Chapter 9

Coordination Compounds

Solutions (Set-1)

SECTION - A

School/Board Exam. Type Questions

Very Short Answer Type Questions :

1. Identify the complex ion and counter ion in $K_4[Fe(CN)_6]$.

Sol. $[Fe(CN)_6]^{4-}$ and K^+ respectively.

2. Write coordination number of central metal atom in $[Pt(en)_2Cl_2]$.

Sol. 6

3. Calculate oxidation number of underlined atom in $K_3[\underline{Fe}(C_2O_4)_3]$.

Sol. +3

4. Calculate EAN of underlined atom in $[\underline{Cr}(NH_3)_6]Cl_3$.

Sol. 33

5. Write IUPAC name of $Na[Co(CO)_4]$.

Sol. Sodium tetracarbonylcobaltate(–I)

6. Assign the charge (x) on coordination sphere $[Ni(DMG)_2]^x$.

Sol. 0 as Ni(II)

7. Why does ammonia readily form complex while ammonium ion does not?

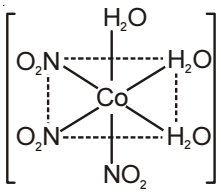
Sol. Ammonium ion (NH_4^+) neither has lone pair of electrons nor a vacant orbital.

8. What is the charge (x) present on $[Fe(CO)_4]^x$?

Sol. x = O

9. Draw the structure of fac-triaquatrinitrito-N-cobalt(III).

Sol.



10. Calculate magnetic moment in $Ni(CO)_4$.

Sol. Zero, as it has no unpaired electron.

Short Answer Type Questions :

11. $K_2[PtCl_6]$ is ionized to three ions, when dissolved in water. Will it give white precipitate with $AgNO_3$?

Sol. No, because all Cl^- are in complex sphere which are not free in solution.

$$K_2[PtCl_6] \rightleftharpoons 2K^+ + [PtCl_4]^{2-}$$

12. Calculate number of unpaired electrons of central atom in $[MnCl_4]^{2-}$.

Sol. Manganese is present as Mn(II) and Cl^- is weak ligand. Hence it has five unpaired electrons

Mn^{+2} 

13. Aqueous solution of potassium ferrocyanide does not give test of iron(II) and it is not poisonous like potassium cyanide. Why?

Sol. Being a complex salt, it ionizes to $4K^+$ and $[Fe(CN)_6]^{4-}$ ions. Absence of Fe(II) does not give the test of iron. Absence of free CN^- makes it non-poisonous.

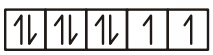
14. What is difference between oxygenation and oxidation?

Sol. In oxygenation, O_2 ligand is incorporated intact while in oxidation, it loses its identity.

15. Which type of *d*-electron configuration exhibit both low and high spin in octahedral complexes?

Sol. d^4, d^5, d^6, d^7.

16. All the octahedral complexes of Ni^{2+} are outer orbital complexes, why?

Sol. Ni^{+2} : 

Thus, only one 3*d*-orbital is available if all electrons paired up due to strong field ligand. Therefore, d^2sp^3 hybridisation is not possible. Only sp^3d^2 is possible which represents outer orbital complex.

17. $NH_2 - NH_2$ although possesses two electron pair for donation but not acts as chelating agent. Why?

Sol. The coordination by $NH_2 - NH_2$ leads to a three membered highly unstable strained ring and thus it does not act as chelating agent.

18. Why complex $[Al(NH_3)_6]^{3+}$ does not exist in aqueous solution?

Sol. $[Al(NH_3)_6]^{3+}$ undergoes the change into $[Al(H_2O)_6]^{3+}$ in aqueous medium due to higher heat of hydration of aluminium ion on account of its small size.

$$[Al(NH_3)_6]^{3+} + 6H_2O \longrightarrow [Al(H_2O)_6]^{3+} + 6NH_3$$

19. SCN^- shows linkage isomerism in coordination compounds. Explain.

Sol. Because it is ambidentate ligand.

20. Explain and arrange the following complexes in increasing order of molar conductivity on the basis of Werner theory :

(i) $[Cr(NH_3)_3(NO_2)_3]$

(ii) $K[Co(NH_3)_2(NO_2)_4]$

(iii) $K_2[Cr(NH_3)(NO_2)_5]$

Sol. i < ii < iii

Molar conductivity $\propto$ number of ions

21. How would you distinguish between $[Co(NH_3)_5SO_4]Br$ and $[Co(NH_3)_5Br]SO_4$ by chemical test?

Sol. $[Co(NH_3)_5SO_4]Br$ will give yellow precipitate of AgBr with $AgNO_3$, while $[Co(NH_3)_5Br]SO_4$ will give white precipitate of $BaSO_4$ with $BaCl_2$.

22. On the basis of VBT, explain geometry, nature of hybridisation and magnetic property of $[Co(ox)_3]^{3-}$.

Sol. Hybridisation – sp^3d^2

Geometry – octahedral

Paramagnetic in nature due to presence of four unpaired electrons.

23. Square planar complexes do not show optical isomerism. Why?

Sol. Because they contain a plane of symmetry.

24. $K_2[PtCl_6]$ is a well known compound but $K_2[NiCl_6]$ does not exist. Why?

Sol. Both Pt and Ni are in (IV) oxidation state and sum of ($IE_1 + IE_2 + IE_3 + IE_4$) is quite high for Ni in comparison to Pt.

25. $Ni(CO)_4$ possesses tetrahedral geometry, while $[Pt(NH_3)_4]^{2+}$ is square planar. Why?

Sol. $Ni(CO)_4$ possesses sp^3 hybridisation and then tetrahedral, whereas $[Pt(NH_3)_4]^{2+}$ possesses dsp^2 hybridisation, thus square planar.

26. Why does $[CoF_6]^{3-}$ give a high spin complex?

Sol. F^- is weak field ligand so it cannot pair up the electrons.

27. $[CuCl_4]^{2-}$ exists but $[CuI_4]^{2-}$ does not. Why?

Sol. $[CuI_4]^{2-}$ decomposed as $[CuI_4]^{2-} \longrightarrow 2CuI + 3I_2$. The instability may be explained as it is complex of oxidising agent (Cu^{2+}) and reducing agent (I^-). Also, I^- is poor electron donor than Cl^- and steric effect may also play some role.

28. What are essential requirements for regarding a compound as an organometallic? Give some examples.

Sol. In organometallic compounds, carbon forms bond with atom (metal/non-metal) which is less electronegative than carbon. For *e.g.*, $B(CH_3)_3$, $SiCl_3(CH_3)$ etc.

Long Answer Type Questions :

29. CO and N_2 are isoelectronic, but CO forms a number of complexes while N_2 forms very few. Explain.

Sol. N_2 is weaker σ-donor being very symmetrical and weaker π-acceptor than CO, so N_2 complexes are not much stable.

30. Explain why $[Cu(en)_2]^{2+}$ is less stable than $[Fe(EDTA)]^-$.

Sol. $[Cu(en)_2]^{2+}$ has two rings in the structure. On the other hand, $[Fe(EDTA)]^-$ has five rings in structure.

Greater the number of rings in chelate, more is stability of complex.

31. Identify (A) and (B) in the given sequence of reaction. Also write their IUPAC names and calculate spin only magnetic moment of B.

$$Fe^{3+}(aq) \xrightarrow{SCN^-(excess)} \underset{(blood\ red)}{A} \xrightarrow{F^-(excess)} \underset{(colourless)}{B}$$

Sol. $\underset{\text{(aq.)}}{Fe^{3+}} + \underset{\text{(excess)}}{SCN^-} \longrightarrow \underset{\text{(blood red)}}{\underset{A}{Fe(SCN)_3}} \xrightarrow[\text{(excess)}]{F^-} \underset{\text{(colourless)}}{\underset{B}{[FeF_6]^{3-}}}$

A = Trithiocyanoferrum(III)

B = Hexafluoroferrate(III) ion

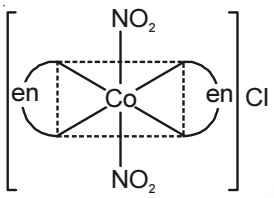
In $[FeF_6]^{3-}$, Fe^{3+} has $3d^5$ configuration.

F^-, being weak, $[FeF_6]^{3-}$ shows sp^3d^2 hybridisation with five unpaired electrons.

$$\mu = \sqrt{5(5+2)} = \sqrt{35} = 5.92 \text{ BM}$$

32. A compound $Co(en)_2 \cdot (NO_2)_2Cl$ exists in different isomeric forms. If it does not show optical activity, reacts with $AgNO_3$ but not with ethane-1,2-diammine, identify its structure.

Sol. It is trans isomer. It reacts with $AgNO_3$, so Cl atom is ionizable. It does not react with 'en', so two NO_2 groups are not adjacent.



33. The coordination number of Ni^{2+} in given complexes is 4.

$NiCl_2$ + KCN (excess) $\longrightarrow$ A (cyano complex)

$NiCl_2$ + conc. KCl (excess) $\longrightarrow$ B (chlorido complex)

Identify A and B, their magnetic moment with geometry.

Sol. A = $K_2[Ni(CN)_4]$

B = $K_2[NiCl_4]$

A is square planar with dsp^2 configuration. Due to absence of unpaired electron, it is diamagnetic (zero magnetic moment).

B is tetrahedral with sp^3 configuration, having two unpaired electrons (paramagnetic)

$$\mu = \sqrt{2(2+2)} = \sqrt{8} \text{ BM}$$

34. Arrange the following complexes in increasing order of CFSE (Δ_o) :

(i) $[Co(NH_3)_6]^{3+}$

(ii) $[Rh(NH_3)_6]^{3+}$

(iii) $[Ir(NH_3)_6]^{3+}$

Sol. a < b < c

Co, Rh and Ir belongs to 3*d*, 4*d* and 5*d* transition series respectively and CFSE increases by 30% between two adjacent members down the group.

35. A solution containing 0.319 gram of complex $CrCl_3 \cdot 6H_2O$ was passed through cation exchanger and the solution given out was neutralized by 28.5 ml of 0.125 M NaOH. What is the correct formula of complex?

Sol. The Cl atoms outside the coordination sphere will be ionized to produce acid HCl.

Thus, meq. of Cl^- ions outside = meq. of HCl formed

= meq. of NaOH used

= 28.5 × 0.125

= 3.56

Molar mass of $CrCl_3 \cdot 6H_2O$ = 266.5

millimoles of complex = $\frac{0.319 \times 10^3}{266.5} = 1.20$

1 millimole complex gives = $\frac{3.56}{1.20}$ millimole Cl^- = 3

Hence, complex is $[Cr(H_2O)_6]Cl_3$.

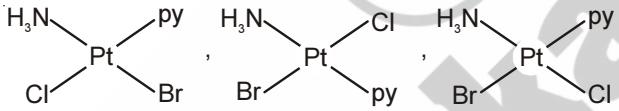
36. Write all the geometrical isomers of $[Pt(NH_3)(Cl)(py)(Br)]$. How many of these will exhibit optical isomerism?

Sol. Oxidation state of Pt = +2

Complex is square planar

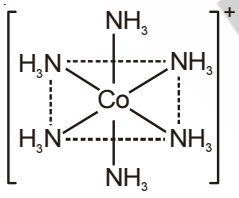
Square planar molecules of M(ABCD) type will not show optical isomerism.

Geometrical isomers are

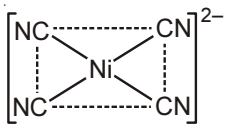


37. Draw the structures of $[Co(NH_3)_6]^{3+}$, $[Ni(CN)_4]^{2-}$ and $Ni(CO)_4$ and write hybridisation of each.

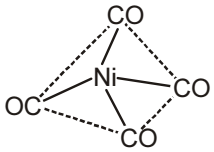
Sol. (i) $[Co(NH_3)_6]^{3+}$ ⇒ octahedral, d^2sp^3



(ii) $[Ni(CN)_4]^{2-}$ ⇒ square planar, dsp^2

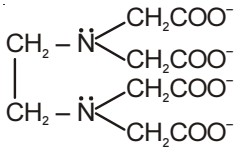


(iii) $[Ni(CO)_4]$ ⇒ tetrahedral, sp^3



38. Explain by structure that EDTA is hexadentate ligand.

Sol. EDTA has six sites to donate electrons.



Two N atoms and four O atoms are electron donor sites.

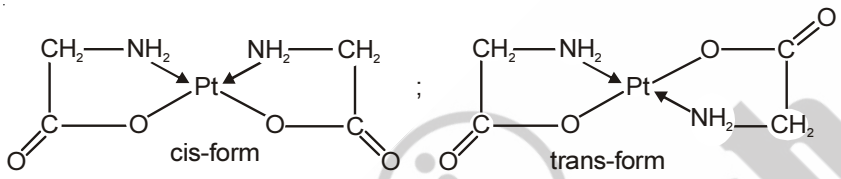
39. A solution of $[Ni(H_2O)_6]^{2+}$ is green but a solution of $[Ni(CN)_4]^{2-}$ is colourless. Why?

Sol. The value of energy difference between *d* levels (Δ) for the H_2O complex is in visible region and that for the cyano complex is in UV region.

40. Draw the structures of geometrical isomers of $[Pt(gly)_2]$ where gly is $NH_2CH_2COO^-$.

$[Ni(NO_2)_6]^{4-}$, $[Ni(NH_3)_6]^{2+}$, $[Ni(H_2O)_6]^{2+}$?

Sol.



cis-form ; trans-form

SECTION - B

Model Test Paper

Very Short Answer Type Questions :

1. Identify the cation and anion in the complex $[Pt(py)_4][PtCl_4]$.

Sol. Cation = $[Pt(py)_4]^{2+}$, Anion = $[PtCl_4]^{2-}$.

2. Give IUPAC name for $[Mn_3(CO)_{12}]$.

Sol. Dodecacarbonyltrimanganese(0)

3. What is hybridisation of $[Cr(NH_3)_6]^{3+}$?

Sol. d^2sp^3

4. What is the relationship between CFSE (Δ_o) and CFSE (Δ_t)?

Sol. $\Delta_o = \frac{4}{9}\Delta_t$

5. Will $[NiCl_4]^{2-}$ show geometrical isomerism?

Sol. No, because it is tetrahedral complex.

6. Why $[Zn(NH_3)_4]^{2+}$ solution is colourless?

Sol. Because it has $3d^{10}$ configuration of Zn^{+2}.

Short Answer Type Questions :

7. Identify the type of (n – 1)*d* orbitals involved in d^2sp^3 hybridisation. Explain.

Sol. In d^2sp^3, $(n-1)d_{z^2}$ and $(n-1)d_{x^2-y^2}$ orbitals are involved in hybridisation because they are more directional toward coordinate axis.

8. Explain why secondary valencies are directional in nature.

Sol. Because, geometry of complex and stereoisomerism due to different arrangements of electron donor groups are decided by secondary valencies.

9. Why AgCl is not precipitated by KCl solution in presence of aqueous NH_3?

Sol. KCl does not precipitize Ag^+ in presence of aqueous NH_3 due to formation of complex $[Ag(NH_3)_2]Cl$.

10. Identify the geometrical shapes of complexes formed by reaction of Ni^{2+} with Cl^-, CN^- and H_2O respectively with hybridisation.

Sol. Tetrahedral, square planar and octahedral
(sp^3) (dsp^2) (sp^3d^2)

11. Why ammonia forms the complex $[Cu(NH_3)_4]^{2+}$ with copper ions in alkaline solutions but not in acidic solution?

Sol. In acidic solution protons coordinate with ammonia forming NH_4^+ ions and NH_3 molecules are not available for coordination.

12. Calculate the spin only magnetic moment of cobalt in $Hg[Co(SCN)_4]$.

Sol. Cation = Hg^{2+}; anion = $[Co(SCN)_4]^{2-}$

SCN^- is weak ligand, does not pair up electrons. Co^{+2} has three unpaired electrons in $3d^7$ configuration. Hence,

$\mu = \sqrt{3(3+2)} = \sqrt{15}$ B.M.

13. Identify the oxidation states of Fe in the complex formed by reaction of $FeCl_3$ and $K_4[Fe(CN)_6]$.

Sol. $4FeCl_3 + 3K_4[Fe(CN)_6] \longrightarrow Fe_4[Fe(CN)_6]_3 + 12KCl$

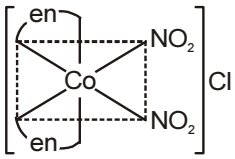
$Fe_4[Fe(CN)_6]_3 \longrightarrow 4Fe^{3+} + 3[Fe(CN)_6]^{4-}$

Oxidation states of Fe are +2 and +3.

Long Answer Type Questions :

14. A complex $Co(en)_2 \cdot (NO_2)_2Cl$ shows optical activity, and it reacts with both $AgNO_3$ and ethane-1,2-diammine. What is the structure of complex? Explain.

Sol. Optical activity shows that it is cis-isomer. Reaction with $AgNO_3$ proves that Cl atom is ionizable. Reaction with 'en' proves that two $-NO_2$ groups are adjacent to each other. Hence, structure is



15. Among the complexes $[Ti(NO_3)_4]$, $K_3[VF_6]$, $[CuNC(CH_3)_4]^+BF_4^-$ and $[Cr(NH_3)_6]Cl_3$; which are expected to be coloured? Explain.

Sol. $[Cr(NH_3)_6]Cl_3$ and $K_3[VF_6]$ are coloured because Cr^{3+} and V^{3+} have $3d^3$ and $3d^2$ configuration respectively and thus show *d-d* transition. Ti^{+4} and Cu^+ has $3d^0$ (empty) and $3d^{10}$ (fully filled) configuration, hence colourless.

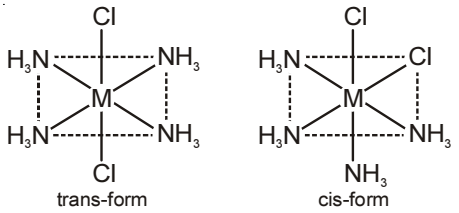
16. Classify $Na_2[CrOF_4]$ and $[Cr(H_2O)_6]Cl_3$ between cationic and anionic complex. Explain.

Sol. In $Na_2[CrOF_4]$, central atom is involved in anionic part $[CrOF_4]^{2-}$, hence it is anionic complex.

In $[Cr(H_2O)_6]Cl_3$, central atom is involved in cationic part $[Cr(H_2O)_6]^{3+}$, hence it is cationic complex.

17. Are geometrical isomers of $[M(NH_3)_4Cl_2]$ optically active? Explain with structures.

Sol. No, both are optically inactive, because both possess axis of symmetry.



18. Explain $-NO_2$ and –CN are ambidentate ligands with structures.

Sol. An ambidentate ligand has two sites on different species available for coordination, only one is used at a time.

In NO_2 $\Rightarrow$ $\leftarrow :N(=O)-O$ (nitrito-N) and $\leftarrow \ddot{O}-N=O$ (nitrito-O)

In CN $\Rightarrow$ $\leftarrow C \equiv N$ (cyano) and $\leftarrow :N \stackrel{+}{=} C$ (iso cyano)

19. A metal complex having composition $Cr(NH_3)_4Cl_2Br$ has been isolated in (A) and (B). (A) reacts with $AgNO_3$ forms white precipitate readily soluble in dilute aq. NH_3, while (B) gives pale yellow precipitate in concentrated ammonia solution. Identify (A) and (B) with hybridisation of chromium and calculate spin only magnetic moment.

Sol. $[Cr(NH_3)_4Cl_2]Br \xrightarrow{AgNO_3} [Cr(NH_3)_4Cl_2]^+ + NO_3^- + \underset{\text{(yellow ppt.)}}{AgBr}$

$[Cr(NH_3)_4BrCl]Cl \xrightarrow{AgNO_3} [Cr(NH_3)_4BrCl]^+ + NO_3^- + \underset{\text{(white ppt.)}}{AgCl}$

Hybridisation of $Cr^{+3} = d^2sp^3$. (three unpaired electrons)

$\mu = \sqrt{n(n+2)}$ B.M.

$= \sqrt{3(3+2)} = \sqrt{15}$ B.M.

❑ ❑ ❑

Solutions (Set-2)

Objective Type Questions

(Classification of Ligands and Nomenclature of Coordination Compounds)

1. The total number of electrons donated by ligands to platinum ion in $[Pt(en)_2Cl_2]$ is
(1) 8 (2) 10 (3) 12 (4) 14

Sol. Answer (3)

In $[Pt(en)_2Cl_2]$, there are 2 monodentate and 2 bidentate ligands.

Hence, electrons donated by ligands = $2 \times 2 + 2 \times 4$

$= 4 + 8$

$= 12$

2. The IUPAC name of $[Ni(CN)_4]^{2-}$ is
(1) Tetracyanonickel (II) ion (2) Tetracyanonickelate (II) ion
(3) Tetracyanonickel (0) ion (4) Tetracyanonickelate (0) ion

Sol. Answer (2)

IUPAC name of $[Ni(CN)_4]^{2-}$ = Tetracyanonickelate (II) ion.

3. Which of the following is not an ambidentate ligand?
(1) CN^- (2) NO_2^- (3) SCN^- (4) NH_3

Sol. Answer (4)

NH_3 can bind only from N side, so NH_3 is not an ambidentate ligand.

4. Primary and secondary valencies of Cu in $[Cu(NH_3)_4]SO_4$ is
(1) 4, 4 (2) 2, 4 (3) 4, 1 (4) 4, 2

Sol. Answer (2)

$[Cu(NH_3)_4]SO_4 \Rightarrow [Cu(NH_3)_4]^{2+} + SO_4^{2-}$

$\Rightarrow$ Primary valency = 2

Cu is bonded to 4, NH_3 ligands.

$\Rightarrow$ Secondary valency = 4

5. IUPAC name of $K[BF_4]$ is
(1) Potassium tetrafluoroborate (2) Tetrafluoroboron (III) potassium
(3) Potassiumtetrafluoridoborate (III) (4) Tetrafluoridoboron (III) potassium

Sol. Answer (3)

IUPAC name of $K[BF_4]$ = Potassiumtetrafluoridoborate (III).

6. Aq. solution of $KCl \cdot MgCl_2 \cdot 6H_2O$ will give test of
(1) K^+ and Mg^{2+} only (2) K^+ and Cl^- only (3) K^+, Mg^{2+} and Cl^- (4) Mg^{2+} and H_2O only

Sol. Answer (3)

$KCl \cdot MgCl_2 \cdot 6H_2O$ is a double salt. So, it will give the test of its constituent ions i.e. K^+, Mg^{2+} and Cl^-.

7. Which of the following complex is homoleptic?
(1) $H_2[PtCl_6]$ (2) $Li[AlH_4]$ (3) $[Ni(CO)_4]$ (4) All of these

Sol. Answer (4)

Homoleptic complexes are the complexes, having all the ligands identical.

⇒ All the given complexes are homoleptic.

8. Structural formula of tetraaquadichloridochromium(III) chloride is

(1) $[(H_2O)_4Cl_2Cr]Cl_2$ (2) $[Cl_2(H_2O)_4Cr]Cl_3$ (3) $[Cr(H_2O)_4Cl_2]Cl$ (4) $[Cr(H_2O)_4Cl_3]$

Sol. Answer (3)

Tetraaquadichloridochromium(III) chloride

⇒ 4 H_2O, 2 Cl^- in secondary valency and 1 Cl^- in primary valency

⇒ $[CrCl_2(H_2O)_4]Cl$

9. Which of the following is not a polydentate ligand?

(1) Oxalate ion (2) Ethylenediamine (3) Thiocyanato (4) EDTA

Sol. Answer (3)

NCS^- can bind from one side only at a time.

⇒ Mono dentate ligand.

10. Correct order of power ligands in spectrochemical series

(1) $I^- < Br^- < Cl^-$ (2) $C_2O_4^{2-} < H_2O < NCS^-$ (3) $NH_3 < CN^- < CO$ (4) All of these

Sol. Answer (4)

The given orders are correct.

(Isomerism in coordination compounds)

11. Oxidation number of platinum in cis-platin is

(1) Zero (2) +2 (3) +4 (4) +6

Sol. Answer (2)

cis-platin ⇒ cis-$[Pt\ Cl_2(NH_3)_2]$

⇒ Oxidation number of Pt = +2

12. Aqueous solution of $CoCl_3 \cdot 6NH_3$ upon addition with $AgNO_3$ produces 3 moles white precipitate. Primary and secondary valency of metal in this complex is

(1) 3, 6 (2) 2, 6 (3) 3, 3 (4) 6, 4

Sol. Answer (1)

3 moles white ppt. ⇒ 3 moles of AgCl

⇒ $3Cl^-$ are outside the coordination sphere

⇒ Primary valency = 3

⇒ 6 NH_3 are co-ordinated with Co, in the coordination sphere ⇒ Secondary valency = 6.

13. The complex $[Cr(H_2O)_5Cl]Br$ and $[Cr(H_2O)_5Br]Cl$ shows

(1) Linkage isomerism (2) Ionisation isomerism (3) Hydrate isomerism (4) Co-ordination isomerism

Sol. Answer (2)

$[Cr(H_2O)_5Cl]Br$ and $[Cr(H_2O)_5Br]Cl$ has same molecular formula but in the first one Br is satisfying the primary valency while in the second one satisfying the secondary valency.

⇒ Ionization isomerism.

14. Which of the following octahedral complexes do not show geometrical isomerism?

(1) $[Co(NH_3)_3Cl_3]$ (2) $[PtCl_2(NH_3)_4]$ (3) $[Pt(NH_3)_2Cl_2]$ (4) $[Co(en)_3]^{3+}$

Sol. Answer (4)

$[Co(en)_3]^{3+}$ will not show geometrical isomerism, because only one structure is possible. (en is bidentate ligand).

15. Coordination isomerism exhibited by

(1) $[Cr(en)_2Cl_2]NO_2$ (2) $[Co(NH_3)_5Br]SO_4$ (3) $[Pt(NH_3)_4][CuCl_4]$ (4) $[Co(NH_3)_5Cl]Cl_2$

Sol. Answer (3)

$[Pt(NH_3)_4][CuCl_4]$ & $[Cu(NH_3)_4][PtCl_4]$ are one of the possible isomers for same chemical formula, having different co-ordination spheres.

16. Which one of the following complexes will have six isomers?

(1) $[Co(en)NH_3Cl_2]Cl$ (2) $[Cr(H_2O)_4Cl_2]Cl$ (3) $[Co(ox)_3]^{3-}$ (4) $[Co(en)_2Br_2]Cl$

Sol. Answer (4)

$[Co(en)_2Br_2]Cl$ will show 6 isomers.

17. Which of the following does not show optical activity?

(1) $[Co(NH_3)_4Cl_2]$ (2) $[Cr(ox)_3]^{3-}$

(3) $[Co(ox)_2(NH_3)_2]Cl$ (4) $[Co(en)(NH_3)_2(H_2O)_2]Cl_2$

Sol. Answer (1)

$[Co(NH_3)_4Cl_2]$ has symmetrical structure

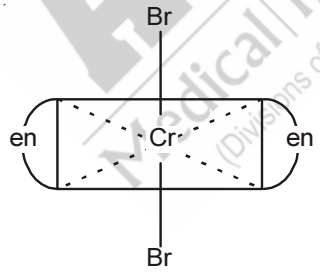
$\Rightarrow$ Will not show optical activity.

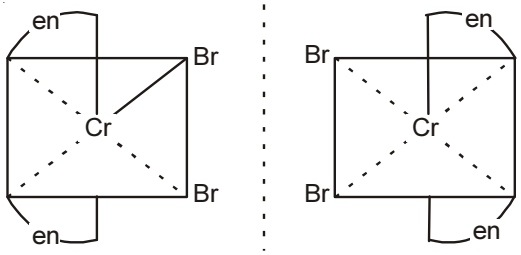
18. How many isomers are possible in $[Cr(en)_2Br_2]$?

(1) 2 (2) 3 (3) 6 (4) 1

Sol. Answer (2)

$[Cr(en)_2Br_2]$ $\Rightarrow$





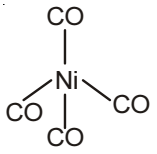
$\Rightarrow$ 3

(Bonding in coordination compounds)

19. The hybridisation of Ni in $[Ni(CO)_4]$ is

(1) sp^3 (2) dsp^2 (3) sp^2 (4) sp^3d

Sol. Answer (1)

$Ni(CO)_4 \Rightarrow$  $\Rightarrow sp^3$ hybridization.

20. Which of the following is/are inner orbital complex?

(1) $[Fe(CN)_6]^{4-}$ (2) $[Cr(NH_3)_6]^{3+}$ (3) $[Mn(CN)_6]^{3-}$ (4) All of these

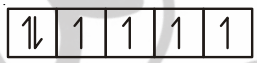
Sol. Answer (4)

CN & NH_3 are ligands and strong enough to pair electrons. Hence, they form inner orbital complexes.

21. Which one of the following is paramagnetic in nature?

(1) $Ni(CO)_4$ (2) $[Ni(CN)_4]^{2-}$ (3) $K_4[Fe(CN)_6]$ (4) $[FeF_6]^{4-}$

Sol. Answer (4)

$[FeF_6]^{4-} \Rightarrow Fe^{2+} \Rightarrow$  $\Rightarrow$ Unpaired electrons

$\Downarrow$

Paramagnetic

(F^- is a weak field ligand)

22. Number of unpaired electrons present in $[Ni(H_2O)_6]^{2+}$

(1) Two (2) One (3) Four (4) Three

Sol. Answer (1)

$[Ni(H_2O)_6]^{2+} \Rightarrow Ni^{2+} \Rightarrow 3d^8 \Rightarrow$ 

$\Downarrow$

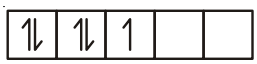
Two unpaired electrons

23. The spin magnetic moment of iron in $K_3[Fe(CN)_6]$

(1) $\sqrt{3}$ BM (2) $\sqrt{5}$ BM (3) $\sqrt{15}$ BM (4) $\sqrt{24}$ BM

Sol. Answer (1)

$K_3[Fe(CN)_6] \Rightarrow [Fe(CN)_6]^{3-} \Rightarrow Fe^{3+}$

$Fe^{3+} \Rightarrow 3d^5 \Rightarrow$  ($\because$ CN^- is strong field ligand)

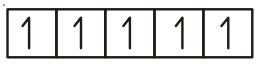
$\Rightarrow$ One unpaired electron

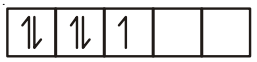
$\therefore \quad \mu = \sqrt{n(n+2)} = \sqrt{1(1+2)} = \sqrt{3}$ BM

24. $[Fe(H_2O)_6]^{3+}$ and $[Fe(CN)_6]^{3-}$ differ in

(1) Oxidation number (2) Coordination number (3) Structure (4) Magnetic nature

Sol. Answer (4)

In $[Fe(H_2O)_6]^{3+} \Rightarrow Fe^{3+} \Rightarrow 3d^5 \Rightarrow$  (H_2O is moderate field ligand)

In $[Fe(CN)_6]^{3+} \Rightarrow Fe^{3+} \Rightarrow 3d^5 \Rightarrow$  (CN^- is strong field ligand)

Different number of unpaired electrons, different magnetic behaviour.

25. The spin only magnetic moment of $[MnBr_4]^{2-}$ is 5.9 B.M. Geometry of the complex ion is
(1) Tetrahedral (2) Octahedral (3) Square planar (4) Pentagonal pyramidal

Sol. Answer (1)

$[MnBr_4]^{2-} \Rightarrow Mn^{2+} \Rightarrow 3d^5$

Given that M = 5.9 BM

Let the number of unpaired electrons be n

$\Rightarrow \sqrt{n(n+2)} = 5.9$

$\Rightarrow n = 5$

$\Rightarrow sp^3$ hybridization $\Rightarrow$ Tetrahedral

26. In the formation of octahedral complex, ligands approach towards _____ and _____ orbital of central metal.
(1) $d_{xy}, d_{x^2-y^2}$ (2) $d_{x^2-y^2}, d_{z^2}$ (3) d_{xy}, d_{yz} (4) d_{z^2}, d_{xz}

Sol. Answer (2)

In formation of octahedral complexes, ligand approaches the metal ion along the coordinate axes.

$\Rightarrow$ The orbitals are $d_{x^2-y^2}$ and d_{z^2}.

27. Which of the following statements are incorrect?
(1) If $\Delta_0 < P$, high spin state is more stable
(2) NO_2 is a strong ligand
(3) Colour of a complex depends upon nature of metal ion only
(4) $\Delta_0 > \Delta_t$

Sol. Answer (3)

Colour of complex ion depends upon the nature of metal ion as well as the nature of ligand too.

$\Rightarrow$ Statement (3) is incorrect.

28. Which of the following complex is most stable?
(1) $[M(NH_3)_6]^{2+}$ (2) $[M(NH_3)_6]^{3+}$ (3) $[Men_2(NH_3)_2]^{3+}$ (4) $[M(en)_3]^{3+}$

Sol. Answer (4)

$\because$ en is a chelating ligand.

Hence, it will form the most stable complex $[M(en)_3]^{3+}$.

29. According to crystal field theory, five *d*-orbitals of an octahedral complex split to give
(1) Two orbitals with lower energy and three orbitals with higher energy
(2) Three orbitals with lower energy and two orbitals with higher energy
(3) One orbital with lower energy and four orbitals with higher energy
(4) Four orbitals with lower energy and one orbital with higher energy

Sol. Answer (2)

d-orbital splits in 2 energy levels i.e. t_{2g} and e_g. e_g is higher (2), t_{2g} is lower (3).

30. Which reagent can be used to identify Ni^{2+} ion?

(1) Resorcinol (2) Dimethyl glyoxime

(3) Diphenyl benzidine (4) Potassium ferrocyanide

Sol. Answer (2)

Ni^{2+} forms $Ni(DMG)_2$ (Red coloured) complex.

(Bonding in metal carbonyls, stability of coordination compounds)

31. Out of following which ligand is a π acid ligand?

(1) CO (2) NH_3 (3) Cl^- (4) H_2O

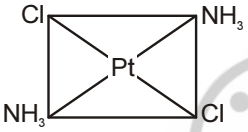
Sol. Answer (1)

CO is a π-acid ligand.

32. Which of the following is not organometallic complex?

(1) Grignard reagent (2) Ferrocene (3) Trans-platin (4) Diethyl zinc

Sol. Answer (3)

Trans platin $\Rightarrow$ 

It is not an organometallic complex.

33. Wilklinson catalyst is

(1) $NiCl_4$ (2) $(Ph_3P)_3RhCl$ (3) $AlCl_3 + TiCl_4$ (4) $Fe(CO)_5$

Sol. Answer (2)

Wilklinson catalyst $\Rightarrow$ $(Ph_3P)_3RhCl$.

34. Stability of the complex depends on

(1) Oxidation state (2) Nature of ligand

(3) Geometry of complex (4) All of these

Sol. Answer (4)

Stability of the complex depends on all the given factors.

35. π bonding is not involved in

(1) Ferrocene (2) Dibenzene chromium (3) Zeise's salt (4) Grignard reagent

Sol. Answer (4)

Grignard reagent is RMgX.

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