



# XII UNIT 9

Coordination Compounds

असतो मा सद्गमय

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MAHESH LATH'S CHEMISTRY MANTRA

105 Dilbagh Nagar Extension Jalandhar

## Unit 9

## Coordination Compounds

**Q1. Using IUPAC norms write the formula for the following: Tetrahydroxozincate(II)**

Ans.  $[\text{Zn}(\text{OH})_4]^{2-}$

**Q2. Using IUPAC norms write the formula for the following: Hexaamminecobalt(III) sulphate**

Ans.  $[\text{Co}(\text{NH}_3)_6]_2(\text{SO}_4)_3$

**Q3. Using IUPAC norms write the formula for the following: Pentaamminenitrito-cobalt(III)**

Ans.  $[\text{Co}(\text{ONO})(\text{NH}_3)_5]^{2+}$

**Q4. Using IUPAC norms write the systematic name of the following:  $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$**

Ans. Hexaamminecobalt(III) chloride

**Q5. Using IUPAC norms write the systematic name of the following:**

$[\text{Pt}(\text{NH}_3)_2\text{Cl}(\text{NH}_2\text{CH}_3)]\text{Cl}$

Ans. Diamminechlorido(methylamine) platinum(II) chloride

**Q6. Using IUPAC norms write the systematic name of the following:  $\text{c}[\text{Cr}(\text{C}_2\text{O}_4)_3]^{3+}$**

Ans. Tris(ethane-1, 2-diammine) cobalt(III) ion

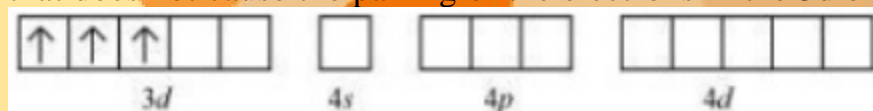
**Q7. What is Spectro chemical series? Explain the difference between a weak field ligand and a strong field ligand.**

Ans. A Spectro chemical series is the arrangement of common ligands in the increasing order of their crystal-field splitting energy (CFSE) values.

$\text{I}^- < \text{Br}^- < \text{S}_2^{2-} < \text{SCN}^- < \text{Cl}^- < \text{N}_3^- < \text{F}^- < \text{OH}^- < \text{C}_2\text{O}_4^{2-} \sim \text{H}_2\text{O} \sim \text{NCS}^- \sim \text{H}^- < \text{CN}^- < \text{NH}_3 < \text{en} \sim \text{SO}_3^{2-} < \text{NO}_2^- < \text{phen} < \text{CO}$

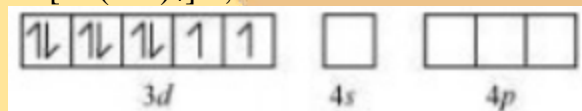
**Q8.  $[\text{Cr}(\text{NH}_3)_6]^{3+}$  is paramagnetic while  $[\text{Ni}(\text{CN})_4]^{2-}$  is diamagnetic. Explain why?**

Ans. Cr is in the +3 oxidation state i.e.,  $d^3$  configuration. Also,  $\text{NH}_3$  is a weak field ligand that does not cause the pairing of the electrons in the 3d orbital.  $\text{Cr}^{3+}$ :

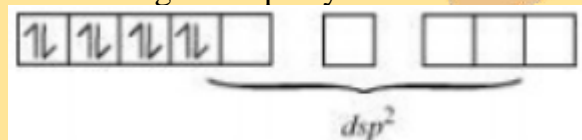


Therefore, it undergoes  $d^2sp^3$  hybridization and the electrons in the 3d orbitals remain unpaired. Hence, it is paramagnetic in nature.

In  $[\text{Ni}(\text{CN})_4]^{2-}$ , Ni exists in the +2 oxidation state i.e.,  $d^8$  configuration.  $\text{Ni}^{2+}$ :



$\text{CN}^-$  is a strong field ligand. It causes the pairing of the 3d orbital electrons. Then,  $\text{Ni}^{2+}$  undergoes  $dsp^2$  hybridization.



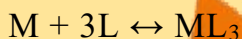
**Q.9 A solution of  $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$  is GREEN BUT A SOLUTION OF  $[\text{Ni}(\text{CN})_4]^{2-}$  colourless. Explain.**

**Ans.** In  $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$  is a weak field ligand. Therefore, there are unpaired electrons in  $\text{Ni}^{2+}$ . In this complex, the d electrons from the lower energy level can be excited to the higher energy level i.e., the possibility of d-d transition is present. Hence,  $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$  is coloured.

In  $[\text{Ni}(\text{CN})_4]^{2-}$ , the electrons are all paired as  $\text{CN}^-$  is a strong field ligand. Therefore, d-d transition is not possible in  $[\text{Ni}(\text{CN})_4]^{2-}$ . Hence, it is colourless. As there are no unpaired electrons, it is diamagnetic.

**Q.10 What is meant by stability of a coordination compound in solution? State the factors which govern stability of complexes.**

**Ans.** The stability of a complex in a solution refers to the degree of association between the two species involved in a state of equilibrium. Stability can be expressed quantitatively in terms of stability constant or formation constant.



$$\beta = \frac{[\text{ML}_3]}{[\text{M}][\text{L}]^3}$$

Stability constant

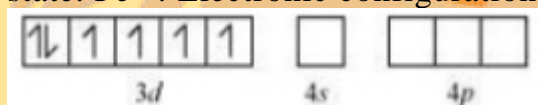
For this reaction, the greater the value of the stability constant, the greater is the proportion of  $\text{ML}_3$  in the solution.

### LONG ANSWER TYPE QUESTIONS

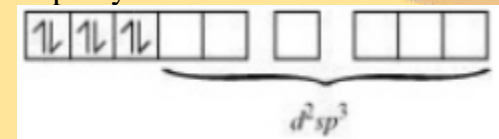
**Q1. Discuss the nature of bonding in the following coordination entities on the basis of valence bond theory:**



**Ans. i.**  $[\text{Fe}(\text{CN})_6]^{4-}$  In the above coordination complex, iron exists in the +II oxidation state.  $\text{Fe}^{2+}$ : Electronic configuration is  $3d^6$  Orbitals of  $\text{Fe}^{2+}$  ion:

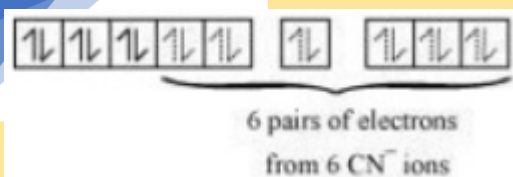


As  $\text{CN}^-$  is a strong field ligand, it causes the pairing of the unpaired 3d electrons. Since there are six ligands around the central metal ion, the most feasible hybridization is  $d^2sp^3$ .  $d^2sp^3$  hybridized orbitals of  $\text{Fe}^{2+}$  are:



6 electron pairs from  $\text{CN}^-$  ions occupy the six hybrid  $d^2sp^3$  orbitals. Then,

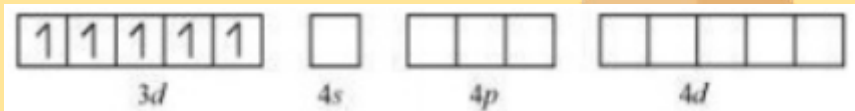




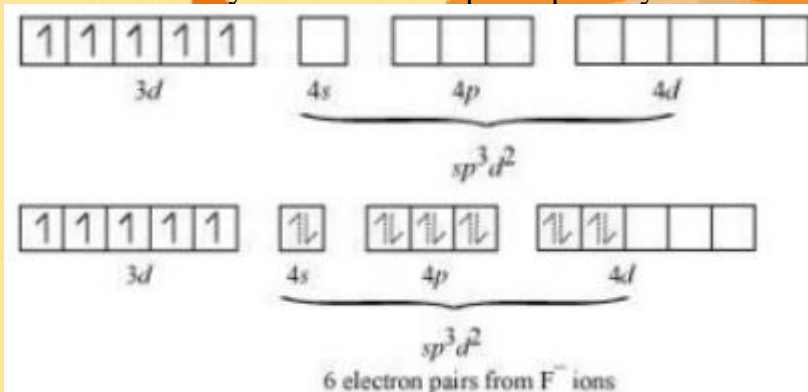
Hence, the geometry of the complex is octahedral and the complex is diamagnetic (as there are no unpaired electrons).

ii.  $[\text{FeF}_6]^{3-}$  In this complex, the oxidation state of Fe is +3.

Orbitals of  $\text{Fe}^{+3}$  ion:

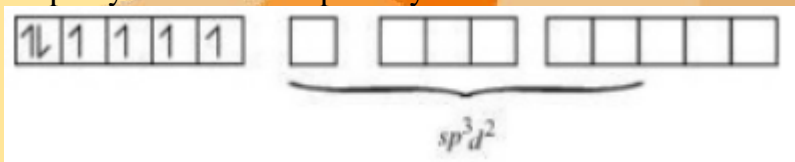


There are 6  $\text{F}^-$  ions. Thus, it will undergo  $d^2sp^3$  or  $sp^3d^2$  hybridization. As  $\text{F}^-$  is a weak field ligand, it does not cause the pairing of the electrons in the  $3d$  orbital. Hence, the most feasible hybridization is  $sp^3d^2$ .  $sp^3d^2$  hybridized orbitals of Fe are:

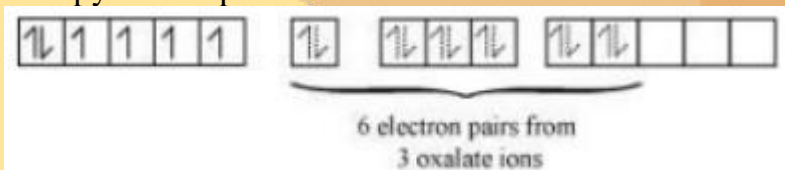


Hence, the geometry of the complex is found to be octahedral.

iii.  $[\text{Co}(\text{C}_2\text{O}_4)_3]^{3-}$  Cobalt exists in the +3 oxidation state in the given complex. Orbitals of  $\text{Co}^{3+}$  ion: Oxalate is a weak field ligand. Therefore, it cannot cause the pairing of the  $3d$  orbital electrons. As there are 6 ligands, hybridization has to be either  $sp^3d^2$  or  $d^2sp^3$  hybridization.  $sp^3d^2$  hybridization of  $\text{Co}^{3+}$ :



The 6 electron pairs from the 3 oxalate ions (oxalate anion is a bidentate ligand) occupy these  $sp^3d^2$  orbitals.

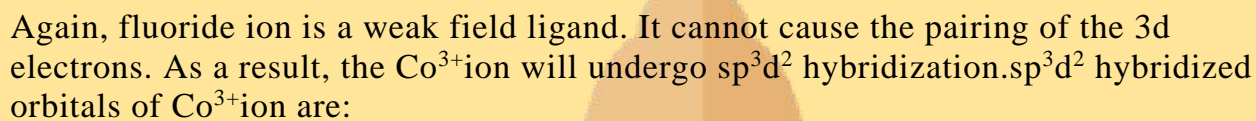


Hence, the geometry of the complex is found to be octahedral.





Orbitals of  $\text{Co}^{3+}$  ion:



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