SOLUTIONS

Module - 2 / JEE-2022

IN-CHAPTER EXERCISES	Chemistry	Stoichiometry - II (Redox Reactions)

EXERCISE-A

1. **(i)** $HClO_4 : (+1)\times 1 + (x)\times 1 + (-2)\times 4 = 0 \Rightarrow x = +7$

(ii) $Ba(ClO_3)_2 : (+2)\times 1 + (x)\times 2 + (-2)\times 6 = 0 \Rightarrow x = +5$

(iii) CrO_2Cl_2 : Chromyl chloride : In chlorides, 0.5 of Cl is always – 1. **(iv)** $Cl_2O_7 : (x)\times 2 + (-2)\times 7 = 0 \Rightarrow x = +7$

2. **(i)** $CN^- \longrightarrow N_2 + HCO_3^-$ and $OCl^- \longrightarrow Cl^-$
(Both C and N are oxidised) (Reduced)

(ii) $O_3 \longrightarrow O_2$ and $C_6H_5OH \longrightarrow CO_2$
Reduced Oxidised

(iii) $I^- \longrightarrow I_2$ and $O_3 \longrightarrow O_2$
Oxidised Reduced

(iv) $S_2O_3^{2-} \longrightarrow HSO_4^-$ and $Cl_2 \longrightarrow Cl^-$
Oxidised Reduced

(v) $C \longrightarrow CO$ and $ZnO \longrightarrow Zn$
Oxidised Reduced

3. **(i)** $Te(s) + NO_3^-(aq.) \longrightarrow TeO_2(s) + NO(g)$

Oxidation : $Te(s) + 2H_2O \longrightarrow TeO_2(s) + 4H^+ + 4e^-$; Reduction : $NO_3^-(aq.) + 4H^+ + 3e^- \longrightarrow NO(g) + 2H_2O$

(ii) $H_2O_2(aq.) + Fe^{2+}(aq.) \longrightarrow Fe^{3+}(aq.) + H_2O(\ell)$

Oxidation : $Fe^{2+}(aq.) \longrightarrow Fe^{3+}(aq.) + e^-$; Reduction : $H_2O_2(aq.) + 2H^+ + 2e^- \longrightarrow 2H_2O(\ell)$

(iii) $Mn(s) + NO_3^-(aq.) \longrightarrow Mn^{2+}(aq.) + NO_2(g)$

Oxidation : $Mn(s) \longrightarrow Mn^{2+}(aq.) + 2e^-$; Reduction : $NO_3^-(aq.) + 2H^+ + 1e^- \longrightarrow NO_2(g) + H_2O(\ell)$

(iv) $Mn^{3+}(aq.) \longrightarrow MnO_2(s) + Mn^{2+}(aq.)$ (Disproportionation Rx^n.)

Oxidation : $Mn^{3+}(aq.) + 2H_2O \longrightarrow MnO_2(s) + 4H^+ + e^-$; Reduction : $Mn^{3+}(aq.) + e^- \longrightarrow Mn^{2+}(aq.)$

4. **(i)** $VO^{2+}(aq.) \longrightarrow V^{3+}(aq.) \Rightarrow VO^{2+}(aq.) + 2H^+ + e^- \longrightarrow V^{3+}(aq.) + H_2O$

(ii) $NO_3^-(aq.) \longrightarrow NO_2(g) \Rightarrow NO_3^-(aq.) + 2H^+ + e^- \longrightarrow NO_2 + H_2O$

(iii) $IO_3^-(aq.) \longrightarrow I_3^-(aq.) \Rightarrow 3IO_3^- + 18H^+ + 18e^- \longrightarrow I_3^- + 9H_2O$

5. **(i)** $CrO_4^{2-}(aq.) \longrightarrow Cr(OH)_4^-(aq.) \Rightarrow CrO_4^{2-}(aq.) + 4H_2O + 3e^- \longrightarrow Cr(OH)_4^- + 4OH^-$

(ii) $Bi^{3+}(aq.) \longrightarrow BiO_3^-(aq.) \Rightarrow Bi^{3+}(aq.) + 6OH^- \longrightarrow BiO_3^-(aq.) + 3H_2O + 2e^-$

(iii) $ClO^-(aq.) \longrightarrow Cl^-(aq.) \Rightarrow ClO^-(aq.) + H_2O + 2e^- \longrightarrow Cl^-(aq.) + 2OH^-$

6. **(i)** $MnO_4^-(aq.) + IO_3^-(aq.) \longrightarrow MnO_2(s) + IO_4^-(aq.)$

Reduction: $MnO_4^-(aq) + 2H_2O + 3e^- \longrightarrow MnO_2(s) + 4OH^-$
Oxidation : $IO_3^-(aq.) + 2OH^- \longrightarrow IO_4^-(aq.) + H_2O + 2e^-$

$$2MnO_4^- + 3IO_3^- + H_2O \longrightarrow 2MnO_2 + 3IO_4^- + 2OH^-$$

(ii) $Cu(OH)_2(s) + N_2H_4(aq.) \longrightarrow Cu(s) + N_2(g)$

Oxidation : $N_2H_4(aq.) + 4OH^- \longrightarrow N_2(g) + 4H_2O + 4e^-$
Reduction : $Cu(OH)_2(s) + 2H_2O + 2OH^- + 2e^- \longrightarrow Cu(s) + 4OH^- + 2H_2O$

$$2Cu(OH)_2(s) + N_2H_4(aq.) \longrightarrow 2Cu(s) + N_2(g) + 4H_2O$$

(iii) $Fe(OH)_2(s) + CrO_4^{2-}(aq.) \longrightarrow Fe(OH)_3(s) + Cr(OH)_4^-(aq.)$

Oxidation : $Fe(OH)_2(s) + OH^- \longrightarrow Fe(OH)_3(s) + e^-$
Reduction : $CrO_4^{2-}(aq.) + 4H_2O + 3e^- \longrightarrow Cr(OH)_4^- + 4OH^-$

$$3Fe(OH)_2 + CrO_4^{2-}(aq.) + 4H_2O \longrightarrow 3Fe(OH)_3 + Cr(OH)_4^- + OH^-$$

(iv) $H_2O_2(aq.) + ClO_4^-(aq.) \longrightarrow ClO_2^-(aq.) + O_2(g)$

Oxidation : $H_2O_2(aq.) + 2OH^- \longrightarrow O_2(g) + 2H_2O + 2e^-$
Reduction : $ClO_4^-(aq.) + 2H_2O + 4e^- \longrightarrow ClO_2^-(aq.) + 4OH^-$

$$2H_2O_2(aq.) + ClO_4^-(aq.) \longrightarrow 2O_2(g) + ClO_2^-(aq.) + 2H_2O$$

7. **(i)** $H_2O_2(aq.) + Cr_2O_7^{2-}(aq.) \longrightarrow Cr^{3+}(aq.) + O_2(g)$

Oxidation: $H_2O_2(aq.) \longrightarrow O_2(g) + 2H^+ + 2e^-$
Reduction : $Cr_2O_7^{2-}(aq.) + 14H^+ + 6e^- \longrightarrow 2Cr^{3+}(aq.) + 7H_2O$

$$Cr_2O_7^{2-}(aq.) + 3H_2O_2 + 8H^+ \longrightarrow 2Cr^{3+} + 3O_2 + 7H_2O$$

(ii) $H_2O_2(aq.) + Mn^{2+}(aq.) \longrightarrow MnO_2(s) + H_2O$

Oxidation : $Mn^{2+}(aq.) + 4OH^- \longrightarrow MnO_2(s) + 2H_2O + 2e^-$
Reduction: $H_2O_2(aq.) + 2e^- \longrightarrow + 2OH^-$

$$Mn^{2+}(aq.) + H_2O_2(aq.) + 2OH^- \longrightarrow MnO_2 + 2H_2O$$

(iii) $Sn^{2+}(aq.) + IO_4^-(aq.) \longrightarrow I^-(aq.) + Sn^{4+}(aq.)$

Oxidation : $Sn^{2+}(aq.) \longrightarrow Sn^{4+}(aq.) + 2e^-$
Reduction: $IO_4^-(aq.) + 8H^+ + 8e^- \longrightarrow I^-(aq.) + 4H_2O$

$$4Sn^{2+}(aq.) + IO_4^-(aq.) + 8H^+ \longrightarrow 4Sn^{4+}(aq.) + I^- + 4H_2O$$

(iv) $MnO_4^-(aq.) + SO_3^{2-}(aq.) \longrightarrow MnO_4^{2-}(aq) + SO_4^{2-}(aq.)$

Oxidation : $SO_3^{2-}(aq.) + 2OH^- \longrightarrow SO_4^{2-}(aq.) + H_2O + 2e^-$
Reduction : $MnO_4^-(aq.) + e^- \longrightarrow MnO_4^{2-}(aq.)$

$$SO_3^{2-}(aq.) + 2MnO_4^-(aq.) + 2OH^- \longrightarrow SO_4^{2-}(aq.) + 2MnO_4^{2-}(aq.) + H_2O$$

(v) $Cr_2O_7^{2-}(aq.) + HI(aq.) \longrightarrow CrI_3(aq.) + I_2(g) + KI$

Oxidation : $2HI(aq.) \longrightarrow I_2(aq) + 2H^+ + 2e^-$
Reduction : $Cr_2O_7^{2-}(aq.) + 14H^+ + 6e^- \longrightarrow 2Cr^{3+} + 7H_2O$

$$Cr_2O_7^{2-}(aq.) + 6HI(aq.) + 8H^+ \longrightarrow 2Cr^{3+}(aq.) + 3I_2(g) + 7H_2O$$

8. (i) $CuO + NH_3 \longrightarrow N_2 + Cu + H_2O$

Oxidation : $2NH_3 \longrightarrow N_2 + 6H^+ + 6e^-$
Reduction : $CuO + 2H^+ + 2e^- \longrightarrow Cu + H_2O$

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

(ii) $HI + HNO_3 \longrightarrow I_2 + NO + H_2O$

Oxidation : $2HI \longrightarrow I_2 + 2H^+ + 2e^-$
Reduction : $HNO_3 + 3H^+ + 3e^- \longrightarrow NO + 2H_2O$

$$6HI + 2HNO_3 \longrightarrow 3I_2 + 2NO + 4H_2O$$

(iii) $P_4 + H_2O \longrightarrow PH_3 + H_2PO_2^- + H^+$

Oxidation : $P_4 + 8H_2O \longrightarrow 4H_2PO_2^- + 8H^+ + 4e^-$
Reduction : $P_4 + 12H^+ + 12e^- \longrightarrow 4PH_3$

$$4P_4 + 24H_2O \longrightarrow 4PH_3 + 12H_2PO_2^- + 12H^+$$

(iv) $H_2S + SO_2 \longrightarrow S + H_2O$

Oxidation : $H_2S \longrightarrow S + 2H^+ + 2e^-$
Reduction : $SO_2 + 4H^+ + 4e^- \longrightarrow S + 2H_2O$

$$2H_2S + SO_2 \longrightarrow 3S + 2H_2O$$

(v) $CN^- + MnO_4^- + H_2O \longrightarrow MnO_2 + CNO^- + OH^-$

Oxidation : $CN^- + 2OH^- \longrightarrow CNO^- + H_2O + 2e^-$
Reduction : $MnO_4^- + 2H_2O + 3e^- \longrightarrow MnO_2 + 4OH^-$

$$3CN^- + 2MnO_4^- + H_2O \longrightarrow 3CNO^- + 2MnO_2 + 2OH^-$$

(vi) $[Fe(CN)_6]^{3-} + N_2H_4 + OH^- \longrightarrow [Fe(CN)_6]^{4-} + N_2 + H_2O$

Reduction : $[Fe(CN)_6]^{3-} + e^- \longrightarrow [Fe(CN)_6]^{4-}$
Oxidation : $N_2H_4 + 4OH^- \longrightarrow N_2 + 4H_2O + 4e^-$

$$4[Fe(CN)_6]^{3-} + N_2H_4 + 4OH^- \longrightarrow 4[Fe(CN)_6]^{4-} + N_2 + 4H_2O$$

(vii) $C_2H_5OH + MnO_4^- \longrightarrow CH_3COO^- + MnO_2 + H_2O + OH^-$

Oxidation : $C_2H_5OH + 5OH^- \longrightarrow CH_3COO^- + 4H_2O + 4e^-$
Reduction : $MnO_4^- + 2H_2O + 3e^- \longrightarrow MnO_2 + 4OH^-$

$$3C_2H_5OH + 4MnO_4^- \longrightarrow 3CH_3COO^- + 4MnO_2 + 4H_2O + OH^-$$

(viii) $P_4 + H^+ + NO_3^-(dil) + H_2O \longrightarrow H_2PO_4^- + NO$

Oxidation : $P_4 + 16H_2O \longrightarrow 4H_2PO_4^- + 24H^+ + 20e^-$
Reduction : $NO_3^- + 4H^+ + 3e^- \longrightarrow NO + 2H_2O$

$$3P_4 + 20NO_3^- + 8H_2O + 8H^+ \longrightarrow 12H_2PO_4^- + 20NO$$

(ix) $HS^- + HSO_3^- \longrightarrow S_2O_3^{2-} + H_2O$

Oxidation : $HS^- + 3H_2O \longrightarrow S_2O_3^{2-} + 8H^+ + 8e^-$
Reduction : $2HSO_3^- + 4H^+ + 4e^- \longrightarrow S_2O_3^{2-} + 3H_2O$

$$2HS^- + 4HSO_3^- \longrightarrow 3S_2O_3^{2-} + 3H_2O$$

(x) $Fe^{3+} + NH_2OH \longrightarrow Fe^{2+} + N_2O + H^+$

Oxidation : $2NH_2OH \longrightarrow N_2O + H_2O + 4H^+ + 4e^-$
Reduction : $Fe^{3+} + e^- \longrightarrow Fe^{2+}$

$$4Fe^{3+} + 2NH_2OH \longrightarrow 4Fe^{2+} + N_2O + H_2O + 4H^+$$

(xi) $O_2^- + H_2O \longrightarrow OH^- + O_2$

Oxidation : $O_2^- \longrightarrow O_2 + e^-$
Reduction : $O_2^- + 2H_2O + 3e^- \longrightarrow 4OH^-$

$$4O_2^- + 2H_2O \longrightarrow 3O_2 + 4OH^-$$

(xii) $IO_3^- + HSO_3^- \longrightarrow I^- + H^+ + SO_4^{2-}$

Oxidation : $HSO_3^- + H_2O \longrightarrow SO_4^{2-} + 3H^+ + 2e^-$
Reduction : $IO_3^- + 6H^+ + 6e^- \longrightarrow I^- + 3H_2O$

$$IO_3^- + 3HSO_3^- \longrightarrow 3SO_4^{2-} + I^- + 3H^+$$

(xiii) $I^- + IO_3^- + H^+ \longrightarrow I_2 + H_2O$

Oxidation : $2I^- \longrightarrow I_2 + 2e^-$
Reduction : $2IO_3^- + 12H^+ + 10e^- \longrightarrow I_2 + 6H_2O$

$$IO_3^- + 5I^- + 6H^+ \longrightarrow 3I_2 + 3H_2O$$

(xiv) $Fe_2S_3 + H_2O + O_2 \longrightarrow Fe(OH)_3 + S$

Oxidation : $S^{2-} \longrightarrow S + 2e^-$

Reduction: $O_2 + 2H_2O + 4e^- \longrightarrow 4OH^-$

$O_2 + 2S^{2-} + 2H_2O \longrightarrow 2S + 4OH^-$

$\Rightarrow \quad 2Fe_2S_3 + 3O_2 + 6H_2O \longrightarrow 4Fe(OH)_3 + 6S$

(xv) $IBr + BrO_3^- + H_2O \longrightarrow IO_3^- + Br^- + H^+$

Oxidation : $I^+ + 3H_2O \longrightarrow IO_3^- + 6H^+ + 4e^-$

Reduction: $BrO_3^- + 6H^+ + 6e^- \longrightarrow Br^- + 3H_2O$

$3I^+ + 2BrO_3^- + 3H_2O \longrightarrow 3IO_3^- + 2Br^- + 6H^+$

$\Rightarrow 3IBr + 2BrO_3^- + 3H_2O \longrightarrow 3IO_3^- + 5Br^- + 6H^+$

(xvi) $CrI_3 + H_2O_2 + OH^- \longrightarrow CrO_4^{2-} + IO_4^- + H_2O$

Oxidation : $CrI_3 + 32OH^- \longrightarrow CrO_4^{2-} + 3IO_4^- + 16H_2O + 27e^-$

Reduction: $H_2O_2 + 2e^- \longrightarrow 2OH^-$

$2CrI_3 + 27H_2O_2 + 10OH^- \longrightarrow 2CrO_4^{2-} + 6IO_4^- + 32H_2O$

(xvii) $H_2O_2 + Fe^{2+} + H^+ \longrightarrow H_2O + Fe^{3+}$

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

Reduction: $H_2O_2 + 2H^+ + 2e^- \longrightarrow 2H_2O$

$2Fe^{2+} + H_2O_2 + 2H^+ \longrightarrow 2Fe^{3+} + 2H_2O$

(xviii) $As_2S_3 + MnO_4^- + H_2O + H^+ \longrightarrow H_3AsO_4 + Mn^{2+} + S$

Oxidation : $As_2S_3 + 8H_2O \longrightarrow 2H_3AsO_4 + 3S + 10H^+ + 10e^-$

Reduction: $MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O$

$As_2S_3 + 2MnO_4^- + 6H^+ \longrightarrow 2H_3AsO_4 + 3S + 2Mn^{2+}$

9. (i) (B) **(A)** $\overset{+6}{C}rO_4^{2-} \longrightarrow \overset{+7}{C}r_2O_7^{2-}$ (Oxidation) **(B)** $\overset{+5}{B}rO_3^- \longrightarrow \overset{+1}{B}rO^-$ (Reduction)

(C) $H_3\overset{+3}{A}sO_3 \longrightarrow H\overset{+5}{A}sO_4^{2-}$ (oxidation) **(D)** $\overset{+3}{A}l(OH)_3 \longrightarrow \overset{+3}{A}l(OH)_4^-$

(ii) (D) $CN^- + H_2O \longrightarrow CNO^- + 2H^+ + 2e^-$

(iii) (D) **(A)** $CaCO_3 \longrightarrow Ca^{2+} + CO_2$ **(B)** $CrO_4^{2-} \longrightarrow Cr_2O_7^{2-}$

(C) $Cr_2O_7^{2-} \longrightarrow CrO_4^{2-}$ **(D)** $Cu_2O \longrightarrow Cu^{2+} + Cu$

(iv) (C) $Ba(H_2PO_2)_2 \equiv Ba^{2+} + 2H_2PO_2^-$ $(+1)\times 2 + (x)\times 1 + (-2)\times 2 = -1 \Rightarrow x = +1$

(v) (B) $2NO_3^- + 16H^+ + 14e^- \longrightarrow N_2H_4 + 6H_2O$ No. of e^-s per mole of $NO_3^- = \frac{14}{2} = 7$

(vi) (B) SO_2 : S is + 4 ; H_2SO_4 : S is + 6 ; $Na_2S_2O_3$: S is + 2 ; $Na_2S_4O_6$: S is $\frac{10}{4}$

(vii) (C) (A) $\overset{-1}{H_2}\overset{-1}{O_2} : \overset{-1}{H_2}\overset{-1}{O_2} \longrightarrow \overset{-2}{H_2O}$

$\overset{-1}{H_2}\overset{-1}{O_2} \longrightarrow \overset{0}{O_2}$ ✓

(B) $H_2S : S^{2-} \longrightarrow S^\circ$ ×
It can only increase

(C) $SO_2 : \overset{+4}{S}O_2 \longrightarrow S^\circ$

$\overset{+4}{S}O_2 \longrightarrow \overset{+6}{S}O_4^{2-}$ ✓

(D) $HNO_2 : \overset{+3}{H}\overset{+3}{N}O_2 \longrightarrow \overset{+5}{H}NO_3$

$\overset{+3}{H}\overset{+3}{N}O_2 \longrightarrow \overset{+2}{N}O$ ✓

(viii) (D) $SO_2 \longrightarrow SO_x^{2-} \Rightarrow (+6)\times 1 + (-2)\times x = -2 \Rightarrow x = 4$

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

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

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

EXERCISE-B

1. $C_2O_4^{2-} + 2MnO_4^- \xrightarrow{OH^-} 2CO_2 + MnO_4^{2-}$; $5C_2O_4^{2-} + 2MnO_4^- \xrightarrow{H^+} CO_2 + Mn^{2+}$

$$\frac{n_{MnO_4^-/H^+}}{n_{MnO_4^-/OH^-}} = \frac{2/5}{2/1} = 0.2$$

2. $MnO_4^- + Fe(HC_2O_4)_2 \xrightarrow{H^+}$

$MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O$ ....(i)

$\left.\begin{matrix} Fe^{2+} \longrightarrow Fe^{3+} + e^- \\ (HC_2O_4^- \longrightarrow 2CO_2 + H^+ + 2e^-)\times 2 \end{matrix}\right\}$ ....(ii)

$MnO_4^- + Fe(HC_2O_4)_2 + 6H^+ \longrightarrow Mn^{2+} + Fe^{3+} + 4CO_2 + 4H_2O$

1 mol $Fe(HC_2O_4)_2 \equiv 1$ mol MnO_4^-

$Ca(OH)_2 + Fe(HC_2O_4)_2 \longrightarrow$

Typical neutralisation $HC_2O_4^-$ is monobasic acid as well as monoacidic base

$\Rightarrow$ 1 mol $Fe(HC_2O_4)_2 \equiv 2 \times 1 = 2$ gm eq $= 2 \times$ moles of $Ca(OH)_2 \Rightarrow$ moles Ca $(OH)_2 \equiv 1$

3. $V_2O_5 + 10H^+ + 6e^- \longrightarrow 2V^{2+} + 5H_2O$; $V^{2+} + I_2 \longrightarrow V^{4+} + 2I^-$

10 gm

$\downarrow I_2 \rightarrow V^{4+}$

Moles $V^{2+} \equiv 2$ Moles $V_2O_5 = \frac{20}{182} =$ Moles $I_2 \Rightarrow$ Moles $I_2 = 10/91$

4. $\dfrac{Cr_2O_7^{2-} + 14H^+ + 6e^- \longrightarrow 2Cr^{3+} + 7H_2O \text{ and } 2I^- \longrightarrow I_2 + 2e^-}{K_2Cr_2O_7 + 14HI \longrightarrow 2KI + 2CrI_3 + 3I_2 + 7H_2O}$; Moles HI $= \dfrac{3.584}{128} = 0.028$

(a) Moles of $K_2Cr_2O_7 = \dfrac{94}{294} = 0.32 \Rightarrow$ Moles of HI required $= 14 \times 0.32 <$ moles HI available.

$\Rightarrow$ HI is the limiting reagent. $\Rightarrow$ Moles $K_2Cr_2O_7$ consumed $= \dfrac{1}{14} \times 0.028 = 0.002$

$\Rightarrow$ Moles $K_2Cr_2O_7$ Left $= 0.32 - 0.002 = 0.318 \Rightarrow$ % of $K_2Cr_2O_7 = \dfrac{0.318}{0.32} = 99.375\%$

(b) Mole of $I_2 = \dfrac{3}{14} \times$ moles HI $= 0.006 \Rightarrow V_{I_2} = \dfrac{0.0821 \times 546 \times 0.006}{1} = 268.96$ ml

5. $0.02\,M\ KMnO_4 + 40\ ml, 0.1M\ FeSO_4 \xrightarrow{H+}$
$(\equiv 4\,mmole)$

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

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

$MnO_4^- + 5Fe^{2+} + 8H^+ \longrightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O$

$\Rightarrow \quad 2KMnO_4 + 10FeSO_4 + 8H_2SO_4 \longrightarrow 2MnSO_4 + 5Fe_2(SO_4)_3 + K_2SO_4 + 8H_2O$

$\Rightarrow \quad 1\,mmol\ KMnO_4 \equiv 5\,mmol\ FeSO_4 \Rightarrow 4\ mmol\ FeSO_4 = \dfrac{4}{5}\ mmol\ KMnO_4 = 0.02 \times V_{KMnO_4} \Rightarrow V_{KMnO_4} = 40ml$

6. $MnO_4^- + NO_2^- \longrightarrow NO_3^- + MnO_2$

$\Rightarrow \quad MnO_4^- + 3e^- \longrightarrow MnO_2 + 4OH^-$

and $NO_2^- + 2OH^- \longrightarrow NO_3^- + H_2O + 2e^-$

$3NO_2^- + 2MnO_4^- + H_2O \longrightarrow 3NO_3^- + 2MnO_2 + 2OH^-$

$\Rightarrow \quad 2mol\ MnO_4^- \equiv 3mol\ NO_2^- \quad \Rightarrow \quad 1\,mol\,MnO_4^- \equiv 1.5\,mol\,NO_2^-$

7. $40\,ml\,KMnO_4 + 0.8g\,Na_2C_2O_4 . 2H_2O \xrightarrow{H^+}$

$2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \longrightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$

$mmol\,C_2O_4^{2-} \equiv \dfrac{0.8}{170} \times 1000 = \dfrac{80}{17} \quad \Rightarrow \quad mmol\ MnO_4^- \equiv \dfrac{80}{17} \times \dfrac{2}{5} = 40 \times M_{KMnO_4}$

(i) $N_{KMnO_4^-} = 5M_{KMnO_4} = \dfrac{4}{17}\ N = 0.235N$ **(ii)** Strength $=$ NE $= 0.235 \times \dfrac{158}{5} = 7.43\ g/L$

8. $C_2H_5OH + 2Cr_2O_7^{2-} + 16H^+ \longrightarrow 2CO_2 + 4Cr^{3+} + 11H_2O$

Moles of $Cr_2O_7^{2-} = 8.76 \times 0.05 \Rightarrow$ mmoles $C_2H_5OH = \dfrac{1}{2} \times 8.76 \times 0.05 = 0.219\,mmol\,C_2H_5OH = 0.01\,g\,C_2H_5OH$

$\Rightarrow \quad$ % of alcohol level $= \dfrac{0.01}{10} \times 100 = 0.1\%$

9. (i) (D) $\text{mmoles } IO_3^- = \frac{0.66}{198} \times 1000 = \frac{10}{3}$

$IO_3^- + 3HSO_3^- \longrightarrow I^- + 3H^+ + 3SO_4^{2-}$ $\quad \text{mmoles } HSO_3^- = 3 \times \frac{10}{3} = 10$

$\Rightarrow$ amount of $NaHSO_3 = 10 \times 10^{-3} \times 104 = 1.04$ gm

(ii) (C) $4I^- + Hg^{2+} \longrightarrow HgI_4^{2-}$

1 mol 1 mol

– $1-\frac{1}{4}$ $\frac{1}{4}$ mol $\Rightarrow$ 0.25 mol HgI_4^{2-}

EXERCISE-C

1. $KI + H_2O_2 \longrightarrow I_2 + H_2O$ (20 ml)

$I_2 \rightarrow$ 15 ml, 0.4N $Na_2S_2O_3$

Meq $Na_2S_2O_3 = 0.4 \times 15 = 6 =$ Meq. $I_2 =$ Meq. $H_2O_2 = 20 \times N_{H_2O_2} \Rightarrow N_{H_2O_2} = \frac{6}{20} \Rightarrow$ Vol. Strength of $H_2O_2 = \frac{6}{20} \times 5.6 = 1.68$

2. $Cu \xrightarrow{0.4gm} CuSO_4 \xrightarrow{H^+/KI} I_2 + Cu_2I_2$

$I_2 \rightarrow 0.248$ gm $Na_2S_2O_3.5H_2O$

Mmoles $Na_2S_2O_3.5H_2O = \frac{0.248}{248} \times 1000 = 1 \Rightarrow$ Mmoles $I_2 = 1 \times \frac{1}{2}$ $\quad [I_2 + 2Na_2S_2O_3 \xrightarrow{H^+} I^- + S_4O_6^{2-}]$

$2Cu^{2+} + 4I^- \longrightarrow I_2 + Cu_2I_2$

$\Rightarrow$ 1 mmol $I_2 \equiv 2$ mmol $Cu^{2+} \Rightarrow$ Mmoles $Cu^{2+} = 2 \times \frac{1}{2} = 1 =$ Mmoles Cu $\Rightarrow g_{Cu} = 10^{-3} \times 63.5 = 0.0635$

$\%\,Cu = \frac{0.0635}{0.4} \times 100\% = 15.87\%$

3. $\underbrace{\underset{x\text{ gm}}{Na_2C_2O_4} + K_2C_2O_4}_{0.367\text{ gm}} + 0.04N, 125\text{ml } KMnO_4$

$\Rightarrow$ Meq. O.A. = Meq. R.A. $\Rightarrow 0.04 \times 125 = \left[\frac{x}{134/2} + \frac{0.367-x}{166/2}\right] \times 1000 \Rightarrow x = 0.2$ gm

$\Rightarrow \%\,Na_2C_2O_4 = \frac{0.2}{0.367} \times 100\% = 54.7\%$

4. Meq. $KMnO_4 = (0.1 \times 5) \times V =$ Meq. $Na_2S_2O_3 = \frac{0.158}{158/1} \times 1000 \Rightarrow V = 2$ml

5. $\underbrace{FeSO_4.7H_2O + Fe_2(SO_4)_3.9H_2O}_{5.5g} \equiv$ 5.4ml, 0.1N $KMnO_4$ (Only $FeSO_4$ is oxidised)

$\Rightarrow$ Meq. $FeSO_4 . 7H_2O = 0.1 \times 5.4 = 0.54 \Rightarrow g_{FeSO_4.7H_2O} = \frac{0.54 \times 278}{1000} = 0.15$

$\Rightarrow$ $g_{Fe_2(SO_4)_3.9H_2O} = 5 - 0.15 = 5.35gm \Rightarrow$ Moles $Fe_2(SO_4)_3.9H_2O = \frac{5.35}{562} = 9.52 \times 10^{-3}$

6. $Fe(HC_2O_4)_2 : M_o = 234$ **(i)** Acid : $2H^+ \Rightarrow$ n-factor = 2 $\Rightarrow E = \frac{234}{2} = 117$

(ii) R.A. : n-factor = 5 $\Rightarrow E = \frac{234}{5} = 46.8$ $\begin{bmatrix} HC_2O_4^- \longrightarrow 2CO_2 + H^+ + 2e^- \\ Fe^{2+} \longrightarrow Fe^{3+} + e^- \end{bmatrix}$

7. 3.55 gm $Ca(ClO)_2 + H_2O$ ($\downarrow Cl_2$) $\longrightarrow$ 100 ml $\longrightarrow$ 25 ml + KI $\xrightarrow{H^+}$ $I_2 \equiv Na_2S_2O_3$ (20 ml, 0.125 N)

Meq $Na_2S_2O_3 = 0.125 \times 20 = 2.5 =$ Meq Cl_2(in 25 ml) $\Rightarrow$ Meq $Cl_2 = 2.5 \times 4 = 10$ (in 100 ml)

$\Rightarrow \frac{g}{71/2} \times 1000 = 10 \Rightarrow g = 0.355 \Rightarrow$ % of available $Cl_2 = \frac{0.355}{3.55} \times 100\% = 10\%$

$\Rightarrow Br_2 + 12OH^- \longrightarrow 2BrO_3^- + 6H_2O + 10e^-$

8. (i) $MnO_4^{2-} \longrightarrow MnO_2 + MnO_4^-$

$MnO_4^{2-} + 4H^+ + 2e^- \longrightarrow MnO_2 + 2H_2O$

$MnO_4^{2-} \longrightarrow MnO_4^- + e^-$

$3MnO_4^{2-} + 4H^+ \longrightarrow MnO_2 + 2MnO_4^- + 2H_2O$

$\Rightarrow E \equiv \frac{3}{2} M_{MnO_4^{2-}} = \frac{3}{2} \times 119 = 178.5$

(ii) $Cl_2 + OH^- \longrightarrow Cl^- + ClO_2^-$

$Cl_2 + 2e^- \longrightarrow 2Cl^-$ **....(i)**

$Cl_2 + 8OH^- \longrightarrow 2ClO_2^- + 4H_2O + 6e^-$ **....(ii)**

$4Cl_2 + 8OH^- \longrightarrow 2Cl^- + 2ClO_2^- + 4H_2O$

$\Rightarrow E \equiv \frac{4}{6} \times 71 = 47.33$

(iii) $HCuCl_2 \longrightarrow Cu + Cu^{2+} + 4Cl^- + 2H^+$

$HCuCl_2 + e^- \longrightarrow Cu + 2Cl^- + H^+$ **....(i)**

$HCuCl_2 \longrightarrow Cu^{2+} + 2Cl^- + H^+ + e^-$ **....(ii)**

$2HCuCl_2 \longrightarrow Cu + Cu^{2+} + 4Cl^- + 2H^+$

$\Rightarrow E \equiv \frac{2 \times M_{HCuCl_2}}{1} = 271$

9. (i) (B) Meq $KMnO_4$ = Meq H_2O_2 $\Rightarrow 10 \times \frac{10}{5.6} = \frac{g}{158/5} \times 1000 \Rightarrow g = 0.563gm$

(ii) (D) $2S_2O_3^{2-} \longrightarrow S_4O_6^{2-} + 2e^- \Rightarrow$ n – factor = 1

(iii) (C) $CrO_4^{2-} \longrightarrow Cr(OH)_4^{-6}$ [n – factor of $CrO_4^{2-} = 3$] ; $S_2O_3^{2-} \longrightarrow SO_4^{2-}$ [n – factor of $S_2O_3^{2-} = 8$]

$\Rightarrow (0.1 \times 3) \times V = (0.25 \times 8) \times 40 \Rightarrow V = \frac{800 \, ml}{3}$

(iv) (B) $I^- + H_2SO_4 \longrightarrow I_2 + H_2S$

$\Rightarrow 2I^- \longrightarrow I_2 + 2e^-$ and $H_2SO_4 + 8H^+ + 8e^- \longrightarrow H_2S + 4H_2O$

$8KI + 5H_2SO_4 \longrightarrow 4I_2 + H_2S + 4H_2O + 4K_2SO_4$

$\text{Moles } H_2S = \frac{3.4}{34} = 0.1 \Rightarrow \text{Moles } H_2SO_4 = 0.1 \times 5 = 0.2 \times V \Rightarrow V = 2.5L$

(v) (B) $\text{Meq } As_2O_3 = \frac{0.46}{198/4} \times 1000 \ [As_2O_3 \longrightarrow AsO_4^{3-}] = \text{Meq } KMnO_4 = (5 \times M) \times 25 \Rightarrow M = 0.074$

(vi) (A) $Sn^{2+} \longrightarrow Sn^{4+} + 2e^- \Rightarrow 2\text{gmeq} . (\equiv 1 \text{ mol}) \equiv \text{gmeq. } K_2Cr_2O_7 = 6 \times \text{moles} \Rightarrow \text{Moles } K_2Cr_2O_7 = 1/3$

(vii) (D) $\text{Meq. } KMnO_4 = 10 \times \frac{1}{0.56} = 10 \times N_{H_2O_2} \Rightarrow x = 5.6 \times N_{H_2O_2} = 10$

(viii) (D) $H_3PO_2 \longrightarrow PH_3 + H_3PO_3$

$H_3PO_2 + 4H^+ + 4e^- \longrightarrow PH_3 + 2H_2O$

$H_3PO_2 + H_2O \longrightarrow H_3PO_3 + 2H^+ + 2e^-$

$\Rightarrow E_{H_3PO_2} = \frac{3M_{H_3PO_2}}{4}$