Chemistry Study Materials for Class 12 (NCERT Based Questions with Answers)

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The d & f - Block Elements

Question 16: Describe the preparation of potassium permanganate. How does the acidified Permanganate solution react with (i) iron (II) ions (ii) SO_2 and (iii) oxalic acid? Write the ionic equations for the reactions.

Solution 16: Potassium permanganate can be prepared from pyrolusite (MnO_2). The ore is fused with KOH in the presence of either atmospheric oxygen or an oxidizing agent, such as KNO_3 or $KClO_4$, to give K_2MnO_4.

$$2MnO_2 + 4KOH + O_2 \xrightarrow{Heat} 2K_2MnO_4 + 2H_2O$$
(*Green*)

The green mass can be extracted with water and then oxidized either electrolytically or by passing chlorine/ozone into the solution. Electrolytic oxidation.

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

$$H_2O \longrightarrow H^+ + OH^-$$

At anode, manganate ions are oxidized to permanganate ions.

$$MnO_4^{2-} \longrightarrow MnO_4^{1-} + e^-$$
Green *Purple*

Oxidation by chlorine

$$2K_2MnO_4 + Cl_2 \longrightarrow 2KMnO_4 + 2KCl$$

$$2MnO_4^{2-} + Cl_2 \longrightarrow 2MnO_4^{1-} + 2Cl^{-1}$$

Oxidation by ozone

$$2K_2MnO_4 + O_3 + H_2O \longrightarrow 2KMnO_4 + 2KOH + O_2$$

$$2MnO_4^{2-} + O_3 + H_2O \longrightarrow 2MnO_4^{1-} + 2OH^{-1} + O_2$$

(i)Acidified $KMnO_4$ solution oxidizes Fe (II) ions to Fe (III) ions i.e.,

$$MnO_4^{1-} + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O$$

$$Fe^{2+} \longrightarrow Fe^{3+} + e^-]\times 5$$

$$MnO_4^{1-} + 5Fe^{2+} + 8H^+ \longrightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O$$

(ii)Acidified potassium permanganate oxidizes SO_2 to sulphuric acid.

$$MnO_4^{1-} + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O]\ X\ 2$$

$$2H_2O + 2SO_2 + O_2 \longrightarrow 4H^+ + 2SO_4^{2-} + 2e^-]\ X 5$$

$$2MnO_4^{1-} + 2H_2O + 10SO_2 + 5O_2 \longrightarrow 2Mn^{2+} + 10SO_4^{2} + 4H^+$$

(iii)Acidified potassium permanganate oxidizes oxalic acid to carbon dioxide.

$$MnO_4^{1-} + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O]\ X\ 2$$

$$C_2O_4^{2-} \longrightarrow 2CO_2 + 2e^-]\ X 5$$

$$2MnO_4^{1-} + 5C_2O_4^{2-} + 16H^+ \longrightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$$

Question 17: For M^{2+}/M and M^{3+}/M^{2+} systems, the $E^\ominus$ values for some metals are as follows

$Cr^{2+}/Cr = 0.9V$ $\quad Cr^{3+}/Cr^{2+} = 0.4V$ $\quad Mn^{2+}/Mn = 1.2V$
$Mn^{3+}/Mn^{2+} = 1.5V$ $\quad Fe^{2+}/Fe = 0.4V$ $\quad Fe^{3+}/Fe^{2+} = 0.8V$

Use this data to comment upon:

(i) The stability of Fe^{3+} in acid solution as compared to that of Cr^{3+}or Mn^{3+} and

(ii) The ease with which iron can be oxidized as compared to a similar process for either chromium or manganese metal.

Solution 17: (i) The $E^\ominus$ value for Fe^{3+}/Fe^{2+} is higher than that for Cr^{3+}/Cr^{2+} and lower than that for Mn^{3+}/Mn^{2+}. So, the reduction of Fe^{3+} to Fe^{2+} is easier than the reduction of Mn^{3+} to Mn^{2+}, but not as easy as the reduction of Cr^{3+} to Cr^{2+} Hence, Fe^{3+} is more stable than Mn^{3+}, but less stable than Cr^{3+}. These metal ions can be arranged in the increasing order of their stability as: $Mn^{3+} < Fe^{3+} < {}_{Cr}3+$

(ii)The reduction potentials for the given pairs increase in the following order.

$Mn^{2\ominus}/Mn \ominus Cr^{2\ominus}/Cr \ominus Fe^{2\ominus}/Fe$. So, the oxidation of Fe to Fe^{2+} is not as easy as the oxidation of Cr to Cr^{2+} and the oxidation of Mn to Mn^{2+}. Thus, these metals can be arranged in the increasing order of their ability to get oxidized as: Fe < Cr < Mn

Question 18: Predict which of the following will be coloured in aqueous solution?

Ti^{3+}, V^{3+}, Cu^{+}, Sc^{3+}, Mn^{2+}, Fe^{3+} and CO^{2+}. Give reasons for each.

Solution 18: Only the ions that have electrons in *d*-orbital will be coloured. The ions in which *d*-orbital is empty will be colourless.

Element	Atomic Number	Ionic State	Electronic configuration in ionic State
Ti	22	Ti^{3+}	$[Ar]3d^1$
V	23	V^{3+}	$[Ar]3d^2$
Cu	29	Cu^{+}	$[Ar]3d^{10}$
Sc	21	Sc^{3+}	[Ar]
Mn	25	Mn^{2+}	$[Ar]3d^5$
Fe	26	Fe^{3+}	$[Ar]3d^5$
Co	27	Co^{2+}	$[Ar]3d^7$

From the above table, it can be easily observed that only Sc^{3+} has an empty *d*-orbital. All other ions, except , Sc^{3+}, will be coloured in aqueous solution because of *d*−*d* transitions.

Question 19: Compare the stability of +2 oxidation state for the elements of the first transition series.

Sc			+3				
Ti	+1	+2	+3	+4			
V	+1	+2	+3	+4	+5		
Cr	+1	+2	+3	+4	+5	+6	
Mn	+1	+2	+3	+4	+5	+6	+7
Fe	+1	+2	+3	+4	+5	+6	
Co	+1	+2	+3	+4	+5		
Ni	+1	+2	+3	+4			
Cu	+1	+2	+3				
Zn		+2					

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