

CHEMISTRY STUDY MATERIALS FOR CLASS 12

(NCERT BASED QUESTIONS - ANSWERS OF CHAPTER - 09)

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Co-ordination Compounds

Question 4: What is meant by unidentate, bidentate and Ambidentate ligands? Give two examples for each.

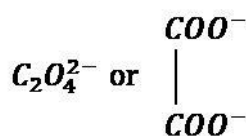
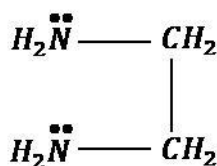
Solution 4: A ligand may contain one or more unshared pairs of electrons which are called the donor sites of ligands. Now, depending on the number of these donor sites, ligands can be classified as follows:

(a) **Unidentate ligands:** Ligands with only one donor sites are called unidentate ligands. For e.g., NH_3 , Cl^- etc.

(b) **Bidentate ligands:** Ligands that have two donor sites are called bidentate ligands. For e.g.,

.. (i) Ethane-1,2-diamine

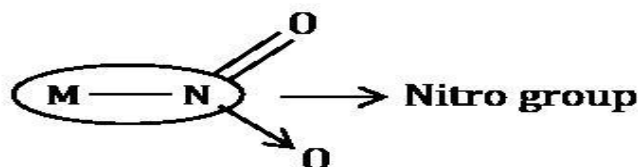
(ii) Oxalate ion



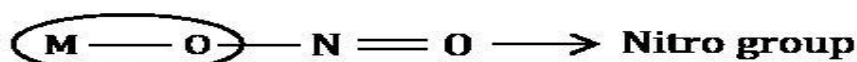
(b) **Ambidentate ligands:** Ligands that can attach themselves to the central metal atom through two different atoms are called Ambidentate Ligands.

For example:

(i) Nitro group



(The donor atom is N)



(The donor atom is oxygen)

(ii) Thiocyanate

Q. 5: Specify the oxidation numbers of the metals in the following coordination entities:

- (i) $[\text{Co}(\text{H}_2\text{O})(\text{CN})(\text{en})_2]^{2+}$ (ii) $[\text{CoBr}_2(\text{en})_2]^+$ (iii) $[\text{PtCl}_4]^{2+}$
 (iv) $\text{K}_3[\text{Fe}(\text{CN})_6]$ (v) $[\text{Cr}(\text{NH}_3)_3\text{Cl}_3]$

Solution 5:

- (i) $[\text{Co}(\text{H}_2\text{O})(\text{CN})(\text{en})_2]^{2+}$ (ii) $[\text{CoBr}_2(\text{en})_2]^+$

Let the oxidation number of Co be x. Let the oxidation number of Co be x.

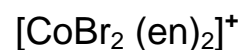
The charge on the complex is +2. The charge on the complex is +1.



$$x + 0 + (-1) + 2(0) = +2$$

$$x - 1 = +2$$

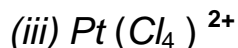
$$x = +3$$



$$x + 2(-1) + 2(0) = +1$$

$$x - 2 = +1$$

$$x = +3$$



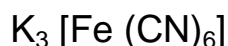
Let the oxidation number of Pt be x. Let the oxidation number of Fe be x.

The charge on the complex is +2. The charge on the complex is 0.



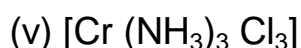
$$x + 4(-1) = +2$$

$$x - 4 = +2$$



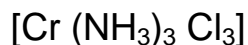
$$3(+1) + x + 6(-1) = 0$$

$$x = +3$$



Let the oxidation number of Cr be x.

The charge on the complex is 0.



$$x + 3(0) + 3(-1) = 0 \quad \text{or, } x - 3 = 0 \quad \text{or, } x = 3$$

Question 6: Using IUPAC norms write the formulas for the following:

- | | |
|---|---|
| (i) Tetrahydroxozincate(II) | (ii) Potassium tetrachloridopalladate(II) |
| (iii) Diamminedichloridoplatinum(II) | (iv) Potassium tetracyanonickelate(II) |
| (v) pentaamminenitrito-O-cobalt(III) | (vi) Hexaamminecobalt(III)sulphate |
| (vii) Potassium tri(oxalato)chromate(III) | (viii) Hexaammineplatinum(IV) |
| (ix) Tetrabromidocuprate(II) | (x) Pentaamminenitrito-N-cobalt(III) |

Solution 6:

- (i) $[\text{Zn}(\text{OH})_4]^{2-}$ (ii) $\text{K}_2[\text{PdCl}_4]$ (iii) $[\text{Pt}(\text{NH}_3)_2]\text{Cl}_2$ (iv) $\text{K}_2[\text{Ni}(\text{CN})_4]$
 (v) $[\text{Co}(\text{NH}_3)_5(\text{ONO})]^{2+}$ (vi) $[\text{Co}(\text{NH}_3)_6]_2(\text{SO}_4)_3$ (vii) $\text{K}_3[\text{Cr}(\text{C}_2\text{O}_4)_3]$
 (viii) $[\text{Pt}(\text{NH}_3)_6]^{4+}$ (ix) $[\text{Cu}(\text{Br})_4]^{2+}$ (x) $[\text{Co}(\text{NH}_3)_5(\text{NO}_2)]^{2+}$

Question 7: Using IUPAC norms write the systematic names of the following:

- (i) $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$ (ii) $[\text{Pt}(\text{NH}_3)_2\text{Cl}(\text{NH}_2\text{CH}_3)]\text{Cl}$
 (iii) $[\text{Ti}(\text{H}_2\text{O})_6]^{3+}$ (iv) $[\text{Co}(\text{NH}_3)_4\text{Cl}(\text{NO}_2)]\text{Cl}$
 (v) $[\text{Mn}(\text{H}_2\text{O})_6]^{2+}$ (vi) $[\text{NiCl}_4]^{2-}$
 (vii) $[\text{Ni}(\text{NH}_3)_6]\text{Cl}_2$ (viii) $[\text{Co}(\text{en})_3]^{3+}$ (ix) $[\text{Ni}(\text{CO})_4]$

Solution 7:

- (i) Hexaamminecobalt(III) chloride
 (ii) Diamminechlorido(methylamine)platinum(II) chloride
 (iii) Hexaqua titanium(III) ion (iv) Tetraamminichloridonitrito-N-Cobalt(III) chloride
 (v) Hexaquamanganese(II) ion (vi) Tetrachloridonickelate(II) ion
 (vii) Hexaamminenickel(II) chloride (viii) Tris(ethane-1, 2-diammine) cobalt(III) ion
 (ix) Tetracarbonylnickel(0)

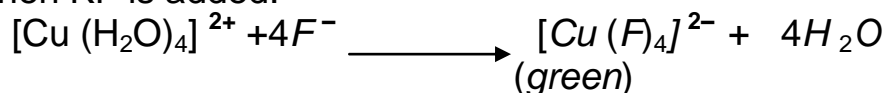
Question 13: Aqueous copper sulphate solution (blue in colour) gives:

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

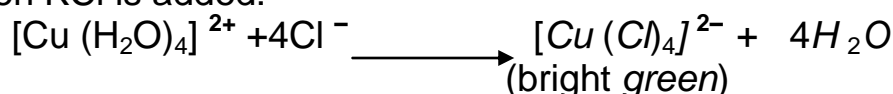
Explain these experimental results.

Solution 13: Aqueous CuSO_4 exists as $(\text{Cu}(\text{H}_2\text{O})_4)\text{SO}_4$. It is blue in colour due to the presence of $[\text{Cu}(\text{H}_2\text{O})_4]^{2+}$ ions.

(i) When KF is added:



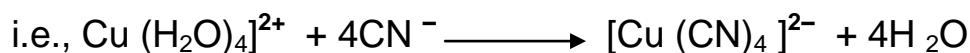
(ii) When KCl is added:



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 $\text{H}_2\text{S}(\text{g})$ is passed through this solution?

Solution 14:

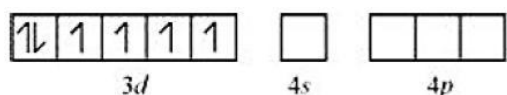


Thus, the coordination entity formed in the process is $\text{K}_2[\text{Cu}(\text{CN})_4]$, is a very stable complex, which does not ionize to give Cu^{2+} ions when added to water. Hence, Cu^{2+} ions are not precipitated when $\text{H}_2\text{S}(aq)$ is passed through the solution.

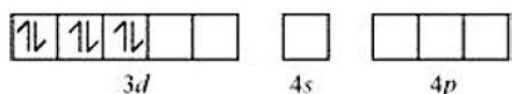
Question 15: Discuss the nature of bonding in the following coordination entities on the basis of valence bond theory:

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

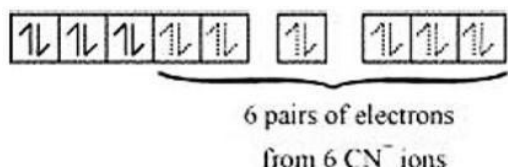
Solution 15: (i) $[\text{Fe}(\text{CN})_6]^{4-}$ In the above coordination complex, iron exists in the +II oxidation state. Fe^{2+} : Electronic configuration is $3d^6$ Orbitals of Fe^{2+} ion.



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

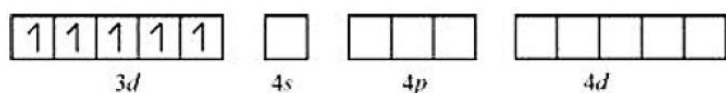


Since there are six ligands around the central metal ion, the most feasible hybridization is d^2sp^3 hybridized orbitals of Fe^{2+} are:



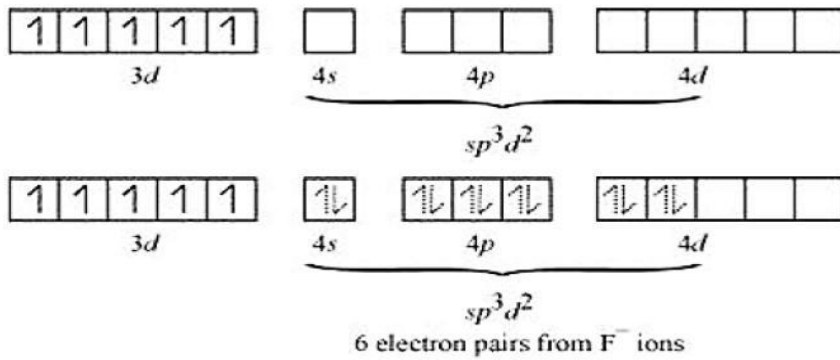
Hence, the geometry of the complex is octahedral and the complex is diamagnetic (as there are no unpaired electrons).

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



There are 6 F^- ions. Thus, it will undergo d^2sp^3 and sp^3d^2 hybridization. As 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 .

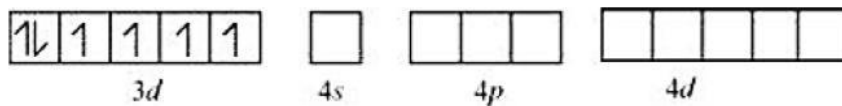
sp^3d^2 hybridized orbitals of Fe are:



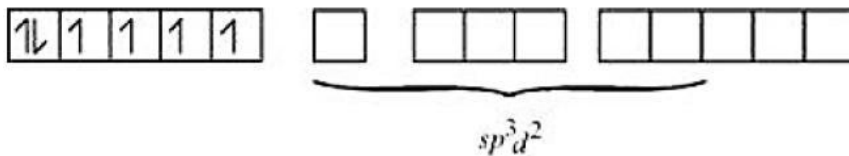
Hence, the geometry of the complex is found to be octahedral.

(iii) $[\text{Co}(\text{C}_2\text{O}_4)_3]^{3-}$ Cobalt exists in the +3 oxidation state in the given complex.

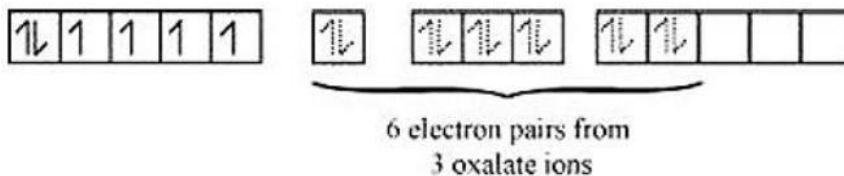
Orbitals of Co^{3+} ion:



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 Co^{3+}



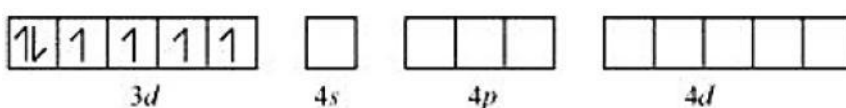
The 6 electron pairs from the 3 oxalate ions (oxalate anion is a bidentate ligand) occupy these sp^3d^2 orbitals.



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

(iv) $[\text{CoF}_6]^{3-}$ Cobalt exists in the +3 oxidation state.

Orbitals of Co^{3+} ion:



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