Answers and Solutions

Basic terms

1. (b) (CN) are linked with secondary valency.

2. (c) In Cuprammonium sulphate $[Cu(NH_3)_4]SO_4$

co-ordination no. of Cu is 4.

3. (b) As it makes use of its two atoms to form two co-ordinate covalent bonds with the central metal ion.

4. (b) $[Co\,(en)_2Br_2]Cl_2$

$C.N.$ of $Co =$ 2 × number of bidentate ligand

+1×number of monodentate ligand =2× 2 + 1× 2 = 6.

7. (b) The charge does not decide the formation of bond but availability of lone pair decide the formation of Co-ordinate bond.

8. (c) In $[Co(en)_2Cl_2]^+$

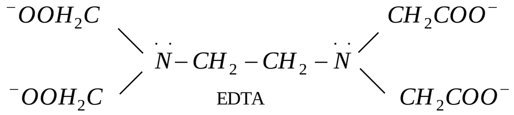
No. of monodentate ligand = 2

No. of bidentate ligand = 2

Co-ordination no. of the metal = 2 + 2(2)= 6.

10. (c)

11. (d)



EDTA

12. (c) According to modern view primary valency of complex compound is its oxidation number while secondary valency is the co-ordination number.

15. (b) Co-ordination number is equal to total number of ligands in a complex.

16. (b) Cuprammonium salt-$[Cu\,(NH_3)_4]SO_4$

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

So, it will give two ions in water.

17. (a) The co-ordination no. = no. of ligands attached.

18. (c) Primary valencies are also known as oxidation state.

$K_2[\,Ni(CN)_4],\ 2 + x - 4 = 0 \Rightarrow x = +2$

20. (b) Ag^+ has two coordination number forms complex with excess of CN^- $Ag(CN)_2$.

21. (b) According to Lewis the ligands are basic in nature.

22. (c) The number of atoms of the ligand that are directly bounded to the central metal atom or ion by coordinate bond is known as the coordination number of the metal atom or ion coordination number of metal = number of σ bonds formed by metal with ligand .

23. (b) $Ag_2S + 4NaCN \rightleftharpoons 2Na\left[Ag(CN)_2\right] + Na_2S$

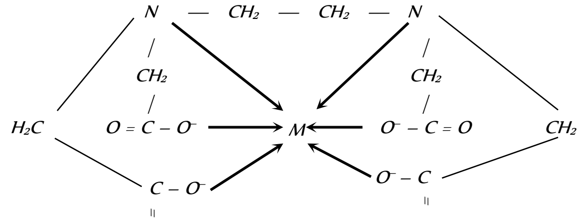
Sodium dicyno argentate

$2Na[Ag(CN)_2] + Zn \rightarrow Na_2[Zn(CN)_4] + 2Ag\downarrow$

Sodium tetracyno zincate (ppt)

24. (d) In $K_4Fe(CN)_6$, the species retains its identity in solid as well as in solution state.

26. (d) The number of atom of the ligand that are directly bound to the central metal atom or ion by coordinate bonds is known as the coordinate number of the metal or ion. It is actually the number of chemical bonds which the ligand form with the central metal atom or ion.



27. (a) CN^- ions acts both as reducing agent as well as good complexing agent.

29. (b) ZnS structure shows the coordination number of Zn is 4.

30. (c) Wilkinson's catalyst is $Rh(P.Ph_3)_3Cl]$.

31. (b) The complexes can be written as follows

$\underset{(A)}{[Co(NH_3)_6]Cl_3}\ \underset{(B)}{[Co(NH_3)_5Cl]Cl_2}\ \underset{(C)}{[Co(NH_3)_4Cl_4]Cl}$

Hence, number of primary valencies are 3, 2 and 1 respectively.

32. (c) Ligand must have capacity to donate lone pair of electrons to form co-ordinate bond.

33. (b) $K_3[Fe(CN)_6]$ because in it CN^- donats a lone pair of electron.

34. (b) Al has 6 co-ordination number.

35. (d) $K_4[Fe(CN)_6] \rightarrow 4K^+ + [Fe(CN)_6]^{4-}$

Complex has negative charge so it is anionic complex.

36. (d) Co-ordination number is equal to total number of ligands in a complex.

37. (b) Lithium tetrahydroaluminate is $Li[Al(H)_4]$.

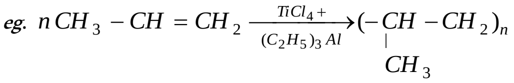
40. (b) Negative ligands end in $-O$ *eg.* SO_4^{2-} (sulphato).

44. (b) Turnbull's blue is $K\{Fe^{\text{II}}[Fe^{\text{III}}(CN)_6]\}$.

46. (a) $\underset{}{Fe + 5CO \xrightarrow[\text{Pressure}]{\text{Heat}} \underset{\text{Iron pentacarbonyl.}}{[Fe(CO)_5]}}$

48. (c) When a ligand attaches to the central metal atom through two or more atoms to form a ring like structure is known as chelats and the ligand is called chelating ligand.

53. (b)



eg. $nCH_3 - CH = CH_2 \xrightarrow[(C_2H_5)_3Al]{TiCl_4+} (-\underset{\underset{CH_3}{|}}{CH} - CH_2)_n$

55. (d) CH_3Li is the organometallic compound in which lithium bonded with carbon and organometallic are those in which metal-carbon bond found.

56. (d) Potash alum is a mixed salt of K_2SO_4 and $Al_2(SO_4)_3$ and on dissolving, it gives all three ion Al^{3+}, K^+ and SO_4^{2-} of which it is made.

57. (a) Carnallite is a double salt with molecular formula $KCl\,.\,MgCl_2.6H_2O$. It gives K^+, Mg^{2+} and Cl^- ions in solution.

59. (a) General formula for alum is

$M_2SO_4.R_2(SO_4)_3.24H_2O$

$M =$ mono valent cation $(K^+, Na^+ ....)$

$R =$ Trivalent cation (Al^{+3}, Fe^{+3})

Hence, $K_2SO_4Al_2(SO_4)_2.24H_2O$ represent an alum.

60. (d) $K_4[Fe(CN)_6]$ is a complex salt. On ionisation it will dissociate in $4K^+$ and $[Fe(CN)_6]^{4-}$ ion. Hence, in $K_4[Fe(CN)_6]$ five ions are present.

61. (c) Due to $C-Mg$ bond.

62. (d) EAN = (At. number $-O.S + 2\times C.N.$)

Hence, EAN of Ni in $Ni(CO)_4$ is

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

Nomenclature, Oxidation State & EAN number

1. (b) $[Co\,(H_2O)_6]Cl_2 \rightleftharpoons [Co\,(H_2O)_6]^+ + 2Cl^-$.

5. (d) Follow IUPAC rule.

7. (b) Follow IUPAC rule.

9. (a) Follow IUPAC rule.

10. (a) Follow IUPAC rule.

11. (c) EAN =Atomic number – Oxidation state + 2 × number of Ligands = 26 – 2 + 2 (6) = 36.

12. (a) EAN of Pt in $[PtCl_6]^{2-} = 80$

13. (b) $Na_2[Cr\,F_4O]$

$x + 4\,(-1) + (-2) = -2$

$x - 6 = -2 \Rightarrow x = +4$.

14. (a) Follow IUPAC rule.

16. (c) Follow IUPAC rule.

17. (d) Follow IUPAC rule.

18. (b) The oxidation state of metal in metal carbonyl is zero.

19. (d) $x + 6\times(0) + 3\times(-1) = 0$

$x - 3 = 0$, $x = +3$, Oxidation number of Cr is $= +3$.

20. (a) EAN = (atomic no)- (oxidation state) + (2 × number of Ligands) = 28 - 2 + 2 × 4 = 34

21. (b) Follow IUPAC rule.

22. (b) $[\underset{x}{Pt}(\underset{0}{C_2\,H_4})\underset{-1}{Cl_3}]^-$

$x + 0 + 3x(-1) = -1$, $x - 3 = -1$, $x = +2$.

23. (a) $[Co\,(NH_3)_6]Cl_3 \rightarrow [Co(NH_3)_6]^{3+} + 3Cl^-$

$x + 6\,(0) = +3 \Rightarrow x = +3$.

24. (b) Follow IUPAC rule.

25. (a) EAN = at. no. of central atom - oxidation state $+ 2\times$ (no. of ligands) $= 27 - 3 + 2\times 6 = 36$.

26. (d) Follow IUPAC rules for nomenclature.

27. (c) EAN of a central metal ion=(atomic no. of central atom) – oxidation state + no. of ligands × 2 $= 26 - 3 + (6\times 2) = 23 + 12 = 35$

28. (b) $+1\times 4 + x - 1\times 4 = 0$

$4 + x - 4 = 0 \Rightarrow x = 0$ for Ni.

29. (a) Follow IUPAC rule.

30. (a) In complex $K_4[Fe(CN)_6]$ the Fe obey EAN rule strictly.

31. (a) $Ni\,(CO)_4$ has O.N. zero for Ni.

32. (b) $3\times(+1) + x + 6\times(-1) = 0$ or $x = 6 - 3 = +3$ Oxidation state of $Fe = +3$.

33. (a) Complexes containing carbonyl ligand (CO) have zero oxidation state.

34. (b) Follow IUPAC rule.

35. (c) Follow IUPAC rule.

36. (b) Follow IUPAC rule.

38. (a) Follow IUPAC rule.

39. (b) Follow IUPAC rule.

41. (a) Follow IUPAC rule.

42. (b) $[\,Ni(CN)_4\,]^x$, $(Ni = +2)$ $(CN = -1)$

$x = 2 + 4(-1) \Rightarrow x = -2$.

44. (b) $[Cu(NH_3)_4]^{2+}$ so, copper has + 2 valency.

47. (a) Follow IUPAC rule.

50. (c) Follow IUPAC rule.

51. (b) $[\underset{x}{Co}\,(\underset{0}{H_2O})_5\,\underset{-1}{Cl}]^{+2}$

$x - 1 = 2 \Rightarrow x = +3$.

52. (b) It is clear from the chemical formulae that Ag is central metal atom and ligands are 2 ammonia molecule.

Hence, compound is $[Ag(NH_3)_2]Cl$.

53. (a) In the compounds $[Co(NH_3)_5\,NO_2]Cl_2$, the oxidation state of cobalt is +3 and here 5 NH_3 ligand, a NO_2 ligand are attached to the central atom. therefore its name is pentaamminecobalt (III) chloride.

54. (b) $\overset{+6}{Cr}O_2\,Cl_2$, $\overset{+7}{Mn}O_4$.

55. (b) In the given ion $[Cr(NH_3)_6]^{3+}$, the oxidation state of chromium is +3 and here $6NH_3$ ligand are attached to the central metal atom. Therefore its IUPAC name is hexamminechromium (III) ion.

56. (a) It is potassium ammine dicyano dioxo peroxo-chromate (VI)

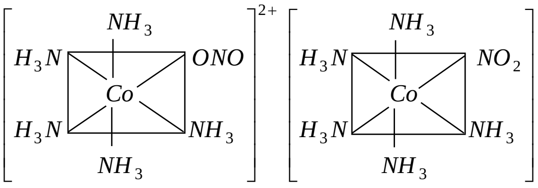
57. (b) Potassium hexa cyanoferrate (III).

Isomerism and Magnetic Properties

1. (a) Octahedral complexes of the type $[MA_4B_2], [MA_2B_4], [MA_3B_3]$ exhibit geometrical isomerism.

2. (d) The number of unpaired electrons in the Complex ion $[CoF_6]^{3-}$ is 4.

4. (c)



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

5. (c) The two given compounds have same composition but in solution both will give different ions. The isomerism is known as ionisation isomerism.

6. (d) Both produce different ions in solution state-

$$[Co(NH_3)_4Cl_2]NO_2 \rightleftharpoons [Co(NH_3)_4Cl_2]^+ NO_2^-$$

$$[Co(NH_3)_4Cl.NO_2]Cl \rightleftharpoons [Co(NH_3)_4Cl.NO_2]^+ + Cl^-$$

7. (b) The compound which has same composition but give different ions in solution, show ionization. So $[Co(NH_3)_5Br]\ SO_4$ is ionization isomer.

$$[Co(NH_3)_5Br]SO_4 \rightleftharpoons [Co(NH_3)_5Br]^{2+} + SO_4^{2-}$$

$$[Co(NH_3)_5SO_4]Br \rightleftharpoons [Co(NH_3)SO_4]^+ + Br^-.$$

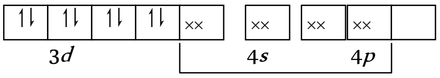
9. (a) Co-ordination isomerism is caused by the interchange of ligands between cis and trans structure.

10. (c) $[Co(NH_3)_5NO_2]Cl_2$ will not show geometrical isomerism because this complex showed 4 and 6 co-ordination number.

13. (b) $[Fe(H_2O)_6]^{2+}$ has four unpaired electrons, $[Cr(H_2O)_6]^{3+}$, $[Cu(H_2O)_6]^{2+}$ and $[Zn(H_2O)_6]^{2+}$ have 3, 1, 0 unpaired electrons respectively.

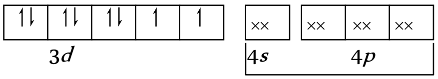
14. (c) The electronic configuration of *Ni* in $[Ni(CN)_4]^{2-}, [Ni(Cl_4)]^{2-}$ and $Ni(CO)_4$ are as following

Ni^+ in $[Ni(CN)_4]^{2-}$ –



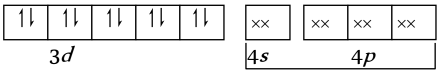
dsp^2

Ni^{2+} in $[Ni(Cl_4)]^{2-}$ –



sp^3

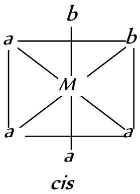
Ni in $[Ni(CO)_4]$ –



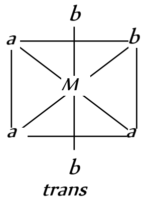
sp

CO and CN^- are strong ligands so they induces pairing of electrons so their complexes are diamagnetic while Cl^- is a weak ligand so it does not induce the pairing of electrons so its complex is paramagnetic.

15. (a) $[Co\ (NH_3)_4\ Cl_2]^+$ is the Ma_4b_2 and Ma_2b_3 type complex.



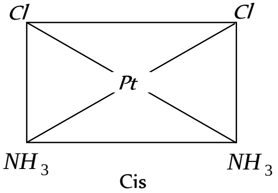
cis



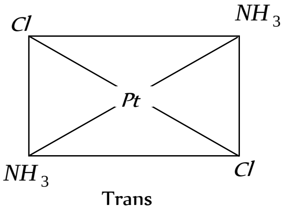
trans

16. (b) In $[Ag(NH_3)_2]Cl, Ag^+$ contains d^{10} configuration. All others contain unpaired electrons.

17. (a) $Pt(NH_3)_2Cl_2$.

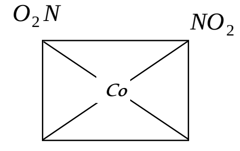


Cis

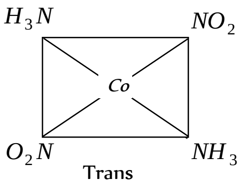


Trans

19. (a)



Cis

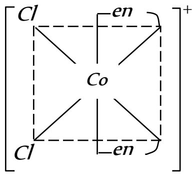


Trans

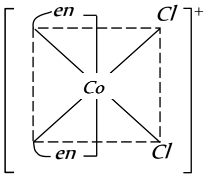
21. (c) $[Co(en)_2NO_2Cl]Br$; $[Co(en)_2ONOCl]Br$

22. (b) Because it will not give any ions in solution.

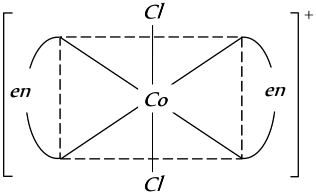
23. (b) $[Co\ (en)_2Cl_2]^+$ have three optical isomers which are.



d-cis form



l-cis forms



Trans-meso form

24. (a) Magnetic moment of $[Cu(NH_3)_4]^{2+}$ ion is 1.414 due to the presence of one unpaired electron.

25. (a) Due to the presence of one unpaired electron, both are slightly paramagnetic.

27. (d) 1. $[Cu(NH_3)_4].[PtCl_4]$

2. $[Cu(NH_3)_3Cl].[PtCl_3(NH_3)]$

3. $[Cu(NH_3)_2Cl_2].[PtCl_2(NH_3)_2]$cis

4. $[Cu(NH_3)_2Cl_2].[PtCl_2(NH_3)_2]$Trans

5. $[Cu(NH_3)Cl_3].[Pt(Cl)(NH_3)_3]$

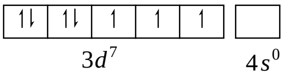
6. $[Pt(NH_3)_4Cl].[CuCl_4]$

29. (c) Co-ordination isomerism is possible when both +*ve* and -*ve* ions of a salt are complex ions and the two isomers differ in the distribution of ligands in the cation and the anion.

30. (a) On ionisation it gives maximum number of (four) ions.

31. (b) The anhydrous complex of Cu^+ do not involve *d–d* transition and are thus colourless.

32. (a) Mn^{2+}



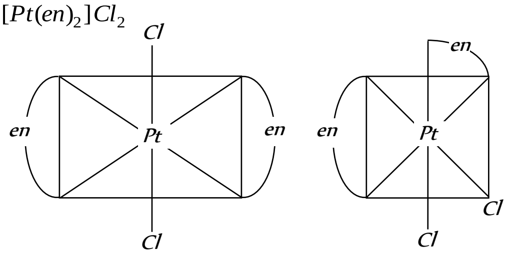
In presence of H_2O which is a weak ligand no pairing occurs which results in unpaired electrons left in the compound, due to which it shows paramagnetism.

33. (c) Geometrical isomers (cis and trans) and linkage isomers (–SCN and –NCS).

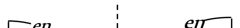
34. (a) Due to presence of strong ligand all the e^- get paired. So no. of unpaired electrons are 0.

36. (c) Both have same composition but give different ions in the solution.

37. (d) $[Pt(en)_2]Cl_2$

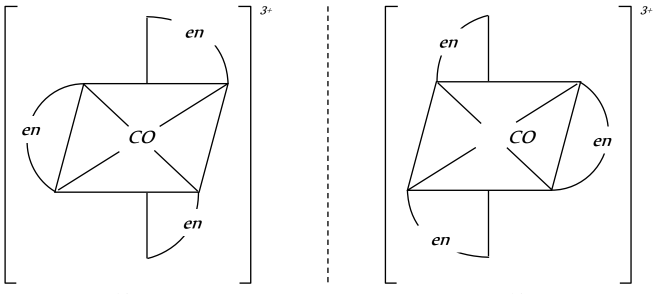


Geometrical isomers



38. (a) CO is a strong ligand so induce pairing of electrons and hence $Ni(CO)_4$ is diamagnetic.

40. (b) $[Co(en)_3]^{3+}$



41. (a)$_3 Cl_3$ ve optica use it is of formula MA_3B_3 which does not show optical isomerism.

42. (c) Change in composition of co-ordination sphere yield ionization isomers.

$[Cr(H_2O)_6]Cl_3$ and $[CrCl_3(H_2O)_3].3H_2O$

43. (d) NO_2 is ambident and can be linked either to N -side as $(-NO_2)$ or to O -side as $(-ONO)$.

44. (a) As $[Co(NH_3)_3Cl_3]$ does not losses any Cl^- ions in the solution so it will not give ppt. with $AgNO_3$.

45. (b) $[Co(NH_3)_6]Cl_3 \rightleftharpoons [Co(NH_3)_6]^{3+} + 3Cl^-$.

46. (e) $CoCl_3.5NH_3.H_2O$ is pink in colour.

47. (a) The configuration of Ni^{2+} has two unpaired electron so it is paramagnetic.

48. (d) $[Pt(NH_3)_4]Cl_2 \rightarrow [Pt(NH_3)_4]^{+2} + 2Cl^-$

As it gives Cl^- ions in solution so it will give white ppt. of $AgCl$ with $AgNO_3$.

49. (c) $[Co(NH_3)_5Cl]Cl_2 \rightleftharpoons [Co(NH_2)_5Cl]^{2+} + 2Cl^-$

50. (c) $[Cr(NH_3)_5Cl]SO_4 \rightarrow [Cr(NH_3)_5Cl]^{2+} + SO_4^{2-}$

$(Cr(NH_3)_5Cl]^{2+} + SO_4^{2-} + BaCl_2 \rightarrow$

$[Cr(NH_3)_5Cl]Cl_2 + BaSO_4 + HCl$.

51. (d) $[Pt(NH_3)Cl_2Br]Cl \rightleftharpoons \underbrace{[Pt(NH_3)Cl_2Br]^+ + Cl^-}$

Cl^- ion is precipitable.

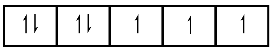
52. (a) $Cu(II)$ complexes are blue.

53. (c) It will ionize in the following manner.

$[Co(NH_3)_5]Cl_2 \rightleftharpoons [Co(NH_3)_5]^{2+} + 2Cl^-$ (3 ions).

54. (a) $_{27}Co \rightarrow [Ar]3d^7 4s^2$

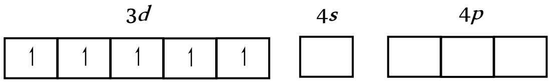
$Co^{2+} \rightarrow 3d^7 4s^0$



Number of unpaired electrons = 3.

55. (a) $K_3[FeF_6]$

$Fe^{3+} = [Ar]3d^5 4s^0$

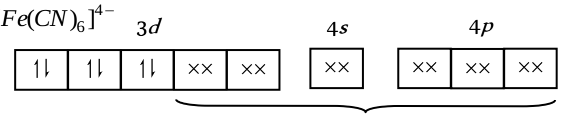


Number of unpaired electrons = 5

Magnetic moment $= \sqrt{n(n+2)} = \sqrt{5(5+2)}$

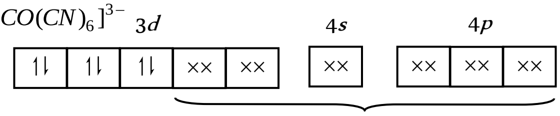
$= \sqrt{35}$ = 5.91 BM.

56. (c) $[Fe(CN)_6]^{4-}$



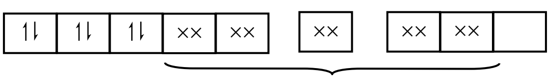
dsp, Paramagnetism

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



dsp, Paramagnetism

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



dsp, Paramagnetism

57. (c) When coordinate compounds gives different ions in solution then it produces ionic isomerism while this situation is not present in $[Co(en)_2Cl_2]Cl$.

Hybridisation and Geometry

3. (a) $2Cl^-$ ions are ionizable

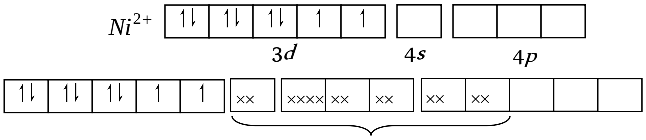
$\therefore [Co(NH_3)_5Cl]Cl_2 \rightleftharpoons \underbrace{[Co(NH_3)_5Cl]^{2+} + 2Cl^-}_{\text{3 ions}}$

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

4. (b) Copper complexes usually involve with four co-ordination number and have square planar in shape.

5. (a) Complex with $sp^3d -$ hybridisation show square pyramidal geometry.

6. (b) sp^3d^2



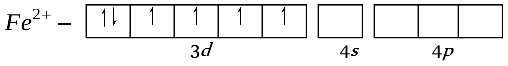
sp^3d^2 hybridisation

8. (d) Metal carbonyls does not show overlapping.

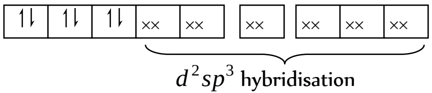
9. (c) sp^3d^2 – hybridisation gives octahedral complex.

11. (b) Copper complexes usually involve co-ordination number of four and are thus square planar in shape.

12. (c) $[Fe(CN)_6]^{4-}$



In presence of CN^-



Hence, Octahedral geometry.

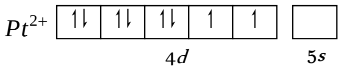
13. (d) $Fe(CO)_5$ has dsp^3-hybridisation so it show trigonal bipyramidal geometry.

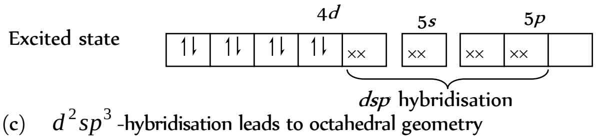
16. (b) Due to formation of inner orbital complex.

17. (d) $Ni(CO)_4$ and $Ni(PPh_3)_2Cl_2$ have sp^3 and dsp^2-hybridisation respectively.

18. (d) $[Cu(NH_3)_4]^{2+}$ has square planer structure.

19. (a) Since hybridisation is dsp^2 so it is square planar,

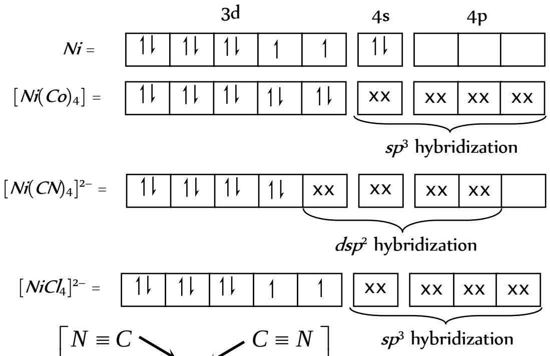




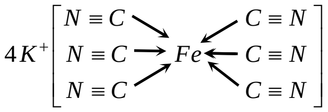
23. (c) d^2sp^3-hybridisation leads to octahedral geometry

25. (c) $[CoF_6]^{3-}$ is an outer complex having d^2sp^3 hybridisation.

27. (d)



28. (d)



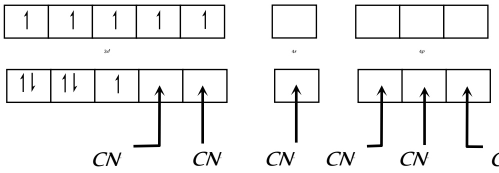
29. (d) $K_3[Fe(CN)_6]$

Electronic configuration of $Fe = [Ar]4s^2 3d^6$

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

Number of ligand (coordination numbr)=6

Nature of ligand is strong field.



Hybridization of Fe is d^2sp^3.

32. (c) The compounds which show d^6 – configuration are octahedral complexes.

33. (a) CN^- ligand has strong field ligand because of higher value of Δ.

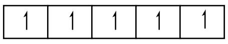
35. (c) Ammine (NH_2) is neutral ligand.

37. (c) A strong field ligand produces low spin complexes.

38. (d) Cyanide ion is strong field ligand because it is a pseudohalide ion pseudohalide ions are stronger coordinating ligand & they have the ability to form σ bond (from the pseudohalide to the metal) and π bond (from the metal to pseudohalide).

39. (d) $Mn^{25} \longrightarrow 3d^5 + 4s^2$

$Mn^{2+} \longrightarrow 3d^5$



In presence of weak ligand field, there will be no pairing of electrons. So it will form a high spin complex. i.e. the number of unpaired electrons = 5.

40. (b) The complexes, in which, the metal and ligand form a bond that involves the π – electrons of the ligand are know as π – complexes *e.g.* Ferrocene

$Fe\ (\eta^5 - C_5H_5)_2$, zeise's salt $K[PtCl_3(\eta^2 - C_2H_4)]$.

41. (b) CO has strong $M \to L$ π – bonding ability so it can accept electron pairs from metal ion so it is a π-acid ligand.

42. (a) d^4 (in strong ligand field).

43. (c) Both $Ni(CO)_4$ and $Ni(PPh_3)_2Cl_2$ are tetrahedral.

Complexes and complex stability

1. (d) The cyano and ammine complexes are far more stable than those formed by halide ions. This is due to the fact that NH_3 and CN^- are strong lewis bases.

4. (b) Greater the charge on central metal ion greater is the stability of complex.

5. (a) $CuSO_4$ on reaction with KCN gives $K_3[Cu(CN)_4]$

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

6. (a) The most probable complex which gives three moles ions in aqueous solution may be $[Co(NH_3)_5NO_2]Cl_2$ because it gives two chlorine atoms on ionisation.

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

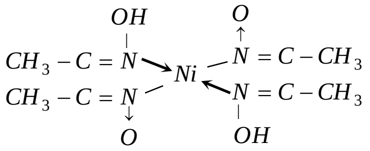
7. (d) $$\underset{\text{pot. ferrocyanide}}{3K_4[Fe(CN)_6]} + 4FeCl_3 \to \underset{\substack{\text{(Ferri ferrocynide)} \\ \text{(Prussion blue)}}}{Fe_4[Fe(CN)_6]_3} + 12KCl$$

8. (b) $Fe_2(SO_4)_3 \to 2Fe^{3+} + 3SO_4^{2-}$

$$K_4[Fe(CN)_6] + 2Fe^{3+} \to \underset{\text{Prussion blue}}{Fe_4[Fe(CN)_6]_3}.$$

9. (c) $[Co(NH_3)_5Cl]^x + 2Cl^- \to [Co(NH_3)_5Cl]Cl_2$.

10. (b) Ni reacts with dimethylglyoxime to give red *ppt.* of nickel-dimethyl glyoxime complex.



12. (b) $AgCl + 2NH_4OH \rightarrow [Ag(NH_3)_2]\,Cl + 2H_2O$

$$\underset{[Ag(NH_3)_2]^{+}Cl^{-}}{\upharpoonleft\downharpoonright}$$

13. (a) $Ag_2S + NaCN \rightleftharpoons Na\,[Ag(CN)_2] + Na_2S$.

14. (b) $Fe_2(SO_4)_3 \rightarrow 2Fe^{3+} + 3SO_4^{-2}$.

15. (b) Aluminum is a *p*-block element and does not form complex compounds.

Application of Organometallics

1. (d) $(CH_3CH_2)_3Al + TiCl_4$ is the Ziegler-Natta catalyst.

2. (d) Alum acts as coagulating agent.

4. (c) $4CH_3CH_2CH_2CH_2-Li + SnCl_2 \rightarrow (C_4H_9)_4Sn$.

6. (b) As there is no direct bonding between the metal atom and the carbon atom.

9. (a) $(CH_3)_4Sn$ is a $\sigma-$bonded organometallic compound.

10. (d) Wilkinson's catalyst is used as homogeneous catalyst in the hydrogenation of alkenes as –

$$H-H + \rangle C=C\langle \;\longrightarrow H-C-C-H.$$

12. (b) $C_2H_5\ Li$ is an organo-metallic compound.

13. (a) Because there is direct bonding of metal ion with carbon.

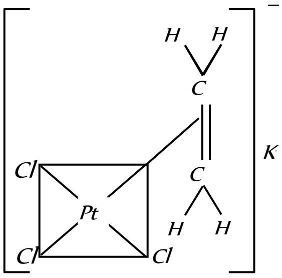
14. (c) Organometallic compounds are those compounds in which carbon atom is directly linked to metal. But in sodium ethoxide as oxygen is attached to sodium metal so it is not a organometallic compound.

16. (c) $Al(OC_2H_5)_3$ contains bonding through O and thus it does not have metal-carbon bond.

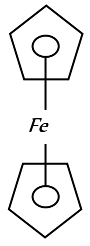
17. (c) Chlorophyll are green pigment in plant & contain magnesium instead of calcium.

19. (d) This reaction carried out in alkaline *pH i.e.*, 9–11

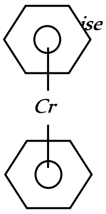
20. (a)



ise's salt



Ferrocene



$(C_2H_5)_4Sn$
tetraethyl tin

dibenzene chromium

Critical Thinking Questions

1. (b) Its coordination number will be 6 because it is bonded with three bidentale ligands.

Oxi. No. of Cr in $\underset{-1}{K_3}[Cr(\underset{-2}{C_2O_4})_3]$ is

$$x + 3(-2) + 3(+1) = 0 \;\Rightarrow x = +3$$

2. (b) *e.g.* $Fe(CO)_5, Ni(CO)_4$ *etc.*

3. (a) $\underset{0.02\text{ mole}}{[Co\,(NH_3)_5SO_4]Br} + AgNO_3 \rightarrow$

$$\underset{0.02\text{ mole}\,(y)}{[Co\,(NH_3)_5.SO_4]NO_3} + AgBr$$

$\underset{0.02\text{ mole}}{[Co\,(NH_3)_5Br_2]SO_4} + BaCl_2 \rightarrow$

$$\underset{0.02\text{ mole}(z)}{[Co\,(NH_3)_5Br]Cl_2} + BaSO_4$$

On using one *lit.* solution, we will get 0.01 mole *y* and 0.01 mole *z.*

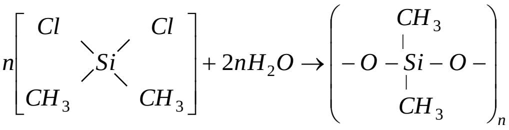
4. (b) $[Fe(\eta^5 - C_5H_5)_2]$ is the organometallic compound which has σ and π bonds present.

5. (b) $[\underset{x}{Ni}\ \underset{0}{(NH_3)_4}]\underset{-2}{SO_4}$

$x + 0 + (-2) = 0 \Rightarrow x = +2$ is valency and 4 is *C.N.* of *Ni.*

6. (b) Co-ordination number is equal to total number of ligands in a complex.

7. (c)



$$n\begin{bmatrix} Cl & & Cl \\ & Si & \\ CH_3 & & CH_3 \end{bmatrix} + 2nH_2O \rightarrow \left(\begin{matrix} CH_3 \\ -O-Si-O- \\ CH_3 \end{matrix}\right)_n$$

8. (c) Because it is a polydentate ligand which binds the central atom nickel forming a ring like structure.

9. (d) $4KCN + CuSO_4 \rightarrow \underset{\text{Potassium tetracynocuprate}}{K_3[Cu(CN)_4]}$

10. (a) $\underset{\text{gold ore}}{\text{Roasted}} + CN^- + H_2O \xrightarrow{O_2} [Au(CN)_2]^- + OH^-$

$\left[Au(CN)_2\right]^- + Zn \rightarrow \left[Zn(CN)_4\right]^{2-}$.

11. (d) Potassium ferrocynide $K_4[Fe(CN)_6]$ will ionize as

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

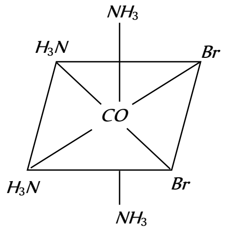
So, it will give five ions in solution.

12. (d)

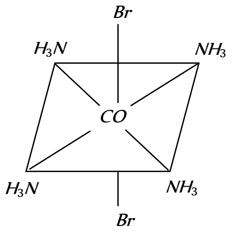
Complex ion	Hybridization of central atom
$[Fe(CN)_6]^{4-}$	d^2sp^3 (inner)
$[Mn(CN)_6]^{4-}$	d^2sp^3 (inner)
$[Co(NH_3)_6]^{3+}$	d^2sp^3 (inner)
$[Ni(NH_3)_6]^{2+}$	sp^3d^2 (outer)

13. (d) $[Co(en)_2Cl_2]^+$ shows geomerical as well as optical isomerism.

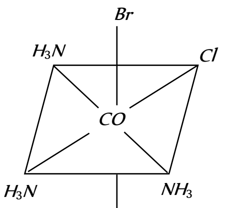
14. (a)

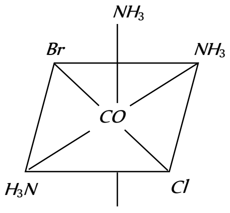


cis

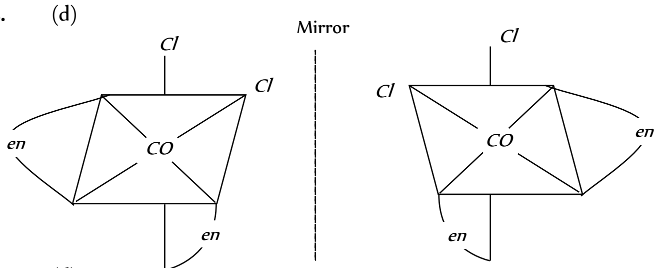


Trans

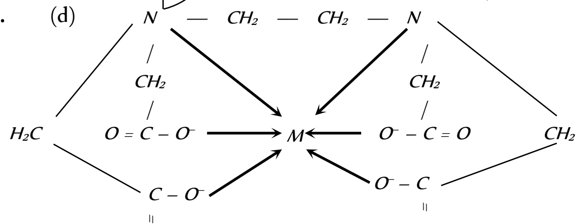




15. (d)



16. (d)



Ethylenediamine tetraacetate ion (EDTA)

They have six donor atoms. poly dentate ligands have flexidentate character. It is not necessary that all the donor atoms present in the polydentate ligands should form co-ordinate bonds with central metal atom or ion.

17. (a,d) In $K_3[Fe(CN)_6]$ the ligand are negative which is present in coordination spheres shows a dual behaviour. It may satisfied both primary & secondary valencies while neutral ligand satisfied only secondary valencies.

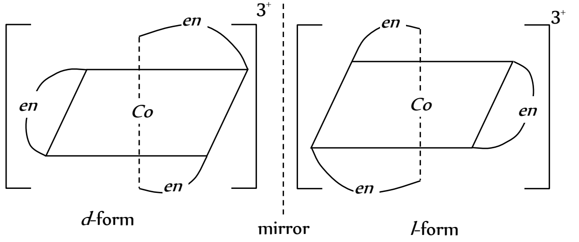
18. (a) Cis Isomer of $[Pt(NH_3)_2Cl_2]$ is used as an anticancer drugs for treating several type of malignant tumours. When it is injected into the blood stream the more reactive Cl groups are lost so the Pt atom bonds to a N atom in guanosine (a part of DNA) This molecule can bond to two different guanosine units & by bridging between them it upsets the normal reproduction of DNA.

19. (c) $CoCl_2$ is a weak Lewis acid, reacting with chloride ion to produce salt containing the tetrahedral $[CoCl_4]^{2-}$ ion. $CoCl_2$ is blue when anhydrous, and a deep magneta colour when hydrated, for this reason it is widely used as an indicator for water.

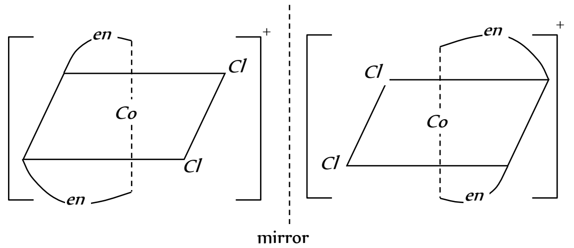
20. (a) The absorption of energy or the observation of colour in a complex transition compound depends on the charge of the metal ion and the nature of the ligands attached. The same metal ion with different ligands shows different absorption depending upon the type of ligand. The presence of weak field ligands make the central metal ion to absorb low energies *i.e.,* of higher wavelength. The field strength of ligands can be obtained from spectrochemical series. *i.e.*

(weak field) $I^- < Br^- < S^{2-} < Cl^- < NO_3^- < F^- < OH^- < H_2O < NH_3 < NO_2^- < CN^- < CO$ (strong field)

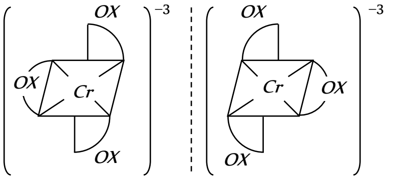
21. (b) $[Co(en)_3]Cl_3$



cis-$[Co(en)_2Cl_2]Cl$



22. (c)



Assertion and Reason

1. (d) Potassium ferrocyanide and potassium ferricyanide both are not diamagnetic because both do not have paired electrons. Assertion and reason both are false.

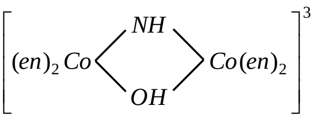
2. (c) It is correct statement that NF_3 is a weaker ligand than $N(CH_3)_3$, the reason is that fluorine is highly electronegative therefore, it with draw electrons from nitrogen atom. Hence, the lone pair of nitrogen atom cannot be ligated. While $N(CH_3)_3$ is a strong ligand because CH_3 has electron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

3. (d) Both assertion and reason are false. $[Ni(en)_3]Cl_2$ is a chelating compound and chelated complexes are more stable than similar complexes involves breaking of two bonds rather than one. In $[Ni(en)_3]Cl_2$, Ni with d^8 configuration shows octahedral geometry. Six electrons will occupy the t_{2g} orbitals and two electrons will occupy the e_g orbitals.

4. (a) Both assertion and reason are true and reason is the correct explanation of assertion . When a monodentate ligand has two possible donor atoms and attached in two ways to the central metal atom are called ambidentate ligands.

5. (c) Assertion is true but reason is false. Tetrahedral complexes do not show geometrical isomerism because the relative position of the atoms with respect to each other will be the same.

6. (e) Assertion is false but reason is frue.



$$\left[(en)_2Co\begin{matrix}NH\\ \\OH\end{matrix}Co(en)_2\right]^{3+}$$

is named as tetrakis (ethylene diamine)- μ -hydroxo- μ -imido dicobalt (III) ion. For more than one bridging group the word μ is repeated before each bridging group.

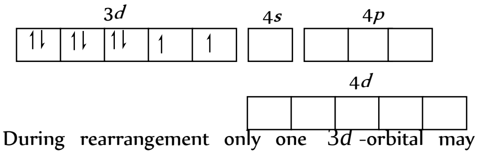
7. (b) Both assertion and reason are true but reason is not the correct explanation of assertion. $[Fe(CN)_6]^{3-}$ has EAN equal to 35 and thus possesses unpaired electron to show paramagnetic nature while $[Fe(CN)_6]^{4-}$ possesses no unpaired electron and thus shows diamagnetic nature.

8. (e) Assertion is false but reason is true. H_2N-NH_2 does not act as chelating ligand. The coordination by hydrazine leads to a three member highly unstable strained ring and thus it does not act as chelating agent.

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

10. (b) Both assertion and reason are true but reason is not the correct explanation of assertion.

Ni^{2+} configuration



During rearrangement only one $3d$-orbital may be made available by pairing the electrons. Thus, inner d^2sp^3 hybridization is not possible, so, only sp^3d^2 (outer) hybridization can occur.

11. (c) $K_4[Fe(CN)_6]$ and $K_3[Fe(CN)_6]$ both are low spin complex due to strong ligand field. That is why it is false that crystal field splitting in ferrocyanide ion is greater than ferricyanide ion.