CBSE Test Paper-04

Class - 12 Chemistry (Coordination Compounds)

1. The octahedral complex, trioxalatochromate(III) will show
   a. Structural isomerism
   b. Optical isomerism
   c. Linkage isomerism
   d. Geometrical isomerism
2. The metal-carbon bond in metal carbonyls possess
   a. σ character
   b. π character
   c. single bond
   d. both σ and π character.
3. K_3CoF_6 is high spin complex. What is the hybrid state of Co atom in this complex?
   a. d^2sp^3
   b. dsp^2
   c. sp^3d
   d. sp^3d^2
4. The coordination number of Cr in $[Cr(NH_3)_3(H_2O)_3]Cl_3$ is
   a. 2
   b. 3
   c. 4
   d. 6
5. What is used as the complexing agent in volumetric analysis of ions like $Mg^{2+}$and Ca^{2+}?
   a. DMG
   b. EDTA
   c. All of these
   d. KSCN
6. Write the IUPAC name of $[Cu(NH_3)_4]SO_4$.

7. Write IUPAC name of given compound : $[Fe(C_2O_4)_3]^{3-}$.

8. Write formula for pentaamminechloro- platinum (IV) chloride.

9. Name two main factors that favours a metal ions forming complex.

10. How is the magnitude of Δ_0 affected by (i) nature of ligands and (ii) oxidation state of metal ion?

11. Write the IUPAC name of $[Co(NH_3)_3ONO]Cl_2$

12. Discuss the nature of bonding in metal carbonyls.

13. a. What is the basis of formation of spectrochemical series?
    b. Draw the structures of geometrical isomers of the coordination complexes: $[Co(NH_3)_3Cl_3$ and $[CoCl_2(en)_2]^+$.

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?

15. List various types of isomerism possible for coordination compounds, giving an example of each.

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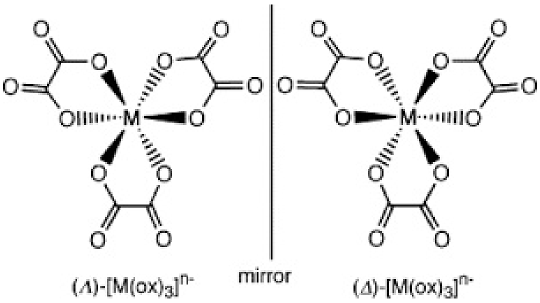
Solutions

1. (b) Optical isomerism

   Explanation: This complex has non-superimposable mirror images as shown.

   where M=Cr, n=3

   Thus, this complex shows optical isomerism

2. (d) both σ and π character.

   Explanation: The metal-carbon bond in metal carbonyls possesses both σ and π character. The M–C σ bond is formed by the donation of lone pair of electrons on the carbonyl carbon into a vacant orbital of the metal. The M–C π bond is formed by the donation of a pair of electrons from a filled d orbital of metal into the vacant antibonding π* orbital of carbon monoxide. The metal to ligand bonding creates a synergic effect which strengthens the bond between CO and the metal.

3. (d) sp^3d^2

   Explanation: Given complex can be written as $K_3[CoF_6]$. There are 3 Potassium ions K^+ means an overall +3 charge on cations and so the charge on the complex anion is -3. Each F^- ligand has -1 charge so there is a total of -6 charge on ligands. Let oxidation state of Co (Z=27) be x

   $x + (-6) = -3$

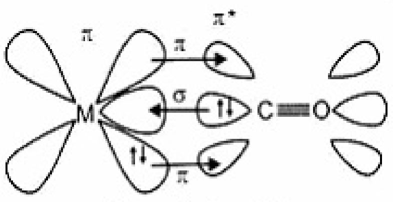
   $x = -3 + 6 = +3$

   So oxidation state of Co=+3 and its electronic configuration is $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$. Since its a high spin complex means there is no pairing of electrons in 3d subshell. Coordination number of Co is 6 as there are 6 ligands bound to it, so this octahedral complex has hybridization sp^3d^2.

4. (d) 6

   Explanation: Coordination number of the central metal atom/ion is equal to number of neutral molecules or negative ions bound to the central metal atom/ion by non-ionisable secondary linkages. These neutral molecules or negative ions are the ones which are shown inside the square bracket. Here there are 3 NH_3 molecules and 3 H_2O molecules associated with Cr inside the bracket. So the coordination number of Cr is 6.
5. (b) EDTA

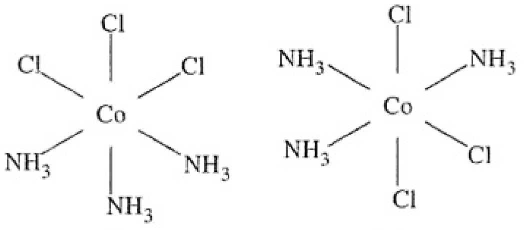
   Explanation: EDTA (ethylenediaminetetraacetato) is a hexadentate ligand and it forms stable chelate complex with given metal ions. The selective estimation of these ions can be done due to difference in stability constants of complexes of these ions with EDTA.
6. Tetraamine copper II sulphate
7. Trioxalatoferrate (III) ion
8. $[PtCl(NH_3)_5]Cl_3$
9. - Smaller size of cation and higher charge.
   - Presence of vacant d-orbitals.
10. i. Greater the strength of ligand, greater is the value of Δ_0
    ii. Δ_0 is also affected by oxidation state of central metal ion. Higher the charge on the central metal ion, greater will be the value of Δ_0
11. Hexaammine nitritocobalt III chloride
12. i. The metal carbon bond in metal carbonyls possess both S and P character.
    ii. The M-C σ bond is formed by the donation of lone pair of electrons on the carbonyl carbon into a vacant orbital of the metal.
    iii. The M-C π bond is formed by the donation of a pair of electrons form a filled d orbital of metal into the vacant anti bonding π^* orbital of carbon monoxide.
    iv. The metal to ligand bonding creates a synergic which strengthens the bond between CO and the metal.



Synergic bonding

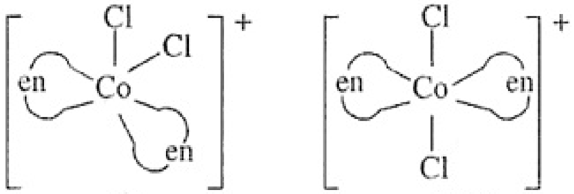
13. a. It is an experimentally determined series based on the absorption of light by complexes with different ligands. Li general, the ligands can be arranged in a series in order of increasing field strength as given below: I^- < Br < SCN^- < Cl^- < S^{2-} < F^- < OH" < C_2O < H_2O < NCS^- <EDT A^{4-} < NH_3 < en < CN^- < CO

Geometrical isomers of $[Co(NH_3)_3CI_3]$



cis- *trans-*

b. Geometrical isomers of $[CoCI_2(en)_2]^+$



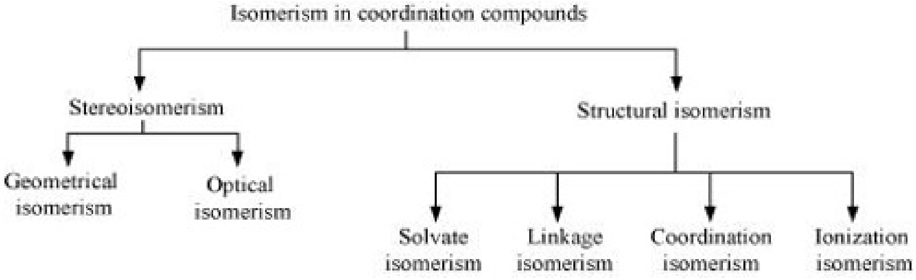
cis- *trans-*

14. $2CuSO_4 + 10KCN \rightarrow 2K_3 [Cu(CN)_4] + 2K_2SO_4 + (CN)_2$

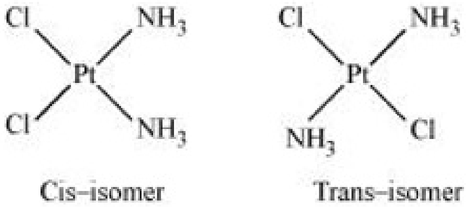
Thus, coordination entity formed = $[Cu(CN)_4]^{3-}$

As CN^- is a strong ligand, the complex ion is highly stable and does not dissociate to give Cu^{2+} ions. Hence, no precipitate with H_2S is formed.

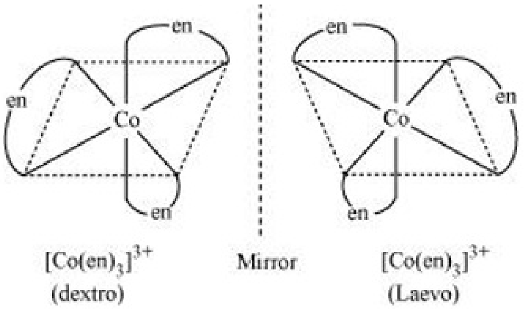
15.



i. Geometric isomerism: This type of isomerism is common in heteroleptic complexes. It arises due to the different possible geometric arrangements of the ligands. For example:



ii. Optical isomerism: This type of isomerism arises in chiral molecules. Isomers are mirror images of each other and are non-superimposable.



iii. Linkage isomerism: This type of isomerism is found in complexes that contain ambidentate ligands. For example: $[Co(NH_3)_5 (NO_2)] Cl_2$ and $[Co(NH_3)_5 (ONO)Cl_2$

Yellow form Red form

iv. Coordination isomerism:

This type of isomerism arises when the ligands are interchanged between cationic and anionic entities of different metal ions present in the complex.

$[Co(NH_3)_6] [Cr(CN)_6$ and $[C(NH_3)_6] [Co(CN_3)_6]$

v. Ionization isomerism:

This type of isomerism arises when a counter ion replaces a ligand within the coordination sphere. Thus, complexes that have the same composition, but furnish different ions when dissolved in water are called ionization isomers. For e.g., $Co(NH_3)_5SO_4Br$, and $Co(NH_3)_5BrSO_4$

vi. Solvate isomerism:

Solvate isomers differ by whether or not the solvent molecule is directly bonded to the metal ion or merely present as a free solvent molecule in the crystal lattice.

$[Cr(H_2O)_6] Cl_3$ $[Cr(H_2O)_5Cl]Cl_2.H_2O[Cr(H_2O)_5Cl_2$ $Cl.2H_2O$

Violet Blue-green Dark green