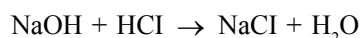


09.

Co- Ordination Compounds

TERMS USED

Simple salts: When an acid reacts with an alkali, neutralisation takes place and a simple salt is produced.



Molecular or addition compounds : When solutions containing two or more salts in stoichiometric portions are allowed to evaporate, we get crystals of compounds known as molecular or addition compounds.

Ligands : The natural molecules or ions which are attracted with the central metal ion are called ligands.

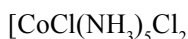
Coordination number or ligancy: It is the total number of the atoms of the ligands that can coordinate to the central metal ion. Numerically coordination number represents the total number of the chemical bonds formed between the central metal ion and the donor atoms of the ligands.

Coordination sphere: The central metal ion and the ligands that are directly attached to it are enclosed in a square bracket which Werner has called coordination sphere.

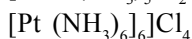
NOMENCLATURE OF COORDINATION COMPOUNDS



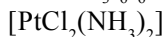
hexaamminecobalt (III)
chloride



pentaamminechlorocobalt (III) chloride



hexaammineplatinum (IV) chloride

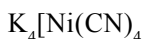


diamminedichloroplatinum (II)



potassium pentacyanonitro socobaltate (II)

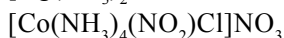
potassium tetracyanonickelate



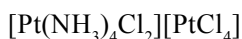
potassium tetracyanonic kelate



diammine silver (I) chloride



tetraamminechloronitrocobalt
(III) nitrate



tetraamminedichloroplatinum

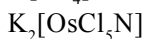
(IV) tetrachloroplatinate (II)



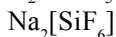
sodium tetrafluorooxochromate (IV)



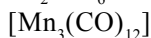
potassium tetrafluoroborate (III)



potassium pen tachloronitridoos mate (VI)



sodium hexafluorosilicate (IV)



dorlecacarbonyltrimanganese (0)

WERNER'S COORDINATION THEORY

More important postulates of this theory :

- i) Most elements exhibit two types of valencies
 - a) **Primary valency:** This corresponds to oxidation state of the metal ion. This is also called principal, ionisable or ionic valency. It is satisfied by negative ions and its attachment with the central metal ion is shown by dotted lines.
 - b) **Secondary valency :** It is also termed as co-ordination number of the central metal ion. This is satisfied by either negative ions or neutral molecules. The ligands which satisfy the co-ordination number are directly attached to the metal atom or ion and shown by thick lines.
- ii) Every element tends to satisfy both its primary and secondary valencies. In order to meet this requirement a negative ion may often show a dual behaviour, i.e it may satisfy both primary and secondary valencies in every case fulfilment of coordination number of the central metal ion appears

essential.

SIDGWICK'S ELECTRONIC-INTERPRETATION OF CO ORDINATION

According to sidgwick's concept, the ligand attached with the central metal ion have atoms which have atleast one unshared electron pair. He further says that when the ligands are attached with the central metal ion, they donate the electron pair to the central metal ion. The atoms which donate the electron pair to the central metal ion are called donors and the central metal ion which accepts the electron pair is called an acceptor. According to Sidgwick the bond established between the ligands and the central metal ion is a co-ordinate or dative or semi polar bond. The bond formed is usually represented as $M \rightarrow L$ which indicates that the donor group, L has donated an electron pair to the metal ion, M(acceptor).

SIDGWICK'S CONCEPT OF EFFECTIVE ATOMIC NUMBER (EAN concept) :

Sidgwick suggested that after the ligands have donated a certain number of electrons to the central metal ion through bonding, the total number of electrons on the central atom, including those gained from ligands in the bonding is called the effective atomic number of the central metal ion and in many case this total number of electrons surrounding the coordinated metal ion is equal to the atomic number of the inert gas.

ISOMERISM IN CO-ORDINATION CHEMISTRY

Two or more chemical compounds having identical chemical formula but different structures and spatial arrangements are called isomers and the phenomenon known as isomerism.

TYPES : This is of two types.

1. Structural isomerism

1. **Ionization isomerism** : This isomerism results when compounds with same molecular formula give different ions in the solution.
2. **Hydrate isomerism** : It arises when some ligand H_2O molecules become water of hydration outside the coordination sphere, i.e here water forms a part of the coordination entity or is outside it.
3. **Linkage isomerism**: This isomerism results when a monodentate ligand has two possible donor atoms and attaches

in two ways to the central metal atoms, i.e. a ligand can ligate through two different atoms present in it.

4. **Co-ordination isomerism**: This type of isomerism is shown by compounds in which both cation as well as anion are complexes and ligands may interchange their positions between the two complex ions.

II. Stereo isomerism

Isomers differ only in spatial arrangement of atoms or groups about the central metal atom.

1. **Geometrical isomerism** : This isomerism arises due to the difference in geometrical arrangement of the ligands around the central atom. When the donor atoms of the same ligands are on adjacent positions, it is called cis-isomer and when these are in the opposite position, it is called trans isomer. Therefore, this kind of isomerism is also called cis-trans isomerism. Geometrical isomerism can not arise in a tetrahedral complex (C.N = 4) because this geometry contains all the ligands in this position with respect to each other, i.e. each ligand is equidistant from the other three ligands and all bond angles are the same, this isomerism is however found in many square planar (C.N = 4) and octahedral (C.N = 6) complexes.

2. **Optical isomerism** : Chiral molecules, i.e. molecules which do not have plane of symmetry exhibit optical isomerism. The optical active isomers called enantiomers or enantiomorphs are super imposable mirror images of each other and rotate the plane of polarised light equally but in opposite direction, i.e. left called laevorotatory and right called dextrorotatory.

No mirror image isomerism is possible with tetrahedral and square planar complexes of the type $[Ma_4]$, $[Mab_3]$ and $[Mab_3]$ because all the possible arrangement of the ligands round the central metal ion, M are exactly equivalent.

CONDITIONS FOR A MOLECULE TO SHOW OPTICAL ISOMERISM EXISTING IN DIFFERENT FORMS

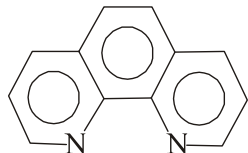
- i) The molecule should be asymmetric, i.e. it should have no plane of symmetry and
- ii) The molecule should not be super imposable

on its mirror image.

OBJECTIVE TYPE QUESTIONS

- Which of the following can be termed as mixed complex?
 - $K_4[Fe(CN)_6]$
 - $Cu(NH_3)_4 SO_4$
 - $[Co(NH_3)_4NO_2C][Cl]$
 - K_2FeO_4
- Which among the following represent chelating ligands?
 - SCN^-
 - CN^-
 - 2, 2-Dipyridyl
 - OH^-
- On the basis of Werner theory, the complex $CoCl_3 \cdot 6NH_3$ or $Co(NH_3)_6Cl_3$, hexammine cobalt (III) chloride has
 - 2 primary valencies and 4 secondary valencies
 - 3 primary valencies and 6 secondary valencies
 - 2 oxidation state and 4 coordination number
 - none of the above
- Complex compound $Cu(NH_3)_4 SO_4$ and $Pt(NH_3)_6 Cl_4$ have coordination number
 - 2 and 4 respectively
 - 2 and 6 respectively
 - 4 and 6 respectively
 - 3 and 6 respectively.
- Which of the following will give maximum number of isomers?
 - $[Co(NH_3)_4Cl_2]$
 - $[Ni(en)(NH_3)_4]^{2+}$
 - $[NiC_2O_4(en)_2]^{2-}$
 - $[Cr(SCN)_2(NH_3)_4]^+$
- Glycinate ion
 - has formula $H_2N-CH_2-COO^-$
 - is a chelating ligand
 - is unsymmetrical bidentate ligand
 - all of these
- Which of the following ligand gives chelate complexes?
 - SCN^-
 - 2, 2-Dipyridyl
 - Pyridine
 - $NH_2 - NH_3$
- Which of the following complexes is likely to show optical activity?
 - trans- $[Co(NH_3)_4Cl_2]^+$
 - $[Cr(H_2O)_6]^{3+}$
 - cis- $[Co(NH_3)_2(en)_2]^{3+}$
 - trans- $[Co(NH_3)_2(en)_2]^{3+}$
- A monodentate ligand is
 - aquo
 - ammine
 - pyridines
 - all of these
- Co-ordination number of Ni in $[Ni(C_2O_4)_3]^{4-}$ is
 - 3
 - 6
 - 4
 - 2
- In the complex $[Pt(py)_4][PtCl_4]$, the oxidation numbers of Pt atom in former and later part of the compound are respectively
 - 0 and 0
 - +4 and +2
 - +2 and +2
 - 0 and +4
- A hexadentate ligand is
 - triethylene tetramine
 - ethylene triammine
 - diethylene diammine triacetate
 - ethylene diammine tetraacetate
- Which one of the following compounds will exhibit linkage isomerism?
 - $[Co(en)_2Cl_2]Cl$
 - $[Pt(PH_3)_2Cl_2]$
 - $[Co(NH_3)_5NO_2]Cl_2$
 - $[Co(NH_3)_4]Cl$
- Which of the following organometallic compound is σ and π -bonded?
 - $[Fe(\eta^5-C_5H_5)_2]$
 - $K[PtCl_3(\eta^2-C_2H_4)]$
 - $[Co(CO)_5NH_3]^{2+}$
 - $Fe(CH_3)_3$
- In the complex $[Co(NH_3)_6][CdCl_x]$ the oxidation number of cobalt is +3. The value of x is
 - 3
 - 4
 - 2
 - 5
- Which statement about co-ordination number of a cation is true?
 - Metal ions exhibit only a single characteristic co-ordination number
 - The co-ordination number is equal to the number of ligands bonded to the metal atom
 - The co-ordination number is determined solely by the number of empty d-orbitals in the atom
 - The co-ordination number is equal to the number of co-ordinate bonds between metal cation and ligands.
- The compound which exhibit optical isomerism is
 - $[Co(NH_3)_4Cl_2]^+$
 - $[Co(NH_3)Cl_3]$

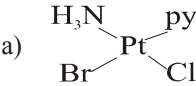
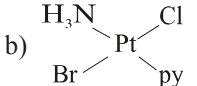
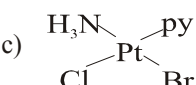
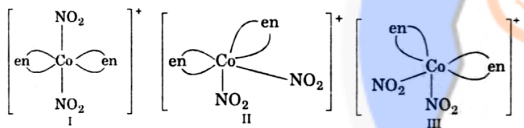
- c) $\text{cis} [\text{Co}(\text{en})_3]^{3+}$ d) $\text{trans} [\text{Co}(\text{en})_3]^{3+}$
19. The compound which exhibit geometrical isomerism is
- a) $\text{Pt} (\text{NH}_3)_2\text{Cl}_2$ b) $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]^+$
- c) $[\text{Co}(\text{en}_3)]^{3+}$ d) all of these
20. Which of the following statement is incorrect ?



- a) $\text{Ni}(\text{CO})_4$: Tetrahedral, paramagnetic
- b) $[\text{Ni}(\text{CN})_4]^{2-}$: Square planar, diamagnetic
- c) $\text{Ni}(\text{CO})_4$: Tetrahedral, diamagnetic
- d) $[\text{Ni}(\text{Cl})_4]^{2-}$: Tetrahedral, paramagnetic
21. The ligand shown here is
- a) Tridendate
- b) 1, 10-phenanthroline
- c) 1, 10 phenanthrine
- d) 2, 2-dipyridyl
22. Ni metal is in highest oxidation state in the complex
- a) $\text{Ni}(\text{CO})_4$ b) K_2NiF_6
- c) $[\text{Ni}(\text{NH}_3)_6] (\text{BF}_4)_2$ d) $\text{K}_4 [\text{Ni} (\text{CN})_6]$
23. The oxidation state of Pt $[(\text{en})] \text{H}_2\text{O}_4 (\text{NO})_2\text{Cl}]^{2+}$ is
- a) + 2 b) + 4
- c) + 6 d) - 4
24. The outer orbital hybridisation is involved in
- a) $[\text{Zn}(\text{NH}_3)_4]^{2+}$
- b) $[\text{Co}(\text{NH}_3)_6]^{3+}$
- c) $[\text{Cr}(\text{NH}_3)_6]^{3+}$
- d) $[\text{V}(\text{NH}_3)_6]^{3+}$
25. In quantitative analysis of second group in lab, H_2S gas is passed. Cu^{2+} and Cd^{2+} react with KCN, then is which of the following condition, precipitate will not be formed due to relative stability ?
- a) $\text{K}_2[\text{Cu} (\text{CN})_4]$ – more stable $\text{K}_2[\text{Cd} (\text{CN})_4]$ – less stable
- b) $\text{K}_2[\text{Cu} (\text{CN})_4]$ – less stable $\text{K}_2[\text{Cd} (\text{CN})_4]$ – more stable
- c) $\text{K}_3[\text{Cu} (\text{CN})_4]$ – more stable $\text{K}_2[\text{Cd} (\text{CN})_4]$ less stable
- d) $\text{K}_2[\text{Cu}(\text{CN})_4]$ less stable $\text{K}_3 [\text{Cd} (\text{CN})_4]$ – more stable
26. According the Werner's theory, the primary valencies of the central metal atom
- a) are satisfied by negative ions
- b) are satisfied by negative ions or neutral

- molecule
- c) decide the geometry of the complex
- d) are equal to its co-ordination number
27. In an isomer of $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]$ two chlorine atoms and the cobalt atom are all colinear. This is a
- a) linkage isomer
- b) coordination sphere isomer
- c) trans isomer
- d) cis isomer
28. In $\text{Ni}(\text{CO})_4$, the oxidation state and coordination number of nickel is
- a) 0 and 2 respectively
- b) 0 and 4 respectively
- c) 2 and 4 respectively
- d) 0 and 4 respectively
29. The coordination number of a metal III coordination compound is
- a) sum of primary and secondary valencies
- b) same as the oxidation number of the central metal atom
- c) same as the primary valency
- d) same as the secondary valency
30. Which complex compound will give four isomers?
- a) $\text{Fe} (\text{en})_3 \text{Cl}_3$
- b) $[\text{Fe}(\text{PPh}_3)_3\text{NH}_3\text{ClBr}]\text{Cl}$
- c) $[\text{Co} (\text{en})_2\text{Cl}_2]\text{Cl}$
- d) $[\text{Co}(\text{PPh}_3)_3\text{Cl}] \text{Cl}_3$
31. Which of the following complex will give white precipitate with barium chloride solution ?
- a) $[\text{Cr}(\text{NH}_3)_5\text{Cl}]\text{SO}_4$
- b) $\text{Cr}(\text{NH}_3)\text{SO}_4\text{Cl}$
- c) $[\text{Co}(\text{NH}_3)_6]\text{Br}_3$
- d) None of these.
32. The IUPAC name of the complex $[(\text{CO})_3\text{Fe}(\text{CO})_3\text{Fe}(\text{CO})_3]$ is
- a) Nonacarbonyldiiron (0)
- b) Tricarbonyl iron (0) μ -tricarbonyl iron (0)
- c) Hexacarbonyl iron (0) μ -tricarbonyl iron (0)
- d) Hexacarbonyl μ -tncarbonyldiiron (0)
33. The brown ring test for NO_2^- and NO_3^- is due to the formation of complex ion with the formula
- a) $[\text{Fe}(\text{H}_2\text{O}) (\text{NO})_5]^{2+}$
- b) $[\text{Fe}(\text{H}_2\text{O})_5\text{NO}]^{2+}$
- c) $[\text{Fe}(\text{NO})(\text{CN})_5]^{2+}$
- d) $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$
34. Which one is an example of octahedral complex?
- a) FeF_6^{3-}

- b) $[\text{Zn}(\text{NH}_3)_4]^{2+}$
 c) $[\text{Ni}(\text{CN})_4]^{2-}$
 d) $[\text{Cu}(\text{NH}_3)_4]^{2+}$
35. Cr in $[\text{Cr}(\text{NH}_3)_6]\text{Br}_3$ has how many unpaired electrons ?
 a) 4
 b) 3
 c) 2
 d) 1
36. What is the name of the complex $[\text{Al}(\text{OH})_2(\text{H}_2\text{O})_4]_2\text{SO}_4$?
 a) B is [Tetrahydroxodioxo aluminate (III) sulphate
 b) Dihydroxotetrahydrido aluminium (III) sulphate,
 c) Tetraaquodihydroxo aluminium (III) sulphate
 d) Tetraaquolihydroxo aluminium (IV) sulphate
37. The IUPAC name of $[\text{Fe}_2(\text{CO})_4(\text{C}_5\text{H}_5)_2]$ is
 a) Cyclopentene tetracarbonyl iron (0)
 b) B is (η^5 -cyclopentadienyl) tetracarbonyl iron (0)
 c) B is (η^5 -cyclopentadienyl) tetracarbonyl iron (II)
 d) None of these.
38. $\text{K}_3[\text{Al}(\text{C}_2\text{O}_4)_3]$ is called
 a) potassium alumino-oxalate
 b) potassium alumino (III) oxalate
 c) potassium trioxalato aluminate
 d) potassium trioxalato aluminate (III)
39. The IUPAC name $[\text{CoCl}(\text{NO}_2)(\text{en})_2]\text{Cl}$ is
 a) bis (ethylene diammine) chloro nitro cobalt (III) chloride
 b) chlorobis (ethylene diammine) nitro cobalt (III) chloride
 c) chloro nitro bis (ethylene diammine) cobalt (II) chloride
 d) chloro nitro bis (ethylene diammine) cobalt (III) chloride
40. The IUPAC name of $[\text{Co}(\text{NH}_3)_3\text{ClBrNO}_2]$ will be
 a) Triamine bromochloro nitro cobalt (III)
 b) Triamine bromochloro cobaltate (III)
 c) Triamine nitro chloro cobalt (III)
 d) Triamine nitro chl oro bromo cobaltate (III)
41. Which of the following is correct value of x in $\text{Cr}(\text{CO})_x$?
 a) 2
 b) 4
 c) 6
 d) unpredictable
42. Polydentate ligands generally form complexes which have high formation constants as compared to monodentate ligands. This is due to 'chelate effect'. Which one of the following thermodynamic functions favours this the most ?
 a) ΔH
 b) ΔS
 c) $p\Delta V$
 d) T
43. The IUPAC name of $\text{Hg}[\text{Co}(\text{CNS})_4]$ is
 a) mercury tetra thiocyanatocobaltate (II)
 b) mercury cobalt (tetra sulphocyno (II)
 c) mercury tetra sulpho-cyanide cobaltate (II)
 d) mercury sulphocyno cobalt (II)
44. The IUPAC name of $[\text{Cr}(\text{en})_2]\text{Cl}_3$ is
 a) tris ethylene diammine chromium (III) chloride
 b) tris (ethylene diammine) chromium (III) chloride
 c) tris chlorotris ethylene diammine chromium, (III)
 d) tris (ethylene diammine) chromiumate (III) chloride
45. The number of isomers of the complex $[\text{Pt}(\text{NH}_3)_4][\text{CuCl}_4]$ are
 a) 2
 b) 3
 c) 4
 d) 5
46. The complexes, $[\text{PtCl}_2(\text{NH}_3)_4]\text{Br}_2$ and $[\text{PtBr}_2(\text{NH}_3)_4]\text{Cl}_2$ are
 a) Geometrical isomers
 b) Linkage isomers
 c) Ionisation isomers
 d) Co-ordination isomers
47. The oxidation number of Ni in the complex $\text{K}_4[\text{Ni}(\text{CN})_6]$ is
 a) -2
 b) -1
 c) 0
 d) +1
48. The formula of dicyanobis (oxalato) nicklate (II) is
 a) $\text{K}_3[\text{Ni}_2(\text{CN})_2(\text{OX})_2]$
 b) $\text{K}_4[\text{Ni}(\text{CN})_2(\text{OX})_2]$
 c) $\text{K}_2[\text{Ni}(\text{CN})_2(\text{OX})_2]$
 d) $\text{K}_4[\text{Ni}(\text{CN})(\text{OX})_2]$
49. Bonding in co-ordination compounds in solution is explained by
 a) valence bond theory
 b) crystal field theory
 c) ligand field theory
 d) all of these
50. A complex compound is made up of two ligands nitrate and chloride. It gives two mole precipitate of AgCl when reacts with AgNO_3 . The formula of the compound will be

- a) $[\text{Co}(\text{NH}_3)_5\text{NO}_3]\text{Cl}_2$
 b) $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{NO}_3\text{Cl}$
 c) $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]\text{Cl}]\text{NO}_3$
 d) $[\text{Co}(\text{NH}_3)_4\text{ClNO}_3]\text{Cl}$
51. The complexes $[\text{Pt}(\text{NH}_3)_4][\text{PtCl}_6]$ and $[\text{Pt}(\text{NH}_3)_4\text{Cl}_2]\text{C}_2\text{PtCl}_4$ are
 a) linkage isomers
 b) optical isomers
 c) co-ordination isomers
 d) ionisation isomers
52. Which among the following arrangement are geometrical isomers ?
- a)  b) 
- c)  c) All of these
53. Three arrangements have been shown for the complex cation bisethylenediaminedinitro cobalt (III). Which of the following is incorrect ?
- 
- a) I and III are geometrical isomers
 b) II and III are geometrical isomers
 c) I and II are geometrical isomers
 d) II and III are optical isomers
54. The number of geometrical isomers of the complex $[\text{Co}(\text{NO}_2)_3(\text{NH}_3)_3]$ is
 a) 4
 b) 3
 c) 2
 d) 0
55. Which type of isomerism is exhibited by the following pair of species $[(\text{PPh}_3)_2\text{Pd}(\text{SCN})_2]$ and $\{\text{P}(\text{C}_6\text{H}_5)_3\}_2\text{Pd}(\text{NCS})_2$?
 a) Co-ordination isomerism
 b) Linkage isomerism
 c) Geometrical isomerism
 d) Ionisation isomerism
56. Among the following compounds select those which are linkage isomers of each other ?
 a) $[\text{Co}(\text{NH}_3)_5\text{NO}_2]^{2+}$
 b) $[\text{Co}(\text{NH}_3)_5\text{ONO}]^{2+}$
 c) $[\text{Co}(\text{NH}_3)_5\text{Br}]^{2+}$
 d) Both a) and b)
57. Which of the following complex will show geometrical as well as optical isomerism ?
 a) $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$
 b) $[\text{Pt}(\text{NH}_3)\text{Cl}_4]$
 c) $[\text{Pt}(\text{en})_3]^{4+}$
 d) $[\text{Pt}(\text{en})^2\text{Cl}_2]$
58. A compound is made by mixing cobalt (III) nitrite and potassium nitrite solutions in the ratio of 1 : 3. The aqueous solution of the compound showed 4 particles per molecule whereas molar conductivity reveals the presence of six electrical charges. The formula of the compound is
 a) $\text{Co}(\text{NO}_2)_3 \cdot 2\text{KNO}_2$
 b) $\text{Co}(\text{NO}_2)_3 \cdot 3\text{KNO}_2$
 c) $\text{K}_3[\text{Co}(\text{NO}_2)_6]$
 d) $\text{K}[\text{Co}(\text{NO}_2)_4]$
59. The pair of compounds $[\text{Cr}(\text{H}_2\text{O})_6]\text{Cl}_3$ and $[\text{Cr}(\text{H}_2\text{O})_5\text{Cl}]\text{Cl}_2\text{H}_2\text{O}$.
 a) are hydration isomers
 b) have different colours
 c) have their 0.1 M aqueous solutions have same molar conductivity
 d) have different IUPAC names.
60. The formula of dichlorobis (urea) copper (II) is
 a) $[\text{Cu}(\text{O}=\text{C}(\text{NH}_2)_2)_2]\text{Cl}_2$
 b) $[\text{CuCl}_2(\text{O}=\text{C}(\text{NH}_2)_2)_2]$
 c) $[\text{Cu}(\text{O}=\text{C}(\text{NH}_2)_2)\text{Cl}]\text{Cl}$
 d) $[\text{CuCl}_2(\text{O}=\text{C}(\text{NH}_2)_2)_2]$
61. Organometallic compound is
 a) Nickel tetracarbonyl
 b) $[\text{Co}(\text{en})_3]\text{Cl}_3$
 c) Chlorophyll
 d) $\text{K}_3[\text{Fe}(\text{C}_2\text{O}_4)_3]$
62. Which of the following pairs contains only tetrahedral complexes ?
 a) $[\text{ZnCl}_4]^{2-}$ and $[\text{MnCl}_4]^{2-}$
 b) $[\text{Zn}(\text{NH}_3)_4]^{2+}$ and $[\text{Cu}(\text{NH}_3)_4]^{2+}$
 c) $[\text{MnCl}_4]^{2-}$ and $[\text{Ni}(\text{CN})_4]^{2-}$
 d) $[\text{ZnCl}_4]^{2-}$ and $[\text{Ni}(\text{CN})_4]^{2-}$
63. Which of the following complexes is inner orbital complex ?
 a) $\text{Ni}(\text{CO})_4$
 b) $[\text{Fe}(\text{CN})_6]^{4-}$
 c) $[\text{CoF}_6]^{3-}$
 d) $[\text{Ni}(\text{NH}_3)_6]^{2+}$
64. Among the complex ions given below which is/are outer-orbital complex ?
 a) $[\text{FeF}_6]^{3-}$
 b) $[\text{CoF}_6]^{3-}$
 c) $[\text{Fe}(\text{H}_2\text{O})_2]^{2+}$
 d) Both a) and b)
65. The number of geometrical isomers of

- $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$ is
 a) 1 b) 2
 c) 3 d) 4
66. The co-ordination number and oxidation state of chromium in $\text{K}_3\text{Cr}[\text{C}_2\text{O}_4]_3$ are respectively
 a) 6 and + 3 b) 3 and 0
 c) 4 and + 2 d) 3 and + 3
67. In which of the following pairs of species the number of unpaired electrons are same ?
 a) $[\text{CoF}_6]^{3-}$, $[\text{FeF}_6]^{3-}$
 b) $[\text{Fe}(\text{CN})_6]^{3-}$, $[\text{Fe}(\text{CN})_6]^{4-}$
 c) $[\text{Fe}(\text{CN})_6]^{4-}$, $[\text{Ni}(\text{CN})_4]^{2-}$
 d) $[\text{CoF}_6]^{3-}$, $[\text{Fe}(\text{CN})_6]^{3-}$
68. The tetracyanonickelate (II) ion is
 a) divalent anion
 b) a low spin complex
 c) diamagnetic in nature
 d) All of these
69. The tetrachlorocuprate (I) ion
 a) has tetrahedral geometry
 b) is a trivalent anion ,
 c) has two unpaired electrons
 d) none of these
70. Which is a bidentate ligand ?
 a) $\text{CH}_3\text{C} \equiv \text{N}$ b) CH_3NH_2
 c) Br^- d) $\text{C}_2\text{O}_4^{2-}$
71. Which of the following species combine to form ferrocene ?
 a) Fe^{3+} and two molecules of cyclopentadiene
 b) Fe and two C_5H_6 molecules
 c) Fe^{2+} ion and two cyclopentadienyl ions
 d) Fe^{2+} and two C_5H_6 molecules.
72. When a complex is formed by cyclopentadienyl ions and ferrous ions, then
 a) charge on the complex is + 2
 b) total charge on the complex is - 1
 c) the aqueous solution of the complex is highly electrical conducting
 d) complex represents sandwich compound.
73. What is false true about the complex $\text{K}_3[\text{Al}(\text{Ox})_3]$?
 a) It can show geometrical isomerism
 b) Co-ordination number of Al is 3
 c) Oxidation number of Al is + 3
 d) Its name is tripotassium trioxalato aluminate (III)
74. Which one of the following does not produce linkage isomers on coordination ?
 a) NO^- b) CNS
 c) CN d) SO_4^{2-}
75. The IUPAC name of complex compound $\text{K}_3[\text{Fe}(\text{CN})_6]$ is
 a) Potassium hexacyanoferrate (III)
 b) Potassium ferro cyanide iron (III)
 c) Potassium hexa cyno ferrate (II)
 d) Potassium cyno hexa ferrate (II)
76. When silver chloride dissolves in ammonium hydroxide forming a compound X, then
 a) X is a complex compound
 b) X is diamagnetic in nature
 c) X is cationic complex
 d) all of these
77. Which of the following complexes is/are polynuclear ?
 a) $[\text{Co}(\text{NH}_3)_6][\text{CoCl}_6]$
 b) $[\text{Pt}(\text{NH}_3)_4][\text{CuCl}_4]$
 c) $(\text{NH}_3)_5\text{Cr} - \text{O} - \text{O} - \text{Cr}(\text{NH}_3)_5$
 d) $[\text{Co}(\text{en})_2\text{Cl}_2\text{SO}_4]$
78. Which of the following complexes will exhibit optical isomerism?
 a) $[\text{Al}(\text{Ox})_3]^{3-}$
 b) $[\text{Co}(\text{EDTA})^-]$
 c)
 d) All of these
79. When the 3d-orbitals of a metal are split by the approach of the four ligands in tetrahedron environment, the number of d-orbitals lowered in energy are
 a) two b) three
 c) all five d) four
80. Which of the following will exhibit maximum ionic conductivity ?
 a) $\text{K}_4[\text{Fe}(\text{CN})_6]$ b) $[\text{Co}(\text{NH}_3)_6]\text{Cl}_6$
 c) $[\text{Cu}(\text{NH}_3)_4]\text{Cl}_2$ d) $[\text{Ni}(\text{CO})_4]$
81. In a complex $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$, the distance between Cl^- and Cl^- is 2.82 a. The possible geometry of the complex can be
 a) square pyramidal
 b) tetrahedral
 c) cis square planar
 d) trans square planar

82. Which one of the following is Zeisse's salt?
 a) $\text{Fe}(\text{n}^5\text{C}_3\text{H}_5)_2$ b) $\text{Cr}(\text{n}^6\text{C}^6\text{H}^6)_2$
 c) $[(\text{C}_2\text{H}_4)_4\text{PtCl}_3]^-$ d) Et_4Pb
83. The possible number of isomers for the complex $[\text{MCl}_2\text{Br}_2]\text{SO}_4$ is
 a) 1 b) 2
 c) 4 d) 5
84. In any ferric salt, on adding potassium ferrocyanide, the prussian blue is obtained is
 III II
 a) $\text{K}_3[\text{Fe}(\text{CN})_6]$ b) $\text{KFe}[\text{Fe}(\text{CN})_6]$
 c) $\text{FeSO}_4 \cdot \text{Fe}(\text{CN})_6$ d) $\text{Fe}_4[\text{Fe}(\text{C})_6]_3$
85. Of the following, Wilkinsons's catalyst is
 a) Ph_3P b) $(\text{PH}_3\text{P})_3$
 c) $(\text{PH}_3\text{P})_3 \text{Rh Cl}$ d) None of these
86. Haemoglobin is a complex compound with a metal in the centre. The metal is
 a) Mg b) Ca
 c) K d) Fe
87. For an octahedral complex which one of the following electronic configurations predicts it to be diamagnetic ?
 a) d^8 high spin b) d^4 low spin
 c) d^6 low spin d) d^3 (low or high spin)
88. Which of the following complex has square planar structure ?
 a) $\text{Ni}(\text{CO})_4$ b) $[\text{NiCl}_4]^{2-}$
 c) $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$ d) $[\text{Cu}(\text{NH}_3)_4]^{2+}$
89. Amongst the following ions which one has the highest paramagnetism?
 a) $[\text{Cr}(\text{H}_2\text{O})_6]^{3+}$ b) $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$
 c) $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ d) $[\text{Zn}(\text{H}_2\text{O})_6]^{2+}$

Answer Key

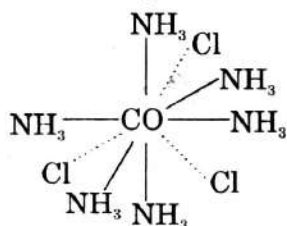
Q.No.	Asn	Q.No.	Asn	Q.No.	Asn
1.	c)	2.	c)	3.	b)
4.	c)	5.	d)	6.	d)
7.	b)	8.	c)	9.	d)
10.	b)	11.	c)	12.	c)
13.	d)	14.	c)	15.	c)
16.	d)	17.	d)	18.	c)
19.	d)	20.	a)	21.	b)
22.	b)	23.	b)	24.	d)
25.	c)	26.	a)	27.	c)
28.	b)	29.	d)	30.	b)
31.	a)	32.	d)	33.	b)
34.	a)	35.	b)	36.	c)
37.	c)	38.	d)	39.	b)
40.	a)	41.	c)	42.	a)
43.	a)	44.	b)	45.	b)
46.	c)	47.	b)	48.	b)
49.	d)	50.	a)	51.	c)
52.	d)	53.	b)	54.	c)
55.	b)	56.	d)	57.	d)
58.	c)	59.	c)	60.	d)
61.	c)	62.	a)	63.	b)
64.	a)	65.	b)	66.	a)
67.	c)	68.	d)	69.	b)
70.	d)	71.	c)	72.	d)
73.	c)	74.	d)	75.	a)
76.	d)	77.	c)	78.	d)
79.	a)	80.	a)	81.	c)
82.	c)	83.	b)	84.	b)
85.	c)	86.	d)	87.	c)
88.	d)	89.	b)		



EXPLANATIONS

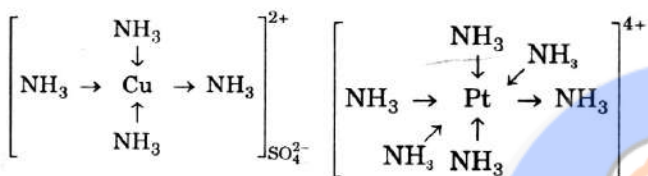
2. 2, 2-Dipyridyl is a bidentate ligand and also causes chelation.

3. The complex can be represented as



In this, three dotted lines indicate the three primary valencies (or oxidation state) of cobalt; while six thick lines indicate its secondary valency or coordination number.

4. The ammine complex of given Cu and Pt complex can be represented as



5. Maximum number of isomers are possible for $[\text{Cr}(\text{SCN})_2(\text{NH}_3)_4]^+$ i.e., cis, trans and linkage isomers.

6. Glycinate is an unsymmetrical bidentate ligand.

7. 2, 2-dipyridyl is a bidentate ligand.

10. Oxalate ion ($\text{C}_2\text{O}_4^{2-}$) is a bidentate ligand, so is $[\text{Ni}(\text{C}_2\text{O}_4)_3]^{4-}$, Ni^{2+} ion has co-ordination number 6.

11. The complex is $\text{K}_4[\text{Mo}(\text{CN})_8]$. Hence oxidation number of Mo is 8.

13. (a) is tetradentate, (b) is pentadentate and (c) is tridentate.

14. The $-\text{NO}_2$ group can bind to the metal either through nitrogen or through oxygen.

15. Both σ and π -bonds are present in the organometallic compound $[\text{Co}(\text{CO})_5\text{NH}_3]^{2+}$ in which Co atom is attached with NH_3 by σ -bonds while CO is attached by π bonds.

16. Since oxidation number of cobalt is +3 and that of Cd is +2. Thus charge on $[\text{CdCl}_x]^{3-}$ should be -3. Hence, $x + 2 = -3$, or $x = 5$.

18. Only cis $[\text{Co}(\text{en})_3]^{3+}$ which gives non-super imposable mirror image represents dextro and levo form.

20. $[\text{Ni}(\text{CO})_4]$ has Ni atom in zero oxidation state and hybridization is sp^3 . So it has tetrahedral shape and diamagnetic behaviour.

21. It is phenanthroline with two coordinating sites.

22. Oxidation number of Ni in $\text{Ni}(\text{CO})_4$ is 0; in $\text{K}_2[\text{NiF}_6]$ it is +4. In $[\text{Ni}(\text{NH}_3)_6](\text{BF}_4)_2$ it is +2 and in $\text{K}_4[\text{Ni}(\text{CN})_6]$ it is +2.

23. Complex ion contains

(i) ethylene diamine (en) which is neutral

(ii) two aquo molecules which is also neutral

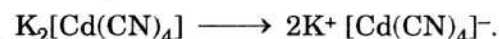
(iii) a nitrogroup which carries -1 charge and

(iv) a chloro group which also carries -1 charge.

Although the ligands carry -2 charge but on the whole complex ion carries +2 charge. This suggests that platinum carries +4 charge,

$$[x + 0 + 0 + (-1) + (-1)] = +2 \text{ or } x = 4]$$

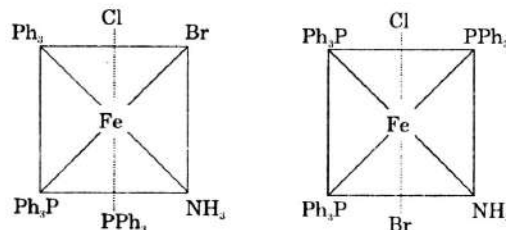
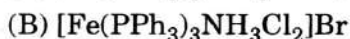
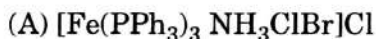
25. $\text{K}_3[\text{Cu}(\text{CN})_4]$ do not dissociate easily as $\text{K}_2[\text{Cd}(\text{CN})_4]$ does.



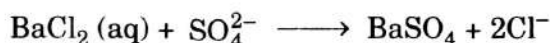
28. The complex contains four carbonyl groups, hence its coordination number is 4. Since carbonyl is a neutral ligand and the complex does not carry electric charge on it therefore, nickel atom must be neutral, i.e. it is in zero oxidation state.

29. Metal possesses two types of linkages—Primary and secondary. The primary linkage is ionisable and the secondary linkage is non-ionizable. Every metal has a fixed number of secondary linkages. The primary linkages are satisfied by negative ions and the secondary linkages are satisfied by negative or neutral groups.

30. The complex amine bromo chloro tris (Triphenyl phosphine) Iron (II) chloride will show geometrical and ionisation isomerism



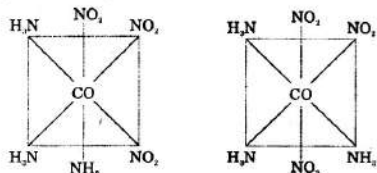
31. $[\text{Cr}(\text{NH}_3)_5\text{ClSO}_4]$ ionises as $[\text{Cr}(\text{NH}_3)_5\text{Cl}]^{2+}$ and SO_4^{2-} and its aqueous solution will give test for SO_4^{2-} ions.



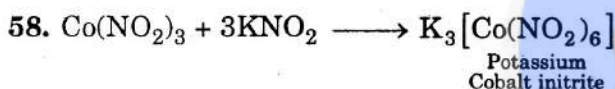
9.10

CO-ORDINATION COMPOUNDS

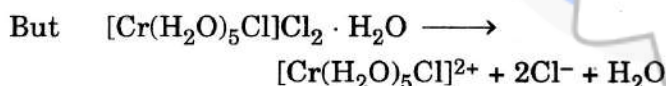
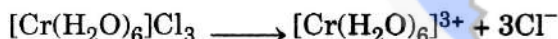
34. $[\text{FeF}_6]^{3-}$ is sp^3d^2 hybridised.
35. The oxidation state of Cr in $[\text{Cr}(\text{NH}_3)_6]\text{Br}_3$ is +3 and configuration of Cr^{3+} is $1s^2 2s^2 2p^6 3p^6 3d^3$. So there are three unpaired electrons.
41. Following EAN rule, the value of x should be 6.
46. These produce different ions in aqueous solutions.
54. Number of geometrical isomers of the complex $[\text{Co}(\text{NO}_2)_3(\text{NH}_3)_3]$ is two i.e. cis and trans.



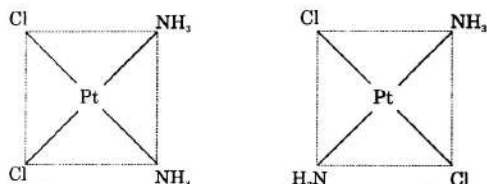
57. $[\text{Pt}(\text{en})_2\text{Cl}_2]$ will show two geometrical forms and cis form will show optical isomerism.



59. Their molar conductivities are different because they contain different number of ions



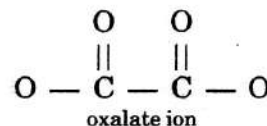
63. $[\text{Fe}(\text{CN})_6]^{4-}$ is inner orbital complex.
65. Two geometrical isomers are possible for $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$. These are



67. Both $[\text{Fe}(\text{CN})_6]^{4-}$ and $[\text{Ni}(\text{CN})_4]^{2-}$ have five unpaired electrons.

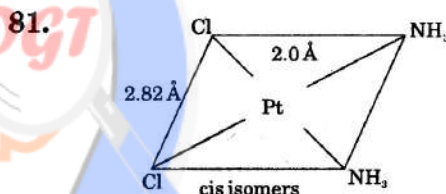
69. The ion is $[\text{Cu}(\text{Cl}_4)]^{3-}$. It is a trivalent anion.

70. $\text{C}_2\text{O}_4^{2-}$ has two co-ordination sites, so it is a bidentate ligand, which has two oxygen atoms for binding with metal ion.



71. Ferrocene is made of Fe^{2+} and two $(\text{C}_5\text{H}_5)^-$ ions.
74. (a), (b) and (c) are ambident nucleophiles, which attack on both sides; hence give linkage isomerism.

78. a, b, c have chiral structures and hence show enantiomerism. c also has one optically inactive form called meso form in addition to two enantiomeric forms.

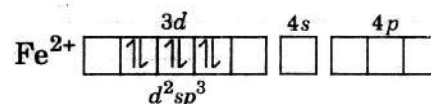


82. (a) is Ferrocene, (b) is dibenzene chromium, (d) is lead tetraethyl.

83. $[\text{MCl}_2\text{Br}_2]\text{SO}_4$ gives $[\text{MCl}_2\text{BrSO}_4]\text{Br}$ and $[\text{MClBr}_2\text{SO}_4]\text{Cl}$ as ionization isomers and also cis and trans geometrical isomers are expected.

84. Prussian blue is $\text{KFe}^{\text{III}}[\text{Fe}^{\text{II}}(\text{CN})_6]$

87. In $\text{K}_4[\text{Fe}(\text{CN})_6]$, Fe^{2+} is in divalent state.



After rearrangement against Hund's rule.

88. $[\text{Cu}(\text{NH}_3)_4]^{2+}$ is square planar structure.

89. Among the given species $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$ has maximum number of unpaired electrons.