CBSE Test Paper-05

Class 12 Chemistry (The d- & f- Block Elements)

1. Electronic configuration of Mn^{2+} is
   a. [Ar] $3d^5$
   b. [Ar] $3d^4$
   c. [Ar] $3d^3$
   d. [Ar] $3d^2$
2. How many d–block elements have ability to evolve hydrogen gas from 2% nitric acid?
   a. Many
   b. 1
   c. 3
   d. 2
3. The product of oxidation of I^- with MnO_4^- in acidic medium is
   a. I_2
   b. IO_3^-
   c. IO^-
   d. IO_4^-
4. Ag^+ ion is isoelectronic with
   a. Pd^{2+}
   b. Cd^{2+}
   c. Cu^+
   d. Zn^{2+}
5. Which of the following compound is amphoteric?
   a. $Fe(OH)_2$
   b. $Fe(OH)_3$
   c. $Cr(OH)_3$
   d. $Cr(OH)_2$

6. Actionoid contraction is more than lanthanoid contraction. Give reason.

7. Why transition elements act as good catalyst?

8. Why do most transition metal ions exhibit paramangnetism?

9. Complete the following reactions:
   $Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow \_\_\_ + 7H_2O$

10. Write balanced equations to represent what happens when
    i. Acidified $KMnO_4$ solution reacts with iron (II) ions
    ii. Pyrolusite is fused with KOH in the presence of air

11. The outer electronic configuration of atoms of two members of lanthanoid series are given below:
    i. $4f^1\ 5d^1\ 6s^2$
    ii. $4f^7\ 5d^0\ 6s^2$
    Find their atomic number. What oxidation states will possibly be exhibited by these elements?

12. What is meant by disproportionation. Give two examples of disproportionation reaction in aqueous solution.

13. 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.

14. What is meant by 'disproportionation'? Give two examples of disproportionation reaction in aqueous solution.

15. Describe the preparation of potassium permanganate. How does the acidified permanganate solution react with
    i. iron
    ii. ions
    iii. SO_2
    iv. oxalic acid?
    Write the ionic equations for the reactions.

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Solutions

1. a. [Ar] $3d^5$

   Explanation: Atomic number of Mn is 25 with electronic configuration of [Ar] $3d^5$ $4s^2$. On removal of two electrons to get Mn^{2+}, electronic configuration becomes [Ar] $3d^5$.

2. d. 2

   Explanation: Both Zn and Fe can displace Hydrogen from HNO_3.

3. a. I_2

   Explanation: Iodine is liberated from potassium iodide.

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

4. b. Cd^{2+}

   Explanation: Atomic number of Ag is 47 with electronic configuration of [Kr] $4d^{10}$ $5s^1$ whereas for Cd, atomic number is 48 and electronic configuration is [Kr] $4d^{10}$ $5s^2$. Ag^+ is isoelectronic with Cd^{2+}, since electronic configuration of both of them is [Kr] $4d^{10}$.

5. c. $Cr(OH)_3$

   Explanation: Amphoteric substances are those which can act as either acids or bases. $Cr(OH)_3$ in water produces either salts (chromates), if combined with alkaline hydroxides (strong bases) such as potassium or sodium chromates and it can produce chromium salts if combined with strong acids (HCl, HF, H_2SO_4 etc.) giving chromium sulfate, chloride, fluoride etc.

6. Decrease or contraction in atomic size due to increase in the effective nuclear charge on the outermost shell and poor shielding by 5f electrons. This is referred to as actinoid contractions.

   The actinoid contraction is more than Lanthanoid contraction as the shielding power of 5f orbitals is poorer than 4f orbitals.

7. The transition metals and their compounds are known for their catalytic activity. This activity is due to their ability to adopt multiple oxidation states and to form complexes.

8. Most transition metal ions exhibit paramaganetism due to presence of unpaired electrons in them. Thus, they are attracted in external magnetic field.

9. $Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$

10. i. $5Fe^{2+} + MnO_4^- + 8H^+ \rightarrow Mn^{2+} + 4H_2O + 5Fe^{3+}$
    ii. $2MnO_2 + 4KOH + O_2 \xrightarrow{\Delta} 2K_2MnO_4 + 2H_2O$
11. i. Ce (58) it shows +4 oxidation state.
    ii. Eu (63) it shows +2 oxidation state.
12. The reaction in which same substance is oxidized and reduced simultaneously is called disproportionation reactions.
    For example:
    a. $Cu^+ \rightarrow Cu + Cu^{2+}$
    b. Cr(V) undergoes disproportion in acidic medium as follows:
    $CrO_4^{3-} + 8H^+ \rightarrow 2CrO_4^{2-} + Cr^{3+} + 4H_2O$
13. When an electron from a lower energy d orbital is excited to a higher energy d orbital, the energy of excitation corresponds to the frequency of light absorbed. This frequency generally lies in the visible region. The colour observed corresponds to the complementary colour of the light absorbed. This is known as d-d transition. Only the ions in which d-d transition is possible will be coloured. The ions in which d-orbitals are empty or completely filled will be colourless as no d-d transition is possible in those configurations.

Element and Atomic Number	**Electronic configuration of metal**	**Ionic State**	**Electronic configuration of ions**
Ti (Z=22)	[Ar]$3d^2 4s^2$	Ti^{3+}	[Ar]$3d^1$
V(Z=23)	[Ar]$3d^3 4s^2$	V^{3+}	[Ar]$3d^2$
Cu(Z=29)	[Ar]$3d^{10} 4s^1$	Cu^+	[Ar]$3d^{10}$

Sc(Z=21)	[Ar]$3d^1 4s^2$	Sc^{3+}	[Ar]
Mn(Z=25)	[Ar]$3d^5 4s^2$	Mn^{2+}	[Ar]$3d^5$
Fe(Z=26)	[Ar]$3d^6 4s^2$	Fe^{3+}	[Ar]$3d^5$
Co(Z=27)	[Ar]$3d^7 4s^2$	Co^{2+}	[Ar]$3d^7$

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

14. Reactions in which a relatively less stable oxidation state undergoes simultaneous oxidation to one higher oxidation state and reduction to one lower oxidation state. This is called disproportionation reactions. For example,
    i. $\underset{Cr(V)}{3CrO_4^{3-}} + 8H^+ \rightarrow \underset{Cr(VI)}{2CrO_4^{2-}} + \underset{Cr(III)}{Cr^{3+}} + 4H_2O$

       Cr(V) is oxidized to Cr(VI) and reduced to Cr(III).
    ii. $\underset{Mn(VI)}{3MnO_4^{2-}} + 4H^+ \rightarrow \underset{Mn(VII)}{2MnO_4^-} + \underset{Mn(iV)}{MnO_2} + 2H_2O$

        Mn (VI) is oxidized to Mn (VII) and reduced to Mn (IV).
15. Potassium permanganate can be prepared from pyrolusite (MnO_2) The ore is fused with KOH in the presence of either atmospheric oxygen or an oxidising agent, such as KNO_3 or $KClO_4$ to give K_2MnO_4.

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

    This produces green colour K_2MnO_4 which disproportionates in a neutral or acidic solution to give permanganate.

    $3MnO_4^{2-} + 4H^+ \rightarrow 2MnO_4^- + MnO_2 + 2H_2O$

    Commercially it is prepared by the alkaline oxidative fusion of MnO_2 followed by the electrolytic oxidation of manganate (Vl).

    $$MnO_2 \xrightarrow{fused\ with\ KOH,\ oxidised\ with\ KNO_3\ or\ air} MnO_4^{2-}$$

    $$MnO_4^{2-} \xrightarrow{Electrolytic\ oxidation\ in\ alkaline\ solution} MnO_4^-$$

    In the laboratory, a manganese (II) ion salt is oxidised by peroxodisulphate to permanganate.

$2Mn^{2+} + 5S_2O_8^{2-} + 8H_2O \rightarrow 2MnO_4^{-} + 10SO_4^{2-} + 16H^{+}$

$KMnO_4$ act as a good oxidising agent in acidic medium. In acidic medium MnO_4^{-} itself get reduced to Mn^{2+} and make the other substance get oxidised.

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

$$\begin{array}{rcl} MnO_4^{-} + 8H^{+} + 5e^{-} & \longrightarrow & Mn^{2+} + 4H_2O \\ Fe^{2+} & \longrightarrow & Fe^{3+} + e^{-}]\times 5 \\ \hline MnO_4^{-} + 5Fe^{2+} + 8H^{+} & \longrightarrow & Mn^{2+} + 5Fe^{3+} + 4H_2O \\ \hline \end{array}$$

ii. Acidified potassium permanganate oxidizes SO_2 to sulphuric acid.

$$\begin{array}{rcl} MnO_4^{-} + 6H^{+} + 5e^{-} & \longrightarrow & Mn^{2+} + 3H_2O\,]\times 2 \\ 2H_2O + 2SO_2 + O_2 & \longrightarrow & 4H^{+} + 2SO_4^{2-} + 2e^{-}]\times 5 \\ \hline 2MnO_4^{-} + 10SO_2 + 5O_2 + 4H_2O & \longrightarrow & 2Mn^{2+} + 10SO_4^{2-} + 8H^{+} \\ \hline \end{array}$$

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

$$\begin{array}{rcl} MnO_4^{-} + 8H^{+} + 5e^{-} & \longrightarrow & Mn^{2+} + 4H_2O]\times 2 \\ C_2O_4^{2-} & \longrightarrow & 2CO_2 + 2e^{-}]\times 5 \\ \hline 2MnO_4^{-} + 5C_2O_4^{2-} + 16H^{+} & \longrightarrow & 2Mn^{2+} + 10CO_2 + 8H_2O \\ \hline \end{array}$$