

# CHEMISTRY STUDY MATERIALS FOR CLASS 12

## (NCERT BASED QUESTIONS - ANSWERS OF CHAPTER - 09)

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### Co-ordination Compounds

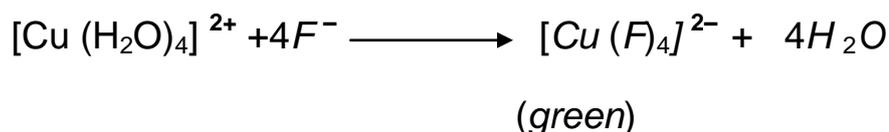
**Question 13:** Aqueous copper sulphate solution (blue in colour) gives:

- (i) a green precipitate with aqueous potassium fluoride, and
- (ii) a bright green solution with aqueous potassium chloride

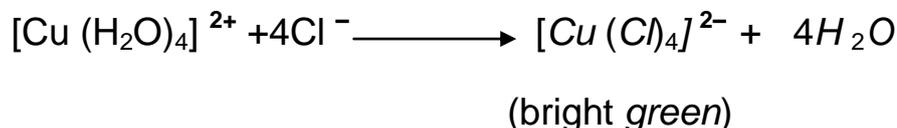
Explain these experimental results.

**Solution 13:** Aqueous  $CuSO_4$  exists as  $[Cu(H_2O)_4] SO_4$ . It is blue in colour due to the presence of  $[Cu(H_2O)_4]^{2+}$  ions.

(i) When KF is added:



(ii) When KCl is added:



In both these cases, the weak field ligand water is replaced by the  $F^-$  and  $Cl^-$  ions.

**Question 14:** What is the coordination entity formed when excess of aqueous KCN is added to an aqueous solution of copper sulphate? Why is it that no precipitate of copper sulphide is obtained when  $H_2S(g)$  is passed through this solution?

**Solution 14:**



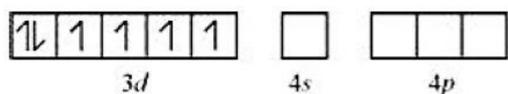
Thus, the coordination entity formed in the process is  $K_2[Cu(CN)_4]$ , is a very stable complex, which does not ionize to give  $Cu^{2+}$  ions when added to water. Hence,  $Cu^{2+}$  ions are not precipitated when  $H_2S(g)$  is passed through the solution.

**Question 15:** Discuss the nature of bonding in the following coordination entities on the basis of valence bond theory:

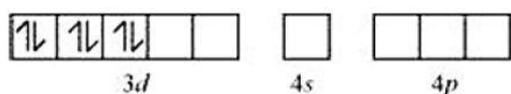
- (i)  $[\text{Fe}(\text{CN})_6]^{4-}$       (ii)  $[\text{FeF}_6]^{3-}$       (iii)  $[\text{Co}(\text{C}_2\text{O}_4)_3]^{3-}$       (iv)  $[\text{CoF}_6]^{3-}$

**Solution 15:**

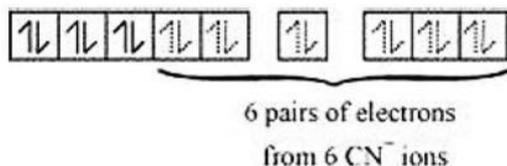
- (i)  $[\text{Fe}(\text{CN})_6]^{4-}$  In the above coordination complex, iron exists in the +II oxidation state.  $\text{Fe}^{2+}$ : Electronic configuration is  $3d^6$  Orbitals of  $\text{Fe}^{2+}$  ion.



As  $\text{CN}^-$  is a strong field ligand, it causes the pairing of the unpaired 3d electrons.

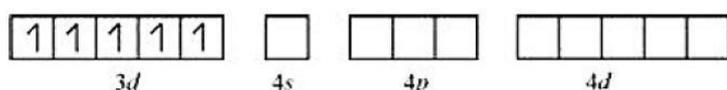


Since there are six ligands around the central metal ion, the most feasible hybridization is  $d^2sp^3$  hybridized orbitals of  $\text{Fe}^{2+}$  are:



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

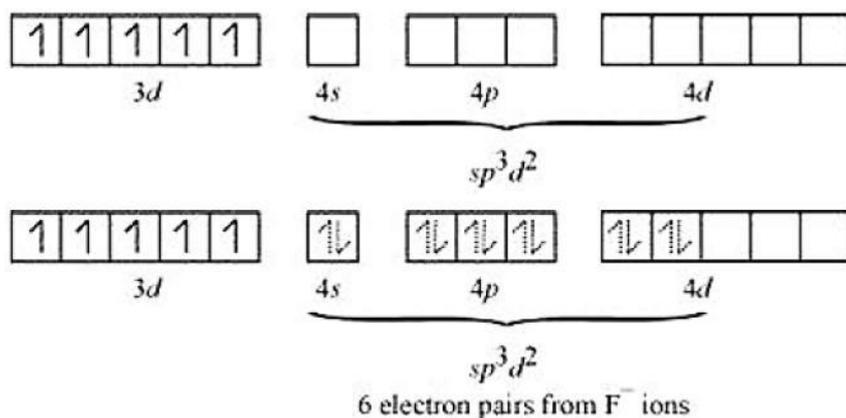
- (ii)  $[\text{FeF}_6]^{3-}$  In this complex, the oxidation state of Fe is +3.



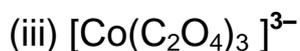
There are 6  $\text{F}^-$  ions. Thus, it will undergo  $d^2sp^3$  and  $sp^3d^2$  hybridization. As  $\text{F}^-$  is a weak field ligand, it does not cause the pairing of the electrons in the 3d orbital.

Hence, the most feasible hybridization is  $sp^3d^2$ .

$sp^3d^2$  hybridized orbitals of Fe are:

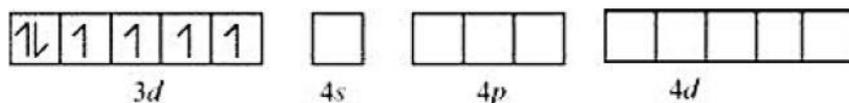


Hence, the geometry of the complex is found to be octahedral.



Cobalt exists in the +3 oxidation state in the given complex.

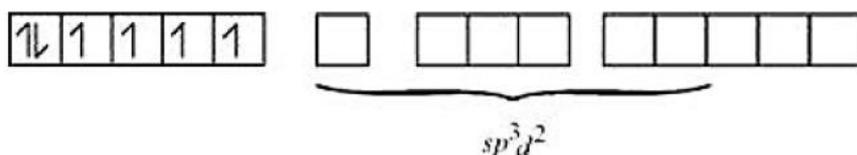
Orbitals of  $\text{Co}^{3+}$  ion:



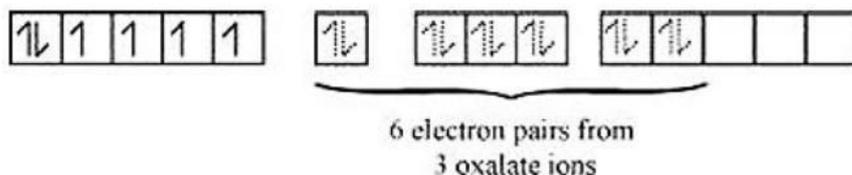
Oxalate is a weak field ligand. Therefore, it cannot cause the pairing of the 3d orbital electrons.

As there are 6 ligands, hybridization has to be either  $sp^3d^2$  and  $d^2sp^3$  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.

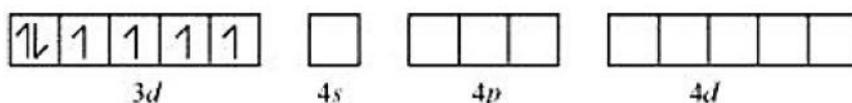


Hence, the geometry of the complex is found to be octahedral.



Cobalt exists in the +3 oxidation state.

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



Again, fluoride ion is a weak field ligand. It cannot cause the pairing of the 3d electrons. As a result, the  $\text{Co}^{3+}$  ion will undergo  $sp^3d^2$  hybridization.

$sp^3d^2$  hybridized orbitals of  $\text{Co}^{3+}$  ion are.

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