⁻ + 2e⁻ + 4H⁺
(2u²⁺ + SO₂ \rightarrow Cu⁺ + SO₄²⁻
Cu²⁺ + e⁻ \rightarrow Cu⁺ × (2)
H₂O + SO₂ \rightarrow SO₄²⁻ + 2e⁻ + 4H⁺
(g) $C_{12}^{0} + I_{2}^{0} \longrightarrow $0_{3}^{-} + CI-$
2e⁻ + Cl₂ \rightarrow 2Cl⁻ × (5)
3H₂O + I₂ \rightarrow 2Cl⁻ × (5)
3H₂O + I₂ \rightarrow 2IO₃⁻ + 10Cl⁻ + 6H⁺
(h) Fe⁺² \rightarrow Fe⁺³ + e⁻
2H₂O + 6CN³⁻ \rightarrow 6NO₃⁻ + 6(8e⁻) + 36H⁺
Se⁻ + MnO₄⁻ + 8H⁺ \rightarrow Mn²⁺ + 4H₂O × (6H⁺)
Fe(CN)₆⁴⁻ + 30H²O \rightarrow Fe³⁺ + 6CO₂
 $6NO_{3}^{-} + 60H+ + 61e- × (5)$$

$$+30CO_{2} + 30NO_{3}^{-} + 61Mn^{2+} + 94H_{2}O$$
(i) $Cu^{+1} \rightarrow Cu^{+2} + e^{-} \times (3)$
 $P^{3-} + 4H_{2}O \rightarrow H_{3}PO_{4} + 8e^{-} + 5H^{+}$
 $Cu_{3}P + 4H_{2}O \rightarrow 3Cu^{2+} + H_{3}PO_{4} + 5H^{+} + 11e^{-}$
 $Cr_{2}O_{7}^{2-} + 3e^{-} + 14H^{+} \rightarrow Cr^{+3} + 7H_{2}O$
 $6Cu_{3}P + 124H^{+} + 11Cr_{2}O_{7}^{2-} \rightarrow 18Cu^{2+}$
 $+ 6H_{3}PO_{4} + 22Cr^{+3} + 53H_{2}O$

Sol 3: (a)
$$2Cu^{2+} + 2I^{-} \rightarrow 2Cu + I_{2}$$

(b) $Fe_{3}O_{4}^{+8/3} + 4H_{2}O \rightarrow Fe_{2}O_{3}^{+3} + 8OH^{-} + 2e^{-} \times (3)$
 $3OH^{-} + MnO_{4}^{-} + 3e^{-} \rightarrow MnO_{2} + 2H_{2}O \times (2)$
 $3Fe_{3}O_{4} + 12H_{2}O + 8OH^{-} + 2MnO_{4}^{-} \rightarrow 3Fe_{2}O_{3} + 24OH^{-} + 4H_{2}O$
 $6Fe_{3}O_{4} + 2MnO_{4}^{-} + 8H_{2}O \rightarrow 9Fe_{2}O_{3} + 16OH^{-} + 2MnO_{3}$
(c) $C_{2}H_{5}^{2}OH + OH^{-} \rightarrow C_{2}H_{3}O^{-} + H2O Re^{-}$
 $3e^{-} + MnO_{4}^{-} + 4H2O \rightarrow MnO_{2} + 8OH^{-}$

$$3C_{2}H_{5}OH + 2MnO_{4}^{-} + OH - \rightarrow 3C_{3}H_{3}O^{-} + 2MnO_{2} + 5H_{2}O$$
(d) $Cr + {}^{3+}8OH^{-} \rightarrow CrO_{4}^{2-} + 4H_{2}O + 3e^{-}$

$$3I^{-} + 8OH^{-} \rightarrow {}^{+7}3IO_{4} + 24e^{-} + 4H_{2}O$$

$$e^{-} + H_{2}O_{2}^{-1} + H_{2}O \rightarrow H_{2}O^{-2} + 2OH^{-}$$

$$2CrI_{3} + 27H_{2}O_{2} + 10OH^{-} \rightarrow$$
$$2CrO_{4}^{2-} + 6IO_{4}^{-} + 32H_{2}O$$

(e) 258KOH + K4Fe(CN)₆ + 61Ce(NO₃)₄
$$\rightarrow$$
 61Ce(OH)₃ + Fe(OH)₃ + 36H₂O + 6K₂CO₃ + 250KNO₃

Sol 4: (a) $I^{\Theta} + H_2O_2 \rightarrow H_2O + I_2$ (acidic medium) $(I^{\Theta} \xrightarrow{1e^-} I_2^0) \times 2$

$$H_2^{+1} \xrightarrow{-1} H_2^{-2 \times 1e} H_2^{-2}$$

$$\begin{split} &2I^{\Theta} + H_2O_2 \rightarrow H_2O + I_2 + 2H^+ + OH^{\Theta} \\ &\therefore 2HI + H_2O_2 \rightarrow 2H_2O + I_2 + H^+ \\ &(b) Cu^{+2} + I^{\Theta} \rightarrow Cu^+ + I_2 \\ &(Cu^{+2} \xrightarrow{1e^-} Cu^+) \times 2 \\ &(I^{\Theta} \xrightarrow{1e^-} I) \times 2 \\ &2Cu^{+2} + 2I^{\Theta} \rightarrow 2Cu^+ + I_2 \\ &By the oxidation number method, \end{split}$$



 $\therefore \text{ To balance the electrons transferred,}$ $2Cu^{+2} + 2I^{\Theta} \rightarrow 2Cu^{+} + I_{2}$ To balance charges on both sides, $2Cu^{+2} + 2I^{\Theta} + 2H^{+} \rightarrow 2Cu^{+} + I_{2} + H_{2}O$ $\therefore 2Cu^{+2} + 2HI \rightarrow 2Cu^{+} + I_{2} + H_{2}O$

(c) CuO + NH₃ \rightarrow Cu + N₂ + H₂O

To balance the electrons transferred to balance oxygen

$$\begin{array}{c} 2e \\ 0 \\ CuO + NH_3 \rightarrow Cu + N_2 + H_2O \\ 3e^{-3} \\ 3e^{-3} \end{array}$$

$$3CuO + 2NH_3 \longrightarrow 3Cu + N_2 + 3H_2O$$

(d)
$$H_2SO_3 + Cr_2O_7^{2-} \to H_2SO_4 + 2Cr^{+3}$$

(+4) (+12) (+6) (+6) (2e⁻) (6e)

To balance the number of electrons transferred,

$$9H_2SO_3 + Cr_2O_7^{2-} \rightarrow 9H_2SO_4 + 2Cr^{+3}$$

To balance charges on both sides,

$$3H_2SO_3 + Cr_2O_7^{2-} + 8H^+ \rightarrow 3H_2SO_4 + 2Cr^{+3} + 4H_2O$$

We observe that the number of oxygen atoms are simultaneously balanced



$$\therefore \operatorname{Cr}_2\operatorname{O}_7^{2-} + \operatorname{C}_2\operatorname{H}_4\operatorname{O} \to \operatorname{9C}_2\operatorname{H}_4\operatorname{O}_2 + \operatorname{4Cr}^{+3}$$

To balance charges on both sides,

 $\therefore 2Cr_{2}O_{7}^{2-} + 9C_{2}H_{4}O + 16H^{+} \rightarrow 9C_{2}H_{4}O_{2} + 4Cr^{+3} + 8H_{2}O$ (f) $3CI^{-} + SbCl_{3} \rightarrow SbCl_{5} + 2e^{-} \times (2)$ $6e^{-} + KIO_{3}^{+5} + 6H^{+} \rightarrow |_{1}^{+1} + 3H_{2}O + K^{+}$

$$2SbCl_{3} + KIO_{3} + 8HCl \rightarrow 2SbCl_{5} +$$

$$ICl + 4H_{2}O + KCl$$
(g) $As_{2}^{+5}S_{5}^{-2}$

$$As^{+5} \rightarrow H_{3}AsO_{4} \sqrt{No redox charge}$$

$$5S^{2-} + 4H_{2}O \rightarrow 5H_{2}^{+6}O_{4} + 40e^{-}$$

$$e^{-} + HNO_{3} + H^{+} \rightarrow NO_{2}^{+4} + H_{2}O$$

$$As_2S_5 + 2HNO_3 \rightarrow 5H_2SO_4 + 40NO_2 + 2H_3ASO_4 + 12H_2O_2$$

Sol 5: Disproportionation is a specific type of redox reaction in which a species is simultaneously reduced and oxidized to form two different product.

Eg. $\operatorname{MnO}_{4}^{2-} \longrightarrow \operatorname{MnO}_{4}^{-} + \operatorname{MnO}_{2}^{-}$

Sol 6: Ion-electron method :-

- (I) Divide the complete equations into two half reaction.
- (II) Balance the atoms in each half reaction separately according to the following steps :-
- (a) Balance all atoms other then O and H.

(b) For O and H.

1. Acidic Medium:

(i) Add H_2O to the side which is oxygen deficient.

(ii) Add H⁺ to the side which is hydrogen deficient.

2. Basic Medium:

(i) Add OH⁻ to the side which has less -ve charge.

(ii) Add H_2O to the side which is oxygen deficient.

(iii) Add H⁺ to the side which is hydrogen deficient.

3. Oxidation State Method: This method is based on the fact that the number of electrons gained during reduction must be equal to the number of e^{-s} lost during oxidation.

Sol 7: Definition of Redox Reaction: Reaction which involves change in oxidation state of their atom, generally involve the transfer of electron between species. So, the most essential conditions that must be satisfied is the exchange of electron change in oxidation state.

Sol 8: No, oxidation state term is just introduced to easily calculate the exchange of electron in redox reaction.

So, oxidation no. of an element in a particular compound represents the no. of e⁻s lost or gained by an element during its change from free state into that compound or it represent the extent of oxidation or reduction of an element during its charge from free state into that compound.

Sol 9: Redox Couple: Oxidation half reaction and reduction half reaction contributes to redox couple

$$M \longrightarrow M^{+n} + ne^{-} \qquad \text{Oxidation}$$

$$A + ne^{-} \longrightarrow A^{-n} \qquad \text{Reduction}$$

$$M + A \longrightarrow M^{+n} + A^{-n}$$

Sol 10: (1) Combination of half cells (a) and (b)

$$Zn(s) / Zn^{2+} (aq) ||Cu(s) / Cu^{2+} (aq)$$

Anode
E.M.F. of the cell, E
$$= E_{right} - E_{left} = 0.34 - (-0.76)$$
$$= 1.10 V$$
(2) Combination of half cells (b) and (d)

$$Cu(s) / Cu^{2+}(aq) ||Ag(s) / Ag^{2+}(aq)$$

Anode Cathode

E.M.F. of the cell, E = $E_{right} - E_{left} = 0.80 - (+0.34)$ = 0.46 V



(i) Ion-electron method :-

 $2MnO_{4}^{-} + 5C_{2}H_{2}O_{4} \rightarrow 2Mn^{+2} + 10CO_{2}$ (ii) Oxidation number method :-







$$H_2S^{-2} \longrightarrow S + 2e^- + 2H^+$$
$$Cl_2 + 2e^- \longrightarrow 2Cl^-$$

$$H_{2}S + CI_{2} \longrightarrow S^{0} + 2CI^{-}$$

$$H_{2}S^{-2} + CI_{2} \longrightarrow S^{0} + 2CI^{-2}$$

$$-2e^{-} + 2e^{-}$$

So, no need to multiply this equation with any coefficients.

Sol 12 (a)
$$\operatorname{Fe}^{3+} + e^{-} \rightarrow \operatorname{Fe}^{2+}$$

 $2I^{-} - 2e^{-} \rightarrow I_{2}$
(b) $Zn \rightarrow Zn^{2+} + 2e^{-}$
 $2H^{+} + 2e^{-} \rightarrow H_{2}(g)$
(c) $AI^{3+} + 3e^{-} \rightarrow AI(s)$
 $Ag^{+} + e \rightarrow Ag(s)$

Sol 13: Oxidation: Increase in oxidation number

 $2CI^{-} \longrightarrow CI_{2}$

Reduction: Decrease in oxidation number

$$KMnO_4 \longrightarrow Mn^2$$

Sol 14: (a) Combination reaction: Reaction in which two or more elements on compounds combine together to form a single compound

 $2Mg + O_2 \longrightarrow 2MgO + heat$

(b) Decomposition reaction: Reaction is the separation of a chemical compound into elements or simpler compounds

$$2H_2O_2 \longrightarrow 2H_2O + O_2$$

(c) Displacement reaction:

Reaction in which on element or ion moves out of ore compound and into another

Eg. Fe + $CuSO_{a} \longrightarrow Cu + FeSO_{a}$

Sol 15: Oxidation No.: No. of e^{-s} lost or gained by an element during its change from free state into compound or represent the extent of oxidation or reduction of an element during its change from free state into that compound.

Valence: Number of valence bonds a given atom has formed or can form with one or more than one with other atoms.

Sol 16: S in SO₂ has oxidation state +4. It lies between the minimum oxidation state (-2) and maximum oxidation state (+6) of S. Thus, S in SO₂ can show an increase in its ox. no. (i.e., act as reducant) or can show a decrease in its ox. no. (i.e. acts as oxidant). On the other hand in H_2S , S is in - 2 oxidation state and can only increase its oxidation state to act as reducant.

Sol 17: Half Reaction: This is either the oxidation or reduction reaction component of a redox reaction. This is obtained by considering the change in oxidation states of individual substances involved in the redox reaction

$$Zn + CuSO_4 \longrightarrow ZnSO_4 + Cu$$

 $Zn \longrightarrow Zn^{2+} + 2e^{-}$

oxidation half reaction

 $e^- + CuSO_4 \longrightarrow Cu + SO_4^{2-}$

Reduction half reaction.

Sol 18: (i) Oxidation-Oxidation is the loss of electrons or an increase in oxidation state by a molecule, atom, or ion.

(ii) Reduction-Reduction is the gain of electrons or a decrease in oxidation state by a molecule, atom, or ion.

(iii) Oxidizing agent an oxidizing agent is a chemical species that removes an electron from another species.

(iv) Reducing agent-Reducing agent is an element or compound that loses an electron to another chemical species in a redox chemical reaction.

Exercise 2

Mole Concept

Single Correct Choice Type

Sol 1: (B) A + $O_2 \rightarrow$

 $M_{1}V_{1} = N_{2}V_{2}$ Equivalent of A = Equivalent of O₂ $\frac{x}{\text{Equivalent weight of A}} = \left(\frac{16}{16}\right) \times 2$

 $\frac{x}{2}$ = equivalent weight of A

Sol 2: (C) Mass O₂ in 88 gm

$$CO_2 = \frac{88 \times 32}{44} = 64 \text{gm}$$

Mole of O = $\frac{64}{16}$ = 4 mole So, mass of CO is = 4 × (12 + 16) = 112 gm

Sol 3: (B) Mg +
$$\frac{1}{2}O_2 \rightarrow MgO$$

0.25 mole

Mass of MgO = $0.5 \times (24 + 16) = 20 \text{ gm}$

Sol 4: (B) Let's diabasic acid is C_xH_yO_z

Weight of C = $\frac{x(12)}{M}$

Weight = H =
$$\frac{y}{M}$$

Weight of O = $\frac{z(16)}{M}$
x(12) = 8 × y \Rightarrow 3x = 2y
x(12) = $\frac{1}{2}$ × 16(z) \Rightarrow 3x = 2z
y = z = $\frac{3}{2}$ x
 \Rightarrow Empirical formula C₂H₃O₃
Ag₂(C_xH_yO₂) \xrightarrow{A} 2Ag
 $\frac{0.5934}{108}$
Mole of salt = $\frac{0.5934}{2 \times 108} = \frac{1}{(216 + (24 + 3 + 48)x)]}$
216 + 75x = 364
x ~ z
So the formula would be = C₄H₆O₆
Sol 5: (B) 12C(s) + 11H₂(g) + $\frac{11}{2}$ O₂(g) \rightarrow C₁₂H₂₂O₁₁(s)
 $\frac{84}{12}$ $\frac{12}{1}$ $\frac{56}{22.4}$
7 12 2.5
Here O₂ is limiting reagent
Moles of C₁₂H₂₂O₁₁ formed = $\frac{2.5}{11} \times 2 = \frac{5}{11}$ mole
Mass = $\frac{5}{11} \times [(12 \times 12) + 22 + (11 \times 16)] = 155.45$ gm
Sol 6: (B) M(CO₃) \rightarrow CO₂ + MO
or
M₂(CO₃) \rightarrow CO₂ + M₂O
Mass of CO₃ = 12 + 48 = 60
Mole of CO₂ = $\frac{12.315}{(PV)}$ (RT) = $\frac{12.315}{1 \times (12.315)} \times 0.0821 \times 300 = 0.5$ mole
Mole of M(CO₃) or M₂CO₃ = 0.5 mole
So, mass of CO₃ in carbonate = 0.5 × 60 = 30 gram
Checking all options one by one

(B) is correct.

Sol 7: (D) Empirical formula would be NH_2 because ratio of N and H is given 1 : 2. By stability we see N_2H_4 is correct answer.

Sol 8: (C)
$$C_xH_y + O_2 \rightarrow CO_2 + H_2O$$

 $5V \quad 10V \quad 5V \qquad \downarrow$
 $10V$

By oxygen atom balance $H_2O = 10V$ By hydrogen atom balance y(5) = 2(10) \therefore y = 4By carbon balance = x(5) = 5the molecule is CH_4

Sol 9: (A) Molecular weight of NO₂ = 32 + 14 = 46Molecular weight of NO = 16 + 14 = 30let's x = NO $1 - x = NO_2$ 34 = x(30) + (1 - x) 4616x = 12 $x = \frac{3}{4}$ so NO₂ % = 25%

Sol 10: (A)
$$5A_2 + 2B_4 \rightarrow 2AB_2 + 4A_2B_4$$

4 mole
Molecular mass of $AB_2 = 250$
Molecular mass of $A_2B = 140_4$
 $B_4 = 480_4$
 $A_2 = 20_4$
Moles of AB_2 to be produced $= \frac{1000}{250} = 4$ mole
Moles of A_2B to be produced $= \frac{1000}{140} = 7.14$ mole
So, mass of A_2 , B_4 would to according to AB_2
So, mass of A_2 required $= \frac{5}{2} \times 4 \times 20 = 10 \times 20 = 200$ gm
Mass of B_4 required $= 4 \times 480 = 2 \times 960$ gm $= 1920$ gm
Total mass $= 1920 + 200 = 2120$ gm

Sol 11: (C) $C_x H_y O_z + O_2 \rightarrow CO_2 + H_2 O$ 132 gm 54 gm $\downarrow \qquad \downarrow \qquad \downarrow$ 3 mole 3 mole y = 6 mole

Sol 12: (A) Zn +
$$\frac{1}{2}O_2$$
 → ZnO
x gm
 $\frac{1}{2} \times \frac{x}{65} = \frac{v}{22.4}$
 $v = \frac{x}{65} \times 11.2 = \frac{2x}{65} \times 5.6$ lit.

Sol 13: (B) Let's say 100 gm of clay is given initially

12 gm water
x gm silica
y gm other
After that
$$(100 - A)$$
gm of clay
 $(12 - A)$ gm water $\left(\frac{100 - A}{2}\right)$ silica
 $(12 - A) = \frac{(100 - A) \times 7}{100}$
1200 - 100A = 700 - 7A
93A = 500
 $A = \frac{500}{93}$
By conservation of silica
 $\frac{100 - \frac{500}{93}}{2} = x$
x = 47. 31
Sol 14: (C) C₂H₄O₂ + 2O₂ \rightarrow 2CO₂ +
x gm 620-x gm
11 11
 $\frac{x}{60}$ mole $\frac{620 - x}{32}$

To produce maximum energy $C_2H_4O_2$ and O_2 will be fully consumed.

2H,0

$$x\frac{x}{60} = \frac{620 - x}{32} \times \frac{1}{2}$$

64x = 37200 - 60x
x = 300 gm
Weight of CO₂ = 2 × $\frac{300 \times 44}{60}$ = 440 gm

x = 3 mole

Sol 15: (A) (Organic compound) + $H_2O \rightarrow N_2$ 0.42 gm

Moles of N₂ = $\frac{PV}{RT} = \frac{860}{760} \times \frac{100}{11} \times \frac{10^{-3}}{0.08 \times 250}$ = $\frac{86}{167200} = 5.143 \times 10^{-4}$

Mass of N₂ = $5.143 \times 10^{-4} \times 28 = 0.0144$ gm

Fraction = $\frac{0.0144}{0.42} = 0.034 = \frac{10}{3}\%$

Sol 16: (C) Moles of H⁺ = (0. 1) (0. 3) + (0. 2) (0. 3) × 2 = 0. 15 mole

Normality = $\frac{0.15}{500} \times 1000 = 0.3$ N

Sol 17: (D) Moles of NaOH = (0. 300) (0. 5) = 0. 15 moles

For molarity = 0. 2 M = $\frac{0.15}{V}$ V = 750 mL Volume to be added = 750 - 300 = 450 mL

Sol 18: (A) Moles of water =
$$\frac{250}{18} = 13.888$$
 mole
urea = NH₂-C-NH₂
||
O
Moles urea = $\frac{3}{60} = 0.05$ mole

Mole fraction = 0.0036

Sol 19: (B) $P4S_3 + 8O_2 \rightarrow P_4O_{10} + 3SO_2$ Moles of $O_2 = \frac{384}{32} = 12$ mole Moles of $P_4S_3 = \frac{440}{124 + 96} = 2$ mole L. R. $= O_2$ So mass of P_4O_{10} produced $= \frac{12}{8} \times [124 + 160] = 426$ gm

Sol 20: (C) $PCI_5 \rightarrow PCI_3 + CI_2$ Initially 1 mole

After $\frac{1}{2}$ mole $\frac{1}{2}$ mole $\frac{1}{2}$ mole

Initially $M_{avg.} = M_{PCI_5} = 31 + 5(35.5) = 208.5$

After M_{avg.} =
$$\frac{M}{3/2} = \frac{208.5}{3} \times 2 = 208.5 \times \frac{2}{3}$$

So change in $M_{avg.}$ = 33. 33%

Sol 21: (A)
$$3Mg + 2NH_3 \rightarrow Mg_3N_2 + 3H_2$$

2 mole 2 mole

Mass of Mg₃N₂ produced =
$$\frac{2}{3} \times (72 + 28) = \frac{200}{3}$$
gm

Sol 22: (C) Let's say solution is in 100 gm. HCl mole = 1 mole Molality = $\frac{\text{moles of solute}}{\text{mass of solvent (in kg)}}$

Molality =
$$\frac{1}{(100 - 36.5)} \times 1000 = 15.75$$

Sol 23: (B) Weight of Na₂CO₃.xH₂O in 10 mL solution

$$= \frac{0.025}{5} = 0.07$$

$$2 \times \frac{0.07}{46 + 12 + 48 + x(18)} = \frac{9.9}{10} \times 10^{-3}$$

$$\frac{0.14}{106 + 18x} = 0.99 \times 10^{-3}$$

$$0.07 = [104.94 + 17.82 \text{ x}] \times 10^{-3}$$

$$35.06 = 17.82 \text{ x}$$

$$x \sim 2$$

Sol 24: (C) Washing soda (Na_2CO_3) in 25 cc = 0. 12 gm $2 \times \frac{0.12}{106 + 18x} = 1.7 \times 10^{-3}$ 240 = 180. 2 + 30. 6 x x ~ 2 Percentage of carbonate = $\frac{106}{106 + 36} \sim 76\%$

Sol 25: (B) No. of carbon atoms

$$= \frac{1.2 \times 10^{-3}}{12} \times 6.023 \times 10^{23} = 6.02 \times 10^{19}$$

Sol 26: (C) 21.31 = (0.79)(24) + (0.21 - x)(25) + (x)(26)24.31 = 18.96 + 5.25 + xx = 0.1 = 10%Sol 27: (D) Using HPh $Na_2CO_2 \longrightarrow NaHCO_3^- + H^+$ NaOH \xrightarrow{HCI} NaCl + H⁺ Using MeOH Na₂CO₃ <u>HCI</u> H₂CO₃ + NaCl NaOH \xrightarrow{HCI} NaCl + H⁺ Moles of HCl used in HPh = 4m mole Moles of HCl used in MeOH = 4.5 m mole It means that for NaHCO₃ \rightarrow H₂CO₃ required mole of HCl 0.5 m mole Moles of $Na_2CO_3 = 0.5$ m mole = 0.5 × 10⁻³ × 106 gm/250 mL = 5.3 mg/25 mL = 2.12 g/L NaOH moles = 3.5 m mole Mass of NaOH = 40×3.5 = 140 mg/25 mL= 5.6 g/L

None of these

Sol 28: (A) Moles of HCl = 0.25 × 30 m mole = 7.5 m mole $\frac{7.5}{2} = 10^{-3} = \frac{x(0.5)}{138} + \frac{(1 - x)0.5}{74}$ 7. 5 × 10⁻³ Solving this x ~ 96% $K_2CO_3 \sim 96\%$ $Li_2CO_3 \sim 4\%$

Sol 29: (C) $KMnO_4 + 5FeSO_4 \rightarrow Mn^{2+} + Fe^{3+}$ $\frac{2.0}{152}$ moles of $KMnO_4$ $= \frac{2.0}{5 \times 152} = 2.631 \times 10^{-3}$ Volume × molarity = moles Volume = $\frac{2.631 \times 10^{-3}}{0.05} = 52.63$ mL

Redox Reactions

Single Correct Choice Type

Sol 1: (A) Equivalent weight = Molecular weight × n_{factor}

$$= (\mathsf{M}_0)_{\mathsf{FeSO}_4} \times 1$$
$$\mathsf{Fe}^{+2} \to \mathsf{Fe}^{+3}$$
Sol 2: (D) Equit

Sol 2: (D) Equivalent weight = Molecular weight \times n_{factor} = (M)_{K₂Cr₂O₇ \times 6}

$$Cr_2O_7 \rightarrow Cr^{+3}$$

Sol 3: (A) $H_2S + KMnO_4 \rightarrow S + Mn^{2+}$

$$\frac{m}{34} \times 2 = \frac{1.58}{158} \times 5 = 0.85$$

Sol 4: (C)
$$HNO_3 + I_2^0 \rightarrow I_2O_5 + NO_2^{+5}$$

 $\frac{m}{63} \times 1 = \frac{127}{127 \times 2} \times 10 = 315$

Sol 5: (C) $N_1V_1 = N_2V_2$ Oxalic acid $KMnO_4$ $10 \times 10^{-3} \times N = 20 \times 10^{-3} \times 0.02 \times (5)$ n-factor =0.2N

Sol 6: (C) $\frac{m}{34} \times 2 = 10 \times 10^{-3} \times 1$; m = 0. 17 ∴ Purity = $\frac{0.17}{0.2} \times 100 = 85\%$

Sol 7: (B) $KMnO_4 + FeC_2O_4 \rightarrow Mn^{2+} + Fe^{3+} + CO_2$ $n_{KMnO_4} \times 5 = 1 \times (1 + 2) = \frac{3}{5}$

Sol 8: (C) $M_2x_2 + xH_2 \rightarrow 2M + xH_2O$ 1 mole M_2x_2 gives 2 moles M

$$\therefore \frac{3.15 \text{ g}}{(\text{MW})} \rightarrow \frac{1.05}{\text{M}}$$
$$\therefore 6\text{M} = 2\text{M} + \text{x(16)}$$
$$\therefore 4\text{M} = \text{x(16)}$$

 $\therefore M = 4x$ Now, $(EW)_{M} = \frac{(MW)_{M}}{x} = \frac{M}{X}$ $\therefore (EW)_{M} = \frac{M}{X} = 4.$

Sol 9: (B) Oxidation means increase of oxidation number ∴ So, there is loss of electrons.

Sol 10: (C) $K_2Cr_2O_7$ $2K^+$ $2Cr^{x+}$ $7O^{2-}$ + 2 + 2x - 14 = 0x = +6

Sol 11: (D) $K_2Cr_2O_7 \rightarrow K_2Cr_2O_7$ +6 → +3 ∴ Change in oxidation No. = [3].

Sol 12: (C) $P + NaOH \rightarrow PH_3 + NaH_2PO_2$ P is getting oxidised and also reduced \therefore It is oxidation and reduction (D is proportionation)

Sol 13: (C) CH_2O $C^{x+} 2H^+ O^{2-}$ x + 2 - 2 = 0x = 0

Sol 14: (B) $CH_4 \rightarrow C^{x+} + 4H^+ x = -4$ $CH_3CI C^{x+} + 3H^+ + CI^- x = -2$ $CH_2CI_2 x + 2 - 2 = 0 x = 0$ $CHCI_3 x + 1 - 3 = 0 x = 2$ $CCI_4 x - 4 = 0 x = +4$

Sol 15: (C) Redox: Exchange of electrons

: Change in oxidation state.

(c) $Ba^{2+} O_2^{2-} + H_2 \overset{+6}{SO}_4 \rightarrow Ba^{2+} SO_4^{2-} + H_2 \overset{-1}{O}_2$ No change in oxidation

Sol 16: (D) (a) +4 - 6 + x = 0; x = +2(b) + 2 + x - 8 = 0; x = +6(c) +2x - 2 = 0; x = +1(d) x + 5(0) = 0; x = 0 **Sol 17 (C)** (a) $HCIO^{-2} + 1 + x - 2 = 0$; x = +1(b) $HCIO_2 + 1 + x - 4 = 0$; x = +3(c) $HCIO_3 + 1 + x - 6 = 0$; x = 5(d) $HCIO_4 + 1 + x - 8 = 0$; x = +7

Sol 18: (D) $M^{3+} \rightarrow M^{6+} + 3e^{-}$

Sol 19: (A) $MnO_4^- + x - 8 = -1; x = +7$

Sol 20: (A) The oxidation number of carbon in CHCl₃ is +4

Sol 21: (C) $Pb^{2+} \rightarrow Pb^{4+} + 2e^{-}$

Sol 22: (A) $C_{12} H_{22} O_{11}$ 12x + 22 + 11(-2) = 0; x = 0

Sol 23: (D) SO_4^{2-} $S^{x+} + 4O^{2-}$ x - 8 = -2; x = +6



Sol 25: (C)
$$SO_3^{2-} \longrightarrow SO_4^{+b}$$

 $-2e^{-}$

Sol 26: (A) $S_2O_7^{2-} + 2x - 14 = -2$ 2x = +12; x = +6

Sol 27: (A)
$$\underbrace{\operatorname{MnO}_{2}^{+4} + H^{+} + X \longrightarrow \operatorname{Mn}^{2^{+}}_{-2e^{-}}}_{-2e^{-}} H_{2}O$$

$$S_8$$

8x = 0; x= 0
Covalency = 2

Sol 28: (D) N₃H $3x + 1 = 0; x = x = -\frac{1}{3}$ **Sol 29: (C)** K₃ [Fe(CN)₆] +3 - (x - 6) = 0; x = +3

Sol 30: (D) MH₂

+ x + 2 = 0; x = -2

Sol 31: (C) PH_{3}^{-3} to $H_{3}^{+5}PO_{4}^{-3}$

Sol 32: (C) In chlorine atom had +5 oxidation state. HClO₃ + 1 + x - 6 = 0; x = 5

Previous Years' Questions

Mole Concept

Sol 1: (A) If we consider that $\frac{1}{6}$, in place of $\frac{1}{12}$, mass of carbon atom is taken to be the relative atomic mass unit, the mass of one mole of a substance will decrease twice.

Sol 2: (C) According to definition of molar solution is one that contains one mole of a solute in one litre of the solution.

Sol 3: (D) $2AI_{(s)} + 6HCI_{(s)} \longrightarrow$ $2AI_{(aq)}^{3+} + 6CI_{(aq)}^{-} + 3H_{2(g)}$

For each mole of HCl reacted, 0.5 mole of is formed at STP.

1 mole of an ideal gas occupies 22.4 lit at STP.

Volume of H_2 gas formed at STP per mole of HCl reacted is 22.4 × 0.5 litre.

Sol 4: (B) From molecular formula of magnesium phosphate, it is evident that each mole of $Mg(PO_4)_2$ contains 8 mole of oxygen atoms.

Therefore, 0.25 mole of oxygen atom will remain present in $\frac{0.25}{8}$ mole i.e. 3.125×10^{-2} mole of Mg(PO₄)₂.

Sol 5: (A) 200 mg of $CO_2 = 200 \times 10^{-3} = 0.2 \text{ g}$

44g of $CO_2 = 6 \times 10^{23}$ molecules (approx.)

$$0.2 \text{ g of CO}_2 = \frac{6 \times 10^{23}}{44} \times 0.2$$

 $= 0.0272 \times 10^{23} = 2.72 \times 10^{21} \text{ molecule}$ Now, 10^{21} molecule are removed. So remaining molecules $= 2.72 \times 10^{21} - 10^{21}$ $= 10^{21}(2.72 - 1) = 1.72 \times 10^{21}$ molecule Now, 6.023×10^{23} molecules = 1 mol 1.72×10^{21} molecules $= \frac{1 \times 1.72 \times 10^{21}}{6.023 \times 10^{23}}$ $= 0.285 \times 10^{-2} = 2.85 \times 10^{-3}$

Sol 7: (A)
$$M_f = \frac{M_1 V_1 + M_2 V_2}{V_1 + V_2}$$

= $\frac{0.5 \times \frac{3}{4} + 2 \times \frac{1}{4}}{1} = 0.875 \text{ M}$

Sol 8: (D) 18 g H₂O contains 2 g H ∴ 0.72 g H₂O contains 0.08 g H. 44 g CO₂ contains 12 g C ∴ 3.08 g CO₂ contains 0.84 g C ∴ C : H = $\frac{0.84}{12}$: $\frac{0.08}{1}$ = 0.07 : 0.08 = 7 : 8 ∴ Empirical formula = C₇H₈

Sol 9: (B) M_{0.98} O

Consider one mole of the oxide. Moles of M = 0.98, Moles of $O^{2-} = 1$ Let moles of $M^{3+} = x$ \Rightarrow Mole of $M^{2+} = 0.98 - X$ \Rightarrow Doing charge balance $(0.98 - x) \times 2 + 3x - 2 = 0$ $\Rightarrow 1.96 - 2x + 3x - 2 = 0$ $\Rightarrow x = 0.04$ $\Rightarrow \%$ of $M^{3+} = \frac{0.04}{0.98} \times 100 = 4.08\%$

Sol 10: (B) Let the mass of $O_2 = x$ Mass of $N_2 = 4x$ Number of moles of $O_2 = \frac{x}{32}$ Number of moles of N₂ = $\frac{4x}{28} = \frac{x}{7}$: Ratio $=\frac{x}{32}:\frac{x}{7}=7:32$ **Sol 11: (D)** 1 g of $C_8H_7SO_3Na = \frac{1}{206}$ mole $2C_8H_7SO_3Na + Ca^{2+} \rightarrow (C_8H_7SO_3)_2Ca + 2Na^{+}$ $\frac{1}{206} \text{ mole } \frac{1}{412} \text{ mole}$

Sol 16: (D)
$$K_2Cr_2O_7 + 6KI + 7H_2SO_4 \longrightarrow$$

 $4K_2SO_4 + Cr_2(SO_4)_3 + 7H_2O + 3I_2$
 $^{+3}Cr_2(SO_4)_3 \longrightarrow 2Cr^+ 3SO_4^{-2}$

Sol 17: (C) Number of e⁻ transferred in each case is 1, 3, 4, 5.

Sol 18: (D)
$$Z_{n+2}^{0} A_{gCN} \longrightarrow 2A_{g}^{0} +Z_{n}^{2}(CN)_{2}$$

Oxidation
Reduction

Sol 19: (A)
$$6MnO_4^- + I^- + 6OH^- \longrightarrow 6MnO_4^{2-} + IO_3^- + 2H_2O$$

. .

Sol 12: (A)
$$C_x H_y(g) + \left(x + \frac{y}{4}\right) O_2(g) \rightarrow x CO_2(g) + \frac{y}{2} H_2 O(\ell)$$

15 mL

Volume of O_2 used $=\frac{20}{100} \times 375 = 75$ ml. Volume of air remaining = 300 mL

Total volume of gas left after combustion = 330 mL

Volume of CO_2 gases after combustion = 330 - 300 = 30 mL.

$$C_{x}H_{y}(g) + \left(x + \frac{y}{4}\right)O_{2}(g) \rightarrow xCO_{2}(g) + \frac{y}{2}H_{2}O(\ell)$$

$$\frac{x}{1} = \frac{30}{15} \Rightarrow x = 2$$

$$\frac{x + \frac{y}{4}}{1} = \frac{75}{15} \Rightarrow x + \frac{y}{4} = 5$$

$$\Rightarrow y = 12$$

$$\Rightarrow C_{2}H_{12}$$

Redox Reactions

Sol 13: (C) Prevent action of water and salt.

Sol 14: (A)
$$2HI + H_2 + 6O_4 \longrightarrow I_2 + 6O_2 + 2H_2O$$

Sol 15: (C) CH_2O
 $x + 2 - 2 = 0; x = 0$

Sol 20: (A)
$$H - O - P - OH$$
, hence it is dibasic. It acts as a
O

reducing agent also.

Sol 21: (C)

$$MnO_{4}^{-} + C_{2}O_{4}^{2-} + H^{+} \rightarrow Mn^{2} + CO_{2} + H_{2}O$$

vf = 1(7-2) vf = 2(3-2)
= 5 = 2

.:. Balanced Equation:

 $2MnO_4^- + 5C_2O_4^2 - +16 \text{ H}^+ \rightarrow 2Mn^2 + 10 \text{ CO}_2 + 8H_2O$ So, x = 2, y = 5 & z = 16.

Sol 22: (D) The reducing agent oxidises itself:

(A)
$$H_2O_2^{-1} + 2H^+ + 2e^- \rightarrow 2H_2O^{-2}$$

(B) $H_2O_2^{-1} - 2e^- \rightarrow O_2^0 + 2H^+$
(C) $H_2O_2^{-1} + 2e^- \rightarrow 2OH^-$
(D) $H_2O_2^{-1} + 2OH^- - 2e^- \rightarrow O_2^0 + H_2O$

Note: Powers of 'O' are oxidation number of 'O' in the compound.

Sol 23: (B)

The complex $\left[\text{CoCl}(\text{NH}_3)_5 \right]^+$ decomposes under acidic medium, so $\left[\text{CoCl}(\text{NH}_3)_5 \right]^+ + 5\text{H}^+ \rightarrow \text{Co}^{2+} + 5\text{NH}_4^+ + \text{Cl}^-$

Sol 24: (A) H_2O_2 can undergo reduction as well as oxidation because oxidation number of oxygen in H_2O_2 is -1. So, it can act both as reducing agent and oxidising agent.

JEE Advanced/Boards

Exercise 1

Mole Concept

Sol 1: 4HCl + MnO₂ → MnCl₂ + 2H₂O + Cl₂
69.6 gm
69.6 gm of MnO₂ =
$$\frac{69.6}{87}$$
mole
Mole of HCl = $\frac{69.6}{87} \times 4$ mole
Weight of HCl = $\frac{69.6}{87} \times 4 \times 35.5 = 116$ gm
Sol 2: 3TiO₂₍₅₎ + 4C₍₅₎ + 6Cl_{2(g)}
4.32 gm 5.76 gm 6.82 gm

0.054 mole 0.48 mole 0.0960 mole $\rightarrow 3 \text{TiCl}_{4(q)} + 2 \text{CO}_{2(q)} + 2 \text{CO}_{(q)}$

L. R. = Cl_2

So TiCl₄ mole produced

 $=\frac{1}{2} \times 0.0960 = 0.048$ mole

Weight of $TiCl_4$ produced = 0.048 × 190 = 9.12 gm

Sol 3:
$$2SO_{2(g)} + O_{2(g)} + 2H_2O(\ell) \rightarrow 2H_2SO_4$$

5.6 moles 4.8 moles
L. R. = SO_2
So H_2SO_4 mole obtained in maximum = 5.6 mole

Sol 4: $Na_2CO_3 = x$ gram Pure $Na_2CO_3 = (0.95)x$ gm $Na_2CO_3 + 2HCl(acid) \rightarrow H_2CO_3 + 2NaCl$ Mole of acid = (45.6 mL) × (0.235) = 10.716 m mole Moles of Na_2CO_3 required = 5.358 m mole Weight of Na_2CO_3 required = (0.95)x 5.358 (106) × 10^{-3} x = 0.597 gm

Sol 5: $BaCl_2 = 12\%$ Molecular weight of $BaCl_2.2H_2O = 208 + 36 = 244$ $BaCl_2 = 6 \text{ gm}$ $BaCl_2. 2H_2O = 6 \times \frac{244}{208} = 7.038 \text{ gm}$ $H_2O = 42.962 \text{ gm}.$

Sol 6: NaOH mole = 50(0.2) = 10 mole HCl mole = 5 mole FeCl₃ mole = 1.5 mole (acidic) NaOH + HCl \rightarrow NaCl + H₂O After this reaction NaOH left = 5 mole FeCl₃ + 3NaOH \rightarrow Fe(OH)₃ + 3NaCl 1. 5 After this reaction NaOH left = 5 - (1. 5)3 = 0.5 mole Volume after reaction = 15 + 5 + 50 = 70 litre Normality = $\frac{0.5}{70}$ = 7.142×10⁻³N 2Fe(OH)₃ \rightarrow Fe₂O₃ + 3H₂O Weight of Fe₂O₃ = $\frac{1.5}{2}$ ×160 = 120 gm

Sol 7: Oleum = $H_2S_2O_7 = H_2SO_4 + SO_3$ $H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$ Mole of NaOH = (26.7)x (0.4) m mole = 10.68 m mole Mole of $H_2SO_4 = 5.34$ m mole Weight of $H_2SO_4 = 0.523$ gm $H_2S_2O_7 = H_2SO_4 + SO_3$ $\times \text{ gram} \quad (0.5 - x) \text{ gm}$ $SO_3 + H_2O \rightarrow H_2SO_4$ $= \frac{(0.5 - x)}{80} \times 98$ gm Total $H_2SO_4 = x + \frac{(0.5 - x)98}{80} \times 0.523$ $x = \frac{0.0895}{0.225} \sim 0.3977$ gm

$$\text{\% SO}_3 = \frac{0.5 - 0.3977}{0.5} \sim 20.4\%$$

Sol 8: HPh: NaOH + HCl \rightarrow NaCl + H₂O ...(1)

 $Na_2CO_3 + HCI \rightarrow NaHCO_3 + NaCl$...(2)

after MeOH:

 $NaHCO_3 + HCI \rightarrow H_2CO_3 + NaCl$...(3)

Mole of HCl (when HPh) = 1.75 m mole

Mole of HCl (when MeOH) = 0.25 m mole (extra added) Amount of $NaHCO_3 = 0.25$ m mole

Amount of HCl required in (2) and (3) = $(0.25)_2 = 0.5 \text{ m}$ mole Amount of Na₂CO₃ = 0.25 m mole Amount of NaOH = 1.75 - (0.25) = 1.5 m mole NaOH (in gram) = $1.5 \times 10^{-3} \times 40 = 0.06 \text{ gm}$ per 200 mL

 Na_2CO_3 (in gram) = 0.25 × 10⁻³ × 106 = 0.0265 gm/200 mL

Sol 9:
$$2\text{KO}_{2(s)} + \text{H}_2\text{O}_{(\ell)} \rightarrow 2\text{KOH}_{(s)} + \frac{3}{2}\text{O}_{2(g)}$$

0. 158 mole 0. 1 mole

L. $R = KO_2$

Moles of O_2 formed = $\frac{3}{4} \times 0.158 = 0.1185$

Sol 10: $CaCl_2 + H_2CO_3 \rightarrow CaCO_3 + 2HCl$ $CaCO_3 \rightarrow CaO + CO_2$ 0.959 gm Moles of CaO = 0.017125 mole Moles of CaCl_2 = 0.017125 mole Mass of CaCl_2 = (0.017125) × 111 = 1.9 gm

% of CaCl₂ =
$$\frac{1.9}{4.22} = 45\%$$

Sol 11: $C_6H_{12}O \xrightarrow{Conc. H_2SO_4} C_6H_{10}$ 100 gm Moles of cyclohexanol = $\frac{100}{100}$ = 1 mole Mole of cyclohexene = 0. 75 mole Mass of cyclohexene = (0. 75) × 89 = 66. 75 gm Sol 12: 2NaCl → Na₂SO₄ (By Na = atom balance) Pure NaCl mole = $\frac{(0.95)250}{23+35.5}$ = 4.059 mole Pure Na₂SO₄ = $\frac{4.059}{2} \times (46+96)$ = 288.24 gm Na₂SO₄ (90% pure) = $\frac{288.24 \times 100}{90}$ = 320.27 gm Sol 13: AgCl → unreacted AgBr → AgCl × gm AgCl formed = $\frac{x}{188} \times (1435)$ gm = 0.763 x Total weight after reaction = 0.4066 - x + 0.763 x Weight lost = (1 - 0.763)x = 0.0725× = 0.306 gm = 30.6% Weight of Cl in initial mixture = $(0.4066 - 0.306) \times \frac{35.5}{140.5} = 0.0248$ gm

% of CI =
$$\frac{0.0248}{0.4066} = 6.1\%$$

Sol 14: CaCO₃ + H₂SO₄ \rightarrow CaSO₄ + H₂CO₃ 0.5 gm Moles of CaCO₃ = moles of H₂SO₄ required = $\frac{0.5}{63.5+60}$ = 4.048 × 10⁻³ mole m litre of 0.5M H₂SO₄ required $\frac{4.048}{0.5}$ = mL = 8.096 mL Sol 15: H₂SO₄ + 2NaOH \rightarrow Na₂SO₄ + 2H₂O Moles of NaOH = $15 \times \frac{1}{10}$ = 1.5 m mole Moles of H₂SO₄ required = $\frac{1.5}{2}$ = 0.75 m mole In 12 mL, mole of H₂SO₄ = 0.75 m mole In 1 L, mole of H₂SO₄ = $\frac{0.75}{12}$ mole In 1 L, weight of H₂SO₄ required = $\frac{0.75}{12} \times 98$ gram = 6.125 gm/L

Sol 16: Ethane
$$(C_2H_6) \xrightarrow{\text{monobromination}}$$

 $\xrightarrow{\text{wurtz}}$ n-butane (C_4H_{10})
 $2 C_2H_6 \rightarrow C_4H_{10}$ (by carbon balance)
XV

Let's say volume of ethane = x l

Weight of $C_4 H_{10} = \frac{x}{2 \times 22.4} \times \frac{90}{100} \times \frac{85}{100} \times 58 = 55.53 l$ x = 55.53 l

Sol 17: Mole of HCl = 30×0.25 m mole = 7.5 m mole let's say x fraction is K₂CO₃ so

$$\frac{7.5}{2} \times 10^{-3} = \frac{x(0.5)}{138} + \frac{(1-x)(0.5)}{74}$$

x ~ 96%

Sol 18: Mass of solution of HCl

= 100 × 1.18 gm = 118 gm Mass of HCl in solution = (0.36) (118) = 42. 48 gm n_{HCl} = mole of HCl = $\frac{42.48}{365}$ = 1.163 mole $2KMnO_4 + \frac{16HCl}{1.163 \text{ mole}} \rightarrow 2KCl + 2MnCl_2 + 8H_2O + \frac{5Cl_2}{0.363 \text{ mole}}$ $\frac{6Cl_2}{0.363 \text{ mole}} + \frac{6Ca(OH)_2 \rightarrow Ca(ClO_3)_2}{0.0606 \text{ mole}} + 5CaCl_2 + 6H_2O$ $Ca(ClO_3)_2 + Na_2SO_4 \rightarrow CaSO_4 + 2NaClO_3$ 0.1212 moleMass prepared of NaClO₃ = 0.1212 x molecular weight = 12.911 gm

Sol 19: NaH₂PO₄
$$\xrightarrow{Mg^{2*}}{NH_4^*}$$
 Mg(NH₄)PO₄. 6H₂O
 $\xrightarrow{\Lambda}$ $\frac{1}{2}$ Mg₂P₂O₇ (by P-balance)
Mole of Mg₂P₂O₇ = $\frac{1.054}{224}$ = 4.747 × 10⁻³
Weight of NaH₂PO₄ = 2 × 4.747 × 10⁻³ × 119.98
(Molecular weight) = 1.139 gm

Sol 20: Moles of $HNO_3 = 8 \times 5$ m mole = 40 m mole Mole of HCl = 4. 8 × 5 m mole = 24 m mole Let's say volume of H_2SO_4 is V mL So mole of $H_2SO_4 = 17$ V m mole Moles of HNO₃ in 30 mL (picked up from 2 *l* sol)

$$= \frac{40}{2000} \times 30 = \frac{120}{200} \text{ m mole}$$

Moles of HCl in 30 mL (picked up from 2 l sol)

$$=\frac{24}{2000}\times 30=\frac{72}{200}$$
 m mole

Moles of H₂SO₄ is 30 mL (picked up from 2 lt. sol)

$$=\frac{17V}{2000}\times 30=\frac{51V}{200}$$
 m mole

Total moles of H⁺ from 30 mL solution = $\frac{120}{200} + \frac{72}{200} + \frac{102V}{200}$ = $\left(\frac{192 + 102V}{200}\right)$ m mole Mole Na₂CO₃ · 10H₂O = $\frac{1}{286}$ mole Mole of OH = $\frac{2}{286}$ mole (in 100 mL) Mole of OH in 42.9 mL = $\frac{2 \times 0.429}{2.86}$ = $\frac{0.858}{286}$ = 0.003 mole $10^{-3} \times \left(\frac{192 + 102V}{200}\right)$ = 0.003 ; V = 4 mL Amount of sulphate ion in gm = $\frac{51 \times 4}{200} \times (96) \times 10^{-3}$ = 0.097.92 gm/30 mL = 6.528 gm/L

Sol 21: Mg
$$\xrightarrow{N_2}{O_2}$$
 MgO + Mg₃N₂
MgO + 2HCl \rightarrow MgCl₂ + H₂O
 $\frac{x}{2}$ mole
Mg₃N₂ + HCl \rightarrow 3MgCl₂ + 2NH₃
 $\frac{60-x}{2}$ mole $\left(\frac{60-x}{3}\right)$ mole
MgCl₂ + 2NaOH \rightarrow Mg(OH)₂ + 2NaCl
 $\left(x+\frac{60-x}{2}\right)$
NH₃ + HCl \rightarrow NH₄ + Cl⁻
initially 10 Meq. x mole
after (10 - x) m mole
HCl + NH₄⁺ + \overrightarrow{OH}_{4} \rightarrow NH₄OH + Cl⁻

 $\frac{x}{2} + \frac{60 - x}{2} = \frac{12}{2}$ x = 27.27%

Sol 22: PV = $n_{T}RT$ (1) (40) = n_{T} (0.0821) (400) n_{T} = Total mole = 1.2180 $C_{2}H_{6} + \frac{7}{2} O_{2} \rightarrow 2CO_{2} + 3H_{2}O$ $C_{2}H_{4} + 3O_{2} \rightarrow 2CO_{2} + 2H_{2}O$

Mole of O₂ required

$$= \frac{7}{2} + 3(1.218 - x) = \frac{130}{32}$$

x = 0.817 mole

Mole fraction of $C_2H_4 = \frac{1.218 - 0.817}{1.218} = 0.33$ Mole fraction of $C_2H_6 = 0.67$

Sol 23:
$$Pb(NO_{x gm}^{3})_{2} \xrightarrow{\Lambda} PbO + 2NO_{2} + \frac{1}{2}O_{2}$$

 $2NaNO_{3} \xrightarrow{\Lambda} Na_{2}O + 2NO_{2} + \frac{1}{2}O_{2}$
 $\left[\frac{(5-x)}{85}\right] + \frac{1}{4}\left(\frac{5-x}{85}\right) + 2(x)$

Sol 24: $3Pb(NO_3)_2 + Cr_2(SO_4)_3 \rightarrow 3PbSO_4 + 2Cr(NO_3)_3$ L. R. = CrSO₄ So moles of PbSO₄ formed = 2. 5 m mole × 3 = 7. 5 m mole Molar conc. of $[Pb^{2+}] = \frac{11.25 - 7.5}{70} = 0.0536$ M Molar conc. of $[NO_3^-] = \frac{(2 \times 11.25)}{70} = 0.32$ M $[Cr^{3+}] = \frac{2 \times 2.5}{70} = 0.0714$ M Sol 25: NaCl CaCl₂ + Na₂CO₃ → CaCO₃ + 2NaCl $CaCO_{3} \xrightarrow{\Lambda} CaO_{1.12gm} + CO_{2}$ Mole of CaO = $\frac{1.12}{56} = 0.02$ mole Moles of CaCl₂ = 0.02 mole Weight of CaCl₂ = 2.22 gm NaCl = 10 - 2.22 = 7.78 gm % NaCl = 77.8%

Sol 26: (i) $Fe_2O_2 + 2AI \rightarrow AI_2O_2 + 2Fe$ (ii) Mole ratio (to complete reaction) = 1:2mass ratio = $1 \times (112 + 48) (2 \times 27) = 80 : 27$ (iii) 2.7 kg of Al = $\frac{2700}{27}$ mole = 100 mole 16 kg of $Fe_2O_3 = \frac{16000}{160}$ mole = 1000 mole L . R. = AI So energy released = $200 \times \frac{100}{2} = 10000$ unit **Sol 27:** N₂ : H₂ (mole) = 1 : 3 $N_2 + 3H_2 \rightarrow 2NH_3$ Initially 1 3a 1-x 3-3x after 2x P(Molecular weight) = SRT $1(M.W.) = (0.497) \times (0.0821) (298)$ Molecular weight = 12. 15 gm $\frac{(2x)(17) + (3 - 3x)2 + (1 - x)28}{4 - 2x} = 12.15$ 34x + 6 - 6x + 28 - 28x = 48.63 - 24.31 x24.31x = 14.63x = 0.602% composition by volume $N_2 = \frac{1 - 0.602}{4 - 2(0.602)} = \frac{0.398}{2.795} = 14.21\%$ $H_2 = 3(N_2\%) = 42.86\%$ $NH_3 = \frac{2(0.602)}{2.795} = 42.86\%$ We know average molecular weight = 12.15

So (1) (12.15)

 $=\frac{Mass}{224} \times (0.0821) \times (273)$ Mass = 12.14 gm. **Sol 28:** $x(CH_2)_2SiCl_2 + ZnOH \rightarrow ZnCl^- +$ $nH_{2}O + [(CH_{3})_{2}SiO]_{n}$ Volume of film = $6 \times 10^{-10} \times 300 \times 1 \times 3 \text{ m}^3$ $= 54 \times 10^{-8} \text{ m}3 = 0.54 \text{ cm}^3$ Mass of the film = 0. 54 gm Mole of $[(CH_3)_2 SiO]_n = \frac{0.54}{n[30 + 28 + 161]}$ Mass of $[(CH_3)_2SiCl_2] = \frac{0.54}{71} \times (58 + 71) = 0.941 \text{ gm}.$ **Sol 29** P_4 + 3 O_2 \rightarrow P_4O_6(i) $P_4 + 5O_2 \rightarrow P_4O_{10} \quad(ii)$ (i) $P_4 + 3O_2 \rightarrow P_4O_6$ 4–y 1–x $P_4 + 5O_2 \rightarrow P_4O_{10}$ х V 5x = y3(1 - x) = 4 - y3 - 3x = 4 - 5x $x = \frac{1}{2}$ $y = \frac{5}{2}$ $P_4O_6 = P_4O_{10} = 50\%$ (ii) $P_4 + 3O_2 \rightarrow P_4O_6$ 3-х 11-у $P_4 + 5O_2 \rightarrow P_4O_{10}$ Х 5x = y3(3 - x) = 11 - y9 - 3x = 11 - 5xx = 1 $P_4O_{10} = \frac{1}{2};$ $P_4O_6 = \frac{2}{3}$ (iii) $P_4 + 3O_2 \rightarrow P_4O_6$ 3-x 13-y

 $P_4 + 5O_2 \rightarrow P_4O_{10}$ х у 5x = y3(3 - x) = 13 - y9 - 3x = 13 - 5xx = 2 $P_4 O_6 = 2$ $P_4O_{10} = 1$ **Sol 30:** Cl^- + AgNO₃ \rightarrow AgCl + NO₃⁻ Let's say V mL must be added Weight of solution = (1.04 V) gmWeight of $AgNO_3 = 0.05 \times (1.04 \text{ V})gm$ Moles of AgNO₃ = $\frac{(0.05)(1.04V)}{173}$ Minimum moles of Cl- (it will be case of more molecular weight i. e. KCI) $=\frac{0.3}{39+355}=\frac{0.3}{745}$ $\frac{(0.05)(1.04V)}{173} = \frac{0.3}{74.5}$ V = 13.4 mL.Sol 31: In 500 mL of NaOH Weight of solution = $1.8 \times 500 = 900$ gm So, weight of NaOH = (0.08) (900) = 72 gm Mole of NaOH = $\frac{72}{40}$ = 1.8 mole Moles of $H^+ = 18$ mole On heating NaHCO₃ \rightarrow CO₂ + H₂O On C-balance $n_{CO_2} = n_{NaHCO_3}$ Mass of NaHCO₃ = $\frac{18.6}{44} \times (84) = 33.50 \text{ gm}$ $H^{+} = 1.8 = \frac{18.6}{44} + 3\left[\frac{x}{27 + 3(35.5)}\right] + 0$ $1.8 = \frac{x}{44.5} + 0.418 \implies x = 61.5 \text{ gm} = \text{mass of AlCl}_3$ Mass of $KNO_3 = 124 - 97 = 27 \text{ gm}$ Total mole = 0.267 + 0.460 + 0.422 = 1.149 mole **Sol 32:** $\frac{1}{2}$ CH₃COCH₃ + $\frac{3}{2}$ CaOCl₂ \rightarrow CHCl₃ + x

Mole of CHCl₃ = $\frac{30}{1195}$ By carbon balance Mole of acetone (ideally) $=\frac{1}{2}\times\frac{30}{119.5}$ As the yield is 75% So, weight required $=\frac{30}{2\times1195}\times\frac{100}{75}\times(58)=9.7$ gm **Sol 33:** Cu₂O + x Let's assume total 100 gm is given Cu = 66.67 gm $0 = \frac{66.67}{63.5} \times \frac{1}{2} \times 16$ Oxygen (O) = 8.4 $\% Cu_2 O = 66.67 + 8.4 = 75\%$ **Sol 34:** Hg + $I_2 \rightarrow$ HgI, $\left(\frac{M}{200} - x\right) \left(\frac{M}{254} - \frac{x}{2}\right)$ $2Hg + I_2 \rightarrow Hg_2I_2$ x mole $\frac{x}{2}$ Let's say M gm is initially taken $\frac{M}{200} - x = \frac{M}{254} - \frac{x}{2}$ $M\left(\frac{54}{200}\right)\frac{1}{254} = \frac{x}{2}$ $M = \left(\frac{254}{0.54}\right) x$ (gm) Hg₂I₂ = $\frac{x}{2}$ × (200 + 127) × 2 = 327 x HgI₂(gm) $=\left(\frac{M}{200}-x\right)=\left[\frac{254}{(0.54)(200)}-1\right]$ x Molecular weight = $(1.351 \times 454) \times HgI_2$ HgI_2 : $Hg_2I_2 = 0.532 : 1$.

Redox Reactions

Sol 1: (a) NaNO₂ Na⁺ N^{x+} $2O_2^-$ + 1 + x - 4 = 0; x = +3 (b) H₂ 2x = 0; x = 0(c) $Cl_{2}O_{7}$ 2x - 14 = 0; x = +7(d) KCrO₂Cl $K^{+} Cr^{x+} 3O^{2-} Cl^{-}$; + 1 + x - 6 - 1 = 0; x = +6 (e) Ba Cl₂ + x - 2 = 0; x = +2(f) ICl + x - 3 = 0; x = +3 $(g) K_2 Cr_2 O_7$ +2+2x-14=0; x=+6(h) CH₂O + x + 2 - 2 = 0; x = 0(i) Ni (CO), + x + 0 = 0; x = 0(j) NH₂OH H⁺¹ N-0 + 3 + x - 2 = 0; x = -1**Sol 2:** (a) $CuSO_4 + 4KI \longrightarrow 2CuI + I_2^{+1} + I_2^{0} + 2K_2SO_4$ Reduced Oxidised (b) $2Na_2S + 4HCI + SO_2 \longrightarrow 4NaCI + 3S_{Oxidised} + 2H_2O_{Reduce}$ (c) $NH_4NO_2 \xrightarrow{\Delta} N_2 + 2H_2O_{Reduced} Oxidised$ **Sol 3:** (a) $3Fe + 4H_2O \longrightarrow Fe_3O_4 + 4H_2 = 8$ electrons

(b) $AICI_3 + 3K \longrightarrow AI + 3KCI = 3$ electrons

Sol 4: (a) Sulphur shows various oxidation states such as -2, 0, +2, +4, +6

In H_2S , oxidation no. of S is '-2'

So now it can only act as a reducing agent because it can't get more electrons since $S^{2\mathchar`-}$ is in its lowest oxidation state.

But in SO_2 , oxidation state of S is +4 which is an intermediate oxidation state. So, it can gain or lose electrons and can go to -2, 0, +2 or higher +6 oxidation state.

(b) Oxidation state of oxygen in H_2O_2 is '-1' so it can get oxidised or reduced because O have multiple oxidation state like -2, -1, 0. By losing electrons it can form O_2 and act as a reducing agent and by gaining e⁻s, it can form H_2O and behave as an oxidising agent.

Sol 5: NO_2^- is oxidized to NO_3^- by MnO_4^- (in basic medium) which is reduced to MnO_2^-

$$\begin{array}{c|c} \mathsf{MnO}_{4}^{-} + \mathsf{NO}_{2}^{-} \longrightarrow \mathsf{NO}_{3}^{-} + \mathsf{MnO}_{2} \\ & & \mathsf{NO}_{3}^{-} + \mathsf{MnO}_{2} \\ & & \mathsf{oxidation} \\ & & \mathsf{reduction} \end{array}$$

Thus, $MnO_4^- \longrightarrow MnO_3$ oxidation number decreases by 3-units

 $NO_2^- \longrightarrow NO_3^-$ oxidation number increases by 2 units

Thus,
$$2MnO_4^- \equiv 3NO_2^-$$

 $MnO_4^- \equiv \frac{3}{2}NO_2^- = 1.5 \text{ mol } NO_2^-$

Sol 6: (a) HSO_3^- (b) NO_2^- (c) CI^-

Sol 7: (a) $4Zn + 10HNO_3 \longrightarrow 4Zn(NO_3)_2 + N_2O + 5H_2O$ (b) $6HI + 2HNO_3 \longrightarrow 3I_2 + 2NO + 4H_2O$

Sol 8: 5 moles of H_2SO_4 can produce 1 mole of H_2S $0.2 \times V \times 10^{-3} = nH_2SO_4$ (equating equivalents) \therefore Volume = 25 lit.

Sol 9: \therefore 20 × 0. 2 × 2 = 0.167 M Normality = n_r × M = 0.5 N

Sol 10: mole of $As_2O_3 = 5.54 \times 10^{-4}$ equating equivalents, $(5.54 \times 10^{-4}) \times (2) = (26.1 \times 10^{-3}) \times M \times 5$ \therefore Molarity = 8.49 $\times 10^{-3}$, Normality = molarity \times n-factor = $(8.49 \times 10^{-3}) \times (5) = 4.24 \times 10^{-2}$

Sol 11: CaO
$$\longrightarrow$$
 CaC₂O₄
 $^{+3}_{CaC_2O_4^+}$ KMnO₄ \longrightarrow CO₂ + Mn²⁺
 \downarrow $+5e^ \uparrow$ \uparrow
 $-2e^-$

Equating equivalents

(equivalent)
$$_{CaC_2O_4}$$
 = (equivalent) $_{KMnO_4}$
 $n_{CaC_2O_4} \times 2 = 40 \times 0.25 \times 10^{-3}$
Moles of $CaC_2O_4 = 5 \times 10^{-3}$
 \therefore Mole of $CaO = CaC_2O_4 = 5 \times 10^{-3}$
 \therefore Mass of $CaO = 0.28$
 \therefore % composition
 $= \frac{0.28}{0.518} \times 100 = 54\%$

Sol 12: Reaction

$$KMnO_4 + H_2O_2^{-1} \longrightarrow Mn^{2+} + O_2$$

$$\underbrace{5e^-}_{+2e} + 2e$$

Assume mass of $H_2O_2 = x \text{ gm}$

... Molarity of

$$H_2O_2 = \frac{\frac{x}{34} \times 1000}{20} = 147 \text{ x M}$$

Moles of KMnO₄ =
$$\frac{0.316}{158} = 2 \times 10^{-3}$$

Now equating equivalents,

Equivalents of H_2O_2 = Equivalents of KMnO₄ 1.47x × 20 × 10⁻³ × 2 = 2 × 10⁻³ × 5 \therefore x = 0. 17 gm \therefore Purity of H_2O_2 = 85% (i) moles O_2 evolved = moles of H_2O_2 consumed. \therefore Moles of O_2 = 5 × 10⁻³ \therefore Volume = $\frac{nRT}{P}$ = 124.8 ml (ii) **Sol 13:** (CaOCI)+ Cl⁻ 5.7 gm is taken \therefore Lets take moles of CaOCI₂ = x molarity of CaOCI₂ = $\frac{x}{500}$ × 1000 = 2x Now on treatment with KI + HCI

 $(CaOCI)^+CI^- + KI + HCI \rightarrow I_2$ treated with Na₂S₂O₃ \therefore Equivalents of I₂ = equivalents of Na₂S₂O₃ = $24.35 \times \frac{1}{10} \times 10^{-3} = 2.435$ milliequ. Now, equiv. of I_2 = equiv. of Bleaching powder $2.435 \times 10^{-3} = 2x \times 25 \times 10^{-3}$ ∴ x = 4.87 × 10⁻² ... Mass of bleaching powder = 1.73 gm :. % availability = $\frac{1.73}{57} \times 100 = 30.33\%$ **Sol 14:** (i) $3C_2H_5OH + 2K_2Cr_2O_7 + 8H_2SO_4 \longrightarrow$ $3 C_{2}H_{4}O_{2} + 1Cr_{2}(SO_{4})_{3} + 2 K_{2}SO_{4} + 11H_{2}O_{2}$

(ii)
$$1As_2S_5 + 40HNO_3 \longrightarrow$$

 $40NO_2 + 12H_2O + 2H_3AsO_4 + 5H_2SO_4$
(iii) $2CrI_3 + 27CI_3 + 64KOH \longrightarrow$
 $6KIO_4 + 2K_2CrO_4 + 54KCI + 32H_2O$
(iv) $3As_2S_3 + 14HCIO_3 + 18H_2O \longrightarrow$
 $14HCI + 6H_3AsO_4 + 9H_2SO_4$

Sol 15:

(i) $As_2S_3 + 12OH^- + 14H_2O \longrightarrow 2As^{3-}O_4 + 3S^{2-}O_4 + 20H_2O$

(ii) $2CrI_{3} + 10OH^{-} + 27H_{2}O_{2} \longrightarrow 2Cr^{2-}O_{4} + 6IO_{4}^{-} + 32H_{2}O_{4}$ (iii) $P_4 + 3OH^- + 3H_2O \longrightarrow 3H_2PO_2^- + PH_3$ (iv) $3As_2S_3 + 4H_2O + 10NO_3^- + 10^+ \longrightarrow$ $6H_{R}AsO_{4} + 9S + 10NO$

Sol 16:

 $\begin{array}{c} \mathsf{NO}_3^- + \mathsf{Mg}(s) + \mathsf{H}_2 \mathsf{O} \twoheadrightarrow \mathsf{Mg}(\mathsf{OH})_{2(g)} + \mathsf{OH}_{(\mathsf{aq},)}^- + \overset{-3}{\mathsf{NH}}_{3(g)} \\ & & & & & & & \\ & & & & & & & & \\ & & & & & & & & \\ & & & & & & & & & \\ & & & & & & & & & \\ & & & & & & & & & & \\ & & & & & & & & & & \\ & & & & & & & & & & \\ & & & & & & & & & & \\ & & & & & & & & & & \\ & & & & & & & & & & \\ & & & & & & & & & & \\ & & & & & & & & & & \\ & & & & & & & & & & \\ & & & & & & & & & & \\ & & & & & & & & & \\ & & & & & & & & & \\ & & & & & & & & & \\ \end{array}$

 $NH_3 + HCI \longrightarrow NH_4CI$ Say molarity of NO_3^- ions = x M \therefore Moles of NO₃⁻ = x × 25 × 10⁻³ Equivalents of NO₃ = Equivalents of NH₃ = 8 × x + 25 × 10⁻³ = 0.2 x \therefore Moles of NH₃ = 0.2 x Moles of NaOH = $32.10 \times 10^{-3} \times 0.1 = 3.21 \times 10^{-3}$ Now, moles of HCl = (moles of NH_3) + (moles of NaOH) $50 \times 0.15 \times 10^{-3} = 0.2x + 3.21 \times 10^{-3}$ $x = 2.145 \times 10^{-2}$:. Molarity = 8x = 0.1716 M **Sol 17:** $KReO_4 + Zn \longrightarrow Zn^{2+} + Re^{+2}$ KMnO4 \therefore Moles of KReO₄ = 9.28 × 10⁻⁵

 \therefore Moles of KMnO₄ = 0.05 × 11.45 × 10⁻³ × 5 Now equating equivalents of $Re^{x+} = KMnO_{4}$ $(x_{Re^{x+}})(7-x) = 5.725 \times 10^{-4}$ (1) Now equating equivalents of $KReO_{4} = Re^{x+}$ $9.28 \times 10^{-5} = \text{Re}^{x+} = \text{X}_{\text{Re}^{x+}}$ $\therefore 7 - x = \frac{5.725 \times 10^{-4}}{9.28 \times 10^{-5}}; x = +1$ **Sol 18:** Let moles of $FeC_2O_4 = x$ $FeSO_{A} = y$ $FeC_2O_4 + FeSO_4 + KMnO_4 \rightarrow Fe^{2+} + CO_2^{\uparrow}$ Zn-dil HCl

KMnO₄

Now, $(2x + x + y) 0.1 = 60 \times 0.02 \times 5$

$$3x + y = 60$$

 $x + y = 40 \times 0.02 \times 5 = 4$
 $\therefore 4 - x = 6 - 3x$
 $2x = 2$
 $x = 1$
 $y = 3$
 \therefore Normality = 1 × 3 × 10⁻² = 0.03N of FeC₂O₄
 $= 3 \times 10^{-2} = 0.03$ M of FeSO₄

Sol 19: Mass of KCl = x gm

 $H_2O = 1 - x - y gm$ KCIO₃ = y gm Treating with SO₂

$$\begin{array}{c} ^{+5} \\ \mathsf{CIO}_3^- + \ \mathsf{SO}_2 \longrightarrow \ \mathsf{SO}_4^2 + \mathsf{CI}^- \\ \hline & +6e^- & \bullet \\ \hline & -2e^- \end{array}$$

Then silver chloride formed

 $\therefore \text{ Total moles of chloride } = 10^{-3} = \frac{x}{74.5} + \frac{y}{122.5}$

Now for another experiment



 \therefore Equivalents reacted = 3 × 10⁻³



Equivalents of Fe²⁺ = Equivalent of CIO_3^- 3 × 10⁻³

$$= \frac{\frac{y}{122.5}}{25010} \times 10^{+3} \times 25 \times 10^{-3} \times 6$$

y = 0.6125 gm

Moles of $CIO_3^- = 0.005$

Molar ratio = 1 : 1

Sol 20: (iii) One mL of $Na_2S_2O_3$ is equivalent to 0.0499 gm of $CuSO_4$ 0.2 millimole of $CuSO_4$ Since reaction is balanced $Hg_5(IO_6)_2 \longrightarrow 8I_2$ 1 8 5×10^{-4} 4 millimole $2 CuSO_4 \longrightarrow I_2$ 2 1 0.2 millimole 0.1 millimole \therefore 0.1 millimole of I_2 equivalent to 0.2 millimole of $CuSO_4$ But we have 4 millimole So, 1 mL \longrightarrow 0.1 millimole 40 mL \longleftarrow 4 millimole

Sol 21: BaCO₃ + CaCO₃ + CaO x y dil. HCl

CO₂↑
$$H_{co_2} = 7.5 \times 10^{-3}$$

 $x + y = 7.5 \times 10^{-3}$
BaCrO₄ + I⁻ \longrightarrow I₂ + Cr³⁺
0.1 x
Equating equivalents of BaCrO₄ = I⁻
0.1 x - 3 = 20 × 0.05 × 10^{-3}
 $x = \frac{10^{-2}}{3} = 3.33 \times 10^{-3}$
 $\therefore y = 4.167 \times 10^{-3}$
Mass of BaCO₃ = 0.659 gm
CaCO₃ = 0.4167 gm
 \therefore Mass of CaO = 0.1733
% CaO = 13.87%

Sol 22: $Cu_2S + CuS + MnO_4^- \longrightarrow X$ X y $Mn^{2+} + Cu^{2+} + SO_2$ $200 \times 0.75 \times 10^{-3} = \frac{175 \times 10^{-3}}{5} + moles of required$ \therefore Moles required of $MnO_4^- = 0.115$ Let moles of $Cu_2S^{-2} = x$ CuS = y $\therefore 0.115 \times 5 = 8x + 6y$ Let m = mass of Cu₂S 8x + 6y = 0.575 $\frac{8m}{159} + \frac{6(10 - m)}{95.5} = 0.575$ [(5.03 × 10⁻²) - (6.28 × 10⁻²)] m = -5.327 × 10⁻² m = 4.26 gm % CuS = $\frac{5.74}{10} \times 100 = 57.4\%$

Sol 23:
$$2H^+ + O_3^0 + I^- \rightarrow O_2 + I_2 + H_2O^{-2}$$

moles of air
= $0.406 = \frac{PV}{RT}$
 \bigvee Na₂S₂O₃

Equivalents of
$$I_2 = 1.5 \times 10^{-3} \times 0.01 = 1.5 \times 10^{-5}$$

Moles of $O_3 = x$
 $\therefore x \times 6 = 1.5 \times 10^{-5}$
 $x = 2.5 \times 10^{-6}$
 \therefore Volume of $O_3 = 1.847 \times 10^{-4}$ lit.
 $% O_3 = 1.847 \times 10^{-3} = \frac{V_{O_3}}{10} \times 100$

Sol 24:
$$MnO_{4}^{-} + H_{2}C_{2}O_{4} + Fe^{2+} \longrightarrow$$

 $30 \times 1.5 \quad 1.5 \times 0.5 \quad 15 \times 0.4$
 $Fe^{3+} + CO_{2} + Mn^{2+}$
 $(30 \times 1.5) - (15 \times 0.5 + 15 \times 0.4) = 31.5$ milliequivalents

:. Final of MnO₄⁻ = $\frac{31.5 \times 10^{-3}}{60 \times 10^{-3}}$ = 0.525 M

Final molarity of

 $Fe^{3+} = \frac{15 \times 0.4 \times 10^{-3}}{60 \times 10^{-3}} = 0.1 \text{ M}$

:. Final normalities $MnO_4^- = 0.105M$ $Fe^{3+} = 0.1M$

Sol 25: (i) Equivalents of
$$I^- = 20 \times 0.1 \times 10^{-3}$$

 $H_2 O_2^{-1} + I^- \longrightarrow H_2 O_2^{-2} + I_2$
 \therefore Equivalents of $H_2 O_2 = 2 \times 10^{-3}$
 \therefore Moles of $H_2 O_2 = \frac{2 \times 10^{-3}}{2} = 10^{-3}$

Now, molarity =
$$\frac{10^{-3}}{25} \times 10^3 = 0.04$$
 M
∴ Normality = 0.04 × 2 = 0.08 N
(ii) 20 × 0.3 × 10^{-3} = equivalent of I⁻
∴ Normality of H₂O₂ = $\frac{20 \times 0.3 \times 10^{-3}}{25 \times 10^{-3}} = 0.24$
∴ Strength = 1.344

Sol 26: Let molarity of $Na_2S_2O_3$ solution = xM \therefore Equivalent of thiosulphate = Eq. of I⁻ = Eq. of I₂ = x × 45 × 10⁻³ $\frac{0.1}{214} \times 5 = x \times 45 \times 10^{-3}$

x = 0.062 M

Sol 27: $\stackrel{^{+2}}{\text{Mn}} SO_4 \cdot 5H_2O \xrightarrow{\Lambda} Mn_3^{+8/3}O_4$ Now $Mn_3O_4 + FeSO_4 \rightarrow Fe^{3+} + Mn^{+2} + KMnO_4$ Let assume no. of moles of $MnSO_4 \cdot 5H_2O = x$ \therefore Moles of $Mn_3O_4 = 3x$ $3x(6)+100 \times 0.1 \times 10^{-3} = 0.12 \times 100 \times 10^{-3}$ $25 \times N = 30 \times 0.1$ N = 0.12 $\therefore x = 1.11 \times 10^{-4}$ \therefore Mass of $MnSO_4 \cdot 4H_2O = 1.338 \text{ gm}.$

Sol 28:

(i)
$$CIO_{3}^{+5} + Fe^{+2} \longrightarrow CI^{-} + Fe^{+3} + H_{2}O$$

 $6H^{+} + CIO_{3}^{+5} + 5e^{-} \longrightarrow CI^{-} + 3H_{2}O$
 $Fe^{+2} \longrightarrow Fe^{+3} + e^{-} \times (5)$
 $\overline{6H^{+} + CIO_{3}^{-} + 5Fe^{2+} \rightarrow 5Fe^{3+} + CI^{-} + 3H_{2}O}$

(ii)
$$8CuS^{-2} \rightarrow S_8 + 16e^- + 8Cu^{2+} \times (3)$$

 $4H^+ + NO_3^- + 3e^- \rightarrow NO + 2H_2O \times (16)$

 $24 \text{CuS} + 16 \text{NO}_3^- + 64 \text{H}^+ \longrightarrow 24 \text{Cu}^{2+} + 3\text{S}_8 + 16 \text{NO} + 32 \text{H}_2\text{O}$

(iii)
$$S_2O_3^{2-} + Sb_2O_5 \longrightarrow SbO + H_2SO_3$$

 $6H^+ + Sb_2O_5 + 6e^- \rightarrow 2SbO + 3H_2O$
 $H_2O + S_2O_3^{2-} \rightarrow 2H_2SO_3 + 4e^- + 2H^+$
 $\overline{Sb_2O_5 + S_2O_3^{2-} + 4H^+} \rightarrow 2SbO + 2H_2SO_3$

(iv)
$$2HCI^{-1} \rightarrow CI_{2}^{o} + 2H^{+} + 2e^{-} \times (5)$$

$$\frac{5e^{-} + KMNO_{4} \rightarrow KCI + MnCI_{2} + 4H_{2}O \times (2) + 8H^{+}}{10HCI + 2KMnO_{4} \rightarrow 5CI_{2} + 2KCI + 2MnCI_{2} + 8H_{2}O}$$

(v)
$$H_2SO_4 + \overset{+5}{KCIO_3} \rightarrow \overset{+7}{HCIO_4} + 2e^- + KHSO_4$$

$$\frac{3SO_4 + KCIO_3 \rightarrow CIO_2 + H_2O + KHSO_4}{3KCIO_3 + 3H_2SO_4 \rightarrow 3KHSO_4 + HCIO_4 + 2CIO_2 + H_2O}$$
(vi) $4H^+ + \overset{+5}{HNO_3} + 3e^- \longrightarrow \overset{+2}{NO} + 2H_2O \times (2)$

(vi)
$$4H^+ + HNO_3 + 3e^- \longrightarrow NO + 2H_2O \times (2)$$

 $\frac{^{+1}}{2HBr} \longrightarrow Br_2 + 2e^- + 2H^+ \times (3)$
 $2HNO_3 + 6HBr \rightarrow 2NO + 3Br_2 + 4H_2O$

(vii)
$$H^{+} + 2IO_{4}^{-} + 14e^{-} \rightarrow I_{2}^{0} + 4H_{2}O$$

$$\frac{2I^{-} \rightarrow I_{2} + 2e^{-} \times (7)}{IO_{4}^{-} + 7I^{-} + 8H^{+} \rightarrow 4I_{2} + 4H_{2}O}$$

Sol 29:
$$P_4 + 3O_2 \rightarrow P_4O_6 \dots$$
 (i)
 $P_4 + 5O_2 \rightarrow P_4O_1 \dots$ (ii)
(i) $P_4 + 3O_2 \rightarrow P_4O_6$
 $1-x - 4-y$
 $P_4 + 5O_2 \rightarrow P_4O_{10}$
 $x - y$
 $5x = y$
 $3(1-x) = 4 - y$
 $3 - 3x = 4 - 5x$
 $x = \frac{1}{2}$
 $y = \frac{5}{2}$
 $P_4O_6 = P_4O_{10} = 50\%$
(ii) $P_4 + 3O_2 \rightarrow P_4O_6$
 $3-x - 11-y$

$$P_{4} + 5O_{2} \rightarrow P_{4}O_{10}$$

$$x \quad y$$

$$5x = y$$

$$3(3 - x) = 11 - y$$

$$9 - 3x = 11 - 5x$$

$$x = 1$$

$$P_{4}O_{10} = \frac{1}{3}; \qquad P_{4}O_{6} = \frac{2}{3}$$
(iii)
$$P_{4} + 3O_{2} \rightarrow P_{4}O_{6}$$

$$3 - x \quad 13 - y$$

$$P_{4} + 5O_{2} \rightarrow P_{4}O_{10}$$

$$x \quad y$$

$$5x = y$$

$$3(3 - x) = 13 - y$$

$$9 - 3x = 13 - 5x$$

$$x = 2$$

$$P_{4}O_{6} = 2$$

$$P_{4}O_{10} = 1$$

Sol 30:

(i)
$$H_2O + 2e^- + Ag_2^{+1}O \rightarrow 2Ag + 2OH^-$$

$$\frac{4OH^- + S_2O_4^{2-} \rightarrow 2SO_3^{2-} + 2e^- + H_2O}{S_2O_4^{2-} + Ag_2O + 2OH^- \rightarrow 2Ag + 2SO_3^{2-} + H_2O}$$

(ii)
$$\overset{\circ}{Cl_{2}} + 2e^{-} \rightarrow 2Cl^{-}$$

 $\frac{\overset{\circ}{Cl_{2}} + 2OH^{-} \rightarrow 2ClO^{-} + 2e^{-} + 2H_{2}O}{Cl_{2} + 2OH \rightarrow Cl^{-} + ClO^{-} + H_{2}O}$
(iii) $2OH^{-} + \overset{\circ}{H_{2}} \rightarrow \overset{+1}{H_{2}O} + 2e^{-} + H_{2}O \times (3)$
 $\frac{3e^{-} + ReO_{4}^{-} \rightarrow ReO_{2} + 4OH^{-} \times (2)}{3H_{2} + 2ReO_{4}^{-} \rightarrow 2ReO_{2} + 2H_{2}O + 2OH^{-}}$
(iv) $\overset{+4}{ClO_{2}} + e^{-} \rightarrow \overset{+3}{ClO_{2}^{-}} \times (2)$
 $\frac{2H_{2}O + SbO_{2}^{-} \rightarrow Sb(OH)_{6}^{-} + 2e^{-} + 2OH^{-} + H_{2}O}{2ClO_{2} + SbO_{2}^{-} + 2OH^{-} + 2H_{2}O \rightarrow 2ClO_{2}^{-} + Sb(OH)_{6}^{-}}$

(v) $4H_2O + MnO_4^{+7} + 5e^- \rightarrow Mn^{+2} + 8OH^ Fe^{+2} \rightarrow Fe^{+3} + e^-$ ×(5)

 $\mathrm{MnO_4^-}\ +\ 5\mathrm{Fe^{+2}}\ +\ 4\mathrm{H_2O}\ {\rightarrow}\ \mathrm{Mn^{2+}}\ +\ 5\mathrm{Fe^{3+}}\ +\ 8\mathrm{OH^-}$

Exercise 2

Mole Concept

Single Correct Choice Type

Sol 1: (D) $A + Cl_2 \rightarrow ACl_2$

 $\frac{x}{M} \quad \frac{y}{71+M}$

 $\frac{x}{M} = \frac{y}{71 + M}$

71x + Mx = My

$$M = \frac{71x}{x - y}$$

Sol 2: (B) Equivalents of $H_2SO_4 = 1.200 \times 0.2 = 0.24$ Moles of $H_2SO_4 = 0.12$ Mass of $H_2SO_4 = 0.12 \times 98 = 11.76$ gm

Sol 3: (C) NaI consumption per day

$$= \frac{0.5}{100} \times 3 \text{ gm} = 0.015 \text{ gm}$$

Number of I⁻ = $\frac{0.015}{127 + 23} \times 6.023 \times 10^{23} = 6.023 \times 10^{19}$

Assertion Reasoning Type

Sol 4: (B) Statement-I: moles of $N_2 = \frac{0.28}{28} = 0.01$ mole PV = nRT At same P and T, V \propto n If M. W. = 44 gm of gas n = 0.01 mole V \propto n So, volume will be same as moles are also same.

Sol 5: (A) We know that for isotopes

 $M_{avg.} = x(M_1) + (1-x)M_2$

So, statement-II is explaining statement-I and both are correct.

Sol 6: (C) Statement-I: Mass of urea = 60

Mass of nitrogen = 28

$$\% = \frac{28}{60} = 46.66$$

Statement-II: Urea not ionic.

Sol 7: (B) Statement-I: $S_2O_3^{2-}$ 2x + 3(-2) = -2 x = +2

Statement: Yes, Because these may be per-oxide bond.

Sol 8: (A) Statement-I: Molarity = $\frac{n}{v}$ density increases $\Rightarrow n \uparrow (at const. V)$

= molality =
$$\frac{\text{moles of solute}}{\text{mass of solvent}}$$

Density increases = moles of solute \uparrow

Molality and molarity both changes.

Statement-II: Density results in change in mass thus increases moles.

Sol 9: (C) Statement-I: Incorrect because it depends in extent of reaction

Statement-II: Correct.

Multiple Correct Choice Type

Sol 10: (A, C, D) (A) $NH_3 \rightarrow HNO_3 + HNO_2$ (till reaction III)

by nitrogen balance

$$n_{HNO_3} = \frac{1}{2}n_{NH_3}$$

(B) $3HNO_2 \rightarrow HNO_3 + 2NO + H_2O$ Let's say 1 mole of NH₂ is initially taken.

It makes
$$\frac{1}{2} - \frac{1}{2}$$
 mole of HNO₂ and HNO₃ till

reaction-III $\frac{1}{2}$ mole HNO₂ make $\frac{1}{6}$ mole of HNO₃ in reaction-IV so HNO₃ made

$$= \frac{1}{2} + \frac{1}{6} \text{ mole } = \frac{2}{3} \text{ mole}$$

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

(C) By above data, it is correct

(D) Mole of NO produced = $\frac{1}{2} \times \frac{2}{3} = 50 \%$ of HNO₃

Comprehension Type

Paragraph 1

Sol 11: (A) Initially mole of HCl = $\frac{1}{2}$ mole = $\frac{1}{2} \times 36.5$ gm = 18.25 gm

So, after heating mole of HCl

 $= \frac{18.25 - 2.75}{36.5} = \frac{15.5}{36.5} = 0.424 \text{ mole}$ Normality = $\frac{0.424}{0.750} = 0.5662 \sim 0.58$

Sol 12: (C) Please note that, there is a small hypo in questions,

Instead of Ca(OH), it should be Ca(OH)₂ Ca(OH)₂ + 2HCI \rightarrow CaCl₂ + 2H₂O Moles of HCI = 0.1 × 10 = 1m mole Moles of Ca(OH)₂ required = 0.5 m mole Volume = $\frac{0.5}{0.1}$ mL = 5 mL

Sol 13: (A) We know valency factor for Na₂CO₃ is 2

So, molarity will be = $\frac{0.5}{2} = 0.25$ M

Sol 14: (A) 6.90 N means in 1 lit. solution

KOH = 6.90 moles

Weight of KOH = $6.90 \times (56) = 386.4 \text{ gm}$

given 30% by weight is KOH

So, weight of solution = 12.88 gm

Density =
$$\frac{12.88}{1} = 12.88$$

Sol 15: (C) Ferrous ammonium sulphate = $FeSO_4(NH_4)_2SO_4.6H_2O$ Molecular weight = 390 Moles in 0.1 N, 250 mL = $\frac{(0.1)(0.250)}{Valency factor}$ $Fe^{2+} \rightarrow Fe^{3+}$ Valency factor = 1 Mass of ferrous ammonium sulphate required = (0.1) (0.250) (390) = 9.8 gm

Paragraph 2

Sol 16: $CuCl_2 + AgCl \rightarrow unreacted$ $\underset{x \text{ gm}}{\text{CuBr}_2} + \underset{y \text{ gm}}{\text{2AgBr}} + \underset{\text{CuCl}_2}{\text{2AgBr}} + \underset{\text{CuCl}_2}{\text{CuCl}_2}$ Let's say initially $CuBr_2 = x gm$ $CuCl_{2} = 4.925 - x gm$ AgCl = y gram (reacts with reacted) AgCI = 5.74 - y gram (in reacted) Finally same AgCl \rightarrow AgBr and CuBr, \rightarrow CuCl₂ (completely) Moles of AgCl in reaction = $\frac{y}{1425}$ = Mole of AgBr produced Finally AqCl = (5.74 - y) gm AgBr = $\frac{y}{143.5} \times (80 + 108) = y(1.310)$ AgCl + AgBr = 6.63 = 5.74 + v(0.310)y = 2.87 gmSo moles of CuBr₂ = $\frac{2.87}{2 \times 143.5} = \frac{x}{223.5}$ x = 2.235 gm (1) **(C)** CuBr₂ mass % = $\frac{2.235}{4.925}$ = 45.38% (2) (B)% mass of Cu = $\left| \left(\frac{2.235}{223.5} \right) + \left(\frac{4.925 - 2.235}{63.5 + 71} \right) \right| \times \frac{63.5}{4.925}$ $=\frac{0.03\times63.5}{4.925}=38.68\%$

(3) **(B)** Mole % of AgBr =

$$\frac{\left(\frac{2.87}{143.5}\right)}{\left(\frac{2.87}{143.5}\right) + \left(\frac{9.74 - 2.87}{143.5}\right)} = 50\%$$

(4) (A) Moles of $CuBr_2$ = Moles of $CuCl_2$ produced

= 0.01 mole

Moles of CuCl₂ initially take

 $= \frac{4.925 - 2.235}{134.5} = 0.02 \text{ mole}$

Mole of Cl⁻ in final solution = $(0.01 + 0.02) \times 2 = 0.06$

Paragraph 3

Sol 17: UF₆ + xH₂O → UO_xF_y + gas (F_{6-y} H_{2x}) 3.52gm 3.08 gm 0.8 gm

0.01 mole

Gas contains 95% fluorine by mass

$$= 0.8 \times \frac{95}{100} = (6 - y) \times 19$$

y = 5. 96
 $0.8 \times \frac{5}{100} = (2x)$
x = 0. 02
(1) (C) So empirical formula $F_{6-596} H_{2(0.02)}$
= $F_{0.04} H_{0.04}$
= HF
(2) (A) Empirical formula of solid = $UO_x F_y$
final reaction
 $UF_6 + BH_2O \rightarrow UO_x F_y + A(HF)$
0. 01 0. 01
 $A = 2B (H-balance)$
 $6 = Y + A (F - balance)$
 $B = X = \frac{A}{2} (O - balance)$
 $Y = 6 - A$
 $UO_{\frac{A}{2}}F_{6-A}$ molecular weight = $\frac{3.08}{0.01} = 308$ gm

8A + 114 - 19A = 70 11A = 44 A = 4So UO_2F_2 (3) **(A)** % of F converted = $\frac{A}{6} = 66.66\%$

Match the Columns

Sol 18: A
$$\rightarrow$$
 r; B \rightarrow p; C \rightarrow q
 $\frac{1}{3}$ Al₅O1₂ molecular weight = 267 + 135 + 196 = 598
(A) Y = $\frac{267}{598}$ = 44.95%
(B) Al = $\frac{135}{598}$ = 22.57%
(C) O = $\frac{196}{598}$ = 32.32%

Sol 19: A \rightarrow r; B \rightarrow q; C \rightarrow p C₆H₈O₆ molecular weight = 72 + 8 + 96 = 176 Moles of C₆H₈O₆ = $\frac{17.6 \text{ mg}}{176}$ = 0.1 m mole (A) O - atom = 6 × n_{C₆H₈O₆ × N_A = 3.6 × 10²⁰ (B) Mole = $\frac{1}{176}$ = 5.68 × 10⁻³ (C) Moles of C₆H₈O₆ = 0.1 m mole}

Sol 20: (C) Volume strength $2H_2O_2(\ell) \rightarrow O_2(g) + 2H_2O(\ell)$ 1 It. of H_2O_2 gives x It. of O_2 gas then X is said to be volume strength of H_2O_2 It X - V is given at S. T. P. then Mole of O_2 produced = $\frac{x}{22.4}$ Mole of H_2O_2 required = $\frac{x}{11.2}$ (in litre) Molarity = $\frac{x}{11.2}$ Normality = $\frac{x}{11.2} \times (valency factor) = \frac{x}{5.6}$ Strength in g/L = $\frac{x}{11.2} \times 34 = \frac{17x}{5.6}$

Volume strength = Normality \times 5.6

Sol 21: (B) (A) acid + acid \rightarrow No reaction

$$M_{avg.} = \frac{M_1V_1 - M_2V_2}{V_1 + V_2} = \frac{\text{Total no. of moles}}{\text{Total volume}}$$

Similarly (B)

(C) acid + basic \rightarrow

$$M_{avg.} = \frac{M_1V_1 - M_2V_2}{V_1 + V_2}$$

(D) Mili equivalent = $x \times M \times VmL$

(E) Molarity =
$$\frac{\text{moles}}{\text{volume}} = \frac{M_1V_1}{\text{Volume}} = \frac{M_1V_1}{V_2}$$

or = $\frac{\text{moles}}{\text{volume}} = \frac{\text{mass (gm)}}{M_{\text{solute}} \times \text{Volume (lt.)}}$

Redox Reactions

Single Correct Choice Type

Sol 1: (C) $N_2 H_4 \rightarrow y = 10e^-$

Each nitrogen coses 5e-

: Oxidation no. of N in

y = -2 + 5 = +3

Sol 2: (D) The ore which get easily oxidised is best reducing agent

 $I^- \rightarrow \frac{1}{2} I_2$ is most feasible because.

Sol 3: (C) Alumino thermite process :-

 $\begin{array}{l} \mathsf{AI}\,+\,\mathsf{Mn_3O_4}\rightarrow\mathsf{Al_2O_3}\,+\,\mathsf{Mn}\\ \downarrow\\ \mathsf{Reducing\ agent} \end{array}$

Sol 4: (D) (a) Oxidation number of S in $H_2S=+2$ Oxidation number of S in $SO_2 = +4$

(b) H_2O_2 can undergo reduction as well as oxidation because oxidation number of oxygen in H_2O_2 is -1. So, it can act both as reducing agent and oxidising agent.

Sol 5: (C)
$$\operatorname{ClO}_{3}^{+5} + 6\mathrm{H}^{+} + x \rightarrow \mathrm{Cl}^{-} + 3\mathrm{H}_{2}\mathrm{O}$$

 \downarrow
 $6\mathrm{e}^{-} + 5 \rightarrow -1$

Sol 6: (A) $[Fe(H_2O)_5(NO)^+]^{-1} SO_4^{2-}$ $Fe^{x+} 5(H_2O)^0 (NO)^+$ x + 1 = +2; x = +1Sol 7: (A) $KO_2^ K^+ O_2^- 2x = -1$ $\therefore x = -\frac{1}{2}$ Sol 8: (B) $3Br_2^+ 6CO_3^{2-} + 3H_2O \rightarrow 5Br^- + 6HCO_3^- + +5BrO_3^ BrO \rightarrow Br^{-1}$ Reduction $BrO \rightarrow Br^{+5}$ Oxidation

Comprehension Type

Sol 9: (D)
$$H_2O_2 + KI \longrightarrow I_2$$

(×5)

Sol 10: (D) Eq. of hypo solution eq. of I_2 $20 \times 0.1 \times 10^{-3} = 50 \times 10^{-3} \times N_{H_2O_2}$ $\therefore N_{H_2O_2} = 0.04$ \therefore Concentration of H_2O_2 in gm/lit. = $\frac{0.04}{4} \times 34 = 0.34$

Sol 11: (D) : Eq. of MnO₂ + Eq. of hypo solution $\frac{m}{87} \times 2 = 30 \times 0.1 \times 10^{-3}$ m = 0.1305 $\therefore \% = \frac{0.1305}{0.5} \times 100 = 26.1\%$

Sol 12: (D) $As^{5+} + 2\Gamma \longrightarrow As^{3+} + I_2$ $+2e^- \qquad \uparrow \qquad \uparrow \qquad \uparrow \qquad \uparrow \qquad \uparrow$

 \therefore Valence factor = 5 for As

2 for I

Paragraph 2

Sol 13: (C)
$$Cl_2 \longrightarrow Cl + ClO_3^{+5}$$

Disproportionation

(oxidation as well as reduction)





$$H_2 S \rightarrow S \qquad 0 - (-2) = +2$$

$$SO_2 \rightarrow S \qquad 0 - (4) = -4$$

Multiple Correct Choice Type

Sol 16: (A, B, D) Meq. of formed = Meq. of HCl used for NH₃

 $= 50 \times 0.15 - 32.10 \times 0.10$ = 4.29

These Meq. of NH_3 are derived using valance factor of $NH_3 = 1$ (an acid base reaction)

In redox change valence factor of NH₃ is 8;

 $8e + N^{5+} \rightarrow N^{3-}$

: Meq. of NH₃ for valence factor

Also, Meq. of $NO_3^- = Meq.$ of NH_3

 $= 8 \times 4.29 = 34.32$

$$\therefore N_{NO_{3}^{-}} = \frac{34.32}{25} = 1.37$$

 $(N \times V \text{ in } mL = Meq.)$

Assertion Reasoning Type



Valency of Cr is 6 all O have higher electronegativity than Cr

 \therefore Cr's oxidation no. = +6

K ₂ Cr ₂ O ₇	OH⁻∖ ∖H⁺	K ₂ CrO ₄
Orange		Yellow
dichromate		chromate

	$BaCl_2$	$+ Al_2(SO_4)_3 -$	\longrightarrow BaSO ₄ + A	√ICl ₃
Meq. before	30×0.1	40×0.2	0	0
reaction	= 3	= 8	= 0	= 0
Meq. after reactior	n 0	5	3	3

Sol 18: (D) Avg. oxidation no. of Pb_3O_4 is $+\frac{8}{3}$. But in reality, Pb_3O_4 is made up of PbO + PbO₂. So, actively, Pb have oxidation state +2, +4.

Sol 19: (C) Oxidation no. of Cl = +7 it can not be greater than this

.:. It can get only reduced

 \therefore HClO₄ is an oxidising agent

 \therefore In HClO₃, oxidation no. of chlorine = + 5

E. N. order O > CI > H

Sol 20: (D) Since S_2^{2-} has $S - S^-$ linkage structure \therefore FeS₂²⁻ \rightarrow Fe²⁺ (S - S) oxidation no. = +2

Sol 21: (B) Yes, the given reaction is an example of disproportionation

 \therefore H₂O₂ is a reducing as well as an oxidising agent

So it is not only bleaching (oxidising agent)

$$H_2O_2^{-1} \longrightarrow H_2O^{-2} + \frac{1}{2}O_2^{0}$$

Sol 22: (A) K₂Cr₂O₇

K₂CrO₄

Orange dichromate Yellow chromate



These reactions show E° > 0

 \therefore It is not feasible because iodine can show multiple oxidation state.

Match the Columns

 $\begin{array}{l} \textbf{Sol 24:} A \rightarrow w; \ B \rightarrow x; \ C \rightarrow u; \ D \rightarrow p; \ E \rightarrow v; \ F \rightarrow q; \ G \rightarrow r; \\ H \rightarrow s; \ I \rightarrow t \end{array}$

(1) Increase in oxidation no:- Loss of electrons (oxidation)

(2) Decrease in oxidation no:- Gain of only e-s (reduction)

(3) Oxidation agent:- Gain of e⁻s

(4) Reducing agent:- Loss of e-s

(5) $2Cu^+ \longrightarrow Cu^{2+} + Cu$ $\downarrow -e^- \uparrow + e^-$

Disproportionation reaction

(6) Redox reaction

(7) Mn_3O_4 oxidation no:-

 $+\frac{8}{3} \text{ fractional}$ (8) CH₂Cl₂ x + 2 - 2 = 0 zero oxidation no. x = 0 (9) NaOH + HCl → NaCl + H2O

Simple neutralisation reaction

Sol 25:
$$A \rightarrow p$$
, s; $B \rightarrow r$; $C \rightarrow p$, q; $D \rightarrow p$

(a) $O_2^- \longrightarrow O_2^0 + O_2^{-1}$

Disproportionation

Redox reaction

(b)
$$\operatorname{CrO}_{4}^{2-} + \operatorname{H}^{+} \rightarrow \operatorname{Cr}_{2}\operatorname{O}_{7}^{2-}$$

dimeric bridged
tetrahedral ion
 $O = \operatorname{Cr}_{0} \circ \operatorname{Cr}_$

(c) $MnO_4^- + NO_2^- + H^+ \rightarrow Mn^{2+} + NO_3^$ tetrahedral trigonal

Redox Reaction



 $Fe^{3+} + NO_2 + H_2O$ Redox reaction

Previous Years' Questions

Mole Concept

Sol 1: Average atomic weight

 $= \frac{\text{Percentage of an isotope × atomic weight}}{100}$ $\Rightarrow 10.81 = \frac{10.01x + 11.01(100 - x)}{100}$

⇒ x = 20%

Therefore, natural boron contain 20% (10.01) isotope and 80% other isotope.

Sol 2: From the vapour density information,

Molar mass = Vapour density × 2

(:: Molar mass of $H_2 = 2$)

= 38.3 × 2 = 76.6

Now, let us consider 1.0 mole of mixture and it contains x mole of N_2 .

$$\Rightarrow 46x + 92 (1 - x) = 76.6$$

 \Rightarrow x = 0.3348

Also, in 100 g mixture, number of moles $=\frac{100}{76.6}$

 \Rightarrow Moles of in mixture

$$=\frac{100}{76.6}\times 0.3348 = 0.437$$

Sol 3: Heating below 600°C converts $Pb(NO_3)_2$ into PbO but to NaNO₃ into NaNO₂ as:

$$Pb(NO_3)_2 \xrightarrow{\Delta} PbO(s) + 2NO_2 \uparrow + \frac{1}{2}O_2 \uparrow$$

MW. 330 222

 $NaNO_3 \xrightarrow{\Lambda} NaNO_2(s) + \frac{1}{2}O_2 \uparrow$

69

MW.85

Weight loss = $5 \times \frac{28}{100} = 1.4 \text{ g}$ \Rightarrow Weight of residue left = 5 - 1.4 = 3.6 g Now, let the original mixture contain x g of $Pb(NO_3)_2$

 $\therefore 330 \text{ g gives } 222 \text{ g PbO}$ $\therefore x \text{ g Pb}(\text{NO}_3)_2 \text{ will give } \frac{222 \text{ x}}{330} \text{ g PbO}$ Similarly, 85 g NaNO₃ gives 69 g $\Rightarrow (5 - x)\text{g will give}$ $\frac{69(5 - x)}{85} \text{ g NaNO}_2$ $\Rightarrow \text{Residue: } \frac{222x}{330} + \frac{69(5 - x)}{85} = 3.6\text{g}$ $x = 3.3 \text{ g Pb}(\text{NO}_3)_2$ $\Rightarrow \text{NaNO}_3 = 1.7 \text{ g}$

Sol 4: Compound B forms hydrated crystals with $Al_2(SO_4)_3$ Also, B is formed with univalent metal on heating with sulphur. Hence, compound B must have the molecular formula M_2SO_4 and compound A must be an oxide of M which reacts with sulphur to give metal sulphate as

 $A + S \longrightarrow M_2 SO_4$

 \therefore 0.321 g sulphur gives 1.743 g of M₂SO₄

 \therefore 32.1 g S (one mole) will give 174.3 g M₂SO₄

Therefore, molar mass of $M_2SO_4 = 174.3$ g

 \Rightarrow 174.3 = 2 × Atomic weight of M + 32.1 + 64

 \Rightarrow Atomic weight of M = 39, metal is potassium (K)

 $\rm K_2SO_4$ on treatment with aqueous $\rm Al_2(SO_4)_3$ gives potashalum.

$$K_{2}\underset{B}{\text{SO}_{4}} + \text{Al}_{2}(\text{SO}_{4})_{3} + 24\text{H}_{2}\text{O} \longrightarrow K_{2}\text{SO}_{4}\text{Al}_{2}(\underset{C}{\text{SO}_{4}})_{3} \cdot 24\text{H}_{2}\text{O}$$

If the metal oxide A has molecular formula $MO_{x'}$ two moles of it combine with one mole of sulphur to give one mole of metal sulphate as

 $2KO_{x} + S \longrightarrow K_{2}SO_{4}$ $\Rightarrow x = 2, i.e., A is KO_{2}.$

Sol 5: 93% H_2SO_4 solution weight by volume indicates that there is 93 g H_2SO_4 in 100 mL of solution.

If we consider 100 mL solution, weight of solution = 184 g

Weight of H₂O in 100 mL solution

= 184 – 93 = 91 g

 $\Rightarrow Molality = \frac{Moles of solute}{Weight of solvent(g)} \times 1000$

$$=\frac{93}{98}\times\frac{1000}{91}=10.43$$

Sol 6: Partial pressure of $N_2 = 0.001$ atm,

T = 298 K, V= 2.46 dm³.

From Ideal Gas law : pV = nRT

$$n(N_2) = \frac{pV}{RT} = \frac{0.001 \times 2.46}{0.082 \times 298} = 10^{-7}$$

 \Rightarrow No. of molecules of

$$= 6.023 \times 10^{23} \times 10^{-10}$$

$$= 6.023 \times 10^{17}$$

Surface sites used in adsorption

$$=\frac{20}{100}\times 6.023\times 10^{17}=2\times 6.023\times 10^{16}$$

 \Rightarrow Sites occupied per molecules

 $=\frac{\text{Number of sites}}{\text{Number of molecules}}=\frac{2\times6.023\times10^{16}}{6.023\times10^{16}}=2$

Sol 7: (D) The balanced chemical reaction is $3BaCl_2 + 2Na_3PO_4 \longrightarrow Ba_3(PO_4)_2 + 6NaCl$

In this reaction, 3 moles of BaCl₂ combined with 2 moles of Na₃PO₄ Hence, 0.5 mole of BaCl₂ requires

 $\frac{2}{3} \times 0.5 = 0.33$ mole of Na₃PO₄.

Since available Na_3PO_4 (0.2 mole) is less than required mole (0.33), it is the limiting reactant and would determine the amount of product $Ba_3(PO_4)_2$.

- \therefore 2 moles of Na₃PO₄ gives 1 mole Ba₃(PO₄)₂
- \therefore 0.2 mole of Na₃PO₄ would give

$$\frac{1}{2} \times 0.2 = 0.1 \text{ mole Ba}_{3}(PO_{4})_{2}$$

Sol 8: (B) The following reaction occur between

 $S_2O_3^{-2} \text{ and } Cr_2O_7^{-2}:$ 26H⁺ + 3S_2O_3^{-2} + 4Cr_2O_7^{-2} \longrightarrow 6SO_4^{-2} + 8Cr^{3+} + 13H_2O

Change in oxidation number of $Cr_2O_7^{-2}$ per formula unit is 6 (it is always fixed for $Cr_2O_7^{-2}$).

Hence, equivalent weight of K₂Cr₂O₇

Sol 9: Na₂S₄O₆ is a salt of H₂S₄O₆ which has the following Let there be x millimole of Cu²⁺ structure

 \Rightarrow Difference in oxidation number of two types of sulphur = 5.

Sol 10: (B) 1. Both assertion and reason are factually true but the reason does not exactly explain the assertion. The correct explanation is, methyl orange and phenolphthalein changes their colours at different pH.

Sol 11: For the oxidation of Aⁿ⁺ as:

 $A^{n+} \longrightarrow AO_3^-$ n-factor = 5 - n

Gram equivalent of $A^{n+} = 2.68 \times 10^{-3} (5 - n)$

Now equating the above gram equivalent with gram equivalent of KMnO₄:

 $2.68 \times 10^{-3}(5-n) = 1.61 \times 10^{-3} \times 5$

Sol 12: The redox reaction involved is :

 $H_2O_2 + 2I^- + 2H^+ \longrightarrow 2H_2O + I_2$

If M is molarity of H₂O₂ solution, then

$$5M = \frac{0.508 \times 1000}{254}$$

(:: 1 mole H₂O₂ = 1 mole

Also, n-factor of H_2O_2 is 2, therefore normality of H_2O_2 solution is 0.8 N.

I₂)

 \Rightarrow Volume strength = Normality \times 5.6 = 0.8 × 5.6 = 4.48 V

Sol 13: With KMnO₄ oxalate ion is oxidized only as: $5C_2O_4^{-2} + 2MnO_4^{-} + 16H^+ \longrightarrow 2Mn^{2+} + 10CO_2 + 8H_2O_2$

Let, in the given mass of compound, x millimol of $C_2 O_4^{-2}$ ion is present, then

Meq. of $C_2 O_4^{-2}$ = Meq of MnO_4^{-2} \Rightarrow 2x = 0.02 × 5 × 22.6; \Rightarrow x = 1.13

At the later stage, with I⁻, Cu²⁺ is reduced as :

$$\begin{aligned} & 2Cu^{2+} + 4I^- \longrightarrow 2CuI + I_2 \\ & \text{and } I_2 + 2S_2O_3^{-2} \longrightarrow 2I^- + S_4O_6^{-2} \end{aligned}$$

$$\Rightarrow \text{Meq of } Cu^{2+} = \text{Meq of } I_2 = \text{meq of hypo}$$

$$\Rightarrow x = 11.3 + 0.05 = 0.565$$

$$\Rightarrow \text{Meq of } Cu^{2+} : \text{Meq of } C_2O_4^{-2} = 0.565 : 1.13 = 1 : 2$$

Sol 14: Let us consider 10 mL of the stock solution contain x millimol oxalic acid H₂C₂O₄ and y millimol of NaHC₂O₄. When titrated against NaOH, basicity of oxalic acid is 2 while that of $NaHC_2O_4$ is 1.

$$\Rightarrow 2x + y = 3 \times 0.1 = 0.3$$
 ...(i)

When titrated against acidic KMnO4, n-factor of both oxalic acid and NaHC, O₄ would be 2.

$$2x + 2y = 4 \times 0.1 = 0.4 \qquad ...(ii)$$

Solving equations (i) and (ii) gives $y = 0.1, x = 0.1$.
 \Rightarrow In 1.0 L solution, mole of $= \frac{0.1}{1000} \times 100 = 0.01$
Mole of NaHC₂O₄ $= \frac{0.1}{1000} \times 100 = 0.01$
 \Rightarrow Mass of H₂C₂O₄ $= 90 \times 0.01 = 0.9$ g
Mass of NaHC₂O₄ $= 112 \times 0.01 = 1.12$ g
Sol 15: (D) (p) PbO₂ + H₂SO₄ $\xrightarrow{\Delta}$ PbSO₄ + O₂ + $\frac{1}{2}$ O₂
(q) 2Na₂S₂O₃ + Cl₂ + 2H₂O
 \longrightarrow 2NaCl + 2NaHSO₄ + 2S
(r) N₂H₄ + 2I₂ \longrightarrow N₂ + 4HI

(s)
$$XeF_2 + 2NO \longrightarrow Xe + 2NOF$$

Sol 16: (A, B, D) The balanced equation is $CIO_3^- + 6I^- + 6H_2SO_4 \rightarrow 3I_2 + CI^- + 6HSO_4^- + 3H_2O_4$

Sol 17: (A) $KIO_4 + H_2O_2 \rightarrow KIO_3 + H_2O + O_2$ $NH_2OH + 3H_2O_2 \rightarrow HNO_3 + 4H_2O_3$