CHAPTER

09

Coordination Compounds

A Quick Recapitulation of the Chapter

1. **Coordination compounds** are those in which a central metal atom or ion is attached with a fixed number of groups or molecules (ligands) through coordinate bonds.
2. **Double salts** when dissolved in water dissociate almost completely into ions in the same way in which the individual components of the double salts combine.
3. In complex compounds, the **central metal atom** or ion can act as Lewis acid and ligands act as Lewis base.
4. Molecules which can donate a lone pair of electron to the central atom or ion are called **ligands**.
5. Chelating ligand is a neutral molecule, free radical or ion with two or more lone pairs of electrons on different atoms.
6. The charge present on central metal atom or ion is called oxidation number of central atom.
7. Complexes in which a metal is bound to
   (i) only one kind of ligands → homoleptic complexes, e.g. $[Co(NH_3)_6]^{3+}$.
   (ii) more than one kind of donor group → heteroleptic complexes, e.g. $[Co(NH_3)_4Cl_2]^+$.
8. (i) The part of the coordination which is present outside the square brackets is known as **ionisation sphere**.
   (ii) The central atom/ion and the ligands present in the square brackets are collectively known as **coordination sphere**.
9. **Werner's Theory**
   (i) According to Werner's theory of coordination compounds, metals possess two types of valencies, called primary or ionisable valency (oxidation number) and secondary or non-ionisable valency (coordination number).
   (ii) Every metal atom must satisfy both of its valencies. Primary valencies are non-directional.
   Secondary valencies are directed in space towards fixed position giving a definite shape to the complex.
10. The positive part of a coordination compound is named first and is followed by the name of negative part.
11. The ligands are named first followed by the central metal. The prefixes di, tri etc., are also used to indicate number of each kind of ligand present.

    The oxidation state of central metal is indicated in roman numbers in parantheses.

    If a complex species has negative charge, the name of the central metal ends in -ate.
12. **Isomerism** geometrical isomerism arises when two identical ligands occupy adjacent positions to each other (*cis*-isomer) or placed opposite to each other (*trans*-isomer)

    Square planar complexes of the type MA_2X_2, $MABX_2$, MA_2XY and $MABXY$ and octahedral complexes of the type MA_4X_2, MA_3X_3 show geometrical isomerism.

13. Compounds of type $MA_2X_2Y_2$, MA_2X_2YZ, MA_2XYZL, $MABXYZL$, $M(AA)_3$, $M(AA)_2X_2$ shows optical isomerism.
14. Ionisation isomerism arises when complex compounds with same molecular formula give different ions in solution.
15. **Linkage isomerism** arises when a complex contains a monodentate ligand with more than one donor atoms.
16. **Coordination isomerism** arises when there is exchange of ligands between complex cation and complex anion.
17. **Hydrate isomerism** arises when different number of water molecules present in the coordination sphere.
18. **Valence Bond Theory** (VBT) According to valence bond theory (VBT), the metal atom or ion under the influence of ligands can use $(n-1)\,d, ns, np, nd$ orbitals for hybridisation to yield square planar, tetrahedral or octahedral geometry. These hybridised then overlap with ligand orbitals which can donate an electron pair for bonding.
19. A complex compound may be inner orbital complex or outer orbital complex depending upon whether *d*-orbitals of the inner shell or outer shell are involved in hybridisation. **Inner orbital complex** is generally high spin complex while **outer orbital complex** is generally high spin complex.
20. If no unpaired electron is present, the complex is diamagnetic. If unpaired electron/s is/are present, complex is paramagnetic and its magnetic moment $\mu = \sqrt{n(n+2)}$ where, n is the number of unpaired electrons present.
21. **Crystal Field Theory** It is a more appropriate theory than VBT. According to CFT, under the influence of ligand field, degeneracy of the *d*-orbital is destroyed and it splits into two or more energy levels.
22. The extent of splitting depends on the strength of ligand. A strong ligand causes greater splitting while a weak ligand causes smaller splitting.
23. The difference of energy between the two sets of *d*-orbital (in octahedral complexes) is called **crystal field splitting energy** (CFSE) or Δ. The magnitude of Δ_o depends upon the nature of the ligands.
24. The increasing order of Δ_o is given below:

    $I^- < Br^- < S^{2-} < SCN^- < Cl^- < F^- < OH^- < C_2O_4^{2-}$
    $< H_2O < NCS^- < NH_3 < en < NO_2^- < CN^- < CO$

    This series is called **spectrochemical series**.
25. **Bonding in metal carbonyls** The metal carbon bond in metal carbonyl possess 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.
26. Haemoglobin is a complex of iron, vitamin B_{12} is a complex of Co, chlorophyll is a complex of Mg. Wilkinson catalyst is used for the hydrogenation of alkenes.

Objective Questions Based on NCERT Text

Topic 1

Werner's Theory of Coordination Compounds

1. Primary valency of binary compounds $CrCl_3$, $CoCl_2$ and $PdCl_2$ are

(a) 2, 2 and 3 respectively (b) 2, 3 and 2 respectively
(c) 3, 3 and 2 respectively (d) 3, 2 and 2 respectively

2. Given, the molecular formula of some hexa coordinated complex

A. $CoCl_3 \cdot 6NH_3$ B. $CoCl_3 \cdot 5NH_3$
C. $CoCl_3 \cdot 4NH_3$

If the number of coordinated NH_3 molecules in *A, B* and *C* respectively are 6, 5 and 4, the primary valency, in (*A*), (*B*) and (*C*) respectively

(a) 6, 5 and 4 (b) 3, 2 and 1
(c) 0, 1 and 2 (d) 3, 3 and 3

3. Which one of the following complexes will consume more equivalents of aqueous solution of $AgNO_3$? **(JEE Main 2016)**

(a) $Na_2[CrCl_6]$
(b) $[Cr(H_2O)_5Cl]Cl_2$
(c) $[Cr(H_2O)_6]Cl_3$
d) $Na_2[CrCl_5(H_2O)]$

4. According to Werner's theory, the primary valencies of the central metal atom

(a) are satisfied by negative ions or neutral molecule
(b) are satisfied by negative ions
(c) are equal to its coordination number
(d) decide the geometry of the complex

5. Werner proposed the term secondary valency for the

(a) number of groups bound indirectly to the metal ion
(b) number of groups bound directly to the metal ion
(c) total number of groups bound directly as well as indirectly to the metal ion
(d) None of the above

6. According to postulates of Werner's theory for coordination compounds, which of the following is true?

(a) Primary valencies are ionisable
(b) Secondary valencies are ionisable
(c) Only primary valencies are non-ionisable
(d) Primary and secondary valencies are non-ionisable

7. Consider the formula $[Co(NH_3)_6]^{3+}(3Cl^-)$.

In this formula the species within the square bracket and the ions outside the square bracket respectively

(a) Coordination entities and counterions
(b) Counterions and coordination entities
(c) Counterions and counter entities
(d) Coordinated ions and counter entities

8. The primary and secondary valencies of chromium in the complex ion, dichlorodioxalato chromium (III) respectively are

(a) 3 and 4 (b) 4 and 3 (c) 6 and 3 (d) 3 and 6

9. What is/are true about the double salt and a complex ion?

(a) Both are formed by the combination of two or more stable compounds in stoichiometric ratio
(b) Double salts do not dissociate into simple ions when dissolved in water
(c) Complex ion dissociate into simple ions when dissolved in water
(d) All of the above are true

10. Categorise the following compounds into double salts and complex ions.

I. $[Fe(CN)_6]^{4-}$ II. $[KCl \cdot MgCl_2 \cdot 6H_2O]$
III. $FeSO_4 \cdot (NH_4)_2SO_4 \cdot 6H_2O$ IV. $KAl(SO_4)_2 \cdot 12H_2O$

Choose the correct option.

(a) I, II – complex ions; III, IV – double salts
(b) II, III – complex ions; I, IV – double salts
(c) I – complex ion; II, III, IV – double salts
(d) I, II, IV – complex ions; III – double salt

Topic 2
Some Important Terms to Coordination Compounds

11. One mole of the complex compound $Co(NH_3)_5Cl_3$, gives 3 moles of ions on dissolution in water. One mole of the same complex reacts with 2 moles of $AgNO_3$ solution to yield 2 moles of AgCl(*s*). The structure of the complex is

(a) $[Co(NH_3)_5Cl]Cl_2$ (b) $[Co(NH_3)_3Cl_2] \cdot 2NH_3$
(c) $[Co(NH_3)_4Cl_2]Cl \cdot NH_3$ (d) $[Co(NH_3)_4Cl]Cl_2 \cdot NH_3$

12. Both Co^{3+} and Pt^{4+} have a coordination number of six. Which of the following pairs of complexes will show approximately the same electrical conductance for their 0.001 M aqueous solution?

(a) $CoCl_3 \cdot 4NH_3$ and $PtCl_4 \cdot 4NH_3$
(b) $CoCl_3 \cdot 3NH_3$ and $PtCl_4 \cdot 5NH_3$
(c) $CoCl_3 \cdot 6NH_3$ and $PtCl_4 \cdot 5NH_3$
(d) $CoCl_3 \cdot 6NH_3$ and $PtCl_4 \cdot 3NH_3$

13. Ligands can be small ions small molecules, larger molecules etc. The correct example if are

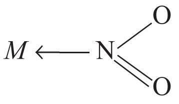
(a) simple ions like Cl^-, small molecules like H_2O
(b) larger molecules like $H_2NCH_2CH_2NH_2$
(c) macromolecules like proteins
(d) All of the above

14. Which of the following is hexadentate ligand?

(a) Ethylene diamine
(b) Ethylene diamine tetra acetic acid
(c) 1,10-phenanthroline
(d) Acetyl acetonate

15. Classify the following structures into nitrito–N(*A*), nitrito–O(*B*), thiocyanato (*C*), and isothiocyanato (*D*)

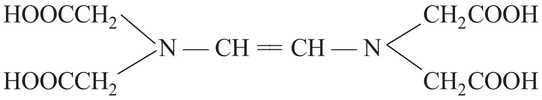
I. $M \longleftarrow O - N = O$
II. $M \longleftarrow SCN$
III. $M \longleftarrow NCS$
IV.



Choose the correct option.

(a) I – *A*; II – *B*; III – *C*; IV – *D*
(b) I – *B*; II – *C*; III – *D*; IV – *A*
(c) I – *D*; II – *C*; III – *B*; IV – *A*
(d) I – *C*; II – *A*; III – *D*; IV – *B*

16. The correct structure of ethylenediaminetetraacetic acid (EDTA) is

(a)


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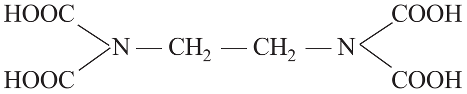

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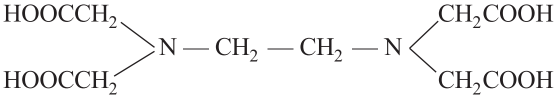
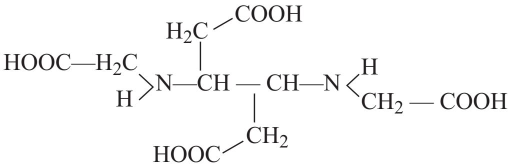


(d)


17. Among the properties (*A*) reducing, (*B*) oxidising, (*C*) complexing, the set of properties shown by CN^- ion towards metal species is

(a) *B* and *C* (b) *A* and *C* (c) *A, B* and *C* (d) *A* and *B*

18. Coordination number (CN) of a metal ion in a complex can be defined as

(a) number of ligand donor atoms

(b) number of ligand donor atoms to which the metal is indirectly bonded

(c) number of ligand donor atoms to which the metal is directly bonded

(d) None of the above

19. The most stable system for a chelate is

(a) five fused cyclic system

(b) four fused cyclic system

(c) three fused cyclic system

(d) two fused cyclic system

20. A ligand can also be regarded as

(a) Bronsted base (b) Bronsted acid

(c) Lewis base (d) Lewis acid

21. Coordination number of Pt and Ni in $[PtCl_6]^{2-}$ and $[Ni(NH_3)_4]^{2+}$ are respectively.

(a) 4 and 6 (b) 6 and 4 (c) 4 and 4 (d) 6 and 6

22. In the complex ions, $[Fe(C_2O_4)_3]^{3-}$ and $[Co(en)_3]^{3+}$ the coordination number of Fe and Co is 6. Why?

(a) Because $C_2O_4^{2-}$ and ethane-1,2-diamine are bidentate ligands

(b) Because $C_2O_4^{2-}$ and ethane-1,2-diamine are ambidentate ligands

(c) Because $C_2O_4^{2-}$ and ethane-1,2-diamine are polydentate ligands

(d) None of the above

23. The coordination number of a central metal atom in a complex is determined by

(a) the number of ligands around a metal ion bonded by σ-bonds

(b) the number of ligands around a metal ion bonded by π-bonds

(c) the number of ligands around a metal ion bonded by σ and π bonds both

(d) the number of only anionic ligands bonded to the metal ion

24. A chelating agent has two or more than two donor atoms to bind to a single metal ion. Which of the following are chelating agents?

I. Oxalato
II. Glycinato
III. Ethane-1,2-diamine
III. Thiosulphato

Choose the correct option.

(a) I, II and III (b) II, III and IV

(c) I, III and IV (d) I, II and IV

25. Coordination number of Fe in $[Fe(CN)_6]^{4-}$ and $[Fe(CN)_6]^{3-}$ are respectively

(a) 2 and 3 (b) 6 and 6

(c) 6 and 3 (d) 6 and 4

26. In the complex $K_4[Fe(CN)_6]$ identify the coordination sphere and the counter ion.

(a) K^+ coordination sphere; $[Fe(CN)_6]^{4-}$ counter ion

(b) $[Fe(CN)_6]^{4-}$ coordination sphere; K^+ counter ion

(c) $(CN)_6$ coordination sphere; K^+ counter ion

(d) None of the above

27. The oxidation number of the central atom in a complex is defined as the charge it would carry

(a) if all the ligands are removed along with the electron pairs that are donated by the central atom

(b) if all the ligands are removed along with the electron pairs that are shared with the central atom

(c) if all the ligands are removed from the central metal atom

(d) if all the electrons pairs are shared with the central atom

28. The oxidation state of Fe in the brown ring complex $[Fe(H_2O)_5NO]SO_4$ is

(a) +3 (b) 0 (c) +2 (d) +1

29. A complex compound in which the oxidation number of a metal is zero, is

(a) $[Ni(CO)_4]$ (b) $[Pt(NH_3)_4]Cl_2$

(c) $K_3[Fe(CN)_6]$ (d) $K_4[Fe(CN)_6]$

30. The pair of compounds having metals in their highest oxidation states is

(a) $[MnO_4]^-$, CrO_2Cl_2 (b) $[NiCl_4]^{2-}$, $[CoCl_4]^-$

(c) MnO_2, $FeCl_3$ (d) $[Fe(CN)_6]^{3-}$, $[Co(CN)_6]^{-3}$

31. The equation which is balanced and represents the correct product (s) is **(JEE Main 2014)**

(a) $Li_2O + 2KCl \longrightarrow 2LiCl + K_2O$

(b) $[CoCl(NH_3)_5]^+ + 5H^+ \longrightarrow Co^{2+} + 5NH_4^+ + Cl^-$

(c) $[Mg(H_2O)_6]^{2+} + (EDTA)^{4-} \xrightarrow{\text{Excess NaOH}} [Mg\ (EDTA)]^{2+} + 6H_2O$

(d) $CuSO_4 + 4KCN \longrightarrow K_2[Cu(CN)_4] + K_2SO_4$

32. $[Co(NH_3)_6]^{3+}$ and $[Co(NH_3)_4Cl_2]^+$ are the examples of

(a) homoleptic complexes

(b) heteroleptic complexes

(c) $[Co(NH_3)_6]^{3+}$ homoleptic complex; $[Co(NH_3)_4Cl_2]^+$ heteroleptic complex

(d) $[Co(NH_3)_6]^{3+}$ heteroleptic complex; $[Co(NH_3)_4Cl_2]^+$ homoleptic complex

Topic 3

Nomenclature of Coordination Compounds

33. Which of the following statement is incorrect for nomenclature of coordination compounds?

(a) The cation is named first in both positively and negatively charged coordination entities

(b) The ligands are named in an alphabetical order before the name of central atom/ion

(c) Names of anionic ligands with electron

(d) Prefixes mono, di, tri etc., are used to indicate the number of the individual ligands in coordination

34. The neutral ligands NH_3, CO and NO respectively are named is

(a) ammine, carbonyl and nitrosyl

(b) amine, carbonyl and nitrito

(c) amine, carboxyl and nitrito

(d) amine, carboxyl and nitrosyl

35. If the complex ion is anion, the name of the metal ends with the suffix-ate, for cationic complex ion,

(a) the metal is named same as the element

(b) the name of the metal ends with the seffix -ate

(c) the metal is named ends with the suffix –O

(d) None of the above

36. Name the compound $[Co(en)_2Cl_2]_2SO_4$

(a) dichloroethylenediamminecobalt (III) sulphate

(b) dichlorobisethylenediamminecobalt (III) sulphate

(c) 2-bisdichloroethylenediamminecobalt (III) sulphate

(d) dichlorobisethylenediamminecobalt (II) sulphate

37. Which among the following will be named as dibromidobis (ethylenediammine) chromium (III) bromide ? **(AIEEE 2012)**

(a) $[Cr(en)_3]Br_3$

(b) $[Cr(en)_2Br_2]Br$

(c) $[Cr(en)Br_4]^-$

(d) $[Cr(en)Br_2]Br$

38. Identify the false statement.

(a) Molecular formula of tetraamminediaquacobalt (III) chloride is $[Co(NH_3)_4(H_2O)_2Cl_3]$

(b) $[PtCl_2(en)_2](NO_3)_2$ is the molecular formula of dichlorido bis- (ethane-1,2-diammine) platinum (IV) nitrate

(c) Molecular formula of iron (III) hexacyanoferrate (II) is $Fe_4[Fe(CN)_6]_3$

(d) If complex name starts with metal, it is an anionic complex

39. In the given compound $[Pt(NH_3)_2Cl(NH_2)(CH_3)]Cl$ identify the metal (A), counter ion (B) and ligands (C).

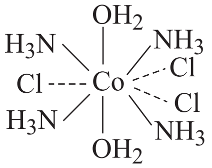
(a) $A \rightarrow Cl;\ B \rightarrow Pt;\ C \rightarrow NH_3$

(b) $A \rightarrow Pt;\ B \rightarrow Cl;\ C \rightarrow NH_3, \overline{Cl}, \overline{N}H_2$ and CH_3

(c) $A \rightarrow Pt;\ B \rightarrow Cl;\ C \rightarrow NH_3, \overline{Cl}$

(d) $A \rightarrow Cl;\ B \rightarrow Pt;\ C \rightarrow \overline{N}H_2, CH_3$

40. Give the name of



(a) tetraammineaquacobalt chloride

(b) tetraamminediaquacobalt (III) chloride

(c) tetraamminediaquacobalt (IV) chloride

(d) None of the above

41. The IUPAC name of the complex $[Co(NH_3)_4Cl_2]Cl$ is

(a) tetraammine dichlorocobalt (III) chloride

(b) tetraammine dichlorocobalt (IV) chloride

(c) tetraammine dichlorocobalt (II) chloride

(d) dichloro tetraammine cobalt (II) chloride

42. Ammonia gas does not evolve from the complex $FeCl_3 \cdot 4NH_3$ but it gives white precipitate with aqueous solution of $AgNO_3$. Coordination number of central metal ion in above complex is six. Give IUPAC name of the complex.

(a) Ammonium trichloro triammine iron (III)

(b) Tetraammine iron (III) chloride

(c) Dichlorotetraammine ferrate (II) chloride

(d) Dichlorotetraammine iron (III) chloride

43. The IUPAC name of compound $K_3[Fe(CN)_5NO]$ is
- (a) pentacyanonitrosylpotassium ferrate (II)
- (b) potassiumcyanopentanitrosyl ferrate (II)
- (c) potassiumpentacyanonitrosyl ferrate (III)
- (d) potassiumpentacyanonitrosyl ferrate (II)

44. The IUPAC name of $[Ni(PPh_3)_2Cl_2]$ is
- (a) bis-dichloro (triphenylphosphine) nickel (II)
- (b) dichlorobis (triphenylphosphine) nickel (II)
- (c) dichlorotriphenylphosphine nickel (II)
- (d) triphenylphosphine nickel (II) dichloride

45. According to IUPAC nomenclature sodium nitroprusside is named as
- (a) sodium pentacyanonitrosyl ferrate (II)
- (b) sodium pentacyanonitrosyl ferrate (III)
- (c) sodium nitroferricyanide
- (d) sodium nitroferrocyanide

46. IUPAC name of $Na_3[Co(NO_2)_6]$ is
- (a) sodium hexanitrito cobaltate (II)
- (b) sodium hexanitro cobaltate (III)
- (c) sodium hexanitrito cobaltate (II)
- (d) sodium cobaltinitrite (II)

47. Write the formula for coordination compound diamminesilver (I) dicyanoargentate (I).
- (a) $[Ag(NH_3)_2][Ag(CN)_2]$ (b) $[Ag(NH_3)_3][Ag(CN)_2]$
- (c) $[Ag(NH_3)_2][Ag(CN)_3]$ (d) $[Ag(NH_2)_2][Ag(CN)_2]$

48. Write the formula for coordination compound named as tris (ethane-1,2-diammine) cobalt (III) sulphate.
- (a) $[Co(H_2N\,CH_2\,CH_2\,NH_2)_3]_2(SO_4)_3$
- (b) $[Co(H_2NCH_2CH_2NH_2)_3]SO_4$
- (c) $[Co(H_2NCH_2CH_2NH_3)_2](SO_4)_3$
- (d) $[Co(H_2NCH_2CH_2NH_2)_3](SO_4)_3$

49. Write the IUPAC name of $K_2[Zn(OH)_4]$.
- (a) Potassium tetraaquazincate (III)
- (b) Potassium tetrahydroxidozincate (III)
- (c) Potassium tetraaquazincate (II)
- (d) Potassium tetrahydroxidozincate (II)

50. In $[Co(H_2NCH_2CH_2NH_2)_3]_2(SO_4)_3$, the counterion is
- (a) $CH, \overline{N}H$ (b) $\overline{C}H_3$ (c) $\overline{N}H_2$ (d) SO_4^-

51. The name of the complex $[Al(OH)_2(H_2O)_4]SO_4$ is
- (a) dihydroxotetrahydridealuminium (III) sulphate
- (b) tetraaquadihydroxyaluminium (III) sulphate
- (c) tetraaquadihydroxyaluminium (IV) sulphate
- (d) None of the above

52. What is the IUPAC name of $Hg[Co(SCN)_4]$?
- (a) Mercury tetrathiocyanato cobalt (II)
- (b) Mercury tetrathiocyanato cobalt (III)
- (c) Mercury tetrathiocyanato cobaltate (III)
- (d) Mercury tetracyanato cobaltate (III)

53. Write the formula for the coordination compund dichloridobis (ethane-1, 2-diamine) platinum (IV) nitrate
- (a) $[PtCl_2(en)_2](NO_3)_2$ (b) $[PtCl_2(NO_3)_2](en)_2$
- (c) $[Pt(en)_2(NO_3)]Cl_2$ (d) None of these

54. The IUPAC name of coordination compound $K_3[Al(C_2O_4)_3]$ is
- (a) potassium trioxalatoaluminate (III)
- (b) potassium hexacarbonylaluminate (III)
- (c) trioxalato aluminium III potassium
- (d) potassium trioxalato aluminate (II)

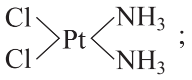
55. Write the IUPAC name of the coordination compound $Fe_4[Fe(CN)_6]_3$.
- (a) Iron (II) hexacyanidoferrate (II)
- (b) Iron (III) hexacyanidoferrate (II)
- (c) Iron (II) hexacyanoferrate (III)
- (d) Iron (II) hexacyanoiron (III)

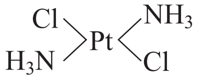
Topic 4

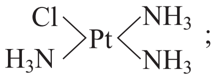
Isomerism in Coordination Compounds

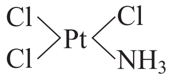
56. Choose the odd one out
- (a) solvate isomerism (b) coordination isomerism
- (c) ionisation isomerism (d) optical isomerism

57. Identify the geometrical isomers of $Pt[(NH_3)_2Cl_2]$

I. 

II. 

III. 

IV. 

Choose the correct option.
- (a) I and II (b) II and III
- (c) I and III (d) II and IV

58. Which type of isomerism arises when bidentate ligands (L–L) are present in complexes of formula $[MX_2(L-L)_2]$?
- (a) Optical isomerism
- (b) Geometrical isomerism
- (c) Linkage isomerism
- (d) Solvate isomerism

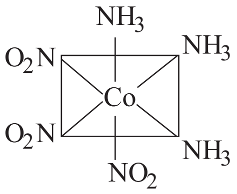
59. The existence of two different coloured complexes with the composition $[Co(NH_3)_4Cl_2]^+$ is due to **(CBSE AIPMT 2012)**

(a) ionisation isomerism
(b) linkage isomerism
(c) geometrical isomerism
(d) coordination isomerism

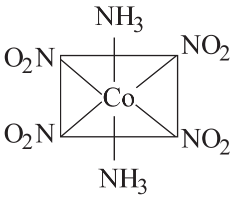
60. Which one amongst the following, exhibit geometrical isomerism?

(a) $[Co(NH_3)_5Br]SO_4$
(b) $[Co(EDTA)]^-$
(c) $[Cr(SCN)_6]^{3-}$
(d) $[Pt(NH_3)_2Cl_2]$

61. Identify the facial (*fac*) and meridional (*mer*) isomers from the following.



A



B

(a) *mer-* *mer-* (b) *fac-* *fac-*
(c) *mer-* *fac-* (d) *fac-* *mer-*

62. Which one of the following has an optical isomer ? (en = ethylenediamine) **(AIEEE 2011)**

(a) $[Zn(en)(NH_3)_2]^{2+}$
(b) $[Co(en)_3]^{3+}$
(c) $[Co(H_2O)_4(en)]^{3+}$
(d) $[Zn(en)_2]^{2+}$

63. The correct statement on the isomerism associated with the following complex ions, **(JEE Main 2016)**

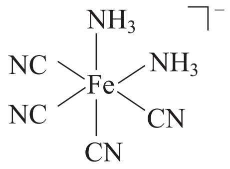
I. $[Ni(H_2O)_5NH_3]^{2+}$
II. $[Ni(H_2O)_4(NH_3)_2]^{2+}$
III. $[Ni(H_2O)_3(NH_3)_3]^{2+}$

(a) I and II show geometrical and optical isomerism
(b) II and III show only optical isomerism
(c) II and III show only geometrical isomerism
(d) II and III show geometrical and optical isomerism

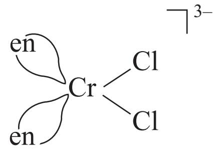
64. In a coordination entity of the type $[PtCl_2(en)_2]^{2+}$, optical activity is shown by

(a) only *cis*-isomer
(b) only *trans*-isomer
(c) both *cis*- and *trans*-isomers
(d) None of the above

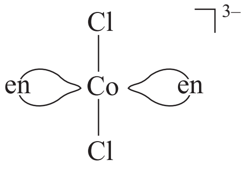
65.



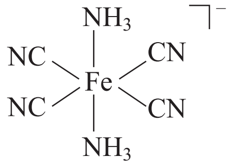
A



B



C



D

In the above structures identify the *cis*- and *trans*-isomers.

(a) *cis*-isomers ⇒ *B, C*; *trans*-isomers ⇒ *A, D*
(b) *cis*-isomers ⇒ *A, D*; *trans*-isomers ⇒ *B, C*
(c) *cis*-isomers ⇒ *A, B*; *trans*-isomers ⇒ *C, D*
(d) *cis*-isomers ⇒ *A, C; trans*-isomers ⇒ *B, D*

66. The complex, $[Pt(py)(NH_3)BrCl]$ will have how many geometrical isomers? **(CBSE AIPMT 2012)**

(a) 2 (b) 3
(c) 4 (d) 0

67. Which of the following coordination compounds would exhibit optical isomerism?

(a) Pentaamminenitrocobalt (III) iodide
(b) Diamminedinitroplatinum (II)
(c) *trans*-dicyanobis (ethylenediamine)
(d) *Tris*-(ethylenediamine) cobalt (III) bromide

68. Which type of Ligand is contained in linkage isomerism?

(a) Unidentate (b) Bidentate
(c) Polydentate (d) Ambidentate

69. Coordination isomerism arises

(a) when the counter ion in a complex salt is itself a potential ligand
(b) from the interchange of ligands between cationic and anionic entities of different metal ions present in a complex
(c) Both (a) and (b) are correct
(d) None of the above

70. The complexes $[Co(NH_3)_6][Cr(CN)_6]$ and $[Cr(NH_3)_6][Co(CN)_6]$ are the examples of which type of isomerism? **(CBSE AIPMT 2012)**

(a) Geometrical isomerism
(b) Linkage isomerism
(c) Ionisation isomerism
(d) Coordination isomerism

71. The pair of $[Co(SO_4)(NH_3)_5]Cl$ and $[CoCl(NH_3)_5]SO_4$ constitutes

(a) optical isomers (b) linkage isomers
(c) coordination isomers (d) ionisation isomers

72. $[Co(NH_3)_5SO_4]Br$ and $[Co(NH_3)_5Br]SO_4$ are

(a) linkage isomers (b) coordination isomers
(c) ionisation isomers (d) solvate isomers

73. Which one of the following complexes shows optical isomerism? **(JEE Main 2016)**

(a) *cis*- $[Co(en)_2Cl_2]Cl$
(b) *trans*- $[Co(en)_2Cl_2]Cl$
(c) $[Co(NH_3)_4Cl_2]Cl$
(d) $[Co(NH_3)_3Cl_3]$

Topic 5

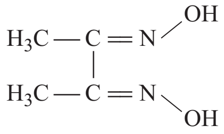
Bonding in Coordination Compounds

74. Which one of the following is an outer orbital complex and exhibits paramagnetic behaviour? **(CBSE AIPMT 2012)**

(a) $[Ni(NH_3)_6]^{2+}$ (b) $[Zn(NH_3)_6]^{2+}$
(c) $[Cr(NH_3)_6]^{3+}$ (d) $[Co(NH_3)_6]^{3+}$

75. Red precipitate is obtained when ethanol solution of dimethylglyoxime is added to ammoniacal Ni(II). Which of the following statements is not true? **(CBSE AIPMT 2010)**

Dimethylglyoxime =



(a) Red complex has a square planar geometry
(b) Complex has symmetrical H-bonding
(c) Red complex has a tetrahedral geometry
(d) Dimethylglyoxime functions as bidentate ligand

76. The *d*-electron configuration of Cr^{2+}, Mn^{2+}, Fe^{2+} and Co^{2+} are d^4, d^5, d^6 and d^7 respectively. Which one of the following will exhibit minimum paramagnetic behaviour?
(Atomic number of Cr = 24, Mn = 25, Fe = 26, Co = 27) **(CBSE AIPMT 2011)**

(a) $[Cr(H_2O)_6]^{2+}$ (b) $[Mn(H_2O)_6]^{2+}$
(c) $[Fe(H_2O)_6]^{2+}$ (d) $[Co(H_2O)_6]^{2+}$

77. Which of the following complex ions is diamagnetic in nature? **(CBSE AIPMT 2011)**

(a) $[CoF_6]^{3-}$ (b) $[NiCl_4]^{2-}$
(c) $[Ni(CN)_4]^{2-}$ (d) $[CuCl_2]^{2-}$

78. $[Ni(CN)_4]^{2-}$, $[MnBr_4]^{2-}$ and $[CoF_6]^{3-}$, geometry, hybridisation and magnetic moment of the ions respectively, are

(a) tetrahedral, square planar, octahedral
sp^3, dsp^2, sp^3d^2 : 5.9, 0, 4.9
(b) tetrahedral, square planar, octahedral
dsp^2, sp^3, sp^3d^2 : 0, 5.9, 4.9
(c) square planar, tetrahedral, octahedral
dsp^2, sp^3, d^2sp^3 : 5.9, 4.9, 0
(d) square planar, tetrahedral, octahedral
dsp^2, sp^3, sp^3d^2 : 0, 5.9, 4.9

79. The pair having the same magnetic moment is [atomic number, Cr = 24, Mn = 25, Fe = 26 and Co = 27] **(JEE Main 2016)**

(a) $[Cr(H_2O)_6]^{2+}$ and $[Fe(H_2O)_6]^{2+}$
(b) $[Mn(H_2O)_6]^{2+}$ and $[Cr(H_2O)_6]^{2+}$
(c) $[CoCl_4]^{2-}$ and $[Fe(H_2O)_6]^{2+}$
(d) $[Cr(H_2O)_6]^{2+}$ and $[CoCl_4]^{2-}$

80. For d^4 ions, the number of possible patterns of electron distribution arises is

(a) two (b) three
(c) four (d) five

81. For d^4 ions, the fourth electron enters one of the e_g orbitals giving the configuration $t_{2g}^3 e_g^1$, when

(a) $\Delta_o > P$ (b) $\Delta_o < P$
(c) $\Delta_o = P$ (d) $\Delta_o \geq P$

82. Which one of these statements about $[Co(CN)_6]^{3-}$ is true? **(NEET 2016)**

(a) $[Co(CN)_6]^{3-}$ has no unpaired electrons and will be in a low-spin configuration
(b) $[Co(CN)_6]^{3-}$ has four unpaired electrons and will be in a low-spin configuration
(c) $[Co(CN)_6]^{3-}$ has four unpaired electrons and will be in a high-spin cofiguration.
(d) $[Co(CN)_6]^{3-}$ has no nupaired electrons and will be in a high-spin configuration.

83. Among the ligands NH_3, en, CN^- and CO, the correct order of their increasing field strength, is **(AIEEE 2011)**

(a) $CO < NH_3 < en < CN^-$ (b) $NH_3 < en < CN^- < CO$
(c) $CN^- < NH_3 < CO < en$ (d) $en < CN^- < NH_3 < CO$

84. Identify the correct trend given below
(Atomic number, Ti= 22, Cr = 24 and Mo = 42) **(JEE Main 2016)**

(a) Δ_o of $[Cr(H_2O)_6]^{2+} < [Mo(H_2O)_6]^{2+}$ and Δ_o of $[Ti(H_2O)_6]^{3+} < [Ti(H_2O)_6]^{2+}$
(b) Δ_o of $[Cr(H_2O)_6]^{2+} > [Mo(H_2O)_6]^{2+}$ and Δ_o of $(Ti(H_2O)_6)^{2+} > [Mo(H_2O)_6]^{2+}$
(c) Δ_o of $[Cr(H_2O)_6]^{2+} > [Mo(H_2O)_6]^{2+}$ and Δ_o of $[Ti(H_2O)_6]^{2+} < [Mo(H_2O)_6]^{2+}$
(d) Δ_o of $[Cr(H_2O)_6]^{2+} < [Mo(H_2O)_6]^{2+}$ and Δ_o of $[Ti(H_2O)_6]^{3+} > [Ti(H_2O)_6]^{2+}$

85. Which of the following complex ion is not expected to absorb visible light? **(CBSE AIPMT 2010)**

(a) $[Ni(H_2O)_6]^{2+}$ (b) $[Ni(CN)_4]^{2-}$
(c) $[Cr(NH_3)_6]^{3+}$ (d) $[Fe(H_2O)_6]^{2+}$

86. When concentrated HCl is added to an aqueous solution of $CoCl_2$, its colour changes from reddish pink to deep blue. Which complex ion gives blue colour in this reaction? **(JEE Main 2015)**

(a) $[CoCl_4]^{2-}$ (b) $[CoCl_6]^{3-}$
(c) $[CoCl_6]^{4-}$ (d) $[Co(H_2O)_6]^{2+}$

87. Crystal field stabilisation energy for high spin d^4 octahedral complex is **(CBSE AIPMT 2010)**

(a) $-0.6\Delta_o$ (b) $-1.8\Delta_o$
(c) $-1.6\,\Delta_o + P$ (d) $-1.2\,\Delta_o$

88. Atomic number of Mn, Fe and Co are 25, 26 and 27 respectively. Which of the following inner orbital octahedral complex ions are diamagnetic?

I. $[Co(NH_3)_6]^{3+}$ II. $[Mn(CN)_6]^{3-}$
III. $[Fe(CN)_6]^{4-}$ IV. $[Fe(CN)_6]^{3-}$

Choose the correct option.

(a) II and III (b) I and IV
(c) I and III (d) II and IV

89. A magnetic moment of 1.73 BM will be shown by one among the following. **(CBSE AIPMT 2012)**

(a) $[Cu(NH_3)_4]^{2+}$ (b) $[Ni(CN)_4]^{2-}$
(c) $TiCl_4$ (d) $[CoCl_6]^{4-}$

90. The octahedral complex of a metal ion M^{3+} with four monodentate ligands L_1, L_2, L_3 and L_4 absorb wavelengths in the region of red, green, yellow and blue, respectively. The increasing order of ligand strength of the four ligands is **(NEET 2016)**

(a) $L_4 < L_3 < L_2 < L_1$
(b) $L_1 < L_3 < L_2 < L_4$
(c) $L_3 < L_2 < L_4 < L_1$
(d) $L_1 < L_2 < L_4 < L_3$

91. Cobalt (III) chloride forms several octahedral complexes with ammonia. Which of the following will not give test for chloride ions with silver nitrate at 25°C? **(NEET 2016)**

(a) $CoCl_3 \cdot 3NH_3$ (b) $CoCl_3 \cdot 4NH_3$
(c) $CoCl_3 \cdot 5NH_3$ (d) $CoCl_3 \cdot 6NH_3$

92. Which of the following statement(s) is/are not true when EDTA solution is added to Mg^{2+} ion solution?

(a) pH of the solution decreases when Mg^{2+} ion is present in hard water
(b) Four coordinate sites of Mg^{2+} occupied by EDTA and remaining two sites occupied by water molecules
(c) Colourless $[Mg\text{-}EDTA]^{2-}$ chelate is formed
(d) All six coordinate sites of Mg^{2+} are occupied

93. Which of the following complex ions has electrons that are symmetrically filled in both t_{2g} and e_g orbitals? **(JEE Main 2015)**

(a) $[FeF_3]^{3-}$ (b) $[Mn(CN)_6]^{4-}$
(c) $[CoF_6]^{3-}$ (d) $[Co(NH_3)_6]^{2+}$

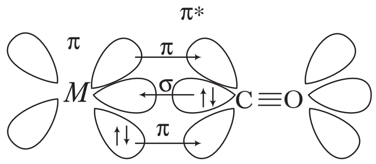
94. Metal-carbon bond in metal carbonyls possess

(a) only σ-character (b) only π-character
(c) Both σ and π-character (d) Neither σ nor π-character

95. The M — C π-bond is formed by the

(a) donation of a pair of electrons
(b) sharing of a pair of electrons
(c) receiving a pair of electrons
(d) None of the above

96. Consider the following figure.



Which type of bond formed between metal and ligand?

(a) synergic bond (b) σ-bond
(c) π-bond (d) None of these

97. Decacarbonyldimanganese(0) is made up of two square pyramidal $Mn(CO)_5$ units joined by 2

(a) Mn — Mn bond (b) Mn ≡ Mn bond
(c) Mn ≡ Mn bond (d) Mn — Mn bond

98. π-bond is available in

I. $[NiCl_4]^{2-}$ II. $Ni(CO)_4$
III. $[Co_2(CO)_8]$ IV. $Cr(CO)_6$

The correct option is

(a) II, III and IV (b) I, II and III
(c) I, III and IV (d) I, II, III and IV

99. In $Fe(CO)_5$, the Fe—CO bond possesses
(a) σ-character only
(b) π-character only
(c) Both (a) and (b)
(d) ionic character

100. In emerald, Cr^{3+} ions occupy octahedral sites in the mineral beryl. The chemical formula of beryl is
(a) $Be_2AlSi_3O_9$
(b) $Be_6Al_4Si_{12}O_{18}$
(c) $Be_3Al_2Si_6O_{18}$
(d) $BeAISi_2O_6$

101. Among the following metal carbonyls, C—O bond order is lowest in
(a) $[Mn(CO)_6]^+$
(b) $[Fe(CO)_5]$
(c) $[Cr(CO)_6]$
(d) $[V(CO)_6]^-$

102. The total number of metal-metal bond present in $[Co_2(CO)_8]$ is
(a) 0
(b) 3
(c) 2
(d) 1

103. In which compound synergic effect is present?
(a) $[Ni(CO)_4]$
(b) $[NiCl_4]^{2-}$
(c) $[CuCl_4]^{2-}$
(d) $[Mn(H_2O)_6]^{2+}$

Topic 6

Stability Importance and Applications of Coordination Compounds

104. For the reaction of the type $M + 4L \rightleftharpoons ML_4$
(a) larger the stability constant, lower the proportion of ML_4 that exists in solution
(b) larger the stability constant, higher the proportion of ML_4 that exists in solution
(c) smaller the stability constant, higher the proportion of ML_4 that exists in solution
(d) None of the above

105. $M + 4L \rightleftharpoons ML_4$
For this reaction, overall stability constant (β_4) is expressed as
(a) $\beta_4 = [ML]/[ML_3][L]$
(b) $\beta_4 = [ML_4]/[ML_3][L]$
(c) $\beta_4 = [ML_4]/[M][L]^4$
(d) $\beta_4 = [ML]/[M][L]$

106. The reciprocal of the formation constant is called
(a) instability constant
(b) dissociation constant
(c) stability constant
(d) Both (a) and (b)

107. What is the overall equilibrium constant for the format ion $[ML_4]^{2-}$ ion, given that β_4 for this complex is 2.5×10^{13} ?
(a) 2.5×10^{13}
(b) 5×10^{-13}
(c) 2.5×10^{-14}
(d) 4.0×10^{-13}

108. Coordination compounds find their use in
(a) qualitative chemical analysis
(b) quantitative chemical analysis
(c) qualitative physical analysis
(d) Both (a) and (b)

109. Hardness of water is estimated by simple titration with Na_2 - EDTA because
(a) Ca^{2+} ions form stable complexes with EDTA
(b) Mg^{2+} ions form stable complexes with EDTA
(c) Ca^{2+} ions form unstable complexes with EDTA
(d) Both (a) and (b)

110. Estimation of calcium and magnesium is done by
(a) EDTA
(b) oxalate
(c) phosphate
(d) None of the above

111. Gold combines with cyanide in the presence of oxygen and water to form coordination entity in aqueous solution. The coordination entity is
(a) $[Au(CN)_2]^-$
(b) $[Au(CN)_2]^{2-}$
(c) $[Au(CN)_2]^{3-}$
(d) $[Au(CN)_2]^{4-}$

112. Coordination compounds have great importance in biological systems. In this context which of the following statements is incorrect?
(a) Chlorophyll is green pigment in plants and contain calcium
(b) Haemoglobin is the red pigment of blood and contains iron
(c) Cyanocobalamine is vitamin B_{12} and contains cobalt
(d) Carboxypeptidase-A is an enzyme and contains zinc

113. The pigment responsible for photosynthesis, chlorophyll is a coordination compound of
(a) Cu
(b) Zn
(c) Mg
(d) Ca

114. Which of the following statements is not correct?
(a) In oxyhaemoglobin Fe^{2+} is paramagentic
(b) During respiration the size of Fe^{2+} increases when it changes from diamagnetic to paramagnetic state
(c) Four heme groups are present in haemoglobin
(d) Heme is the prosthetic group and it is non-protein part

115. Cyanocobalamine, the antipernicious anemia factor, is a coordination compound of
(a) Mn
(b) Mo
(c) Co
(d) Cr

116. Wilkinson catalyst is used for the hydrogenation of
(a) alkanes
(b) alkynes
(c) alkenes
(d) All (a) (b) and (c)

117. Articles can be electroplated with silver and gold much more smoothly and evenly from solutions of the complexes, respectively are

(a) $[Ag(CN)_2]^{2-}$ and $[Au(CN)_2]^{2-}$
(b) $[Ag(CN)_2]^-$ and $[Au(CN)_2]$
(c) $[Au(CN)_2]$ and $[Ag(CN)]_2^-$
(d) AgCN and AuCN

118. In photography, the use of $Na_2S_2O_3 \cdot 5H_2O$ is

(a) for converting AgBr into Ag_2SO_4
(b) for converting AgBr into soluble thiosulphate complex
(c) for converting AgBr into silver thiosulphate
(d) in reduction of Ag metal from AgBr

119. The excess of copper and iron are removed by chelating ligands

(a) disferrioxime-B
(b) D-penicillamine
(c) disferrioxime -B and D-penicillamine respectively
(d) D-penicillamine and disferrioxime -B respectively

120. For lead-poisoning, the antidote used is

(a) white of an egg
(b) *cis*-platin
(c) nickel
(d) EDTA

Special Format Questions

I. More Than One Correct Option

121. A bridging ligand possesses

(a) polydentate nature
(b) two or more donor centres
(c) the tendency to get itself attached to two metal ions
(d) only one dentate site

122. Diethylene triamine are

(a) chelating agent (b) polydentate ligand
(c) tridentate ligand (d) not a ligand

123. A ligand having an unshared pair of electorns may be a

(a) neutral molecule
(b) positively charged ion
(c) negatively charged ion
(d) group containing a lone pair of electrons

124. The oxidation number of metal atom are zero in

(a) $Ni(CO)_4$ (b) $Fe(CO)_5$
(c) $Na[Co(CO)_4]$ (d) $[Cu Cl_4]^{2-}$

125. Which of the following do not have square planar geometry?

(a) $[CoCl_4]^2$ (b) $[FeCl_4]^{2-}$
(c) $[NiCl_4]^{2-}$ (d) $[PtCl_4]^{2-}$

126. Which of the following are true for ligands metal complex?

(a) Larger the ligand, the more stable is the metal ligand complex
(b) Highly charged ligand forms stronger bonds
(c) Larger the permanent dipole moment of ligand, the more stable is the bond
(d) Greater the ionisation potential of central metal, the stronger the bond

127. Which ions are not paramagnetic?

(a) $Ni(NH_3)_4]^{2+}$ (b) $[Ni(CO)_4]$
(c) $[Co(NH_3)_6]^{3+}$ (d) $[Ni(CN)_4]^{2-}$

128. Which is true in case of $[Ni(CO)_4]$?

(a) Hybridisation of Ni is sp^3
(b) Tetrahedral shape
(c) Diamagnetic
(d) Square planar

129. Which of the following pairs do not represent linkage isomers?

(a) $[Cu(NH_3)_4][PtCl_4]$ and $[Pt(NH_3)_4][CuCl_4]$
(b) $[Pd(PPh_3)_2(NCS)_2]$ and $[Pd(PPh_3)_2(SCN)_2]$
(c) $[Co(NH_3)_5]NO_3SO_4$ and $[Co(NH_3)_5SO_4]NO_3$
(d) $[PtCl_2(NH_3)_4]Br_2$ and $[PtBr_2(NH_3)_4]Cl_2$

130. Which complex is d^2sp^3 hybridised?

(a) $[Co(NH_3)_6]^{2+}$ (b) $[Fe(CN)_6]^{3-}$
(c) $[Cu(NH_3)_4]^{2+}$ (d) None of the above

II. Statements Based Questions Type I

■ **Directions** (Q. Nos. 131-132) *In the following questions, a Statement* I *is followed by a corresponding Statement* II. *Of the following Statements, choose the correct one.*

(a) Both Statement I and Statement II are correct and Statement II is the correct explanation of Statement I.
(b) Both Statement I and Statement II are correct but Statement II is not the correct explanation of Statement I.
(c) Statement I is correct but Statement II is incorrect.
(d) Statement I is incorrect but Statement II is correct.

131. **Statement I** When EDTA solution is added to Mg^{2+} ion solution then four coordinate site of Mg^{2+} are occupied by EDTA and remaining two sites are occupied by water molecules.

Statement II EDTA is a hexadentate ligand.

132. **Statement I** Haemoglobin is the red pigment of blood and contains iron.

Statement II Cynocobalamine is B_{12} and contains cobalt.

III. Statement Based Questions Type II

133. Consider the following statements,

I. In coordination compounds metals show two types of linkages (valencies).
II. The primary valencies are normally ionisable and are satisfied by negative ions.

The correct statement(s) is/are

(a) Only I
(b) Only II
(c) Both I and II
(d) Neither I nor II

134. $[CoCl_3(NH_3)_3]$

I. It is a coordination entity.
II. Cobalt ion is surrounded by three ammonia molecules.
III. Cobalt ion is surrounded by three chloride ions.

The correct statements about $[CoCl_3(NH_3)_3]$ are

(a) I and II are correct
(b) II and III are correct
(c) I and III are correct
(d) I, II and III are correct

135. Consider the following statements.

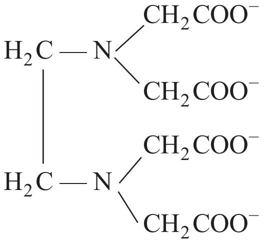
I. When di or polydentate ligand uses its two or more donor atoms to bind a single ion, it is called chelate ligand.
II. When a ligand is bound to a metal ion through several donor atoms, the ligand is said to be a chelate ligand.
III. Ligand which can ligate through two different atoms is called didentate ligand.

The correct statement(s) is/are

(a) I and II
(b) Only III
(c) Only I
(d) I and III

136. Which of the following statement(s) is/are true about $[EDTA^{4-}]$?

I. It is ethylene diaminetetracetate ion.
II. It is a hexadentate ligand.
III. It can bind through two nitrogen and four oxygen atoms to a central metal ion.
IV. Its structure is



The correct set of statements is

(a) I, II and III
(b) II and IV
(c) I, III and IV
(d) I, II, III and IV

137. Coordination number of the central atom/ion is determined

I. only by the σ-bonds formed by the ligand with the central atom/ion.
II. only by the π-bonds formed by the ligand with the central atom/ion.

Choose the correct option.

(a) Only II
(b) Both I and II
(c) Either I or II
(d) Only I

138. Which of the following complex can be ionised in solution?

I. $[CoCl_3(NH_3)_3]$
II. $[Pt(NH_3)_6]Cl_4$
III. $K_2[PtF_6]$
IV. $K_4[Fe(CN)_6]$

Choose the correct option.

(a) I, II and III
(b) II, III and IV
(c) I, III and IV
(d) I, II, III and IV

139. Consider the following statements, while naming a coordination compound.

I. The central metal atom is listed first.
II. The ligands are then listed in alphabetical order.
III. The placement of a ligand in the list does not depend on its charge.

The correct statement(s) is/are

(a) I and II
(b) II and III
(c) Only I
(d) All I, II and III

140. I. Polydentate ligands are not listed in alphabetical order.
II. In case of abbreviated ligand, the first letter of the abbreviation is used to determine the position of the ligand in the alphabetical order.

The correct option is

(a) Only I
(b) Only II
(c) Both I and II
(d) Neither I nor II

141. Consider the following rules of naming coordination compounds,

I. The cation is named first in both positively and negatively charged coordination entities.

II. The ligands are named in an alphabetical order after the name of the central atom/ion.

The incorrect statement(s) is/are

(a) Only I (b) Only II
(c) Both I and II (d) Neither I nor II

142. I. If the complex ion is a cation, the metal is named same as the element.

II. Co in a complex ion is called cobalt and Pt is called platinum.

III. If the complex ion is an anion, the name of the metal ends with the suffix–ate.

The correct set of statements is

(a) I and III (b) II and III
(c) I and II (d) I, II and III

143. I. $[Ag(NH_3)_2][Ag(CN)_2]$ is named as diamminesilver (I) dicyanoargentate (I).

II. The molecular formula of *tris* (ethane-1,2-diammine) cobalt(III) sulphate is $[Co(H_2NCH_2CH_2NH_2)_3]_2(SO_4)_3$.

The incorrect statement(s) is/are

(a) Only I (b) Only II
(c) Both I and II (d) Neither I nor II

144. Consider the following structure and statements regarding the structure $[Co(H_2NCH_2CH_2NH_2)_3]_2(SO_4)_3$.

I. Counter anion in the molecule $\rightarrow$ Sulphate

II. Charge on each complex cation $\rightarrow +2$

III. Neutral molecule in the compound $\rightarrow$ Ethane-1,2-diammine

Which of the above statement(s) is/are true?

(a) Only II (b) Only III
(c) II and III (d) I and III

145. Which of the following are the types of stereoisomerism?

I. Linkage isomerism II. Optical isomerism
III. Geometrical isomerism IV. Ionisation isomerism

Choose the correct pair of stereoisomers.

(a) I and II (b) II and III (c) I and IV (d) I, II and III

146. Optical isomers

I. are mirror images.

II. cannot be superimposed on one another.

III. are also called as enantiomers.

The correct statement(s) is/are

(a) I and II (b) II and III
(c) I and III (d) I, II and III

147. The two forms *dextro* and *laevo*

I. depend upon the direction they rotate the plane of polarised light in a polarimeter.

II. *l*-rotates to the right.

III. *d*-rotates to the left.

The correct statement(s) is/are

(a) Both II and III (b) I, II and III
(c) Only I (d) None of these

148. Consider the following statements about solvate isomerism.

I. It is also known as 'hydrate isomerism' where water is involved as a solvent.

II. It is also similar to ionisation isomerism.

III. Aqua complex $[Cr(H_2O)_6]Cl_3$ (violet) is an example of solvate isomerism. Its solvate isomer is $[Cr(H_2O)_5Cl]Cl_2 \cdot H_2O$.

The correct set of statements is

(a) I and II (b) II and III
(c) I and III (d) I, II and III

149. In the octahedral complex $[Co(NH_3)_6]^{3+}$

I. the cobalt ion is in $+3$ oxidation state.

II. it is in $3d^6$ electronic configuration.

III. diamagnetism exists.

Which of these are true? Choose the correct option.

(a) I and II (b) II and III
(c) I and III (d) I, II and III

150. What is true about $[MnCl_6]^{3-}$, $[FeF_6]^{3-}$ and $[CoF_6]^{3-}$?

I. Each of these are outer orbital complexes.

II. Each of these have sp^3d^2 hybridisation.

III. Each of these are paramagnetic.

IV. $[MnCl_6]^{3-}$, $[FeF_6]^{3-}$ and $[CoF_6]^{3-}$ have four, five and four unpaired electrons respectively.

Choose the correct statements.

(a) I, II and III (b) II, III and IV
(c) I, III and IV (d) All four are true

151. Which of the following are the limitations of VBT?

I. It does not give quantitative interpretation of magnetic data.

II. It does not distinguish between weak and strong ligands.

III. It does not explain the colour exhibited by coordination compounds.

IV. It does not give a quantitative interpretation of the thermodynamic or kinetic stabilities of coordination compounds.

Identify the correct option from the choices given below.

(a) I, II, III and IV (b) II, III and IV
(c) I, III and IV (d) II, III and IV

152. Which of the following facts are related to CFT?

I. The five d-orbitals in an isolated gaseous metal atom/ion have same energy, i.e. they are degenerate.
II. If a spherically symmetrical field of negative charges surrounds the metal atom/ion, the degeneracy is maintained.
III. When this negative field is due to ligands in a complex, it becomes asymmetrical and the degeneracy of the d-orbitals is lifted.
IV. It results in splitting of d-orbitals. This pattern of splitting depends upon the nature of the crystal field.

The correct set of statements is

(a) I, II, III and IV
(b) II, III and IV
(c) I, II and III
(d) I, III and IV

153. I. $[PtCl_4]^{2-}$ complex has a tetrahedral geometry.
II. $[Ni(CO)_4]$ complex has a square planar geometry.

The incorrect statement(s) is/are

(a) Only I
(b) Only II
(c) Both I and II
(d) Neither I nor II

154. Ruby, the gemstone

I. is aluminium oxide (Al_2O_3).
II. contains 0.5–1% Cr^{3+} ions (d^3).
III. Cr^{3+} ions are randomly distributed in positions normally occupied by Al^{3+}.

The true statement(s) is/are

(a) I and II
(b) Only III
(c) II and III
(d) I, II and III

155. Which of the following statements are correct for $[Fe(CN)_6]^{3-}$ complex?

I. It shows d^2sp^3 hybridisation.
II. It shows sp^3d^2 hybridisation.
III. It is paramagnetic.
IV. It is diamagnetic.

Choose the correct option.

(a) I and III (b) II and III (c) III and IV (d) I and II

156. An aqueous pink solution of cobalt(II) chloride changes to deep blue on addition of excess of HCl. This is because

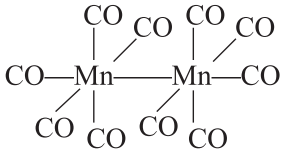
I. $[Co(H_2O)_6]^{2+}$ is transformed into $[CoCl_6]^{4-}$.
II. $[Co(H_2O)_6]^{2+}$ is transformed into $[CoCl_4]^{2-}$.
III. Tetrahedral complexes have smaller crystal field splitting than octahedral complexes.
IV. Tetrahedral complexes have larger crystal field splitting than octahedral complex.

Choose the correct option.

(a) II and III
(b) I and IV
(c) I, III and IV
(d) II and IV

157. Decacarbonyldimanganese (0).

I. Is made up of two square pyramidal $Mn(CO)_5$ units.
II. These units are joined by a Mn—O—Mn bond.
III. Its structure is



The fact(s) is/are

(a) I and II
(b) II and III
(c) I and III
(d) I, II and III

158. Consider the following statements.

I. If $\Delta_o < P$, low spin state is more stable.
II. CO is a very weak ligand.
III. Tetrahedral complexes exhibit nearly 50% CFSE value than octahedral complexes.
IV. The colour of a complex depends on the nature of metal ion.

The incorrect statements are

(a) I, II and III
(b) I, III and IV
(c) I, II and IV
(d) II, III and IV

159. Which of the following are false about $[Cu(NH_3)_4]SO_4$?

I. It is paramagnetic with one unpaired electron in the d-subshell.
II. Its aqueous solution cannot conduct electricity.
III. It gives white $BaCl_2$ solution.
IV. It is a square planar complex.

Choose the correct option.

(a) I and II
(b) II and III
(c) III and IV
(d) I, II and IV

IV. Assertion-Reason Type Questions

■ **Directions** (Q. Nos. 160-181) *In the following questions, a statement of Assertion* (A) *is followed by a corresponding statement of Reason* (R). *Of the following statements, choose the correct one.*

(a) Both A and R are correct; R is the correct explanation of A.
(b) Both A and R are correct; R is not the correct explanation of A.
(c) A is correct; R is incorrect.
(d) R is correct; A is incorrect.

160. Assertion (A) Transition metals generally form coordination compounds.

Reason (R) These usually have partly filled d-orbitals of the nth shell.

161. Assertion (A) Mohr's salt gives NH_4^+, Fe^{2+} and SO_4^{2-} ions in aqueous solution.

Reason (R) Mohr's salt is a double salt.

162. Assertion (A) Primary and secondary are the two types of linkages shown by coordination compounds.

Reason (R) The ions/groups bound by the secondary linkages to the metal have characteristic spatial arrangements corresponding to different coordination numbers.

163. Assertion (A) Toxic metal ions are removed by the chelating ligands.

Reason (R) Chelate complexes tend to be more stable.

164. Assertion (A) In the coordination compound $[Co(H_2NCH_2CH_2NH_2)_3]_2$, ethane-1,2-diammine is a neutral molecule.

Reason (R) Oxidation number of Co in the complex ion is +3.

165. Assertion (A) Usually a sulphate ion is a bidentate ligand but it can also act as monodentate in certain complexes.

Reason (R) Many times multidentate ligands do have flexidentate character.

166. Assertion (A) Oxidation number of Cr in $[Cr(NH_3)_3(H_2O)_3]Cl_3$ is same as the charge of the complex ion, +3.

Reason (R) All the ligands are neutral molecules in this compound.

167. Assertion (A) Isomers differ in one or more physical or chemical properties.

Reason (R) These have different arrangement of atoms.

168. Assertion (A) Geometrical isomerism arises in heteroleptic complexes.

Reason (R) Different geometric arrangements of the ligands are possible.

169. Assertion (A) Tetrahedral complexes do not show geometrical isomerism.

Reason (R) The relative positions of the unidentate ligands attached to the central metal atom are the same with respect to each other.

170. Assertion (A) Square planar complexes do not show optical isomerism.

Reason (R) These complexes do not possess chiral structures.

171. Assertion (A) All square planar complexes do not necessarily exhibit geometrical isomerism.

Reason (R) In such complexes metal generally assumes sp^3-hybrid state.

172. Assertion (A) The total number of isomers shown by $[Co(en)_2Cl_2]^+$ complex ion is three.

Reason (R) $[Co(en)_2Cl_2]^+$ complex ion has an octahedral geometry.

173. Assertion (A) Octahedral geometry and diamagnetism exist in $[Co(NH_3)_6]^{3+}$.

Reason (R) It has no unpaired electron.

174. Assertion (A) The ligands nitro and nitrito are called ambidentate ligands.

Reason (R) These ligands give linkage isomers.

175. Assertion (A) Removal of water from $[Ti(H_2O)_6]Cl_3$ on heating renders it colourless.

Reason (R) In the absence of ligand, crystal field splitting does not occur.

176. Assertion (A) The coordination complexes $[Ni(CN)_4]^{2-}$ and $[NiCl_4]^{2-}$ have not the same shape and similar magnetic behaviour.

Reason (R) Both are square planar in shape but $[Ni(CN)_4]^{2-}$ is diamagnetic but $[Ni(Cl)_4]^{2-}$ is paramagnetic.

177. Assertion (A) The stability of $[Ni(en)_3]Cl_2$ is lower than that of $[Ni(NH_3)_6]Cl_2$.

Reason (R) The geometry of Ni is trigonal bipyramidal in $[Ni(en)_3]Cl_2$.

178. Assertion (A) Complexes are preferred in the electrolytic bath for electroplating.

Reason (R) Complexes dissociate slowly and hence give a smooth and even deposit.

179. Assertion (A) Potassium ferricyanide is paramagnetic while potassium ferrocyanide is diamagnetic.

Reason (R) Crystal field splitting in ferrocyanide ion is greater than that of ferricyanide ion.

180. Assertion (A) As compared to non-chelated complexes, chelated complexes are more stable.

Reason (R) Labile complexes are the complexes which contain ligands those can be easily replaced by other ligands.

181. Assertion (A) Metal carbonyls can also be called organometallics.

Reason (R) Metal carbonyls do contain metal carbon bond.

V. Matching Type Questions

182. Match the columns and choose the correct option from the codes given below.

	Column I (Compound)		Column II (Colour)
A.	$CoCl_3 \cdot 6NH_3$	1.	Violet
B.	$CoCl_3 \cdot 5NH_3$	2.	Green
C.	$CoCl_3 \cdot 4NH_3$	3.	Purple
D.	$CoCl_3 \cdot 3NH_3$	4.	Yellow

Codes

	A	B	C	D
(a)	1	2	3	4
(b)	2	1	4	3
(c)	3	1	4	2
(d)	4	3	2	1

183. Match the columns (formulation of cobalt III chloride ammonia complexes) and choose the correct option from the codes given below.

	Column I (Colour)		Column II (Formula)		Column III (Solution conductivity corresponds to)
A.	Yellow	1.	$[Co(NH_3)_6]^{3+}\,3Cl^-$	I.	1 : 2 electrolyte
B.	Green	2.	$[CoCl(NH_3)_5]^{2+}\,2Cl^-$	II.	1 : 1 electrolyte
C.	Purple	3.	$[CoCl_2(NH_3)_4]^+\,Cl^-$	III.	1 : 3 electrolyte

Codes

	A	B	C
(a)	2(I)	1(II)	3(III)
(b)	3(II)	2(III)	1(I)
(c)	1(III)	3(II)	2(I)
(d)	2(III)	3(I)	1(II)

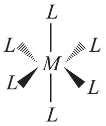
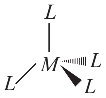
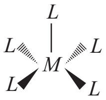
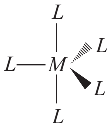
184. Match the following columns and choose the correct option from the codes given below.

	Column I		Column II
A.	$[Co(NH_3)_6]^{3+}$	1.	Tetrahedral
B.	$[Ni(CO)_4]$	2.	Octahedral
C.	$[PtCl_4]^{2-}$	3.	Square planar

Codes

	A	B	C
(a)	1	2	3
(b)	2	1	3
(c)	3	2	1
(d)	3	1	2

185. Match the columns and choose the correct option from the codes given below.

	Column I		Column II
A.		1.	Square planar
B.		2.	Square pyramidal
C.		3.	Octahedral
D.		4.	Tetrahedral
E.		5.	Trigonal bipyramidal

Codes

	A	B	C	D	E		A	B	C	D	E
(a)	1	2	3	4	5	(b)	5	4	3	2	1
(c)	3	1	4	2	5	(d)	4	5	1	3	2

186. Match the following columns and choose the correct option from the codes given below.

	Column I (Coordination compound)		Column II (Structure)
A.	Potassium tetrahydroxidozincate (II)	1.	$K_3[Al(C_2O_4)_3]$
B.	Potassium trioxalatoaluminate (III)	2.	$[Ni(CO)_4]$
C.	Dichloridobis(ethane-1,2-diammine) cobalt (III)	3.	$[CoCl_2(en)_2]^+$
D.	Tetracarbonyl nickel (0)	4.	$K_3[Zn(OH)_4]$

Codes

	A	B	C	D		A	B	C	D
(a)	1	2	3	4	(b)	2	4	1	3
(c)	3	2	1	4	(d)	4	1	3	2

187. Match the following columns and choose the correct option from the codes given below.

	Column I (Structure)		Column II (Coordination compound)
A.	$Hg[Co(SCN)_4]$	1.	Diamminechloridonitrito-N-platinum(II)
B.	$[Co(NH_3)_5(CO)_3]Cl$	2.	Pentaamminecarbonatocobalt (III) chloride
C.	$[CoCl_2(en)_2]Cl$	3.	Dichloridobis (ethane-1,2-diamine) cobalt (III) chloride
D.	$[Pt(NH_3)_2Cl(NO_2)]$	4.	Mercury tetrathiocyanato cobaltate(III)

Codes

	A	B	C	D
(a)	1	3	2	4
(b)	4	3	2	1
(c)	4	2	3	1
(d)	1	2	3	4

188. Match the following columns and choose the correct option from the codes given below.

Column I (Coordination compound)	**Column II** (Name)
A. $K_3[Fe(C_2O_4)_3]$	1. Amminebromidochloridonitrito -N-platinate (II)
B. $[Co(NH_3)_5Cl]Cl_2$	2. Potassiumtrioxalato ferrate (III)
C. $[Pt(NH_3)BrCl(NO_2)]^-$	3. Pentaamminechloridocobalt (III) chloride

Codes

	A	B	C		A	B	C
(a)	2	3	1	(b)	3	1	2
(c)	1	2	3	(d)	3	2	1

189. Match the following columns and choose the correct option from the codes given below.

Column I (IUPAC name)	**Column II** (Formula)
A. Tetrahydroxoidozincate (II)	1. $[Co(NH_3)_5(ONO)]^{2+}$
B. Hexaammine platinum (IV)	2. $[CuBr_4]^{2-}$
C. Tetrabromidocuprate (II)	3. $[Zn(OH)_4]^{2-}$
D. Pentaamminenitrito-O-cobalt (III)	4. $[Pt(NH_3)_6]^{4+}$

Codes

	A	B	C	D
(a)	1	2	3	4
(b)	4	3	1	2
(c)	3	4	2	1
(d)	2	1	4	3

190. Match the following columns and choose the correct option from the codes given below.

Column I (IUPAC name)	**Column II** (Formula)
A. Hexaamminenickel (II) chloride	1. $[Ni(NH_3)_6]Cl_2$
B. *Tris* (ethane-1,2-diammine) cobalt (III) ion	2. $[Co(en)_3]^{3+}$
C. Diammine chlorido (methylammine) platinum (II) chloride	3. $[Pt(NH_3)_2Cl(NH_2CH_3)]Cl$
D. Hexaaquatitanium (III) ion	4. $[Ti(H_2O)_6]^{3+}$

Codes

	A	B	C	D		A	B	C	D
(a)	4	3	2	1	(b)	1	2	3	4
(c)	3	1	4	2	(d)	2	4	1	3

191. Match the following columns.

Column I (Coordination entity)	**Column II** (Colour of light absorbed)	**Column III** (Colour of coordination entity)
A. $[Ti(H_2O)_6]^{3+}$	I. Yellow	1. Blue
B. $[Cu(H_2O)_4]^{2+}$	II. Blue	2. Violet
C. $[Co(NH_3)_6]^{3+}$	III. Red	3. Yellow orange
D. $[CoCl(NH_3)_5]^{2+}$	IV. Blue green	4. Violet

Codes

	A	B	C	D
(a)	I(3)	II(4)	III(2)	IV(1)
(b)	II(4)	IV(3)	I(2)	III(1)
(c)	III(1)	I(2)	IV(3)	II(4)
(d)	IV(2)	III(1)	II(3)	I(4)

192. Match Column I with Column II and choose the correct option from the codes given below.

Column I (Complex)	**Column II** (Central metal ion properties of complex ion)
A. $[Ni(CN)_4]^{2-}$	1. Ti^{4+}
B. Chlorophyll	2. sp^3; paramagnetic
C. *Ziegler-Natta* catalyst	3. non-planar
D. $[NiCl_4]^{2-}$	4. Mg^{2+}
E. Deoxyhaemoglobin	5. Planar
	6. dsp^2; diamagnetic

Codes

	A	B	C	D	E
(a)	6	4	1	2	3
(b)	2	4	1	6	3
(c)	2	4	1	6	5
(d)	6	4	1	2	5

193. Match the following Column I with Column II and choose the correct option from the codes given below.

Column I (Complex)	**Column II** (Structure and magnetic moment)
A. $[Ag(CN)_2]^-$	1. Square planar and 1.73 BM
B. $[Cu(CN)_4]^{3-}$	2. Linear and zero
C. $[Cu(CN)_6]^{3-}$	3. Octahedral and zero
D. $[Cu(NH_3)_4]^{2+}$	4. Tetrahedral and zero
E. $[Fe(CN)_6]^{4-}$	5. Octahedral and 2.86 BM

Codes

	A	B	C	D	E
(a)	1	2	3	4	5
(b)	5	3	1	4	2
(c)	2	4	5	1	3
(d)	3	5	4	2	1

194. Match the Column I with Column II and choose the correct option from the codes given below.

	Column I (Homoleptic carbonyls)		**Column II** (Structure)
A.	Tetracarbonyl nickel(0)	1.	Tetrahedral
B.	Pentacarbonyl iron (0)	2.	Trigonal bipyramidal
C.	Hexacarbonyl chromium (0)	3.	Octahedral

Codes

	A	B	C
(a)	1	2	3
(b)	3	2	1
(c)	2	3	1
(d)	2	1	3

195. Match the Column I with Column II and choose the correct option from the codes given below.

	Column I (Coordination compound)		**Column II** (Uses in medicinal chemistry)
A.	*cis*-platin	1.	Removal of excess of Cu
B.	EDTA	2.	Removal of excess of Fe
C.	Desferrioxime-B	3.	Lead poisoning
D.	D-penicillammine	4.	Tumours

Codes

	A	B	C	D
(a)	1	2	3	4
(b)	2	4	1	3
(c)	3	1	4	2
(d)	4	3	2	1

196. Match the following columns.

	Column I (Metal ion configuration in strong ligand field)		**Column II** (CFSE Δ_o value)
A.	d^4	1.	– 2.4
B.	d^5	2.	– 2.0
C.	d^6	3.	– 1.8
D.	d^7	4.	– 1.6

Codes

	A	B	C	D
(a)	4	2	1	3
(b)	1	2	3	4
(c)	3	4	2	1
(d)	2	3	4	1

VI. Passage Based Questions

■ **Directions** (Q. Nos. 197-198) *Read the following table and answer the following questions.*

On the basis of the following observations made with aqueous solutions.

	Formula	**Moles of AgCl precipitated per mole of the compounds with excess AgNO$_3$**
I.	$PdCl_2 \cdot 4NH_3$	2
II.	$NiCl_2 \cdot 6H_2O$	2
III.	$PtCl_4 \cdot 2HCl$	0
IV.	$CoCl_3 \cdot 4NH_3$	1
V.	$PtCl_2 \cdot 2NH_3$	0

197. The secondary valencies of I and III is
(a) 4 and 5 respectively
(b) 4 and 6 respectively
(c) 6 and 4 respectively
(d) 2 and 4 respectively

198. Complexes having the secondary valence of 6 are
(a) I, II and III
(b) I, II, III and IV
(c) II, III and IV
(d) I, II, III, IV and V

■ **Directions** (Q. Nos. 199-201) *Consider the following passage and answer the following questions.*

The coordination number of nickel (II) ion is 4.

$$\underset{\text{(Excess)}}{NiCl_2 + KCN} \longrightarrow \underset{\text{(Cyano complex)}}{X}$$

$$X + \underset{\text{(Excess)}}{\text{conc. HCl}} \longrightarrow \underset{\text{(Chloro complex)}}{Y}$$

199. The IUPAC name for the complexes X and Y respectively are
(a) potassium tetracyanonickel (II) and potassium tetrachloronickel (II)
(b) tetracyanonickel (II) and tetrachloronickel (II)
(c) tetracyano potassium nickelate (II) and tetrachloro potassium nickelate (III)
(d) potassium tetracyanonickelate (II) and potassium tetrachloronickelate (II)

200. The hybridisation of X and Y are
(a) sp^3d^2, d^2sp^3 (b) dsp^2, sp^3 (c) dsp^2, sp^3 (d) sp^3, dsp^3

201. The magnetic nature of X and Y are
(a) Both are diamagnetic
(b) Both are paramagnetic
(c) X is diamagnetic while Y is paramagnetic containing two unpaired electrons
(d) X is diamagnetic while Y is paramagnetic containing one unpaired electron

NCERT & NCERT Exemplar Questions

NCERT

202. Which of the following species is not expected to be a ligand?

(a) NO
(b) NH_4^+
(c) $NH_2CH_2CH_2NH_2$
(d) CO

203. A chelating agent has two or more than two donor atoms to bind a single metal ion. Which of the following is not a chelating agent?

(a) Thiosulphato
(b) Oxalato
(c) Glycinato
(d) Ethane-1, 2-diammine

204. When 0.1 mol $CoCl_3(NH_3)_5$ is treated with excess of $AgNO_3$, 0.2 mol of AgCl is obtained. The conductivity of solution will correspond to

(a) 1 : 3 electrolyte
(b) 1 : 2 electrolyte
(c) 1 : 1 electrolyte
(d) 3 : 1 electrolyte

205. When 1 mole of $CrCl_3 \cdot 6H_2O$ is treated with excess of $AgNO_3$, 3 moles of AgCl are obtained. The formula of the complex is

(a) $[CrCl_3(H_2O)_3] \cdot 3H_2O$
(b) $[CrCl_2(H_2O)_4]Cl \cdot 2H_2O$
(c) $[CrCl(H_2O)_5]Cl_2 \cdot H_2O$
(d) $[Cr(H_2O)_6]Cl_3$

206. The correct IUPAC name of $[Pt(NH_3)_2Cl_2]$ is

(a) Diamminedichloridoplatinum (II)
(b) Diamminedichloridoplatinum (IV)
(c) Diamminedichloridoplatinum (0)
(d) Dichloridodiammineplatinum (IV)

207. IUPAC name of $[Pt(NH_3)_2Cl(NO_2)]$ is

(a) platinum diamminechloronitrite
(b) chloronitrito-N-ammineplatinum (II)
(c) diamminechloridonitrito-N-platinum (II)
(d) diamminechloronitrito-N-platinate (II)

208. Indicate the complex ion which shows geometrical isomerism.

(a) $[Cr(H_2O)_4Cl_2]^+$
(b) $[Pt(NH_3)_3Cl]$
(c) $[Co(NH_3)_6]^{3+}$
(d) $[Co(CN)_5(NC)]^{3-}$

209. What kind of isomerism exists between $[Cr(H_2O)_6]Cl_3$ (violet) and $[Cr(H_2O)_5Cl]Cl_2 \cdot H_2O$ (greyish-green)?

(a) Linkage isomerism
(b) Solvate isomerism
(c) Ionisation isomerism
(d) Coordination isomerism

210. Due to the presence of ambidentate ligands coordination compounds show isomerism. Palladium complexes of the type $[Pd(C_6H_5)_2(SCN)_2]$ and $[Pd(C_6H_5)_2(NCS)_2]$ are

(a) linkage isomers
(b) coordination isomers
(c) ionisation isomers
(d) geometrical isomers

211. The compounds $[Co(SO_4)(NH_3)_5]Br$ and $[Co(SO_4)(NH_3)_5]Cl$ represent

(a) linkage isomerism
(b) ionisation isomerism
(c) coordination isomerism
(d) no isomerism

NCERT Exemplar

212. The stabilisation of coordination compounds due to chelation is called the chelate effect. Which of the following is the most stable complex species?

(a) $[Fe(CO)_5]$
(b) $[Fe(CN)_6]^{3-}$
(c) $[Fe(C_2O_4)_3]^{3-}$
(d) $[Fe(H_2O)_6]^{3+}$

213. The CFSE for octahedral $[CoCl_6]^{4-}$ is 18,000 cm^{-1}. The CFSE for tetrahedral $[CoCl_4]^{2-}$ will be

(a) 18000 cm^{-1}
(b) 16000 cm^{-1}
(c) 8000 cm^{-1}
(d) 20000 cm^{-1}

214. Which of the following complexes formed by Cu^{2+} ions is most stable?

(a) $Cu^{2+} + 4NH_3 \longrightarrow [Cu(NH_3)_4]^{2+}, \log K = 11.6$
(b) $Cu^{2+} + 4CN^- \longrightarrow [Cu(CN)_4]^{2-}, \log K = 27.3$
(c) $Cu^{2+} + 2en \longrightarrow [Cu(en)_2]^{2+}, \log K = 15.4$
(d) $Cu^{2+} + 4H_2O \longrightarrow [Cu(H_2O)_4]^{2+}, \log K = 8.9$

215. The colour of the coordination compounds depends on the crystal field splitting. What will be the correct order of absorption of wavelength of light in the visible region, for the complexes, $[Co(NH_3)_6]^{3+}$, $[Co(CN)_6]^{3-}$ and $[Co(H_2O)_6]^{3+}$.

(a) $[Co(CN)_6]^{3-} > [Co(NH_3)_6]^{3+} > [Co(H_2O)_6]^{3+}$
(b) $[Co(NH_3)_6]^{3+} > [Co(H_2O)_6]^{3+} > [Co(CN)_6]^{3-}$
(c) $[Co(H_2O)_6]^{3+} > [Co(NH_3)_6]^{3+} > [Co(CN)_6]^{3-}$
(d) $[Co(CN)_6]^{3-} > [Co(NH_3)_6]^{3+} > [Co(H_2O)_6]^{3+}$

216. Identify the correct statements for the behaviour of ethane-1, 2- diamine as a ligand.
(a) It is a neutral ligand
(b) It is a didentate ligand
(c) It is a chelating ligand
(d) It is a unidentate ligand

217. Which of the following complexes are homoleptic?
(a) $[Co(NH_3)_6]^{3+}$ (b) $[Co(NH_3)_4Cl_2]^+$
(c) $[Ni(CN)_4]^{2-}$ (d) $[Ni(NH_3)_4Cl_2]$

218. Which of the following complexes are heteroleptic?
(a) $[Cr(NH_3)_6]^{3+}$ (b) $[Fe(NH_3)_4Cl_2]^+$
(c) $[Mn(CN)_6)]^{4-}$ (d) $[Co(NH_3)_4Cl_2]$

219. Identify the optically active compounds from the following.
(a) $[Co(en)_3]^{3+}$ (b) $trans-[Co(en)_2Cl_2]^+$
(c) $cis-[Co(en)_2Cl_2]^+$ (d) $[Cr(NH_3)_5Cl]$

220. Which of the following complexes show linkage isomerism?
(a) $[Co(NH_3)_5(NO_2)]^{2+}$ (b) $[Co(H_2O)_5CO]^{3+}$
(c) $[Cr(NH_3)_5]SCN^{2+}$ (d) $[Fe(en)_2Cl_2]^+$

221. Atomic number of Mn, Fe and Co are 25, 26 and 27 respectively. Which of the following inner orbital octahedral complex ions are diamagnetic?
(a) $[Co(NH_3)_6]^{3+}$ (b) $[Mn(CN)_6]^{3-}$
(c) $[Fe(CN)_6]^{4-}$ (d) $[Fe(CN)_6]^{3-}$

222. Atomic number of Mn, Fe, Co and Ni are 25, 26, 27 and 28 respectively. Which of the following outer orbital octahedral complexes have same number of unpaired electrons?
(a) $[MnCl_6]^{3-}$ (b) $[FeF_6]^{3-}$
(c) $[CoF_6]^{3-}$ (d) $[Ni(NH_3)_6]^{2+}$

223. Which of the following options are correct for $[Fe(CN)_6]^{3-}$ complex?
(a) d^2sp^3 hybridisation (b) sp^3d^2 hybridisation
(c) Paramagnetic (d) Diamagnetic

224. An aqueous pink solution of cobalt(II) chloride changes to deep blue on addition of excess of HCl. This is because
(a) $[Co(H_2O)_6]^{2+}$ is transformed into $[CoCl_6]^{4-}$
(b $[Co(H_2O)_6]^{2+}$ is transformed into $[CoCl_4]^{2-}$
(c) tetrahedral complexes have smaller crystal field splitting than octahedral complexes
(d) tetrahedral complexes have larger crystal field splitting than octahedral complex

■ **Directions** (Q.Nos. 225 to 229) *In the following questions a statement of Assertion* (A) *followed by a statement of Reason* (R) *is given. Choose the correct answer out of the following choices.*
(a) Assertion and Reason both are true, Reason is correct explanation of Assertion.
(b) Assertion and Reason both are true but Reason is not the correct explanation of Assertion.
(c) Assertion is true, Reason is false.
(d) Assertion is false, Reason is true.

225. **Assertion** (A) Toxic metal ions are removed by the chelating ligands.

Reason (R) Chelate complexes tend to be more stable.

226. **Assertion** (A) Linkage isomerism arises in coordination compounds containing ambidentate ligand.

Reason (R) Ambidentate ligand has two different donor atoms.

227. **Assertion** (A) Complexes of MX_6 and MX_5L type (X and L are unidentate) do not show geometrical isomerism.

Reason (R) Geometrical isomerism is not shown by complexes of coordination number 6.

228. **Assertion** (A) $[Fe(CN)_6]^{3-}$ ion shows magnetic moment corresponding to two unpaired electrons.

Reason (R) Because it has d^2sp^3 type hybridisation.

229. **Assertion** (A) $[Cr(H_2O_6)]Cl_2$ and $[Fe(H_2O)_6]Cl_2$ are reducing in nature.

Reason (R) Unpaired electrons are present in their *d*-orbitals.

230. Match the compounds given in Column I with the oxidation state of cobalt present in it (given in Column II) and assign the correct code.

	Column I (Compound)		**Column II** (Oxidation state of Co)
A.	$[Co(NCS)(NH_3)_5](SO_3)$	1.	+4
B.	$[Co(NH_3)_4Cl_2]SO_4$	2.	0
C.	$Na_4[Co(S_2O_3)_3]$	3.	+2
D.	$[Co_2(CO)_8]$	4.	+3

Codes

	A	B	C	D
(a)	1	2	4	3
(b)	4	3	2	1
(c)	3	1	4	2
(d)	4	1	3	2

231. Match the coordination compounds given in Column I with the central metal atoms given in Column II and assign the correct code.

Column I (Coordination compound)	**Column II** (Central metal atom)
A. Chlorophyll	1. Rhodium
B. Blood pigment	2. Cobalt
C. Wilkinson catalyst	3. Magnesium
D. Vitamin B_{12}	4. Iron

Codes

	A	B	C	D		A	B	C	D
(a)	3	4	1	2	(b)	3	4	5	1
(c)	4	3	2	1	(d)	3	4	2	1

232. Match the complex species given in Column I with the possible isomerism given in Column II and assign the correct code.

Column I (Complex species)	**Column II** (Isomerism)
A. $[Co(NH_3)_4Cl_2]^+$	1. Optical
B. *cis* $-[Co(en)_2Cl_2]^+$	2. Ionisation
C. $[Co(NH_3)_5(NO_2)]Cl_2$	3. Coordination
D. $[Co(NH_3)_6][Cr(CN)_6]$	4. Geometrical

Codes

	A	B	C	D
(a)	1	2	4	3
(b)	4	3	2	1
(c)	4	2	1	3
(d)	4	1	2	3

233. Match the complex ions given in Column I with the colours given in Column II and assign the correct code.

Column I (Complex ion)	**Column II** (Colour)
A. $[Co(NH_3)_6]^{3+}$	1. Violet
B. $[Ti(H_2O)_6]^{3+}$	2. Green
C. $[Ni(H_2O)_6]^{2+}$	3. Pale blue
D. $[Ni(H_2O)_4(en)]^{2+}$ (*aq*)	4. Yellowish orange

Codes

	A	B	C	D		A	B	C	D
(a)	1	2	4	5	(b)	4	3	2	1
(c)	3	2	4	1	(d)	4	1	2	3

234. Match the complex ions given in Column I with the hybridisation and number of unpaired electrons given in Column II and assign the correct code.

Column I (Complex ion)	**Column II** (Hybridisation, number of unpaired electrons)
A. $[Cr(H_2O)_6]^{3+}$	1. dsp^2, 1
B. $[Co(CN)_4]^{2-}$	2. sp^3d^2, 5
C. $[Ni(NH_3)_6]^{2+}$	3. d^2sp^3, 3
D. $[MnF_6]^{4-}$	4. sp^3d^2, 2

Codes

	A	B	C	D		A	B	C	D
(a)	3	1	4	2	(b)	4	3	2	1
(c)	3	2	4	1	(d)	4	1	2	3

Answers

1.	(a)	**2.**	(b)	**3.**	(c)	**4.**	(b)	**5.**	(d)	**6.**	(a)	**7.**	(a)	**8.**	(d)	**9.**	(a)	**10.**	(c)	**11.**	(a)	**12.**	(c)	**13.**	(d)	**14.**	(b)	**15.**	(b)
16.	(c)	**17.**	(b)	**18.**	(c)	**19.**	(a)	**20.**	(c)	**21.**	(b)	**22.**	(a)	**23.**	(a)	**24.**	(b)	**25.**	(b)	**26.**	(b)	**27.**	(b)	**28.**	(d)	**29.**	(a)	**30.**	(a)
31.	(b)	**32.**	(c)	**33.**	(c)	**34.**	(a)	**35.**	(a)	**36.**	(b)	**37.**	(d)	**38.**	(a)	**39.**	(b)	**40.**	(b)	**41.**	(a)	**42.**	(d)	**43.**	(d)	**44.**	(b)	**45.**	(b)
46.	(b)	**47.**	(a)	**48.**	(a)	**49.**	(d)	**50.**	(d)	**51.**	(b)	**52.**	(c)	**53.**	(a)	**54.**	(a)	**55.**	(b)	**56.**	(d)	**57.**	(a)	**58.**	(b)	**59.**	(c)	**60.**	(d)
61.	(d)	**62.**	(b)	**63.**	(c)	**64.**	(a)	**65.**	(c)	**66.**	(b)	**67.**	(d)	**68.**	(d)	**69.**	(b)	**70.**	(d)	**71.**	(d)	**72.**	(c)	**73.**	(a)	**74.**	(a)	**75.**	(c)
76.	(d)	**77.**	(c)	**78.**	(d)	**79.**	(d)	**80.**	(a)	**81.**	(b)	**82.**	(a)	**83.**	(b)	**84.**	(b)	**85.**	(b)	**86.**	(a)	**87.**	(a)	**88.**	(c)	**89.**	(a)	**90.**	(b)
91.	(a)	**92.**	(b)	**93.**	(a)	**94.**	(c)	**95.**	(a)	**96.**	(a)	**97.**	(d)	**98.**	(a)	**99.**	(c)	**100.**	(c)	**101.**	(b)	**102.**	(d)	**103.**	(a)	**104.**	(b)	**105.**	(c)
106.	(d)	**107.**	(a)	**108.**	(d)	**109.**	(c)	**110.**	(a)	**111.**	(a)	**112.**	(a)	**113.**	(c)	**114.**	(a)	**115.**	(c)	**116.**	(c)	**117.**	(b)	**118.**	(b)	**119.**	(d)	**120.**	(d)
121.	(ab)	**122.**	(ac)	**123.**	(ad)	**124.**	(ab)	**125.**	(abc)	**126.**	(cd)	**127.**	(bcd)	**128.**	(a c)	**129.**	(acd)	**130.**	(ab)	**131.**	(d)	**132.**	(b)	**133.**	(c)	**134.**	(d)	**135.**	(c)
136.	(d)	**137.**	(d)	**138.**	(b)	**139.**	(d)	**140.**	(b)	**141.**	(b)	**142.**	(d)	**143.**	(d)	**144.**	(d)	**145.**	(b)	**146.**	(d)	**147.**	(c)	**148.**	(b)	**149.**	(d)	**150.**	(d)
151.	(a)	**152.**	(a)	**153.**	(c)	**154.**	(a)	**155.**	(a)	**156.**	(a)	**157.**	(d)	**158.**	(c)	**159.**	(a)	**160.**	(c)	**161.**	(a)	**162.**	(b)	**163.**	(a)	**164.**	(b)	**165.**	(a)
166.	(a)	**167.**	(a)	**168.**	(a)	**169.**	(a)	**170.**	(a)	**171.**	(d)	**172.**	(c)	**173.**	(a)	**174.**	(a)	**175.**	(a)	**176.**	(c)	**177.**	(d)	**178.**	(a)	**179.**	(c)	**180.**	(b)
181.	(d)	**182.**	(d)	**183.**	(c)	**184.**	(b)	**185.**	(c)	**186.**	(d)	**187.**	(c)	**188.**	(a)	**189.**	(c)	**190.**	(b)	**191.**	(d)	**192.**	(a)	**193.**	(c)	**194.**	(a)	**195.**	(d)
196.	(a)	**197.**	(b)	**198.**	(c)	**199.**	(d)	**200.**	(b)	**201.**	(c)	**202.**	(b)	**203.**	(a)	**204.**	(b)	**205.**	(d)	**206.**	(a)	**207.**	(c)	**208.**	(a)	**209.**	(b)	**210.**	(a)
211.	(d)	**212.**	(c)	**213.**	(c)	**214.**	(b)	**215.**	(c)	**216.**	(abc)	**217.**	(ac)	**218.**	(bd)	**219.**	(ac)	**220.**	(ac)	**221.**	(ac)	**222.**	(ac)	**223.**	(ac)	**224.**	(bc)	**225.**	(a)
226.	(a)	**227.**	(b)	**228.**	(d)	**229.**	(b)	**230.**	(d)	**231.**	(a)	**232.**	(d)	**233.**	(b)	**234.**	(a)												

Hints & Explanations

2. (*b*) The primary valency is ionisable valency. It corresponds to oxidation state of metal. The primary valency is always satisfied by anion

$$\underset{(A)}{[Co(NH_3)_6]Cl_3} \longrightarrow [Co(NH_3)_6]^{+} + 3Cl^-$$

$\therefore$ Number of primary valency is 3.

$$\underset{(B)}{[Co(NH_3)_5Cl]Cl_2} \longrightarrow [Co(NH_3)_5Cl]^{2+} + 2Cl^-$$

$\therefore$ Number of primary valency is 2.

$$[Co(NH_3)_4Cl_2]Cl \longrightarrow [Co(NH_3)_4Cl_2]^{+} + Cl^-$$

$\therefore$ Number of primary valency is 1.

3. (*c*) $[Cr(H_2O)_6]Cl_3$ contains maximum number of ionisable anion ($3Cl^-$). Hence, it will consume more equivalents of aqueous solution of $AgNO_3$ and forms three moles of AgCl (white ppt.)

Complex	**Dissociation in aqueous solution of $AgNO_3$**
(a) $Na[CrCl_6]$	$3Na^+ + [CrCl_6]^{3-}$
(b) $[Cr(H_2O)_5Cl]Cl_2$	$[Cr(H_2O)_5Cl]^{2+} + 2Cl^-$
(c) $[Cr(H_2O)_6]Cl_3$	$[Cr(H_2O)_6]^{3+} + 3Cl^-$
(d) $Na_2[CrCl_5(H_2O)]$	$2Na^+ + [CrCl_5(H_2O)]^{2-}$

6. (*a*) According to postulates of Werner's theory for coordination compounds, metal atoms exhibit two types of valencies; i.e. primary valency and secondary valency. The primary valency is ionisable while the secondary valency is non-ionisable.

8. (*d*) The primary and secondary valencies of chromium in the complex ion, dichlorodioxalato chromium (III) are 3 and 6 respectively.

10. (*c*) $[Fe(CN)_6]^{4-}$ is a complex ion while rest of the compounds are double salts.

11. (*a*) $[Co(NH_3)_5Cl]Cl_2 \rightleftharpoons \underbrace{[Co(NH_3)_5Cl]^{2+} + 2Cl^-}_{3\text{ ions}}$

$$\underset{2\text{ mol}}{2Cl^-} + \underset{2\text{ mol}}{2Ag^+} \longrightarrow \underset{2\text{ mol}}{2AgCl}$$

12. (*c*) Co^{3+} and $Pt^{4+} = 6$ coordination number.

$CoCl_3 \cdot 6NH_3$ and $PtCl_4 \cdot 5NH_3$

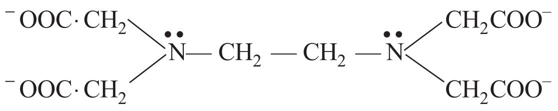
$$[Co(NH_3)_6]Cl_3 \xrightarrow{\text{In solution}} [Co(NH_3)_6]^{3+} + 3Cl^-$$

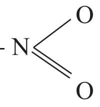
$$[PtCl(NH_3)_5]Cl_3 \xrightarrow{\text{In solution}} [PtCl(NH_3)_5]^{3+} + 3Cl^-$$

Number of ionic species are same in the solution of both complexes, therefore their equimolar solutions will show same conductance.

13. (*d*) Ligands can be simple ions like Cl^-, small molecules like H_2O, larger molecules like $H_2NCH_2CH_2NH_2$ and macromolecules like proteins.

14. (*b*) EDTA is a hexadentate ligand because it has six donor centres.



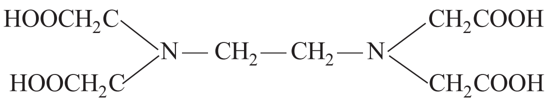
15. (*b*) Nitrito –N $\Rightarrow M \longleftarrow$ 

Nitrito – O $\Rightarrow M \longleftarrow O{-}N{=}O$

Thiocyanato $\Rightarrow M \longleftarrow$ SCN

Isothiocyanato $\Rightarrow M \longleftarrow$ NCS

16. (*c*) EDTA structure is



17. (*b*) CN^- is a better complexing agent (*C*) as well as reducing agent (*A*).

Thus, properties of (*A*) and (*C*) are shown by $\overline{CN}$.

Property (*C*)

$$Ni^{2+} + 4\,CN^- \longrightarrow [Ni(CN)_4]^{2-}$$

Property (*A*)

$$\overset{II}{Cu}\,Cl_2 + 5KCN \longrightarrow K_3[\overset{I}{Cu}(CN)_4] + \frac{1}{2}(CN)_2 + 2KCl$$

(CN^- reduces Cu^{2+} to Cu^+).

18. (*c*) Coordination number (CN) of a metal ion in a complex can be defined as the number of ligand donor atoms to which the metal is directly bonded.

19. (*a*) Greater is the number of chelate rings, greater is the stability of the chelate. Hence, five fused cyclic system is most stable for a chelate.

21. (*b*) Coordination number of Pt and Ni in $[PtCl_6]^{2-}$ and $[Ni(NH_3)_4]^{2+}$ are 6 and 4 respectively.

22. (*a*) In the complex ion, $[Fe(C_2O_4)_3]^{3-}$ and $[Co(en)_3]^{3+}$, the coordination number of Fe and Co is 6 because $C_2O_4^{2-}$ and ethane –1, 2-diamine are bidentate ligands.

24. (*b*) Glycinato, ethane-1, 2-diamine, thiosulphato are chelating agents.

25. (*b*) The number of ligands attached to the central metal ion is called the coordination number.

So, coordination number of Fe in $[Fe(CN)_6]^{4-}$ and $[Fe(CN)_6]^{3-}$ are 6 and 6 respectively.

26. (*b*) In the complex $K_4[Fe(CN)_6]$, K^+ is the counter ion while coordination sphere is $[Fe(CN)_6]^{4-}$.

27. (*b*) The oxidation number of the central atom in a complex is defined as the charge it would carry if all the ligands are removed along with the electron pairs that are shared with the central atom.

28. (*d*) Let the oxidation state of Fe in $[Fe(H_2O)_5NO]SO_4$ is *x*. $[Fe(H_2O)_5NO]^{2+}$

$\therefore \quad x + 0 + 1 = 2$

$\Rightarrow \quad x = +1$

Here, NO exists as a nitrosyl ion (NO^+).

29. (*a*) CO is a neutral ligand, so the oxidation state of metal in metal carbonyl is always zero.

$$[Ni(CO)_4]$$
$$x + (0 \times 4) = 0$$
$$x = 0$$

30. (*a*) In MnO_2 and $FeCl_3$ oxidation states of Mn and Fe are +4 and +3 respectively.

In $[MnO_4]^-$ and CrO_2Cl_2 oxidation states of Mn and Cr are +7 and +6 respectively.

In $[Fe(CN)_6]^{3-}$ and $[Co(CN)_3]$ oxidation states of Fe and Co are +3 and +3 respectively.

In $[NiCl_4]^{2-}$ and $[CoCl_4]^-$, oxidation states of Ni and Co are +2 and +3 respectively.

31. (*b*) (a) $Li_2O + KCl \longrightarrow 2LiCl + K_2O$

This is wrong equation, since a stronger base K_2O cannot be generated by a weaker base Li_2O.

(b) $[CoCl(NH_3)_5]^+ + 5H^+ \longrightarrow Co^{2+}(aq) + 5NH_4^+ + Cl^-$

This is correct. All ammine complexes can be destroyed by adding $H^{\oplus}$. Hence, on adding acid to $[CoCl(NH_3)_5]$, it gets converted to $Co^{2+}(aq)$ NH_4^+ and Cl^-.

(c) $[Mg(H_2O)_6]^{2+} + EDTA^{4-} \xrightarrow[\text{Excess}]{OH^-} [Mg(EDTA)]^{2+} + 6H_2O$

This is wrong, since the formula of complex must be $[Mg(EDTA)]^{2-}$.

(d) The 4th reaction is incorrect. It can be correctly represented as

$2CuSO_4 + 10\,KCN \longrightarrow 2K_3[Cu(CN)_4] + 2K_2SO_4 + (CN)_2\uparrow$

33. (*c*) Names of anionic ligands with e^-.

37. (*d*) Two Br, two (en) and one Cr are parts of the complex. Charge on the complex is

$$\left.\begin{array}{l} 2\,(Br) = -2 \\ 2\,(en) = 0 \\ 1\,(Cr) = +3 \end{array}\right\} = +1$$

Thus, complex ion is $[Cr(en)_2Br_2]^+$

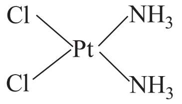
Since, anion is bromide, thus complex is $[Cr(en)_2Br_2]$ Br.

39. (*b*) In the given compound $[Pt(NH_3)_2Cl(NH_2)(CH_3)]Cl$ the metal is Pt, counter ion is Cl and ligands are $(NH_3)_2Cl(NH_2)(CH_3)$.

45. (*b*) Sodium pentacyanonitrosyl ferrate (III) $-Na_2[Fe(CN)_5NO]$

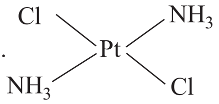
56. (*d*) Optical isomerism is the type of stereoisomerism.

57. (*a*) I.



cis-isomer

II.

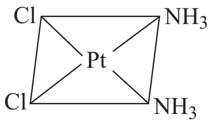


trans-isomer

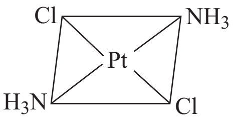
58. (*b*) Geometrical isomerism arises when bidentate ligands (*L–L*) are present in complexes of formula $[MX_2(L-L)_2]$.

59. (*c*) The existence of two different coloured complexes is due to geometrical isomerism as *cis* and *trans* forms are present.

60. (*d*) $[\overset{II}{Pt}(NH_3)_2Cl_2]$ shows geometrical isomerism.



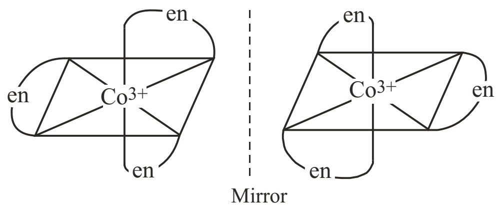
cis
(orange yellow)



trans
(pale yellow)

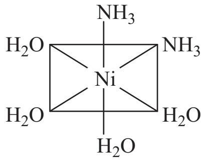
61. (*d*) A→ *fac*–; B→ *mer*–

62. (*b*) Complex $[Co(en)_3]^{3+}$ has no plane of symmetry and centre of symmetry that's why it is optically active.

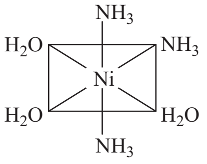


63. (*c*) (II) and (III) show only geometrical isomerism.

$[Ni(H_2O)_4(NH_3)_2]^{2+}$ show *cis* and *trans*-isomers. These are followings

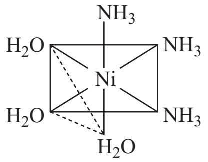


cis

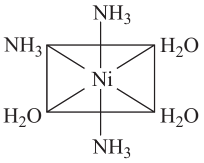


trans

$[Ni(H_2O)_3(NH_3)_3]^{2+}$ show facial and meridional geometrical isomerism.



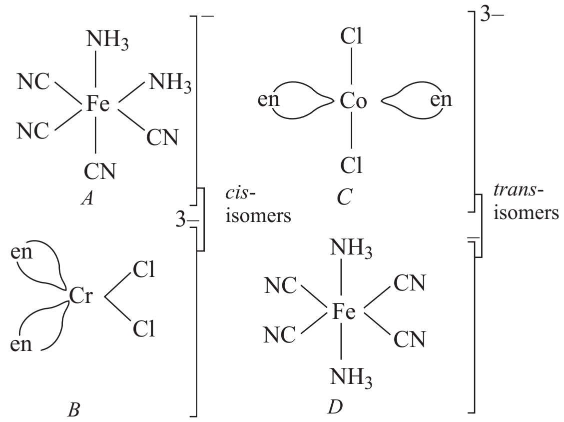
fac-isomer



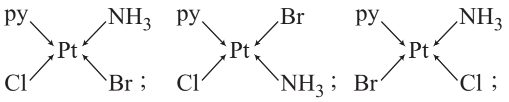
mer-isomer

64. (*a*) In a coordination entity of the type $[PtCl_2(en)_2]^{2+}$, optical activity is shown by *cis*-isomer only.

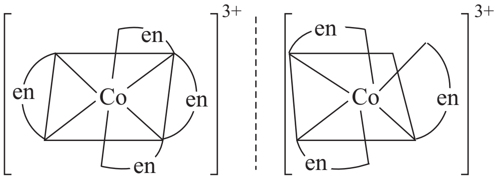
65. (*c*)



66. (*b*) $M(ABCD)$ type complex have three geometrical isomers as



67. (*d*) *Tris*-(ethylenediammine)cobalt (III)bromide, $[Co(en)_3]Br_3$ exhibits optical isomerism.



d-form mirror *l*-form

68. (*d*) Linkage isomerism arises in a coordination compound containing ambidentate ligand.

69. (*b*) Coordination isomerism arises from the interchange of ligands between cationic and anionic entities of different metal ions present in a complex.

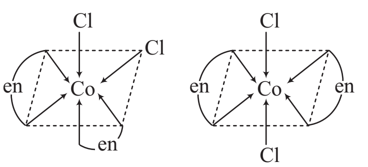
70. (*d*) When the cation and anion both are complex ions, the coordination compound exhibit coordination isomerism.

Thus, the given examples are of coordination isomerism.

71. (*d*) These examples are ionisation isomers because of chloride and sulphate ion. It has no isomerism.

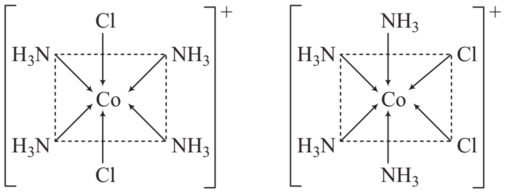
72. (*c*) $[Co(NH_3)_5SO_4]Br$ and $[Co(NH_3)_5Br]SO_4$ are ionisation isomers.

73. (*a*)



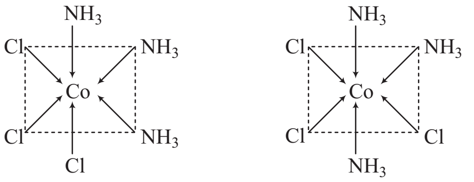
cis-$[Co(en)_2Cl_2]Cl$ (optically active) *trans*-$[Co(en)_2Cl_2]Cl$ (optically inactive due to plane of symmetry)

$[Co(NH_3)_4Cl_2]Cl$ can exist in both *cis* and *trans* forms that are given below:



trans-$[Co(NH_3)_4Cl_2]Cl$ (optically inactive) *cis*-$[Co(NH_3)_4Cl_2]Cl$ (optically inactive)

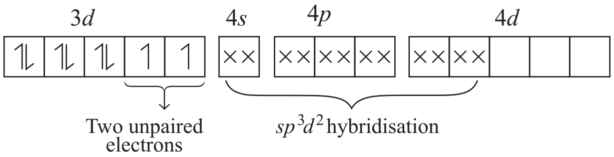
$[Co(NH_3)_3Cl_3]$ exists in *fac* and *mer*-isomeric forms and both are optically inactive.



fac-isomer (optically inactive) *mer*-isomer (optically inactive)

74. (*a*) Outer orbital complex utilises *d*-orbitals for bonding and exhibit paramagnetic behaviour, only if there present unpaired electrons.

(a) In $[Ni(NH_3)_6]^{2+}$, $Ni^{2+} = [Ar]\ 3d^8 4s^0$ $[Ni(NH_3)_6]^{2+} =$



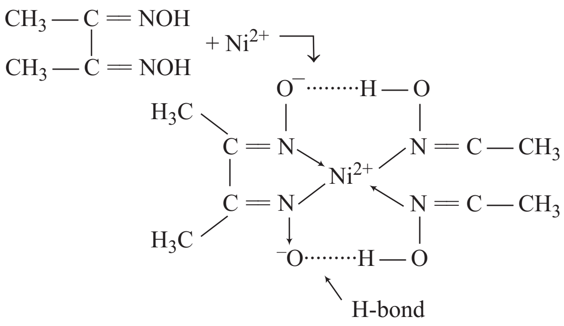
So, this is an outer orbital complex having paramagnetic character.

(b) $[Zn(NH_3)_6]^{2+}$, sp^3d^2 hybridisation, outer orbital complex and diamagnetic.

(c) $[Cr(NH_3)_6]^{3+}$, d^2sp^3 hybridisation, inner orbital complex and paramagnetic.

(d) $[Co(NH_3)_6]^{3+}$, d^2sp^3 hybridisation, inner orbital complex and diamagnetic.

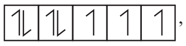
75. (*c*)



DMG acts as a bidentate ligand.

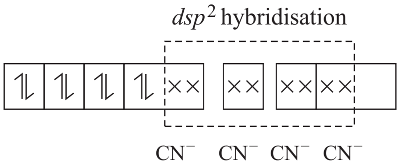
76. (*d*) Smaller the number of unpaired electrons, smaller is the paramagnetic behaviour.

$$\mathrm{Co}^{2+} \longrightarrow 3d^7, 4s^0$$



Thus, Co^{2+} has minimum paramagnetic behaviour.

77. (*c*) Ni has dsp^2 hybridisation where CN^- is a strong field ligand.

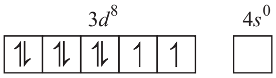


Since, all the electrons are paired, it is diamagnetic.

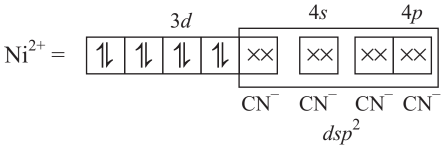
78. (*d*) For $[\mathrm{Ni(CN)_4}]^{2-}$, oxidation state of Ni is +2.

CN^- = strong field ligand

Ni^{2+} (ground state) =



In $[\mathrm{Ni(CN)_4}]^{2-}$

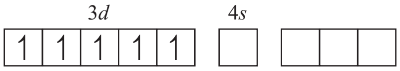


dsp^2 hybridisation, i.e. square planar geometry, zero unpaired electron, i.e. zero magnetic moment.

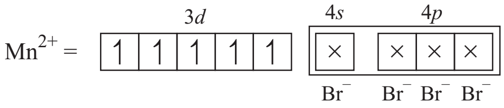
For $[\mathrm{MnBr_4}]^{2-}$, oxidation state of Mn is +2.

Br^- = weak field ligand

Mn^{2+} (in ground state)

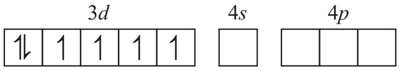


In $[\mathrm{MnBr_4}]^{2-}$,



sp^3 hybridisation, i.e, tetrahedral geometry, five unpaired electrons, i.e. magnetic moment = 5.9 as $[\mu = \sqrt{n(n+2)}$ and $n = 5]$

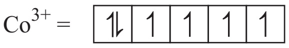
Co^{3+} in ground state =

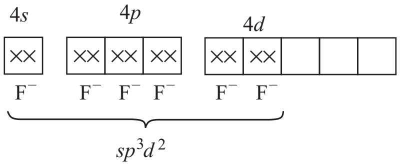


For $[\mathrm{CoF_6}]^{3-}$, oxidation state of Co is +3

F^- = weak field ligand

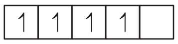
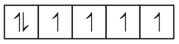
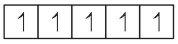
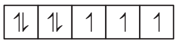
In $[\mathrm{CoF_6}]^{3-}$





sp^3d^2 hybridisation, i.e. octahedral geometry four unpaired electrons, i.e. magnetic moment is 4.91 BM.

79. (*d*) The complexes, in which metals ions have same number of unpaired electrons will have same magnetic moment.

Complex ion	Electronic configuration of metal ion	Number of unpaired electrons (n)
$[\mathrm{Cr(H_2O)_6}]^{2+}$	Cr^{2+}; $[\mathrm{Ar}]\,3d^4$	 ; 4
$[\mathrm{Fe(H_2O)_6}]^{2+}$	Fe^{2+}; $[\mathrm{Ar}]\,3d^6$	 ; 4
$[\mathrm{Mn(H_2O)_6}]^{2+}$	Mn^{2+}; $[\mathrm{Ar}]\,3d^5$	 ; 5
$[\mathrm{CoCl_4}]^{2-}$	Co^{2+}; $[\mathrm{Ar}]\,3d^7$	 ; 3

80. (*a*) For d^4 ions, the number of possible patterns of electron distribution arises is two.

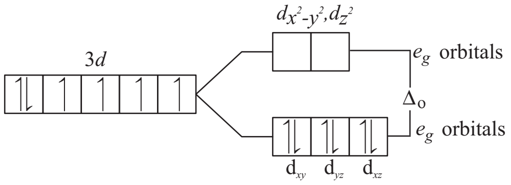
81. (*b*) The fourth electron enters one of the e_g orbitals giving the configuration $t_{2g}^3 e_g^1$ when $\Delta_o < P$.

82. (*a*) $[\mathrm{Co(CN)_6}]^{3-}$

$\mathrm{Co}^{3+} = 1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^6$

CN^- is a strong field ligand and as it approaches the metal ion, the electron must pair up.

The splitting of the *d*-orbitals into two sets of orbitals in as octahedral complex $[\mathrm{Co(CN)_6}]^{3-}$ may be represented as



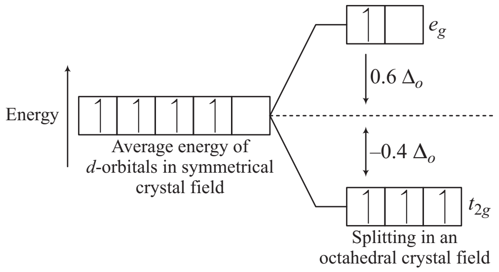
Here, for d^6 ions, three electrons first inter orbitals with parallel spin out the remaining may pair up in t_{2g} orbital giving rise to low spin complex (strong ligand) field.

$\therefore$ $[\mathrm{Co(CN)_6}]^{3-}$ has no unpaired electrons and will be in low spin configuration.

83. (*b*) Based on spectrochemical series, ligands arranged in increasing order of crystal field strength are as

$NH_3 < en < CN^- < CO$

84. (*b*) For $[Cr(H_2O)_6]^{2+}$ and $Cr^{2+} = [Ar], 3d^4$



As H_2O is a weak field lignad, so pairing of electrons does not occur.

CFSE for $[Cr(H_2O)_6]^{2+} = 3(-0.4\Delta_o) + 1(0.6\Delta_o) = -0.6\Delta_o$

Similarly,

Complex	Metal ion	Electronic configuration	CFSE
$[Mo(H_2O)_6]^{2+}$	Mo^{2+}	t_{2g}^3, e_g^1	$-0.6\,\Delta_o$
$[Ti(H_2O)_6]^{3+}$	Ti^{3+}	t_{2g}^1, e_g^0	$-0.4\,\Delta_o$
$[Ti(H_2O)_6]^{2+}$	Ti^{2+}	t_{2g}^2, e_g^0	$-0.8\,\Delta_o$

$\Delta_o \propto$ Crystal Field Stabilisation Energy (CFSE)

Δ_o depends on Z_{eff} and for 3*d*-series, Z_{eff} is less than 4*d* -series.

Hence, Δ_o of $[Cr(H_2O)_6]^{2+} > [Mo(H_2O)_6]^{2+}$

From above table,

Δ_o of $[Ti(H_2O)_6]^{3+} > \Delta_o$ of $[Ti(H_2O)_6]^{2+}$

85. (*b*) $[Ni(CN)_4]^{2-}$ do not contain unpaired electrons, so cannot absorb visible light.

86. (*a*) When concentrated HCl is added in an aqueous solution of $CoCl_2$ then it forms $[CoCl_4]^{2-}$ complex.

$$\underset{\text{Pink colour complex}}{[Co(H_2O)_6]^{2+}} + 4Cl^- \longrightarrow \underset{\text{Blue colour complex}}{[Co(Cl_4)]^{2-}} + 6H_2O$$

87. (*a*) CFSE $= 3(-0.4) + 1(0.6) = -0.6\,\Delta_O$

88. (*c*) $[Co(NH_3)_6]^{3+}$ and $[Fe(CN)_6]^{4-}$, inner orbital complex ions are diamagnetic.

89. (*a*) Magnetic moment, μ is related with number of unpaired electrons as

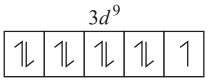
$$\mu = \sqrt{n(n+2)}\ \text{BM}$$

$$(1.73)^2 = n(n+2)$$

On solving $n = 1$

Thus, the complex compound having one unpaired electron exhibit a magnetic moment of 1.73 BM.

(a) In $[Cu(NH_3)_4]^{2+}$, $Cu^{2+} = [Ar]\ 3d^9$



(Although in the presence of strong field ligand NH_3, the unpaired electrons gets excited to higher energy level but it still remains unpaired.)

[Thus, $[Cu(NH_3)_4]^{2+}$ is the complex that exhibits a magnetic moment of 1.73 BM.]

90. (*b*) Ligand field strength $\propto$ Energy of light absorbed

$$\propto \frac{1}{\text{Wavelength of light absorbed}}$$

Wavelength of absorbed light decreases

λ	L_1	L_3	L_2	L_4
Absorbed light	Red	Yellow	Green	Blue

As the energy of wavelengths absorbed increases, greater extent of crystal-field splitting, hence higher field strength of the ligand.

Increasing order

Energy $\underset{\text{(Red)}}{L_1} < \underset{\text{(Yellow)}}{L_3} < \underset{\text{(Green)}}{L_2} < \underset{\text{(Blue)}}{L_4}$

Ligand field strength $L_1 < L_3 < L_2 < L_4$

91. (*a*) $[Co(NH_3)_6]Cl_3 \longrightarrow [Co(NH_3)_6]^{3+} + 3Cl^-$

$[Co(NH_3)_3]Cl_3 \longrightarrow [Co(NH_3)_3Cl_3]$

$[Co(NH_3)_4Cl_2]Cl \longrightarrow [Co(NH_3)_4Cl_2] + Cl^-$

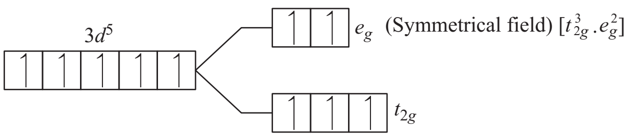
$[Co(NH_3)_5Cl]Cl_2 \longrightarrow [Co(NH_3)_5Cl]^{2+} + 2Cl^-$

So, $[CO(NH_3)_3Cl_3]$ does not ionise so does not give test for chloride ions.

92. (*b*) Hard water has commonly high pH, when EDTA solution is added to it, six coordinated Mg-EDTA complex is formed which lead to decrease in pH of solution.

93. (*a*) (a) $[FeF_3]^{2-}$ oxidation state of Fe = +3

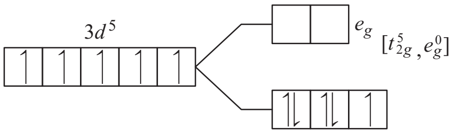
So, $Fe^{3+} = [Ar]3d^5$ where, F^- is weak field ligand.



Hence, $[FeF_3]^{3-}$ produces more symmetrical field.

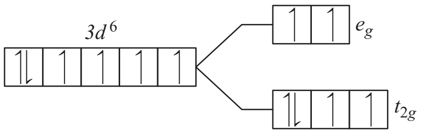
(b) $[Mn(CN)_6]^{4-}$ oxidation state of Mn = +2

So, $Mn^{2+} = [Ar]3d^5$ where, CN^- is strong field ligand, so , it produce unsymmetrical field.



(c) $[CoF_6]^{3-}$ oxidation state of Co = +3

So, $Co^{3+} = [Ar]3d^6$



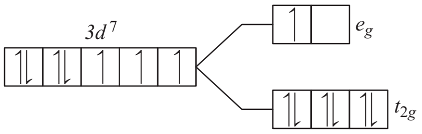
Due to weak field ligand of F^-, it produces unsymmetrical field

i.e. t_{2g}^4, e_g^2

(d) $[Co(NH_3)_6]^{2+}$ oxidation state of Co= +2

So, $Co^{2+} = [Ar]3d^7$

where, NH_3 is strong field ligand,



t_{2g}^6, e_g^1 (unsymmetrical field).

94. (*c*) Metal-carbon bond in metal carbonyls possess both σ and π-character.

95. (*a*) The *M*—C π-bond is formed by the donation of a pair of electrons.

96. (*a*) The metal-carbon bond in metal carbonyls possess both σ and π-character. The metal to ligand bonding creates a synergic effect which strengthens the bond between Co and the meal.

98. (*a*) The complexes which contain −Co ligand, will have π-bond. All these three contain π-bond in their ligand.

99. (*c*) In $Fe(CO)_5$, the Fe—CO bond possesses both sigma and pi-bonds characters.

101. (*b*) $Mn^+ = 3d^5, 4s^1$. In the presence of CO, effective configuration $= 3d^6, 4s^0$.

Three lone pairs of back bonding with vacant orbital of C in CO

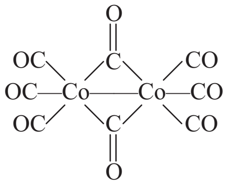
$Fe^0 = 3d^6, 4s^2$. In the presence of CO, effective configuration $= 3d^8$. 4 lone pairs of back bonding with CO.

$Cr^0 = 3d^5, 4s^1$. Effective configuration $= 3d^6$, 3 lone pairs or back bonding with CO.

$V^- = 3d^4, 4s^2$. Effective configuration $= 3d^6$, 3 lone pairs for back bonding with CO.

Maximum back bonding in $Fe(CO)_5$, therefore, CO bond order is lowest here.

102. (*d*)



Total number of metal -metal bond = 1

103. (*a*) The *M*—C π-bond in metal carbonyl which is formed by the donation of an electron pair from a filled *d*-orbital of metal into the vacant antibonding π-orbital of CO, strengthens the *M*—C σ-bond.

This is called synergic effect and is usually observed in metal carbonyls. Thus, $[Ni(CO)_4]$ exhibits synergic effect.

104. (*b*) For the reaction of the type

$$M + 4L \rightleftharpoons ML_4,$$

larger the stability constant, the higher the proportion of ML_4 that exists in solution.

105. (*c*) For $M + 4L \rightleftharpoons ML_4$,

the overall stability constant (β_4) is expressed as

106. (*d*) The reciprocal of the formation constant is called instability constant or dissociation constant.

107. (*a*) β_4 for $[ML_4]^{2-}$ can be written as

$$\beta_4 = \frac{[ML_4]^{2-}}{[M^{2+}][L^{-1}]^4} = 2.5 \times 10^{13}$$

The overall equilibrium constant for formation of $[ML_4]^{2-}$ can be written as, $K = \frac{[ML_4]^{2-}}{[M^{2+}][L^{-1}]^4}$

$K = \beta_4 = 2.5 \times 10^{13}$; where, $\beta_4 = [ML_4]/[M][L]^4$

108. (*d*) Coordination compounds find use in both qualitative and quantitative chemical analysis.

109. (*c*) Hardness of water is estimated by simple titration with Na_2 EDTA because Ca^{2+} and Mg^{2+} ions form stable complexes with EDTA.

110. (*a*) Estimation of calcium and magnesium is done by EDTA.

111. (*a*) Gold combines with cyanide in the presence of oxygen and water to form the coordination entity $[Au(CN)_2]^-$ in aqueous solution.

112. (*a*) Chlorophyll contains Mg, hence (a) is incorrect statement.

114. (*a*) Haemoglobin is prophyrin complex of ferrous iron being coordinated to four nitrogen atoms and additionally coordinated to a water molecule. The water molecule appears to be replaceable reversible by a molecule of oxygen to give oxyhaemoglobin. Fe^{2+} is diamagnetic due to strong field ligands.

116. (*c*) Wilkinson catalyst is used for the hydrogenation of alkenes.

118. (*b*) $AgBr + 2Na_2S_2O_3 \longrightarrow \underset{\text{Soluble complex}}{Na_3[Ag(S_2O_3)_2]} + NaBr$

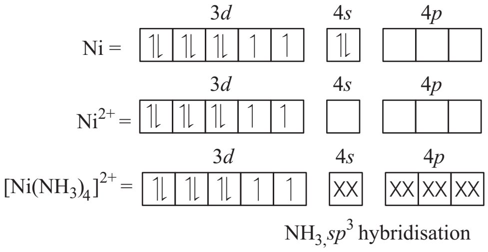
119. (*d*) The excess of copper and iron are removed by the chelating ligands D-penicillamine and desterrioxime–B via the formation of coordination compounds.

120. (*d*) For lead poisoning, the antidote used is EDTA.

125. (*a,b,c*) Cl^- is a weak field ligand but Cl^- causes the pairing of electron with large Pt^{2+} and consequently give dsp^2 hybridisation with square planar geometry.

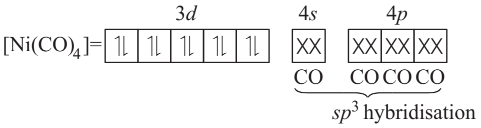
127. (*b,c,d*) The complexes which do not have unpaired electrons are diamagnetic.

(a) $[Ni(NH_3)_4]^{2+}$

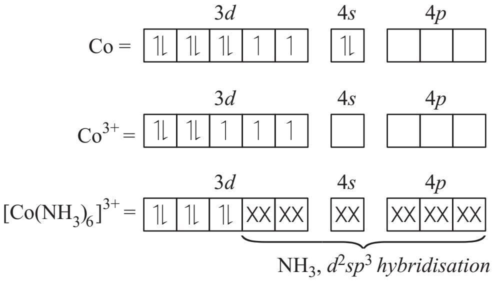


The resulting complex will be tetrahedral. It has two unpaired electrons thus, paramagnetic.

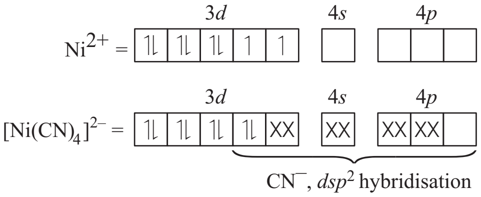
(b) $Ni(CO)_4$



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



(d) $[Ni(CN)_4]^{2-}$



In options (b),(c) and (d). no unpaired electrons are present. Thus, these are not paramagnetic.

129. (*a,c,d*) Linkage isomerism is caused due to presence of ambidentate ligands. In option (b), ambidentate ligand SCN is present. Thus, the pair mentioned in this option will show linkage isomerism.

133. (*c*) In coordination compounds metals show two types of linkages (valencies). (i) Primary and (ii) Secondary valencies. The primary valencies are normally ionisable and are satisfied by negative ions.

135. (*c*) When di- or polydentate ligand uses its two or more donor atoms to bind a single ion, it is called chelate ligand.

137. (*d*) Coordination number of the central atom/ion is determined only by the σ-bonds formed by the ligand with the central atom/ion.

138. (*b*) Only $[CoCl_3(NH_3)_3]$ complex does not ionised in solution, as no ion is present outside the coordination sphere.

140. (*b*) Polydentate ligands are listed in alphabetical order.

141. (*b*) Ligands are named in a alphabetical order before the name of central metal ion.

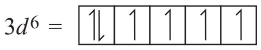
142. (*d*) Co in a complex ion is called cobalt and Pt is called platinum. If the complex ion is an anion the name of the metal ends with the suffix-ate.

144. (*d*) Charge on each complex cation in the given compound is +3.

146. (*d*) All the statements are true about optical isomers

147. (*c*) The two forms, *dextro* and *laevo*, depend upon the direction they rotate the plane of polarised light in a polarimeter. *l*-rotates to the left and *d*-rotates to the right.

149. (*d*) In the octahedral complex $[Co(NH_3)_6]^{3+}$, the cobalt ion is in +3 oxidation state. It is in $3d^6$ electronic configuration and it is diamagnetic in nature.



NH_3 being strong field ligand causes pairing resulting in a diamagnetic complex.

150. (*d*) All the statements are true.

151. (*a*) All the statements are true.

152. (*a*) All the given facts are true related to CFT.

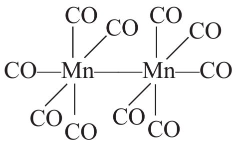
153. (*c*) $[PtCl_4]^{2-}$ complex has a square planar geometry.

$[Ni(CO)_4]$ complex has a tetrahedral geometry.

155. (*a*) $[Fe(CN)_6]^{3-}$ complex has d^2sp^3 hybridisation and it is paramagnetic, due to pairing of electrons by strong field ligand CN^-.

156. (*a*) An aqueous pink solution of cobalt (II) chloride changes to deep blue on addition of excess of HCl. This is because $[Co(H_2O)_6]^{2+}$ is transformed into $[CoCl_4]^{2-}$ and also the tetrahedral complexes have smaller crystal field splitting than octahedral complexes.

157. (*d*) Decacarbonyldimanganese (0) is made up of two square pyramidal $Mn(CO)_5$ units. These units are joined by a Mn—Mn bond. Its structure is



158. (*c*) Tetrahedral complexes have $\frac{4}{9}$th of CFSE value than octahedral complexes.

159. (*a*) $[Cu(NH_3)_4]SO_4$ is paramagnetic with one unpaired electron in the *d*-subshell. Its aqueous solution cannot conduct electricity.

160. (*c*) Assertion is correct, reason is incorrect.

161. (*a*) Mohr's salt gives NH_4^+, Fe^{2+} and SO_4^{2-} ions in aqueous solution because it is a double salt.

164. (*b*) Ethan-1, 2-diammine is a neutral molecule.as it carries no charge. Oxidation number of Co in the complex ion is +3.

165. (*a*) Usually a sulphate ion is a bidentate ligand but it can also act as a monodentate in certain complexes because many times multidentate ligands do have flexidentate character.

166. (*a*) Oxidation number of Cr in $[Cr(NH_3)_3(H_2O)_3]Cl_3$ is same as the charge of the complex ion, i.e. +3 because all the ligands are neutral molecules in this compound.

167. (*a*) Isomers differ in one or more physical or chemical properties because these have different arrangement of atoms.

168. (*a*) Geometrical isomerism arises in heteroleptic complexes because different geometric arrangements of the ligands are possible.

169. (*a*) Tetrahedral complexes do not show geometrical isomerism because the relative positions of the unidentate ligands attached to the central metal atom are same with respect to each other.

171. (*d*) Square planar complexes necessarily exhibit geometrical isomerism.

172. (*c*) Assertion is correct, reason is incorrect.

173. (*a*) Octahedral geometry and diamagnetism exist in $[Co(NH_3)_6]^{3+}$ as it has no unpaired electron.

174. (*a*) The ligands nitro and nitrito are called ambidentate ligands. These give linkage isomers.

175. (*a*) Removal of water from $[Ti(H_2O)_6]Cl_3$ on heating renders it colourless because in the absence of ligand, crystal field splitting does not occur.

176. (*c*) The coordination complexes $[Ni(CN)_4]^{2-}$ and $[NiCl_4]^{2-}$ have not the same shape also differ in magnetic behaviour also.

177. (*d*) $[Ni(en)_3]Cl_2$ is more stable than $[Ni(NH_3)_6]Cl_2$.

178. (*a*) Complexes are preferred in the electrolytic bath for electroplating because complexes dissociate slowly and hence give a smooth and even deposit.

179. (*c*) Crystal field splitting in ferrocyanide ion is smaller than that of ferricyanide ion.

180. (*b*) As compared to non-chelated complexes, chelated complexes are more stable.

Labile complexes are those complexes which contain ligands those can be easily replaced by other ligands.

181. (*d*) Reason is correct; Assertion is incorrect.

182. (*d*) A → 4, B → 3, C → 2, D → 1

183. (*c*) A → 1(III); B → 3(II); C → 2(I)

184. (*b*) A → 2, B → 1, C → 3

Shape of $[Co(NH_3)_6]^{3+}$ is octahedral because it is d^2sp^3 hybridised.

Shape of $[Ni(CO)_4]$ is tetrahedral, as it is sp^3 hybridised.

Shape of $[PtCl_4]^{2-}$ is square planar, as it is dsp^2 hybridised.

185. (*c*) A → 3, B → 1, C → 4, D → 2, E → 5

186. (*d*) A → 4, B → 1, C → 3, D → 2

187. (*c*) A → 4, B → 2, C → 3, D → 1

188. (*a*) A → 2, B → 3, C → 1

189. (*c*) A → 3; B → 4; C → 2; D → 1

190. (*b*) A → 1, B → 2, C → 3, D → 4

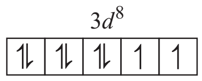
191. (*d*) A → IV (2), B → III (1), C → II (3), D → I (4)

192. (*a*) A → 6, B → 4, C → 1, D → 2, E → 3

A. $[Ni(CN)_4]^{2-}$

$$Ni(28) = [Ar]\,3d^8 4s^2$$

$$Ni^{2+} = [Ar]\,3d^8, 4s^0$$



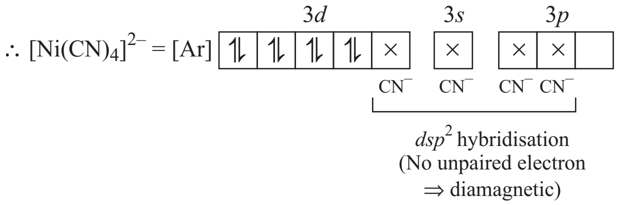
Since, CN^- is a strong field ligand, it causes pairing of electrons.

B. Chlorophyll contains Mg^{2+} ion.

C. *Ziegler-Natta* catalyst is $Ti^{4+} + (C_2H_5)_3Al$

D. $[NiCl_4]^{2-}$

In this case, Cl^- is a weak field ligand so doesn't cause pairing. Hence,



Due to the presence of unpaired electrons, it is paramagnetic.

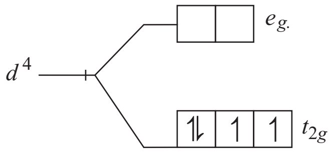
E. Deoxyhaemoglobin is non-planar while oxyhaemoglobin is planar.

193. (*c*) A → 2, B → 4, C → 5, D → 1, E → 3.

194. (*a*) A → 1, B → 2, C → 3

195. (*d*) A → 4, B → 3, C → 2, D → 1

196. (*a*) A → 4, B → 2, C → 1, D → 3



CFSE = −4 × 0.4 = −1·6

For d^5, CFSE $= -5 \times 0.4 = -2.0$

For d^6, CFSE $= -6 \times 0.4 = -2.4$

For d^7, CFSE $= -6 \times 0.4 + 1 \times 0.6$

$= -2.4 + 0.6 = -1.8$

197. (*b*) Secondary valency means coordination number. So, the secondary valencies of I and III are 4 and 6 respectively.

198. (*c*) Complexes having the secondary valencies (coordination number) of 6 are II, III and IV.

199. (*d*) $\underset{\text{(excess)}}{NiCl_2 + 4KCN} \longrightarrow \underset{\substack{X \\ \text{Potassium tetra} \\ \text{cyanonickelate (II)}}}{K_2[Ni(CN)_4]} + 2KCl$

$K_2[Ni(CN)_4] + 4HCl \longrightarrow \underset{\substack{\text{Potassium} \\ \text{tetrachloronickelate (II)}}}{K_2[Ni(Cl)_4]} + 4HCN$

200. (*b*) Hybridisation of $X \rightarrow K_2[Ni(CN)_4]$ is dsp^2

$Y \rightarrow K_2[NiCl_4]$ is sp^3.

201. (*c*) *X* contains paired electrons whereas *Y* contains unpaired electrons.

202. (*b*) Ligand must have an electron pair to donate metal ion. These electron pair must be loosely bounded to ligand

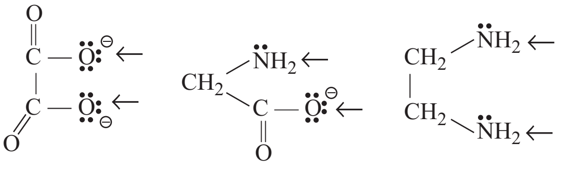
e.g. $:\ddot{N} = O, \ddot{N}H_2CH_2CH_2\ddot{N}H_2, :CO,$

Among NH_4^+ does not have any pair of electron.

Hence NH_4^+ is not a ligand.

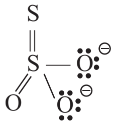
203. (*a*) A chelating ligand has two or more binding donor atoms to a single metal ion

e.g.



Oxalato Glycinato Ethan-1, 2-diamine

Here (←) denotes binding site. Thiosulphato ($S_2O_3^{2-}$) is not a chelating ligand because geometrically it is not favourable for $S_2O_3^{2-}$ to chelate a metal ion.



204. (*b*) One mole of $AgNO_3$ precipitates one mole of chloride ion. In the above reaction, when 0.1 mole of $CoCl_3(NH_3)_5$ is treated with excess of $AgNO_3$, 0.2 mole of AgCl is obtained thus, there must be two free chloride ions in the solution of electrolyte.

So, molecular formula of complex will be $[Co(NH_3)_5Cl]Cl_2$ and electrolytic solution must contain $[Co(NH_3)_5Cl]^{2+}$ and two Cl^- as constituent ions. Thus, it is 1 : 2 electrolyte.

$[Co(NH_3)_5Cl]Cl_2 \longrightarrow [Co(NH_3)_5Cl]^{2+}(aq) + 2Cl^-(aq)$

Hence, option (b) is the correct.

205. (*d*) 1 mole of $AgNO_3$ precipitates one free chloride ion (Cl^-).

Here, 3 moles of AgCl are precipitated by excess of $AgNO_3$. Hence, there must be three free Cl^- ions.

So, the formula of the complex is $[Cr(H_2O)_6]Cl_3$ and correct choice is (d).

206. (*a*) The complex compound is $[Pt(NH_3)_2Cl_2]$.

The ligands present in the compound are

(i) NH_3 – neutral ligand represented as ammine.

(ii) Cl^- anion ligand (ending with-o-) represented as chlorido, di prefixed to represent two ligands.

The oxidation number of platinum in the compound is 2. Hence, correct IUPAC name of $[Pt(NH_3)_2Cl_2]$ is Diamminedichloridoplatinum (II).

So, option (a) is correct.

207. (*c*) Correct IUPAC name can be written as

The ligands present in the given coordination compound are:

(i) (NH_3) represented as ammine

(ii) Cl^s represented as chlorido

(iii) NO_2^s represented as nitrito-N

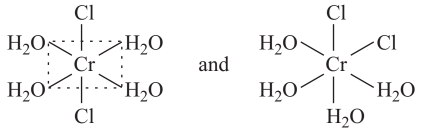
According to IUPAC rule, ligands are named in an alphabetical order before central atom. Prefix di-will be used to indicate the number of NH_3 ligands present.

Oxidation state of metal is indicated by Roman numeral in parenthesis. So, IUPAC name will be diamminechloronitrito-N-platinum (II)

Hence, option (c) is correct.

208. (*a*) $[Cr(H_2O)_4Cl_2]^+$ shows geometrical isomerism because it is a MA_4B_2 type coordination compound which contains two set of equivalent ligands, four H_2O and 2Cl.

Hence, the possible geometrical isomers are



trans-isomer *cis*-isomer

Hence, correct choice is option (a).

209. (*b*) Solvate isomerism is shown when two compounds having same molecular formula differ by water or solvent molecule directly bonded to metal ion or present as free solvent molecules in the crystal lattice.

When water is present as solvent and show this type of isomerism is known as hydrate isomerism.

Coordination compound $[Cr(H_2O)_6]Cl_3$ and $[Cr(H_2O)_5Cl]H_2O \cdot Cl_2$ are solvate isomers, because water is exchanged by chloride ion. This is why both of them show different colour on exposure to sunlight.

210. (*a*) The ligand(s) which has two different bonding sites are known as ambident ligands, e.g. NCS, NO_2 etc.

Here, NCS has two binding sites at N and S.

Hence, NCS (thiocyanate) can bind to the metal ion in two ways

$$M \leftarrow \text{NCS or } M \rightarrow \text{SNC}$$

Thus, coordination compounds containing NCS as a ligand can show linkage isomerism, i.e. $[Pd(C_6H_5)_2(SCN)_2]$ and $[Pd(C_6H_5)_2(NCS)_2]$ are linkage isomers.

Hence, correct choice is option (a).

211. (*d*) Compounds having same molecular formula but different structural formula are known as isomers. $[Co(SO_4)_2(NH_3)_5]Br$ and $[Co(SO_4)(NH_3)_5]Cl$ have not same molecular formula. Hence, they are not isomers.

212. (*c*) Chelation (formation of cycle by linkage between metal ion and ligand) stabilises the coordination compound. The ligand which chelates the metal ion are known as chelating ligand.

Here, only $[Fe(C_2O_4)_3]^{3-}$ is a coordination compound which contains oxalate ion as a chelating ligand. Hence, it stabilises coordination compound by chelating Fe^{3+} ion.

213. (*c*) CFSE for octahedral and tetrahedral complexes are closely related to each other by formula $\Delta_t = \frac{4}{9}\Delta_o$.

where, Δ_o = CFSE for octahedral complex, Δ_t = CFSE for tetrahedral complex

According to question, $\Delta_o = 18000 \text{ cm}^{-1}$

$$\therefore \quad \Delta_t = \frac{4}{9}\Delta_o = \frac{4}{9} \times 18000 \text{ cm}^{-1}$$

$$= 4 \times 2000 \text{ cm}^{-1} = 8000 \text{ cm}^{-1}$$

Hence, correct choice is option (c).

214. (*b*) Greater the value of log *K*, greater will be stability of complex compound formed.

For reaction, $Cu^{2+} + 4CN^- \longrightarrow [Cu(CN)_4]^{2-}$

$$K = \frac{[(Cu(CN)_4)^{2-}]}{[Cu^{2+}][CN^-]^4} \text{ and } \log K = 27.3$$

For this reaction, log *K* has highest value among the given four reactions. Hence, *K* will also be higher among these four complexes, i.e. stability of the complexes with higher pH, will be highest among these four complexes.

215. (*c*) As we know that, strong field ligand splits the five degenerate energy levels with more energy separation than weak field ligand, i.e. as strength of ligand increases crystal field splitting energy increases.

Hence, $$\Delta E = \frac{hc}{\lambda} \Rightarrow \Delta E \propto \frac{1}{\lambda} \Rightarrow \lambda \propto \frac{1}{\Delta E}$$

As energy separation increases, the wavelength decreases.

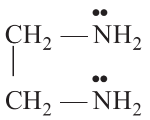
Thus, the correct order is

$$[Co(H_2O)_6]^{3+} > [Co(NH_3)_6]^{3+} > [Co(CN)_6]^{3-}$$

Here, strength of ligand increases, ΔE increases, CFSE increases and λ absored decreases.

Hence, correct choice is option (c).

216. (*a, b, c*) Molecular formula of ethan-1, 2-diammine is



$$\begin{array}{l} CH_2 - \ddot{N}H_2 \\ | \\ CH_2 - \ddot{N}H_2 \end{array}$$

(a) Ethan-1, 2-diammine is a neutral ligand due to absence of any charge.

(b) It is a bidentate ligand due to presence of two donor sites one at each nitrogen atom of amino group.

(c) It is a chelating, ligand due to its ability to chelate with the metal.

Hence, options (a), (b) and (c) are correct choices.

217. (*a, c*) **Homoleptic complex** The complex containing only one species or group as ligand is known as homoleptic ligand.

e.g. $[Co(NH_3)_6]^{3+}, [Ni(CN)_4]^{2-}$

Here, $[Co(NH_3)_6]^{3+}$ contain only NH_3 as a ligand and $[Ni(CN)_4]^{2-}$ contain CN as a ligand. While other two complexes $[Co(NH_3)_4Cl_2]^+$ and $[Ni(NH_3)_4Cl_2]$ contain NH_3 and Cl as ligands.

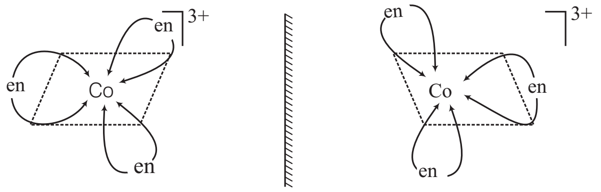
Hence, options (a) and (c) are correct choices.

218. (*b, d*) **Heteroleptic complexes** Coordination complexes which contain more than one type of ligands are known as heteroleptic complexes.

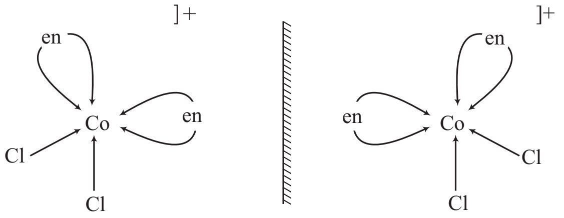
e.g. $[Fe(NH_3)_4Cl_2]^+$ contain NH_3 and Cl as a ligand is as heteroleptic complex. Similarly, $[Co(NH_3)_4Cl_2]$ contain NH_3 and Cl as ligand is also a heteroleptic complex.

Hence, options (b) and (d) are correct choices.

219. (*a, c*) $[Co(en)_3]^{3+}$ and *cis* $-[Co(en)_2Cl_2]^+$ are optically active compounds because their mirror images are non-superimposable isomer.



Non-superimposable isomers of $[Co(en)_3]^{3+}$

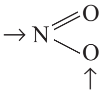


Non-superimposable isomers of $[Co(en)_2Cl_2]^+$

Hence, options (a) and (c) are correct choices.

220. (*a, c*) Coordination compounds containing a ligand with more than one non-equivalent binding position (known as ambident ligand) show linkage isomerism.

e.g. $[Co(NH_3)_5(NO_2)]^+$ contains NO_2 which have two donor sites N and O can be shown by arrow (→) as



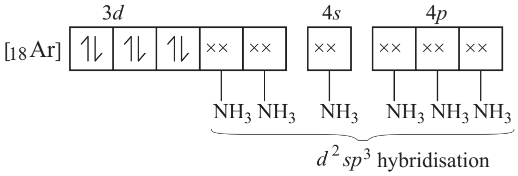
$[Cr(NH_3)_5SCN]^{2+}$ contains SCN which have two different donor sites S and N can be shown by arrow (→) as

$$\rightarrow S-C\equiv N\leftarrow$$

Hence, $[Co(NH_3)_5(NO_2)]^{2+}$ and $[Cr(NH_3)_5SCN]^{2+}$ show linkage isomerism. While $[Co(H_2O)_5\ CO]^{3+}$ and $[Fe(en)_2Cl_2]^+$ has no ambident ligand. So, these two will not show linkage isomerism.

Hence, options (a) and (c) are correct choices.

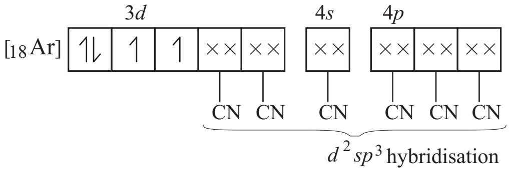
221. (*a, c*) Molecular orbital electronic configuration of Co^{3+} in $[Co(NH_3)_6]^{3+}$ is



Number of unpaired electron = 0

Magnetic property = Diamagnetic

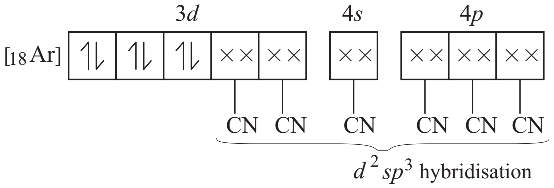
Molecular orbital electronic configuration of Mn^{3+} in $[Mn(CN)_6]^{3-}$



Number of unpaired electrons = 2

Magnetic property = Paramagnetic

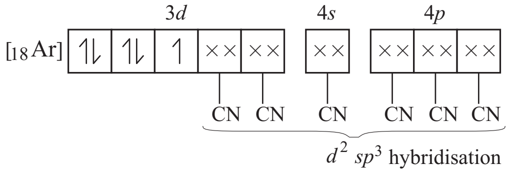
Molecular orbital electronic configuration of Fe^{2+} in $[Fe(CN)_6]^{4-}$ is



Number of unpaired electron = 0

Magnetic property = Diamagnetic

Molecular orbital electronic configuration of Fe^{3+} in $[Fe(CN)_6]^{3-}$



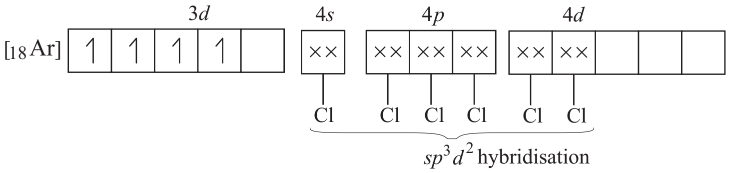
Number of unpaired electron = 1

Magnetic property = Paramagnetic

Thus, $[Co(NH_3)_6]^{3+}$ and $[Fe(CN)_6]^{4-}$ are diamagnetic.

Hence, correct choices are options (a) and (c).

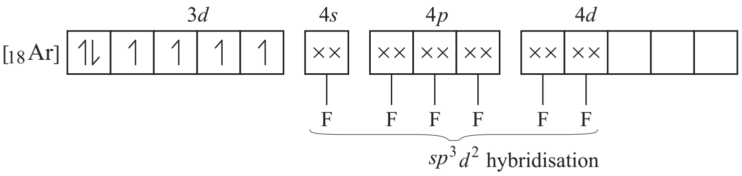
222. (*a, c*) Molecular orbital electronic configuration of Mn^{3+} in $[MnCl_6]^{3-}$ is



Number of unpaired electrons = 4

Magnetic property = Paramagnetic

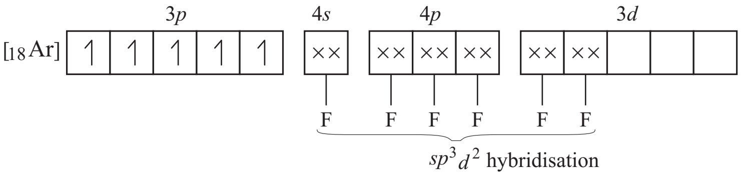
Molecular orbital electronic configuration of Co^{3+} in $[CoF_6]^{3-}$ is



Number of unpaired electrons = 4

Magnetic property = Paramagnetic

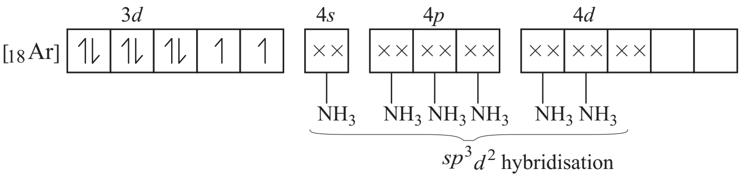
Molecular orbital electronic configuration of Fe^{3+} in $[FeF_6]^{3-}$is



Number of unpaired electrons = 5

Magnetic property = Paramagnetic

Molecular orbital electronic configuration of Ni^{2+}in $[Ni(NH_3)_6]^{2+}$ is



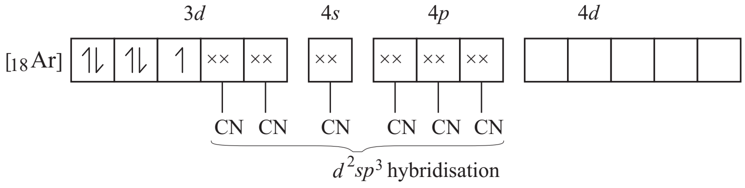
Number of unpaired electrons = 2

Magnetic property = Paramagnetic

Thus, $[MnCl_6]^{3-}$ and $[CoF_6]^{3-}$ are paramagnetic having four electrons each.

Hence, correct choices are (a) and (c).

223. (*a, c*) According to VBT, the molecular orbital electronic configuration of Fe^{3-} in $[Fe(CN)_6]^{3-}$ is



Hybridisation = d^2sp^3

Number of unpaired electron = 1

Magnetic property = Paramagnetic

Hence, correct choices are options (a) and (c).

224. (*b, c*) Aqueous pink solution of cobalt (II) chloride is due to electronic transition of electron from t_{2g} to e_g energy level of $[Co(H_2O)_6]^{2+}$ complex. When excess of HCl is added to this solution

(i) $[Co(H_2O)_6]^{2+}$ is transformed into $[CoCl_4]^{2-}$.

(ii) Tetrahedral complexes have smaller crystal field splitting than octahedral complexes because $\Delta_t = \frac{4}{9}\Delta_o$

Hence, options (b) and (c) are correct choices.

225. (*a*) Assertion and Reason both are correct and Reason is the correct explanation of Assertion.

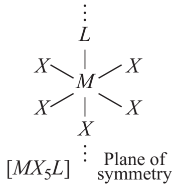
Toxic metal ions are removed by chelating ligands. When a solution of chelating ligand is added to solution containing toxic metals ligands chelates the metal ions by formation of stable complex.

226. (*a*) Assertion and Reason both are correct and Reason is correct explanation of Assertion. Linkage isomerism arises in coordination compounds containing ambidentate ligands because ambidentate ligand has two different donor atoms.

e.g. SCN, NO_2 etc.

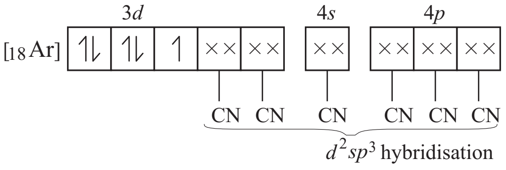
227. (*b*) Assertion and Reason both are correct and Reason is not correct explanation of Assertion.

Complexes of MX_6 and MX_5L type (X and L are unidentate) do not show geometrical isomerism due to presence of plane of symmetry and necessary condition for showing geometrical isomerism is that complex is must of MA_4B_2 type or $[M(AB)_2X_2]$ type



228. (*d*) Assertion is false but Reason is true.

According to VBT, MOEC of Fe^{3+} in $[Fe(CN)_6]^{3-}$ is



Hybridisation = d^2sp^3

$n = 1$

Hence, correct Assertion is $[Fe(CN)_6]^{3-}$ ion shows magnetic moment corresponding to one unpaired electron.

i.e., $\mu = \sqrt{n(n+2)} = \sqrt{1(1+2)}$

$= \sqrt{3} = 1.73\,\text{BM}$

229. (*b*) Assertion and Reason both are true but Reason is not correct explanation of Assertion.

Correct Reason is

$[Cr(H_2O_6)]Cl_2$ and $[Fe(H_2O)_6]Cl_2$ are reducing in nature due to formation of more stable complex ion after gaining of electron.

230. (*d*) A → (4); B → (1); C → (3); D → (2)

Oxidation state of CMI (central metal ion) can be calculated by considering the oxidation state of whole molecule is equal to charge present on coordination sphere.

A. $[Co(NCS)(NH_3)_5]SO_3$.

Let oxidation state of Co is x.

$$x - 1 + 5 \times 0 = +2$$
$$x = +2 + 1 = +3$$

B. $[Co(NH_3)_4Cl_2]SO_4$

Let oxidation state of Co = x

$$\Rightarrow \quad x + 4 \times 0 + 2 \times (-1) = +2$$
$$\Rightarrow \quad x - 2 = +2$$
$$x = +4$$

C. $Na_4[Co(S_2O_3)_3]$

Let oxidation state of Co = x

$$x + 3 \times (-2) = -4$$
$$x - 6 = -4$$
$$x = -4 + 6 = +2$$

D. $[Co(CO)_8]$

Let oxidation state of Co = x

$$x - 8 \times 0 = 0$$
$$x = 0$$

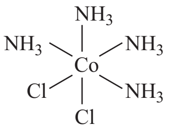
Hence, correct choice is option (d).

231. (*a*) A → (3); B → (4); C → (1); D → (2)

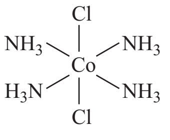
232. (*d*) A → (4); B → (1); C → (2); D → (3)

Isomerism in coordination compound is decided by type of ligands and geometry of coordination and arrangement of ligands.

A. $[Co(NH_3)_4Cl_2]^+$ shows geometrical isomerism due to presence of two types of ligand whose $[Co(NH_3)_4Cl_2]^+$ arrangement around central metal ion.

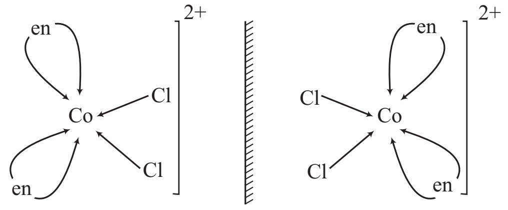


cis-isomer



trans-isomer

B. $cis-[Co(en)_2Cl_2]^+$ shows optical isomer due to its non-superimposable mirror image relationship.



C. $[Co(NH_3)_5(NO_2)]Cl_2$ shows ionisation isomer due to its interchanging ligand from outside the ionisation sphere.

D. $[Co(NH_3)_6][Cr(CN)_6]$ shows coordination isomer due to interchanging of ligand in between two metal ions from one coordination sphere to another coordination sphere.

Hence, correct choice is option (d).

233. (*b*) A → (4); B → (3); C → (2); D → (1)

Colour of coordination compound is closely related to CFSE of coordination compound. Depending upon the CFSE of given coordination compounds. Correct matching will be as follows

Column I (Complex ion)	**Column II** (Colour)
A. $[Co(NH_3)_6]^{3+}$	4. Yellowish orange
B. $[Ti(H_2O)_6]^{3+}$	3. Pale blue
C. $[Ni(H_2O)_6]^{2+}$	2. Green
D. $[Ni(H_2O)_4(en)]^{2+}(aq)$	1. Violet

Hence, correct choice is option (b).

234. (*a*) A → (3); B → (1); C → (4); D → (2)

Formation of inner orbital complex and outer orbital complex determines hybridisation of molecule which inturn depends upon field strength of ligand and number of vacant *d*-orbitals.

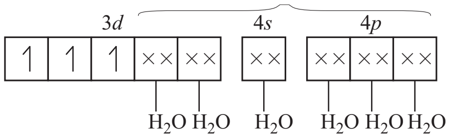
(i) Strong field ligand forms inner orbital complex with hybridisation d^2sp^3.

(ii) Weak field ligand forms outer orbital complex with hybridisation sp^3d^2.

According to VBT, hybridisation and number of unpaired electrons of coordination compounds can be calculated as

A. $[Cr(H_2O)_6]^{3+}$

MOEC (Molecular orbital electronic configuration) of Cr^{3+} in $[Cr(H_2O)_6]^{3+}$ is

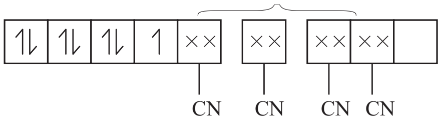


Hybridisation = d^2sp^3

n (number of unpaired electrons) = 3

B. $[Co(CN)_4]^{2-}$

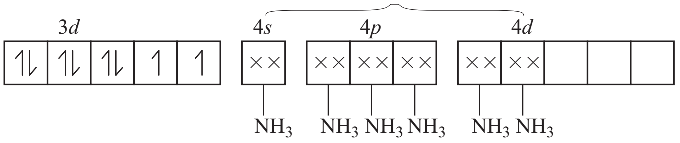
MOEC of Co^{2+} in $[Co(CN)_4]^{2-}$ is



Hybridisation = dsp^2 and $n = 1$

C. $[Ni(NH_3)_6]^{2+}$

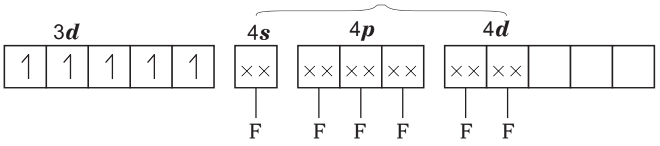
MOEC of Ni^{2+} in $[Ni(NH_3)_6]^{2+}$ is



Hybridisation = sp^3d^2 and $n = 2$

D. $[MnF_6]^{4-}$

MOEC of Mn^{2+} in $[MnF_6]^{4-}$ is



Hybridisation = sp^3d^2

$n = 5$

Hence, correct choice can be represented by (a).