

# CHEMISTRY STUDY MATERIALS FOR CLASS 12 (NCERT BASED QUESTIONS WITH ANSWERS)

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## The d & f - Block Elements

**Question 11: Explain giving reasons:**

- (i) Transition metals and many of their compounds show paramagnetic behaviour.
- (ii) The enthalpies of atomisation of the transition metals are high.
- (iii) The transition metals generally form coloured compounds.
- (iv) Transition metals and their many compounds act as good catalyst.

**Solution 11: (i)** Transition metals show paramagnetic behaviour. Paramagnetism arises due to the presence of unpaired electrons with each electron having a magnetic moment associated with its spin angular momentum and orbital angular momentum. However, in the first transition series, the orbital angular momentum is quenched. Therefore, the resulting Paramagnetism is only because of the unpaired electron.

(ii) Transition elements have high effective nuclear charge and a large number of valence electrons. Therefore, they form very strong metallic bonds. As a result, the enthalpy of atomization of transition metals is high.

(iii) Most of the complexes of transition metals are coloured. This is because of the absorption of radiation from visible light region to promote an electron from one of the *d*-orbitals to another. In the presence of ligands, the *d*-orbitals split up into two sets of orbitals having different energies. Therefore, the transition of electrons can take place from one set to another. The energy required for these transitions is quite small and falls in the visible region of radiation. The ions of transition metals absorb the radiation of a particular wavelength and the rest is reflected, imparting colour to the solution.

(iv) The catalytic activity of the transition elements can be explained by two basic facts.

(a) Owing to their ability to show variable oxidation states and form complexes, transition metals form unstable intermediate compounds. Thus, they provide a new path with lower activation energy,  $E_a$ , for the reaction.

(b) Transition metals also provide a suitable surface for the reactions to occur.

**Question 12: What are interstitial compounds? Why are such compounds well known for transition metals?**

**Solution 12:** Transition metals are large in size and contain lots of interstitial sites. Transition elements can trap atoms of other elements (that have small atomic size), such as H, C, N, in the interstitial sites of their crystal lattices. The resulting compounds are called interstitial compounds.

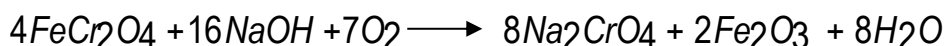
**Question 13: How is the variability in oxidation states of transition metals different from that of the non- transition metals? Illustrate with examples.**

**Solution 13:** In transition elements, the oxidation state can vary from +1 to the highest oxidation state by removing all its valence electrons. Also, in transition elements, the oxidation states differ by 1 ( $Fe^{2+}$  and  $Fe^{3+}$   $Cu^{1+}$  and  $Cu^{2+}$ ) in non-transition elements, the oxidation states differ by 2, for example, +2 and +4 or +3 and +5, etc.

**Question 14: Describe the preparation of potassium dichromate from iron chromite ore. What is the effect of increasing pH on a solution of potassium dichromate?**

**Solution 14:** Potassium dichromate is prepared from chromite ore  $FeCr_2O_4$  in the following steps.

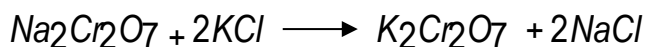
**Step (1):** Preparation of sodium chromate



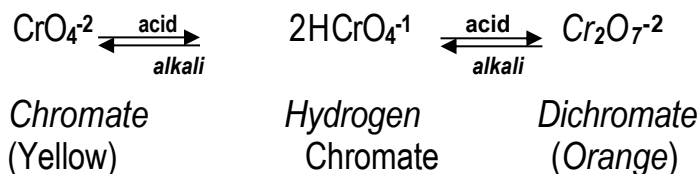
**Step(2):** Conversion of sodium chromate into sodium dichromate



**Step(3):** Conversion of sodium dichromate to potassium dichromate

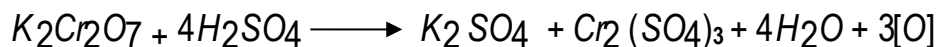


Potassium chloride being less soluble than sodium chloride is obtained in the form of orange coloured crystals and can be removed by filtration. The dichromate ion  $Cr_2O_7^{2-}$  exists in equilibrium with chromate  $CrO_4^{2-}$  ion at pH 4. However, by changing the pH, they can be interconverted.

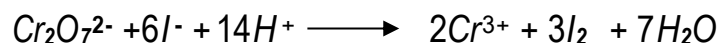
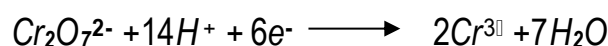


**Question 15: Describe the oxidizing action of potassium dichromate and write the ionic equations for its reaction with: (i) iodide (ii) iron(II) solution and (iii) H<sub>2</sub>S**

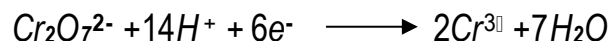
**Solution 15:**  $K_2Cr_2O_7$  acts as a very strong oxidizing agent in the acidic medium.



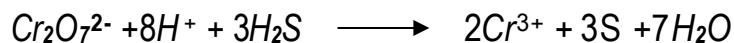
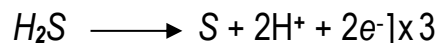
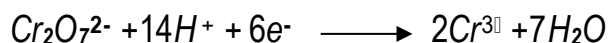
(i)  $K_2Cr_2O_7$  takes up electrons to get reduced and acts as an oxidizing agent. The reaction with other iodide, iron (II) solution, and  $H_2S$  are given below. (i)  $K_2Cr_2O_7$  oxidizes iodide to iodine.



(ii)  $K_2Cr_2O_7$  oxidizes iron (II) solution to iron (III) Solution i.e., ferrous ions to ferric ions.

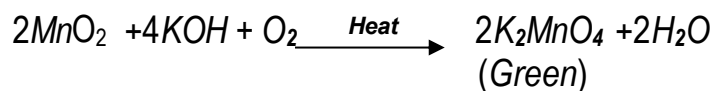


(iii)  $K_2Cr_2O_7$  Oxidizes  $H_2S$  to sulphur

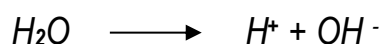
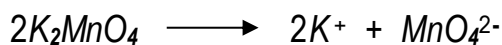


**Question 16: Describe the preparation of potassium permanganate. How does the acidified Permanganate solution react with (i) iron (II) ions (ii)  $SO_2$  and (iii) oxalic acid? Write the ionic equations for the reactions.**

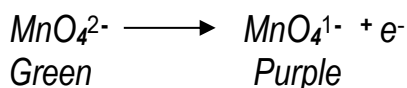
**Solution 16:** Potassium permanganate can be prepared from pyrolusite ( $MnO_2$ ). The ore is fused with  $KOH$  in the presence of either atmospheric oxygen or an oxidizing agent, such as  $KNO_3$  or  $KClO_4$ , to give  $K_2MnO_4$ .



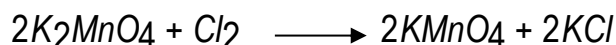
The green mass can be extracted with water and then oxidized either electrolytically or by passing chlorine/ozone into the solution. Electrolytic oxidation.



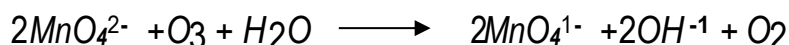
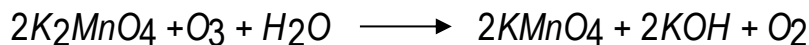
At anode, manganate ions are oxidized to permanganate ions.



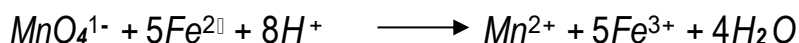
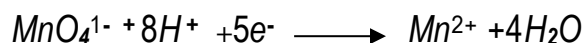
### Oxidation by chlorine



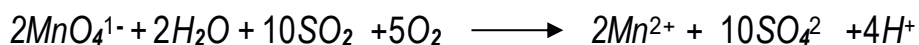
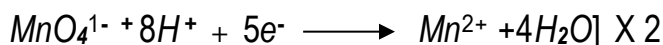
### Oxidation by ozone



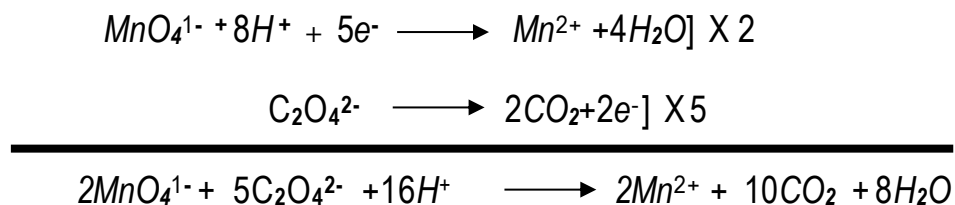
(i) Acidified  $\text{KMnO}_4$  solution oxidizes Fe (II) ions to Fe (III) ions i.e.,



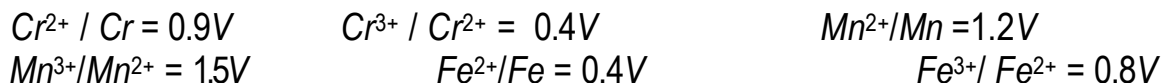
(ii) Acidified potassium permanganate oxidizes  $\text{SO}_2$  to sulphuric acid.



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



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



Use this data to comment upon:

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

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

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

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

$\text{Ti}^{3+}$ ,  $\text{V}^{3+}$ ,  $\text{Cu}^{2+}$ ,  $\text{Sc}^{3+}$ ,  $\text{Mn}^{2+}$ ,  $\text{Fe}^{3+}$  and  $\text{CO}^{2+}$ . 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 <sup>3+</sup>	[Ar]3d <sup>1</sup>
V	23	V <sup>3+</sup>	[Ar]3d <sup>2</sup>
Cu	29	Cu <sup>+</sup>	[Ar]3d <sup>10</sup>
Sc	21	Sc <sup>3+</sup>	[Ar]
Mn	25	Mn <sup>2+</sup>	[Ar]3d <sup>5</sup>
Fe	26	Fe <sup>3+</sup>	[Ar]3d <sup>5</sup>
Co	27	Co <sup>2+</sup>	[Ar]3d <sup>7</sup>

From the above table, it can be easily observed that only Sc<sup>3+</sup> has an empty *d*-orbital. All other ions, except , Sc<sup>3+</sup>, 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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