COORDINATION COMPOUNDS

FACT/DEFINITION TYPE QUESTIONS

1. According to the postulates of Werner for coordination compounds
(a) primary valency is ionizable
(b) secondary valency is ionizable
(c) primary and secondary valencies are non-ionizable
(d) only primary valency is non-ionizable.

2. Which of the following postulates of Werner's theory is incorrect?
(a) Primary valencies are satisfied by negative ions.
(b) Secondary valencies are satisfied by neutral molecules or negative ions.
(c) Secondary valence is equal to the coordination number and it depends upon the nature of ligand attached to metal.
(d) The ions/ groups bound by the secondary linkages to the metal have charecteristic spatial arrangements.

3. $CrCl_3$ has primary valence of
(a) 3 (b) 4
(c) 2 (d) 1

4. 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 two moles of $AgNO_3$ solution to yield two moles of AgCl (s). The structure of the complex is
(a) $[Co(NH_3)_3Cl_3].2NH_3$
(b) $[Co(NH_3)_4Cl_2]Cl.NH_3$
(c) $[Co(NH_3)_4Cl]Cl_2.NH_3$
(d) $[Co(NH_3)_5Cl]Cl_2$

5. When $AgNO_3$ is added to a solution of $Co(NH_3)_5Cl_3$, the precipitate of AgCl shows two ionisable chloride ions. This means :
(a) Two chlorine atoms satisfy primary valency and one secondary valency
(b) One chlorine atom satisfies primary as well as secondary valency
(c) Three chlorine atoms satisfy primary valency
(d) Three chlorine atoms satisfy secondary valency

6. Which one is the most likely structure of $CrCl_3.6H_2O$ if 1/3 of total chlorine of the compound is precipitated by adding $AgNO_3$
(a) $CrCl_3.6H_2O$
(b) $[Cr(H_2O)_3Cl_3].(H_2O)_3$
(c) $[CrCl_2(H_2O)_4]Cl.2H_2O$
(d) $[CrCl(H_2O)_5]Cl_2.H_2O$

7. $K_4[Fe(CN)_6]$ is a :
(a) double salt (b) complex compound
(c) acid (d) base

8. The number of ions formed on dissolving one molecule of $FeSO_4(NH_4)_2SO_4.6H_2O$ in water is:
(a) 4 (b) 5
(c) 3 (d) 6

9. The solution of $K_4[Fe(CN)_6]$ in water will
(a) give a test K^+ (b) give a test Fe^{2+}
(c) give a test of CN^- (d) give a test of $[Fe(CN)_6]^{4-}$

10. In the coordination compound, $K_4[Ni(CN)_4]$, the oxidation state of nickel is
(a) 0 (b) +1
(c) +2 (d) –1

11. 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 sigma and pi-bonds both
(b) the number of ligands around a metal ion bonded by pi-bonds
(c) the number of ligands around a metal ion bonded by sigma bonds
(d) the number of only anionic ligands bonded to the metal ion.

12. The oxidation state of Cr in $[Cr(NH_3)_4Cl_2]^+$ is
(a) 0 (b) +1
(c) +2 (d) +3

13. In $Ni(CO)_4^-$, oxidation number of Ni is :
(a) 4 (b) –4
(c) 0 (d) +2

14. $[EDTA]^{4-}$ is a :
(a) monodentate ligand (b) bidentate ligand
(c) quadridentate ligand (d) hexadentate ligand

15. The compound having the lowest oxidation state of iron is:
(a) $K_4Fe(CN)_6$ (b) K_2FeO_4
(c) Fe_2O_3 (d) $Fe(CO)_5$

16. The coordination number and the oxidation state of the element 'E' in the complex $[E(en)_2(C_2O_4)]NO_2$ (where (en) is ethylene diamine) are, respectively,
(a) 6 and 2 (b) 4 and 2
(c) 4 and 3 (d) 6 and 3

17. Some salts although containing two different metallic elements give test for only one of them in solution. Such salts are
(a) complex (b) double salts
(c) normal salts (d) None of these

18. Coordination number of Ni in $[Ni(C_2O_4)_3]^{4-}$ is
(a) 3 (b) 6
(c) 4 (d) 5

19. According to Lewis, the ligands are
(a) acidic in nature
(b) basic in nature
(c) some are acidic and others are basic
(d) neither acidic nor basic

20. Ligand in a complex salt are
(a) anions linked by coordinate bonds to a central metal atom or ion
(b) cations linked by coordinate bonds to a central metal or ion
(c) molecules linked by coordinate bonds to a central metal or ion
(d) ions or molecules linked by coordinate bonds to a central atom or ion

21. The ligand $N(CH_2CH_2NH_2)_3$ is
(a) tridentate (b) pentadentate
(c) tetradentate (d) bidentate

22. An example of ambidentate ligand is
(a) Ammine (b) Aquo
(c) Chloro (d) Thiocyanato

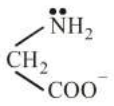
23. Which of the following does not form a chelate ?
(a) EDTA (b) Oxalate
(c) Pyridine (d) Ethylenediamine

24. A *bidenate* ligand always
(a) has bonds formed to two metals ions
(b) has a charge of +2 or – 2
(c) forms complex ions with a charge of +2 or –2
(d) has two donor atoms forming simultaneously two sigma (σ) bonds.

25. An *ambident ligand* is one which
(a) is linked to the metal atom through two donor atoms
(b) has two donor atoms, but only one of them has the capacity to form a coordinate bond [or a sigma (σ) bond]
(c) has two donor atoms, but either of two can form a coordinate bond
(d) forms chelate rings.

26. NH_2-NH_2 serves as
(a) Monodentate ligand (b) Chelating ligand
(c) Bridging ligand (d) Both (a) and (c)

27. Which one of the following is NOT a ligand ?
(a) PH_3 (b) NO^+
(c) Na^+ (d) F^-

28. Glycinato ligand is:
(a)


(b) bidentate ligant
(c) two donor sites N and O^-
(d) All of the above

29. Which one does not belong to ligand?
(a) PH_3 (b) NO^+
(c) BF_3 (d) Cl^-

30. Which ligand is expected to be bidentate?
(a) $C_2O_4^{2-}$ (b) $CH_3C\equiv N$
(c) Br^- (d) CH_3NH_2

31. Which one of the following ligands forms a chelate
(a) Acetate (b) Oxalate
(c) Ammonia (d) Cyanide

32. Choose the correct statement.
(a) Coordination number has nothing to do with the number of groups or molecules attached to the central atom
(b) Coordination number is the number of coordinating sites of all the ligands connected to the central atom or the number of coordinate bonds formed by the metal atom with ligands
(c) Werner's coordination theory postulates only one type of valency
(d) All the above are correct

33. O_2 is a
(a) Monodentate ligand (b) Bidenate ligand
(c) Tridentate ligand (d) Hexadenate ligand

34. The stabilisation of cooordination 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) $[Fe(H_2O)_6]^{3+}$

35. A chelating agent has two or more than two donor atoms to bind to a single metal ion. Which of the following is not a chelating agent ?
(a) thiosulphato (b) oxalato
(c) glycinato (d) ethane - 1, 2-diamine

36. Which of the following species is not expected to be a ligand?
(a) NO (b) NH_4^+
(c) $NH_2CH_2CH_2NH_2$ (d) Both (a) and (b)

37. Which of the following complexes are homoleptic ?

(i) $[Co(NH_3)_6]^{3+}$ (ii) $[Co(NH_3)_4Cl]^+$

(iii) $[Ni(CN)_4]^{2-}$ (iv) $[Ni(NH_3)_4Cl_2]$

(a) (i) and (ii) (b) (ii) and (iii)
(c) (iii) and (iv) (d) (i) and (iii)

38. Which of the following complexes are heteroleptic ?

(i) $[Cr(NH_3)_6]^{3+}$ (ii) $[Fe(NH_3)_4Cl_2]^+$

(iii) $[Mn(CN)_6]^{4-}$ (iv) $[Co(NH_3)_4Cl_2]$

(a) (i), (iv) (b) (ii) and (iv)
(c) (i) and (ii) (d) (i) and (iv)

39. Central atoms/ions in coordination compounds are.

(a) Lewis acid (b) Lewis bases
(c) Neutral molecules (d) All of these

40. What is the denticity of the ligand ethylenediaminetetra actetate ion?

(a) 4 (b) 2
(c) 6 (d) 1

41. $K_3[Al(C_2O_4)_3]$ is called

(a) Potassium aluminooxalate
(b) Potassium trioxalatoaluminate (III)
(c) Potassium aluminium (III) oxalate
(d) Potassium trioxalatoaluminate (VI)

42. The hypothetical complex chlorodiaquatriamminecobalt (III) chloride can be represented as

(a) $[CoCl(NH_3)_3(H_2O)_2]Cl_2$
(b) $[Co(NH_3)_3(H_2O)Cl_3]$
(c) $[Co(NH_2)_3(H_2O)_2Cl]$
(d) $[Co(NH_3)_3(H_2O)_3]Cl_3$

43. The IUPAC name of the coordination compound $K_3[Fe(CN)_6]$ is

(a) Tripotassium hexacyanoiron (II)
(b) Potassium hexacyanoiron (II)
(c) Potassium hexacyanoferrate (III)
(d) Potassium hexacyanoferrate (II)

44. The IUPAC name for the complex $[Co(ONO)(NH_3)_5]Cl_2$ is

(a) pentaamminenitrito-N-cobalt(II) chloride
(b) pentaamminenitrito-N-cobalt(III) chloride
(c) nitrito-N-pentaamminecobalt(III) chloride
(d) nitrito-N-pentaamminecobalt(II) chloride

45. The IUPAC name of $K_2[PtCl_6]$ is

(a) hexachloroplatinate potassium
(b) potassium hexachloroplatinate (IV)
(c) potassium hexachloroplatinate
(d) potassium hexachloroplatinum (IV)

46. The IUPAC name of $[Ni(NH_3)_4][NiCl_4]$ is

(a) Tetrachloronickel (II) - tetraamminenickel (II)
(b) Tetraamminenickel (II) - tetrachloronickel (II)
(c) Tetraamminenickel (II) - tetrachloronickelate (II)
(d) Tetrachloronickel (II) - tetrachloronickelate (0)

47. As per IUPAC nomenclature, the name of the complex $[Co(H_2O)_4(NH_3)_2]Cl_3$ is :

(a) Tetraaquadiaminecobalt (III) chloride
(b) Tetraaquadiamminecobalt (III) chloride
(c) Diaminetetraaquacoblat (II) chloride
(d) Diamminetetraaquacobalt (III) chloride

48. The IUPAC name of the complex $[Co(NH_3)_4(H_2O)Cl]Cl_2$ is

(a) aquatetramminechloridocobalt (III) chloride
(b) chloridoaquatetramminechloridocobalt (III) chloride
(c) chloridoaquatetramminechloridocobalt (III) chloride
(d) tetrammineaquachloridocobalt (III) chloride

49. As per IUPAC nomenclature, the name of the complex $[Co(H_2O)_4(NH_3)_2]Cl_3$ is :

(a) Tetraaquadiaminecobalt (III) chloride
(b) Tetraaquadiamminecobalt (III) chloride
(c) Diaminetetraaquacobalt (II) chloride
(d) Diamminetetraaquacobalt (III) chloride

50. Chemical formula for iron (III) hexacyanoferrate (II) is

(a) $Fe[Fe(CN)_6]$ (b) $Fe_3[Fe(CN)_6]$
(c) $Fe_3[Fe(CN)_6]_4$ (d) $Fe_4[Fe(CN)_6]_3$

51. The IUPAC name of $K_3[Ir(C_2O_4)_3]$ is

(a) potassium trioxalatoiridium (III)
(b) potassium trioxalatoiridate (III)
(c) potassium tris (oxalato) iridium (III)
(d) potassium tris (oxalato) iridate (III)

52. IUPAC name of $Na_3[Co(ONO)_6]$ is

(a) Sodium cobaltinitrite
(b) Sodium hexanitrito cobaltate (III)
(c) Sodium hexanitrocobalt (III)
(d) Sodium hexanitritocobaltate (II)

53. Which of the following is the correct name of compound. $[Co(NH_3)_4(H_2O)Cl]Cl_2$

(a) Tetraamineaqua chloride cobalt (III) chloride
(b) Tetraamineaqua chlorido cobalt (II) chloride
(c) Tetraamineaqua chloride cobalt (II) chloride
(d) Tetraamineaqua chlorido cobalt (III) chloride

54. The number of geometrical isomers for $[Pt(NH_3)_2Cl_2]$ is

(a) 2 (b) 1
(c) 3 (d) 4

55. Which of the following will give maximum number of isomers?

(a) $[Ni(C_2O_4)(en)_2]^{2-}$ (b) $[Ni(en)(NH_3)_4]^{2+}$
(c) $[Cr(SCN)_2(NH_3)_4]^+$ (d) $[Co(NH_3)_4Cl_2]$

56. Which one of the following octahedral complexes will not show geometric isomerism? (A and B are monodentate ligands)

(a) $[MA_5B]$ (b) $[MA_2B_4]$
(c) $[MA_3B_3]$ (d) $[MA_4B_2]$

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

(a) pentamminenitrocobalt(III) iodide
(b) diamminedichloroplatinum(II)
(c) trans-dicyanobis (ethylenediamine) chromium (III) chloride
(d) tris-(ethylendiamine) cobalt (III) bromide

58. The type of isomerism present in Pentaminenitrochromium (III) chloride is
(a) optical (b) linkage
(c) ionisation (d) polymerisation.

59. Which of the following compounds shows optical isomerism?
(a) $[Co(CN)_6]^{3-}$ (b) $[Cr(C_2O_4)_3]^{3-}$
(c) $[ZnCl_4]^{2-}$ (d) $[Cu(NH_3)_4]^{2+}$

60. Which of the following ions can exhibit optical isomerism–
(a) $[Co(NH_3)_4Cl_2]^+$ (b) $[Co(NH_3)_2Cl_4]^-$
(c) Cis-$[Co(en)_2Cl_2]^+$ (d) trans-$[Co(en)_2Cl_2]^+$

61. Which would exhibit co-ordination isomerism
(a) $[Cr(NH_3)_6][Co(CN)_6]$ (b) $[Co(en)_2Cl_2]$
(c) $[Cr(NH_3)_6]Cl_3$ (d) $[Cr(en)_2Cl_2]^+$

62. $[Co(NH_3)_5NO_2]Cl_2$ and $[Co(NH_3)_5(ONO)]Cl_2$ are related to each other as
(a) geometrical isomers (b) optical isomers
(c) linkage isomers (d) coordination isomers

63. Coordination isomerism is caused by the interchange of ligands between the
(a) cis and trans structure
(b) complex cation and complex anion
(c) inner sphere and outer sphere
(d) low oxidation and higher oxidation states

64. Change in composition of co-ordination sphere yields which type of isomers
(a) optical (b) geometrical
(c) ionisation (d) None of these

65. Which of the following **does not** show optical isomerism?
(a) $[Co(NH_3)_3Cl_3]^0$ (b) $[Co(en)Cl_2(NH_3)_2]^+$
(c) $[Co(en)_3]^{3+}$ (d) $[Co(en)_2Cl_2]^+$
(en = ethylenediamine)

66. 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?
(a) Linkage isomerism
(b) Ionization isomerism
(c) Coordination isomerism
(d) Geometrical isomerism

67. The complex, $[Pt(py)(NH_3)BrCl]$ will have how many geometrical isomers ?
(a) 3 (b) 4
(c) 0 (d) 2

68. Which of the following has a square planar geometry?
(a) $[PtCl_4]^{2-}$ (b) $[CoCl_4]^{2-}$
(c) $[FeCl_4]^{2-}$ (d) $[NiCl_4]^{2-}$
(At. nos.: Fe = 26, Co = 27, Ni = 28, Pt = 78)

69. Which of the following pairs represent linkage isomers?
(a) $[Pd(PPh_3)_2(NCS)_2]$ and $[Pd(PPh_3)_2(SCN)_2]$
(b) $[Co(NH_3)_5NO_3]SO_4$ and $[Co(NH_3)_5SO_4]NO_3$
(c) $[PtCl_2(NH_3)_4]Br_2$ and $[PtBr_2(NH_3)_4]Cl_2$
(d) $[Cu(NH_3)_4][PtCl_4]$ and $[Pt(NH_3)_4][CuCl_4]$

70. Which one of the following has an optical isomer?
(a) $[Zn(en)(NH_3)_2]^{2+}$ (b) $[Co(en)_3]^{3+}$
(c) $[Co(H_2O)_4(en)]^{3+}$ (d) $[Zn(en)_2]^{2+}$
(en = ethylenediamine)

71. Which one of the following complex ions has geometrical isomers ?
(a) $[Ni(NH_3)_5Br]^+$ (b) $[Co(NH_3)_2(en)_2]^{3+}$
(c) $[Cr(NH_3)_4(en)_2]^{3+}$ (d) $[Co(en)_3]^{3+}$
(en = ethylenediamine)

72. The ionisation isomer of $[Cr(H_2O)_4Cl(NO_2)]Cl$ is
(a) $[Cr(H_2O)_4(O_2N)]Cl_2$
(b) $[Cr(H_2O)_4Cl_2](NO_2)$
(c) $[Cr(H_2O)_4Cl(ONO)]Cl$
(d) $[Cr(H_2O)_4Cl_2(NO_2)].H_2O$

73. Isomerism exhibited by $[Cr(NH_3)_2(H_2O)_2Cl_2]^+$ are –
(a) ionization, optical (b) hydrate, optical
(c) geometrical, optical (d) coordinate, geometrical

74. Type of isomerism which exists between $[Pd(C_6H_5)_2(SCN)_2]$ and $[Pd(C_6H_5)_2(NCS)_2]$ is :
(a) Linkage isomerism (b) Coordination isomerism
(c) Ionisation isomerism (d) Solvate isomerism

75. Which of the following complex will show geometrical as well as optical isomerism (en=ethylenediammine)
(a) $Pt(NH_3)_2Cl_2$ (b) $[Pt(NH_3)Cl_4]$
(c) $[Pt(en)_3]^{4+}$ (d) $[Pt(en)_2Cl_2]$

76. The number of geometrical isomers from $[Co(NH_3)_3(NO_2)_3]$ is
(a) 2 (b) 3
(c) 4 (d) 0

77. The number of isomers exhibited by $[Cr(NH_3)_3Cl_3]$ is
(a) 2 (b) 3
(c) 4 (d) 5

78. For the square planar complex [M (a) (b) (c) (d)] (where M = central metal and a, b, c and d are monodentate ligands), the number of possible geometrical isomers are
(a) 1 (b) 2
(c) 3 (d) 4

79. Which of the following will exhibit optical isomerism ?
(a) $[Cr(en)(H_2O)_4]^{3+}$
(b) $[Cr(en)_3]^{3+}$
(c) *trans*-$[Cr(en)(Cl_2)(NH_3)_2]^+$
(d) $[Cr(NH_3)_6]^{3+}$

80. Which of the following will give maximum number of isomers?
(a) $[Co(NH_3)_4Cl_2]$ (b) $[Ni(en)(NH_3)_4]^{2+}$
(c) $[Ni(C_2O_4)(en)_2]$ (d) $[Cr(SCN)_2(NH_3)_4]^{2+}$

81. The compounds $[PtCl_2(NH_3)_4]Br_2$ and $[PtBr_2(NH_3)_4]Cl_2$ constitutes a pair of
(a) coordination isomers (b) linkage isomers
(c) ionization isomers (d) optical isomers

82. Which one of the following will not show geometrical isomerism ?
(a) $[Cr(NH_3)_4Cl_2]Cl$ (b) $[Co(en)_2Cl_2]Cl$
(c) $[Co(NH_3)_5NO_2]Cl_2$ (d) $[Pt(NH_3)_2Cl_2]$

83. A similarity between optical and geometrical isomerism is that

(a) each gives equal number of isomers for a given compound

(b) if in a compound one is present then so is the other

(c) both are included in stereoisomerism

(d) they have no similarity

84. The type of isomerism present in nitropentaamminechromium (III) chloride is

(a) optical (b) linkage

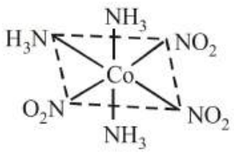
(c) ionization (d) polymerization

85. 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

86. Which of the following type of isomerism is shown by given complex compound?



(a) Facial (b) Meridional

(c) Cis (d) Both b and c

87. 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

88. The geometry of $Ni(CO)_4$ and $Ni(PPh_3)_2Cl_2$ are

(a) both square planar

(b) tetrahedral and square planar

(c) both tetrahedral

(d) None of these

89. The number of unpaired electrons in the complex $[Cr(NH_3)_6]Br_3$ is (Atomic number Cr = 24)

(a) 4 (b) 1

(c) 2 (d) 3

90. Which of the following facts about the complex $[Cr(NH_3)_6]Cl_3$ is wrong?

(a) The complex involves d^2sp^3 hybridisation and is octahedral in shape.

(b) The complex is paramagnetic.

(c) The complex is an outer orbital complex

(d) The complex gives white precipitate with silver nitrate solution.

91. Which of the following statements is correct ? (Atomic number of Ni = 28)

(a) $Ni(CO)_4$ is diamagnetic and $[NiCl_4]^{2-}$ and $[Ni(CN)_4]^{2-}$ are paramagnetic

(b) $Ni(CO)_4$ and $[Ni(CN)_4]^{2-}$ are diamagnetic and $[NiCl_4]^{2-}$ is paramagnetic

(c) $Ni(CO)_4$ and $[NiCl_4]^{2-}$ are diamagnetic and $[Ni(CN)_4]^{2-}$ is paramagnetic

(d) $[NiCl_4]^{2-}$ and $[Ni(CN)_4]^{2-}$ are diamagnetic and $Ni(CO)_4$ is paramagnetic

92. Which of the following species represent the example of dsp^2 - hybridisation ?

(a) $[Fe(CN)_6]^{3-}$ (b) $[Ni(CN)_4]^{2-}$

(c) $[Ag(CN)_2]^-$ (d) $[Co(CN)_6]^{3-}$

93. Which one of the following will show paramagnetism corresponding to 2 unpaired electrons? (Atomic numbers : Ni = 28, Fe = 26)

(a) $[FeF_6]^{3-}$ (b) $[NiCl_4]^{2-}$

(c) $[Fe(CN)_6]^{3-}$ (d) $[Ni(CN)_4]^{2-}$

94. Atomic number of Cr and Fe are respectively 25 and 26, which of the following is paramagnetic?

(a) $[Cr(CO)_6]$ (b) $[Fe(CO)_5]$

(c) $[Fe(CN)_6]^{-4}$ (d) $[Cr(NH_3)_6]^{+3}$

95. CN^- is a strong field ligand. This is due to the fact that

(a) it carries negative charge

(b) it is a pseudohalide

(c) it can accept electrons from metal species

(d) it forms high spin complexes with metal species

96. Which one of the following cyano complexes would exhibit the lowest value of paramagnetic behaviour ?

(a) $[Co(CN)_6]^{3-}$ (b) $[Fe(CN)_6]^{3-}$

(c) $[Mn(CN)_6]^{3-}$ (d) $[Cr(CN)_6]^{3-}$

(At. Nos : Cr = 24, Mn = 25, Fe = 26, Co = 27)

97. $[Sc(H_2O)_6]^{3+}$ ion is :

(a) colourless and diamagnetic

(b) coloured and octahedral

(c) colourless and paramagnetic

(d) coloured and paramagnetic

98. Which has maximum paramagnetic nature ?

(a) $[Mn(H_2O)_6]^{2+}$ (b) $[Cu(NH_3)_4]^{2+}$

(c) $[Fe(CN)_6]^{4-}$ (d) $[Cu(H_2O)_4]^{2+}$

99. The compound which is not coloured is

(a) $K_4[Fe(CN)_6]$ (b) $K_3[Fe(CN)_6]$

(c) $Na_2[CdCl_4]$ (d) $Na_2[CuCl_4]$

100. Which of the following complexes exhibits the highest paramagnetic behaviour ?

(a) $[V(gly)_2(OH)_2(NH_3)_2]^+$ (b) $[Fe(en)(bpy)(NH_3)_2]^{2+}$

(c) $[Co(ox)_2(OH)_2]^{2-}$ (d) $[Ti(NH_3)_6]^{3+}$

where gly = glycine, en = ethylenediamine and bpy = bipyridyl moities)

(At.nos Ti = 22, V = 23, Fe = 26, Co = 27)

101. Which of the following complex ion is not expected to absorb visible light ?

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

(c) $[Fe(H_2O)_6]^{2+}$ (d) $[Ni(H_2O)_6]^{2+}$

102. Of the following complex ions, which is diamagnetic in nature?
(a) $[NiCl_4]^{2-}$ (b) $[Ni(CN)_4]^{2-}$
(c) $[CuCl_4]^{2-}$ (d) $[CoF_6]^{3-}$

103. Which one of the following is an outer orbital complex and exhibits paramagnetic behaviour ?
(a) $[Ni(NH_3)_6]^{2+}$ (b) $[Zn(NH_3)_6)]^{2+}$
(c) $[Cr(NH_3)_6]^{3+}$ (d) $[Co(NH_3)_6]^{3+}$

104. 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 ?
(i) $[MnCl_6]^{3-}$ (ii) $[FeF_6]^{3-}$
(iii) $[CoF_6]^{3-}$ (iv) $[Ni(NH_3)_6]^{2+}$
(a) (ii) and (iii) (b) (i) and (iv)
(c) (i) and (ii) (d) (i) and (iii)

105. Which of the following options are correct for $[Fe(CN)_6]^{3-}$ complex ?
(i) Possess d^2sp^3 hybridisation
(ii) Possess sp^3d^2 hybridisation
(iii) It is paramagnetic
(iv) It is diamagnetic
(a) (i) and (iii) (b) (ii) and (iii)
(c) (i) and (iv) (d) (ii) and (iv)

106. Which of these statements about $[Co(CN)_6]^{3-}$ is true ?
(a) $[Co(CN)_6]^{3-}$ has four unpaired electrons and will be in a low-spin configuration.
(b) $[Co(CN)_6]^{3-}$ has four unpaired electrons and will be in a high spin configuration.
(c) $[Co(CN)_6]^{3-}$ has no unpaired electrons and will be in a high-spin configurtion.
(d) $[Co(CN)_6]^{3-}$ has no unpaired electrons and will be in a low-spin configuration.

107. The complex ion which has highest magnetic moment among the following is
(a) $[CoF_6]^{3-}$ (b) $[Co(NH_3)_6]^{3+}$
(c) $[Ni(NH_3)_4]^{2+}$ (d) $[Ni(CN)_4]^{2-}$

108. Which of the following complex ions is diamagnetic?
(a) $[FeF_6]^{3-}$ (b) $[CoF_6]^{3-}$
(c) $[Co(C_2O_4)_3]^{3-}$ (d) $[Fe(CN)_6]^{3-}$

109. Which of the following has square planar structure?
(a) $[Ni(CO)_4]$ (b) $[NiCl_4]^{2-}$
(c) $[Ni(CN)_4]^{2-}$ (d) $\left[Ni\left(H_2O\ _6\right)\right]^{2+}$

110. Which of the following correctly explains the fact that $[Co(NH_3)_6]^{3+}$ is an inner orbital complex whereas $[CoF_6]^{3-}$ is an outer orbital complex?
(a) NH_3 being a strong ligand results into pairing of 3d orbital electrons in Co^{3+}.
(b) F^- being a strong ligand results into pairing of 3d orbital electrons in Co^{3+}.
(c) F^- being a weak ligand cannot cause the pairing of electrons present in 3d orbital of Co^{3+}.
(d) Both (a) and (c).

111. Which of the following statements is incorrect?
(a) $[MnCl_6]^{3-}$ is more paramagnetic than $[Mn(CN)_6]^{3-}$
(b) Both $[Co(C_2O_4)_3]^{3-}$ and $[CoF_6]^{3-}$ are paramagnetic.
(c) $[Fe(CN)_6]^{3-}$ forms inner orbital complex whereas $[FeF_6]^{3-}$ forms outer orbital complex.
(d) Both (a) and (b).

112. Which of the following is not correctly matched?

	Coordination polyhedron	**Shape**
(A)	$[Co(NH_3)_6]^{3+}$	Octahedral
(B)	$[Ni(CO)_4]$	Square planar
(C)	$[PtCl_4]^{2-}$	Tetrahedral

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

113. Which of the following are inner orbital complex (i.e., involving d^2sp^3 hybridisation) and is paramagnetic in nature?
(a) $[Mn(CN)_6]^{3-}$, $[Fe(CN)_6]^{3-}$, $[Co(C_2O_4)_3]^{3-}$
(b) $[MnCl_6]^{3-}$, $[FeF_6]^{3-}$, $[CoF_6]^{3-}$
(c) $[Mn(CN)_6]^{3-}$, $[Fe(CN)_6]^{3-}$
(d) $[MnCl_6]^{3-}$, $[Fe(CN)_6]^{3-}$, $[Co(C_2O_4)_3]^{3-}$

114. Which of the following is the limitation of valence bond theory?
(a) It does not distinguish between weak and strong ligands.
(b) It does not give quantitative interpretation of magnetic data.
(c) It does not explain the colour exhibited by coordination compounds
(d) All of these

115. Which complex of Co^{2+} will have the weakest crystal field splitting –
(a) $[CoCl_6]^{4-}$ (b) $[Co(CN)_6]^{4-}$
(c) $[Co(NH_3)_6]^{2+}$ (d) $[Co(en)_3]^{2+}$

116. The crystal field stabilization energy (CFSE) is the highest for
(a) $[CoF_4]^{2-}$ (b) $[Co(NCS)_4]^{2-}$
(c) $[Co(NH_3)_6]^{3+}$ (d) $[CoCl_4]^{2-}$

117. In which of the following complexes of the Co (at. no. 27), will the magnitude of Δ_o be the highest?
(a) $[Co(CN)_6]^{3-}$ (b) $[Co(C_2O_4)_3]^{3-}$
(c) $[Co(H_2O)_6]^{3+}$ (d) $[Co(NH_3)_6]^{3+}$

118. Among the ligands NH_3, en, CN^- and CO the correct order of their increasing field strength, is :
(a) $NH_3 < en < CN^- < CO$
(b) $CN^- < NH_3 < CO < en$
(c) $en < CN^- < NH_3 < CO$
(d) $CO < NH_3 < en < CN^-$

119. Among the following complexes the one which shows zero crystal field stabilization energy (CFSE):
(a) $[Mn(H_2O)_6]^{3+}$ (b) $[Fe(H_2O)_6]^{3+}$
(c) $[Co(H_2O)_6]^{2+}$ (d) $[Co(H_2O)_6]^{3+}$

120. The crystal field splitting energy for octahedral (Δ_0) and tetrahedral (Δ_t) complexes is related as

(a) $\Delta_t = -\frac{1}{2}\Delta_0$ (b) $\Delta_t = -\frac{4}{9}\Delta_0$

(c) $\Delta_t = -\frac{3}{5}\Delta_0$ (d) $\Delta_t = -\frac{2}{5}\Delta_0$

121. Which one of the following is the correct order of field strength of ligands in spectrochemical series?

(a) $I^- < Cl^- < F^- < H_2O < CN^-$

(b) $F^- < H_2O < I^- < CN^- < Cl^-$

(c) $CN^- < I^- < F^- < Cl^- < H_2O$

(d) $H_2O < F^- < CN^- < Cl^- < I^-$

122. 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,

$[Co(NH_3)_6]^{3+}, [Co(CN)_6]^{3-}, [Co(H_2O)_6]^{3+}$

(a) $[Co(NH)_6]^{3-} > [Co(NH_3)_6]^{3+} > [Co(H_2O)_6]^{3+}$

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

123. Which of the following statements related to crystal field splitting in octahedral coordination entities is incorrect?

(a) The $d_{x^2-y^2}$ and d_{z^2} orbitals has more energy as compared to d_{xy}, d_{yz} and d_{xz} orbitals.

(b) Crystal field spitting energy (Δ_o) depends directly on the charge of the metal ion and on the field produced by the ligand.

(c) In the presence of Br^- as a ligand the distribution of electrons for d^4 configuration will be t_{2g}^3, e_g^1,

(d) In the presence of CN^- as a ligand $\Delta_o < P$.

124. Which of the following is incorrect regarding spectrochemical series?

(a) $NH_3 > H_2O$ (b) $F^- > C_2O_4^{2-}$

(c) $NCS^- > SCN^-$ (d) en > $edta^{4-}$

125. For which of the following ligands magnitude of the crystal field splitting (Δ_o) will be greater than pairing energy (P)?

(a) Cl^- (b) SCN^-

(c) CO (d) S^{2-}

126. Violet colour of $[Ti(H_2O)_6]Cl_3$ on heating changes to____.

(a) Green (b) Colourless

(c) White (d) Red

127. Which of the following is the limitation of crystal field theory?

(i) Ligands are assumed as point charges.

(ii) It does not accounts for the covalent character of bonding between the ligand and the central atom.

(iii) It does not explain how colour of coordination compounds depends on ligand attached to central metal atom/ion.

(a) (i) and (ii) (b) (ii) and (iii)

(c) (ii) only (d) (i), (ii) and (iii)

128. If magnetic moment of $[MnBr_4]^{2-}$ is 5.9 BM. Predict the number of electrons?

(a) 2 (b) 3

(c) 6 (d) 5

129. Arrange the following complexes in increasing order toward the wavelength of light they absorb? Where M is metal ion. $[M(NH_3)]^{3+}$ = a, $[M(CN)_6]^{3-}$ = b, $[M(C_2O_4)_3]^{3-}$ = c, $[MF_6]^{3-}$ = d,

(a) d, c, a, b (b) d, a, c, b

(c) b, a, c, d (d) a, b, c, d

130. Which of the following does **not** have a metal- carbon bond?

(a) $Al(OC_2H_5)_3$ (b) C_2H_5MgBr

(c) $K[Pt(C_2H_4)Cl_3]$ (d) $Ni(CO)_4$

131. In $Fe(CO)_5$, the Fe – C bond possesses

(a) ionic character (b) σ-character only

(c) π-character (d) both σ and π characters

132. The charge on the central metal ion in the complex $[Ni(CO)_4]$ is

(a) +2 (b) +4

(c) 0 (d) +3

133. The unpaired electrons in $Ni(CO)_4$ are

(a) zero (b) one

(c) three (d) four

134. The correct structure of $Fe(CO)_5$ is (Z=26 for Fe)

(a) octahedral (b) tetrahedral

(c) square pyramidal (d) trigonal pyramidal

135. 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

136. Coordination compounds have great importance in biological systems. In this context which of the following statements is **incorrect** ?

(a) Cyanocobalamin is B_{12} and contains cobalt

(b) Haemoglobin is the red pigment of blood and contains iron

(c) Chlorophylls are green pigments in plants and contain calcium

(d) Carboxypeptidase - A is an exzyme and contains zinc.

137. Which one of the following coordination compounds is used to inhibit the growth of tumours?

(a) Trans-platin (b) EDTA complex of calcium

(c) $[(Ph_3P)_3RhCl]$ (d) Cis-platin

138. For $[Co_2(CO)_8]$, what is the total number of metal – carbon bonds and number of metal–metal bonds.

(a) 10,1 (b) 8, 2
(c) 8, 1 (d) 10, 0

139. Consider the following reactions.

$$X + Y \rightleftharpoons XY \qquad K_1 = \frac{[XY]}{[X][Y]}$$

$$XY + Y \rightleftharpoons XY_2 \qquad K_2 = \frac{[XY_2]}{[XY][Y]}$$

$$XY_2 + Y \rightleftharpoons XY_3 \qquad K_3 = \frac{[XY_3]}{[XY_2][Y]}$$

On the basis of reactions above which of the following is incorrect?

(a) Overall stability constant = $K_1K_2K_3$

(b) $K_1K_2K_3 = \frac{[XY_3]}{[X][Y]^3}$

(c) Dissociation constant = $\frac{1}{\text{Formation constant}}$.

(d) All of the above are correct.

140. Calculate the value of log K_3 when log values of K_2, K_1, K_4 and β_4 respectively are 4.0, 3.20, 4.0 and 11.9 ?

(a) 2.0 (b) 2.7
(c) 3.0 (d) 2.5

STATEMENT TYPE QUESTIONS

141. Identify the correct statements for the behaviour of ethane- 1, 2-diamine as a ligand.

(i) It is a neutral ligand.
(ii) It is a didentate ligand.
(iii) It is a chelating ligand.
(iv) It is a unidentate ligand.

(a) (i), (ii) and (iii) (b) (ii) and (iii)
(c) (iii) and (iv) (d) (i), (iii) and (iv)

142. Read the following statements

(i) Macromolecules cannot behave as a ligand.
(ii) $[EDTA]^{4-}$ can bind through two oxygen and four nitrogen atom.
(iii) Chelate complexes are more stable than similar complexes containing unidentate ligands.
(iv) Coordination number of the central atom/ion is determined only by the number of sigma bonds formed by the ligand with central atom/ion

Which of the following is the correct code for statements above?

(a) FFTT (b) FTFT
(c) TFTF (d) FFFT

143. Which of the following statements regarding formulas and naming of coordination compounds are correct?

(i) During nomenclature names of neutral ligands are kept same except for H_2O, NH_3 and CO.
(ii) If the complex is anion, the name of the metal ends with the suffix–ate.
(iii) While writing formula of coordination compounds polydentate ligands are listed alphabeticaly.
(iv) The cation is named first in both positively and negatively charged coordination entities.

(a) (i), (ii) and (iii) (b) (ii), (iii) and (iv)
(c) (i), (iii) and (iv) (d) (i), (ii), (iii) and (iv)

144. Which of the following statements are correct?

(i) Square planar complexes of MABXL type show three isomers-two *cis* and one *trans*.
(ii) Complexes of Ma_3B_3 type show three isomers-two cis and one trans.
(iii) Optical isomerism is common in octahedral complexes involving bidentate ligands.
(iv) $[Co(NH_3)_4Cl\,(NO_2)]Cl$ show linkage isomerism.
(v) Hydrate isomerism is another name of solvate isomerism.

(a) (i), (ii) and (iii) (b) (i), (iii) and (iv)
(c) (ii), (iii) and (v) (d) (iii), (iv) and (v)

145. Which of the following statements are correct?

(i) When light of wavelength 600nm is absorbed by complex $[Ti(H_2O)_6]^{3+}$ its configuration changes from $t_{2g}^1\, e_g^0 \longrightarrow t_{2g}^0\, e_g^1$ and it appears violet in colour.
(ii) Anhydrous $CuSO_4$ is white but $CuSO_4.5H_2O$ is blue in colour as presence of H_2O as a ligand causes crystal field spitting.
(iii) Ruby is aluminum oxide containing 0.5 – 1% Cr^{3+} ions with d^3 configuration.
(iv) Crystal field theory predict correctly that anionic ligands should exert the greater splitting effect.

(a) (i), (ii) and (iii) (b) (ii) and (iii)
(c) (i), and (ii) (d) (ii), (iii) and (iv)

146. Which of the following statement(s) is/are incorrect?

(i) In metal carbonyls M–C σ bond is formed by the donation of lone pair of electrons on the carbonyl carbon into a vacant orbital of metal.
(ii) M—C π bond is formed by the donation of a pair of electrons from a filled *d* orbital of metal into the vacant antibonding π^* orbital of CO.
(iii) Bonding in metal carbonyls is called synergic bonding.

(a) (i) and (ii) (b) (iii) only
(c) (ii) only (d) None of these

MATCHING TYPE QUESTIONS

147. Match the columns.

Column-I **(Ligand)**	**Column-II** **(Type of ligand)**
(A) Triphenylphosphine	(p) Unidenate
(B) BF_3	(q) Didentate
(C) Ethylenediamine	(r) Not a ligand
(D) Ethylenediaminetetracetateion	(s) Hexadenate

(a) A – (p), B – (r), C – (q), D – (s)
(b) A – (p), B – (q), C – (r), D – (s)
(c) A – (p), B – (r), C – (q), D – (s)
(d) A – (p), B – (q), C – (s), D – (p)

148. Match the complex species given in Column-I with the isomerism exhibited in Column-II and assign the correct code:

Column-I **(Complex species)**	**Column-II** **(Isomerism)**
(A) $[Co[NH_3)_4Cl_2]^+$	(p) optical
(B) *cis*-$[Co(en)_2Cl_2]^+$	(q) ionisation
(C) $[Co(NH_3)_5(NO_2)]Cl_2$	(r) coordination
(D) $[Co(NH_3)_6][Cr(CN)_6]$	(s) geometrical

(a) A – (s), B – (p), C – (q), D – (r)
(b) A – (p), B – (r), C – (q), D – (s)
(c) A – (q), B – (s), C – (p), D – (r)
(d) A – (p), B – (r), C – (s), D – (q)

149. Match the columns.

Column-I	**Column-II**
(A) $[Ni(CN)_4]^{2-}$	(p) Ti^{4+}
(B) Chlorophyll	(q) sp^3; paramagnetic
(C) Ziegler - Natta catalyst	(r) Non-planar
(D) $[NiCl_4]^{2-}$	(s) Mg^{2+}
(E) Deoxyhaemoglobin	(t) Planar
	(u) dsp^2; diamagnetic

(a) A – (u), B – (s), C – (p), D – (q), E – (r)
(b) A – (q), B – (s), C – (p), D – (u), E – (r)
(c) A – (q), B – (s), C – (p), D – (u), E – (t)
(d) A – (u), B – (s), C – (p), D – (q), E – (t)

150. Match the columns.

Column-I **(Complexes)**	**Column-II** **(Absorbed Light)**
(A) $[Ni(H_2O)_4(en)]^{2+}(aq)$	(p) Yellow Orange
(B) $[Ni(H_2O)_4(en)_2]^{2+}(aq)$	(q) Blue–Green
(C) $[Ni(en)_3]^{2+}(aq)$	(r) Red

(a) A – (r), B – (q), C – (p)
(b) A – (p), B – (r), C – (q)
(c) A – (q), B – (r), C – (p)
(d) A – (r), B – (p), C – (q)

151. Match the columns.

Column-I	**Column-I**
(A) Estimation of water hardness.	(p) $[Ag(CN)_2]^-$
(B) Extraction of silver.	(q) $[Ni(CO)_4]$
(C) Hydrogenation of alkenes.	(r) Na_2EDTA
(D) Photography	(s) $[(Ph_3P)_3RhCl]$
(E) Purification of Nickel.	(t) $[Ag(S_2O_3)_2]^{3-}$

(a) A – (r), B – (p), C – (s), D – (t), E – (q)
(b) A – (p), B – (r), C – (s), D – (t), E – (q)
(c) A – (r), B – (s), C – (p), D – (t), E – (q)
(d) A – (r), B – (p), C – (s), D – (q), E – (t)

152. Match the columns.

Column-I **(Coordination compound)**	**Column-II** **(Central metal atom)**
(A) Chlorophyll	(p) Rhodium
(B) Blood pigment	(q) Cobalt
(C) Wilkinson catalyst	(r) Calcium
(D) Vitamin B_{12}	(s) Iron
	(t) Magnesium

(a) A – (t), B – (s), C – (p), D – (q)
(b) A – (s), B – (q), C – (p), D – (r)
(c) A – (p), B – (q), C – (r), D – (s)
(d) A – (r), B – (t), C – (p), D – (q)

ASSERTION-REASON TYPE QUESTIONS

Directions : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

153. Assertion : NF_3 is a weaker ligand than $N(CH_3)_3$.

Reason : NF_3 ionizes to give F^- ions in aqueous solution.

154. Assertion : $[Fe(CN)_6]^{3-}$ is weakly paramagnetic while $[Fe(CN)_6]^{4-}$ is diamagnetic.

Reason : $[Fe(CN)_6]^{3-}$ has +3 oxidation state while $[Fe(CN)_6]^{4-}$ has +2 oxidation state.

155. Assertion : $[Ti(H_2O)_6]^{3+}$ is coloured while $[Sc(H_2O)_6]^{3+}$ is colourless.

Reason : *d-d* transition is not possible in $[Sc(H_2O)_6]^{3+}$.

CRITICAL THINKING TYPE QUESTIONS

156. A co-ordination complex compound of cobalt has the molecular formula containing five ammonia molecules, one nitro group and two chlorine atoms for one cobalt atom. One mole of this compound produces three mole ions in an aqueous solution. On reacting this solution with excess of $AgNO_3$ solution, we get two moles of AgCl precipitate. The ionic formula for this complex would be

(a) $[Co(NH_3)_4(NO_2)Cl][(NH_3)Cl]$
(b) $[Co(NH_3)_5Cl][Cl(NO_2)]$
(c) $[Co(NH_3)_5(NO_2)]Cl_2$
(d) $[Co(NH_3)_5][(NO_2)_2Cl_2]$

157. What is the secondary valence of following compounds $PtCl_2.2NH_3$, $CoCl_3.4NH_3$ and $NiCl_2.6H_2O$
if moles of AgCl precipitated per mole of the given compounds with excess $AgNO_3$ respectively are: 0, 1 and 2

(a) 6, 4, 4 (b) 4, 6, 6
(c) 4, 4, 6 (d) 2, 4, 6

158. $C_{63}H_{88}CoN_{14}O_{14}P$ is the formulae of the Cyanocobalamine, (vitamin B_{12}) it contain CN^- and CN^- is very poisonous, than why this compound does not prove to be fatal for us? (it inhibit the electron transport chain ?

(a) CN^- forms covalent bond
(b) CN^- is coordinating to the cobalt as the ligand
(c) CN^- hydrolysis immediately
(d) All of these

159. Suppose someone made aqueous solution of $NiCl_2$ and recrystallized its aqueous solution in excess of water and if two moles of precipitate AgCl was formed on treatment with AgNO3, what is the most probable structure of the compound ?

(a) $[Ni(Cl)_2(H_2O)_4]$ (b) $[Ni(H_2O)_6]Cl_2$
(c) $[Ni(H_2O)_5Cl]$ (d) $[Ni(H_2O)_4Cl_2].2H_2O$

160. Total number of electron count in $Ni(CO)_4$ and $Fe(CO)_5$ respectively are.

(a) 36, 36 (b) 34, 36
(c) 36, 34 (d) 34, 34

161. The formula for the complex, dichlorobis (urea) copper (II) is

(a) $[Cu\{O=C(NH_2)_2\}]Cl_2$
(b) $[Cu\{O=C(NH_2)_2\}Cl]Cl$
(c) $[CuCl_2\{O=C(NH_2)_2\}_2]$
(d) $[CuCl_2][\{O=C(NH_2)_2\}]_2$

162. According to IUPAC nomenclature sodium nitroprusside is named as

(a) Sodium pentacyanonitrosylferrate (III)
(b) Sodium nitroferrocyanide
(c) Sodium nitroferricyanide
(d) Sodium pentacyanonitrosylferrate (II)

163. The total number of possible isomers for the complex compound $[Cu^{II}(NH_3)_4][Pt^{II}Cl_4]$

(a) 3 (b) 6
(c) 5 (d) 4

164. Which of the following will give a pair of enantiomorphs?

(a) $[Cr(NH_3)_6][Co(CN)_6]$ (b) $[Co(en)_2Cl_2]Cl$
(c) $[Pt(NH_3)_4][PtCl_6]$ (d) $[Co(NH_3)_4Cl_2]NO_2$
($en = NH_2CH_2CH_2NH_2$)

165. The existence of two different coloured complexes with the composition of $[Co(NH_3)_4Cl_2]^+$ is due to :

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

166. Which of the following has an optical isomer

(a) $[Co(en)(NH_3)_2]^{2+}$ (b) $[Co(H_2O)_4(en)]^{3+}$
(c) $[Co(en)_2(NH_3)_2]^{3+}$ (d) $[Co(NH_3)_3Cl]^+$

167. Among the following complexes, optical activity is possible in

(a) $[Co(NH_3)_6]^{3+}$
(b) $[Co(H_2O)_2(NH_3)_2Cl_2]^+$
(c) $[Cr(H_2O)_2Cl_2]^+$
(d) $[Co(CN)_5NC]$

168. $[Co(NH_3)_4(NO_2)_2]Cl$ exhibits

(a) linkage isomerism, ionization isomerism and geometrical isomerism
(b) ionization isomerism, geometrical isomerism and optical isomerism
(c) linkage isomerism, geometrical isomerism and optical isomerism
(d) linkage isomerism, ionization isomerism and optical isomerism

169. Which of the following compounds exhibits linkage isomerism ?

(a) $[Co(en)_2]Cl_3$ (b) $[Co(NH_3)_6][Cr(en)_3]$
(c) $[Co(en)_2NO_2Cl]Br$ (d) $[Co(NH_3)_5Cl]Br_2$

170. Among the following coordination compounds/ions

(i) $\left[Fe(CN)_6\right]^{3-}$ (ii) $\left[Pt(NH_3{}_2)Cl_2\right]$

(iii) $\left[Co(NH_3{}_6)\right]^{3+}$ (iv) $\left[Cr(H_2O{}_6)\right]Cl_3$

Which species exhibit geometrical isomerism?

(a) (ii) only (b) (i) and (ii)
(c) (ii) and (iv) (d) (i) and (iii)

171. Identify the optically active compounds from the following :

(i) $[Co(en)_3]^{3+}$ (ii) *trans* $-[Co(en)_2Cl_2]^+$

(iii) *cis* $-[Co(en)_2Cl_2]^+$ (iv) $[Cr(NH_3)_5Cl]$

(a) (i) and (iii) (b) (ii) and (iii)
(c) (iii) and (iv) (d) (i), (iii) and (iv)

172. For which value of the x, and y, the following square planar compound shows geometrical isomers $[Pt(Cl)_x(Br)_y]^{2-}$

(a) 1, 3 (b) 3, 1
(c) 2, 2 (d) 1, 1

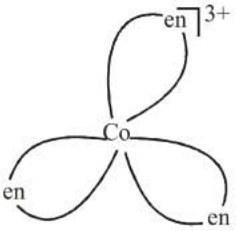
173. How many geometrical isomers are possible for following square planar compound [M (Cl) (Br) (I) (F)] (where M is a metal ion)

(a) 2 (b) 3
(c) 9 (d) 8

174. The terahedral complex [M(A)(B)(X)(Y)], where A,B,X and Y are different ligands and M is a metal ion is

(a) optically inactive
(b) rotate plane polarized light
(c) incomplete information
(d) can't be said

175. The complex given is



(i) non-superimposable on its mirror images
(ii) optically inactive
(iii) rotate plane polarised light
(iv) planar

(a) (i) and (ii) (b) (i) and (iv)
(c) (i), (ii) and (iii) (d) (ii) only

176. The correct statement with respect to the complexes $Ni(CO)_4$ and $[Ni(CN)_4]^{2-}$ is

(a) nickel is in the same oxidation state in both
(b) both have tetrahedral geometry
(c) both have square planar geometry
(d) have tetrahedral and square planar geometry respectively

177. Which one of the following complexes is an outer orbital complex ?

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

(Atomic nos. : Mn = 25; Fe = 26; Co = 27, Ni = 28)

178. The *d*-electron configurations 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?

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

(At, nos. Cr = 24, Mn = 25, Fe = 26, Co = 27)

179. Both $[Ni(CO)_4]$ and $[Ni(CN)_4]^{2-}$ are diamagnetic. The hybridisations of nickel in these complexes, respectively, are

(a) sp^3, sp^3 (b) sp^3, dsp^2
(c) dsp^2, sp^3 (d) dsp^2, sp^2

180. Which one of the following is an inner orbital complex as well as diamagnetic in behaviour? (Atomic number: Zn = 30, Cr = 24, Co = 27, Ni = 28)

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

181. The value of the 'spin only' magnetic moment for one of the following configurations is 2.84 BM. The correct one is

(a) d^5 (in strong ligand field)
(b) d^3 (in weak as well as in strong fields)
(c) d^4 (in weak ligand fields)
(d) d^4 (in strong ligand fields)

182. The d electron configurations of Cr^{2+}, Mn^{2+}, Fe^{2+} and Ni^{2+} are $3d^4$, $3d^5$, $3d^6$ and $3d^8$ respectively. Which one of the following aqua complexes will exhibit the minimum paramagnetic behaviour?

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

(At. No. Cr = 24, Mn = 25, Fe = 26, Ni = 28)

183. According to valence bond theory which of the following statement is correct about the complexes $Ni(CO)_4$ and $[Ni(CN)_4]^{2-}$ if both are diamagnetic in nature

(a) both are tetrahedral
(b) both are square planar
(c) one is square planar and other is tetrahedral
(d) one is tetrahedral and other is square planar

184. Correct statements about the following complexes $[MnCl_6]^{3-}$ and $[Mn(CN)_6]^{3-}$ respectively are.

(a) Magnetic moment is 4.8 and 2.8
(b) inner sphere and outer sphere complexes.
(c) sp^3d^2 and d^2sp^3 complexes.
(d) Both (a) and (c).

185. In which of the following coordination entities the magnitude Δ_0 (CFSE in octahedral field) will be maximum?

(a) $[Co(H_2O)_6]^{3+}$ (b) $[Co(NH_3)_6]^{3+}$
(c) $[Co(CN)_6]^{3-}$ (d) $[Co(C_2O_4)_3]^{3-}$

(At. No. Co = 27)

186. Which of the following complex ions is expected to absorb visible light?

(a) $[Ti(en)_2(NH_3)_2]^{4+}$ (b) $[Cr(NH_3)_6]^{3+}$
(c) $[Zn(NH_3)_6]^{2+}$ (d) $[Sc(H_2O)_3(NH_3)_3]^{3+}$

(At. no. Zn = 30, Sc = 21, Ti = 22, Cr = 24)

187. Crystal field stabilization energy for high spin d^4 octahedral complex is:

(a) $-1.8\ \Delta_0$ (b) $-1.6\ \Delta_0 + P$
(c) $-1.2\ \Delta_0$ (d) $-0.6\ \Delta_0$

188. Low spin complex of d^6-cation in an octahedral field will have the following energy :

(a) $\frac{-12}{5}\Delta_0 + P$ (b) $\frac{-12}{5}\Delta_0 + 3P$

(c) $\frac{-2}{5}\Delta_0 + 2P$ (d) $\frac{-2}{5}\Delta_0 + P$

(Δ_0= Crystal Field Splitting Energy in an octahedral field, P = Electron pairing energy)

189. Which of the following carbonyls will have the strongest C – O bond ?

(a) $[Mn(CO)_6]^+$ (b) $[Cr(CO)_6]$

(c) $[V(CO)_6]^-$ (d) $[Fe(CO)_5]$

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

(a) $Cu^{2+} + 4NH_3 \rightleftharpoons [Cu(NH_3)_4]^{2+}$, $\log K = 11.6$

(b) $Cu^{2+} + 4NH^- \rightleftharpoons [Cu(NH)_4]^{2-}$, $\log K = 27.3$

(c) $Cu^{2+} + 2en \rightleftharpoons [Cu(en)_2]^{2+}$, $\log K = 15.4$

(d) $Cu^{2+} + 4H_2O \rightleftharpoons [Cu(H_2O)_4]^{2+}$, $\text{Log} K = 8.9$

191. 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) $[Fe(CN)_6]^{3-}$

(a) (i) and (ii) (b) (i) and (iii)

(c) (iii) and (iv) (d) (ii) and (iv)

HINTS AND SOLUTIONS

FACT/DEFINITION TYPE QUESTIONS

1. **(a)** The primary valencies are ionisable and represented by dotted line.

2. **(c)**

3. **(a)** $CrCl_3$ has primary valence of 3.

4. **(d)** $Co(NH_3)_5Cl_3 \rightleftharpoons [Co(NH_3)_5Cl]^{+2} + 2Cl^-$

$\therefore$ Structure is $[Co(NH_3)_5Cl]Cl_2$.

Now $[Co(NH_3)_5Cl]Cl_2 + 2AgNO_3$

$$\rightarrow [Co(NH_3)_5Cl](NO_3)_2 + 2AgCl$$

5. **(a)** Since the precipitate of AgCl shows two ionisable chloride ion the complex must have the structure.

$$[Co(NH_3)_5Cl]Cl_2 + 2AgNO_3 \rightarrow$$

$$[Co(NH_3)_5Cl](NO_3)_2 + 2AgCl$$

Hence two chlorine atoms satisfy the primary valency and one, secondary valency

6. **(c)** The ions present in the ionisation sphere are precipited Hence $[CrCl_2(H_2O)_4]Cl.2H_2O$ contains 1/3 Cl in ionisation sphere to be precipited by $AgNO_3$ as AgCl

7. **(b)** Complex compounds do not dissociate into constituent ions.

$K_4[Fe(CN)_6] \longrightarrow 4K^+ + [Fe(CN_6)]^{4-}$

$\therefore$ It is a complex because no CN^- is formed on dissociation.

8. **(b)** It is a double salt:

$$FeSO_4.(NH_4)_2SO_4.6H_2O \longrightarrow$$

$$Fe^{2+} + 2SO_4^{2-} + 2NH_4^+$$

9. **(a)**

10. **(a)** Let the o.s. of Ni in $K_4[Ni(CN)_4]$ be $= x$ then

$4(+1) + x + (-1) \times 4 = 0 \Rightarrow 4 + x - 4 = 0$

$x = 0$

11. **(c)** The coordination number of central metal atom in a complex is equal to number of monovalent ligands, twice the number of bidentate ligands and so on, around the metal ion bonded by coordinate bonds.

Hence coordination number = no. of σ bonds formed by metals with ligands

12. **(d)** Oxidation state of Cr in $[Cr(NH_3)_4Cl_2]^+$.

Let it be x, $1 \times x + 4 \times 0 + 2 \times (-1) = 1$ Therefore $x = 3$.

13. **(c)** The oxidation state of metal in metal carbonyls is always zero.

14. **(d)** $[EDTA]^{4-}$ is a hexadentate ligand, because it has six donor atoms and donate 6 pairs of electrons to central metal atom in the complex.

15. **(d)** In $Fe(CO)_5$, Fe is in minimum oxidation state (zero).

16. **(d)** In the given complex we have two bidentate ligands (i.e en and C_2O_4), so coordination number of E is 6 $(2 \times 2 + 1 \times 2 = 6)$

Let the oxidation state of E in complex be x, then

$[x + (-2) = 1]$ or $x - 2 = 1$

or $x = +3$, so its oxidation state is $+3$

Thus option (d) is correct.

17. **(a)** Salt may be complex salt. Metal atom present in the coordination sphere appears in the form of complex ion and not as simple cation

18. **(b)** Coordinate number is = 2 (number of bindentate ligands

$\therefore$ C.N. of Ni = $(2 \times 3) = 6$

19. **(b)** In the complex formation the ligands whether negative, neutral or positive always donate electrons to the central metal atom hence they act as Lewis bases.

20. **(c)** $K[Co(CN)_4]$ let the O. N. of Co be x then

$1 \times (+1) + 1(+x) + 4(-1) = 0 \Rightarrow x = +3$

21. **(c)** Number of donor atoms (N) in $N(CH_2CH_2NH_2)_3$ are four.

So, $N(CH_2CH_2NH_2)_3$ is a tetradentate ligand.

22. **(d)** Ambidentate ligands are those unidentate ligands which contain more than one coordinating atoms. Thiocyanate is an example of such a ligand.

$M \leftarrow SCN$	$M \leftarrow NCS$
Thiocyanato	Isothiocyanato

23. **(c)** **24.** **(d)**

25. **(c)** Ambident ligand has two donor atoms, either of two can form a coordinate bond.

26. **(c)**

27. **(c)** Na^+ is not a ligand.

28. **(d)** These are facts about glycinato ligand.

29. **(c)** BF_3 has incomplete octet and is Lewis acid; it cannot donate electron pair.

30. **(a)** It has two donor atoms, *i.e.*, $\begin{array}{l} COO^- \\ | \\ COO^- \end{array}$

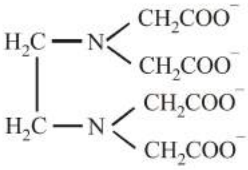
31. **(b)** **32.** **(b)**

33. **(b)** O_2 is a bidentate ligand.

34. **(c)** **35.** **(a)** **36.** **(b)** **37.** **(c)** **38.** **(b)**

39. **(a)**

40. **(c)** $EDTA^{4-}$ can bind through two nitrogen and four oxygen atoms to a central metal ion.



41. **(b)** IUPAC name is Potassium trioxalatoaluminate (III).

42. **(a)** Chlorodiaquatriamminecobalt (III) chloride is $[CoCl(NH_3)_3(H_2O)_2]Cl_2$.

43. **(c)** $K_3[Fe(CN)_6]$ is Potassium hexacyanoferrate (III).

44. **(b)** $[Co(ONO)(NH_3)_5]Cl_2$
pentaamminenitrito-N-cobalt (III) chloride

45. **(b)** $K_2[PtCl_6]$
Potassium hexachloroplatinate (IV)
Oxidation state of Pt is + 4 in the complex and anion is present in form of complex.

46. **(c)** The correct IUPAC name of the given compound is tetramminenickel (II) - tetrachloronickelate (II) thus (c) is the correct answer.

47. **(d)** $[Co(H_2O)_4(NH_3)_2]Cl_3$
= Diamminetetraaquacobalt (III) chloride.

48. **(d)**

49. **(d)** $[Co(H_2O)_4(NH_3)_2]Cl_3$
= Diamminetetraaquacobalt (III) chloride.

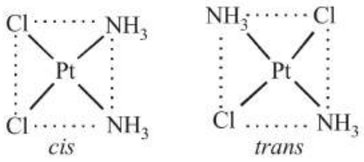
50. **(d)** Chemical formula of iron (III) hexacynaoferrate (II) is $Fe_4[Fe(CN)_6]_3$

51. **(b)** IUPAC name of $K_3[Ir(C_2O_4)_3]$ is potassium trioxalato iridate (III)

52. **(b)** $Na_3[Co(ONO)_6]$ IUPAC name is sodium hexanitritocobaltate (III)

53. **(d)** According to IUPAC nomenclature anionic ligands will end with – ido so that chloro would become chlorid.

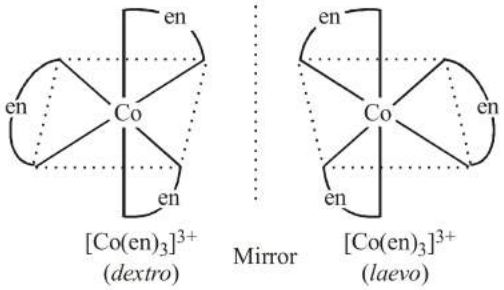
54. **(a)** $Pt(NH_3)_2Cl_2$ is a disubstituted complex and shows only *cis*-& *trans*-isomers



55. **(c)** $[Cr(SCN)_2(NH_3)_4]^+$ shows linkage, geometrical and optical isomerism. Hence produces maximum no. of isomers.

56. **(a)** MA_3B_3 – 2 geometrical isomers
MA_2B_4 – 2 geometrical isomers
MA_4B_2 – 2 geometrical isomers
The complexes of general formula MA_6 and MA_5B having octahedral geometry do not show geometrical isomerism.

57. **(d)** The optical isomers are pair of molecules which are non superimposable mirror images of each other.



The two optically active isomers are collectivity called enantiomers.

58. **(b)** The chemical formula of Pentaminenitrochromium (III) chloride is

$$\left[Cr(NH_3)_5NO_2\right]Cl_2$$

It can exist in following two structures

$\left[Cr(NH_3)_5NO_2\right]Cl_2$ and

$\left[Cr(NH_3)_5ONO\right]Cl_2$

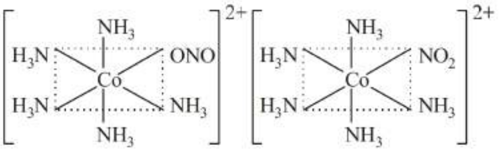
Therefore the type of isomerism found in this compound is linkage isomerism as nitro group is linked through N as $-NO_2$ or through O as – ONO.

59. **(b)**

60. **(c)** *cis*-$[Co(en)_2Cl_2]^+$: *cis*-$[M(aa)_2b_2]$ can show optical isomerism.

61. **(a)**

62. **(c)**



Here more than one atom function as donor, as oxygen in first one and nitrogen in second, so they show linkage isomerism.

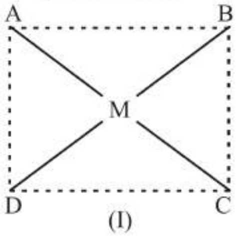
63. **(b)** Co-ordination isomerism is caused by the interchange of ligands between cation and anion complexes.

64. **(c)** Change in composition of co-ordination sphere yield ionisation isomers.
$[Cr(H_2O)_6]Cl_3$ and $[CrCl_3(H_2O)_3].3H_2O$

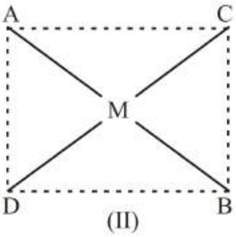
65. **(a)** The octahedral coordination compounds of the type MA_3B_3 exhibit fac-mer isomerism.

66. **(c)** Coordination isomerism occurs when cationic and anionic complexes of different metal ions are present in a salt. The two isomers differ in the distribution of ligands in cation and anion e.g.,
$[Co(NH_3)_6][Cr(CN)_6]$ is an isomer of $[Co(CN)_6][Cr(NH_3)_6]$

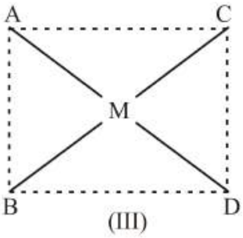
67. **(a)** Complexes of the type M_{ABCD} may exist in three isomeric forms.



(I)



(II)



(III)

Similarly, [Pt (py) (NH_3) BrCl] may exist in three isomeric form in which

$M = Pt, A = Py, B = NH_3, C = Br, D = Cl.$

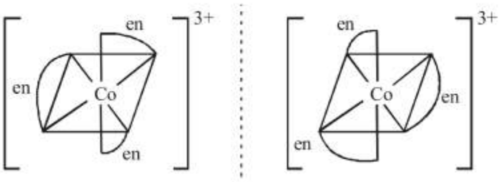
68. **(a)** Complexes with dsp^2 hybridisation are square planar. So, $[PtCl_4]^{2-}$ is square planar in shape.

69. **(a)** The SCN^- ion can coordinate through S or N atom giving rise to linkage isomerism

$M \leftarrow SCN$ thiocyanato

$M \leftarrow NCS$ isothiocyanato.

70. **(b)** Option (b) shows optical isomerism $[Co(en)_3]^{3+}$



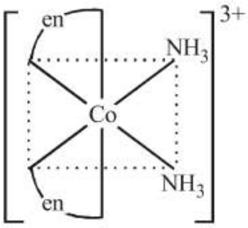
d–form Mirror *ℓ*–form

Complexes of Zn^{++} cannot show optical isomerism as they are tetrahedral complexes with plane of symmetry.

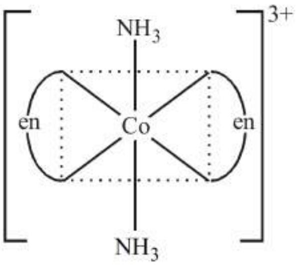
$[Co(H_2O)_4(en)]^{3+}$ have two planes of symmetry hence it is also optically inactive.

$[Zn(en)_2]^{2+}$ cannot show optical isomerism

71. **(b)**



cis



trans-

72. **(b)** Ionisation isomer of $[Cr(H_2O)_4Cl(NO_2)]Cl$ is $[Cr(H_2O)_4Cl_2]NO_2$.

73. **(c)** $Ma_2b_2c_2$ can show both optical & geometrical isomerism.

74. **(a)** The compound shows linkage isomerism because the ligand in the compound is an ambidenate ligand that can bond at more than one atomic site.

i.e., $:NCS^-$ and $:SCN^-$

75. **(d)** $[Pt(en)_2Cl_2]$ is a complex of the type $M(AA)_2 B_2$ which is octahedral Such compounds exhibit optical and geometrical isomerism both

76. **(a)** $[Co(NH_3)_3(NO_2)_3]$ is of the type MA_3B_3. They give two geometrical Isomers

77. **(d)** $[Cr(NH_3)_3Cl_3]$ is of the type MA_3B_3 and exists in two isomeric forms.

78. **(d)** Square planar complex of the formula Mabcd give three geometrical isomers

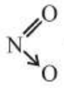
79. **(b)**

80. **(d)** The complex ion $[Cr(SCN)_2(NH_3)_4]^{2+}$ can exhibit geometrical and linkage isomerism

81. **(c)** $[PtCl_2(NH_3)_4]Br_2$ and $[PtBr_2(NH_3)_4]Cl_2$ are ionisation isomers

82. **(c)** Octahedral complex of the type MA_5B do not show geometrical isomerism

83. **(c)** Similarity between optical and geometrical isomerism is that both are included in stereo isomerism

84. **(b)** The compound is $[Cr(NH_3)_5NO_2]Cl_2$ and can exhibit linkage isomerism due to NO_2 group (–  or $O-N=O$)

85. **(b)**

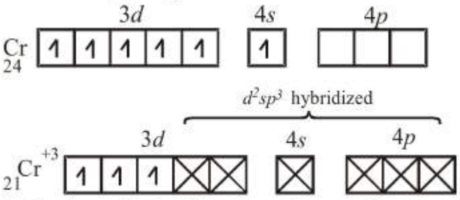
86. **(b)** Given compound shows meridional isomerism.

87. **(a)**

88. **(c)**

	$Ni(CO)_4$	$Ni(PPh_3)_2Cl_2$
O.S.	Ni^0	Ni^{2+}
E.C.	$[Ar]3d^84s^2$	$[Ar]3d^84s^0$
	Pairing of e^-	No pairing of e^-
Hybridization	sp^3 (tetrahedral)	sp^3 (tetrahedral)

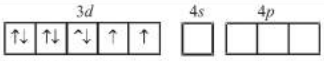
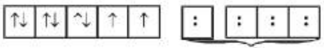
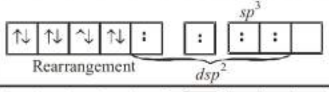
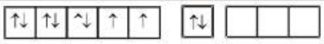
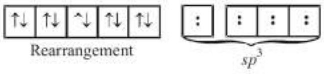
89. **(d)** In $[Cr(NH_3)_6]Br_3$, Cr is in +3 oxidation state



Its ion is octahedral in nature. Due to the presence of three unpaired electrons it is paramagnetic.

90. **(c)** $[Cr(NH_3)_6]Cl_3$ is an inner orbital complex, because in this complex inner d-orbital is used for hybridisation (d^2sp^3)

91. **(b)**

Atom/Ion Complex	Configuration	No. of unpaired electrons	Magnetic nature
Ni^{2+} (d^8)		2	Paramagnetic
$[NiCl_4]^{2-}$		2	Paramagnetic
$[Ni(CN)_4]^{2-}$		0	Diamagnetic
Ni (d^8s^2)		2	Paramagnetic
$[Ni(CO)_4]$		0	Diamagnetic

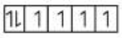
92. **(b)**

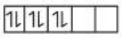
93. **(b)** As in $[NiCl_4]^{-2}$ chloride ion being a weak ligand is not able to pair the electrons in d orbital.

94. **(d)** Cr^{3+} has $4s^o$ $3d^3$ electronic configuration with 3 unpaired electrons, hence paramagnetic. In other cases pairing of d-electrons take place in presence of strong field ligands such as CO or CN^-.

In $Cr(CO)_6$ molecule 12 electrons are contributed by CO group and it contain no odd electron

95. **(b)** CN^- is a strong field ligand as it is a pseudohalide ion. These ions are strong coordinating ligands and hence have the tendency to form σ-bond (from the pseudo halide to the metal) and π-bond (from the metal to pseudo halide)

96. **(a)** Co^{3+} : 

$[Co(CN)_6]^{3-}$: 

CN^- is a strong field ligand and it causes pairing of electrons as a result number of unpaired electrons in Co^{3+} becomes zero and hence it has lowest value of paramagnetic behaviour.

97. **(a)** $Sc = [Ar]\,3d^1, 4s^2$

Oxidation state of Sc in $[Sc(H_2O)_6]^{3+}$ is Sc^{3+}

$Sc^{3+} = [Ar]\,3d^0, 4s^0$.

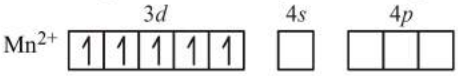
∵ It does not have unpaired electron

∴ Sc^{3+} is diamagnetic and colourless.

98. **(a)** Paramagnetic species has unpaired electron. More the no. of unpaired electrons, more will be paramagnetic character.

Complex	O. S. of metal
$\left[Mn\left(H_2O\ _6\right]\right)^{2+}$	Mn^{2+}
$\left[Cu\left(NH_3\ _4\right]\right)^{2+}$	Cu^{2+}
$\left[Fe\left(CN\ _6\right]\right)^{4-}$	Fe^{2+}
$\left[Cu\left(H_2O\ _4\right]\right)^{2+}$	Cu^{2+}

Electronic configuration of the ion present in complex



No. of unpaired electrons = **5**

Cu^{2+} 

No. of unpaired electron = **1**

Fe^{2+} 

However, CN^- is a strong ligand, so pairing of electrons will occur in the complex having CN^- ions.

∴ Fe^{2+} in presence of CN^-

∴ No. of unpaired electron = **0**

Thus $[Mn(H_2O)_6]^{2+}$ having maximum no. of unpaired electrons has maximum paramagnetic nature.

99. **(c)** In $Na_2[CdCl_4]$, Cd has oxidation state +2.

So, its electronic configuration is $4d^{10}5s^0$

or all the 4*d* orbitals are fully filled.

Hence, there will be no *d*-*d* transition. So, it is colourless.

100. **(c)**

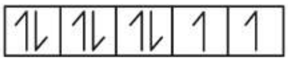
101. **(a)** $[Ni(CN)_4]^{2-}$: Number of unpaired electrons = 0

$[Cr(NH_3)_6]^{3+}$: Number of unpaired electrons = 3

$[Fe(H_2O)_6]^{2+}$: Number of unpaired electrons = 4

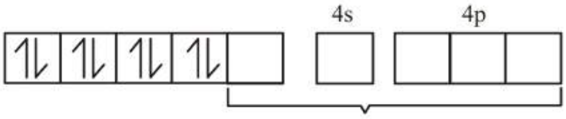
$[Ni(H_2O)_6]^{2+}$: Number of unpaired electrons = 2

102. **(b)** $Ni^{++} = 3d^8\,4s^0$



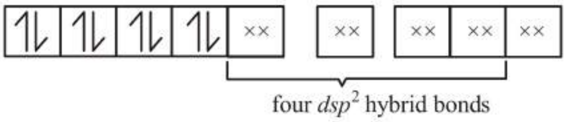
Since, the coordination number of Ni in this complex is 4, the configuration of Ni^{++} at first sight shows that the complex is paramagnetic with two unpaired electron. However, experiments show that the complex is diamagnetic. This is possible when the 3d electrons rearrange against the Hund's rule as shown below. This is in accordance with the fact that the ligand involved here is strong i.e., CN^- ion.

Ni^{++} (after rearrangement)



Hence, now dsp^2 hybridization involving one $3d$, one $4s$ and two $4p$ orbitals, takes place leading to four dsp^2 hybrid orbitals, each of which accepts four electron pairs from CN^- ion forming $[Ni(CN)_4]^{2-}$ ion.

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



Thus, the complex is diamagnetic as it has no unpaired electron.

103. (a) $[Ni(NH_3)_6]^{2+}$

$Ni^{2+} = 3d^8$, according to CFT $= t_{2g}^6 e_g^2$ therefore, hybridisation is sp^3d^2 and complex is paramagnetic.

104. (d) **105. (a)**

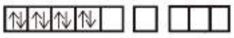
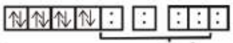
106. (d) In $[Co(CN)_6]^{3-}$ O.N. of Co is +3

$\therefore$ $Co^{+3} = 3d^6\,4s^0$

CN^- is a strong field ligand

$\therefore$ Pairing of electrons occurs so in this complex no unpaired electron is present and it is low spin complex.

107. (a)

Complex	**Configuration**	**No. of unpaired electrons**
$[CoF_6]^{3-}$		4
$[Co(NH_3)_6]^{3+}$		0
$[Ni(NH_3)_4]^{2+}$		0
$[Ni(CN)_4]^{2-}$		0

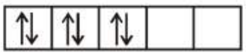
Magnetic moment $= \sqrt{n(n+2\ ,)}$

where n = no. of unpaired electrons

$[CoF_6]^{3-}$ has highest magnetic moment (4.8) due to the presence of 4 unpaired electrons.

108. (c) $[Co(C_2O_4)_3]^{3-}$ has Co^{3+} (d^6 system) due to presence of stronger $C_2O_4^{2-}$ chelating ligand pairing of electrons occurs in this case.

Co^{3+} :

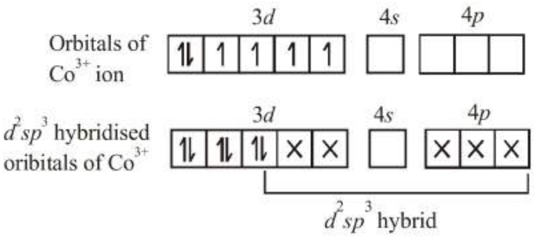


; Diamagnetic.

109. (c) Electronic configuration of Ni^{2+} is $[Ar]\ 3d^8\,4s^0\,4p^0$. CN^- is strong ligand and will do pairing of electrons so will have one d orbital left empty. C.N. is 4 so dsp^2 hybridisation will take place which is square planar, $Ni(CO)_4$ and $[Ni(CN)_4]^{2-}$ are tetrahedral.

110. (d)

111. (b) $[Co(C_2O_4)_3]^{3-}$ is dimagnetic as oxalate is a strong ligand causing pairing of $3d$ electrons in Co^{3+} thereby leading to d^2sp^3 hybridisation.



112. (b) $[Ni(CO_4)] \rightarrow$ tetrahedral

$[PtCl_4]^{2-} \rightarrow$ square planar

113. (c) $[Mn(CN)_6]^{3-}$ and $[Fe(CN)_6]^{3-}$ are inner orbital complexes and paramagnetic while $[Co(C_2O_4)_3]^{3-}$ is diamagnetic in nature.

114. (d)

115. (a) Cl^- is a weak field ligand.

116. (c) Higher the oxidation state of the metal, greater the crystal field splitting energy. In options (a), (b) and (d), Co is present in + 2 oxidation state and in (c) it is present in + 3 oxidation state and hence has a higher value of CFSE.

117. (a) In octahedral complex the magnitude of Δ_o will be highest in a complex having strongest ligand. Out of the given ligands CN^- is strongest. So, Δ_o will be highest for $[Co(CN)_6]^{3-}$. Thus option (a) is correct.

118. (a) Ligands can be arranged in a series in the orders of increasing field strength as given below :

Weak field ligands :

$$I^- < Br^- < S^{2-} < SCN < Cl^- < N_3^-, F^-$$
$$< \text{Urea}, OH^- < \text{oxalate}$$

Strong field ligands

$$O^{--} < H_2O < NCS^- < EDTA < Py, NH_3 <$$
$$en = SO_3^- < \text{bipy, Phen} < NO_2^- < CH_3^-$$
$$< C_6H_5^- < CN^- < CO$$

Such a series is termed as spectrochemical series. It is an experimentally determined series based on the absorption of light by complexes with different ligands.

119. (b) Due to d^5 configuration CFSE is zero.

120. (b) The crystal field splitting in tetrahedral complexes is lower than that in octahedral complexes, and

$\Delta_t = -\frac{4}{9}\Delta_0$.

121. (a) **122. (c)**

123. (d) CN^- is a strong field ligand and form low spin complexes thus $\Delta_o > P$.

124. (b) According to spectrochemical series $C_2O_4^{2-} > F^-$.

125. (c) CO is a strong field ligand and for strong field ligands $\Delta_o > P$.

126. (b) In the absence of ligand , crystal field splitting does not occur and hence the substance is colourless.

127. (a)

128. (d) Magnetic moment can be calculated by using the relation $\sqrt{n(n+2)}$B.M. Where n = number of electrons and B.M. is Bohr magneton.

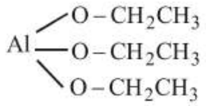
$\therefore\ 5.9 = \sqrt{n(n+2)}$

$\therefore\ n = 5$

129. (c) Energy for excitation (Δ) = hc /wavelength.
Therefore lower the wavelength of light higher will be the energy for excitation, (Δ) i.e crystal field splitting energy.

$\therefore$ correct order will be $b < a < c < d$

130. (a) Triethoxyaluminium has no Al – C linkage



131. (d) Due to some backbonding by sidewise overlapping between *d*-orbitals of metal and *p*-orbital of carbon, the Fe–C bond in $Fe(CO)_5$ has both σ and π character.

132. (c) In case of $[Ni(CO)]_4$, the ligand CO, is neutral thus the charge on Ni is zero.

133. (a) $Ni(CO)_4$. The O. S. of Ni is Zero. Electronic configuration is [Ar] $3d^8\ 4s^2\ 4p^0$. In presence of strong ligand CO the paring of electrons take place and electronic configuration will be [Ar] $3d^{10}4s^0\ 4p^0$. Hence unpaired electrons is zero .

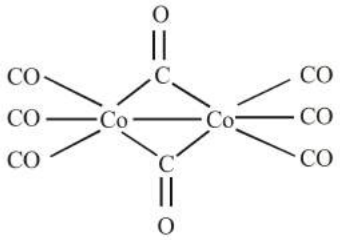
134. (d) $Fe(CO)_5$ (Z=26) O. S. of Fe is zero . Electronic configuaration is [Ar]] $3d^6$, $4s^24p^0$. After pairing of electrons of d and s orbitals, we have one d atomic orbital empty. C. N. is 5 so hybridisation is dsp^3 which is trigonal bipyramidal.

135. (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.

136. (c) The chlorophyll molecule plays an important role in photosynthesis, contain porphyrin ring and the metal Mg not Ca.

137. (d)

138. (a) Structure of $[Co_2(CO)_8]$



Total M – C bonds = 10, Total M – M bonds = 1

139. (a) Overall stability constant $= \frac{1}{K_1K_2K_3} = \frac{[X][Y]^3}{[XY_3]}$

140. (b) $\beta = K_1K_2K_3K_4$

$\log\ \beta = \log\ (K_1\ K_2\ K_3\ K_4)$

$\log\beta = \log K_1 + \log K_2 + \log K_3 + \log K_4$

$\log K_3 = 11.9 - (3.20 + 2.0 + 4.0)$

$\log K_3 = 2.7$

STATEMENT TYPE QUESTIONS

141. (a)

142. (a) Macromolecules like proteins can acts as ligand. $[EDTA]^{4-}$ can bind through two nitrogen and four oxygen atoms.

143. (d)

144. (b) Complexes of Ma_3B_3 type shows fac– meridional isomerism.
Solvate isomerism is refered to as a hydrate isomerism when solvent is water.

145. (b) $[Ti(H_2O)_6]^{3+}$ gives violet colour if light corresponding to the energy of blue-green region of wavelength 498 nm is absorbed by it.
Irrespective of prediction of crystal field theory on the basis of experimental observation shows that anionic ligands are found at the low end of the spectrochemical series.

146. (d)

MATCHING TYPE QUESTIONS

147. (c)

148 (d) A – (p), B – (r), C – (s), D – (q)

149. (a) $[NiCl_4]^{2-}$ is sp^3 hybridised and paramagnetic in nature $[Ni(CN)_4]^{2-}$ is square planar and diamagnetic. Chlorophyll contains Mg^{2+} Ziegler – Natta catalyst contains Ti^{4+} Deoxyhaemoglobin is nonplanar and oxyhaemoglobin planar.

150. (d) Crystal field splitting energy increases with increase in ligand field strength i.e., with increase in no. of 'en' groups and wavelength of absorbed light decrease with increase in ligand field strength

∴ $[Ni(H_2O)_4(en)]^{2+}(aq)$ will absorb light of higher wavelength i.e., Red.

$[Ni(en)_3]^{2+}$ will absorb light of lower wavelength i.e., blue-green and $[Ni(H_2O)_4(en)_2]^{2+}$ will absorb yellow orange light.

151. (a) **152. (a)**

ASSERTION-REASON TYPE QUESTIONS

153. (c) It is correct statement that NF_3 is a weaker ligand than $N(CH_3)_3$, the reason is that fluorine is highly electronegative therefore, it with draw electrons from nitrogen atom. Hence, the lone pair of nitrogen atom cannot be ligated. While $N(CH_3)_3$ is a strong ligand because CH_3 is electron releasing group.

154. (b) Both Assertion and Reason are true but Reason is not the correct explanation of statement-1. $[Fe(CN)_6]^{3-}$ is weakly paramagnetic as it has unpaired electrons while $[Fe(CN)_6]^{2-}$ has no unpaired electron.

∴ It is diamagnetic.

155. (a) Both Assertion and Reason are true and Reason is the correct explanation of statement-1. $[Sc(H_2O_6]^{3+}$ has no unpaired electron in its *d* subshell and thus *d–d* transition is not possible whereas $[Ti(H_2O)_6]^{3+}$ has one unpaired electron in its d subshell which gives rise to *d–d* transition to impart colour.

CRITICAL THINKING TYPE QUESTIONS

156. (c) As it forms two moles of silver chloride thus it has two moles of ionisable Cl.

$$[Co(NH_3)_5NO_2]Cl_2 \rightarrow [Co(NH_3)_5NO_2]^{++} + 2Cl^-$$

$$2Cl^- + 2AgNO_3 \rightarrow 2AgCl + 2NO_3^-$$

157. (b) $PtCl_2.2NH_3 = [Pt(NH_3)_2Cl_2]$

$CoCl_3.4NH_3 = [Co(NH_3)_4Cl_2]Cl$

$NiCl_2.6H_2O = [Ni(H_2O)_6]Cl_2.$

158. (b) CN^- is coordinated to cobalt as the ligand and coordinated compounds have different properties than the individual species.

159. (b) Since complex compound gives 2 moles of AgCl on treatment with $AgNO_3$.

∴ most probable structure is (b).

160. (a) Total number of electron count in $Ni(CO)_4$

= Atomic number – oxidation state + 2 × no. of ligands

$= 28 - 0 + 2 \times 4 = 36$

Similarly for $Fe(CO)_5$,

$= 26 - 0 + 10 = 36$

161. (c) $[CuCl_2\{(O=C(NH_2)_2\}_2]$

162. (a) IUPAC name of sodium nitroprusside $Na_2[Fe(CN)_5NO]$ is sodium pentacyanonitrosylferrate (III) because in it NO is neutral ligand. Hence

$2\times$O.N. of Na + O.N. of Fe + $5\times$O.N. of CN

$1\times$O.N. of NO = 0

$2\times(+1)$ + O.N. of Fe + $5\times(-1) + 1\times 0 = 0$

O.N. of Fe $= 5 - 2 = +3$, Hence ferrate (III)

163. (d) The total number of isomers for the complex compound

$[Cu^{II}(NH_3)_4][Pt^{II}Cl_4]$ is four.

These four isomers are

$[Cu(NH_3)_3Cl]\,[Pt(NH_3)Cl_3]$,

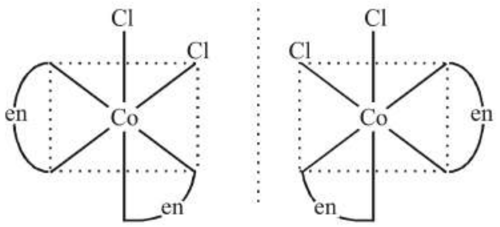
$[Cu(NH_3)Cl_3]\,[Pt(NH_3)_3Cl]$,

$[CuCl_4][Pt(NH_3)_4]$

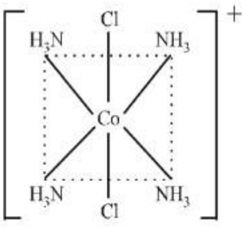
and $\left[Cu(NH_3)_4\right]\left[PtCl_4\right]$.

The isomer $[Cu(NH_3)_2Cl_2][Pt(NH_3)_2Cl_2]$ does not exist due to both parts being neutral.

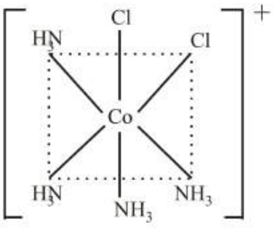
164. (b) Non superimposable mirror images are called optical isomers and may be described as "chiral'. They are also called enantiomers and rotate plane polarised light in opposite directions.



165. (b)

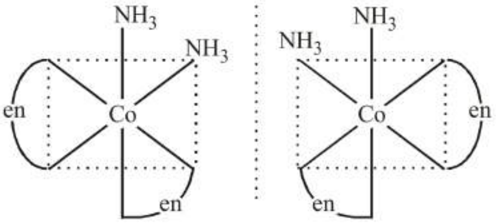


trans (green)



cis (violet)

166. (c)



Enantiomers of *cis*-$\left[\mathrm{Co(en)_2(NH_3)_2}\right]^{3+}$

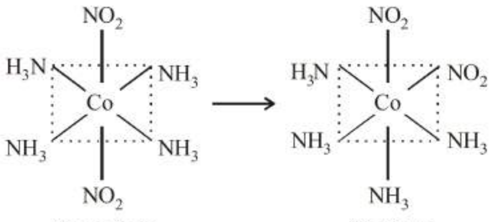
167. (b) It is optically active.

168. (a) The given compound may have linkage isomerism due to presence of NO_2 group which may be in the form $-NO_2$ or $-ONO$.

It may have ionisation isomerism due to presence of two ionisable group $-NO_2$ & $-Cl$. It may have geometrical isomerism in the form of *cis-trans* form as follows :

$[Co(NH_3)_4Cl(NO_2)]NO_2$ & $[Co(NH_3)(NO_2)_2]Cl$
—— Ionisation isomers.

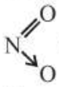
$[Co(NH_3)_5(NO_2)_2]Cl$ & $[Co(NH_3)_5(ONO)_2]Cl$
—— Linkage isomers



Trans-form *Cis-form*

Geometrical isomers

169. (c) The complex compound $[Co(en)_2NO_2Cl]$ Br can have NO_2 group differently linked to central metal atom –



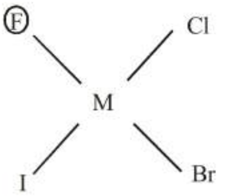
or O – N = O

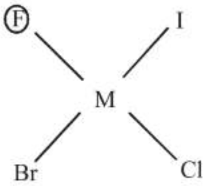
170. (a) Geometrical isomerism is possible only in square planar complexes of the type MA_2B_2 and MA_2BC and for octahedral complexes of the type MA_4B_2 and MA_4BC. Hence only (ii) will show geometrical isomerism.

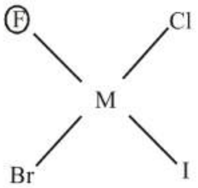
171. (a)

172. (b) Geometrical isomers of following type of square planar complexes is possible. Ma_2b_2 type, Ma_2bc type and Mabcd type.

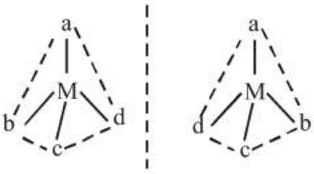
173. (b) Three isomer are possible.



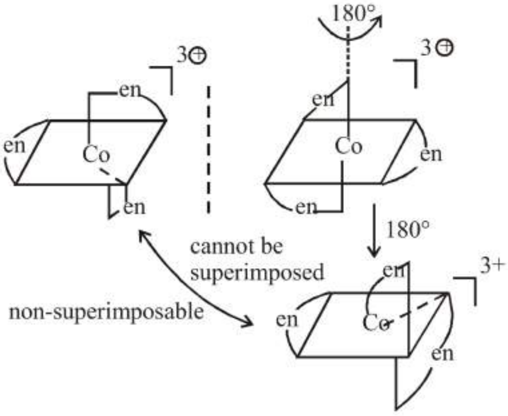




174. (b) Non –superimposable mirror images are optically active, hence rotate plane polarized light.



175. (c) Complex is not superimposable on its mirror image hence optically active i.e., rotate plane polarized light.



176. (d) Nickel in $Ni(CO)_4$ is sp^3 hybridised therefore geometry of $Ni(CO)_4$ is tetrahedral whereas in $[Ni(CN)_4]^{2-}$ nickel is dsp^2 hybridised therefore geometry of $[Ni(CN)_4]^{2-}$ is square planar.

177. (d) Hybridisation

$$\underset{d^2sp^3}{[Fe(CN)_6]^{4-}},\ \underset{d^2sp^3}{[Mn(CN)_6]^{4-}},$$

$$\underset{d^2sp^3}{[Co(NH_3)]^{3+}},\ \underset{sp^3d^2}{[Ni(NH_3)_6]^{2+}}$$

Hence $[Ni(NH_3)_6]^{2+}$ is outer orbital complex.

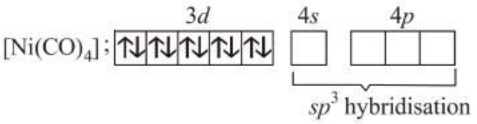
178. (c)

Cr^{2+}	d^4	↑	↑	↑	↑		4
Mn^{2+}	d^5	↑	↑	↑	↑	↑	5
Fe^{2+}	d^6	↑↓	↑	↑	↑	↑	4
Co^{2+}	d^7	↑↓	↑↓	↑	↑	↑	3

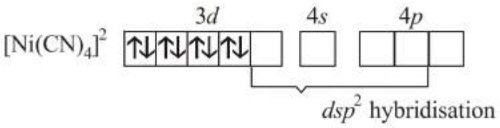
Minimum paramagnetic behaviour = $[Co(H_2O)_6]^{2+}$

179. (b) In carbonyls O.S. of metal is zero

In $[Ni(CO)_4]$, the oxidation state of nickel is zero. Its configuration in $Ni(CO)_4$ is



In $[Ni(CN)_4]^{2-}$ the oxidation state of Ni is 2+ and its configuration is



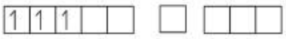
Thus the hybridisations of nickel in these compounds are sp^3 and dsp^2 respectively.

Hence (b) is the correct answer.

180. (c) $[Co(NH_3)_6]^{3+}$, $Co^{3+}(27-3=24)$

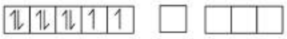
$d^2sp^3 \rightarrow$ (inner octahedral complex & diamagnetic)

$[Cr(NH_3)_6]^{3+}$, $Cr^{3+}(24-3=21)$



$d^2sp^3 \rightarrow$(inner octahedral complex & paramagnetic)

$[Ni(NH_3)_6]^{2+}$, $Ni^{2+}(28-2=26)$

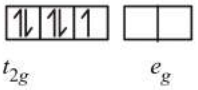


$sp^3d^2 \rightarrow$(outer octahedral complex & paramagnetic)

$[Zn(NH_3)_6]^{2+}$, $Zn^{2+}(30-2=28)$

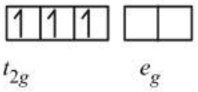
$sp^3d^2 \rightarrow$ (outer octahedral complex &diamagnetic)

181. (d) d^5 —— strong ligand field



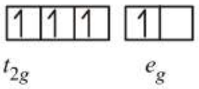
$\mu = \sqrt{n(n+2)} = \sqrt{3} = 1.73BM$

d^3— in weak as well as in strong field



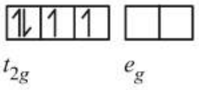
$\mu = \sqrt{3(5)} = \sqrt{15} = 3.87$ B.M.

d^4– in weak ligand field



$\mu = \sqrt{4(4+2)} = \sqrt{24} = 4.89$

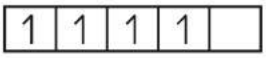
d^4– in strong ligand field



$\mu = \sqrt{2(4)} = \sqrt{8} = 2.82.$

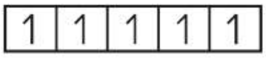
182. (b) Lesser is the number of unpaired electrons smaller will be the paramagnetic behaviour. As Cr^{++}, Mn^{++}, Fe^{++} and Ni^{++} contains.

$Cr^{++}(3d^4)$ =



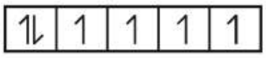
= 4 unpaired e^-.

$Mn^{++}(3d^5)$ =



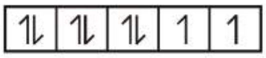
= 5 unpaired e^-.

$Fe^{++}(3d^6)$ =



= 4 unpaired e^-.

$Ni^{++}(3d^8)$ =



= 2 unpaired e^-.

As Ni^{++} has minimum no. of unpaired e^- thus this is least paramagnetic.

183. (d) In case of diamagnetic complexes the electrons are paired. In case of $Ni(CO)_4$ 3*d* orbital is fully filled give rise to sp^3 hybridisation while in case of $[Ni(CN)_4]^{2-}$ nickel is in +2 oxidation state, so one *d*-orbital is vacant give rise to dsp^2 hybridization which is square planar in nature.

184. (d) Number of unpaired electrons in $[MnCl_6]^{3-}$ and $[Mn(CN)_6]^{3-}$ respectively are 4 and 2

∴ Magnetic moment will respectively be 4.8 and 2.8

$[MnCl_6]^{3-}$ is sp^3d^2 hybridised and $[Mn(CN)_6]^{3-}$ will be d^2sp^3 hybridised.

185. (c) In octahedral field the crystal field splitting of d- orbitals of a metal ion depends upon the field produced by the ligands. In general ligands can be arranged in a series in the order of increasing fields and splittings which they produce around a central metal ion. A portion of the series is given below.

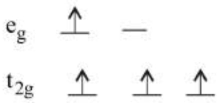
cyanide > ethylene - diamine > ammonia > pyridine > thiocyanate > water > oxalate > hydroxide > fluoride > chloride > bromide > iodide.

Out of the given ligands water, ammonia, cyanide and oxalate, we can find from the above series of ligands that the maximum splitting will occur in case of cyanide (CN^-) i.e. the magnitude of Δ_0 will be maximum in case of $[Co(CN)_6]^{3+}$.

186. (b) Since Cr^{3+} in the complex has unpaired electrons in the d orbital, hence it will absorb visible light and will be coloured

$Ti = [Ar]3d^2 4s^2$; $Ti^{4+} = 3d^0$
$Cr = [Ar]\,3d^5 4s^1$; $Cr^{3+} = 3d^3$
$Zn = [Ar]\,3d^{10} 4s^2$; $Zn^{2+} = 3d^{10}$
$Sc = [Ar]\,3d^1 4s^2$; $Sc^{3+} = 3d^0$

187. (d) d^4 in high spin octahedral complex



$CFSE = (-0.4x + 0.6y)\Delta_0$

Where, $x \rightarrow$ electrons in t_{2g} orbital
$y \rightarrow$ electrons in e_g orbital

$CFSE = [0.6 \times 1] + [-0.4 \times 3] = -0.6\ \Delta_0$

188. (b) $d^6 - t_{2g}^{\;2,2,2}\ e_g^{\;0,0}$ (in low spin)

$$C.F.S.E = -0.4 \times 6\Delta_0 + 3P$$

$$= -\frac{12}{5}\Delta_0 + 3P$$

189. (a) As positive charge on the central metal atom increases, the less readily the metal can donate electron density into the π^* orbitals of CO ligand (donation of electron density into π^* orbitals of CO result in weakening of C – O bond). Hence, the C – O bond would be strongest in $[Mn(CO)_6]^+$.

190. (b) **191. (b)**