CHAPTER 08

REDOX REACTIONS-3

13. Disproportionation Reaction

In a disproportionation reaction an element in one oxidation state is simultaneously oxidises and reduced.
For example,

$$\overset{+1\ -1}{2H_2O_2(aq)} \longrightarrow \overset{+1\ -2}{2H_2O(l)} + \overset{0}{O_2(g)}$$

Hence, the oxygen of peroxide, which is present in -1 oxidation state is connected to zero oxidation state and in O_2 and in H_2O decreases to -2 oxidation state.

14. Balancing of Redox Reactions

➢ **Oxidation Number Method**

(a) Write the correct formula for each reactant and product.
(b) By assigning the oxidation change in oxidation number can be identified.
(c) Calculate the increase and decrease in oxidation number per atom with respect to the reactants. If more than one atom is present then multiply by suitable coefficient.
(d) Balance the equation with respect to all atoms. Balance hydrogen and oxygen atoms also.
(e) If the reaction is carried out in acidic medium, use H^+ ions in the equation. If it is in basic medium use OH^- ions.
(f) Hydrogen atoms in the expression can be balanced by adding (H_20) molecules to the reactants or products.
If there are the same number of oxygen atoms on the both side of equation then it represents the balanced redox reaction.

Half Reaction Method

In this method two half equation are balanced separately and then added together to give balanced equation.

Let us consider the oxidation of Fe^{2+} ions to Fe^{3+} ions by dichromate ions ($Cr_2O_7^{2-}$) ions in acidic medium $(Cr_2O_7)^{2-}$ ions are reduced to Cr^{3+} ions.

Following steps are involved:

1. Write the unbalanced equation for the reaction in ionic form.

$$Fe^{2+}(aq) + Cr_2O_7^{2-}(aq) \longrightarrow Fe^{3+}(aq) + Cr^{3+}(aq)$$

2. **Separate the equation in two half reactions:**

Oxidation half:

$$\overset{+2}{Fe^{2+}}(aq) \longrightarrow \overset{+3}{Fe^{3+}}(aq)$$

Reduction half:

$$\overset{+6\ -2}{Cr_2O_7^{2-}} \longrightarrow \overset{+3}{Cr^{3+}}aq)$$

3. $$Cr_2O_7^{2-}(aq) \longrightarrow 2Cr^{3+}(aq)$$

4. Add H_2O to balance O atoms and H^+ to balance H atoms.

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

5. Add electrons to one side to balance the charges.

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

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

To equalise the number of electrons in both half reactions, we multiply the oxidation half reaction by 6.

$$6Fe^{2+}(aq) \longrightarrow 6Fe^{3+}(aq) + 6e^-$$

6. The net ionic reaction can be written as

$$6Fe^{2+}(aq) + Cr_2O_7^{2-}(aq) + 14H^+(aq) \longrightarrow 6Fe^{3+}(aq) + 2Cr^{3+}(aq) + 7H_2O(l)$$

7. Verify the equation so that same type of number of atoms and the same charges on both sides of the equation.

15. Redox Titrations

Potassium Permanganate Titration: In these titrations' potassium permanganate (pink in colour) acts as an oxidising agent in the acidic medium while oxalic acid or some ferrous salts acts as a reducing agents.

The ionic equation can be written as:

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

$$2MnO_4^- + 16H^+ + 10Fe^{2+} \longrightarrow 2Mn^{2+} + 2H_2O + 10Fe^{3+}$$

On both these titrations, potassium permanganate itself acts as indicator. It is commonly known as self-indicator. The appearance of pink colour in the solution represents the end points.

Potassium Dichromate Titration: In place of potassium permanganate, potassium dichromate can also be used in the presence of dil. H_2SO_4. The ionic equation for the redox reaction with $FeSO_4$ (Fe^{2+} ions) is given.

$$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6Fe^{2+}(aq) \longrightarrow 2Cr^{3+}(aq) + 6Fe^{3+}(aq) + 7H_2O(l)$$

The reaction is used in the estimation of ferrous ions in volumetric analysis.

Sodium Thiosulphate Titration: The redox reaction between sodium thiosulphate ($S_2O_3^{2-}$ ions) and I_2 are also an example of redox titration.

$$I_2(aq) + 2S_2O_3^{2-}(aq) \longrightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

This method based on the fact that iodine itself gives an intense blue colour with starch and has a very specific reaction with thiosulphate ($S_2O_3^{2-}$) ions.