d – Block Elements

Potassium permanganate, $KMnO_4$:

It is prepared by fusing pyrolusite ore (MnO_2) with KOH in the presence of atmospheric oxygen or an oxidizing agent like KNO_3 or $KClO_3$ to get potassium manganate, K_2MnO_4 (green mass). The green mass is extracted with water and is oxidized to potassium

permanganate, either electrolytically or by passing chlorine or ozone into the solution. The purple solution is concentrated by evaporation which on cooling deposits crystals of $KMnO_4$.

$$2MnO_2 + 4KOH + O_2 \rightarrow 2K_2MnO_4 + 2H_2O$$

$$K_2MnO_4 \longrightarrow 2K^+ + MnO_4^{2-}$$

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

Green Purple

Properties:

(i) Potassium permanganate exists as dark purple black prismatic crystals having a greenish metallic lustre. It melts at 523 K. It is moderately soluble in water at room temperature giving a purple solution. However, its solubility in water increases with temperature.

(ii) **Effect of heat**. $2KMnO_4 \rightarrow K_2MnO_4 + MnO_2 + O_2$

(iii) **Oxidising properties**:

(a) In acidic medium :

$$2KMnO_4 + 3H_2SO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 3H_2O + 5[O]$$

[Equivalent weight of $KMnO_4$ in acidic medium $= \frac{158}{5} = 31.6$]

(b) In neutral medium :

$$2KMnO_4 + H_2O \rightarrow 2KOH + 2MnO_2 + 3[O]$$

[Equivalent weight of $KMnO_4$ in neutral medium $= \frac{158}{3} = 52.6$]

(c) In basic medium :

$$2KMnO_4 + 2KOH \rightarrow 2K_2MnO_4 + H_2O + [O]$$

[Equivalent weight of $KMnO_4$ in basic medium $= \frac{158}{1} = 158$]

In basic medium, MnO_4^- (manganate ions) is further reduced to MnO_2 in the presence of reducing agent. As such equivalent weight of $KMnO_4$ in basic medium is same as in neutral medium.

In acidic medium potassium permanganate oxidises.

(i) Ferrous to ferric salt

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

(ii) Oxalates to carbon dioxide

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

(iii) Iodides to iodine

$$10I^- + 2MnO_4^- + 16H^+ \rightarrow 2Mn^{2+} + 5I_2 + 8H_2O$$

(iv) Sulphites to sulphates

$$5SO_3^{2-} + 2MnO_4^- + 6H^+ \rightarrow 2Mn^{2+} + 5SO_4^{2-} + 3H_2O$$

In alkaline solution

(i) Iodides to iodates

$$I^- + 2MnO_4^- + H_2O \rightarrow \quad IO_3^- + 2MnO_2 + 2OH^-$$

Uses.

(i) As oxidizing agent in laboratory and industry.

(ii) In volumetric estimation of ferrous salts, oxalates and other reducing agents in redox titration.

(iii) As disinfectant in water.

(iv) For qualitative detection of halides, oxalates, tartarates.

Use of KMnO4 in redox – titrations:

Potassium permanganate is a powerful and versatile oxidizing agent and is widely used for titration against reducing agents like oxalic acid and Mohr's salt. During the titration, the reduction of potassium permanganate by a reducing agent e.g., oxalic acid or Mohr's salt, produces manganous ions which are nearly colourless.

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

As the titration proceeds and when the whole of the reducing agent is consumed up, then the addition of an excess drop of potassium permanganate solution gives its own colour (pink) to the solution. Therefore, at the end point the colour changes from colourless to pink. Thus, potassium permanganate acts as a self indicator.

****