HINTS & SOLUTIONS

Redox Reactions

[Set-1]

SECTION-A

1. (ii): Oxidation state of Cl is +7 and Cl has 7 valence electrons.

   Sulphur has 6 valence electrons but oxidation state of S in $Na_2S_2O_3$ is +2 and in H_2SO_3 is +4. Nitrogen has 5 valence electrons and oxidation state of N in N_2O_4 is +4.

2. (iv): Oxidation state of oxygen is charging from –2 in H_2O to zero in HOF.

3. (i): Nitrogen is present in its highest oxidation state of +5.

4. (iii):

5. (iv): Highest oxidation state always act as an oxidizing agent and lowest oxidation state as a reducing agent. Whenever the calculated oxidation state is more than its valence electrons, then it contains peroxide linkage.

6. (iv): Oxidation state of oxygen in OF_2 is +2.

7. (iii):

8. (iv):

9. (ii): $\overset{-2}{O}=\overset{+2}{C}=\overset{0}{C}=\overset{+2}{C}=\overset{-2}{O}$

10. (iv): BaO_2, O is –1

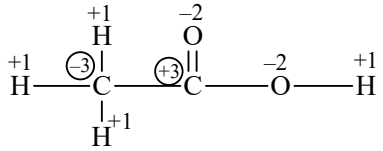
    KO_2, O is $-\frac{1}{2}$

    O_2F_2, O is +1

11. $Mn^{3+} + e^- \longrightarrow Mn^{2+}$ reduction half reaction

    $Mn^{3+} + 2H_2O \longrightarrow MnO_2 + 4H^+ + e^-$ oxidation half reaction

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

12. 

OR

(i) $\underline{Cr_2}O_7^{2-}$ $\quad 2x + 7(-2) = -2$

$x = +6$

Oxidation state of Cr is +6

(ii) $\underline{\underline{Al}}(SO_4)_2^-$ $\quad x + 2(+6) + 8(-2) = -1$

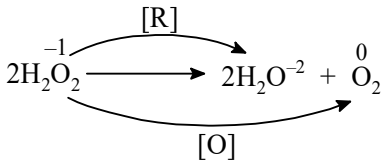
$x + 12 - 16 = -1$

$x = +3$

Oxidation state of Al is +3

13. The redox reactions in which the same substance undergo oxidation and reduction are called disproportionation reactions.

Example:



Considtions:

(i) The element should have minimum three different oxidation states.

(ii) The element undergoing disproportionation should be in the intermediate oxidation state.

14. The skeletal equation is

$$Cr_2O_7^{2-} + SO_3^{2-} + H^+ \longrightarrow Cr^{3+} + SO_4^{2-}$$

(i) Split into two half reactions

$$Cr_2O_7^{2-} \longrightarrow Cr^{3+}$$

$$SO_3^{2-} \longrightarrow SO_4^{2-}$$

(ii) Balance all atoms except O and H

$$Cr_2O_7^{2-} \longrightarrow 2Cr^{3+}$$

$$SO_3^{2-} \longrightarrow SO_4^{2-}$$

(iii) Balance oxygen atoms by adding water

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

$$SO_3^{2-} + H_2O \longrightarrow SO_4^{2-}$$

(iv) Balance all hydrogens by adding H^+ ion

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

$$SO_3^{2-} + H_2O \longrightarrow SO_4^{2-} + 2H^+$$

(v) Balance charge by adding electrons

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

Oxiation: $SO_3^{2-} + H_2O \longrightarrow SO_4^{2-} + 2H^+ + 2e^-$

(vi) Balance the electrons in two half reactions and add

$$Cr_2O_7^{2-} + 3SO_3^{2-} + 8H^+ \longrightarrow 2Cr^{3+} + 3SO_4^{2-} + 4H_2O$$

OR

The skeletal equation is

$$MnO_4^- + I^- \longrightarrow I_2 + MnO_2$$

(i) Split redox reaction into two half reactions

$$MnO_4^- \longrightarrow MnO_2$$

$$I^- \longrightarrow I_2$$

(ii) Balance all atom except O and H

$$MnO_4^- \longrightarrow MnO_2$$

$$2I^- \longrightarrow I_2$$

(iii) Balance O by adding H_2O

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

$$2I^- \longrightarrow I_2$$

(iv) Balance H by adding H^+ ion

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

$$2I^- \longrightarrow I_2$$

(v) Balance charge by adding electrons

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

$$2I^- \longrightarrow I_2 + 2e^-$$

(vi) Add two half reactions after balancing electrons

$$2MnO_4^- + 6I^- + 8H^+ \longrightarrow 2MnO_2 + 3I_2 + 4H_2O$$

(vii) Since the medium is basic, add OH^- ions equal to H^+ ion on both sides, then cancel out H_2O

$$2MnO_4^- + 6I^- + \begin{pmatrix} 8H^+ \\ 8OH^- \end{pmatrix} \longrightarrow 2MnO_2 + 3I_2 + 4H_2O + 8OH^-$$

$$2MnO_4^- + 6I^- + 8H_2O \longrightarrow 2MnO_2 + 3I_2 + 4H_2O + 8OH^-$$

$$2MnO_4^- + 6I^- + 4H_2O \longrightarrow 2MnO_2 + 3I_2 + OH^-$$

15. (i) Pb_3O_4 is a mixture of two oxides PbO in +2 and PbO_2 in +4 oxidation state of Pb. Since higher oxidation state are oxidizing and therefore in the first reaction PbO_2 oxidises HCl to Cl_2 gas and PbO reacts with HCl to give $PbCl_2 + H_2O$.

HNO_3 itself a very strong oxidizing agent, will not react with PbO_2 but reacts with PbO to give acid base reaction.

$$\underbrace{PbO_2 + PbO}_{Pb_3O_4} + 2HNO_3 \longrightarrow Pb(NO_3)_2 + H_2O + PbO_2$$

(ii) $\overset{(-1)}{NaCl} < \overset{(+1)}{Ca(OCl)_2} < \overset{(+5)}{ClO_3^-} < \overset{(+7)}{HClO_4}$

(iii) Split redox reaction into two half reactions

$$P_4 \rightarrow PH_3$$

$$P_4 \rightarrow H_2PO_2^-$$

(a) Balance all atoms except H and O

$$P_4 \rightarrow 4PH_3$$

$$P_4 \rightarrow 4H_2PO_2^-$$

(b) Balance O atom by adding H_2O

$$P_4 \rightarrow 4PH_3$$

$$8H_2O + P_4 \longrightarrow 4H_2PO_2^-$$

(c) Balance H atom by adding H^+ ions

$$P_4 + 12H^+ \longrightarrow 4PH_3$$

$$8H_2O + P_4 \longrightarrow 4H_2PO_2^- + 8H^+$$

(d) Balance charge by adding electrons

$$12e^- + 12H^+ + P_4 \longrightarrow 4PH_3$$

$$8H_2O + P_4 \longrightarrow 4H_2PO_2^- + 8H^+ + 4e^-$$

(e) Add two half reactions after balancing electrons

$$[12e^- + 12H^+ + P_4 \longrightarrow 4PH_3]$$

$$[8H_2O + P_4 \longrightarrow 4H_2PO_2^- + 8H^+ + 4e] \times 3$$

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

$$P_4 + 6H_2O \longrightarrow PH_3 + 3H_2PO_2^- + 3H^+$$

(f) Since the medium is basic, add OH– equals to H+ ions on both sides.

$$P_4 + 6H_2O + 3OH^- \longrightarrow PH_3 + 3H_2PO_2^- + 3H^+ + 3OH^-$$

$$P_4 + 3H_2O + 3OH^- \longrightarrow PH_3 + 3H_2PO_2^-$$

OR

(i) $\overset{(-2)}{H_2O}(s) + \overset{(0)}{F_2}(g) \longrightarrow \overset{(-1)}{HF}(g) + \overset{(0)}{HOF}(g)$

In this reaction, the oxidation state of oxygen is changing from –2 to zero and oxidation state of fluorine is changing from zero to –1. Hence, this reaction is a redox reaction.

Oxidising agent → Fluorine, F_2

Reducing agent → Water, H_2O

(ii) (a) $2\overset{(+6)}{SO_4^{2-}} \longrightarrow \overset{(+6)}{S_2O_8^{2-}} + 2e^-$ (no change in the oxidation state of sulphur)

(b) $\overset{(+4)}{Na_2SO_3} + \overset{(0)}{S} \longrightarrow \overset{(+2)}{Na_2S_2O_3}$

This involves the change in the oxidation state of sulphur.

(iii) $Cl_2O_7 + H_2O_2 \longrightarrow ClO_2^- + O_2 + H^+$

(a) Split the redox reaction into two half reactions

$$Cl_2O_7 \longrightarrow ClO_2^-$$

$$H_2O_2 \longrightarrow O_2$$

(b) Balance all atoms except H and O

$$Cl_2O_7 \longrightarrow 2ClO_2^-$$

$$H_2O_2 \longrightarrow O_2$$

(c) Balance O atoms by adding H_2O

$$Cl_2O_7 \longrightarrow 2ClO_2^- + 3H_2O$$

$$H_2O_2 \longrightarrow O_2$$

(d) Balance H atoms by adding H^+ ions

$$Cl_2O_7 + 6H^+ \longrightarrow 2ClO_2^- + 3H_2O$$

$$H_2O_2 \longrightarrow O_2 + 2H^+$$

(e) Balance charge by adding electrons

$$Cl_2O_7 + 6H^+ + 8e^- \longrightarrow 2ClO_2^- + 3H_2O$$

$$H_2O_2 \longrightarrow O_2 + 2H^+ + 2e^-$$

(f) Add two half reactions after balancing electrons

$$Cl_2O_7 + 4H_2O_2 \longrightarrow 2ClO_2^- + 4O_2 + 2H^+ + 3H_2O$$

