Coordination Compounds

SOLUTIONS

Exercise-I (Conceptual Questions)

1. Ans. (1)

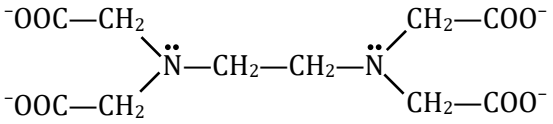
$[Fe(EDTA)]^-$

$x - 4(i) = -$

$x = +4$

Oxidation state of Fe = +3

EDTA is hexadentate ligand hence CN = 6



2. Ans. (4)

$[Pt(en)_2]^{+2}$

$x + 20(0) = +2$

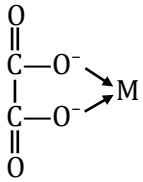
$x = +2$ Oxidation state of Pt = +2

en or Ethylene diamine is a bidentate ligand hence CN = 2 × 2=4

3. Ans. (4)

Bidentate or didentate means, ligands have 2 donor atoms.

$C_2O_4^{-2}$



4. Ans. (2)

$[Pt(C_2H_4)Cl_3]^-$

$x + 0 + 3(-1) = -1$

$x = +2$ Oxidation state of Pt = +2

All ligands are monodentate.

Hence CN = 4

5. Ans. (4)

$[x(SO_4)(NH_3)_5]$

$x + 1(-2) + 5(0) = 0$

$x = +$ Oxidation state of x = +2

SO_4^{-2} is behaving as monodentate ligand

NH_3 is also monodentate.

Hence CN = 6

6. Ans. (3)

Fe shows +1 oxidation state in brown ring complex as NO transfer e^- to convert +1.

$[Fe(H_2O)_5NO]^{+2}$

Fe = +1

7. Ans. (4)

Zeise's salt $K[Pt(C_2H_4)Cl_3]$ has more than one type of ligands, hence it's hetroleptic.

(1) $(C_5H_5)Fe$

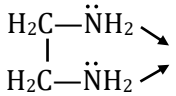
(2) $(C_5H_5)_2Cr$

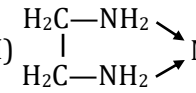
(3) $Fe_4[Fe(CN)_6]_3$

8. Ans. (1)

Statement

(I) $[M(L)_x]^{0/+/-}$ Correct

(II)  two donor atoms Correct

(III)  M Form a ring, Correct

(IV) $[NiCl_2(H_2O)_4]$ $\rightarrow Ni^{+2}$

$[CoCl(NH_3)_5]^{+2}$ $\rightarrow Co^{+3}$

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

All are e^- deficient and accepting ℓp from ligands. (correct)

9. Ans. (2)

$K[Co(CO_4)]$ CO is a neutral ligand.

$K + [Co(CO)_4]^{-1}$

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

$x = -1$ Oxidation state & Co

10. Ans. (2)

Ligand donate lone pair to CMA in NH_4^+ species does not have lone pair to donate.

11. Ans. (2)

CN is no. of co-ordinate bonds are formed by ligands with CMA. → i.e. secondary valenes.

While oxidation state is the amount of change on CMA:- i.e. primary valency.

12. Ans. (4)
Chelation means formation of ring, which can be done by bidented or polydented ligands while SCN^- is monodentate.

13. Ans. (2)
$K_3[Fe(CN)_6]$
$K^+[Fe(CN)_6]^{-3}$
$X + 6(-1) = -3$
$x = +3$ Fe(III)
Potassium hexacynate ferrate(III)-IUPAC
Potassium ferri-cyanide → Common name.

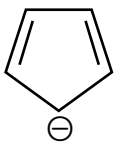
14. Ans. (4)
$[Co(NH_3)_4(H_2O)Br](NO_3)_2$
$[Co(NH_3)_4(H_2O)Br]^{+2}$
$X + 4(0) + 1(0) + 1(-1) = +2$
$x = +3$ Co in +3 oxidation state
NH_3 → ammine
H_2O → aqua
Br^- → Bromido
Hence IUPAC Name –
tetrammineaquabromido cobalt(III) nitrate.

15. Ans. (2)
Trioxalato ferrate (III) – $(C_2O_4^{-2})$
$[Fe(C_2O_4)_3]^{-3}$ Fe = +3

16. Ans. (3)
Chloro-bis(ethylenediamine) nitro cobalt (III) ion
$(Cl^-)(en)_2(NO_2^-)Co^{+3}$
$[CoCl(en)_2NO_2]^+$

17. Ans. (3)
Complex which does not have bi or polydented ligands will not have ring formation or chelate.
Tetraamine dichloro cobalt (III) nitrate (NH_3) Cl both are monodentate ligands.
$[Co(NH_3)_4Cl_2]NO_3$

18. Ans. (2)
$\left[Fe\left(\eta^5 - C_2H_5\right)_2\right]$
$x + 2(-1) = 0$
$x = +2$
$(C_5H_5)^-$
↓
Cyclopentadienyl



hence Bis(Cyclopentadienyl iron (II)

19. Ans. (1)
$[Pt(NH_3)_4Cl_2]$ $[PtCl_4]$
Pt = +4 Pt = +2
CN 6 in +4 oxidation
CN 4 in +2 oxidation
(state)
Tetramminedichloro platinum (IV) tetrachloroplatenate(II)

20. Ans. (1)
$K_2[Cr(CN)_2O_2(NH_3]$
$K^+[Cr(CN)_2O_2(O)_2(NH_3)]^{-2}$
$x + (2)(-1) + (1)(-2) + (2)(-2) + 1(0) = 2$
$x - 2 - 2 - 4 = -2$
$x = +6$
Cr in +6 oxidation state
CN → Cyano
O_2^{-2} → Peroxo
O^{-2} → OXO
NH_3 → Ammine
Hence, Potassium ammine dicyanodioxoperoxochromate(VI)

21. Ans. (1)
$[Co(NH_3)_6]$ $[Cr(CN)_6]$ Co^{+3} CN = 6
Cr^{+3} CN=6
Hexaamminocobalt(III)
hexacyanochromate(III)

22. Ans. (1)
$[Co(NCS)(NH_3)_5]Cl_2 \rightarrow [Co(NCS)(NH_3)_5]^{+2}Cl$
$x + 1(-1) + 5(0) = +2$
$x = +3$ Co in +3 oxidation state
NCS → thicyanato-N
NH_3 → ammine
Pentaammine (thiocyanato-N) cobalt(III) chloride

23. Ans. (3)
Positively changed ligands have suffix as-ium-not-ate.
–ate is used for negatively changed

24. Ans. (2)
$COCl_3.3NH_3$ CO^{+3} CN = 6
Hence $[CO(NH_3)_3Cl_3]$ is a neutral complex hence least ion and least conductivity in aq. Solution.

25. Ans. (2)

Given EAN = 34 Oxidation state = +2 (X^{+2})

Z = 28

EAN = Z–O.S + 2(CN)

34 = 28–(2) + 2(CN)

CN = 4

26. Ans. (2)

$[Co(en)_2Cl_2]^+$ Z of W = 27

x + (2)(0) + 2(–1) = +1 CN

x – 2 = +1

x = +3

EAN = Z–OS + 2(CN)

= 27–(3) + 2(6)

= 27 – 3 + 12

EAN = 36

27. Ans. (3)

$[Cr(NH_3)_6]Cl_3$ $[Cr(NH_3)_6]^{+3}$ Cl^-

Cr = +3 oxidation state Z of Cr = 24

EAN = Z–O.S. + 2(CN)

EAN = 24–(+3) + 2(6)

EAN = 24–3 + 12

EAN = 33

28. Ans. (4)

25% Note or 1/4th of Cl atoms = 1

$PtCl_4.3NH_3$–O.S. of Pt = +4 CN = 6

Hence $[Pt(NH_3)_3Cl_3]Cl$

$PtCl_4.3NH_3$

29. Ans. (2)

$M(CO)_x$ follows EAN Rule Means it will attain nearest noble gas cont., which is $36e^-$ CO is a neutral ligand

Z of Ni = 28Fe = 26 Cr = 24

For 36

Ni 36 = 28–0 + 2(CN)

CN = 4

Fe 36=26–0+2 (CN)

CN = 5

Cr 36 = 24–0 + 2(CN)

CN = 6

30. Ans. (2)

$CoCl_3.5NH_3$ Co O.S. = +3 CN = 6

2 mole of AgCl ppt hence 2 Cl atoms needs to be ionised. Hence formula is

$[Co(NH_3)_5Cl]Cl_2 \rightarrow$

31. Ans. (3)

Secondary valency can be satisfied by neutral cation anion which acts as ligands.

32. Ans. (1)

$CoCl_3.5NH_3$

O.S. of CO = +3 CN = 6

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

Hence 3 ions.

33. Ans. (3)

In Hexaammine chromium(III) ion $[Cr(NH_3)_6]^{+3}$ Cr^{+3} hence $3d^3$ configuration and will have 3 unpaired e^- so paramagnetic.

34. Ans. (4)

$[Ag(NH_3)_2]^+$

sp hyb. hence linear shape

35. Ans. (2)

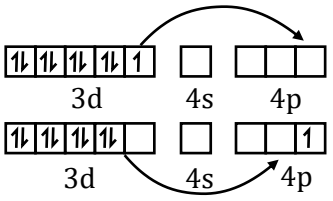
$[FeF_6]^{-3}$ O.S. of Fe = +3 hence $Fe^{+3} \rightarrow [Ar]3d^5$ and F^- is a W.F.L. so CFSE is low, no pairing so

$t_{2g}^3 e_g^2$

hence 5 unpaired e^-

36. Ans. (1)

$[Cu(NH_3)_4]SO_4$ $Cu^{+2} \rightarrow [Ar]3d^9$ & $NH_3 \rightarrow$ SFL



$dsp^2 \rightarrow$ square planar

37. Ans. (1)

Highest paramagnetism = Maximum no. of unpaired e^-

$Fe^{+3} \rightarrow [Ar]3d^5$ (5)

$Fe^{+2} \rightarrow [Ar]3d^6$ (4)

$Cu^{+2} \rightarrow [Ar]3d^9$ (1)

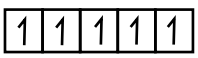
$Zn^{+2} \rightarrow [Ar]3d^{10}$ (0)

Hence $[FeF_6]^{-3}$ has highest paramagnetism

38. Ans. (2)

ML_6^{n+} M^{n+} $d^5 \rightarrow$ WFL meane no. pairing.

Hence 5 unpaired e^-



39. Ans. (1)

$Cu^{+2} \Rightarrow [Ar]3d^9$ 1 unpaired (S.F.L)

$Ni^{+2} \Rightarrow [Ar]3d^8$ 0 unpaired (W.F.L)

$Ti^{+4} \Rightarrow [Ar]$ 0 unpaired

$Co^{+3} \Rightarrow [Ar]3d^6$ 4 unpaired (W.F.L.)

μ = 1.73 BM Means 1 unpaired e^-

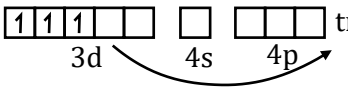
hence $\mu = \sqrt{n(n+2)}$ n=1 μ = 1.73 BM

(1) $[Cu(NH_3)_4]^{+2}$

40. Ans. (1)

$[Cr(NH_3)_6]^{+3} \rightarrow CN = 6$

Cr^{+3} $[Ar]3d^3$



NH_3 d^2sp^3-Octahedral

3 unpaired $e^- \Rightarrow$ Paramagnetic.

41. Ans. (2)

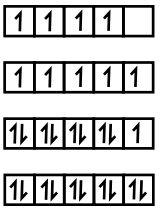
High spin complex = Highest no. of unpaired e^-

$Cr^{+2} = [Ar]3d^4$

$Fe^{+3} = [Ar]3d^5$

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

$Zn^{+2} = [Ar]3d^{10}$



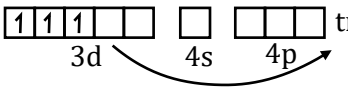
$[Fe(H_2O)_6]^{+3}$ is high spin complex

42. Ans. (3)

Inner orbital complex means inner d orbital is used.

It occurs in presence of SFL or (n-1) as pairing will take place

$[Cr(NH_3)_6]^{+3}$ $Cr^{+3} \rightarrow [Ar]3d^3$



$NH_3 \rightarrow SFL \rightarrow d^2sp^3$

43. Ans. (3)

$K_4[Fe(CN)_6]$

$Fe^{+2} \rightarrow [Ar]3d^6$ $CN^- \rightarrow SFL \rightarrow$ Pairing occurs

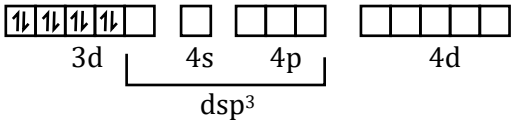
eg 

t_{2g}  -Zero unpaired e^- diamagnetic

3rd option is wrong.

44. Ans. (1)

$[Fe(CO)_5]$ $\underline{Fe}^0$ $[Ar]3d^6$ $CO \rightarrow SFL$



3d 4s 4p are used with different Q.N.

$[Fe(CO)_5]$

45. Ans. (4)

$[Cu(NH_3)_4(OH_2)_2]^{+2}$

$Cu^{+2} \rightarrow [Ar]3d^9$ O.S.= +2

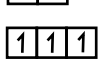
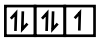
Coordination number = 6

So octahedral.

$x + (4\times0) + (2\times0) = 2$

$x = 2$

46. Ans. (2)

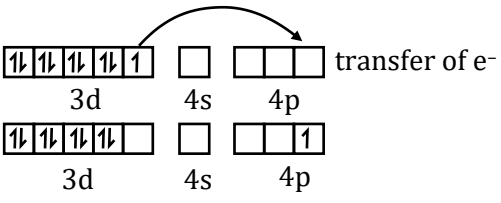
$[FeF_6]^{-3}$	$[Fe(CN)_6]^{-3}$
$Fe^{+3} \rightarrow [Ar]3d^5$	$Fe^{+3} \rightarrow [Ar]3d^5$
W.F.L (F^-)	SFL (CN^-)
No pairing	Pairing
eg 	
t_{2g} 	
5 unpaired	1 unpaired

$[FeF_6]^{-3}$ more magnetic moment than $[Fe(CN)_6]^{-3}$

47. Ans. (2)

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

$Cu^{+2} \rightarrow [Ar]3d^9$ $NH_3 \rightarrow$ SFL



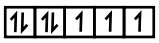
$dsp^2 \rightarrow$ square planar

48. Ans. (2)

$[Fe(H_2O)_5(NO)]SO_4$

$[Fe(H_2O)_5(NO)]^{+2}$ SO_4^{-2}

Fe^+ $[Ar]4s^13d^6 \rightarrow [Ar]4s^03d^7$

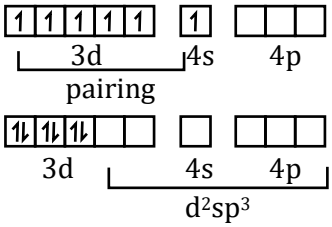


3 unpaired e^-

49. Ans. (2)

$[Cr(CO)_6]$

$Cr \rightarrow [Ar]3d^5 4s^1$ CO → SFL-Pairing occurs



→ Inner orbital complex

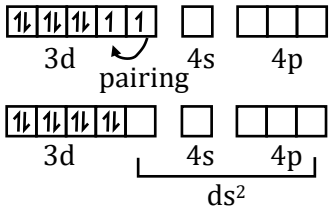
→ Zero unpaired e⁻ SO, diamagnetic.

50. Ans. (2)

$[Ni(en)_2]^{+2}$

$Ni^{+2} \rightarrow [Ar]3d^8$ en → SFL → pairing occurs

CN = 4



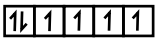
→ zero unpaired → Diamagnetic

→ $d^\circ sp^2$ → square planer

→ CN = 4

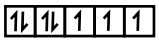
51. Ans. (1)

(I) $[Fe(H_2O)_6]^{+2}$ $Fe^{+2} \rightarrow [Ar]3d^6$



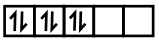
4 unpaired

(II) $[Fe(CN)_6]^{-3}$ $Fe^{+3} \rightarrow [Ar]3d^5$ SFL → Pairing



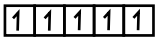
1 unpaired

(III) $[Fe(CN)_6]^{-4}$ $Fe^{+2} \rightarrow [Ar]3d^6$ SFL → Pairing



0 unpaired

(IV) $[Fe(H_2O)_6]^{+3}$ $Fe^{+3} \rightarrow [Ar]3d^5$



5 unpaired

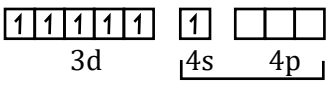
(IV) > (I) > (II) > (III)

52. Ans. (2)

$[MnBr_4]^{-2}$

$Mn^{+2} \rightarrow [Ar]3d^5$ WFL → No pairing

CN = 4



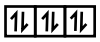
sp^3 → Tetrahedral

53. Ans. (4)

$[Co(C_2O_4)_3]^{-3}$ CN = 6

$Co^{+3} \rightarrow [Ar]3d^6$ Ox-WFL → but for Co^{+3} it act as SFL so pairing will be these

eg 

t_{2g} 

→ Inner d will be used so inner orbital complex

→ d^2sp^3

54. Ans. (1)

$[MnO_4]^-$ ion Mn^{+7}

$Mn = [Ar]3d^5 4s^2$

Mn^{+7} = [Ar] Zero unpaired e^- so diamagnetic

55. Ans. (2)

If unpaired e⁻ are present than they will absorb the energy.

(1) $Cu^+ \rightarrow [Ar]3d^{10}$ Paired

(2) $Cu^{+2} \rightarrow [Ar]3d^9$ Unpaired

(3) $Zn^{+2} \rightarrow [Ar]3d^{10}$ Paired

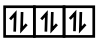
(4) $Cd^{+2} \rightarrow [Ar]4d^{10}$ Paired

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

56. Ans. (2)

$[Ni(H_2O)_2(NH_3)_4]^{+2}$

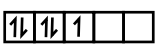
$Ni^{+2} \rightarrow [Ar]3d^8$ eg 

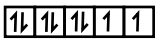
t_{2g} 

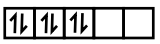
hence 2 unpaired e⁻ n = 2

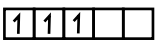
$\mu = \sqrt{n(n+2)}$ = 2.83 BM

57. Ans. (4)

(I) d^5  low spin 1 unpaired

(II) d^8  2 unpaired

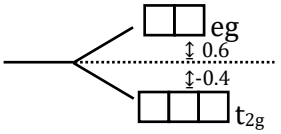
(III) d^6  low spin 0 unpaired

(IV) d^3  3 unpaired

58. Ans. (2)

$$CFSE = -\frac{2}{5}t_{2g} + \frac{3}{5}e_g$$

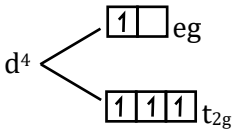
$$= -0.4t_{2g} + 0.6e_g$$



(2) lowered by 0.4 Δ_0

59. Ans. (2)

Δ_0 < P than pairing will not happen as energy gap is less.



(2) $t_{2g}^3 eg^1$

60. Ans. (3)

(A) $[CrF_6]^{-4} \Rightarrow Cr^{+2}$ = [Ar]$3d^4$ (WFL)
= 4 unpaired e^- (iv)

(B) $[MnF_6]^{-4} \Rightarrow Mn^{2+}$ = [Ar]$3d^5$ (WFL)
= 5 unpaired e^- (v)

(C) $[Cr(CN)_6]^{-4} \Rightarrow Cr^{2+}$ = [Ar]$3d^4$ SFL
= 2 unpaired e^- (ii)

(D) $[Mn(CN)_6]^{-4} \Rightarrow Mn^{+2}$ = [Ar]$3d^5$ (SFL)
= 1unpaired e^- (i)

61. Ans. (2)

(i) $Fe^{+2}_{(aq)} + 6NH_3 \rightleftharpoons[K_f] [Fe(NH_3)_6]^{+2}$

(ii) $Fe^{+2}_{(aq)} + 3en \rightleftharpoons[K_f^1] [Fe(en)_3]^{+2}$

Higher the stability of complex; higher will be the formation constant value.

Due to chelation $[Fe(en)_3]^{+2}$ more stable the $[Fe(NH_3)_6]^{+2}$

(2) $K_f < K_f^1$

62. Ans. (3)

Stability of complex order

Synergic bonding > chelation > SFL/Z_{eff} of CMA $[Co(en)_3]^{+3}$ is the most stable complex as maximum no. of chelate ring (3)

63. Ans. (2)

Al^{+3} ion is replaced by Cr^{+3} ion impurity which causes the red colour of Ruby.

(3) Cr^{+3}

64. Ans. (1)

$[Pt(NH_3)_2Cl_2]$ cis platin square planer complex only shows geometrical isomerism.

65. Ans. (2)

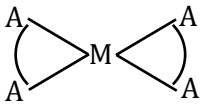
$[Co(NH_3)_5SO_4]Br$

$[Co(NH_3)_5Br]\ SO_4$

→ are ionisation isomers

66. Ans. (3)

$[Cu(en)_2]^{+2}$ can not show geometrical isomers (symmetric bidentate ligand)



67. Ans. (2)

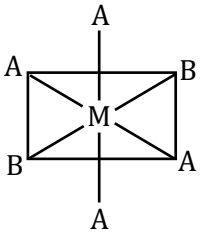
$[Co(NH_3)_3NO_2]Cl_2$ exhibit linkage isomerism.

As NO_2^- can acts as ONO^- also different doner atom.

68. Ans. (2)

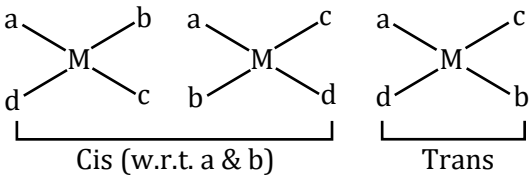
$[Cr(H_2O)_6]Cl_3$ and $[Cr(H_2O)_4Cl_2]Cl.2H_2O$ are hydrate isomers due to water molecules in complex.

69. Ans. (4)



Same functional group are at 180°, have it is trans form.

70. Ans. (4)



[Mabcd] gives 3 geometrical isomerism 2 Cis 1 Trans

71. Ans. (3)

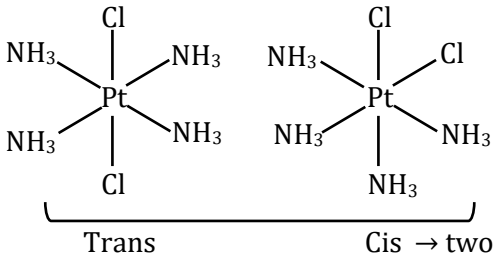
[M abcdef] shows 15 geometrical isomers.

72. Ans. (3)

Two Geometrical isomerism = Cis and trans

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

$2Cl^-$ ions produces 2 moles of AgCl.



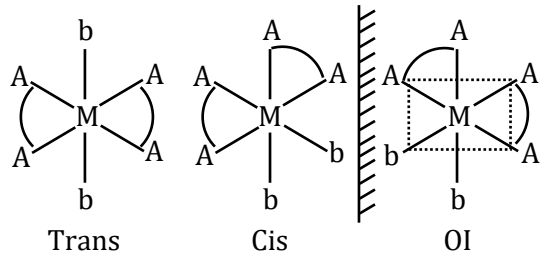
73. Ans. (2)

The given compound is $[M(AA)_2b_2]$ type and cis and trans, geometrical isomers.

74. Ans. (3)

$[Co(en)_2Cl_2]^+$ is $[M(AA)_2b_2]$

Type of complex :



Total stereoisomer = 3

75. Ans. (3)

$[Cr(en)_3]^{+3}$

is $[M(AA)_3]$ type of complex, and have same type of doner atom, so will not show geometrical isomerism.

76. Ans. (4)

$[Pt(NH_3)_3Br]^+$ will have dsp^2 Hybridisation and square planer geometry.

$[Ma_3b]$ will not show geometrical isomerism.

77. Ans. (1)

$[Cr(NH_3)_4Cl_2]^+$ is $[M(A)_4B_2]$ (Cis & trans)

$[Co(NH_3)_3Cl_3]$ is $[M\ A_3B_3]$ (Fec & Mer)

Type of complex both will show geometrical.

78. Ans. (2)

$[Co(NH_3)_3(NO_2)_3]$ show both linkage and geometrical isomer as NO_2 is an ambidente linkage and $[Ma_3b_3]$ type of complex.

79. Ans. (4)

$[Cr(H_2O)_5Cl]Cl_2.H_2O$ can not show linkage isomerism as no ambidente ligand is present. It can only show hydrate isomerism.

80. Ans. (4)

$CrCl_3.6H_2O \Rightarrow$ $[Cr(H_2O)_6]Cl_3$

$[Cr(H_2O)_5Cl]Cl_2.H_2O$

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

Three hydrate isomers.

81. Ans. (2)

CO is non classical or π-acid ligand as it accepts ℓp from CMA in its ABMO orbital.

82. Ans. (2)

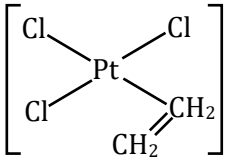
Al_4C_3 is not an OMC it is ionic compound and TEL $Pb(C_2H_5)_4$ is π bonded OMC.

83. Ans. (4)

Organometallic compound contain direct M–C bonds (the carbon must belong to a hydrocarbon group.)

84. Ans. (3)

Zeise's salt is a π-bonded OMC.



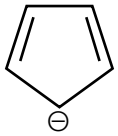
(i) Wilkinson's catalyst $[RhCl(PPH_3)_3]$

(ii) T & L $Pb(C_2H_5)_4$

(iv) R-Mg-X

85. Ans. (2)

$(C_5H_2)_2Fe$ $(C_5H_5)^-$



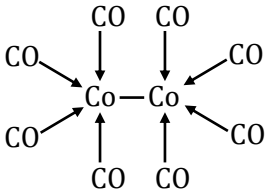
86. Ans. (3)

$B(OCH_3)_3 = CH_3–O–\underset{\underset{CH_3}{|}}{\overset{\overset{O}{|}}{B}}–O–CH_3$

It has no direct M-C bond. So not can OMC

87. Ans. (4)

$[CO_2(CO)_8]$



1-Metal-Metal bond

88. Ans. (4)

$Fe^{+3} + K_4[Fe(CN)_6] \longrightarrow Fe_4[Fe(CN)_6]_3$

salt 1,2-drops Prussian blue

89. Ans. (3)

Undecomposed AgBr (at the time of film development) is removed from photographic film by Hypo solution it forms soluble complex.

$AgBr + 2Na_2S_2O_3 \longrightarrow Na_3[Ag(S_2O_3)_2]^- + NaBr$

Soluble complex

90. Ans. (4)

$AgBr + 2Na_2S_2O_3 \longrightarrow Na_3[Ag(S_2O_3)_2] + NaBr$

$[Ag(S_2O_3)_2]^{-3}$

91. Ans. (4)

Nessler's Reagent is $K_2[HgI_4]$

$HgI_2 + 2KI \longrightarrow K_2[HgI_4]$

92. Ans. (4)

$FeCl_3 + K_4[Fe(CN)_6] \longrightarrow 4KFe[Fe(CN)_6]$

test of Fe+3 ion Colloidal solution

93. Ans. (3)

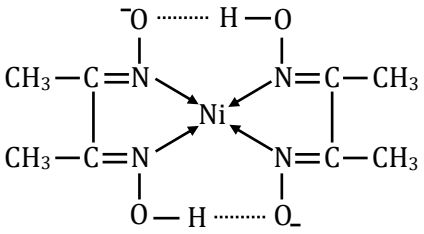
Test of Ni^{+2} ion

$Ni^{+2} + 2dmg \longrightarrow [Ni(dmg)_2]$

Dimethyl glyoxime Rosy Red ppt----

94. Ans. (4)

$[Ni(dmg)_2]$



It is stable due to both H-bonding as well dmg chelation. More number of rings are formed which weakes it is more stable.

Exercise-II (Previous Year Questions)

1. Ans. (2)

Cis-Platin is used as anticancer agent

Cis $[PtCl_2(NH_3)_2]$

2. Ans. (4)

The complex does not have Cl^- as counter ions will not give test of Cl^- ion

(I) $CoCl_3.4NH_3 \rightarrow Co^{+3}$ CN = 6 $[Co(NH_3)_4Cl_2]Cl$

(II) $CoCl_3.5NH_3 \rightarrow [Co(NH_3)_5]Cl_2$

(III) $CoCl_3.6NH_3 \rightarrow [Co(NH_3)_6]Cl_3$

(IV) $CoCl_3.3NH_3 \rightarrow [Co(NH_3)_3Cl_3]$ No Cl^- ion

3. Ans. (4)

$[Co(CN)_6]^{-3} \Rightarrow Co^{+3} \rightarrow [Ar]3d^6$

SFL so pairing occurs

eg ☐☐ ← 0 unpaired electron

t_{2g} ↿⇂ ↿⇂ ↿⇂ ← hence low spin complex

4. Ans. (2)

$[Fe(CN)_6]^{-3}$ Fe^{+3} $CN^- \rightarrow$ cyanido

$x + 6(-1) = -3$ Anionic part hence ferrate

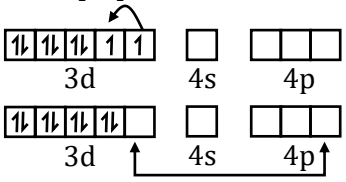
$x = +3$

→ Hexacyanido ferrate (III) ion

5. Ans. (3)

$[Ni(CN)_4]^{-2}$ CN = 4

Ni^{+2} – [Ar]$3d^8$ $CN^- \rightarrow$ SFL pairing occurs



$dsp^2 \rightarrow$ square plane

6. Ans. (3)

$[M(en)_2(C_2O_4)]Cl$

$[M(en)_2(C_2O_4)]^+ Cl^-$

en & C_2O_4 both are bidentate ligand hence

CN = 6

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

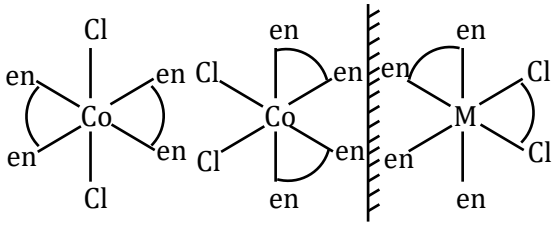
$x = +3$ O.S. of M = +3

total = 6 + 3

= 9

7. Ans. (1)

$[Co(en)_2Cl_2]Cl$ is $[M(AA)_2b_2]$ type complex



Trans

2-GI

2-OI

Total 3 → SI

8. Ans. (3)

For C-O bond

If synergic bond ↑es, Bond order ↓, Bond length ↑es and synergic bonding order is

$M^{-n} > M > M^{+n}$

Hence in

$[Fe(CO)_4]^{-2} \rightarrow Fe^{-2}$ hence will have extra electron to donate CO and synergic bond increases So C-O bond order ↓es and bond length ↑es

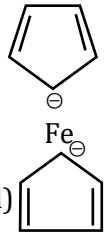
9. Ans. (1)

(I) R–Mg–X Carbon and Metal are bonded by σ-bond.

(II) $Fe(C_5H_5)_2$

(Iii) $Co(C_5H_5)_2$ All are π - doner

(IV) $Ru(C_5H_5)_2$

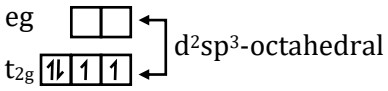


10. Ans. (2)

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

$Mn^{+3} \rightarrow [Ar]3d^4$

SFL → Pairing occurs



11. Ans. (4)

$\Delta = E_{absorb} = \frac{hc}{\lambda_{absorb}}$

For SFL $\Delta\uparrow$ $\lambda\downarrow$es

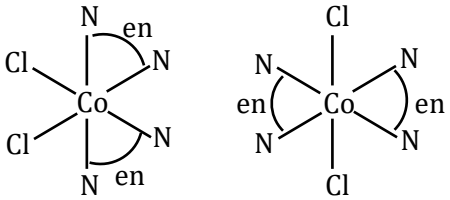
For WFL $\Delta\downarrow$ λ es

So, Order of $\lambda_{absorbed}$

$[Co(en)_3]^{+3} < [Co(NH_3)_6]^{+3} < [Co(H_2O)_6]^{+3}$

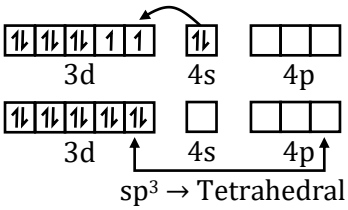
12. Ans. (1)

$[CoCl_2(en)_2]$



13. Ans. (2)

$[Ni(CO)_4]$ $Ni \rightarrow [Ar]3d^84s^2$ SFL pairing

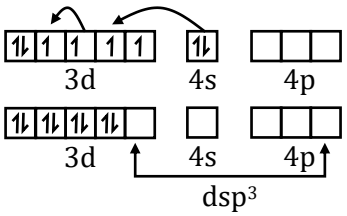


0 → unpaired so diamagnetic

14. Ans. (2)

$Fe(CO)_5 \rightarrow$ No. of metal atom present is one is mononuclear compound with dsp^3 hybridisaton.

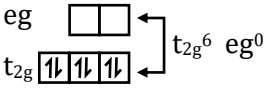
$Fe(CO)_5$ Fe^0 $[Ar]3d^64s^2$



15. Ans. (2)

$K_4[Fe(CN)_6]$

$Fe^{+2} \rightarrow [Ar]3d^6$ CN^- SFL so pairing occurs



16. Ans. (4)

Δ_0 of $[CoCl_6]^{-4} = 18000\ cm^{-1}$

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

$$\Delta_t \text{of } [CoCl_4]^{-2} = \frac{4}{9} \times 18000$$

$= 8000\ cm^{-1}$

17. Ans. (2)

Synergic ligand > Chelating ligand

in $SCN^- \rightarrow$ S doner atom < F^-

$SCN^- < F^- < C_2O_4^{-2} < CN^-$

18. Ans. (3)

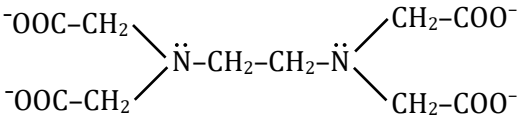
$$\underset{\text{Urea}}{NH_2CONH_2} + H_2O \longrightarrow \underset{(A)}{NH_4OH} + CO_2$$

$$\underset{(A)}{NH_4OH} \longrightarrow \underset{(B)}{NH_3} + H_2O$$

$$Cu^{+2}(aq) + 4NH_3 \longrightarrow \underset{(C)}{[Cu(NH_3)_4]^{+2}} \text{ (deep blue)}$$

19. Ans. (1)

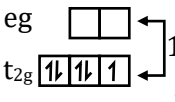
EDTA (ion)



20. Ans. (4)

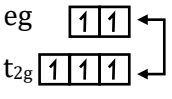
(a) $[Fe(CN)_6]^{-3} \rightarrow Fe^{+3} \rightarrow [Ar]3d^5\ CN^- \rightarrow$SFL

pairing occurs



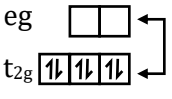
(b) $[Fe(H_2O)_6]^{+3} \rightarrow Fe^{+3} \rightarrow [Ar]3d^5\ H_2O \rightarrow$WFL

no pairing



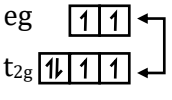
(c) $[Fe(CN)_6]^{-4} \rightarrow Fe^{+2} \rightarrow [Ar]3d^6\ CN^- \rightarrow$ SFL

pairing occurs



(d) $[Fe(H_2O)_6]^{+2} \rightarrow Fe^{+2} \rightarrow [Ar]3d^6 \rightarrow H_2O$ WFL

no pairing



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

21. (3)

IUPAC

$[Ag(H_2O)_2]\ [Ag(CN)_2]$

Coordination number = 2,

Oxidation state = Ag^{+1}

Diaquasilver(I) dicyanidoargentate(I)

22. (4)

$K_3[Al(C_2O_4)_3]$ contain all ligands are of same type i.e. why complex will be homoleptic.

23. (2)

Due to Chelation effect of (en).

24. (3)

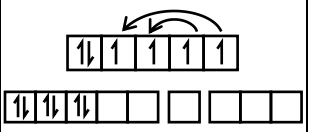
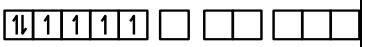
Complex salt is $K_2[Pt(NH_3)_2Cl_2]$

Double salt is $KAl(SO_4)_2.12H_2O$ (potash alum)

25. (4)

Given complex compounds exhibit solvate isomerism having co-ordination number = 6.

26. Ans. (1)

$[Co(NH_3)_6]^{+3}$	$[CoF_6]^{-3}$
$_{27}Co \rightarrow 3d^7\ 4s^2$ $Co^{+3} \rightarrow 3d^6$ $(NH_3 \rightarrow$ SFL) so pairing of electron  d^2sp^3 dia. $\boxed{\mu = 0}$	$_{27}Co \rightarrow 3d^7 4s^2$ $Co^{+3} \rightarrow 3d^6$ $(F^- \rightarrow$ WFL) no pairing of electron  sp^3d^2 Para $\boxed{\mu = 4.9}$

27. Ans. (1)

(A) $[Co(NH_3)_5(NO_2)]Cl_2$ Linkage

NO_2^- can be converted into ONO^-

(B) $[Co(NH_3)_5SO_4]Br$ / $[Co(NH_3)_5Br]\ SO_4$ Ionisation

(C) $[Co(NH_3)_6]\ [Cr(CN)_6]$ Coordination

(D) $[Co(H_2O)_6]Cl_3$ Solvate

28. Ans. (1)

In Homoleptic complex only one kind of ligands are present. While in Hetereoleptic complex more than one kind of ligands are present in coordination sphere.

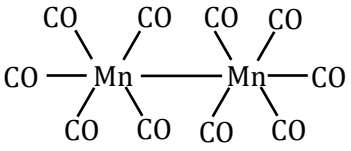
29. Ans. (1)

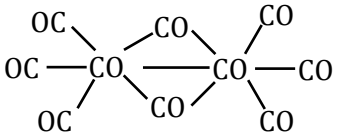
EDTA^{-4} is a hexadentate ligand.

30. Ans. (1)

Except $C_2O_4^{-2}$, all the given, ligands are ambidentate.

31. Ans. (4)





Exercise-III (Analytical Questions)

1. Ans. (1)

$[Fe(H_2O)_5(NO)]SO_4$

$Fe \rightarrow Fe^{+} \rightarrow [Ar]3d^6 4s^1$

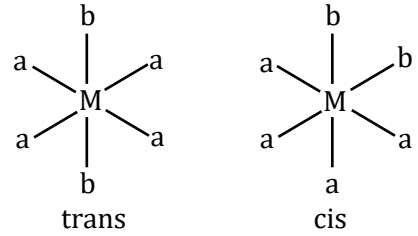
Due to filling of d-orbital, energy gap decreases between 3d & 4s, hence 4s e^- moves to 3d and H_2O & NO both are W.F.L.

d^7 ⇅ ⇅ 1 1 1 3 unpaired e^- and it is paramagnetic.

2. Ans. (2)

$[M(NH_3)_4Cl_2]$ is $[Ma_4b_2]$ type complex

It would have



both will have plane of symmetry, hence only geometrical isomers.

3. Ans. (3)

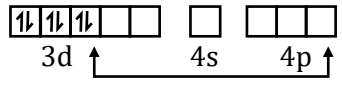
(I) $[Cr(H_2O)_6]Cl_2$ & $[Fe(H_2O)_6]Cl_2$

Cr^{+2} Fe^{+2}

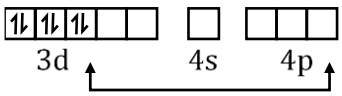
both central metal atom are in their lower oxidation state, so they tend to be good reducing agent, not oxidising agents

(II) $[Fe(CN)_6]^{-4}$

$Fe^{+2} \rightarrow [Ar]3d^6$, $CN^- \rightarrow$ SFL so pairing occurs



d^2sp^3-Inner orbital complex



d^2sp^3-Inner orbital complex

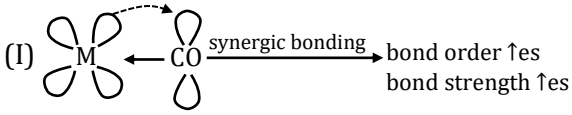
4. Ans. (1)

(I) Cis-Platin is an anticancer drug.

(II) $[Ca(EDTA)]^{+2} + Pb^{+2} \rightarrow [Pb(EDTA)]^{+2} + Ca^{+2}$

Form complex which passes through urine.

5. Ans. (2)

(I) 

(II) d° ☐☐☐☐☐] no. d-d transition possible

d^{10} ⇅ ⇅ ⇅ ⇅ ⇅]

6. Ans. (1)

(I) $CoCl_3.6NH_3 \rightarrow Co^{+3}$ $3Cl^-$

$+3 \rightarrow$ Primary valency

(II) Secondary valency is co-ordination number

For above CN = 6 for Co^{+3}

hence complex $[Co(NH_3)_6]Cl_3$

7. Ans. (4)

(I) VBT does not explain about the colour exhibition it is explained by CFT.

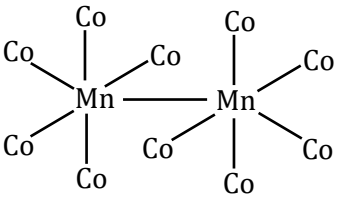
(II) w.r.t. Postulates of CFT, CMA is considerd as point charge and ligand as opposite charge and attraction between them is ionic.

8. Ans. (3)

(I) CFSE explain about the stability of complexes, not depends only for d^4 and d^7 configuration.

(II) Ruby contain Cr^{+3} ion (d^3) not Cr^{+2} ion.

9. Ans. (2)

(I) 

$[Mn_2(CO)_{10}]$

(II) $Fe(CO)_5 \rightarrow Fe^0$

Compound is stable.

10. Ans. (1)

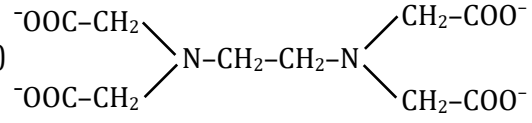
(I) correct statement → biological uses of coordination compound.

(II) $\Delta_t = \frac{4}{9}\Delta_0$

11. Ans. (3)

(A) EDTA is a hexadented ligand hence will form 6 co-ordination bonds with CMA. In general 3d CMA will show 6 CN

So ratio would be 1 : 1

(R) 

12. Ans. (2)

(A) Strength of the ligand ∝ Energy (CFSE)

$\boxed{E = \frac{hc}{\lambda}}$ strong the ligand; lower the $\lambda_{absorbed}$.

Strength $NO_2^- > NH_3 > H_2O$

Hence λ order would be reverse

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

(R) Strength of ligand ∝ E ∝ Stability.

13. Ans. (3)

(A) $KMnO_4$ $K_2Cr_2O_7$ both are coloured

Purple Orange Red

Mn^{+7} Cr^{+6} both have d^0 configuration so no-d-d transition.

the colour of above compounds is due to change transfer by oxygen to metal.

14. Ans. (1)

Cu^{+2} → It is in it's highest oxidation state, hence it acts as oxidising agent.

CN^- & I^- both are reducing agent. So both will react to redox reaction.

$KCN + CuSO_4 \rightarrow Cu(CN)_2 \rightarrow K_3[Cu(CN)_4]$

unstable Cu in +1 O.S.

$KI + CuSO_4 \rightarrow CuI_2 \rightarrow CuI + I_2 + K_2SO_4$

Unstable

15. Ans. (1)

$[Co(NH_3)_5NO_2]^{+2}$ $[Co(NH_3)_5ONO]^{+2}$

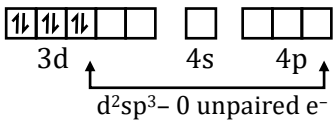
NO_2^- can show ONO^- as ambidentate ligand so above are linkage isomers.

Hence both are different.

16. Ans. (3)

(I) $[Co(H_2O)_6]^{+3}$ Co^{+3} with H_2O acts as SFL hence pairing occurs.

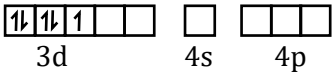
$Co^{+3} \rightarrow [Ar]3d^6$



d^2sp^3– 0 unpaired e^-

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

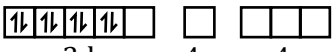
$Fe^{+3} \rightarrow [Ar]3d^5$ $CN^- \rightarrow$ SFL so pairing



d^2sp^3 & 1 unpaired e^-

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

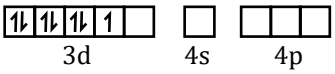
$Ni^{+2} \rightarrow [Ar]3d^8$ $CN^- \rightarrow$ SFL so pairing



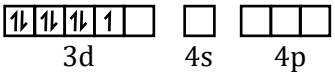
dsp^2 & 0 unpaired e^-

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

$Ni^{+2} \rightarrow [Ar]3d^7$ $CN^- \rightarrow$ SFL so pairing occurs.



dsp^2 & 1 unpaired e^-



dsp^2 & 1 unpaired e^-

17. Ans. (2)

(i) $[Co(NH_3)_6]^+ \rightarrow [Ma_6] \rightarrow$ No isomers (0)

(ii) $[Co(NH_3)_2Cl_2Br_2]^- \rightarrow [Ma_2b_2c_2]$ type. 4 trans and 1-Cis isomers total-(5)

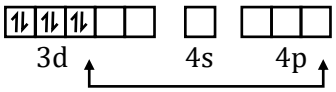
(iii) $[Pt(NH_3)Cl_3]^+ \rightarrow [Ma_3b_3]$ type fac & mer isomers

(iv) $[Pt(NH_3)(H_2O)(Py)ClBrI]^+ \rightarrow [Ma_3b_3]$ type has-(15) GI

18. Ans. (1)

$\mu = \sqrt{n(n+2)}$ n = no. of unpaired e^-

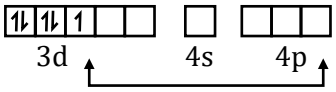
(i) $[Co(O_x)_3]^{-3}$ $Co^{+3} \rightarrow [Ar]3d^6$ O_x is SFL so pairing occurs



d^2sp^3 inner orbital complex

n=0 μ=0

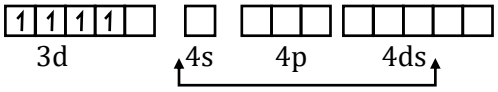
(ii) $[Fe(EDTA)]^-$ $Fe^{+3} \rightarrow [Ar]3d^5$ EDTA SFL so pairing occurs



d^2sp^3-inner orbital complex

n=1, $\mu = \sqrt{3}$

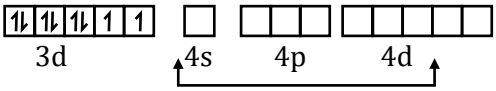
(iii) $[MnF_6]^{-3}$ $Mn^{+3} \rightarrow [Ar]3d^4$ F^- is WFL so no pairing



sp^3d^2-outer orbital

n = 4 m = $\sqrt{24}$

(iv) $[Ni(H_2O)_6]^{+2}$ $Ni^{+2} \rightarrow [Ar]3d^8$ H_2O WFL so no pairing

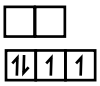


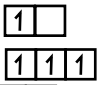
sp^3d^2 outer orbital

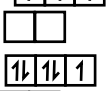
n=2 $m=\sqrt{8}$

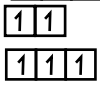
19. Ans. (4)

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

(i) d^4 (low spin)  n = 2 m = $\sqrt{8}$ BM

(ii) d^4(High spin)  n = 4 m = $\sqrt{24}$ BM

(iii) d^5 low spin  n = 1 m = $\sqrt{3}$ BM

(iv) d^5 high spin  n = 5 m = $\sqrt{35}$ BM

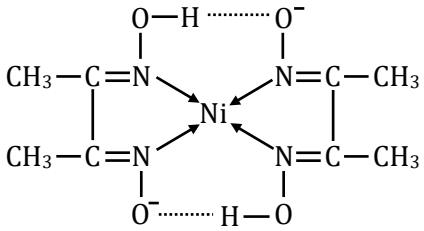
20. Ans. (2)

(i) $[Fe(EDTA)]^-$

no. of chelate ring = denticity–1

EDTA-hexadentate ring = 5

(ii) $[Ni(dmg)_2]$ dmg → bidentate ligand so 2 dmg will give 2 rings but in this compound due to H-bonding 2 more rings are formed so total = 4



(iii) $[Fe(en)_3]^{+3}$ – en → is bidentate ligand

1en = 1 ring

3en = 3 ring

(iv) $[Co(en)_2Cl_2]^+$ –en → is bidentate ligand

1en = 1 ring

2en = 2 rings

21. Ans. (3)

(i) $[Cr(H_2O)_6]^{+2}$ $Cr^{+2} \rightarrow [Ar]3d^4$ WFL so no pairing

$$\Delta = \left(-\frac{2}{5}n_{t_{2g}} + \frac{3}{5}n_{eg}\right)\Delta_0 + x.p$$

$$\Delta_0 = \left(-\frac{6}{5} + \frac{3}{5}\right)\Delta_0 + 0 \quad [x = P.E.]$$

$$\boxed{\Delta_0 = -0.6\Delta_0}$$

(ii) $[Cr(NH_3)_6]^{+2}$ $Cr^{+2} \rightarrow [Ar]3d^4$ SFL so pairing occurs

Conf. → $t_{2g}^4\, eg^0$ $\Delta_0 = -\frac{2}{5}\times 4 + 1P$

$$\boxed{\Delta_0 = -1.6\Delta_0 + P}$$

(iii) $[Fe(H_2O)_6]^{+3}$ $Fe^{+3} \rightarrow [Ar]3d^5$ WFL so no pairing

Conf. → $t_{2g}^3\, eg^2$ $\Delta_0 = -\frac{2}{5}(3) + \frac{3}{5}(2) + 0$

$$\boxed{\Delta_0 = 0}$$

(iv) $[CoF_6]^{-3}$ $Co^{+3} \rightarrow [Ar]3d^6$ WFL so no pairing

Conf. → $t_{2g}^4\, eg^2$ $\Delta_0 = -\frac{2}{5}\times 4 + \frac{3}{5}\times 2 + 0$

$$\boxed{\Delta_0 = -0.4\Delta_0}$$

22. Ans. (2)

(i) Chlorophyll → is compound of Mg

(ii) Blood pigment blood has haemoglobin → which is Fe complex

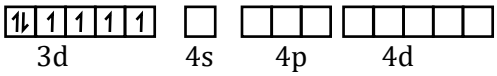
(iii) Vitamin B_{12} → also known as Cobalamin cobalt complex.

(iv) Wilkinson catalyst → $RhCl(PPh_3)_3$

23. Ans. (3)

(A) $[Fe(NH_3)_6]^{+2}$ $Fe^{+2} \rightarrow NH_3$ does not act as SFL so no pairing

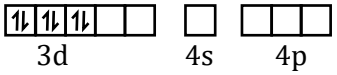
$Fe^{+2} \rightarrow [Ar]3d^6$



sp^3d^2 → outer orbital

(B) $[Co(H_2O)_6]^{+3}$ Co^{+3} H_2O act as SFL so pairing

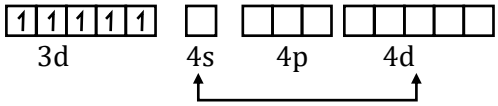
$Co^{+3} \rightarrow [Ar]3d^6$



d^2sp^3 Inner orbital

(C) $[Mn(NH_3)_6]^{+2}$ Mn^{+2} NH_3→WFL-No pairing

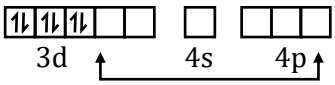
$Mn^{+2} \rightarrow [Ar]3d^5$



sp^3d^2 outer orbital complex

(D) $[Co(C_2O_4)_3]^{-3}$ Co^{+3} $C_2O_4^{-2}$→ SFL so pairing occurs

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



d^2sp^3-Inner orbital complex

24. Ans. (2)

Alum are M_2SO_4. $M_2^{'}(SO_4)_3.24H_2O$ or

$MM^1(SO_4)_2.12H_2O$

M is → +1 cation

M' is → +3 cation

(A) $K.Al(SO_4)_2.12H_2O$ $K \rightarrow K^+$, $Al \rightarrow Al^{+3}$

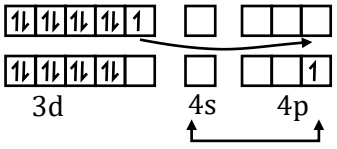
(B) $K_2SO_4.Cr_2(SO_4)_3.24H_2O$ K^+ → cation, Cr^{+3}→ cation

(C) $K_2SO_4.(NH_4)_2SO_4.6H_2O$ Fe^{+2}→cation, NH_4^+→cation

(D) $KCl.MgCl_2.6H_2O$

25. Ans. (1)

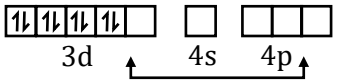
(A) $[Cu(H_2O)_4]^{+2}$ $Cu^{+2} \rightarrow [Ar]3d^9$



dsp^2-square planer

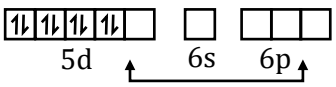
Shifting of e^- does not depend on strength of ligand

(B) $[Ni(CN)_4]^{-2}$ $Ni^{+2} \rightarrow [Ar]3d^8$ CN^- SFL pairing occurs



dsp^2-square planer

(C) $[Pt(Gly)_2] \rightarrow Pt^{+2} \rightarrow [Xe]5d^8$ SFL so pairing Occurs

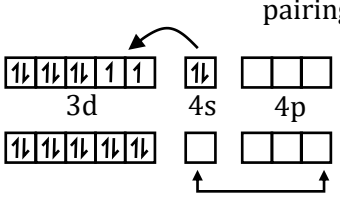


dsp^2-square planer

(D) $[Zn(Cl)_4]^{-2}$ $Zn^{+2} \rightarrow [Ar]3d^{10}$ so sp^3 tetrahedral.

26. Ans. (2)

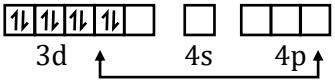
(A) $[Ni(CO)_4]$ $Ni^0 \rightarrow [Ar]3d^84s^2$ CO is SFL so pairing occurs



sp^3-tetrahedral

0-unpaired-Diamagnetic

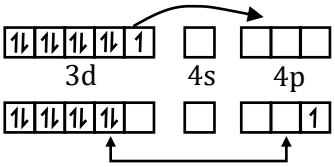
(B) $[Ni(CN)_4]^{-2}$ $Ni^{+2} \rightarrow [Ar]3d^8$ CN^- SFL so pairing occurs



dsp^2→square planer

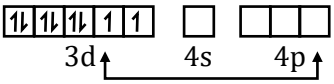
0 unpaired-Diamagnetic

(C) $[Cu(NH_3)_4]^{+2}$ $Cu^{+2} \rightarrow [Ar]3d^9$ NH_3-SFL e^- shifted to 4p



dsp^2-square planer-1unpaired e^- so paramagnetic

(D) $[NiCl_4]^{-2}$ $Ni^{+2} \rightarrow [Ar]3d^8$ Cl^- WFL no pairing



sp^3→tetrahedral & paramagnetic

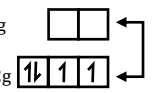
27. Ans. (3)

(A) $[Ni(CO)_4]$ $Ni^0 \rightarrow [Ar]3d^84s^2$ due to SFL CO pairing occurs

Ni → $[Ar]3d^{10}4s^0$

→ 0 unpaired e^- Diamagnetic

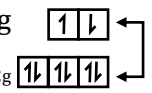
(B) $[Mn(CN)_6]^{-3}$ $Mn^{+3} \rightarrow [Ar]3d^4$ CN^- SFL pairing occurs



2 unpaired so paramagnetic

(C) $[Co(H_2O)_6]^{+3}$ $Co^{+3} \rightarrow [Ar]3d^6$ Co^{+3}, H_2O acts as SFL so pairing occurs

(D) $[Ni(NH_3)_6]^{+2}$ $Ni^{+2} \rightarrow [Ar]3d^8$ NH_3-SFL, pairing occurs



2 unpaired e^- paramagnetic

28. Ans. (1)

(A) Nesseler's reagent → $K_2[HgI_4]$ + KOH

(B) Ferrocene → $[Fe(\eta^5\text{-}C_5H_5)_2]$

(C) Chromocene → $[Cr(\eta^5\text{-}C_5H_5)_2]$

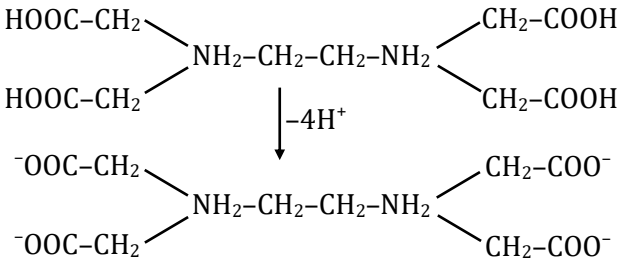
(D) Ziegler Natta catalyst → $(CH_3)_3Al$, $TiCl_4$

$RhCl(PPh_3)_3$ → Wilkinson catalyst.

29. Ans. (1)

$EDTA^{-4}$ is derived from EDTA

EDTA-



30. Ans. (1)

(A) Zeise's salt → $K[PtCl_3(\eta^2\text{–}C_2H_4)]$

π-bonded OMC

(B) Ferrocence→ $[Fe(\eta^5\text{–}C_5H_5)_2]$

π-bonded OMC

(C) Grignard reagent – R-Mg-X

(σ-bonded OMC)

(D) Cis platin