Coordination Compounds

SOLUTIONS

EXERCISE - O

1. Ans. (B)

Complexes may or may not give ions in solution.

for example, $K_4\,[Fe(CN)_6] \rightarrow \; 4K^{\oplus} + [Fe(CN)_6]^{4\ominus}$

$[Ni(CO)_4] \rightarrow$ No ions

2. Ans. (C)

Ions present inside the coordination sphere of a complex do not give their test.

3. Ans. (C)

Number of coordinate bond formed by ligand to central metal atom is known as coordination number of metal.

4. Ans. (C)

en is bidentate ligand produces coordination number $4 + Br_2$ Produces coordination number 2 = 6

5. Ans. (A)

$x + 4\,(-1) = -4 \Longrightarrow x = 0$

6. Ans. (C)

Potash alum, $K_2SO_4.Al_2(SO_4)_3.24H_2O$ when dissolved in water breaks down into $K^{\oplus}, SO_4^{2\ominus}, Al^{3\oplus}$ ions and it is example of double salt.

7. Ans. (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.

8. Ans. (D)

Ligand can be anion, neutral molecule or even cation also linked by coordinate bonds to central atom or ion.

9. Ans. (C)

Coordination number of metal ion.

10. Ans. (D)

(A) POS present due to presence of two Br atoms at trans positions.

(B) POS present due to presence of two I atoms at trans positions.

(C) POS present due to presence of two Br atoms at trans positions.

(D) POS and COS absent, so complex is optically active.

11. Ans. (B)

Ethylene diamine $\begin{matrix} CH_2 - \ddot{N}H_2 \\ | \\ CH_2 - \ddot{N}H_2 \end{matrix}$ Donor site 2 $(\therefore$ Bidentate ligand)

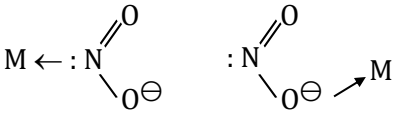
12. Ans. (B)

dien is tridentate ligand.

13. Ans. (D)

Ambidentate ligand are those which are having more than one donor site.

14. Ans. (C)



$M \leftarrow {}^{\ominus}S - C \equiv N$ $M \leftarrow {}^{\ominus}N = C = S$

15. Ans. (C)

Ambident ligand has two donor atoms, either of two can form a coordinate bond.

16. Ans. (C)

Pyridine (C_5H_5N:) is a neutral unidentate ligand.

17. Ans. (A)

Neutral, bidentate and chelating ligand.

18. Ans. (B)

Ligands are connected to the metal ions by coordinate bond

19. Ans. (C)

$[Pt(NH_3)_5Cl]Cl_3 \rightarrow [Pt(NH_3)_5Cl]^{3\oplus} + 3Cl^{\ominus}$

total no. of ions produced = 1 + 3 = 4

20. Ans. (C)

None of the ligand species present is ionisable species, all ligands are present in coordination sphere.

21. Ans. (B)

Maximum coordination number of Co is 6 and all six ligands are present in Coordination sphere

22. Ans. (D)

50% means, 2 mole ion formed one mole get ppt as AgCl.

$\therefore\ [Pt(NH_3)_3Cl_3]Cl \rightarrow [Pt(NH_3)Cl_3]^{\oplus} + Cl^{\ominus}$

23. Ans. (A)

$CoCl_3.5NH_3 \longrightarrow [Co(NH_3)_5Cl]Cl_2$

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

Common coordination of number of Co^{III} is 6.

24. Ans. (C)

According to given condition no. of ion produced is equal to 3 and 2 moles of AgCl get precipitated.

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

1 + 2 = 3 ions.

25. Ans. (B)

$[Co(en)_2Cl_2]^{\oplus}$

= Atomic Number – oxidation Number + 2 [coordination Number]

= 27 – 3 + 2 × 6

= 36

26. **Ans. (B)**

EAN = Atomic Number – oxidation Number + 2 [coordination Number]

$34 = 28 - 2 + 2 \times x$

$8 = 2x \Rightarrow x = 4$

Ans. 4

27. **Ans. (D)**

$Co_2(CO)_8$ EAN of Co = 36

$[Fe(CO)_5]$ EAN of Fe = 36

$[V(CO)_6]^{\ominus}$ EAN of V = 36

$[Mn(CO)_6]$ EAN of Mn = 37

28. **Ans. (B)**

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

EAN = Atomic Number – oxidation Number + 2 [coordination Number]

= 26 – 2 + 2 × 6

= 36

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

EAN = Atomic Number – oxidation Number + 2 [coordination Number]

= 26 – 3 + 2 × 6

= 35

(c) $[Ni(CO)_4]$

EAN = Atomic Number – oxidation Number + 2 [coordination Number]

= 28 – 0 + 2 × 4

= 36

(d) $[Co(NH_3)_6]Cl_3$

EAN = Atomic Number – oxidation Number + 2 [coordination Number]

= 27 – 3 + 2 × 6

= 36

29. **Ans. (C)**

$Fe(CO)_2(NO)_2$

EAN = 26 – (–2) + 2 × 4

= 36

30. **Ans. (D)**

Because after reduction $Co(CO)_4$, EAN becomes 36 and similarly after dimerization.

31. **Ans. (D)**

$[V(CO)_6]$ after accepting an electron satisfy EAN rule hence act as oxidising agent.

32. **Ans. (D)**

After reduction, EAN of $Mn(CO)_5$ becomes 36.

33. **Ans. (B)**

$K_3[Fe(CN)_6]$, Only (b) and (c)

34. **Ans. (C)**

Pentacarbonyliron(0)

35. **Ans. (D)**

TetraammineaquabromoCobalt(III) nitrate

36. Ans. (B)

Because $[Cu(en)_2]SO_4 \longrightarrow [Cu(en)_2]^{2\oplus} + SO_4^{2\ominus}$

2 ions are formed

37. Ans. (A)

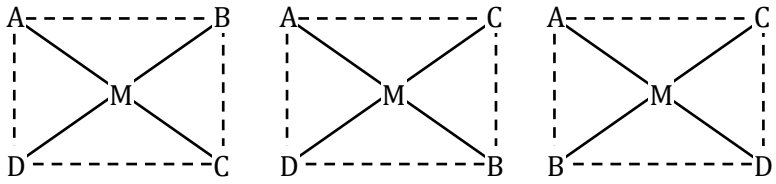
Pentaammine(thiocyanato-N)cobalt(III) chloride

38. Ans. (B)

Bis(η^5-cyclopentadienyl)iron(II)

39. Ans. (A)

Complexes of the type MABCD 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.

40. Ans. (D)

$[CoBr(NH_3)_4]SO_4$

Ions should be exchanged

41. Ans. (B)

Conductivity depends on $Cl^{\ominus}$ ions

$[Cr(H_2O)_4Cl_2]Cl.\,2H_2O$

42. Ans. (D)

$[Pt(en)_2]^{2\oplus}$ not show coordination isomerisim because ligand exchange not posible.

43. Ans. (B)

$[Cr(NH_3)_5NO_2]Cl_2$

NO_2 is Ambidentate ligand

44. Ans. (B)

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

45. Ans. (D)

All coordination isomers of $[Pt(NH_3)_4][PtCl_4]$ are $[Ma_4]$, $[Ma_3b]$ type square planar complex so they do not show geometrical isomerism.

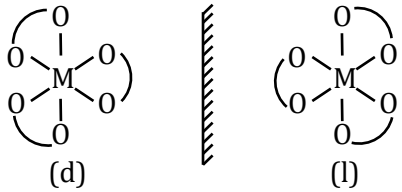
Possible Coordination isomers are :

$[Pt(NH_3)_4][PtCl_4]$

$[Pt(NH_3)_3Cl][Pt(NH_3)Cl_3]$

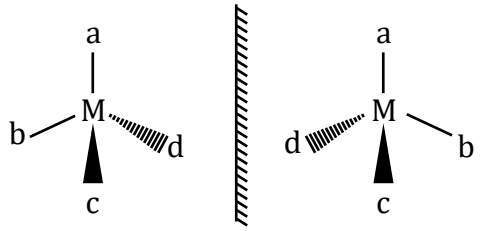
46. Ans. (B)

Octahedral complex with three bidentate ligand are optically active



(d) (l)

47. Ans. (D)



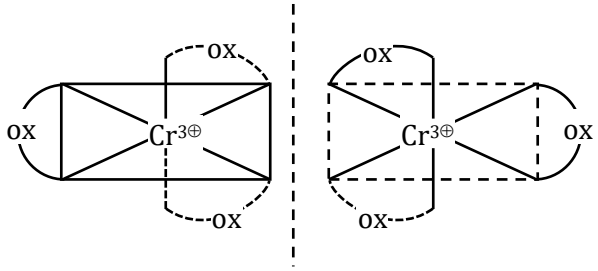
48. Ans. (C)

[M abcd] type square planar complex have 3 stereo isomers

[M abcd] type tetrahydral complex have 2 stereo isomers

49. Ans. (B)

The number of optical isomers for $[Cr(C_2O_4)_3]^{3\ominus}$ is two.



50. Ans. (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.

51. Ans. (C)

$PtCl_4.4NH_3 \Rightarrow [Pt(NH_3)_4Cl_2]Cl_2$

52. Ans. (C)

(A) $[Ma_4]$ type tetrahedral complex.

(B) $[Ma_3b_3]$ type octahedral complex.

(C) $[Zn(gly)_2]$ is $[M(AB)_2]$ type tetrahedral complex, so it shows optical activity. No POS or COS is present.

(D) $[M(AB)_2]$ type square planar complex, so does not show optical activity.

53. Ans. (C)

(A) $[Ma_4]$ Tetrahedral complex does not show G.I.

(B) $[Ma_3b]$ type square planar complex does not show G.I.

(C) $[Ma_2b_2]$ type square planar complex show G.I.

(D) $[Ma_5b]$ type octahedral complex, does not show G.I

54. Ans. (C)

(A) $[Ma_3b_3] \Longrightarrow$ 2 Geometrical Isomers , Optically active = 0

(B) $[Ma_3b_2C] \Longrightarrow$ 3 Geometrical Isomers , Optically active = 0

(C) $[Ma_2b_2c_2] \Longrightarrow$ 5 Geometrical Isomers , Optically active = 2

(D) $[M(AA)a_2b_2] \Longrightarrow$ 3 Geometrical Isomers, Optically active = 2

55. Ans. (C)

II and III are optically active because there is no Plane of symmetry

56. Ans. (C)

	$[Ni(CO)_4]$	$[Ni(PPh_3)_2Cl_2]$
O.S.	Ni^0	$Ni^{2\oplus}$
Electronic configration	$[Ar]3d^8 4s^2$	$[Ar]3d^8 4s^0$
	Pairing of $e^{\ominus}$	No pairing of $e^{\ominus}$
Hybridization	sp^3(tetrahedral)	sp^3(tetrahedral)

57. Ans. (B)

In $[Ni(CO)_4]$; $[Ni(Cl)_4]^{2\ominus}$; $[Zn(NH_3)_4]^{2\oplus}$, all the central atoms have sp^3 hybridisation, while in $[Ni(CN)_4]^{2\ominus}$, its central atom has dsp^2 hybridisation due to strong field ligand ($CN^{\ominus}$).

Hence, $[Ni(CN)_4]^{2\ominus}$ has square planar structure.

58. Ans. (B)

$K_3[Fe(C_2O_4)_3]$ show only optical isomerism.

59. Ans. (B)

(A) sp^3, paramagnetic

(B) sp^3, diamagnetic

(C) dsp^2, diamagnetic

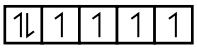
(D) sp^3, paramagnetic

60. Ans. (C)

magnetic moment = $\sqrt{n(n+2)}$ BM, where 'n' is number of unpaired e^-

(A) $Cu^{2\oplus} \Longrightarrow 3d^9$

(B) $Co^{2\oplus} \Longrightarrow 3d^7$

(C) $Fe^{2\oplus} \Longrightarrow 3d^6 \Longrightarrow$  n = 4

(D) $Al^{3\oplus} \Longrightarrow 2p^6$

61. Ans. (A)

In octahedral complex, if electronic configuration is d^1, d^2, d^3 or d^8, d^9, d^{10} then number of unpaired $e^{\ominus}$ same and it is irrespective of nature of ligand.

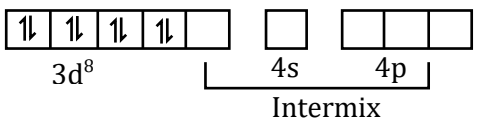
62. Ans. (C)

Magnetic moment is zero.

It means all electrons of $\left[NiX_4\right]^{2\ominus}$

$\left[\underset{II}{Ni}X_4\right]^{2\ominus}$

$Ni^{2\oplus}$: [Ar] $3d^8$ $4s^0$ $4p^0$

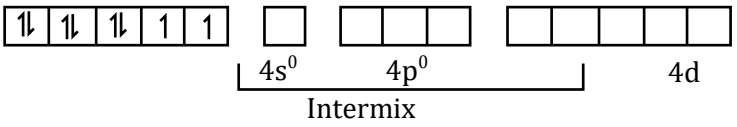
[Ar] 

dsp^2 hybridisation, square planar.

63. Ans. (D)

(A) $\left[\underset{II}{Ni}(H_2O)_6\right]^{2+}$

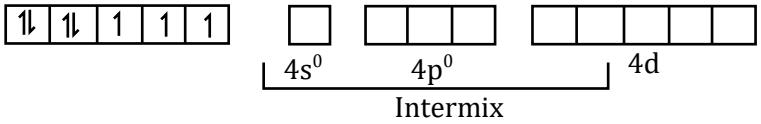
$Ni^{2\oplus}$: [Ar] $3d^8\ 4s^0\ 4p^0\ 4d^0$



sp^3d^2 hybridisation, outer orbital complex

(B) $\left[\underset{I}{Fe}(H_2O)_5\ (NO)\right]SO_4$

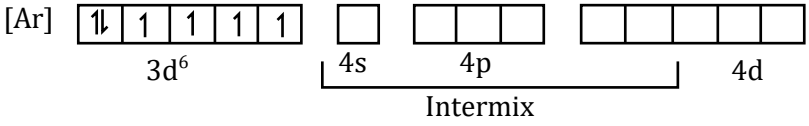
$Fe^{1\oplus}$: [Ar] $3d^7\ 4s^0\ 4p^0\ 4d^0$



sp^3d^2 hybridisation, order orbital complex

(C) $\left[\overset{II}{Fe}(NH_3)_6\right]^{2\oplus}$

$Fe^{2\oplus}$: [Ar] $3d^6\ 4s^0\ 4p^0\ 4d^0$



* NH_3 act as WFL for $Fe^{2\oplus}$ (C.N. = 6)

sp^3d^2 hybridisation, octer orbital complex

64. Ans. (D)

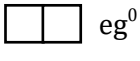
$Co^{3\oplus}$, d^6 configuration with low spin complex. So, zero unpaired electron.

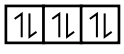
$Co^{3\oplus}$, d^6 configuration with high spin complex. So, 4 unpaired electrons.

65. Ans. (B)

t_{2g} orbitals are lower in energy by 0.4 Δ_O.

66. Ans. (C)

 eg^0

 t_2g^6

67. Ans. (A)

$[Co(C_2O_4)_3]^{3\ominus}$ is diamagnetic.

68. Ans. (A)

$[AuCl_4]^{\ominus}$ is diamagnetic, square planar complex.

69. Ans. (C)

$Pd^{2\oplus}$; d^8 (SFL/WFL) $\xrightarrow{\text{Coordination No.4}}$ square planar, diamagnetic

70. Ans. (D)

CFSE affected by Ligand strength, oxidation Number of central atom and Coordination number

71. Ans. (B)

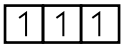
$NH_3 > H_2O > F^{\ominus} > Cl^{\ominus}$ (Ligand strength)

72. Ans. (B)

$\Delta_t = 0.45\,\Delta_O$, $\Delta_{sp} = 1.33\Delta_O$

73. Ans. (A)

CFSE = 3 (-0.4 Δ_0) = $-1.2\Delta_0$



74. Ans. (C)

Strength of ligand → $F^{\ominus} < NH_3 < \bar{C}N < CO$

CO is strong field ligand so it has highest CFSE.

75. Ans. (A)

$CFSE \propto \frac{1}{\lambda} \uparrow E \downarrow$

$\lambda \Longrightarrow x > y > z$

$E \Longrightarrow z > y > x$

76. Ans. (D)

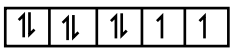
(A) $\underset{6\oplus}{MnO_4^{2\ominus}}$

Electronic configuration of $Mn^{6\oplus}$: $[Ar]3d^1$

So, it is paramagnetic and coloured due to ligand to metal charge transfer.

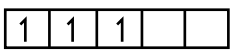
(B) $\left[\underset{+3}{Ni}(H_2O)_6\right]^{2\oplus}$

$Ni^{2\oplus} \longrightarrow [Ar]\ 3d^8 4s^0$

[Ar] 

(C) $\left[\underset{+3}{Cr}Cl_6\right]^{3\ominus}$

$Cr^{3\oplus} \longrightarrow [Ar]\ 3d^3\ 4s^0$

[Ar] 

Paramagnetic and coloured

(D) $\underset{+6}{CrO_4^{2\ominus}}$

$Cr^{6\oplus} \longrightarrow [Ar]\ 3d^0 4^s$

Diamagnetic but coloured due to ligand to metal charge transfer.

77. Ans. (B)

(A) $Na_2[CuCl_4]$

$Cu^{2\oplus}$: $[Ar]3d^9$ → Coloured

(B) $Na_2[CdCl_4]$

Cd : $[Kr]4d^{10}5s^2$

$Cd^{2\oplus}$: $[Kr]4d^{10}$ → Colourless

(C) $K_4[Fe(CN)_6]$

$Fe^{2\oplus}$: $[Ar]3d^6$ → Coloured

(D) $K_3[Fe\ (CN)_6]$

$Fe^{3\oplus}$: $[Ar]3d^5$ → Coloured

Generally, metal ion which have d^1 to d^9 electronic configuration is coloured.

78. Ans. (C)

The higher is the value of $\triangle_O$, Lower is the value of λ max and vice versa.

79. Ans. (C)

Ethylene accepts electron pair from filled d - orbital of $Pt^{2\oplus}$ into its vacant antibonding molecular orbital.

80. Ans. (D)

Greater the negative charge on central atom, greater will be double bond character between M - C

81. Ans. (A)

IR vibrational frequently decreases if charge on central atom is more negative

82. Ans. (C)

In $[Ni(CO)_3\ (PMe_3)]$ extent of synergic bonding towards CO will be maximum. So, C − O bond order will be minimum hence C − O bond length will be maximum.

83. Ans. (A)

(A) $[Fe(\eta^5 - C_5H_5)_2]$

EAN = (26 – 2 + 2 × 6) = 36

(B) K $[PtCl_3(\eta^2 - C_2H_4]$

EAN = [78 – 2 + 6 + 2] = 84

(C) $[V(CO)_6]$

EAN = 23 – 0 + 12 = 35

(D) $[Mn(CO)_6]^0$

EAN = 25 – 0 + 12 = 37

84. Ans. (D)

Fact based

85. Ans. (D)

EDTA is used in the treatment of lead poisoning. Deferrioxime B is used in treatement of iron poisoning and D-penicillamine is used in treatment of heavy metal poisoning, while cis-platin is used for treating cancer.

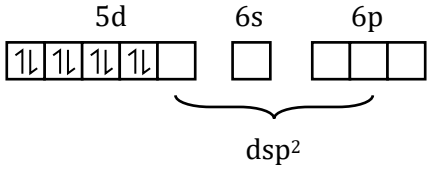
86. **Ans. (C)**

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

87. **Ans. (C)**

(A) $[IrCl(CO)(PPh_3)_2]$ carbonylchloridobis (triphenylphosphine) iridium(I).

(B) Coordination number of Ir is four. Ir is in (+1) oxidation state with $4d^8$ configuration. It is trans isomer, so its geometry should be square planar.



(C) All electrons are paired, hence diamagnetic

(D) Can exhibit GI only.

88. **Ans. (A,B,D)**

Option (C) is incorrect because it will not given the test of Ions present in coordination sphere in aqueous solution

89. **Ans. (A,C)**

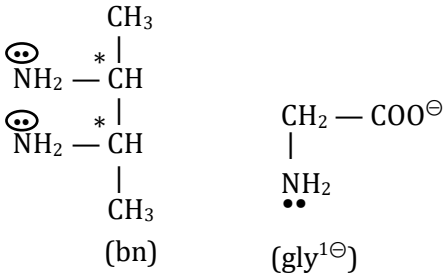
All ligands are not same in coordination sphere

90. **Ans. (B,C,D)**

Generally square planar complexes do not show optical isomerism due to plane of symmetry expect when the ligand have chiral centre present in it.

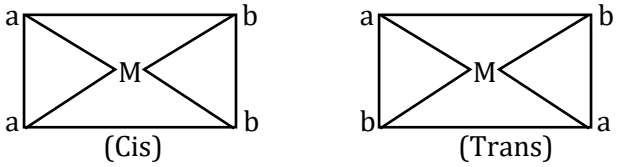
Here bn have chiral centre as shown below

bn:

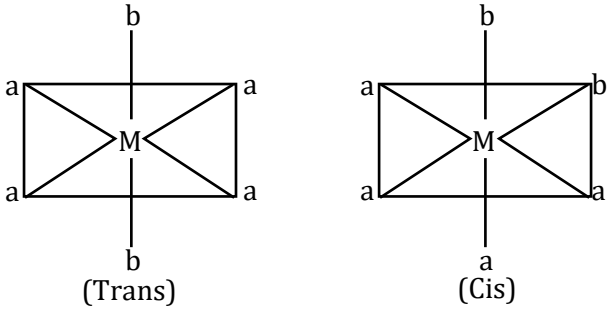


91. **Ans. (A,B)**

(A) Ma_2b_2 (Sq. PI.)

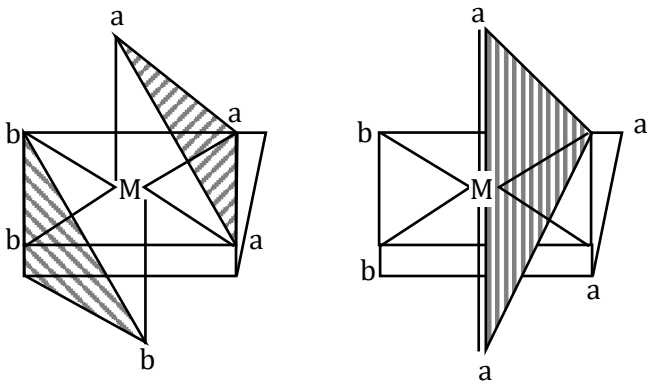


(B) Ma_4b_2 (Octahedral))



92. Ans. (A,B)

(A) $[Cr(NO_3)_3(NH_3)_3] \equiv [Ma_3b_3]$type

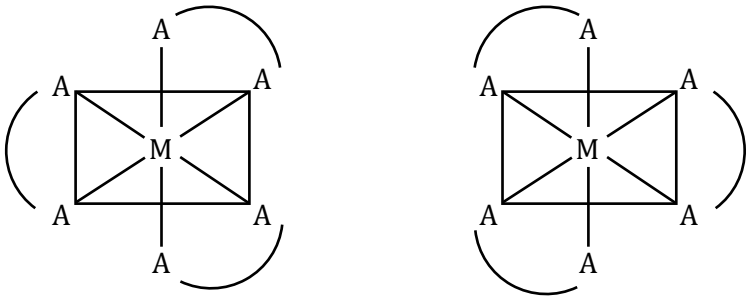


Facial / fac Isomer Meridional/mer isomer

(Optically Inactive) (Optically Inactive)

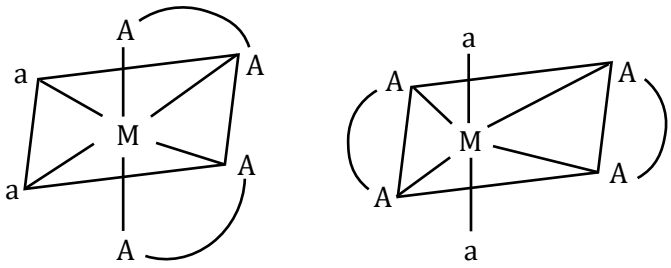
Total stereoisomer (S.I.) = Optically Active (O.A.) + Optically inactive = 0 + 2 = 2

(B) $K_3[Fe(C_2O_4)] \equiv [M(AA)_3]$ type



S.I. = 1 × 2 + 0 = 2

(C) $[CoCl_2(en)_2]+ \equiv [M(AA)_2a_2]$ type

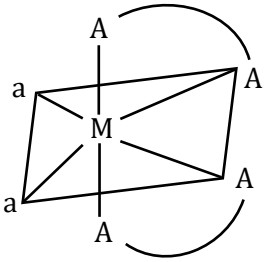


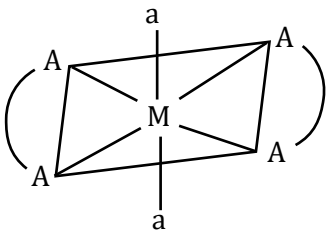
Optically Active (O.A.) Optically Inactive (O.I.)

S.I. = OA + OI

= (1 × 2) + 1 ⇒ 3

(D) $[CoCl_2(en)_2]^{\oplus} \equiv [M(AA)_2\ a_2]$ type





Optically Active (O.A.) Optically Inactive (O.I.)

S.I. = OA + OI = (1 × 2) + 1 ⇒ 3

93. Ans. (A,C,D)

(A) $Ni(CO)_4$

Ni : $[Ar]4s^2 3d^8$

→ sp^3

→ diamagnetic

(B) $[Cu(CN)_4]^{3-}$

Cu^{+1} : $[Ar]3d^{10}$

Diamagnetic

Cu^{+2} : $[Ar]3d^9$

If Ligand is strong field Ligand then it is dsp^2 hybridised.

(C) $[MnBr_4]^{2-}$

Mn^{+2} : $[Ar]3d^5$

Paramagnetic and sp^3

(D) $[IrCl(Co)(PPh_3)_2]$

Ir : $[Xe]6s^2 5d^7$

Diamagnetic ∝ dsp^2

94. Ans. (A,B)

$[Mn(NH_3)_6]^{2+}$

$\Delta_0 < P$

So, It is sp^3d^2

Mn^{+2} : $3d^5$

1	1	1	1	1
d_{xy}	d_{yz}	d_{xz}	$d_{x^2-y^2}$	d_{z^2}

95. Ans. (A,B,D)

(A) $[AgF_4]^-$ → Square Planar

(B) $[AuCl_4]^-$ → Square Planar

(C) $[NiCl_2(PPh_3)_2]$ → Tetrahedral

(D) $[PdCl_2(PMe_3)_2]$ → Square Planar

96. Ans. (A,B,C)

Stability order ∝ Denticity of ligands ∝ Stronger ligand ∝ Z_{eff} value ∝ Oxidation state.

(A) Their formation of entropy decreases in the same order because of denticity of ligand decreases, Hence correct order.

(B) Z_{eff} value decreases from $Ir^{3\oplus}$ to $Co^{3\oplus}$. Hence correct order.

(C) Oxidation state of Cr atom decreases from +3 to +1. Hence correct order.

(D) Incorrect order;
Strength of ligand CO > NH_3 > H_2O
Correct order:
$[Cu(CO)_4]^{2\oplus} > [Cu(NH_3)_4]^{2\oplus} > [Cu(H_2O)_4]^{2\oplus}$

97. Ans. (A,B,C,D)

These ligands not only donate the lone pair of electrons to central metal but also accept the electron from central atom.

98. Ans. (C,D)

(A) $Fe(CO)_5$: EAN = 26 + 5 × 2 = 36
$Ni(CO)_4$: EAN = 28 + 4 × 2 = 36

(B) $[Fe(NH_3)_6]^{2+}$: EAN = 26 – 2 + 12 = 36
$[Cr(C_2O_4)_3]^{3-}$: EAN = 24 – 3 + 12 = 33

(C) $[Fe(H_2O)_5(NO)]^{+2}$: EAN = 26 – 1 + 10 + 2 = 37
$[Mn(CO)_6]$: EAN = 25 + 12 = 37

(D) $[Ti(CO)_6]$: EAN = 22 + 12 = 34
$[Mn(C_2O_4)_3]^{3-}$: EAN = 25 – 3 + 12 = 34

99. Ans. (B)

$NO_2^{\ominus}$ and $SCN^{\ominus}$ are ambidentate ligands.
Ethane-1, 4 diamine is chelating ligand with two donor site.

100. Ans. (D)

(i) $[Co(H_2O)_3F_3]$
Co :[Ar] $4s^2 3d^7$
$Co^{3\oplus}$:[Ar] $3d^6$
In their case $Co^{3\oplus}$ is sp^3d^2 hybridised.
Number of unpaired electrons = 4

(ii) $[NiF_6]^{2\ominus}$
Here pairing will occur
$[NiF_6]^{2\ominus} \rightarrow d^2sp^3$
Number of unpaired electrons = '0'

(iii) $Na_2[NiCl_4]$
$Ni^{2\oplus}$: [Ar] $3d^8$
3d+WFL. → Tetrahedral
hybridisation → sp^3
unpaired electron → 2

(iv) $K_2[Ni(CN)_4]$
$[Ni(CN)_4]^{2\ominus}$
$Ni^{2\oplus}$: [Ar] $3d^8$
$Ni^{2\oplus}$ with strong field ligand is square planar
$[Ni(CN)_4]^{2\ominus} \rightarrow dsp^2$
unpaired electrons = 0

101. Ans. (B)

(ii) $[NiF_6]^{2\ominus}$

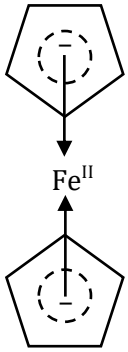
Here pairing will occur

$[NiF_6]^{2\ominus} \rightarrow d^2sp^3$

Number of unpaired electrons = '0'

102. Ans. (D)

Ferrocene : $[Fe(\pi - C_5H_5)_2]^0$



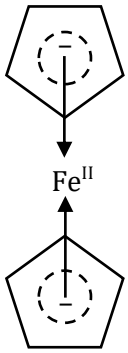
Potassium ferrocynide : $K_4[\overset{II}{Fe}(CN)_6]$

Sodium nitroprusside : $Na_2[\overset{II}{Fe}(CN)_5(\overset{\oplus}{NO})]$

Zeise's salt : $K[\overset{II}{Pt}Cl_3(\pi - C_2H_4)]$

103. Ans. (C)

Ferrocene : $[Fe(\pi - C_5H_5)_2]^0$



Potassium ferrocynide : $K_4[\overset{II}{Fe}(CN)_6]$

Sodium nitroprusside : $Na_2[\overset{II}{Fe}(CN)_5(\overset{\oplus}{NO})]$

Zeise's salt : $K[\overset{II}{Pt}Cl_3(\pi - C_2H_4)]$

104. Ans. (A)

Ligand $C_5H_5^{\ominus}, NO^{\oplus}, CN^{\ominus}, C_2H_4$ can accept electrons in their π^*.

Hence are π – acid ligands.

105. Ans. (C)

106. Ans. (C)

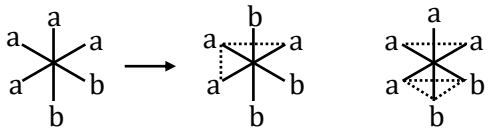
107. Ans. (D)

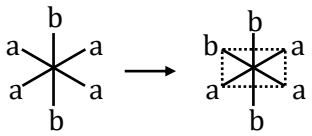
108. Ans. (A)

$[CoCl_2(NH_3)_4]^+ + Cl^- \longrightarrow [CoCl_3(NH_3)_3] + NH_3$

Complex : A

Complex 'A' : $[Ma_4b_2] + a \longrightarrow [Ma_3b_3]$





109. Ans. (B)

$CoCl_3.5NH_3 \xrightarrow{AgNO_3} AgCl$

0.1 mole 0.2 mole

Complex is $[Co(NH_3)_5Cl]Cl_2$

Cation : Anion

1 : 2

110. Ans. (A)

SCN and NCS are ambidentate Ligand, show Linkage isomerism.

EXERCISE - S

1. Ans. (4)

option (I), (II), (IV), (VI) are correct

2. Ans. (33)

$K_3[Cr(C_2O_4)_3]$

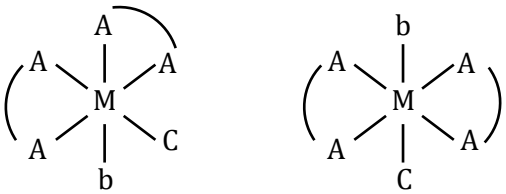
EAN = Atomic Number – oxidation Number + 2 [coordination Number]

= 24 – 3 + (2 × 6)

= 33

3. Ans. (2)

$[M(AA)_2bc]^{4\oplus} \Longrightarrow$ octahedral complex



P.O.S → ✗ P. O. S → ✔

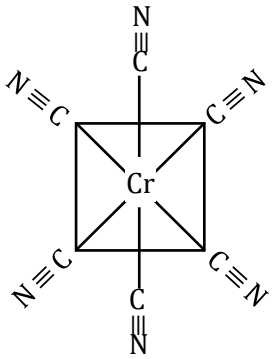
C.O.S → ✗ Optically Inactive

Optically active

4. Ans. (15)

[Mabcdef] type complex has 15 geometrical isomers.

5. **Ans. (9)**



6. **Ans. ((a) 4, (b) 9, (c) 4, (d) 4, (e) 5)**

$[Pt(NH_3)_4]^{+2}$	$[CuCl_4]^{2-}$
$[Pt(NH_3)_3Cl_2]^{+1}$	$[CuCl_3(NH_3)_2]^{-1}$
$[Pt(NH_3)Cl_3]^{-1}$	$[CuCl(NH_3)_3]^{+1}$
$[PtCl_4]^{-2}$	$[Cu(NH_3)_4]^{+2}$

Number of coordination isomers possible : 4

7. **Ans. (2)**

$[CoF_3(H_2O)_3]$	$[Co(OX)_3]^{-3}$
Co^{+3} : $[Ar]3d^6$	Co^{+3} : $[Ar]3d^6$
Hybridisation sp^3d^2	Hybridisation d^2sp^3
↿ ↿ e_g	— — e_g
↿⇂ ↿ ↿ t_{2g}	↿⇂ ↿⇂ ↿⇂ t_{2g}
$\Delta_0 < P$	$\Delta_0 > P$
t_{2g} $e^{\ominus}$: 4	t_{2g} $e^{\ominus}$: 6
e_g $e^{\ominus}$: 2	e_g $e^{\ominus}$: 0
No. of stereoisomers : 2	No. of stereoisomers : 2
Number of GI : 2	Number of GI : 0
EAN : 36	EAN : 36

8. **Ans. (2)**

$[Co(H_2O)_3F_3]$ → hybridization : sp^3d^2

Co^{+3} : $[Ar]3d^6$

↿ ↿ e_g

↿⇂ ↿ ↿ t_{2g}

Total no. of unpaired electrons = 4

Total no. of unpaired electrons in t_2g = 2

9. **Ans. (5)**

Strength of Ligand : $F^{\Theta} < C_2O_4^{2-} < H_2O < NH_3 < en < CN^-$

10. **Ans. (2)**

C_2H_4 and C_6H_6 act as π donor ligand

11. **Ans. (36)**

$[Fe\ (\pi - C_4H_4)(CO)_3]$

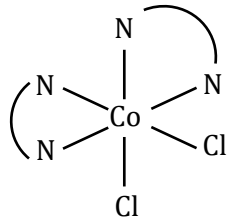
EAN = Atomic Number – oxidation Number + 2 [coordination Number]

= 26 – 0 + 2 × [1 × 4 + 2 × 3]

= 36

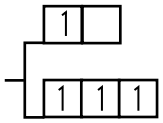
EXERCISE - JEE (Main) PYQ

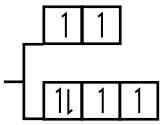
1. Ans. (3)



no plane of symmetry so it can show optical isomerism.

2. Ans. (3)

$Cr^{2\oplus} = [Ar]\ 3d^4$  ; $\mu = \sqrt{24}$ B.M.

$Fe^{2\oplus} = [Ar]\ 3d^6$  ; $\mu = \sqrt{24}$ B.M.

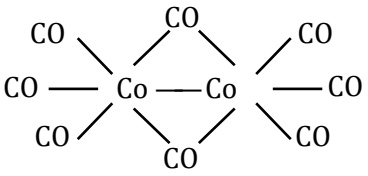
3. Ans. (2)

CFSE = $Cr^{2\oplus}$ (3d) < $Mo^{2\oplus}$ (4d) ,

CFSE $\Longrightarrow Ti^{3\oplus} > Ti^{2\oplus}$

CFSE $\propto$ Charge on central metal

4. Ans. (2)



5. Ans. (4)

Moles of complex = $\frac{\text{Molarity} \times \text{v(ml)}}{1000}$

$= \frac{100\times0.1}{1000} = 0.01\text{mol}$

Moles of ions precipitated with excess of

$AgNO_3 = \frac{1.2\times10^{22}}{6.02\times10^{23}} = 0.02\text{mol}$

so number of ion precipitated = $\frac{0.02}{0.01} = 2\ (Ag^{\oplus}Cl^{\ominus})$

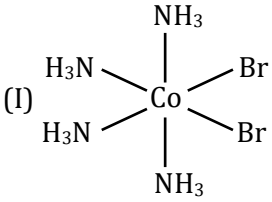
6. Ans. (2)

$[Cr(H_2O)_6]Cl_3 \rightarrow x + 0 = +3, \quad x = +3$

$[Cr(C_6H_6)_2] \rightarrow x + 0, \quad x = 0$

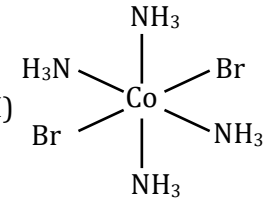
$K_2[Cr(CN)_2(O_2)(O)_2(NH_3)] \rightarrow x + 2(-1) + 2(-2) + 1(-2) + 0 = -2 \Longrightarrow x = +6$

7. **Ans. (1)**

(I) 

$+ Br^{\ominus} \rightarrow$ fac & mer Isomers

cis

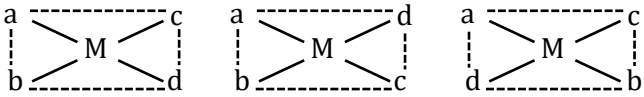
(II) 

$+ Br^{\ominus} \rightarrow$ Only mer isomer

trans

8. **Ans. (4)**

$[Pt(Cl)(NO_2)(NO_3)(SCN)]^{2\ominus}$ complex is [Mabcd] type square planar complex, so it has 3 G.I.



But $NO_2^{\ominus}$ & SCN are ambidentate ligand So total possible isomer of this complex is = 2

$NO_2^{\ominus}/ONO^{\ominus}$

$SCN^{\ominus}/NCS^{\ominus}$

9. **Ans. (3)**

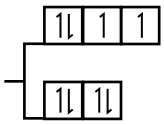
$Mn^{2\oplus} = 3d^5 =$ 5 unpaired electron

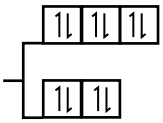
$Co^{2\oplus} = 3d^7 =$ 3 unpaired electron

$Ni^{2\oplus} = 3d^8 =$ 2 unpaired electron

$Zn^{2\oplus} = 3d^{10} =$ Zero unpaired electron

10. **Ans. (2)**

$[NiCl_4]^{2\ominus} = Ni^{2\oplus} = [Ar]3d^8$ (Paramagnetic)  , tetrahedral

$[Ni(CO)_4] = Ni^0 = [Ar]4s^2 3d^8$  diamagnetic, tetrahedral

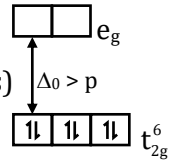
In $[Ni(CO)_4]$, 'CO' pairs the 4s electron into the 3d subshell.

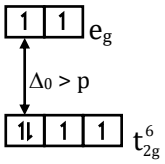
11. **Ans. (2)**

Δ_0 order will be compared by spectro chemical series not by the energies of violet & yellow light.

So Δ_0 order is $[Cr(H_2O)_6Cl_3] < [Cr(NH_3)_6]Cl_3$

12. **Ans. (4)**

(a) $Co^{3\oplus}$ (with strong field ligands)  diamagnetic

(b) If $\Delta_0 < p$; 

(c) Splitting power of ethylenediamine (en) is greater than fluoride ($F^{\ominus}$) ligand therefore more energy absorbed by $[Co(en)_3]^{3\oplus}$ as compared to $[CoF_6]^{3\ominus}$
So wave length of light absorbed by $[Co(en)_3]^{3\oplus}$ is lower than that of $[CoF_6]^{3\ominus}$

(d) $\Delta_f = \frac{4}{9}\Delta_0$

so if $\Delta_0 = 18000\ cm^{-1}$

$\Delta_t = \frac{4}{9} \times 18000 = 8000\ cm^{-1}$

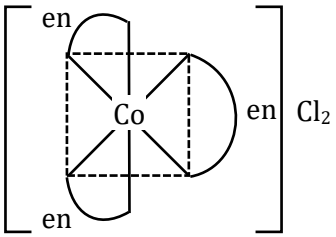
Statement (a) and and (d)) are incorrect.

13. Ans. (2)

The correct option is $[Co(en)_3]Cl_2$

Cyclic complexes, called chelates, are generally more stable than open chain complexes. Chelates having more number of cyclic rings are more stable than those having less numer of cyclic rings.

$\therefore$ Of the given complexes $[Co(en)_3]Cl_2$ is most stable.



14. Ans. (2)

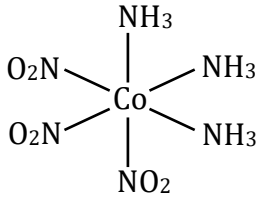
Triamminetrinitrocobalt (III) – $[Co(NH_3)_3(NO_2)_3]$

In $[Ma_3b_3]$ type of complex the possible geometrical isomers are two, facial and meridional.

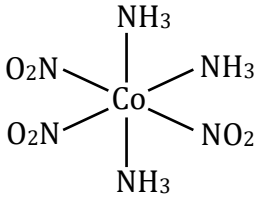
Facial isomer have three identical ligands on one triangular face.

Meridional isomer have three identical ligands in a plane bisecting the molecule.

molecule.



fac



mer

X = 2

Y = 0

Trioxalatochromate (III) – $[Co(ox)_3]^{3\ominus}$

Oxalate is a symmetrical bidenate ligand.

Complex of $[M(AA)_3]^n$ (where, AA is symmetrical bidentate ligand) type does not show geometrical isomerism because the ligands are arranged in different planes.

Y = O

Hence, X + Y = 2.

15. **Ans. (2)**

(i) CFSE $\propto$ charge or oxidation no. of central metal ion.

(ii) CFSE $\propto$ strength of ligand ($en > NH_3 > H_2O > F^{\ominus}$)

$\therefore$ order of CFSE

$$[\overset{III}{Co}(en)_3]^{3\oplus} > \overset{III}{Co}(NH_3)_6]^{3\oplus} > [\overset{III}{CoF_6}]^{3\ominus} > [\overset{II}{Co}(H_2O)_6]^{2\oplus}$$

16. **Ans. (1)**

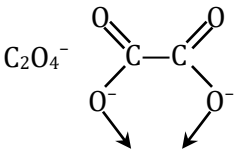
When metal is in low oxidation state then it forms complexes when ligands have good π -accepting character.

17. **Ans. (1)**

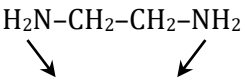
There is unsymmetric filling of e_g subset of $Cu^{2\oplus}$ ion, while there is symmetrical distribution in t_{2g} set, if the complex has same ligand there will be equal repulsion which leads to symmetrical bond length along t_{2g} , but due to uneven filling of electron in e_g subset, either octahedral will be elongated or compressed.

18. **Ans. (1)**

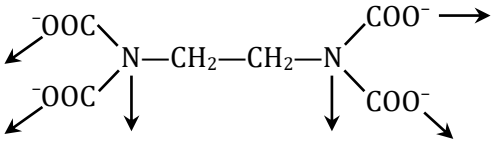
NO_2^-, NCS^- are ambidentate ligand



Ethylene diammine

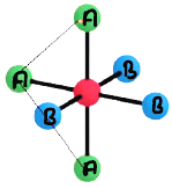


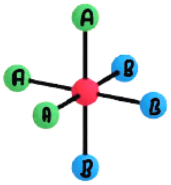
EDTA Ethylene diamine tetra acetate



19. **Ans. (1)**

$[MA_3B_3]$ type of compound exists as facial and meridonial isomer.





20. **Ans. (1)**

Spin magnetic moment of $[Cr(CN)_6]^{3-}(t_{2g}^3 e_g^0)$

$$\mu_1 = \sqrt{3(3+2)} = \sqrt{15} \text{ BM}$$

Spin magnetic moment of $[Cr(H_2O)_6]^{3+}(t_{2g}^3 e_g^0)$

$$\mu_2 = \sqrt{3(3+2)} = \sqrt{15} \text{ BM}$$

$$\frac{\mu_1}{\mu_2} = \frac{\sqrt{15}}{\sqrt{15}} = 1$$

EXERCISE - JEE (Advanced) PYQ

1. Ans. (B)

spin only magnetic moment = $\sqrt{n(n+2)}$ B.M.

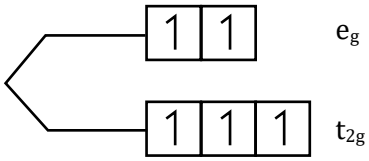
n → number of unpaired electrons

P : $[FeF_6]^{3\ominus}$

F^- → (weak field ligand)

$\Delta_0 < P$

$Fe^{3\oplus}$; [Ar] $3d^5$



number of unpaired electron = 5

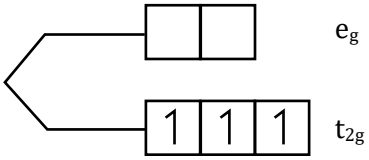
$\mu = \sqrt{5(5+2)} = \sqrt{35}$

Q : $[V(H_2O)_6]^{2\oplus}$

H_2O → (weak field ligand)

$\Delta_0 < P$

$V^{2\oplus}$ → [Ar] $3d^3$



number of unpaired electron = 3

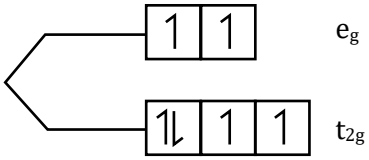
$\mu = \sqrt{3(3+2)} = \sqrt{15}$

R : $[Fe(H_2O)_6]^{2\oplus}$

H_2O → (weak field ligand)

$\Delta_0 < P$

$Fe^{2\oplus}$; [Ar] $3d^6$



number of unpaired electron = 4

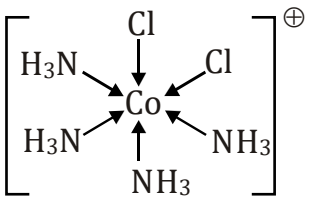
$\mu = \sqrt{4(4+2)} = \sqrt{24}$

Hence, **Ans (B)** : Q < R < P

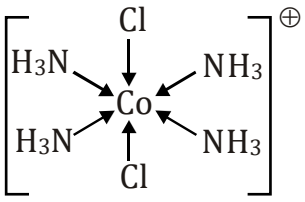
2. Ans. (B,D)

(A) $[Cr(NH_3)_5Cl]Cl_2$ does not show any isomerism while $[Cr(NH_3)_4Cl_2]Cl$ shows geometrical isomerism

(B) $[Co(NH_3)_4Cl_2]^{\oplus}$ and $[Pt(NH_3)_2(H_2O)\ (Cl)]^{\oplus}$



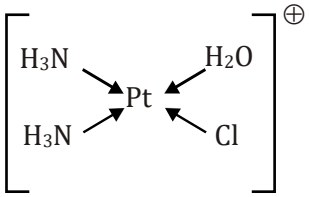
cis



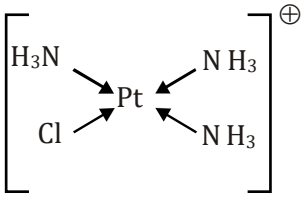
trans

hence, $[Co(NH_3)_4Cl_2]^{\oplus}$ ion shows geometrical isomerism.

$[Pt(NH_3)_2(H_2O)\ (Cl)]^{\oplus}$



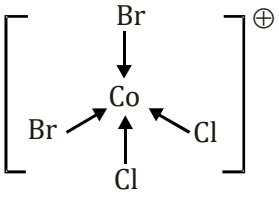
cis



trans

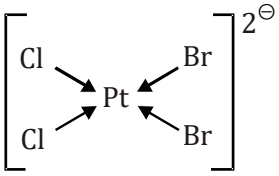
hence, $[Pt(NH_3)_2(H_2O)(Cl)]^{\oplus}$ ion shows geometrical isomerism

(C) $[CoBr_2Cl_2]^{2\ominus}$ and $[PtBr_2Cl_2]^{2\ominus}$

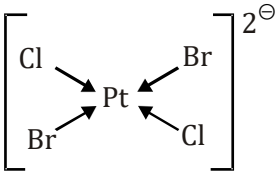


tetrahedral

does not show any isomerism



cis



trans

square planar and shows geometrical isomerism

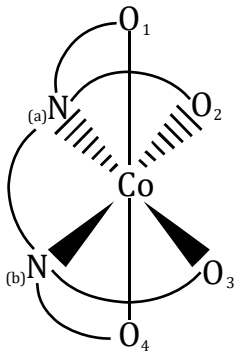
(D) $[Pt(NH_3)_3(NO_3)]Cl$ and $[Pt(NH_3)_3Cl]Br$

$\left.\begin{matrix}[Pt(NH_3)_3(NO_3)]Cl \\ [Pt(NH_3)_3Cl]NO_3\end{matrix}\right\}$ show ionisation isomerism

$\left.\begin{matrix}[Pt(NH_3)_3Cl]Br \\ [Pt(NH_3)_3Br]Cl\end{matrix}\right\}$ show ionisation isomerism

hence, **Ans is (B, D)**

3. Ans. (8)



= $[Co^{III}(EDTA)]^{\ominus}$

Total 8 N–Co–O bond angles

$_{(a)}N–Co–O_1$	$_{(b)}N–Co–O_1$
$_{(a)}N–Co–O_2$	$_{(b)}N–Co–O_2$
$_{(a)}N–Co–O_3$	$_{(b)}N–Co–O_3$
$_{(a)}N–Co–O_4$	$_{(b)}N–Co–O_4$

4. Ans. (B)

(P) $[Cr^{III}(NH_3)_4Cl_2]Cl$:

(1) Complex given in (P) is Paramagnetic & show two geometrical (3 unpaired electrons) isomerism (cis and trans) (does not show ionization isomer)

(Q) $[Ti^{III}(H_2O)_5Cl](NO_3)_2$

(R) $[Pt^{II}(en)(NH_3)Cl]NO_3$

(S) $[Co^{III}(NH_3)_4(NO_3)_2]NO_3$

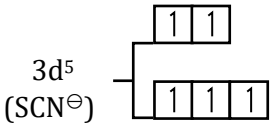
(2) Complex given in (Q) is paramagnetic show ionization (1 unpaired electrons) isomerism

(3) Complex given in (R) is diamagnetic and show ionization (1 unpaired electrons) isomerism

(4) Complex given in (S) is diamagnetic does not show ionization (0 unpaired electrons) isomerism show geometrical isomerism

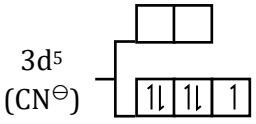
5. Ans. (4)

$Fe^{3\oplus}$: $[Ar]3d^5$



$\mu = \sqrt{35}$ B.M.

$\mu =$ 5.91 BM

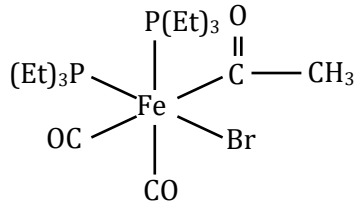


$\mu = \sqrt{3}$ B.M.

μ = 1.73 BM

Difference = 5.9 – 1.7 = 4

6. Ans. (3)



(Total three Fe – C bonds.)

7. Ans. (6)

All six complex ions can show cis–trans isomerism.

8. Ans. (B)

$[Ni(CO_4)] \rightarrow Ni^0 = [Ar]3d^{10} \rightarrow$ zero unpaired $e^{\ominus}$

$[NiCl_4]^{2\ominus} \rightarrow Ni^{2\oplus} = [Ar]3d^8 \rightarrow$ 2 unpaired $e^{\ominus}$

$[Co(NH_3)_4Cl_2]Cl \rightarrow Co^{3\oplus} = [Ar]3d^6 \rightarrow$ Zero unpaired $e^{\ominus}$

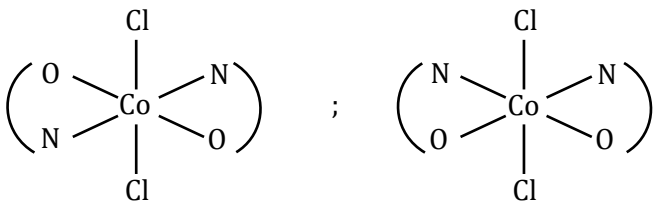
$[CoF_6]^{3\ominus} \rightarrow Co^{3\oplus} = [Ar]3d^6 \rightarrow$ 4 unpaired $e^{\ominus}$

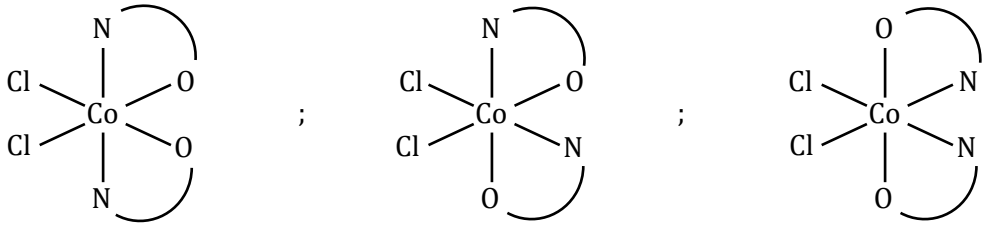
$Na_2O_2 \rightarrow O_2^{2\ominus} \rightarrow$ diamagnetic

$CsO_2 \rightarrow O_2^{\ominus} \rightarrow$ paramagnetic (1 unpaired $e^{\ominus}$)

$[NiCl_4]^{2\ominus}, [CoF_6]^{3\ominus}, CsO_2$ are paramagnetic due to presence of unpaired electron.

9. Ans. (5)





Total no. of Geometrical isomers = 5

10. Ans. (A)

NH_3 is strong field ligand

$[Ni(NH_3)_6]^{2\oplus} \rightarrow Ni^{2\oplus} = [Ar]3d^8$

Octahedral (sp^3d^2)

$Pt^{2\oplus}$ always sq. planar with coordination number 4

$Zn^{2\oplus} = [Ar]3d^{10} \rightarrow$ Tetrahedral

11. Ans. (A,B,D)

$$\underset{\text{Pink (x)}}{\overset{II}{[Co(H_2O)_6]Cl_2}} \xrightarrow[Air/O_2]{\text{Excess } NH_4OH/NH_4Cl} \underset{\text{(Y)}}{\overset{III}{[Co(NH_3)_6]Cl_3}}$$

$$\underset{\text{(x)}}{[Co(H_2O)_6]^{2\oplus}} + \underset{\text{excess}}{4Cl^{\ominus}} \longrightarrow \underset{\text{(z) blue colour}}{[CoCl_4]^{2\ominus}}$$

(A) Hybridisation of (y) is d^2sp^3 as NH_3 is strong field ligand.

(B) $[CoCl_4]^{2\ominus}$ have sp^3 hybridisation as $Cl^{\ominus}$ is weak field ligand.

(C) $[Co^{III}(NH_3)_6]Cl_3 + 3AgNO_3\,(aq.) \rightarrow 3AgCl$

(D) $\underset{\text{Blue}}{[CoCl_4]^{2\ominus}} + 6H_2O \rightleftharpoons \underset{\text{Pink}}{[Co(H_2O)_6]^{2\oplus}} + 4Cl^{\ominus}$ ΔH = –ve (exotherinic)

When ice is added to the solution the equilibrium shifts right hence pink colour will remain predominant

12. Ans. (B,C)

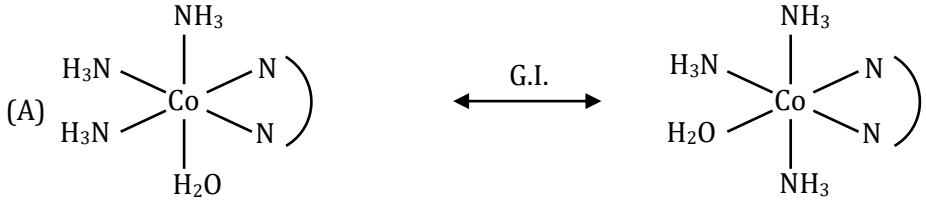
(A) Electronic configuration of central metal atom in both cases is $[Ar]3d^{10}\ 4s^24p^6$ (8 electrons in outermost shell and 18 valence electrons respectively).

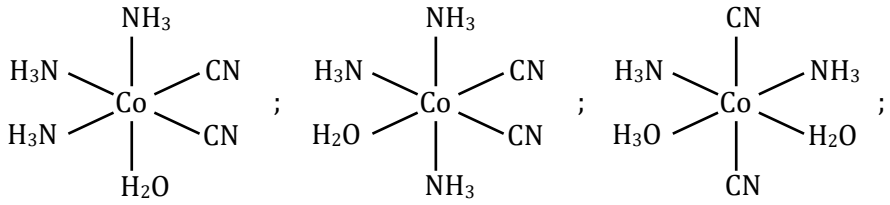
(B) These are low spin in nature due to the presence of strong field ligand

(C) As density of electron increases on the metal, extent of Synergic bonding increases hence strengthen the metal- carbon bond

(D) As M-C bond order ↑ , CO bond length ↑

13. Ans. (A,B,D)



(B) 

(C) It is diamagnetic.

(D) In $[Co(en)(NH_3)_4]^{3\oplus}$ gap between t_{2g} and e_g is more than $[Co(en)(NH_3)(H_2O)]^{3\oplus}$

$\left(\text{Energy} \propto \frac{1}{\lambda_{absorb}}\right)$

14. Ans. (C)

(1) $[FeF_6]^{4\ominus} \rightarrow Fe^{2\oplus} \rightarrow [Ar]3d^6 \Longrightarrow sp^3d^2$

(2) $[Ti(H_2O)_3Cl_3] \rightarrow Ti^{3\oplus} = [Ar]3d^1 \Longrightarrow d^2sp^3$

(3) $[Cr(NH_3)_6]^{3\oplus} \rightarrow Cr^{3\oplus} = [Ar]3d^3 \Longrightarrow d^2sp^3$

(4) $[FeCl_4]^{2\ominus} \rightarrow Fe^{2\oplus} = [Ar]3d^6] \Longrightarrow sp^3$

(5) $[Ni(CO)_4] \rightarrow Ni = [Ar]3d^{10} \Longrightarrow sp^3$

(6) $[Ni(CN)_4]^{2\ominus} = Ni^{2\oplus}\ [Ar]3d^8 \Longrightarrow dsp^2$

15. Ans. (1)

$\Longrightarrow$ H = $1s^1$ ' paramagnetic

$\Longrightarrow$ $NO_2 \Longrightarrow$ odd electron species, paramagnetic

$\Longrightarrow$ $O_2^- \Longrightarrow$ KK $\sigma 2s^2, \sigma^* 2s^2, \sigma p_z^2, \pi 2p_x^2 = \pi 2p_y^2, \pi^* 2p_x^2 = \pi^* 2p_y^1$, paramagnetic

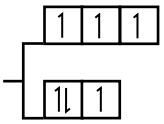
$\Longrightarrow$ $S_2 \Longrightarrow$ similar to O_2, paramagnetic

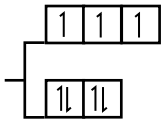
$\Longrightarrow$ $Mn_3O_4 \Longrightarrow \overset{2\oplus}{M}nO.\overset{3\oplus}{M}n_2O_3 \rightarrow$ paramagnetic

$Mn^{2\oplus} \Longrightarrow [Ar]3d^5$

$Mn^{3\oplus} \Longrightarrow [Ar]3d^4$

$\Longrightarrow (NH_4)_2[FeCl_4], Fe^{2\oplus} \Longrightarrow [Ar]3d^6$

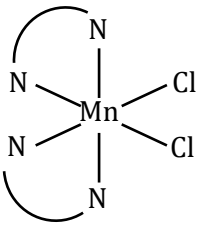
$\Longrightarrow$ $Fe^{2\oplus}$ = [Ar] $3d^6$  , paramagnetic

$\Longrightarrow$ $(NH_4)_2[NiCl_4]$, $Ni^{2\oplus} \Rightarrow$ [Ar] $3d^8$  , paramagnetic

$\Longrightarrow$ $K_2\overset{6\oplus}{M}nO_4, Mn^{6\oplus} \Longrightarrow [Ar]3d^1$, paramagnetic

$\Longrightarrow$ $K_2CrO_4, Cr^{6\oplus} \Longrightarrow [Ar]3d^0$, diamagnetic

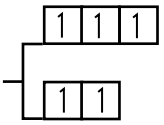
16. Ans. (6)

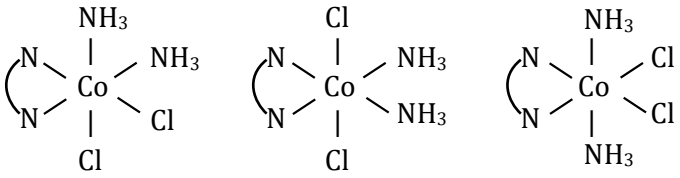
 → It has three such angle at its cis position

→ It has 3 such angles at its cis position

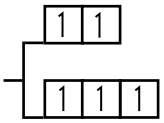
Total Number of angle = 6

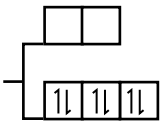
17. Ans. (A,C)

(A) $Fe^{3\oplus}$ = [Ar] $3d^5$ 

(B) 

3 Geometrical isomers

(C) $Fe^{3\oplus}$ = [Ar] $3d^5$  sp^3 (5 unpaired electron)

(D) $Co^{3\oplus}$ = [Ar] $3d^6$  d^2sp^3 (zero unpaired electron)

18. Ans. (A, B, C)

(A) H_2O is diamagnetic so deflection of the pan is upwards.

(B) $K_4[Fe(CN)_6]$ is diamagnetic due to strong field ligand. so deflection of the pan is upwards

(C) O_2 is paramagnetic so deflection off the pan is downwards.

(D) C_6H_6 → diamagnetic so deflection of the pan is upwards.

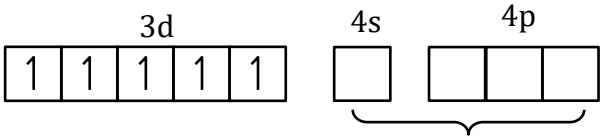
19. Ans. (ABD)

$[FeCl_4]^{\ominus}$

(A) Fe ⟶ [Ar] $3d^64s^2$

$Fe^{3\oplus}$ ⟶ [Ar] $3d^54s^0$

$Cl^{\ominus}$ is W.F.L. and does not pair up the unpaired electron of central metal atom.

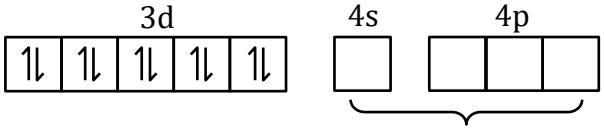
$\therefore$ $Fe^{3\oplus}(d^5)$ in $[FeCl_4]^{\ominus}$ 

Tetrahedral

$[Fe(CO)_4]^{2\ominus}$

Fe ⟶ [Ar] $3d^64s^2$

$Fe^{2\ominus}$ ⟶ [Ar] $3d^84s^2$

$\therefore$ $Fe^{2\ominus}$ (d^{10}) in $[Fe(CO)_4]^{2\ominus}$ 

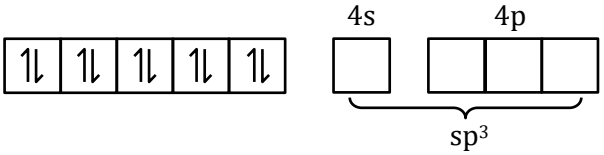
Tetrahedral

(B) **$[Co(CO)_4]^{\ominus}$**

$Co \longrightarrow [Ar]\ 3d^7 4s^2$

$Co^{1\ominus} \longrightarrow [Ar]\ 3d^8 4s^2$

$\therefore\ Co^{\ominus}\ (d^{10})$ in $[Co(CO)_4]^{\ominus}$



sp^3

Tetrahedral

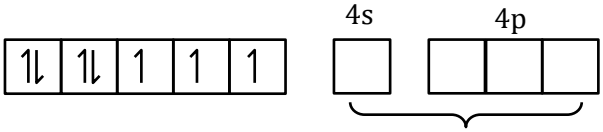
$[CoCl_4]^{2\ominus}$

$Co \longrightarrow [Ar]\ 3d^7 4s^2$

$Co^{2\oplus} \longrightarrow [Ar]\ 3d^7 4s^0$

Cl^- is W.F.L. and does not pair up the unpaired electron of central metal atom.

$\therefore\ Co^{2\oplus}\ (d^7)$ in $[CoCl_4]^{2\ominus}$



sp^3

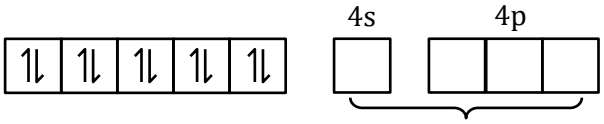
Tetrahedral

(C) **$[Ni(CO)_4]$**

$Ni \longrightarrow [Ar]\ 3d^8 4s^2$

$Ni^0 \longrightarrow [Ar]\ 3d^8 4s^2$

$\therefore$ Ni (d^{10}) in $[Ni(CO)_4]$



sp^3

Tetrahedral

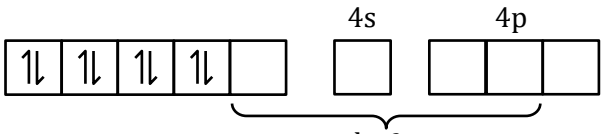
$[Ni(CN)_4]^{2\ominus}$

$Ni \longrightarrow [Ar]\ 3d^8 4s^2$

$Ni^{2\oplus} \longrightarrow [Ar]\ 3d^8 4s^0$

$CN^{\ominus}$ is S.F.L. and pair up the unpaired electron of central metal atom.

$\therefore$ Ni (d^8) in $[Ni(CN)_4]^{2\ominus}$



dsp^2

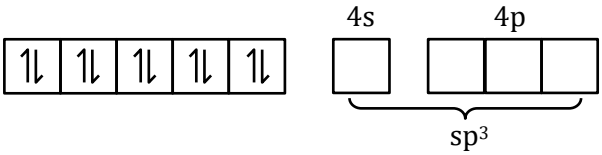
Square planar

(D) **$[Cu(py)_4]^{\oplus}$**

$Cu \longrightarrow [Ar]\ 3d^{10} 4s^1$

$Cu^{1\oplus} \longrightarrow [Ar]\ 3d^{10} 4s^0$

$\therefore Cu^{1\oplus}(d^{10})$ in $[Cu(py)_4]^{\oplus}$



sp^3

Tetrahedral

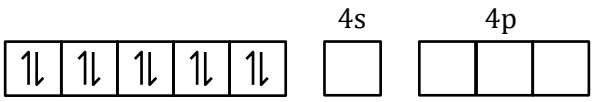
$[Cu(CN)_4]^{3\ominus}$

$Cu \longrightarrow [Ar]\ 3d^{10}4s^1$

$Cu^{1\oplus} \longrightarrow [Ar]\ 3d^{10}4s^0$

$CN^{\ominus}$ is S.F.L. and pair up the unpaired electron of central metal atom.

$\therefore\ Cu^{1\oplus}\ (d^{10})$ in $[Cu(CN)_4]^{3\ominus}$



sp^3

Tetrahedral

20. Ans. (6)

Isomers

(I) $[Pt(NH_3)_4Cl_2]Br_2 \Rightarrow$ G.I. = 2

(II) $[Pt(NH_3)_4Br_2]Cl_2 \Rightarrow$ G.I. = 2

(III) $[Pt(NH_3)_4BrCl]Br.Cl \Rightarrow$ G.I. = 2

I, II, III are ionisation isomers of each other, each having 2 geometrical isomers.

Total possible isomers will be 6

21. Ans. (A)

$[Cr(NH_3)_6]^{3\oplus}$

$Cr^{3\oplus} \Rightarrow [Ar]3d^3$

In presence of NH_3 ligand

e_g

t_{2g}

Number of unpaired electrons = 3

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

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

$\mu = \sqrt{15}$ B.M.

$\Rightarrow$ 3.87 B.M.

$[CuF_6]^{3\ominus}$

$Cu^{3\oplus} \Rightarrow [Ar]3d^8$

In presence of F^- Ligand

$Cu^{3\oplus} \Rightarrow$

e_g

t_{2g}

Number of unpaired electrons = 2

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

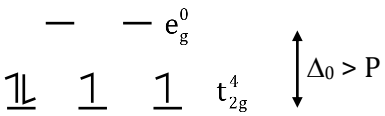
$\mu = \sqrt{2(2+2)} \Rightarrow \sqrt{8}$ B.M.

$\Rightarrow$ 2.84 B.M

22. Ans. (A)

(1) $[Cr(CN)_6]^{4\ominus}$

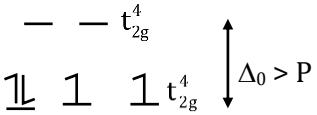
$Cr^{2\oplus} = [Ar]_{18}\,3d^4 4s^0$; low spin complex



P,R,T

(2) $[RuCl_6]^{2\ominus}$

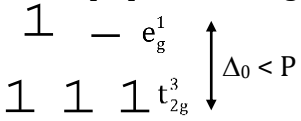
$Ru^{4\oplus} = [Kr]_{36}4d^4 5s^0$; low spin complex



P,R,S,T

(3) $[Cr(H_2O)_6]^{2\oplus}$

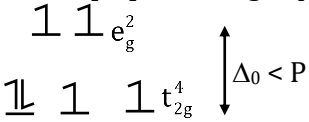
$Cr^{2\oplus} = [Ar]_{18}3d^4 4s^0$; high spin complex



Q,T

(4) $[Fe(H_2O)_6]^{2\oplus}$

$Fe^{2\oplus} = [Ar]_{18}3d^6$; High spin complex

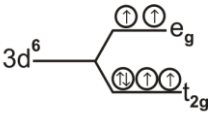


P,Q

23. Ans. (D)

1. $\underset{WFL}{[Fe^{II}(H_2O)_6]^{+2}}$

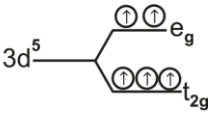
configuration $3d^6$



$t_{2g}^4 e_g^2$ (S)

2. $\underset{WFL}{[Mn^{II}(H_2O)_6]^{+2}}$

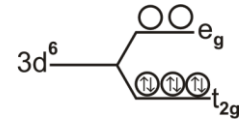
configuration $3d^5$



$t_{2g}^3 e_g^2$ (Q)

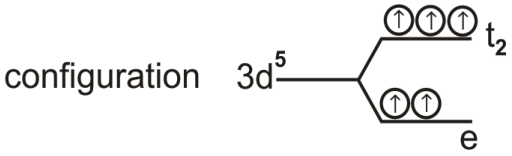
3. $\underset{SFL}{[Co^{III}(NH_3)_6]^{+3}}$

configuration $3d^6$



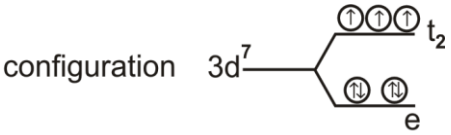
$t_{2g}^6 e_g^0$ (P)

4. $\underset{WFL}{[Fe^{III}Cl_4]^{\ominus}}$



$e^2 t_2^3$ (R)

5. $\underset{WFL}{[Co^{II}Cl_4]^{-2}}$

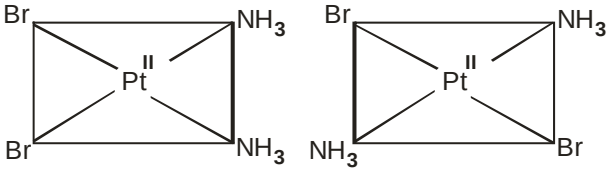


$e^4 t_2^3$ (None)

24. Ans. (C,D)

$[\overset{+2}{Pt}(NH_3)_2Br_2]$

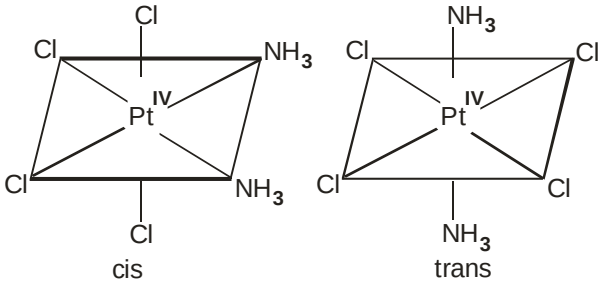
Hybridisation : dsp^2 , geometry : square planar



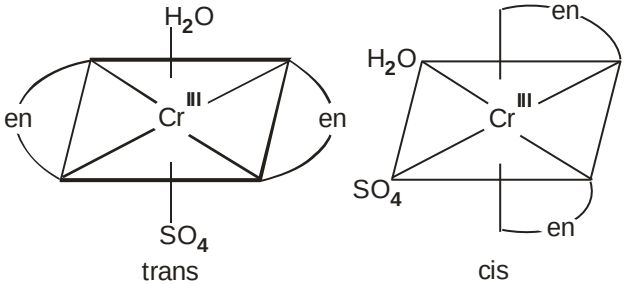
(A) $[Pt(en)(SCN)_2]$: square planar, cis–trans not possible

(B) $[Zn(NH_3)_2Cl_2]$: tetrahedral, cis–trans not possible

(C) $[Pt(NH_3)_2Cl_4]$: octahedral, cis–trans possible



(D) $[Cr(en)_2(H_2O)SO_4]^+$: Octahedral



JEE (Main) Practice Paper

SECTION-A

1. Ans. (1)

(A) Complex salt does not gives test of all ions present in it.

For eg. $K_4[Fe(CN)_6]$ gives test of $K^{\oplus}$ and $[Fe(CN)_6]^{4\ominus}$

(B) Double salt gives test of all ions present in it.

For eg. $KCl.MgCl_2.6H_2O$ given test of $K^{\oplus}$, $Mg^{2\oplus}$ and Cl^{-}.

(C) normal salts are formed by simple acid – base reaction. They also gives test of ions according to their solubility.

2. Ans. (3)

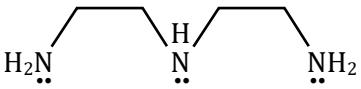
$FeSO_4(aq)$ + excess of $KCN \rightarrow K_4[Fe(CN)_6]$

$K_4[Fe(CN)_6] \xrightarrow{92} 4K^{\oplus} + [Fe(CN)_6]^{4\ominus}$

So $K_4[Fe(CN)_6]$ gives test of $K^{\oplus}$ and $[Fe(CN)_6]^{4\ominus}$ only.

3. Ans. (4)

Diethylene triamine (dien)



(A) It is Capable to form five or six membered ring, so act as chelating ligand.

(B) It's denticity is more than two, so act as polydentate ligand.

(C) Denticity is three.

4. Ans. (2)

$Na_4\{Fe(CN)_5(NOS)]$

$4(+1) + x + 5(-1) + (-1) = 0$

$x = +2$

5. Ans. (1)

Vibrational frequency of 'CO' increases with increase in C—O bond order.

As negative charge on metal ion increases it's electron donation ability increases,

So Metal – Carbon bond order increases and C – O bond order decreases.

So order of IR vibrational frequency is.

$$[Fe(CO)_4]^{2\ominus} < [CO(CO)_4]^{\ominus} < [Ni(CO)_4]$$

O.S. of metal -2 -1 0

6. Ans. (4)

Wilkinson catalyst – $[RhCl(PPh_3)_3] = 52$

cis-platin – $[PtCl_2(NH_3)_2] = 84$

Brown ring complex – $[Fe(H_2O)_5NO]SO_4 = 37$

Prussian blue – $Fe_4[Fe(CN)_6]_3 = 36$

7. Ans. (4)

$$\left[\overset{III}{Co}(en)_3\right]^{3\oplus} SO_4^{2\ominus}$$

$\therefore [Co(en)_3]_2(SO_4)_3$

8. **Ans. (1)**

(A) $[Pt(NH_3)_3Cl_3]$ and $[Pt(NH_3)_4]$ $[PtCl_4]$ are not polymerisation isomer because both have different empirical formula.

(B) $[Pt(NH_3)_4]^{2\oplus}$ $[PtCl_4]^{2\ominus}$

EAN = [(78 – 2) + (2 × 4)] ; EAN = [(78 – 2) + (2 × 4)]

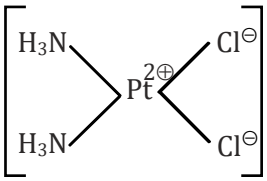
= 84 = 84

(C) Both are coordination isomer.

(D) Synergic bonding is absent.

9. **Ans. (3)**

Cis-platin (Cis – $[Pt(NH_3)_2\ Cl_2]$) acts as anticancer drug



10. **Ans. (4)**

$[Zn(NH_3)Cl_2]$ is tetrahedral in shape. so, geometrical isomerism is not possible.

$[Pt(NH_3)_2Cl_2]$ is square planar in shape.

11. **Ans. (3)**

(A) Both are linkage isomers.

(B) Both are not isomers, because molecular formula is different.

(C) Both are cis- trans isomers.

12. **Ans. (2)**

$[Ma_2bcde]$ have total 15 Stereo isomers

13. **Ans. (1)**

$[Co(en)_2Cl_2]^{\oplus}$ → Geometrical and optical isomerism

$[Co(NH_3)_5Cl]^{2\oplus}$ → No geometrical isomerism

$[Co(NH_3)_4Cl_2]^{\oplus}$ → Geometrical isomerism

$[Cr(ox)_3]^{3\ominus}$→ Optical isomerism

14. **Ans. (4)**

In Case of $[Ni(NH_3)_6]^{2\oplus}$ hybridisation is sp^3d^2.

But is case of $[Fe(CN)_6]^{4\ominus}$, $[Mn(CN)_6]^{4\ominus}$, $[Cr(NH_3)_6]^{3\oplus}$

hybridisation is d^2sp^3

15. **Ans. (2)**

$Co^{\ominus} \rightarrow d^{10}$

$Cd^{2\oplus} \rightarrow d^{10}$

So, both are sp^3

16. **Ans. (2)**

$[Fe(en)_3]^{2\oplus}$ is obtained as X

Since 'en' is a strong field ligand, so the complex will be low spin & diamagnetic Hybridization will be d^2sp^3 (i.e inner orbital complex)

17. **Ans. (2)**

$[CoI_4]^{2\ominus}$ is tetrahedral

Co^{2+} [Ar] $3d^7$ $4s^\circ$ $4p^\circ$

Pairing of $e^{\ominus}$ does not take place,
So it is High spin complex.
$[PdBr_4]^{2\ominus}$ is Square planar
$Pd^{2\oplus}$: [Kr] $4d^8\ 5s^\circ\ 5p^\circ$
Pairing of $e^{\ominus}$ take place, so it is low spin complex.

18. Ans. (3)

(1) $Fe^{II} < Fe^{III}$ (charge)
(2) $NH_3 < CN^-$ (ligand strength)
(3) $en_{chelating} > NH_3$
(4) $en < EDTA_{(extent\ of\ chelation)}$

19. Ans. (1)

(1) Only $K_2Cr_2O_7$ shows colour due to LMCT
(Ligand to metal charge transfer)
(2) $Ti^{4\oplus} \rightarrow d^0$ colourless
(3) $Zn^{2\oplus} \rightarrow d^{10}$ colourless
(4) $Cd^{2\oplus} \rightarrow d^{10}$ colourless

20. Ans. (4)

Possible oxidation state of Vanadium is +2, +3, +4, +5

(A) $VO_2^{\oplus}$	(B) $VO^{2\oplus}$	(C) $[V(H_2O)_6]^{3\oplus}$	(D) $VO_2^{2\oplus}$
x + 2(–2) = +1	x + (–2) = +2	x + (6 × 0) = +3	x + (2 × –2) = +2
x = +5	x = +4	x = +3	x = +6 (Does not exist)

SECTION-B

1. Ans. (10)

Denticity of $EDTA^{4\ominus} = 6$
Denticity of $H_2O = 1$
Total co-ordinations no. = 6 + 4 × 1 = 10

2. Ans. (1)

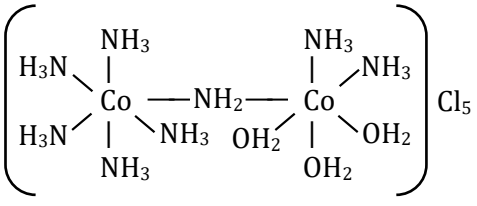
$[PtCl_3(NH_3)_3]Cl \xrightarrow{AgNO_3} AgCl$ (1 mole)

3. Ans. (52)

$[Pd(CO)_4]^{2\oplus}$
CO is two electron down
EAN = (46 – 2) + 4 × 2
= 52

4. Ans. (9)

$(NH_3)_5\ CO\ NH_2CO(NH_3)_2\ (H_2O)_3]\ Cl_5$

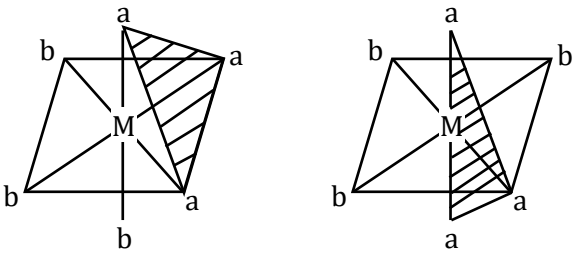


Total Co – N linkages are : 9

5. Ans. (2)

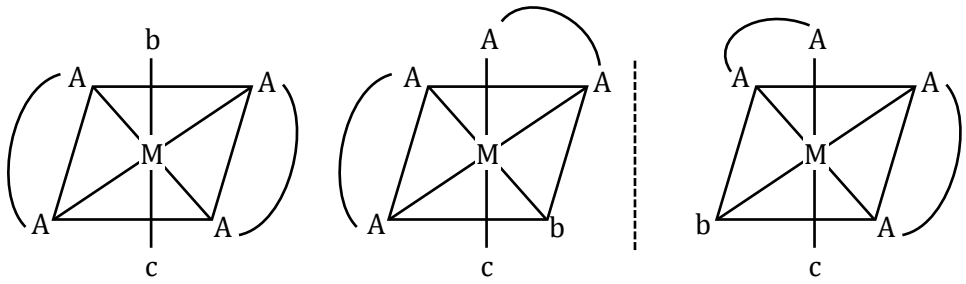
$[CO(H_2O)_6\ Cl_3] \equiv [Ma_3b_3]$

Two forms (two G.I.)



6. Ans. (2)

$[Pd(en)_2(NH_3)(H_2O)]^{4\oplus} \equiv [M(AA)_2\ bc]$



(Inactive) (Active)

Optically active isomers are two

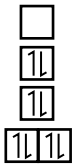
7. Ans. (5)

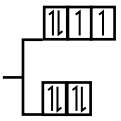
Magnetic moment (spin only) = $\sqrt{n(n+2)}$B.M. for n = 5 (number of unpaired electronics)

μ = 5.89 B.M. Ans. n = 5

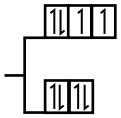
8. Ans. (3)

$[Ni(CO)_4] \rightarrow Ni = [Ar]3d^{10}, \mu = 0$

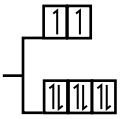
$[Ni(CN)_4]^{2\ominus} \rightarrow Ni^{2\oplus} = [Ar]3d^8$  $\mu = 0$

$[NiCl_2\ (PPh_3)_2] \rightarrow Ni^{2\oplus} = [Ar]3d^8$ 

$\mu = \sqrt{8}$ BM

$[NiCl_4]^{2\ominus} \rightarrow Ni^{2\oplus}\ [Ar]3ds^8$ 

$\mu = \sqrt{8}$ BM

$[NiF_6]^{4\ominus} \rightarrow Ni^{2\oplus} = 3d^8$ 

$\mu = \sqrt{8}$ BM

9. **Ans. (3)**

$CuCl_2 \rightarrow Cu^{2\oplus}$ = [Ar]$3d^9$ (one unpaired electron)

$VOCl_2 \rightarrow V^{4\oplus}$ = [Ar]$3d^1$ (one unpaired electron)

$MnO_4^{\ominus}$ → Coloured due to change transfer spectrum.

All about three are coloured complexes.

10. **Ans. (2)**

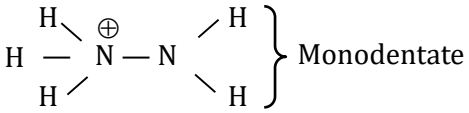
$Co^{3\oplus}$ = [Ar] $3d^6$ — $\boxed{\uparrow}\boxed{\uparrow}$ eg^2; $\boxed{\downarrow\uparrow}\boxed{\uparrow}\boxed{\uparrow}$ t_2^4g

t_2g has two unpaired electron

JEE (Advanced) Practice Paper

1. **Ans. (C)**

$[M(\underbrace{N_2H_5}_{\text{Hydrazinium ion}})_2Cl_2]^{\oplus}ClO_4^{\ominus}$



∴ Co. No. = 4

x + 2 (+1) +2 (–1) = +1

x = +1 (oxidation number of central atom)

2. **Ans. (D)**

$[Co(H_2O)_4(NH_3)_2]Cl_3$

Diamminetetraaquacobalt(III) chloride

3. **Ans. (A)**

$CN^{\ominus}$ → Strong field ligand.

$NiCl_2$ + KCN (excess) → $[Ni(CN)_4]^{2\ominus}$ (dsp^2)

$Cl^{\ominus}$ → Weak field ligand.

$NiCl_2$ + KCl (excess) → $[NiCl_4]^{2\ominus}$ (sp^3)

4. **Ans. (A)**

$Sc^{3\oplus} \rightarrow$ $[_{18}Ar]$ $3d^\circ$ $4s^\circ$

Contain number unpaired $e^{\ominus}$ so d-d transition is not possible but for

$Ti^{3\oplus} \rightarrow$ [Ar] $3d^1$

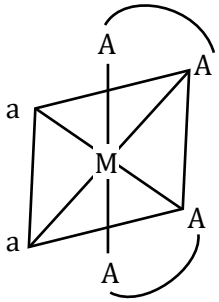
d – d transition is possible

Therefore $[Ti(H_2O)_6]^{3\oplus}$ is coloured but $[Sc(H_2O)_6]^{3\oplus}$ is colour less

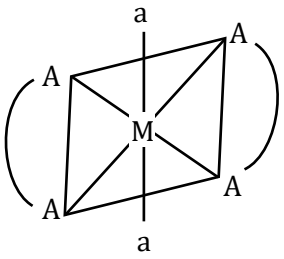
Ans. A

5. **Ans. (ABCD)**

(A) $CoBrCl(en)_2]^{\oplus} \equiv [M(AA)_2\ ab]$ type



(Cis)
Optically Active



(Trans)
Optically Inactive

G.I. = 2

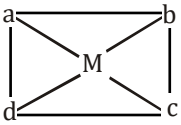
O.I. = 2

S.I. = 3

S.I. = OA + OI $\Rightarrow$ (1 × 2) + 1 = 3

(B) Suboxide and peroxide does not follow alphabetical Order

(C) $[Pt(NO_2)(NH_3)(NH_2OH)(Py)]^+ \equiv [Mabcd]$ type



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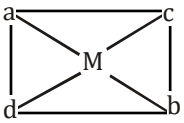
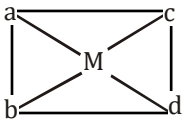


(Inactive)

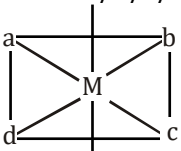


(Inactive)

S.I. = 0 + 3 = 3

$[Pt\,BrCl\,I(NO_2)(NH_3)(Py)] \equiv [Mabcdef]$

a/b/c/d/e



S.I. = OA = O.I

= 15 × 2 + 0 = 30

b/c/d/e/f $\rightarrow$ 5
c/d/e/f $\rightarrow$ 4
d/e/f $\rightarrow$ 3
e/f $\rightarrow$ 2
f $\rightarrow$ 1

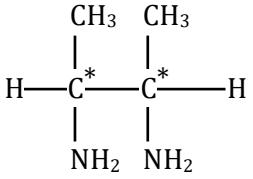
} 15 (All are optically active)

(D) Cis and trans forms are diastereomers of each other.
So, According to question option A, B, C and D are correct option.

6. Ans. (ABCD)

(A) $[Pt(bn)_2]^{2\oplus}$

bn : - Butylene diamine



$\longrightarrow$ Chiral center

$[Pt(bn)_2]^{2\oplus}$ is square planar complex, ligand is having chiral centre; so, it is optically Active isomerism $\rightarrow$ correct Ans.

(B) $[CrCl_2(en)_2]^{\oplus} \equiv [Ma_2(AA)_2]$ Its cis form is optically active.

(C) $[Co(en)_3] \equiv [M(AA)_3]$ It is optically active.

(D) $[Zn(gly)_2] \equiv [M(AB)_2]$ when tetrahedral, it is optically active.

7. Ans. (ABD)

(A) $Na_2[Fe(CN)_5(NO)]$ NO is +1

$2 = x - 5 + 1 = 0 \Rightarrow n = +2 \rightarrow$ Correct Answer.

(B) Co – ordination number = 2

hybridisation = sp

so geometry is linear $\rightarrow$ Correct Answer.

(C) $[Fe(H_2O_6]^{3\oplus}$

$Fe^{3\oplus}$ = [Ar] $3d^5$ | 1 | 1 | 1 | 1 | 1 |

H_2O is weak field ligand (WFL) so, back pairing does not taken place herce hybridisation is sp^3d^2.

According to question option (C) is Incorrect.

(D) $[Ni(CO)_4]$, CO is neutral

$n + 0 = 0 \Rightarrow x = 0$ Correct Answer.

8. Ans. (A,D)

(A) $Ti^{3\oplus} \rightarrow d^1$ coloured due to d-d transition

(B) $MnO_4^{\ominus} \rightarrow$ coloured due to LMCT (ligand to metal charge transfer)

(C) $CrO_4^{2\ominus} \rightarrow$ coloured due to LMCT (ligand to metal charge transfer)

(D) $Fe^{3\oplus} \rightarrow d^5$ coloured due to d-d transition

Note – Coloured compounds with configuration d^{1-9} are coloured due to d-d transition

9. Ans. (B,C,D)

Except linkage, all other isomerism are possible

10. Ans. (A)

(P) $[Cr(H_2O)_4Br_2]^{\oplus} \Rightarrow$ Paramagnetic, d^2sp^3, show Geometrical isomerism

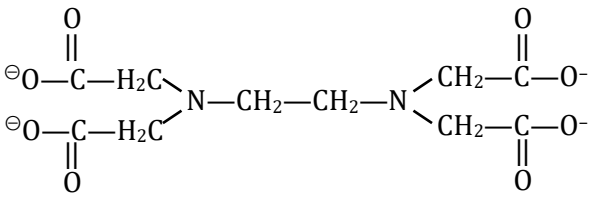
(Q) $[Cu(NH_2CH_2CH_2NH_2)(CN)_2Cl_2]^{2\ominus} \Rightarrow$ Paramagnetic, sp^3d^2, show Geometrical isomerism

(R) $[Pt(ox)_2]^{2\ominus} \Rightarrow$ Diamagnetic, dsp^2

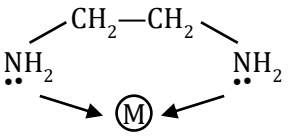
(S) $[Fe(OH)_4]^{\ominus} \Rightarrow$ Paramagnetic, sp^3

11. Ans. (D)

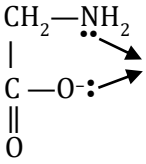
(P) $(EDTA)^{4-}$ Ethylenediamine tetra acetateion (hexadentate)



(Q) en $\Rightarrow$ Ethylenediamine



(R) $(gly)^{\ominus}$ glycinate ion



(S) Amide $NH_2^{\ominus}$ (monodentate)

12. Ans. (B)

Sodium nitro prusside is –

$Na_2[Fe(CN)_5NO] \Rightarrow Fe^{2\oplus}$ & $NO^{\oplus}$

According to C.F.T. due to presence of S.F.L.

$Fe^{2\oplus}$ – [Ar] $3d^6$ 45° $\Rightarrow t_{2g}^6 e_g^{\circ}$

CFSE = $(-0.4 \times 6 + 0.6 \times 0\ \Delta_0)$

= $-2.4\ \Delta°$

Low spin and diamagnetic

Ans. B

13. Ans. (D)

For $[Co(H_2O)_3F_3]$ due to

Presence of W. F. L. no pairing of $e^{\ominus}$ will takes place

$Co^{3\oplus} \rightarrow$ [Ar] $3d^6$ 4s° $\Rightarrow t_{2g}^4 e_g^2$

CFSE = $(-0.4 \times 4 + 0.6 \times 2)\ \Delta_0$

= $-0.4\ \Delta_0$

High spin and paramagnetic complex

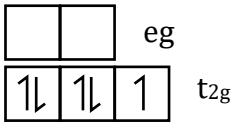
14. Ans. (D)

For $[Mn(CN)_6]^{4\ominus}$

$Mn^{2\oplus} \rightarrow$ [Ar] $3d^5$ 4s°

$CN^{\ominus} \rightarrow$ S.F.L. so back pairing

of $e^{\ominus}$s wil take place



$\Rightarrow t_{2g}^5 e_g^0$

CFSE = $(-0.4 \times 5 + 0.6 \times 0)\ \Delta_0$

= $-2.0\ \Delta_0$

Complex is low spin and paramagnetic

15. Ans. (A)

Molar Conductance $\propto$ number of ions present in solution.

(I) $K^{\oplus} + [Co(NO_2)_4\ (NH_3)_2]^{\ominus}$ total ions = 2

(II) $[Cr(ONO)_3\ (NH_3)_3]$ total ions = 0

(III) $3[Cr(NO_2)_2(NH_3)_5]^{2\oplus} + 2[Co(NO_2)_6]^{3\ominus}$ total ions = 5

(IV) $Mg^{2\oplus} + [Cr(NO_2)_5\ NH_3]^{2\ominus}$ total ions = 2

Note - When number of ions are same then as charge ↑ Molar conductance ↑

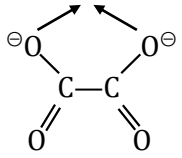
16. **Ans. (D)**

Let O.N. is x

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

$x = +3$

C.N. $= (2 \times 2) + 2 = 6$



oxalate is bi$^{\ominus}$ dentate ligand

$(ox)^{2\ominus}$

17. **Ans. (B)**

$[NiCl4]^{2\ominus} \Rightarrow sp^3$ and tetrahedral

$[Ni(CN)_4]^{2\ominus} \Rightarrow dsp^2$ and square planar

$[Ni(CO)_4] \Rightarrow sp^3$ and tetrahedral

$[Cu(NH_3)_4]^{2\oplus} \Rightarrow dsp^2$ and square planar

$[Ni(NH_3)_6]^{2\oplus} \Rightarrow sp^3d^2$ and octahedral

$[CoF_6]^{3\ominus} \Rightarrow sp^3d^2$ and octahedral

$[Co(NH_3)_6]^{3\oplus} \Rightarrow d^2sp^3$ and octahedral

18. **Ans. (1.33)**

$(Z - 2) + 8 = 35$

Z = 29 means 'Cu'

$$\frac{'p'e^{\ominus}s}{'d'e^{\ominus}s} = \frac{12}{9} = \frac{4}{3} = 1.33$$

19. **Ans. (7.00)**

It has all linkage isomers.

(1) $K_4[Fe(CN)_6]$

(2) $K_4[Fe(CN)_5(NC)]$

(3) $K_4[Fe(CN)_4(NC)_2]$

(4) $K_4[Fe(CN)_3\ (NC)_3]$

(5) $K_4[Fe(CN)_2(NC)_4]$

(6) $K_4[Fe(CN)(NC)_5]$

(7) $K_4[Fe(NC)_6]$

20. **Ans. (–96.80)**

$Ti^{3\oplus}(3d^1) = (t_{2g}^1)$

CFSE $\Rightarrow (-0.4\Delta_0 \times 1) = -0.4\Delta_0$

$\Rightarrow -0.4 \times 242$ ($\because$ $\Delta_0 = 242$)

$\Rightarrow -96.80$