

● **Complex salt and double salt**

The salt that is obtained according to the laws of chemical combination by combination of two or more salts (compounds) having independent existence and maintains the properties of the original salts is called double salt. When $(n-1)d$, ns and np or ns , np and nd orbitals of the atoms or ions of transition elements are vacant, these transition elements accept electron pairs from negative ions or neutral molecules, which are called complex compounds. The differences between double salt and complex salt are as under :

Double Salt	Complex Salt
(i) The salt that is obtained by combination of two or more salts maintains the properties of original salts is called double salt	(i) The salt that is obtained by combination of two or more compounds with new properties are called complex salt.
(ii) They exist as crystal and get dissociated when they are dissolved in water or other solvent.	(ii) They exist as solid or solution even in solution complex ion is not dissociate.
(iii) Metal ion possesses their common valency.	(iii) Metal ion possesses two types of valency, primary and secondary.
(iv) Double salt lose their properties in solution.	(iv) Complex salt do not lose their properties in solution.
(v) Double salt is ionic compound which do not possesses co-ordinate bond.	(v) Complex salt is ionic or nonionic which possesses co-ordinate bond.

- **Werner theory** : Metal ion possesses two types of valency, primary and secondary valency.

Primary valency : It is equal to positive charge of metal ion which formed ionic bond and ionisable. Primary valency is satisfied by only negative ions and it is also known as oxidation number of metal.

Secondary valency : It depends on vacant orbital of metal ion. It is satisfied by negative ion or neutral molecule which is nonionisable. Secondary valency indicates co-ordination number of metal which has directional property. Secondary valency of metal is definite, transition metal ion can possess more than one co-ordination number.

Ligand and their classification : Negative ion or neutral molecule which bound to the metal ion by secondary valency is called as ligand. In complex, metal ion acts as Lewis acid and ligand act as Lewis base. Ligand are classified according to number of electron pair donating atom in them.

Unidentate Ligand : The ligand which can from one atom donates one electron pair and form co-ordinate covalent bond is called unidentate ligand.

Didentate Ligand : The ligand which can donate two electron pairs to metal ion and form two co-ordinate covalent bond is called didentate ligand.

Polydentate Ligand : The ligand in which two or more co-ordination sites are there or the ligand in which two or more atoms donate electron pairs to metal ion and form co-ordinate covalent bond is called polydentate ligand.

Polydentate ligand forms cyclic structure with metal ion and form chelate.

Unidentate negative ligand

Name	formula	electric charge	Name in Complex	Co-ordination site
Halide ion	X (Cl, Br, I)	-1	Halido	X
Hydroxide ion	OH ⁻	-1	Hydroxo	O
Cyanide ion	- CN ⁻¹	-1	Cyano	C
Isocyanide	NC ⁻	-1	Isocyano	N
Nitro ion	NO ₂ ⁻	-1	Nitro	N
Nitrito ion	ONO ⁻	-1	Nitrito	O
Thiocyanate ion	SCN ⁻	-1	Thiocyano	S
Hydride ion	H ⁻	-1	Hydrido	H
Amide ion	NH ₂ ⁻	-1	Amido	N
Acetate ion	CH ₃ COO ⁻	-1	Acetato	O
Nitrate ion	NO ₃ ⁻	-1	Nitrato	O
Cyanate ion	ONC ⁻	-2	Cyanato	O
Oxide ion	O ⁻²	-2	Oxo	O
Peroxide ion	O ₂ ⁻²	-2	Peroxo	O
Sulphide ion	S ⁻²	-2	Sulphido	S
Thiosulphate ion	S ₂ O ₃ ²⁻	-2	Thio sulphato	S
Imine ion	NH ⁻²	-2	Imido	N
Nitride	N ⁻³	-3	Nitrido	N

Unidentate neutral ligand

Name and symbol of ligand	Formula	Name of Lig. in complex	Co-ordination site
Ammonia	NH ₃	Ammine	N
Water	H ₂ O	Aqua	O
phosphine	PH ₃	Phosphine	P
Nitrogen oxide	NO	Nitrosyl	N
Carbon monoxide	CO	Carbonyl	C
Pyridene (Py)	C ₅ H ₅ N	Pyridene	N
Thiourea (tu)	$\begin{array}{c} \text{H}_2\text{N} - \text{C} - \text{NH}_2 \\ \parallel \\ \text{S} \end{array}$	Thiourea	S
Triphenyl phosphine	(C ₆ H ₅) ₃ P or (Ph) ₃ P	Triphenyl phosphane	P
Thiocarbonyl	CS	Thiocarbonyl	S

Didentate Ligand

Name	formula	electric charge	Name of ligand in complex	Co-ordination site
Oxalate ion	OX^{2-} OR COO^- $\begin{array}{c} \\ \text{COO}^- \end{array}$	-2	Oxalato	O
Sulphate ion	SO_4^{2-}	-2	Sulphato	O
Carbonate ion	CO_3^{2-}	-2	Carbonato	O
Ethane 1, 2-diamine	$\begin{array}{c} \text{CH}_2 - \text{CH}_2 \\ \quad \quad \\ \text{NH}_2 - \text{NH}_2 \end{array}$	0	Ethane 1, 2-diamine	N
Glycinate ion	$\text{H}_2\text{N} - \text{CH}_2 - \text{COO}^-$	-1	Glycinate	N and O

Tridentate ligand : Ptn , PO_4^{3-} , AsO_4^{3-} , BO_3^{3-}

Hexadentate ligand : EDTA^{4-}

Positive charge ligand : NO_2^+ , NO^+ , N_2H_5^+

● Stability of complex compound :

As the strength of different ligands to form co-ordinate covalent bond varies, stronger ligand possesses more attraction with metal ion. As a result complexes having stronger ligand possess more stability. The basis of strength of ligand can be determined by same metal ion combined with different ligands.

● The order of strength of ligand :



order of stability of complex ion



- $\text{CuSO}_4 + 4 \text{NH}_{3(\text{aq})} \rightarrow [\text{Cu}(\text{NH}_3)_4]_{(\text{aq})}^{2+} + \text{SO}_4^{2-}_{(\text{aq})}$ in the reaction which of the following acts as Lewis acid ?
 (A) NH_3 (B) Cu^{2+} (C) SO_4^{2-} (D) $[\text{Cu}(\text{NH}_3)_4]^{2+}$
- In complex compound ligand is also known as
 (A) Lewis acid (B) Lewis base (C) Bronsted acid (D) Bronsted base
- How many total ions are formed by ionisation of $[\text{Co}(\text{NH}_3)_6] \text{Cl}_3$?
 (A) 9 (B) 3 (C) 4 (D) 6
- Which of the following will give white precipitates with complex formed by mixing of aqueous solution of CuSO_4 and NH_3 ?
 (A) BaCl_2 (B) AgNO_3 (C) KI (D) HCl
- What is the co-ordination number and oxidation number of Cr in $[\text{Cr}(\text{NH}_3)_4 \text{SO}_4] \text{Br}$?
 (A) 6 and 2 (B) 6 and 3 (C) 4 and 6 (D) 6 and 4
- Oxidation state of Ni in $[\text{Ni}(\text{CO})_4]$ is ?
 (A) +2 (B) -2 (C) 0 (D) 4

7. In which of following complex, oxidation number of metal ion is zero ?
 (A) $\text{Fe}(\text{CO})_5$ (B) $[\text{Ag}(\text{NH}_3)_2]\text{Cl}$
 (C) $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$ (D) $\text{K}_3[\text{Fe}(\text{CN})_6]$
8. What is the co-ordination number of metal ion in octahedral complex ?
 (A) 4 (B) 2 (C) 5 (D) 6
9. Number of unidentate ligand in complex compound is known as
 (A) oxidation number (B) primary valency
 (C) secondary valency (D) tertiary valency
10. Which ligand cannot form chelate ?
 (A) SO_4^{2-} (B) Ox^{2-} (C) O^{2-} (D) CO_3^{2-}
11. Among the given ligand which one has highest number of co-ordination site ?
 (A) en (B) Pn (C) Ptn (D) EDTA^{4-}
12. Which ligand cannot form complex having cyclic structure ?
 (A) Acetate (B) Oxalate
 (C) Ethylene diamine (D) Propylene triamine
13. In which of the following complex the primary valency of metal atom is highest ?
 (A) $\text{K}_2[\text{Cr}_2\text{O}_7]$ (B) $\text{K}[\text{MnO}_4]$
 (C) $\text{K}_3[\text{Fe}(\text{CN})_6]$ (D) $[\text{Mn}(\text{en})_3]\text{Cl}_3$
14. Which of the following is not a tridentate ligand ?
 (A) PO_4^{3-} (B) AsO_4^{3-} (C) N^{3-} (D) BO_3^{3-}
15. Which ligand is required in least number to satisfy secondary valency of metal atom in complex compound ?
 (A) NH_3 (B) en (C) Ptn (D) Pn
16. Which of the following is most stable complex compound ?
 (A) $[\text{NiCl}_4]^{2-}$ (B) $[\text{NiF}_4]^{2-}$ (C) $[\text{Ni}(\text{H}_2\text{O})_4]^{2+}$ (D) $[\text{Ni}(\text{CN})_4]^{2-}$
17. Which is the correct order of strength of ligand for stability of complex compounds ?
 (A) $\text{Cl}^- < \text{H}_2\text{O} < \text{OH}^- < \text{NH}_3$ (B) $\text{Cl}^- < \text{OH}^- < \text{H}_2\text{O} < \text{NH}_3$
 (C) $\text{OH}^- < \text{H}_2\text{O} < \text{Cl}^- < \text{NH}_3$ (D) $\text{OH}^- < \text{Cl}^- < \text{H}_2\text{O} < \text{NH}_3$

Answers : 1. (B), 2. (B), 3. (C), 4. (A), 5. (B), 6. (C), 7. (A), 8. (D), 9. (C), 10. (C), 11. (D), 12. (A), 13. (B), 14. (C), 15. (C), 16. (D), 17. (A)

● Geometrical structure of complex ion :

Geometrical structure of complex depend on magnetic property and hybridisation. In complex if strong ligand combines with metal ion having co-ordination number 4 then hybridisation is dsp^2 and shape is square planar. eg. $[\text{Ni}(\text{CN})_4]^{2-}$. If weak ligand combines with metal ion having co-ordination number 4 then hybridisation is sp^3 and shape is tetrahedral e.g. $[\text{NiCl}_4]^{2-}$. In complex if strong ligand combines with metal ion having co-ordination number 6 then hybridisation is sp^3d^2 and shape is octahedral. e.g. $[\text{Fe}(\text{CN})_6]^{3-}$. In complex ion MnO_4^- and CrO_4^{2-} hybridisation is d^3s , there is no unpaired electron in Mn^{+7} and Cr^{+6} but they are coloured due to d-d transition by electrons of ligand.

Hybridisation and magnetic properties in complex compound

Complex ion	metal ion	Electron configuration of metal ion	Hybridisation	Number of unpair electron	Magnetic property
$[V(H_2O)_6]^{3+}$	V^{3+}	d^2	d^2sp^3	2	diamagnetic
$[Cr(NH_3)_6]^{3+}$	Cr^{3+}	d^3	d^2sp^3	3	diamagnetic
$[MnF_6]^{3-}$	Mn^{3+}	d^4	sp^3d^2	4	diamagnetic
$[Mn(CN)_6]^{3-}$	Mn^{3+}	d^4	d^2sp^3	2	diamagnetic
$[Fe(CN)_6]^{3-}$	Fe^{3+}	d^5	d^2sp^3	1	diamagnetic
$[FeF_6]^{3-}$	Fe^{3+}	d^5	sp^3d^2	5	diamagnetic
$[FeCl_4]^{2-}$	Fe^{+2}	d^6	sp^3	4	diamagnetic
$[CoF_6]^{3-}$	Co^{3+}	d^6	sp^3d^2	4	diamagnetic
$[Co(NH_3)_6]^{3+}$	Co^{3+}	d^6	d^2sp^3	0	paramagnetic
$[Ni(NH_3)_6]^{2+}$	Ni^{2+}	d^8	sp^3d^2	2	diamagnetic
$[NiCl_4]^{2-}$	Ni^{+2}	d^8	sp^3	2	diamagnetic
$[Ni(CN)_4]^{2-}$	Ni^{+2}	d^8	dsp^2	0	paramagnetic
$[Ni(CO)_4]$	Ni	$3d^8 4s^2$	sp^3	0	paramagnetic
$[CuCl_4]^{2-}$	Cu^{2+}	d^9	sp^3	1	diamagnetic
$[Zn(NH_3)_4]^{2+}$	Zn^{2+}	d^{10}	sp^3	0	paramagnetic

19. Which of the following complex is linear ?
 (A) $[Ag(NH_3)_2]Cl$ (B) $[Ni(CO)_4]$ (C) $[Fe(CO)_5]$ (D) $[Cr(CO)_6]$
20. Which of the following complex possess square planar shape ?
 (A) $[Ni(NH_3)_2Cl_2]$ (B) $K_4[Ni(CN)_4]$ (C) $K_2[NiCl_4]$ (D) $K[MnO_4]$
21. Which of the following is the hybridisation of metal ion in $[Cu(NH_3)_4]^{2+}$ complex ion ?
 (A) sp^3 (B) d^3s (C) dsp^2 (D) sp^2d
22. In which of the following complex hybridisation of metal is d^3s ?
 (A) $K[MnO_4]$ (B) $K_2[NiCl_4]$ (C) $K_2[NiF_4]$ (D) $K_2[Ni(CN)_4]$
23. How many unpaired electrons are in valence orbital of complex hexa aqua ferrate (III) ion ?
 (A) 1 (B) 3 (C) 5 (D) 4
24. Which one is not an inner orbital complex ?
 (A) $[Co(NH_3)_6]^{3+}$ (B) $[Ni(NH_3)_2Cl_2]$ (C) $[Fe(CN)_6]^{3-}$ (D) $[FeF_4]^{2-}$
25. Which complex has highest magnetic moment (only spin) ?
 (A) $[Fe(H_2O)_6]^{3+}$ (B) $[Co(NH_3)_6]^{2+}$ (C) $[Fe(CN)_6]^{3-}$ (D) $[Co(NH_3)_3Cl_3]$
26. Which of the following complex is paramagnetic ?
 (A) $[Ni(NH_3)_2Cl_2]$ (B) $K_2[NiCl_4]$ (C) $[Ni(NH_3)_4]Cl_2$ (D) $K_2[CoCl_4]$
27. Which complex has magnetic moment (only spin) 2.83 B.M. ?
 (A) $[Ni(CO)_4]$ (B) $[NiCl_4]^{2-}$ (C) $[Ni(CN)_4]^{2-}$ (D) $[Ni(NH_3)_4]^{2+}$
28. What is the theoretical magnetic moment of complex $[Cr(CO)_6]$?
 (A) 0 (B) 1.73 (C) 5.92 (D) 4.90

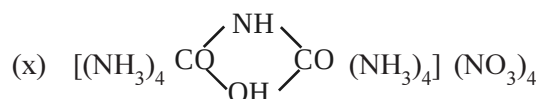
29. Which is the correct statement for complex compound $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$?
 (A) Its shape is octahedral and hybridisation is d^2sp^3 .
 (B) It is paramagnetic.
 (C) It is valence orbital complex.
 (D) It gives white precipitates with AgNO_3 .
30. Which of the following complex is diamagnetic ?
 (A) $[\text{Fe}(\text{CN})_6]^{3-}$ (B) $[\text{FeF}_6]^{3-}$ (C) $[\text{CoF}_6]^{3-}$ (D) $[\text{Fe}(\text{CN})_6]^{4-}$
31. How many unpaired electrons are in $[\text{Fe}(\text{CO})_5]$ complex ?
 (A) zero (B) five (C) four (D) three
32. In which of the following pairs the possible oxidation state of metals is highest ?
 (A) $\text{K}_2[\text{Cr}_2\text{O}_7]$ and $[\text{Mn}(\text{en})_3]\text{Cl}_3$ (B) $\text{K}[\text{MnO}_4]$ and $[(\text{Cr}(\text{NH}_3)_6)]\text{Cl}_3$
 (C) $\text{K}[\text{MnO}_4]$ and $\text{K}_2[\text{Cr}_2\text{O}_7]$ (D) $[\text{Cr}(\text{NH}_3)_6]\text{Cl}_3$ and $[\text{Mn}(\text{en})_3]\text{Cl}_3$
33. Which of the following complex is coloured and does not possess unpaired electron in d-orbital ?
 (A) $[\text{Mn}(\text{en})_3]\text{Cl}_3$ (B) $\text{K}[\text{MnO}_4]$ (C) $[\text{Cr}(\text{NH}_3)_6]\text{Cl}_3$ (D) $\text{K}_3[\text{Fe}(\text{CN})_6]$
34. Which of the following is diamagnetic and tetrahedral complex ?
 (A) $[\text{Ni}(\text{CO})_4]$ (B) $[\text{Ni}(\text{NH}_3)_2\text{Cl}_2]$ (C) $\text{K}_2[\text{Ni}(\text{CN})_4]$ (D) $\text{K}_2[\text{NiCl}_4]$

Answers : 19. (A), 20. (A), 21. (A), 22. (A), 23. (C), 24. (D), 25. (A), 26. (D), 27. (B), 28. (A), 29. (B), 30. (D), 31. (A), 32. (C), 33. (B), 34. (A)

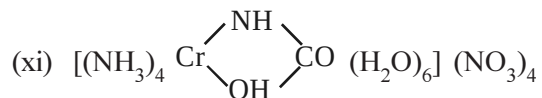
● IUPAC Nomenclature of complex compounds

In nomenclature of co-ordination compounds the name of ligand according to English alphabets is written first and then the name of the metal is written. For the ligands having negative electric charge, the suffix 'O' is joined with the name of the ligand. The neutral ligand is shown according to its original name. If the number of ligand of only one type is more than 1, then according to number of ligand 2, 3, 4 the words di, tri, tetra are used as prefix. If organic ligand is present and the prefix is a number then ligand is placed in bracket and for number 2, 3, 4 etc. corresponding bis, tris, tetrakis prefix are added. If the complex is negative ion, then write names of ligand Alphabetically, the suffix 'ate' is joined with metal ion and then its oxidation state is shown in () bracket in Roman number. If the complex is positive ion or neutral molecule then first write the name of ligand Alphabetically. The name of metal is added at the end and its oxidation state is shown in () bracket in Roman number.

- (i) $[\text{Co}(\text{NH}_3)_5\text{Cl}]^{2+}$: Penta ammine chlorido cobalt (III) ion
 (ii) $[\text{Co}(\text{NH}_3)_3\text{Cl}(\text{CN})\text{NO}_2]$: Triammine chlorido cyano nitrito cobalt (III)
 (iii) $[\text{Cr}(\text{H}_2\text{O})\text{Cl}(\text{en})_2]^{2+}$: Aqua chlorido bis (ethane-1, 2-diamine) chromium (III) ion
 (iv) $[\text{Ag}(\text{CN})_2]^-$: Dicyano argentate (I) ion
 (v) $\text{K}_3[\text{Fe}(\text{C}_2\text{O}_4)_3]$: Potassium tris (oxalato) ferrate (III)
 (vi) $\text{Na}[\text{Au}(\text{CN})_2]$: Sodium dicyano Aurate (III)
 (vii) $\text{Ca}_2[\text{Fe}(\text{CN})_6]$: Calcium hexacyano ferrate (II)
 (viii) $[\text{Cr}(\text{NH}_3)_3(\text{H}_2\text{O})_3]\text{Cl}_3$: Triammine triaqua chromium (III) chloride
 (ix) $[\text{Pt}(\text{NH}_3)_4][\text{PtCl}_4]$: Tetra ammine platinum (II) tetrachloride platinate (II)



Tetra ammine cobalt (III) - μ - amido-
 μ - nitrito tetra ammine cobalt (III) nitrate



Tetra ammine chromium (III) - μ - amido -
 μ - hydroxo tetra aqua cobalt (III) nitrate

● Isomerism in complex compounds

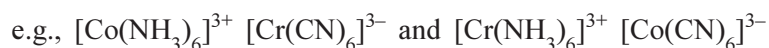
Geometrical isomerism : Geometrical isomerism is generally observed in square planar and octahedral complex. In MA_2B_2 and MA_4B_2 complex compound cis and trans isomerism are produced. In MA_3B_3 complex compound facial and meridional isomerism are produced.

Optical isomerism : Optical isomerism is generally observed in octahedral chelate ions. There are certain complex compounds in which molecular formula and structural formulas are same, but the two isomers produced because of different orientation of ligands in it. They are mirror images to each other and the superimposition of two isomer on each other is not possible. This type of complex ion possess chirality. If it rotates plane of polarised light on left side, then that isomer is called *l* (leavo) or $(-)$ and one which rotates plane of polarised light on right side than that isomer is called *d* (dextro) or $(+)$. Trans isomer is optically inactive.

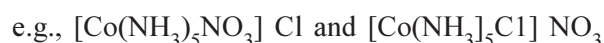
● Structural isomerism :

(i) Linkage isomerism : When unidentate ligand having two different co-ordination sites combine with metal ion by different atom formed isomer which are called as linkage isomer e.g. $[\text{Co}(\text{NO}_2)(\text{NH}_3)_5]^{2+}$ and $[\text{Co}(\text{ONO})(\text{NH}_3)_5]^{2+}$

(ii) Co-ordination isomerism : When in co-ordination compounds, both positive ion and negative ion are complex ion then there is exchange between the two in the co-ordination sphere and isomers are formed. Which are called co-ordination isomers.



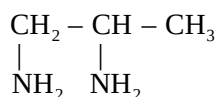
(iii) Ionisation isomerism : The compounds whose proportion by weight and the component are same but they give different ions in solution, then that type of isomerism is called ionisation isomerism.



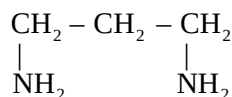
(iv) Hydration isomerism : This type of isomerism is a special type of ionisation isomerism. In which number of water molecules inside and outside of co-ordination sphere are different



(v) **Ligand isomerism** : Isomerism produced due to ligand which are isomer of each other in complex is known as ligand isomerism.



propane 1, 2-diamine



propane 1, 3-diamine

e.g. $[\text{Co}(\text{propane 1, 2-diamine})\text{Cl}_2]^+$ and $[\text{Co}(\text{propane 1, 3-diamine})\text{Cl}_2]^+$

35. Which is correct IUPAC name of $\text{NH}_4[\text{Co}(\text{NH}_3)_2(\text{OX})_2]$?
 (A) Ammonium di ammine bis oxalato cobaltate (III)
 (B) Ammonium di ammine di oxalato cobaltate (II)
 (C) Ammonium di oxalato di ammine cobaltate (III)
 (D) Ammonium di oxalato di ammine cobaltate (II)
36. Which of the following is correct molecular formula for tetra ammine chlorido nitrito chromium (III) nitrate ?
 (A) $[\text{Cr}(\text{NH}_3)_4(\text{ONO})\text{Cl}]\text{NO}_3$
 (B) $[\text{Cr}(\text{NH}_3)_4\text{NO}_2\text{Cl}]\text{NO}_3$
 (C) $[\text{Cr}(\text{NH}_3)_4\text{NO}_3\text{Cl}]\text{NO}_2$
 (D) $[\text{Cr}(\text{NH}_3)_4\text{ONOC}]\text{NO}_3$
37. Which of the following is IUPAC name of $[(\text{en})_2 \text{Co} \begin{array}{c} \text{NH} \\ \diagup \quad \diagdown \\ \text{CO} \quad \text{CO} \\ \diagdown \quad \diagup \\ \text{OH} \end{array} (\text{en})_2]^{+3}$?
 (A) Bis (ethane 1, 2-diamine) cobalt (III) – μ – imido – μ – hydroxo bis (ethane 1, 2 diamine) cobalt (III) ion
 (B) Bis (ethane 1, 2-diamine) cobalt (III) – μ – amido – μ – hydroxo bis (ethane 1, 2 diamine) cobalt (III) ion
 (C) Bis (ethane 1, 2-diamine) cobalt (III) – μ – imido hydroxo bis (ethane 1, 2 diamine) cobalt (III) ion
 (D) Bis (ethane 1, 2-diamine) cobalt (III) – μ – hydroxo amido bis (ethane 1, 2 diamine) cobalt (III) ion
38. Correct formula of tetra ammine cobalt (III) – μ – amido nitrato tetra ammine cobalt (III) nitrate is
 (A) $[(\text{NH}_3)_4 \text{Co} \begin{array}{c} \text{NH}_2 \\ \diagup \quad \diagdown \\ \text{CO} \quad \text{CO} \\ \diagdown \quad \diagup \\ \text{NO}_2 \end{array} (\text{NH}_3)_4] (\text{NO}_3)_4$
 (B) $[(\text{NH}_3)_4 \text{Co} \begin{array}{c} \text{NH} \\ \diagup \quad \diagdown \\ \text{CO} \quad \text{CO} \\ \diagdown \quad \diagup \\ \text{NO}_2 \end{array} (\text{NH}_3)_4] (\text{NO}_3)_3$
 (C) $[(\text{NH}_3)_4 \text{Co} \begin{array}{c} \text{NH} \\ \diagup \quad \diagdown \\ \text{CO} \quad \text{CO} \\ \diagdown \quad \diagup \\ \text{NO}_2 \end{array} (\text{NH}_3)_4] (\text{NO}_3)_2$
 (D) $[(\text{NH}_3)_4 \text{Co} \begin{array}{c} \text{NH}_2 \\ \diagup \quad \diagdown \\ \text{CO} \quad \text{CO} \\ \diagdown \quad \diagup \\ \text{NO}_2 \end{array} (\text{NH}_3)_4] (\text{NO}_3)_3$
39. Which of the following is molecular formula of iron hexa cyano ferrate (II) ?
 (A) $\text{Fe}_2[\text{Fe}(\text{CN})_6]_3$
 (B) $\text{Fe}_3[\text{Fe}(\text{CN})_6]_2$
 (C) $\text{Fe}_4[\text{Fe}(\text{CN})_6]_3$
 (D) $\text{Fe}_3[\text{Fe}(\text{CN})_6]_4$
40. How many ions are obtained by ionisation of iron (III) hexa cyano ferrate (II) ?
 (A) 2 (B) 5 (C) 6 (D) 7

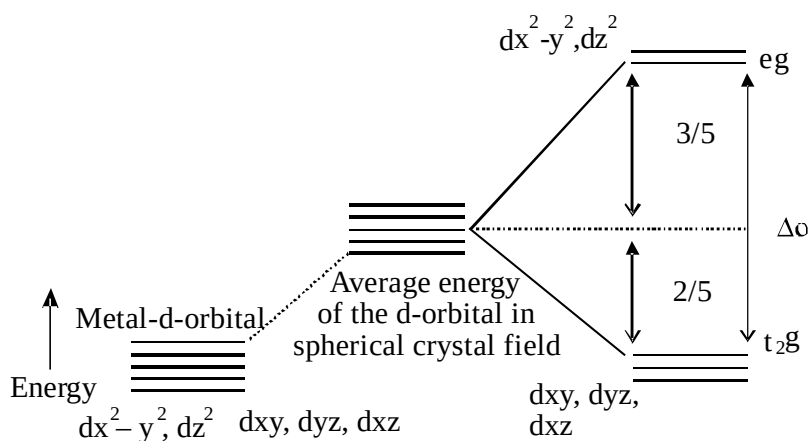
41. Which of the following complexes does not possess geometrical isomerism ?
 (A) $[\text{Cr}(\text{NH}_3)_4\text{Cl}_2]\text{Cl}$ (B) $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$ (C) $[\text{Co}(\text{en})_2\text{Cl}_2]\text{Cl}$ (D) $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$
42. Which of the following complex possesses meridional isomerism ?
 (A) $\text{K}[\text{Fe}(\text{NH}_3)_2(\text{CN})_4]$ (B) $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$
 (C) $[\text{Cr}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$ (D) $[\text{Co}(\text{NH}_3)_3\text{Cl}_3]$
43. Which of the following complex cannot rotate the plane polarised light ?
 (A) $\text{cis}[\text{PtCl}_2(\text{en})_2]^{2+}$ (B) $\text{trans}[\text{PtCl}_2(\text{OX})_2]$
 (C) $[\text{Cr}(\text{en})_3]^{3+}$ (D) $[\text{CrCl}_2(\text{NH}_3)_2\text{en}]^+$
44. Among the given complexes which one of them possesses optical isomerism ?
 (A) $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$ (B) $[\text{Co}(\text{NH}_3)_3\text{Cl}_3]$ (C) $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2\text{en}]$ (D) $[\text{Pt}(\text{NH}_3)_3\text{Cl}_3]$
45. Which of the following pairs possesses linkage isomerism ?
 (A) Penta ammine nitrito cobalt (III) ion and penta ammine nitrito cobalt (III) ion.
 (B) Hexa ammine cobalt (III) hexa cyano chromate (III) ion and Hexa ammine chromium (III) hexa cyano cobaltate (III) ion.
 (C) Penta ammine nitrato (III) chloride and penta aqua chlorido chromium (III) chloride hydrate.
 (D) Hexa aqua chromium (III) chloride and penta aqua chlorido (III) chloride hydrate.
46. Which of the following possesses co-ordination isomerism ?
 (A) $[\text{Cr}(\text{NH}_3)_6][\text{Co}(\text{CN})_6]$ (B) $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$
 (C) $[\text{Co}(\text{OX})_2\text{Cl}_2]$ (D) $[\text{Cr}(\text{en})_2\text{Cl}_2]$
47. $[\text{Cr}(\text{NH}_3)_4\text{Cl}_2]\text{NO}_2$ and $[\text{Cr}(\text{NH}_3)_4\text{ClNO}_2]\text{Cl}$ are which kind of isomer ?
 (A) Linkage (B) Optical (C) Ionisation (D) Geometrical
48. Complex A and B having molecular formula $\text{CrCl}_3(\text{H}_2\text{O})_6$ are precipitate with AgNO_3 giving three and two moles of AgCl respectively, then A and B are which kind of isomers to each other ?
 (A) Co-ordination (B) Hydration (C) Linkage (D) Ionic
49. Which kind of isomerism is present in $[\text{Co}(\text{OX})_3]^{3-}$ complex ion ?
 (A) Optical (B) Geometrical (C) Structural (D) Ligand
50. Which complex ion possesses geometrical and optical isomerism ?
 (A) $[\text{Co}(\text{en})_2\text{Cl}_2]^+$ (B) $[\text{CoCl}(\text{NH}_3)_5]^{2+}$ (C) $[\text{CoCl}_2(\text{NH}_3)_4]^+$ (D) $[\text{Cr}(\text{OX})_3]^{3-}$

Answers : 35. (A), 36. (A), 37. (A), 38. (A), 39. (C), 40. (B), 41. (B), 42. (D), 43. (B), 44. (C), 45. (A), 46. (A), 47. (C), 48. (D), 49. (A), 50. (A)

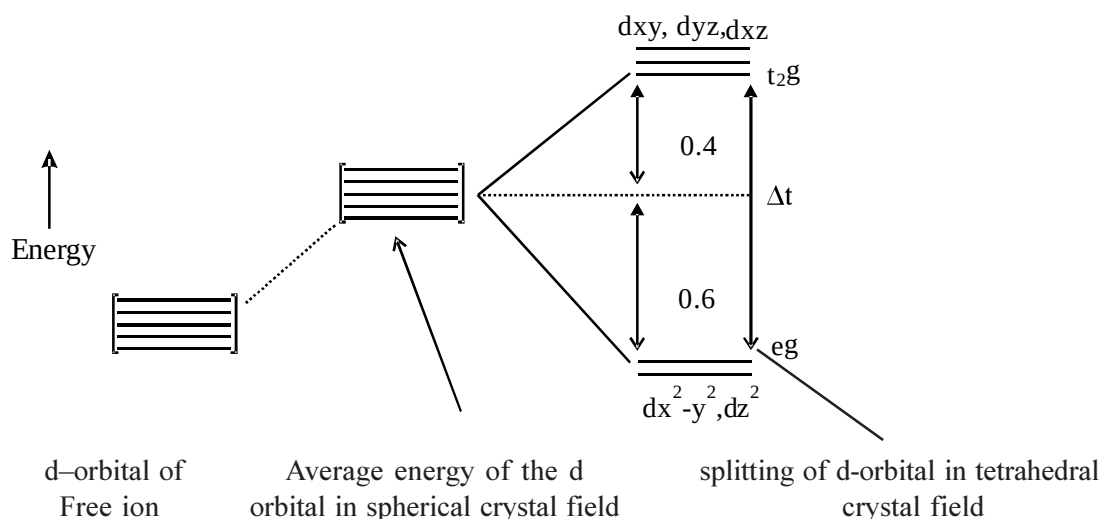
● Crystal field theory

Crystal field theory is known as electrostatic model in which it is believed that there is an ionic bond between metal and ligand. According to this theory negatively charged ligand or polar neutral molecule forms ionic bond with metal ion. All the five types of d-orbitals are degenerated in free gaseous form of metal atom or ion. But when ligands are arranged around the metal atom or ion the d-orbitals do not remain degenerated but get split. The splitting of orbitals depends on the nature of crystal field.

- splitting of d-orbital in octahedral complex.

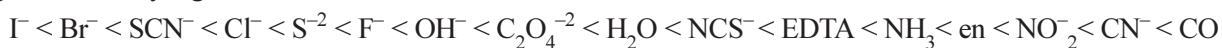


- In eg orbital there will be increase by $\frac{3}{5} \Delta_o$ and there will be $\frac{2}{5} \Delta_o$ decrease in energy of three t_{2g} orbitals
- d-orbital splitting in a tetrahedral crystal field.



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

The splitting of crystal field (Δ_o) depends on electric charge of metal ion and ligand. Some ligands produce strong field, so the splitting of orbitals is more in proportion. While certain ligands produce weak field so the splitting of orbitals is less in proportion. The series of ligands on the basis of increase in strength of field by ligands can be shown as below :



This series is called spectrochemical series.

For the ligands producing weak field, $\Delta_o < P$ and form complexes having higher spin.

For the ligands producing strong field, $\Delta_o > P$ and form complexes having low spin.

● Colour of complex :

Complexes exhibit wide variety of colours. When white light passes through the sample, it forms definite visible spectrum and other forms of white light are removed. The complementary colour is dependent on wavelength. If complex absorbs green colour, then it will be seen red.

The colour of co-ordination compounds can be explained on the basis of crystal field theory. e.g. $[\text{Ti}(\text{H}_2\text{O})_6]^{3+}$ which has violet colour, $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$ green colour and $[\text{Ni}(\text{en})_3]^{2+}$ violet colour.

● **Effective Atomic Number (EAN)**

$$(\text{EAN}) = \text{Atomic No} - \text{O.S.} + 2 \times \text{C.N.}$$

$$= \text{Atomic number} - \text{Oxidation state} + 2 \times \text{co-ordination number}$$

51. How much decrease in energy of t_{2g} orbital by crystal field splitting in octahedral complexes ?
 (A) $\frac{3}{5} \Delta_o$ (B) $\frac{2}{5} \Delta_o$ (C) $\frac{4}{9} \Delta_o$ (D) $\frac{2}{9} \Delta_o$
52. What is the value of Δ_t for crystal field splitting in tetrahedral complexes ?
 (A) $\frac{3}{5} \Delta_o$ (B) $\frac{4}{9} \Delta_o$ (C) $\frac{2}{9} \Delta_o$ (D) $\frac{7}{9} \Delta_o$
53. Energy of which orbitals raised by crystal field splitting in octahedral complexes ?
 (A) d_{xy}, d_{yz} (B) d_{xy}, d_{yz}, d_{xz} (C) $d_{x^2-y^2}, d_{z^2}$ (D) $d_{xy}, d_{x^2-y^2}$
54. Which is correct spectrochemical series ?
 (A) $\text{OH}^- < \text{NCS}^- < \text{NH}_3 < \text{en} < \text{CO}$ (B) $\text{OH}^- < \text{NH}_3 < \text{NCS}^- < \text{en} < \text{CO}$
 (C) $\text{OH}^- < \text{NH}_3 < \text{en} < \text{NCS}^- < \text{CO}$ (D) $\text{OH}^- < \text{NCS}^- < \text{en} < \text{NH}_3 < \text{CO}$
55. Which is the true relation for $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$ complex ?
 (A) $\Delta_o < P$ (B) $\Delta_o > P$ (C) $\Delta_o \geq P$ (D) $\Delta_o = P$
56. What is the value of Δ_o for $[\text{Fe}(\text{CN})_6]^{4-}$ complex compound ?
 (A) $\Delta_o > P$ (B) $\Delta_o < P$ (C) $\Delta_o \leq P$ (D) $\Delta_o = P$
57. Which of the following ligand produces strong field ?
 (A) NH_3 (B) en (C) CO (D) EDTA^{4-}
58. Which ligand form complex having high spins ?
 (A) H_2O (B) NH_3 (C) CO (D) CN^-
59. Among the given complex ions which one does not absorb visible light ?
 (A) $[\text{Ni}(\text{CN})_4]^{2-}$ (B) $[\text{Cr}(\text{NH}_3)_6]^{3+}$ (C) $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$ (D) $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$
60. Which of the following complex ion has highest value of Δ_o ?
 (A) $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$ (B) $[\text{Fe}(\text{NH}_3)_6]^{3+}$ (C) $[\text{Fe}(\text{CN})_6]^{3-}$ (D) $[\text{Fe}(\text{OX})_3]^{3-}$
61. What is the colour change in $[\text{Ni}(\text{H}_2\text{O})_6]^{2+} \xrightarrow{\text{en}} [\text{Ni}(\text{H}_2\text{O})_4\text{en}]^{2+}$?
 (A) Green to light blue (B) Light blue to violet
 (C) Green to violet (D) Pink to violet
62. Which type of ligand are used for diagnostic test for poisoning of lead ?
 (A) Unidentate (B) Didentate (C) Tridentate (D) Hexadentate
63. Which of the following is molecular formula of Wilkinson's catalyst ?
 (A) $[(\text{Ph}_3\text{P})_3\text{RhCl}]$ (B) $[(\text{Rh}_3\text{P})_3\text{PCl}]$ (C) $[\text{Ph}_3\text{P}]\text{RhCl}$ (D) $[(\text{Ph P}_3)_3\text{RhCl}]$
64. Which complex ion is useful in black and white photography ?
 (A) $[\text{Ag}(\text{S}_2\text{O}_3)]^{3-}$ (B) $[\text{Ag}(\text{CN})_2]^-$ (C) $[\text{Ag}(\text{SO}_3)_2]^{3-}$ (D) $[\text{Ag}(\text{NH}_3)_2]^+$

65. Which complex is useful in inhibiting the growth of tumours ?
 (A) Cis platin (B) Trans platin (C) EDTA (D) DMG
66. Among the given ion which one is most stable ?
 (A) $[\text{FeF}_6]^{3-}$ (B) $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$ (C) $[\text{Fe}(\text{CN})_6]^{3-}$ (D) $[\text{Fe}(\text{NH}_3)_6]^{3+}$
67. Which of the following is molecular formula of tetra ammine di aqua cobalt (III) chloride ?
 (A) $[\text{Co}(\text{NH}_3)_4(\text{H}_2\text{O})_2]\text{Cl}$ (B) $[\text{Co}(\text{NH}_3)_3(\text{H}_2\text{O})_2]\text{Cl}_2$
 (C) $[\text{Co}(\text{NH}_3)_4(\text{H}_2\text{O})_2]\text{Cl}_3$ (D) $[\text{Co}(\text{NH}_3)_2(\text{H}_2\text{O})_4]\text{Cl}_3$
68. Aqueous solution of one mole complex compound $\text{Cr}(\text{NH}_3)_5\text{Cl}_3$ gives three mole ions. Same complex compound giving two mole of AgCl with 2 mole of AgNO_3 then which is formula of that complex ?
 (A) $[\text{Cr}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$ (B) $[\text{Cr}(\text{NH}_3)_3\text{Cl}_3]2\text{NH}_3$
 (C) $[\text{Cr}(\text{NH}_3)_4\text{Cl}]\text{Cl}_2\text{NH}_3$ (D) $[\text{Cr}(\text{NH}_3)_4\text{Cl}_2]\text{ClNH}_3$
69. Which complex ion possess optical isomerism ?
 (A) $[\text{Cu}(\text{NH}_3)_4]^{2+}$ (B) $[\text{ZnCl}_4]^{2-}$ (C) $[\text{Cr}(\text{C}_2\text{O}_4)_3]^{3-}$ (D) $[\text{Co}(\text{CN})_6]^{3-}$
70. Which of the following cyano complex has least paramagnetic moment ?
 (A) $[\text{Cr}(\text{CN})_6]^{3-}$ (B) $[\text{Mn}(\text{CN})_6]^{3-}$ (C) $[\text{Fe}(\text{CN})_6]^{3-}$ (D) $[\text{Co}(\text{CN})_6]^{3-}$
71. How many EDTA^{4-} ligand required to form octahedral complex with Zn^{2+} ?
 (A) 3 (B) 6 (C) 2 (D) 1
72. Which complex is not possess tetrahedral structure ?
 (A) $[\text{FeCl}_4]^{2-}$ (B) $[\text{NiCl}_4]^{2-}$ (C) $[\text{PtCl}_4]^{2-}$ (D) $[\text{CoCl}_4]^{2-}$
73. Geometrical structure and number of unpair electron of Nickel in $[\text{NiCl}_4]^{2-}$?
 (A) square planar and 2 (B) tetrahedral and 2
 (C) square planar and 1 (D) tetrahedral and 1
74. What is co-ordination number and oxidation state of Co in $[\text{Co}(\text{en})_2(\text{C}_2\text{O}_4)]\text{NO}_2$?
 (A) 6 and 2 (B) 4 and 3 (C) 6 and 3 (D) 4 and 2
75. Which one is optical isomer ?
 (A) $[\text{Co}(\text{H}_2\text{O})_4\text{en}]^{3+}$ (B) $[\text{Zn}(\text{en})_2]^{2+}$
 (C) $[\text{Zn}(\text{en})(\text{NH}_3)_2]^{2+}$ (D) $[\text{Co}(\text{en})_3]^{3+}$
76. Which of the following complex possess geometrical isomerism ?
 (A) $[\text{Ni}(\text{NH}_3)_5\text{Br}]^+$ (B) $[\text{Co}(\text{en})](\text{NH}_3)_2]^{3+}$
 (C) $[\text{Cr}(\text{NH}_3)_4\text{en}]^{3+}$ (D) $[\text{Co}(\text{en})_3]^{3+}$
77. Which is the incorrect statement for $[\text{Cr}(\text{NH}_3)_6]\text{Cl}_3$ complex ?
 (A) complex is diamagnetic.
 (B) complex is valence orbital complex.
 (C) complex possess octahedral shape and d^2sp^3 hybridisation.
 (D) complex gives white precipitates with silver nitrate.
78. Name of which complex is di bromido bis (ethylene diamine) chromium (III) bromide ?
 (A) $[\text{Cr}(\text{en})_3]\text{Br}$ (B) $[\text{Cr}(\text{en})_2\text{Br}_2]\text{Br}$
 (C) $[\text{Cr}(\text{en})\text{Br}_4]^-$ (D) $[\text{Cr}(\text{en})\text{Br}_2]\text{Br}$

79. Which pair possesses linkage isomerism ?
 (A) $[\text{Cu}(\text{NH}_3)_4][\text{PtCl}_4]$ and $[\text{Pt}(\text{NH}_3)_4][\text{CuCl}_4]$
 (B) $[\text{Pd}(\text{PPh}_3)_2(\text{NCS})_2]$ and $[\text{Pd}(\text{PPh}_3)_2(\text{SCN})_2]$
 (C) $[\text{Co}(\text{NH}_3)_5\text{NO}_3]\text{SO}_4$ and $[\text{Co}(\text{NH}_3)_5\text{SO}_4]\text{NO}_3$
 (D) $[\text{PtCl}_2(\text{NH}_3)_4]\text{Br}_2$ and $[\text{PtBr}_2(\text{NH}_3)_4]\text{Cl}_2$
80. Which of the following complex ion possesses optical isomerism ?
 (A) $[\text{Co}(\text{NH}_3)_3\text{Cl}]^+$ (B) $[\text{Co}(\text{NH}_3)_2\text{en}]^{2+}$
 (C) $[\text{Co}(\text{H}_2\text{O})_4\text{en}]^{3+}$ (D) $[\text{Co}(\text{en})_2(\text{NH}_3)_2]^{3+}$
81. Which of the following complex possesses *l* and *d* isomer ?
 (A) Penta ammine nitro cobalt (III) iodide.
 (B) Diammine dichlorido platinum (II)
 (C) Trans di cyano bis (ethelene diamine) chromium (III) chloride
 (D) Bis (ethelene diamine) cobalt (III) bromide
82. In which complex, hybridisation of Ni is not sp^3 ?
 (A) $[\text{Ni}(\text{CO})_4]$ (B) $[\text{Ni}(\text{CN})_4]^{2-}$ (C) $[\text{NiCl}_4]^{2-}$ (D) $[\text{Ni}(\text{CN})_4]^{4-}$
83. A solution containing 2.675g $\text{CoCl}_3 \cdot 6\text{NH}_3$ (molecular mass = 267.5 g mol^{-1}) is passed through positive ion exchange cycle. Obtained chloride ion from solution gives 4.78 gAgCl with excess AgNO_3 then what is molecular formula of complex ?
 (A) $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$ (B) $[\text{CoCl}_2(\text{NH}_3)_4]\text{Cl}$ (C) $[\text{CoCl}_3(\text{NH}_3)_3]$ (D) $[\text{CoCl}(\text{NH}_3)_5]\text{Cl}_2$
84. Which isomerism can be possessed by complex $[\text{Cr}(\text{NH}_3)_4(\text{NO}_2)_2]\text{Cl}$?
 (A) Linkage, Ionic and geometrical (B) Ionic, geometrical and optical
 (C) Linkage, geometrical and optical (D) Linkage, Ionic and optical
85. Which of the following complex shows least paramagnetic behaviour ?
 (A) $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$ (B) $[\text{Cr}(\text{H}_2\text{O})_6]^{2+}$
 (C) $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$ (D) $[\text{Mn}(\text{H}_2\text{O})_6]^{2+}$
86. Which complex ion absorbs visible light ?
 (A) $[\text{Ti}(\text{en})_2(\text{NH}_3)_2]^{4+}$ (B) $[\text{Cr}(\text{NH}_3)_6]^{3+}$
 (C) $[\text{Zn}(\text{NH}_3)_6]^{2+}$ (D) $[\text{Sc}(\text{H}_2\text{O})_3(\text{NH}_3)_3]^{3+}$
87. In which of the following pairs both species possesses same magnetic moment ?
 (A) $[(\text{Cr}(\text{H}_2\text{O})_6]^{2+}$ and $[\text{CoCl}_4]^{2-}$ (B) $[\text{Cr}(\text{H}_2\text{O})_6]^{2+}$ and $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$
 (C) $[\text{Mn}(\text{H}_2\text{O})_6]^{2+}$ and $[\text{Cr}(\text{H}_2\text{O})_6]^{2+}$ (D) $[\text{CoCl}_4]^{2-}$ and $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$
88. Mixture x = 0.02 mole $[\text{Co}(\text{NH}_3)_5\text{SO}_4]\text{Br}$ and 0.02 mole $[\text{Co}(\text{NH}_3)_5\text{Br}]\text{SO}_4$ is dissolved in 2 litre solution.
 1 litre mixture + ex $\text{AgNO}_3 \rightarrow y$
 1 litre mixture + ex $\text{BaCl}_2 \rightarrow z$
 How many moles of y and z respectively ?
 (A) 0.01 and 0.01 (B) 0.02 and 0.01 (C) 0.01 and 0.02 (D) 0.02 and 0.02
89. Aqueous solution of which complex is bad conductor ?
 (A) $\text{K}_2[\text{PtCl}_6]$ (B) $[\text{Co}(\text{NH}_3)_3(\text{NO}_2)_3]$ (C) $\text{K}_4[\text{Fe}(\text{CN})_6]$ (D) $[\text{Cu}(\text{NH}_3)_4]\text{SO}_4$

90. Which statement is not true for complex $[\text{Co(en)}_2\text{Cl}_2]\text{Cl}$?
 (A) It possesses geometrical isomerism. (B) It possesses optical isomerism.
 (C) It possesses ionisation isomerism. (D) Its shape is octahedral
91. Co-ordination number of Co^{3+} and Pt^{4+} is six then conductance of 0.001M aqueous solution of which pair is nearly same ?
 (A) $\text{CoCl}_3 \cdot 4\text{NH}_3$ and $\text{PtCl}_4 \cdot 4\text{NH}_3$ (B) $\text{CoCl}_3 \cdot 3\text{NH}_3$ and $\text{PtCl}_4 \cdot 5\text{NH}_3$
 (C) $\text{CoCl}_3 \cdot 6\text{NH}_3$ and $\text{PtCl}_4 \cdot 5\text{NH}_3$ (D) $\text{CoCl}_3 \cdot 5\text{NH}_3$ and $\text{PtCl}_4 \cdot 6\text{NH}_3$
92. What is EAN (Effective Atomic Number) of Ni in $[\text{Ni}(\text{CO})_4]$?
 (A) 38 (B) 30 (C) 36 (D) 32
93. Which of the following is hybridisation of metal ion and shape of Wilkinson's catalyst ?
 (A) sp^3d , Trigonal bi pyramidal (B) sp^3 , tetrahedral
 (C) dsp^2 , square planar (D) d^2sp^3 , octahedral
94. A solution prepared by dissolving 0.875 g complex compound $\text{Co}(\text{NH}_3)_4\text{Cl}_3$ (molecular mass 233.5 g mol^{-1}) in 25 g water. Its freezing point is -0.56°C then what is the formula of complex ? (molal depression constant = $4.8 \text{ K kg mole}^{-1}$)
 (A) $[\text{Co}(\text{NH}_3)_4]\text{Cl}_3$ (B) $[\text{Co}(\text{NH}_3)_4\text{Cl}]\text{Cl}_2$
 (C) $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]\text{Cl}$ (D) $[\text{Co}(\text{NH}_3)_3\text{Cl}_3]\text{NH}_3$
95. Magnetic moment of an aqueous solution of titanium chloride is zero. Which of the following formula of complex possessing octahedral structure in aqueous solution ?
 (A) $[\text{Ti}(\text{H}_2\text{O})_6]\text{Cl}_4$ (B) $[\text{Ti}(\text{H}_2\text{O})_6]\text{Cl}_3$
 (C) $[\text{Ti}(\text{H}_2\text{O})_5\text{Cl}]\text{Cl}_2$ (D) $[\text{Ti}(\text{H}_2\text{O})_6]\text{Cl}$
96. In the following reactions two sentences are given. In which one sentence is assertion (A) and other is reason (R). carefully study the sentences and choose the proper option as per following give instructions. (A) = Assertion, (R) = reason
Assertion (A) : $\text{H}_2\text{N} - \text{NH}_2$ is chelating ligand
Reason (R) : Chelating ligand has two or more electron pair which can form tension free cyclic structure with metal ion.
 (A) Both Assertion (A) and reason (R) are correct and R is correct explanation of A.
 (B) Both Assertion (A) and reason (R) are correct but R is not correct explanation of A.
 (C) Assertion (A) is correct but R is incorrect.
 (D) Assertion (A) is incorrect and reason (R) is correct.
97. **Assertion** : All the octahedral complex of Ni^{+2} are outer orbital complex.
Reason : Only weak ligand form outer orbital octahedral complex.
 (A) Both Assertion (A) and reason (R) are correct and R is correct explanation of A.
 (B) Both Assertion (A) and reason (R) are correct but R is not correct explanation of A.
 (C) Assertion (A) is incorrect and R is correct.
 (D) Both (A) and (R) are correct but (R) is incorrect explanation of (A).

- 98. Assertion (A) :** Stability of $[\text{Ni}(\text{en})_3] \text{Cl}_2$ is less than $[\text{Ni}(\text{NH}_3)_6] \text{Cl}_2$.
Reason (R) : Geometry of Ni in $[\text{Ni}(\text{en})_3] \text{Cl}_2$ is square planar.
 (A) Assertion (A) is correct and reason (R) is incorrect.
 (B) Assertion (A) and reason (R) are correct.
 (C) Assertion (A) and reason (R) are incorrect.
 (D) Assertion (A) and reason (R) both are correct but R is not correct explanation of A.
- 99. Assertion (A) :** EDTA^{4-} form large number of complex with all the metal.
Reason (R) : In EDTA^{4-} , two nitrogen atoms and four oxygen atom are co-ordination site.
 (A) Both assertion (A) and reason (R) are correct and R is correct explanation of A.
 (B) Assertion (A) is correct and reason (R) is incorrect.
 (C) Assertion (A) is incorrect and R is correct.
 (D) Both assertion (A) and reason (R) are incorrect.
- 100. Assertion (A) :** $\text{K}_3[\text{Fe}(\text{CN})_6]$ is dimagnetic where as $\text{K}_4[\text{Fe}(\text{CN})_6]$ is paramagnetic.
Reason (R) : Magnetic properties of complex is depends on unpair electron in d-orbital
 (A) Both assertion (A) and reason (R) are incorrect.
 (B) Assertion (A) is incorrect and reason (R) is correct.
 (C) Both assertion (A) and reason (R) are correct and R is correct explanation of assertion (A).
 (D) Both assertion (A) and reason (R) are correct but R is incorrect explanation of A.

Answers : 51. (A), 52. (B), 53. (C), 54. (A), 55. (A), 56. (A), 57. (C), 58. (A), 59. (A), 60. (C), 61. (A), 62. (D), 63. (A), 64. (A), 65. (A), 66. (C), 67. (C), 68. (A), 69. (C), 70. (C), 71. (D), 72. (C), 73. (B), 74. (C), 75. (D), 76. (B), 77. (A), 78. (B), 79. (B), 80. (D), 81. (C), 82. (B), 83. (D), 84. (A), 85. (C), 86. (B), (87. (A), 88. (A), 89. (B), 90. (C), (91. (C), 92. (C), 93. (B), 94. (C), 95.(A), 96. (D), 97. (B), 98. (A), 99. (A), 100. (B)