

COORDINATION COMPOUNDS

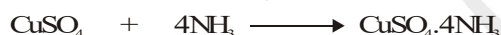
INTRODUCTION

- (a) The concept of coordination compounds arises from the complex formation tendency of transition elements.
- (b) These compounds play a vital role in our lives. Haemoglobin of animal blood and chlorophyll of plants are also coordination compounds of Fe, Mg respectively.

MOLECULAR OR ADDITION COMPOUNDS

- (a) When two or more simple salt solutions are mixed and then subjected for crystallisation, the crystals which are obtained are of addition compounds.

- (b) Some common examples are as follows.



Simple stable compounds Addition or molecular compounds



- (c) The molecular or addition compounds are of two types i.e. Double salt or lattice compound and coordination or complex compounds.

DOUBLE SALT OR LATTICE COMPOUNDS

- (a) The addition compound which undergoes complete ionisation to form three types of ions i.e., two types of cations and one type of anions or vice versa, is called as **double salt**.
- (b) These double salts lose their identity in aqueous solution. **Ex.** when carnallite ($\text{KCl} \cdot \text{MgCl}_2 \cdot 6\text{H}_2\text{O}$) is dissolved in water, it exhibits the properties of KCl and MgCl_2 .

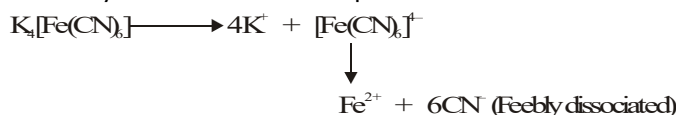
COORDINATION OR COMPLEX COMPOUNDS

- (a) Addition compound of this type undergoes partial ionisation to form a complex ion in aqueous solution is called as complex compound or coordination compound.
- (b) Complexes retain their identity in aqueous solution. i.e., they do not dissociate into separate ion.



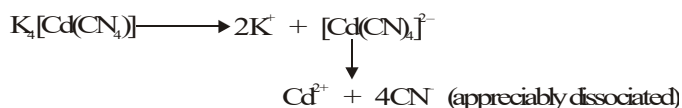
- (c) On the basis of stability of complex ion, complex ions are further divided as follows –

(i) Perfect complexes : The compounds in which complex ion is fairly stable and further dissociation or feeble dissociation is not possible in solution state. **Ex.**



The ferrocyanide ion $[\text{Fe}(\text{CN})_6]^{4-}$ is so insignificantly dissociated that it can be considered as practically undissociated and does not give the test of Fe^{2+} or CN^- ions.

(ii) Imperfect complexes : Those in which complex ion is less stable and is reversibly dissociated to give enough simple ions and thus imparts their tests. **Ex.**



An imperfect complex may be too unstable to exist and may be completely dissociated in solution, now it behaves as a double salts.

VARIOUS TERMS INVOLVED IN COORDINATION COMPOUNDS

(a) **Complex ion :**

An aggregate of metal ion with anions cation or neutral molecules is called as **complex ion**.

(b) **Central metal ion :**

(i) The metal ion which forms complex ion in combination with anions or neutral molecules is called as **central metal ion**.

(ii) Central metal ion acts as an electron pair acceptor and forms coordinate covalent bond.

(c) **Coordination number :**

(i) The number of ligands that combine with the central metal ion to form the complex ion is called as coordination number.

(ii) From every ligand central metal ion accepts lone pair of electrons. Thus the number of lone pair of electrons accepted by the central metal ion in the formation of a complex is called as coordination number.

(iii) The total number of coordinate covalent bonds formed by central metal ion with ligands is called as coordination number.

(d) **Coordination sphere - (entity) :**

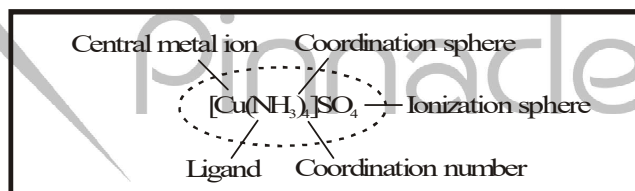
(i) The central metal atom and the ligands directly attached to it are collectively termed as the coordination sphere.

(ii) Coordination sphere is written inside square bracket, for example $[\text{Co}(\text{NH}_3)_6]^{3+}$

(iii) The part outside the bracket is called **ionisation sphere**.

(iv) The species present in the coordination sphere are nonionizable.

(v) The species present in the ionization sphere are ionisable.



(e) **Oxidation state :**

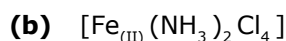
(i) It is a number which represents the electric charge on the central metal atom of a complex ion.

(ii) **Ex.** the oxidation number of Fe, Co and Ni in $[\text{Fe}(\text{CN})_6]^{4-}$, $[\text{Co}(\text{NH}_3)_6]^{3+}$ and $\text{Ni}(\text{CO})_4$ is +2, +3 and 0 respectively.

(f) **Charge On the complex ion :**

It is the algebraic sum of the total charge of the ligands and central metal ion.

Question : What will be the charge on the given complexes-



Sol. (a) Charge on Co is +3

Sol. (b) Charge on Fe is given = +2

Total charge on F^- is = - 6

Total Charge of ligands -4

So, algebraic sum of charge = - 3

So algebraic sum of Charge = -2

\therefore Charge on $[\text{CoF}_6]$ is - 3.

\therefore Charge on $[\text{Fe}(\text{NH}_3)_2\text{Cl}_4]$ is -2.

(g) **Ligands :**

- (i) The anions or neutral molecules which combine with central metal ion to form complex ion are called as ligands.
- (ii) They act as electron pair donor Lewis bases, but strong crystal field ligands like CO, CN⁻ etc can accept electron pair from the metal ion, because these ligands are π - acids.

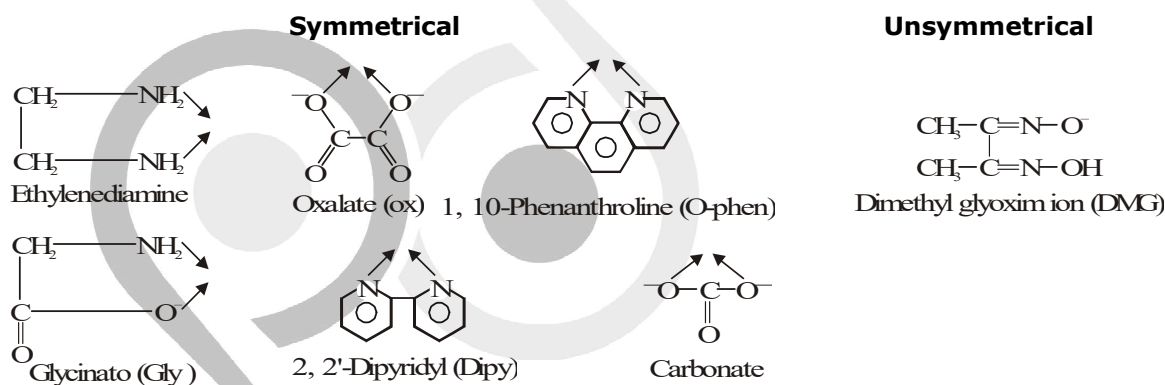
TYPES OF LIGANDS**(a) Unidentate ligands**

Ligands which have only one e⁻ donor atom.

X⁻, CN⁻, NO₂⁻, NH₃, Pyridine, OH⁻, NO₃⁻, H₂O, SO₃⁻², CO, NO, OH⁻, O⁻², (C₆H₅)₃P etc.

(b) Bidentate ligands

Ligands which have two donor atoms and have the ability to link with central metal ion at two positions are called bidentate ligands. Some **Ex.**

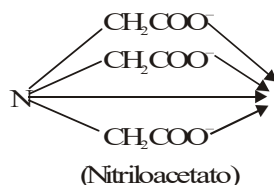
**(c) Tridentate ligands**

The ligands having three donor atoms are called tridentate ligands. **Ex.**

**(d) Tetradentate ligands**

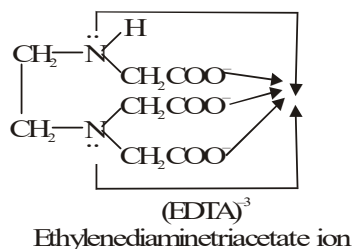
Those ligands possess four donor atoms,

Ex. Nitriloacetato

**(e) Pentadentate ligands**

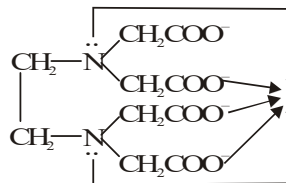
They have five donor atoms.

Ex. Ethylenediamine triacetate ion.



(f) Hexadentate ligands

They have six donor atoms.

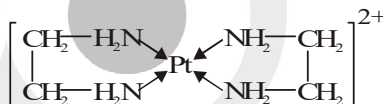


The most important **Ex.**

Ethylenediaminetetraacetate ion (EDTA)⁴⁻

(g)**Chelating ligands**

- (i) Polydentate ligands whose structures permit the attachment of two or more donor site to metal ion simultaneously, thus closing one or more rings are called chelating ligands and formed are known as chelate compounds.
- (ii) A chelate may be defined as a ring structure formed by the combination of a polydentate two or more donor atoms with a metal ion forming part of the ring.
- (iii) The process of formation of chelates is called chelation.
- (iv) Chelate complexes are more stable than ordinary complexes because chelation is an exothermic process.
- (v) This increased stability of the compound is due to chelation, is called the chelate effect.
- (vi) In the complex ion given below, 5 membered rings are formed. So all of these are called chelating ligands. **Ex.**

**(h)****Ambident ligands**

Ligands which can ligate through two different atoms present in it are called ambident ligands.



Ex. CN^- can coordinate through either the nitrogen or the carbon atom to a central metal ion.

Key point : Such possibilities give rise to linkage isomerism in coordination compounds

(i)**Flexidentate ligands**

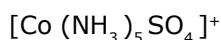
Ligands which sometimes do not use all the linking atoms to get coordinated with central metal ion.

Ex. SO_4^{2-} , CO_3^{2-} , $(\text{EDTA})^{4-}$ etc

Ex. EDTA is normally hexadentate ligand but in the following complexes it is quadri or penta dentate



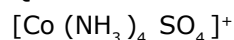
Hexadentate



Sulphate-monodentate



Quadridentate



Sulphate-bidentate

Question : The charge on Iron in $[\text{Fe}(\text{CN})_6]^{3-}$ is

(1) -6

(2) +3

(3) -3

(4) +6

Sol. (2) The algebraic sum of oxidation no. of all atoms in a complex ion is equal to charge on the ion i.e.

$$a + 6 \times (-1) = -3 \Rightarrow \therefore a = +3$$

Question : Co-ordination number of Co in $[\text{CoF}_6]^{-3}$ is

(1) 4

(2) 5

(3) 6

(4) 8

Sol. (3) Co-ordination number is equal to total number of ligands in a complex

Question : The neutral ligand is

(1) Chloro

(2) Hydroxo

(3) Ammine

(4) Oxalato

Sol. (3) :NH_3 has no charge but acts as ligand

Question : $\text{H}_2\text{N} - \text{CH}_2 - \text{CH}_2 - \text{NH}_2$ serves as :

(1) Monodentate ligand

(2) Chelating ligand

(3) Bridging ligand

(4) Cationic ligand

Sol. (2) $\text{NH}_2\text{CH}_2\text{CH}_2\text{NH}_2$ act as a chelating ligand because five membered ring is more stable.

FACTORS AFFECTING THE STABILITY OF COMPLEXES

The stability of complexes depends on the following factors :

(A) Nature of the central metal ion :

- (a) Greater the charge density on the metal ion, Δ_0 is more greater is the tendency to form the stable complex. Thus the complexes formed by metal ion with high charge density are more stable than complexes formed by metal ion with less charge density.

Ex. Fe^{+3} ion forms a more stable complex than Fe^{+2} , Similarly Pt^{4+} complex is more stable than Pt^{2+} complex.

- (b) The stability of the complexes, of some of the cations having same charge but different ionic radii decrease with the increase in ionic radii. (Irving-William's order)

Ion stability	Cu^{+2}	>	Ni^{+2}	>	Co^{+2}	>	Fe^{+2}	>	Mn^{+2}
Ionic radii	0.69		0.78		0.82		0.83		0.91

(B) Nature of ligand :

- (a) A strongly basic ligand forms a more stable complex with the metal ion than a ligand which is weakly basic in nature. Thus a cyano complex will be more stable than a chloro complex.
- (b) When a bidentate ligand combines with the metal ion then a chelated complex is formed. This type of chelated complex will be more stable.

IUPAC NOMENCLATURE OF COORDINATION COMPOUNDS

The present system of nomenclature derived from the suggestions of **Alfred Werner** and recommended by the Inorganic Nomenclature Committee of the I.U.P.A.C. The main rules of naming of complexes are -

- (a) Like simple salts, the positive part of the coordination compound is named first.

Ex. $\text{K}_4[\text{Fe}(\text{CN})_6]$ the naming of this complex starts with potassium.

- (b) Then after ligands of the coordination sphere are to be named.

- (c) The ligands can be neutral, anionic or cationic.

- (i) The neutral ligands are named as the molecule **Ex.** $\text{C}_5\text{H}_5\text{N}$ pyridine, $(\text{C}_6\text{H}_5)_3\text{P}$ Triphenyl phosphine, $\text{H}_2\text{N} - \text{CH}_2 - \text{CH}_2 - \text{NH}_2$ ethylene diamine.

The neutral ligands which are not named as the molecule are -

CO carbonyl, NO nitrosyl, H_2O Aqua, NH_3 ammine.

- (ii) Anionic ligands ending with 'ide' are named by replacing the 'ide' with suffix 'O'.

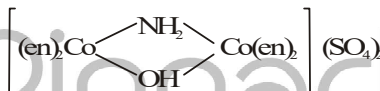
Symbol	Name as ligand	Symbol	Name as ligand
Cl^-	Chloro/Chlorido	N^{3-}	Nitrido
Br^-	Bromo/Bromido	O_2^{2-}	Peroxo, O_2^- superoxo
CN^-	Cyano	O_2H^-	Perhydroxo
O^{2-}	Oxo	S^{2-}	Sulphido
OH^-	Hydroxo	NH_2^-	Amido
H^-	Hydrido	NH^{2-}	imido

Ligands whose names end in 'ite' or 'ate' become 'ito' i.e., by replacing the ending 'e' with 'o' as follows.

CO_3^{2-}	Carbonato	SO_3^{2-}	Sulphito
$\text{C}_2\text{O}_4^{2-}$	Oxalato (Ox) $^{2-}$	CH_3COO^-	Acetato
SO_4^{2-}	Sulphato	NO_2^-	(bonded through oxygen) nitrite (bonded through nitrogen) nitro
NO_3^-	Nitrato	or	Nitrito – N Nitrito – O
$\text{S}_2\text{O}_3^{2-}$	Thiosulphato		

(iii) Positive ligands naming ends in 'ium' $\text{NH}_2-\text{NH}_3^+$ Hydrazinium, NO_2^+ nitronium, NO^+ nitrosonium

- (d) If ligands are present more than once, then their repetition is indicated by prefixes like di, tri, tetra etc. However, when the name of the ligand includes a number, **Ex.** dipyridyl, ethylene diamine, then bis, tris, tetrakis are used in place of di, tri, tetra, etc.
- (e) In case of chelating ligands or ligands having di, tri, tetra, etc, in their name the prefixes bis, tris, tetrakis are used before ligands placed in paranthesis.



Bis(ethylenediamine) cobalt(III)-μ-amido-μ-hydroxobis(ethylenediamine) cobalt (III) sulphate

- (f) When more than one type of ligand is present in the complex, then the ligands are named in the alphabetical order.

(Prior to this naming of ligands was followed in the order – negative, neutral and positive ligands)

- (g) After naming of ligands the central metal ion is to be named followed by its oxidation state in Roman numbers in brackets. (as per IUPAC)

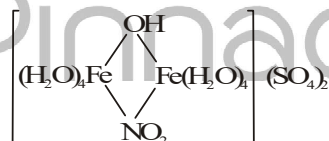
If the complex is neutral or provides a cationic complex ion, then the central metal ion is to be named as it is.

If the complex provides anionic complex ion then the name of central metal ion ends in 'ate'

- (h) After the naming of central metal ion, anion which is in the outer sphere is to be named.

The naming of some of the complexes is done as follows – (as per IUPAC)

Complex Compounds	IUPAC Name
(i) $K_4[Fe(CN)_6]$ (anionic complex) so suffix ate is added with metal's name	Potassium hexacyanoferrate (II)
(ii) $K_2[PtCl_6]$	Potassium hexachloroplatinate (IV)
(iii) $[Co(NH_3)_6]Cl_3$ (Cationic complex) so metal is without any suffix	Hexammine cobalt (III) chloride
(iv) $[Cr(H_2O)_4Cl_2]Cl$	Tetra aqua di chloro chromium (III) chloride
(v) $[Pt(NH_3)_2Cl_4]$	Diammine tetra chloroplatinum (IV)
(vi) $[Co(NH_3)_3Cl_3]$ (Neutral complex) So no suffix is used with metal ion	Triammine trichloro cobalt (III)
(vii) $K_3[Co(NO_2)_6]$	Potassium hexanitro cobaltate (III)
(viii) $Na_3[Fe(CN)_5NO]$	Sodium pentacyano nitrosyl ferrate (II)
(ix) $[NiCl_4]^{-2}$	Tetrachloro nickelate (II) ion
(x) $[Ru(NH_3)_5Cl]^{+2}$	Pentammine chlororuthenium (III) ion
(xi) $[Fe(en)_3]Cl_3$	Tris (ethylenediamine) iron (III) chloride
(xii) $[Ni(Gly)_2]$	Bis (glycinato) nickel (II)
(i) If a complex ion has two metal atoms then it is termed polynuclear. The ligand which connects the two metal ions is called as Bridging ligand or Bridge group . A prefix of Greek letter μ , is repeated before the name of each different kind of bridging group.	

Octo aqua- μ -hydroxo- μ -nitrodiiron(III) sulphate**Question :** Write the formula of the following coordination compounds

- (1) Potassium hexanitritoferrate (III) (2) Dichloroplatinum (IV) tetrachloroplatinate(II)
 (3) Bis (acetylacetonato) oxovanadium(IV) (4) Potassium tetrahydroxozincate (II)
 (5) Sodium pentacyanonitrosylsulphidoferrate(III)

Sol. (1) $K_3[Fe(ONO)_6]$ (2) $[PtCl_2][PtCl_4]$ (3) $[VO(acac)_2]$ (4) $K_2[Zn(OH)_4]$
 (5) $Na_4[Fe(CN)_5NOS]$

Question : Which of the following names are not correct ? Point out the mistakes.

- (1) $[Cu(H_2O)(NH_3)]Br_2$; Amminoaquodibromocopper (I)
 (2) $Na_3[Al(C_2O_4)_3]$; Trisodium trioxalatoaluminate (III)
 (3) $Na_2[Ni(EDTA)]$; Sodium ethylenediaminetetracetato nickelate (II)
 (4) $[Co(NH_3)_5ONO]SO_4$; Pentaamminenitrocobalt (III) sulphate

Sol. (1) Ammine aqua copper (II) bromide (2) Sodium trioxalato aluminate (III)
 (3) It is correct (4) Pentammine nitrito cobalt(III) sulphate

Question : The formula of the complex tris (ethylene diamine) cobalt (III) sulphate is

- (1) $[\text{Co}(\text{en})_2\text{SO}_4]$ (2) $[\text{Co}(\text{en})_3\text{SO}_4]$ (3) $[\text{Co}(\text{en})_3]\text{SO}_4$ (4) $[\text{Co}(\text{en})_3]_2(\text{SO}_4)_3$

Ans. (4)

Question : The IUPAC name of $\text{Fe}(\text{CO})_5$ is

- (1) Pentacarbonyl ferrate (0) (2) Pentacarbonyl Ferrate (III)
(3) Pentacarbonyl Iron (0) (4) Pentacarbonyl Iron (II)

Ans. (3)

Question : The most stable complex among the following is :-

- (1) $\text{K}_3[\text{Al}(\text{C}_2\text{O}_4)_3]$ (2) $[\text{Pt}(\text{en})_2]\text{Cl}_2$ (3) $[\text{Ag}(\text{NH}_3)_2]\text{Cl}$ (4) $\text{K}_2[\text{Ni}(\text{EDTA})]$

Ans. (4)

Question : The correct name of $(\text{CO})_3\text{Fe} \begin{array}{c} \diagup \text{CO} \diagdown \\ \text{CO} \\ \diagdown \text{CO} \diagup \end{array} \text{Fe}(\text{CO})_3$ is

- (1) Bis (tricarbonyl) - μ - tricarbonyl diiron (0)
(2) Hexacarbonyl iron(III) μ - tricarbonyl ferrate(0)
(3) Tricarbonyl iron (0) μ - tricarbonyl iron (0) tricarbonyl
(4) Non carbonyl Iron

Ans. (1)

Question : The compound $\text{Na}_2[\text{Fe}(\text{CN})_5\text{NO}^+]$ is called

- (1) Sodium pentacyanonitrosonium ferrate (II) (2) Sodium nitroprusside
(3) Sodium nitrosoferrocyanide (4) 1 & 2 both

Ans. (4)

Question : Which of the following is cationic complex

- (1) Tetracarbonyl nickel (0) (2) Hexachloroplatinate (III) ion
(3) Hexaaquairon (III) ion (4) Tetraiodomercurate (II) ion

Ans. (3)

Question : $\text{FeCl}_3 \cdot 4\text{H}_2\text{O}$ is actually :

- (1) $[\text{Fe}(\text{H}_2\text{O})_4]\text{Cl}_3$ (2) $[\text{Fe}(\text{H}_2\text{O})_3\text{Cl}]\text{Cl}_2 \cdot \text{H}_2\text{O}$ (3) $[\text{Fe}(\text{H}_2\text{O})_4\text{Cl}_2]\text{Cl}$ (4) $[\text{Fe}(\text{H}_2\text{O})_3\text{Cl}_2]\text{Cl} \cdot \text{H}_2\text{O}$

Ans. (3)

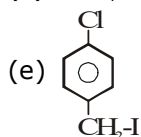
Question : Which of the following compound does not give test of sulphate ion in aqueous solution

- (1) $\text{K}_2\text{SO}_4 \cdot \text{Al}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$ (2) $[\text{Cu}(\text{H}_2\text{O})_4]\text{SO}_4 \cdot \text{H}_2\text{O}$
(3) $[\text{CoSO}_4(\text{NH}_3)_5]\text{Br}$ (4) $\text{FeSO}_4 \cdot (\text{NH}_4)_2\text{SO}_4 \cdot 6\text{H}_2\text{O}$

Ans. (3)

Question : Which of the following compound is expected to yield a white precipitate with AgNO_3 solution :-

- (a) $\text{PtCl}_4 \cdot 4\text{NH}_3$ (b) $\text{COCl}_3 \cdot 3\text{NH}_3$ (c) Impure chloroform (d) Vinyl chloride



(f) Carnelite

- (1) a, c, f (2) a, d, e (3) a, b, c, f (4) a, b, e, f

Ans. (1)

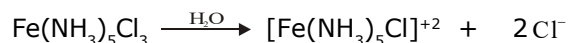
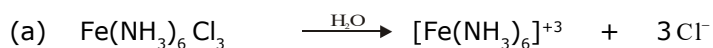
Question : Which of the following is most likely formula of platinum complex, if $\frac{1}{4}$ of total chlorine of the compound is precipitated by adding AgNO_3 to its aqueous solution

- (1) $\text{PtCl}_4 \cdot 6\text{H}_2\text{O}$ (2) $\text{PtCl}_4 \cdot 5\text{H}_2\text{O}$ (3) $\text{PtCl}_2 \cdot 2\text{H}_2\text{O}$ (4) $\text{PtCl}_4 \cdot 3\text{H}_2\text{O}$

Ans. (4)

BONDING IN COORDINATION COMPOUNDS

Werner's Theory of complexes : This was postulated by **Alfred Werner** in 1893. The postulates of Werner's Theory of complexes are –



Every metal forming a complex exhibits two types of valencies - Primary valency and Secondary Valency. In the above complexes chlorines act as primary valency and NH_3 acts as secondary valency.

- (b) Primary valency is equal to oxidation state of metal ion so, primary valency is satisfied by anions whereas secondary valency of the metal ion may be satisfied by anions, neutral molecules or rarely by cations.
- (c) Primary valency is ionisable in nature whereas secondary valency is nonionisable.
- (d) The number of secondary valencies of a metal ion in the complex will remain constant and this is called as coordination number. **Ex.**

1 Fe^{+2} , Fe^{+3} , Co^{+3} , Pt^{+4} , Cr^{+3} , Ru^{+2} , Os^{+3} have a coordination number of **six**

1 Pt^{+2} , Ni^{+2} , Cu^{+2} , Zn^{+2} , Au^{+3} , Hg^{+2} have a coordination number of **four**.

1 Ag^{+1} which is an exceptional ion with coordination number of **two**.

1 Mo^{+3} has the highest coordination number of **eight**.

(e) Shapes and isomerism in complexes :

- 1 The more possible shape of 6-coordinated complexes can be hexagonal planar or octahedral. It can exhibit geometrical or optical isomerism both.
- 1 The shape of 4-coordinated complexes can be square planar (exhibiting geometrical isomerism) or Tetrahedral (exhibiting optical isomerism).

Experimental evidence of werner's theory

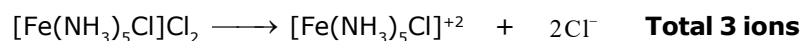
(a) Precipitation of primary valencies on the addition of a suitable reagent.

Ex. $\text{Fe}(\text{NH}_3)_6\text{Cl}_3$ forms 3 moles of AgCl in the form of precipitate on addition of AgNO_3 solution.

This indicates that the complex ionises as $\text{Fe}(\text{NH}_3)_6\text{Cl}_3 \xrightarrow{\text{H}_2\text{O}} [\text{Fe}(\text{NH}_3)_6]^{+3} + 3\text{Cl}^-$

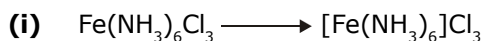
(b) **Electrical conductance of complexes :** More the number of ions provided greater is the electrical conductance of the complex in aqueous medium. **Electrical conductivity \propto no. of Ions.**

Ex. The electrical conductance of aqueous $[\text{Fe}(\text{NH}_3)_6]\text{Cl}_3$ is greater than that of aqueous solution of $[\text{Fe}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$.

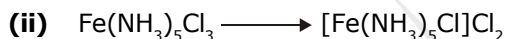
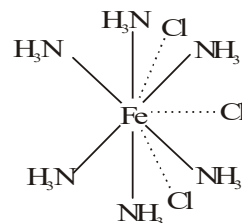


Complex Ions	Modern formula	No. of Cl^- Ions precipitated	Total number of Ions
$\text{PtCl}_4 6\text{NH}_3$	$[\text{Pt}(\text{NH}_3)_6]\text{Cl}_4$	4	5
$\text{PtCl}_4 5\text{NH}_3$	$[\text{Pt}(\text{NH}_3)_5\text{Cl}]\text{Cl}_3$	3	4
$\text{PtCl}_4 4\text{NH}_3$	$[\text{Pt}(\text{NH}_3)_4\text{Cl}_2]\text{Cl}_2$	2	3
$\text{PtCl}_4 3\text{NH}_3$	$[\text{Pt}(\text{NH}_3)_3\text{Cl}_3]\text{Cl}$	1	2
$\text{PtCl}_4 2\text{NH}_3$	$[\text{Pt}(\text{NH}_3)_2\text{Cl}_4]$		0(non-electrolyte)

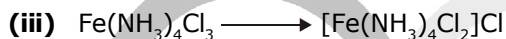
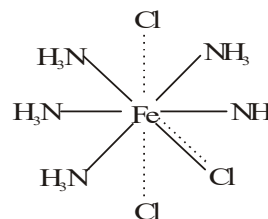
Werner's Representation of complexes



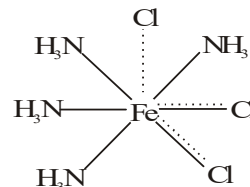
Dotted lines indicate primary valency and continuous lines indicate secondary valency of metal ion.



In this complex 'Cl' groups act as primary valencies and one of the 'Cl' acts as secondary valency also. Thus werner's representation of this complex –



In this complex 'Cl' groups act as primary valency and two of the 'Cl' group act as secondary valencies also. Thus werner's representation of this complex –



Modern Theory of complexes

Central metal ion along with secondary valencies or ligands are written in square brackets and primary valencies outside the square bracket. **Ex.** $[\text{Fe}(\text{NH}_3)_6]\text{Cl}_3$

- Coordination sphere or inner sphere :** This is written in square bracket. This constitutes the central metal ion along with ligands.
- Outer sphere or Ionisation sphere :** This is written outside the square bracket. In aqueous solution the groups written outside the square bracket dissociate and are provided in the form of ions.
- Modern theory of complexes or Electronic Theory of complexes :** Sidgwick and Lowry in 1923 developed this theory, and modified Werner's Theory.
 - According to sidgwick the primary valency is regarded to be formed by transfer of electron and secondary valency is formed by the sharing of electron pair provided by the donor.
 - During formation of primary valency the metal loses electrons. Thus the number of electrons decrease during primary valency formation.
 - In the formation of secondary valency the metal ion gains electrons pairs for the formation of coordinate bond.
 - Thus during the formation of secondary valency, total number of electrons associated with the metal ion increase.
 - The total number of electrons associated with the metal ion in its complex may be equal to or nearly equal to the atomic number of inert gas of the same period. This total number of electrons is called ' **Effective atomic number** ' (E.A.N.) of the metal.

Ex. Effective atomic number of cobalt in $[\text{Co}(\text{NH}_3)_6]^{3+}$ can be calculated as follows :

Atomic number of cobalt = 27

Oxidation state of cobalt in complex = +3

Number of electrons in Co^{+3} ion are $(27-3 = 24)$

During coordinate covalent bonding, Co^{+3} ion gains 6 pairs of electrons.

Thus Effective atomic number of cobalt is $[\text{Co}(\text{NH}_3)_6]^{+3}$ $24+12 = 36$.

(vi) **E.A.N. = (No. of electron in the metal ion) + (No. of electrons gained from the ligands)**

(vii) As the Effective atomic number of cobalt is 36 in this complex, according to sidgwick, this complex will be stable.

(viii) Effective atomic number rule is applicable in many cases, there are several examples in which effective atomic number rule is not obeyed. **Ex.** $[\text{Cr}(\text{H}_2\text{O})_6]^{+3}$ Effective atomic number = 33

Complex	Metal (Oxidation State)	Atomic Number of Metal	Coordination number	Effective atomic number (E.A.N.)
$\text{K}_4[\text{Fe}(\text{CN})_6]$	+2	26	6	$(26 - 2) + (6 \times 2) = 36$ [Kr]
$[\text{Cu}(\text{NH}_3)_4]\text{SO}_4$	+2	29	4	$(29 - 2) + (4 \times 2) = 35$
$[\text{Co}(\text{CH}_3)_6]\text{Cl}_3$	+3	27	6	$(27 - 3) + (6 \times 2) = 36$ [Kr]
$\text{Ni}(\text{CO})_4$	0	28	4	$(28 - 0) + (4 \times 2) = 36$ [Kr]
$\text{K}_2[\text{Ni}(\text{CN})_4]$	+2	28	4	$(28 - 2) + (4 \times 2) = 34$
$\text{K}_2[\text{PtCl}_6]$	+4	78	6	$(78 - 2) + (6 \times 2) = 86$ [Rn]
$\text{K}_3[\text{Cr}(\text{C}_2\text{O}_4)_3]$	+3	24	6	$(24 - 3) + (6 \times 2) = 33$
$\text{K}_3[\text{Fe}(\text{C}_2\text{O}_4)_3]$	+3	26	6	$(26 - 3) + (6 \times 2) = 35$
$\text{K}_2[\text{HgI}_4]$	+2	80	4	$(80 - 2) + (4 \times 2) = 86$ [Rn]
$[\text{Ag}(\text{NH}_3)_2]\text{Cl}$	+1	47	2	$(47 - 1) + (2 \times 2) = 50$
$\text{K}_2[\text{PdCl}_4]$	+2	46	4	$(46 - 2) + (4 \times 2) = 52$

Question : The Effective atomic number of Cr in $\text{Cr}(\text{CO})_6$ is

(1) 36

(2) 38

(3) 28

(4) 54

Ans. (1)

Question : According to the rule of effective atomic number, central atom acquires :

(1) Inert gas configuration

(2) Duplet

(3) Octet

(4) Quartet

Ans. (1)

Question : The Effective atomic number of iron in $\text{K}_4[\text{Fe}(\text{CN})_6]$ is :

(1) 35

(2) 34

(3) 36

(4) 38

Ans. (3)

Valence Bond Theory

This theory was mainly developed by **Linus Pauling**. The main features of this theory are -

- Every metal ion when it forms a complex compound undergoes formation of coordinate covalent bond.
- During this bond formation, the metal ion acts as electron pair acceptor. For this the metal ion provides vacant orbitals.
- The number of vacant orbitals provided is equal to the coordination number of metal ion.

Ex. In the formation of $[\text{Fe}(\text{NH}_3)_6]^{3+}$, Fe^{+3} ion provides six vacant orbitals.

In $[\text{Cu}(\text{NH}_3)_4]^{2+}$, Cu^{+2} ion provides four vacant orbitals.

- (iv) The metal provides vacant orbitals only after the process of hybridisation, thus vacant hybrid orbitals are provided by the metal ion.
- (v) The vacant hybrid orbitals of metal ion get overlapped by orbitals of ligands containing lone pair of electrons.
- (vi) The number of such overlappings is equal to the coordination number of metal ion.
- (vii) The empty 'd' orbitals involved in hybridisation may be inner (n-1)d or outer "nd" orbitals.
- (viii) These complexes are called as **Inner orbital complexes** and **outer orbital complexes** respectively.
- (ix) If inner 'd' orbitals are involved in hybridisation, then it is through only the pairing of unpaired electrons in the 'd' orbitals of metal ion.
- (x) Then such type of complexes will be **diamagnetic** or **less paramagnetic** and will be called as **Low spin complexes**.
- (xi) All outer orbital complexes have **paramagnetic** nature and they are called as **High spin complexes**.

Applications of valence Bond theory

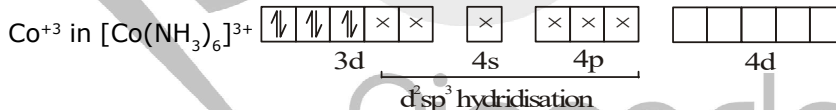
(a) To 6-coordinated complexes :



e^- configuration of $_{27}\text{Co} = [\text{Ar}] 3d^7 4s^2$ So, $\text{Co}^{3+} = [\text{Ar}] 3d^6$



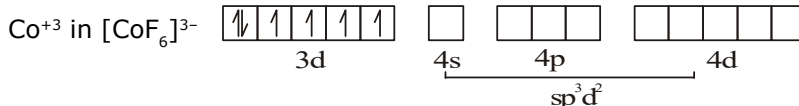
Due to strong ligand electrons get paired up so metal ion provides vacant '3d' orbitals for hybridisation.



This is a **diamagnetic complex**.

As inner 'd' orbitals are involved in hybridisation, hence it is an **inner orbital complex**.

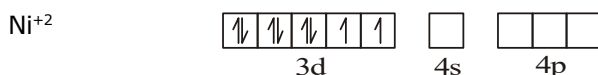
It is a **low spin complex**.



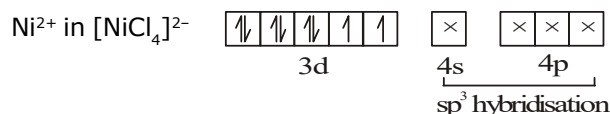
This is a **paramagnetic complex** and **high spin complex**.

The outer 'd' orbitals are involved in hybridisation, hence it is an **outer orbital complex**.

(b) 4-coordinated complexes :

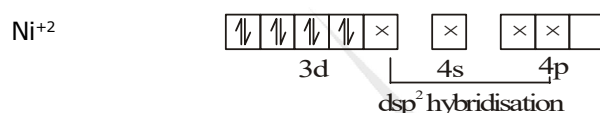


- 1 The unpaired electrons remain as such because Cl^- is a weak ligand as it is a **paramagnetic complex**.



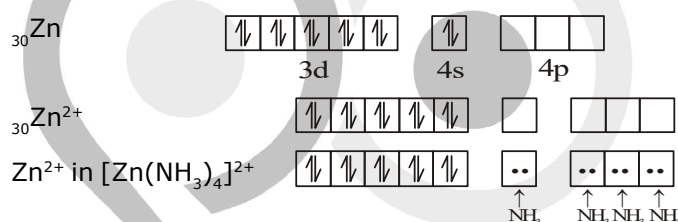
- 1 $[\text{NiCl}_4]^{2-}$ has **tetrahedral geometry**.
 1 It is a **high spin complex**.

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



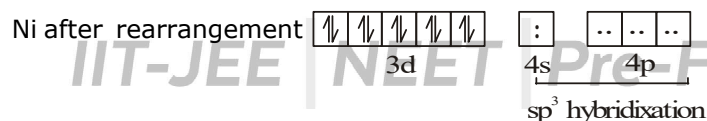
- 1 CN^- is **strong field ligand**. Thus the complex has **square planar geometry**.
 1 The unpaired electrons in '3d' orbitals of Ni^{2+} get paired up, So $[\text{Ni}(\text{CN})_4]^{2-}$ is **diamagnetic** in nature.
 1 This Ni^{2+} complex is an **inner orbital complex** and a **low spin complex**.

$[\text{Zn}(\text{NH}_3)_4]^{2+}$

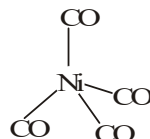


- 1 Because the complex is formed by sp³ hybridisation, hence it is **tetrahedral**.
 1 Since all electrons are paired, hence it is **diamagnetic**.

$[\text{Ni}(\text{CO})_4]$



- 1 CO is strong ligand. So it is **high spin complex**.
 1 The empty one 4s and three 4p orbitals mix to form four new sp³ hybridised orbitals.
 1 Each orbital accepts one electron pair from carbon monoxide molecule forming $[\text{Ni}(\text{CO})_4]$
 1 It is **diamagnetic** in nature, the shape of nickel tetra carbonyl is **tetrahedral** as shown below



Question : When the configuration is d^7 in a transition metal, the paramagnetic susceptibility will be equal to-

- (1) 3.87 B.M. (2) 2.68 B.M. (3) 5.92 B.M. (4) 6.92 B.M.

Sol. (1) The magnetic moment values in Bohr magneton for 1 electron is 1.73, for 2 is 2.83, for 4 is 4.90, for 5 is 5.92, for 6 is 6.92 and so on as further d^7 configuration has three unpaired electron. Hence $\mu = 3.87$ B.M.

Question : The shape of the complex $[\text{Ag}(\text{NH}_3)_2]^+$ is :

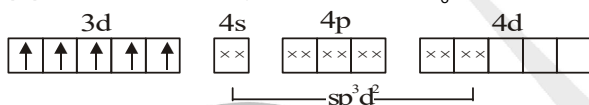
- (1) Octahedral (2) Square planar (3) Tetrahedral (4) Linear

Sol. (4) $\text{Ag}(\text{NH}_3)_2]^+$ has sp -hybridisation and linear complex

Question : Hexafluoroferrate (III) ion is an outer orbital complex. The number of unpaired electrons are

- (1) 1 (2) 5 (3) 4 (4) Unpredictable

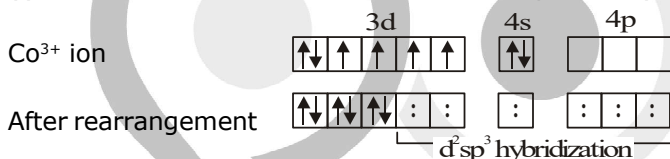
Sol. (2) Electronic configuration of $[\text{FeF}_6]^{3-}$ is -



Question : Find out the hybridization, geometry and magnetic moment of the complexes :

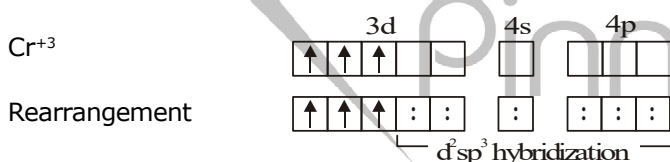
- (i) $[\text{Co}(\text{NH}_3)_6]^{3+}$ (ii) $[\text{Cr}(\text{CN})_6]^{3-}$

Sol. (i) The oxidation state of cobalt in the complex $[\text{Co}(\text{NH}_3)_6]^{3+}$ is +3



It is octahedral and due to no unpaired electrons so zero magnetic moment.

(ii) The oxidation state of chromium in the complex $[\text{Cr}(\text{CN})_6]^{3-}$ +3.



$$\text{mag. moment } (\mu) = \sqrt{3 \times (3 + 2)} = \sqrt{15} = 3.87 \text{ BM}$$

Question : Complex with CN^- ligands are usually

- (1) High spin complexes (2) Low spin complexes
(3) Both (4) None

Sol. (2) A strong field ligand produces low spin complexes.

Question : Which of the following has least conductivity in aqueous solution.

- (1) $\text{Co}(\text{NH}_3)_4\text{Cl}_3$ (2) $\text{Co}(\text{NH}_3)_3\text{Cl}_3$ (3) $\text{Co}(\text{NH}_3)_5\text{Cl}_3$ (4) $\text{Co}(\text{NH}_3)_6\text{Cl}_3$

Sol. (2) $[\text{Co}(\text{NH}_3)_3\text{Cl}_3]$ is non electrolyte

Question : The structure of pentacarbonyl iron is

- (1) Square planar (2) Trigonal bipyramid
(3) Triangular (4) None

- (2) Its magnetic moment is $\sqrt{24}$ BM
 (3) Primary valency of Co is six
 (4) Hybridisation state of CoF_6^{3-} is sp^3d^2

Ans. (3)

Question : Match list - I with list - II and choose the correct answer from the code given below

List - I

(complex)

- (A) $[\text{Ni}(\text{CN})_4]^{-2}$
 (B) $[\text{Pt}(\text{NH}_3)_6]^{+4}$
 (C) $[\text{Ag}(\text{NH}_3)_2]^+$
 (D) $[\text{Zn}(\text{NH}_3)_4]^{+2}$

List - II

(geometry)

- (a) Octahedral
 (b) Squareplanar
 (c) Tetrahedral
 (d) Linear

- | | A | B | C | D |
|-----|---|---|---|---|
| (1) | b | a | d | c |
| (2) | a | b | c | d |
| (3) | c | d | b | a |
| (4) | b | c | d | a |

Ans. (1)

Question : Which of the following compound is square planar and does not have any unpaired electron:

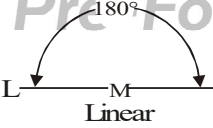
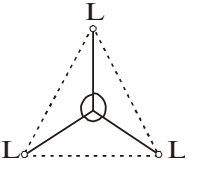
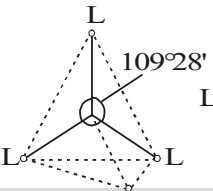
- (a) $[\text{Cu}(\text{NH}_3)_4]^{+2}$ (b) XeF_4 (c) $[\text{Ni}(\text{CO})_4]$
 (d) $[\text{NiCl}_4]^{-2}$ (e) $[\text{Ni}(\text{CN})_4]^{-2}$ (f) $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$
 (1) a, e, f (2) a, b, c (3) b, e (4) b, c, f

Ans. (3)

Question : Which of the following pair of molecule have identical shape :

- (1) $[\text{NiCl}_4]^{2-}$ and XeF_4 (2) $[\text{Zn}(\text{H}_2\text{O})_4]^{2+}$ and SiCl_4
 (3) $[\text{Fe}(\text{CO})_5]$ and XeOF_4 (4) $[\text{Ag}(\text{NH}_3)_2]^+$ and SF_2

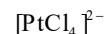
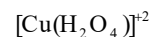
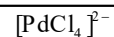
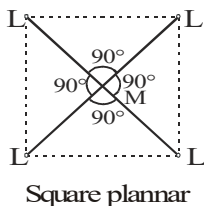
Ans. (2)

Coordination Number	Hybridised orbital	Geometrical shape of the Complex	Examples of Complex
2	sp	 <p>Linear</p>	$[\text{Ag}(\text{NH}_3)_2]^+$ $[\text{Ag}(\text{CN})_2]^-$
3	sp^2		$[\text{HgI}_3]^-$
4	sp^3		$[\text{CuCl}_4]^{-2}$ $[\text{ZnCl}_4]^{-2}$ $[\text{FeCl}_4]^-$ $[\text{Ni}(\text{CO})_4]$ $[\text{Zn}(\text{NH}_3)_4]^{+2}$

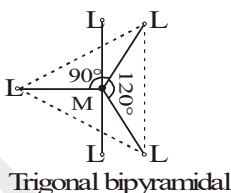
4.

 dsp^2

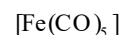
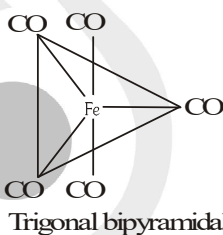
The d-orbital involved is $d_{x^2-y^2}$ orbital



5

 sp^3d 

5.

 dsp^3 

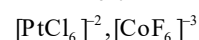
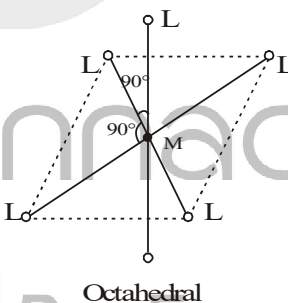
6.

 d^2sp^3

When d-orbitals are $(n-1)d$ -orbitals (Inner orbital complexes) or sp^3d^2

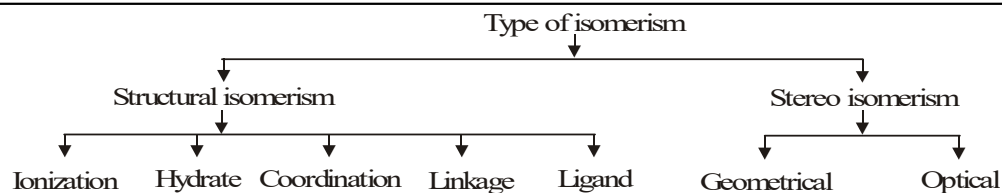
When d-orbitals are nd orbitals (Outer orbital complexes)

In both cases d-orbitals are d_{z^2} and $d_{x^2-y^2}$ orbitals



Crystal Field Theory

- This theory was proposed by **Bethe** and **Vleck**.
- According to this theory when a ligand approaches to the metal ion, the 'd' orbitals of the metal ion undergo splitting forming two sets i.e., higher energy set, eg of $d_{x^2-y^2}$ and d_{z^2} and a lower energy set, t_{2g} of d_{xy} , d_{yz} and d_{xz} .
- If the ligand approaching is strongly basic then more splitting of 'd' orbitals is brought about i.e., the energy difference between ' t_{2g} ' and 'eg' will be very high.
- Under these conditions the electrons of the 'd' orbitals of metal ion get paired up in the t_{2g} set of orbitals. This results in the formation of a diamagnetic or less paramagnetic complex. ($\Delta_0 > PE$)
- If the ligand approaching is weakly basic, then under its influence the 'd' orbitals of metal ion undergo less splitting i.e., the energy difference between t_{2g} and eg orbitals will be less. Due to this the electrons of 'd' orbitals of metal ion get arranged in t_{2g} and eg orbitals forming a paramag-

**STRUCTURAL ISOMERISM :**

It arises due to the difference in the type of chemical linkages and distribution of ligands within and outside the coordination sphere.

Ionisation isomers

The type of isomerism which is due to the exchange of groups or ion between the coordinating sphere and the ionisation sphere. **Ex.**

(a) $\text{Co}(\text{NH}_3)_4 \text{Br}_2 \text{SO}_4$ can represent

(i) $[\text{Co}(\text{NH}_3)_4 \text{Br}_2] \text{SO}_4$ (red violet) (ii) $[\text{Co}(\text{NH}_3)_4 \text{SO}_4] \text{Br}_2$ (red).

These complexes give sulphate ion and bromide ion respectively

(b) $[\text{Pt}(\text{NH}_3)_4 \text{Cl}_2] \text{Br}_2$ and $[\text{Pt}(\text{NH}_3)_4 \text{Br}_2] \text{Cl}_2$

(c) $[\text{Co}(\text{NH}_3)_4 (\text{NO}_3)_2] \text{SO}_4$ and $[\text{Co}(\text{NH}_3)_4 \text{SO}_4] (\text{NO}_3)_2$

Hydrate isomers

This type of isomerism is due to presence of different number of water molecules inside a coordination sphere. **Ex.**

(a) $\text{Cr}(\text{H}_2\text{O})_6 \text{Cl}_3$ has three possible structures

(i) $[\text{Cr}(\text{H}_2\text{O})_6] \text{Cl}_3$ violet (ii) $[\text{Cr}(\text{H}_2\text{O})_5 \text{Cl}] \text{Cl}_2 \cdot \text{H}_2\text{O}$ green

(iii) $[\text{Cr}(\text{H}_2\text{O})_4 \text{Cl}_2] \text{Cl} \cdot 2\text{H}_2\text{O}$ dark green.

These complexes differ from one another with respect to the number of water molecules acting as ligands.

Other hydrate isomers are

(i) $[\text{Co}(\text{NH}_3)_4 \text{H}_2\text{O Cl}] \text{Cl}_2$ (ii) $[\text{Co}(\text{NH}_3)_4 \text{Cl}_2] \text{Cl} \cdot \text{H}_2\text{O}$

Linkage or salt isomers

(a) This type of isomerism arises due to presence of ambidentate ligands like NO_2^- , CN^- and SCN^-

(b) These ligands have two donor atoms but at a time only one atom is directly linked to the central metal atom of the complex.

(c) Such type of isomers are distinguished by infra red (I.R.) spectroscopy. **Ex.**

(i) $[\text{Co}(\text{NH}_3)_5 \text{NO}_2] \text{Cl}_2$ and $[\text{Co}(\text{NH}_3)_5 \text{ONO}] \text{Cl}_2$

(ii) In NO_2^- ligand, The coordinating sites are nitrogen (i.e., NO_2^- Nitro ligand) or through oxygen (i.e. ONO Nitrito ligand)

(iii) The nitro isomer is yellow and is stable to acids whereas nitrito isomer is red and is decomposed by acids.

Coordination isomers

(a) This type of isomerism is exhibited when the complex has two complex ions in it - 'Cationic and anionic'.

(b) This type of isomerism is caused by the interchange of ligands and metal ions between the two complex ions of the same complex. **Ex.**

**Ligand isomers**

(a) Ligands with $\text{C}_3\text{H}_6(\text{NH}_2)_2$ have two different structures i.e. 1, 3-diamino propane and 1, 2-diaminopropane(propylene diamine).

(b) Those complexes which have same molecular formula, but differ with respect to their ligands are called as **Ligand isomers**. **Ex.**

$[\text{Fe}(\text{H}_2\text{O})_2\text{C}_3\text{H}_6(\text{NH}_2)_2\text{Cl}_2]$ has two different structures

**STEREO ISOMERISM :**

(a) They have same molecular formula, same constitution, they differ only with respect to the spatial orientation of ligands in space around the metal ion.

(b) The two stereo isomers which are possible are - Geometrical and optical.

Geometrical or cis - Trans isomers

(a) The ligands occupy different positions around the central metal ion.

(b) When two identical ligands are coordinated to the metal ion from same side then it is **cis isomer**. (Latin, cis means same).

(c) If the two identical ligands are coordinated to the metal ion from opposite side then it is **Trans isomer** (in Latin, Trans means across).

(d) These geometrical isomers differ in physical as well as in chemical properties.

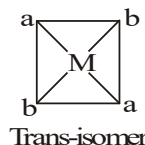
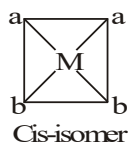
(e) Geometrical isomerism is most important in compounds with coordination numbers 4 and 6.

(f) 4-coordinated complexes with tetrahedral geometry do not exhibit cis - Trans isomerism, because relative position of ligands remain same for each other.

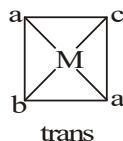
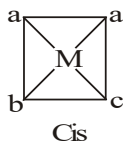
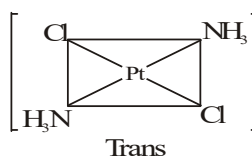
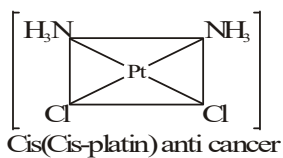
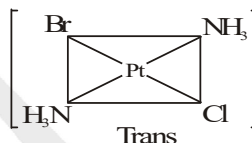
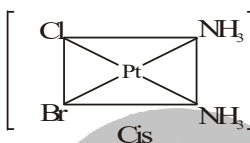
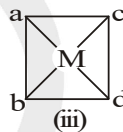
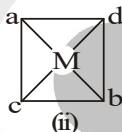
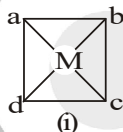
(g) It is exhibited by 4-coordinated complexes with square planar geometry.

Geometrical isomers with coordination number = 4 (Square planar complexes)

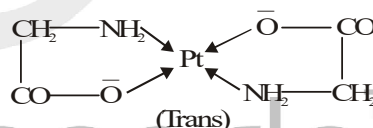
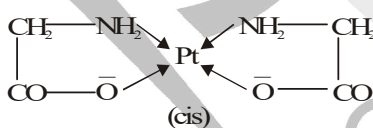
(i) Complexes with general formula, Ma_2b_2 (where both a and b are monodentate) can have Cis-and trans isomers.



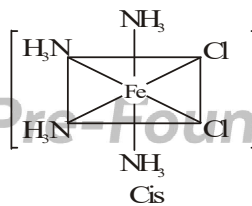
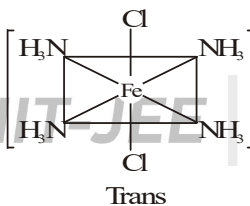
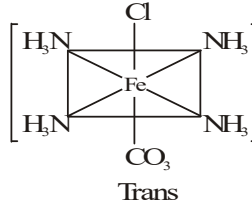
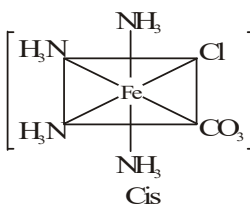
(ii) Complexes with general formula Ma_2bc can have Cis - and trans-isomers.

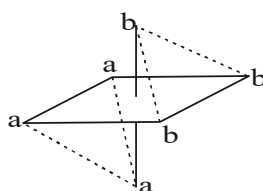
(iii) $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$ (iv) $[\text{Pt}(\text{NH}_3)_2\text{ClBr}]$ (v) Complexes with general formula, Mabcd can have three isomers.

(vi) Diglycinato platinum (iv) complexes

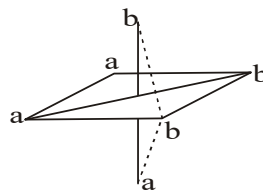


Geometrical isomers with Coordination number = 6

(i) $[\text{Fe}(\text{NH}_3)_4\text{Cl}_2]$ (ii) $[\text{Fe}(\text{NH}_3)_4\text{ClCO}_3]$ 

(iii) Facial and Meridional isomerism (Ma_3b_3)

Facial (fac)



Meridional (Mer)

Note : Other 6-Coordinated geometrical isomers are –

General formula	Total No. of geometrical isomers
Mabcdef	15
Ma_2bcde	9
$\text{Ma}_2\text{b}_2\text{cd}$	6
$\text{Ma}_2\text{b}_2\text{c}_2$	5
Ma_3bcd	4
$\text{Ma}_3\text{b}_2\text{c}$	3
Ma_3b_3	2
Ma_4bc	2
Ma_4b_2	2
Ma_5b	Nil
Ma_6	Nil

Here M = central atom

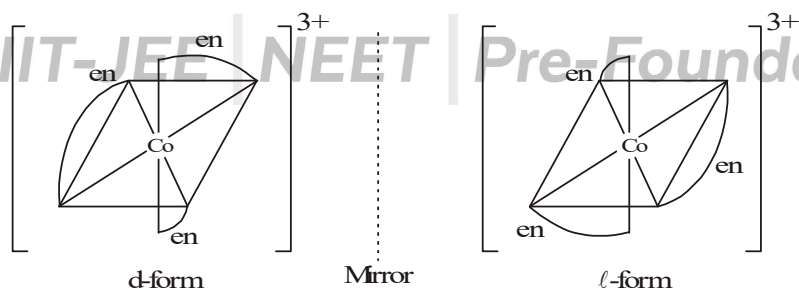
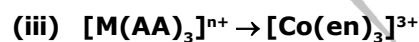
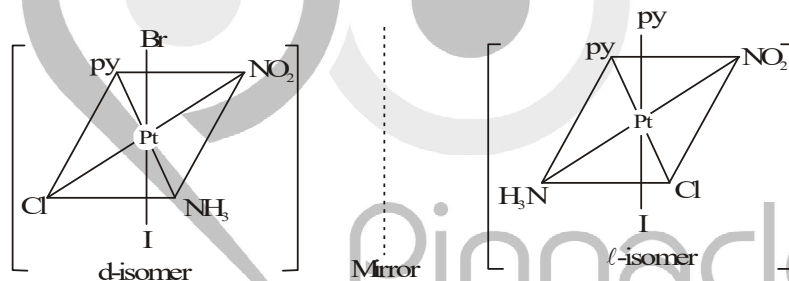
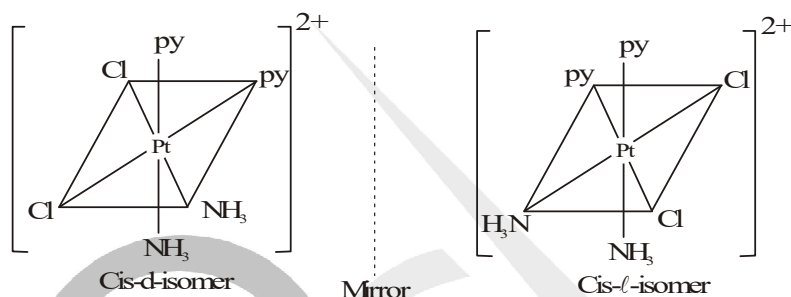
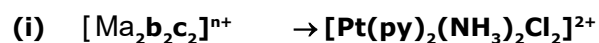
a, b, c, d, e, f = Monodentate ligands

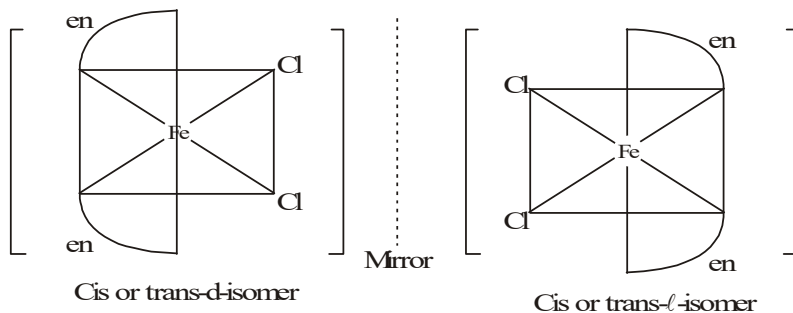
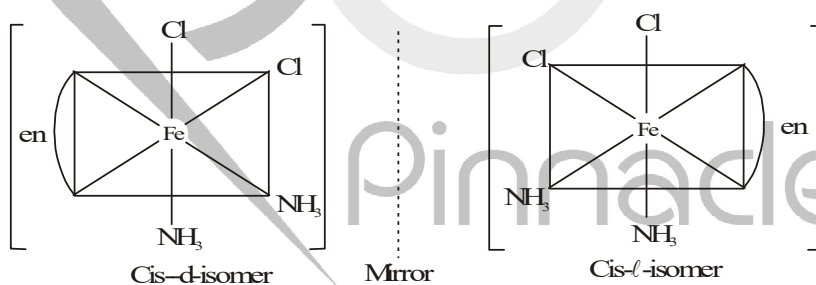
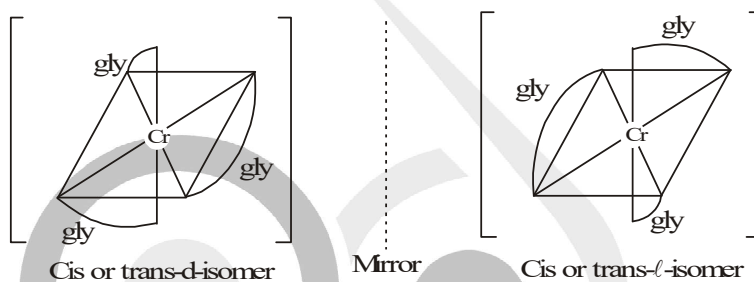
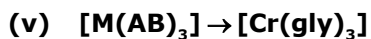
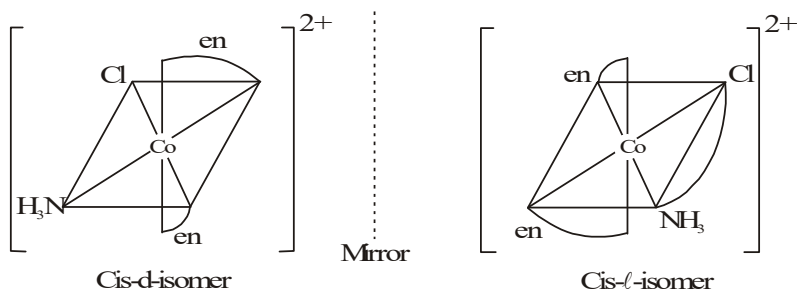
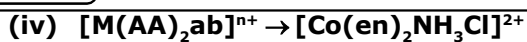
Optical isomers

- Optically active complexes are those which are nonsuperimposable over the mirror image structure.
- An optically active complex is one which is asymmetric in nature i.e., not divisible into two identical halves.
- The complex which rotates plane polarised light to left hand side is **laevo rotatory i.e. ' ℓ ' or '–'** and if the complex rotates the plane polarised light to right hand side then it is **dextro rotatory ' d ' or '+'**.
- Thus complexes which have same physical and chemical properties but differ in their action towards plane polarised light are called as **optical isomers**.
- The ' d ' and ' ℓ ' isomers of a compound are called as **Enantiomers or Enantiomorphs**.
- Only those 6-coordinated complexes in which there are chelating agents i.e. bidentate ligands, exhibit optical isomerism.
- This is due to the absence of elements of symmetry in the complex.
- Optical isomerism is expected in tetrahedral complexes of the type Mabcd .
- These isomers are not isolable due to their labile nature.

- (i) Optical isomerism is not in square planar complexes on account of the presence of axis of symmetry.
- (ii) Optical isomerism is very common in octahedral complexes

Optical isomers with Coordination number = 6





- (i) Trans – $[\text{Fe}(\text{en})_2\text{Cl}_2]$ do not show optical activity due to superimposition of their mirror image.
 (ii) Some more examples are optically active :
 $[\text{Cr}(\text{ox})_3]^{3-}$; $[\text{Fe}(\text{dipy})_3]^{2+}$; $[\text{Cr}(\text{ox})_2(\text{H}_2\text{O}_2)]^-$; $[\text{Pt}(\text{en})_3]^{4+}$ etc.

Question : Which of the following sets is/are example of co-ordination isomerism in complexes ?

- (1) $[\text{Co}(\text{NH}_3)_6] [\text{Cr}(\text{CN})_6]$ and $[\text{Co}(\text{CN})_6] [\text{Cr}(\text{NH}_3)_6]$
 (2) $[\text{Cr}(\text{H}_2\text{O})_5\text{Cl}]\text{Cl}_2 \cdot \text{H}_2\text{O}$ and $[\text{Cr}(\text{H}_2\text{O})_4\text{Cl}_2]\text{Cl} \cdot 2\text{H}_2\text{O}$
 (3) $[\text{Co}(\text{NH}_3)_5\text{Br}]\text{SO}_3$ and $[\text{Cr}(\text{NH}_3)_5\text{SO}_4]\text{Br}$
 (4) $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$ and $[\text{Pt}(\text{NH}_3)_4] [\text{PtCl}_4]$

Sol. (1) When both positive and negative ions are complex, co-ordination isomerism may occur due to the interchange of ligands within the co-ordination sphere itself. **Ex.** $[\text{Co}(\text{NH}_3)_6] [\text{Cr}(\text{CN})_6]$ and $[\text{Co}(\text{CN})_6] [\text{Cr}(\text{NH}_3)_6]$ are two co-ordination isomers, where ammonia and cyanide ligands have been changed within the co-ordination sphere.

Question : Which of the following does/do not exhibit optical isomerism

- (1) Tetrahedral complexes (2) Square planar complexes
 (3) Octahedral complexes (4) Polynuclear complexes

Sol. (2) A square planar complex does not exhibit optical activity because it has a horizontal plane of symmetry.

Question : The number of geometrical isomers of $[\text{Co}(\text{NH}_3)_3(\text{NO}_3)_3]$ are :

- (1) 0 (2) 2 (3) 3 (4) 4

Ans.(2)

Question : Which of the following coordination entity form racemic mixture when combined in equimolar concentration

- (1) $[\text{Cr}(\text{OX})_3]^{3-}$ (2) $[\text{Co}(\text{en})_2\text{Cl}_2]^+$ (3) $[\text{Co}(\text{en})\text{Cl}_4]^-$ (4) All

Ans.(4)

Question : The number of isomeric forms in which $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]^{1+}$ ion can occur is

- (1) 2 (2) 3 (3) 4 (4) 1

Ans.(1)

Question : Which of the following will give maximum number of isomers :-

- (1) $[\text{Co}(\text{py})_3(\text{NH}_3)_3]^{3+}$ (2) $[\text{Ni}(\text{en})(\text{NH}_3)_4]^{2+}$ (3) $[\text{Fe}(\text{C}_2\text{O}_4)(\text{en})_2]^{2-}$ (4) $[\text{Cr}(\text{NO}_2)_2(\text{NH}_3)_4]^+$

Ans.(4)

Question : The total number of possible isomer for the complex comp. :- $[\text{Cu}(\text{NH}_3)_4] [\text{PtCl}_4]$

- (1) 3 (2) 6 (3) 5 (4) 4

Ans.(4)

Question : The complexes $[\text{Co}(\text{NO}_2)(\text{NH}_3)_5]\text{Cl}_2$ and $[\text{Co}(\text{ONO})(\text{NH}_3)_5]\text{Cl}_2$ are the examples of

- (1) Coordination isomerism (2) Ionisation isomerism
 (3) Geometrical isomerism (4) Linkage isomerism

Ans.(4)

Question : The kind of isomerism exhibited by $[\text{Rh}(\text{en})_2\text{Cl}_2][\text{Rh}(\text{en})\text{Cl}_4]$ and $[\text{Rh}(\text{en})_3][\text{RhCl}_6]$ is

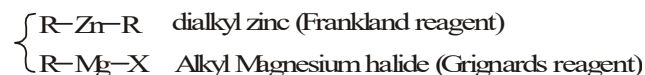
- (1) Linkage (2) Co-ordination (3) Ligand (4) Ionisation

Ans.(2)

ORGANOMETALLIC COMPOUNDS OR C- METAL BOND COMPOUNDS

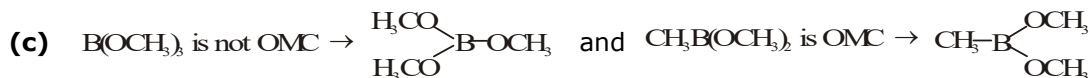
Definition : Compounds containing one or more metal carbon bonds.

- (a) The compounds of metalloids (Ge, Sb) and non metals (B, Si, P, As etc.) which are less electro - ve than carbon are also categorised in this title. **Ex.**



- (b) Sodium acetate $\text{CH}_3\text{C}(=\text{O})\text{ONa}$
 Sodium ethoxide $\text{C}_2\text{H}_5\text{O-Na}$
 Sodium Mercaptide $\text{H}_3\text{C-SNa}$ } These are not organometallic compounds because in these

compounds metal is not directly attached with carbon atom.



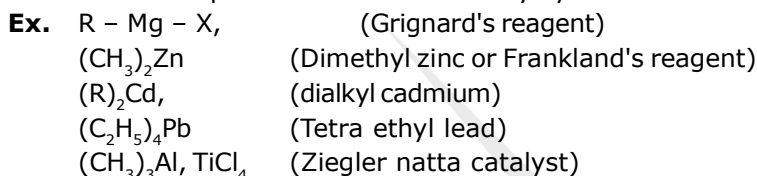
(d) Metal cyanides, carbides and carbonates are not considered OMC because in these compounds metal carbon bond has ionic nature.

Classification of Organometallic Compounds :

OMC can be classified into three main categories –

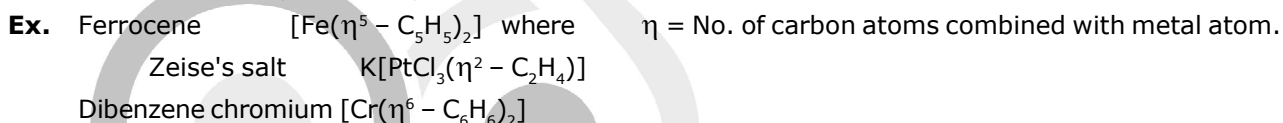
σ - bonded OMC

These compounds are formed mostly by non transition and metalloid elements.



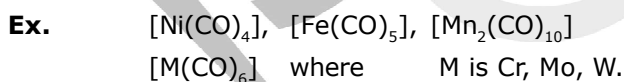
π - bonded OMC

These are usually formed by transition metals.



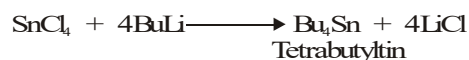
σ and π - bonded OMC

Transition metals of gp. 6, 7, 8, 9 and 10 in their zero oxidation state form such type of OMC. The carbonyl compounds of these metals have both σ and π bonds.



Synthesis of Organometallic Compounds :

(1) By the reaction of metal or metal halide with the desired alkyl halide in presence of dry ether.



(2) Preparation of dibenzene chromium

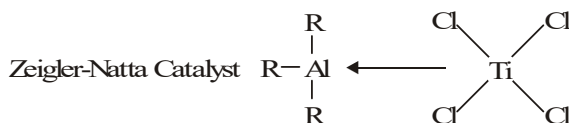


(3) Preparation of metal carbonyl



Application of Organometallic Compounds :

- (a) As homogeneous Catalyst
Wilkinson's catalyst for hydrogenation of olefins is $[P(Ph_3)_3RhCl]$
- (b) As heterogeneous catalyst



Tri alkyl Al \leftarrow Titanium tetrachloride used for polymerisation of alkene.

- (c) Organic synthesis – OMC like $R - Mg - X$, $R_2 - Cd$, $CH_3 - Li$ etc. are used for preparation of almost all type of organic compounds .
- (d) As petrol additive - TEL(Tetraethyl lead) is used as antiknock compd. in petrol.
- (e) In medicine - Organo arsenic compounds are used as medicine for syphilis deases.
- (f) In agriculture - Seeds are treated with ethyl Hg Chloride to protect the plants against infection.

Question : Zeigler natta catalyst is :

- (1) Pt/PTO (2) $Al(C_2H_5)_3 + TiCl_4$
 (3) $K[PtCl_3(\eta^2 - C_2H_4)]$ (4) Pt/Rh

Ans. (2)

Question : In which of the following process OMC is formed with the help of other OMC :

- (1) $SnCl_4 + \text{Butyl lithium} \longrightarrow Bu_4Sn + 4LiCl$
 (2) $C_2H_5I + 4Pb/Na \text{ (alloy)} \longrightarrow (C_2H_5)_4Pb + 4NaI + 3Pb$
 (3) $Ni + 4CO \longrightarrow [Ni(CO)_4]$
 (4) $K_2[PtCl_4] + CH_2 = CH_2 \longrightarrow K[PtCl_3(C_2H_4)] + KCl$

Ans. (1)

Question : Which is/are organometallic compound :-

- (I) Grignard reagent (II) Sodium methoxide (III) trimethyl boron (IV) TEL
 (1) Only I (2) I & II (3) I, II, IV (4) I, III, IV

Ans. (4)

Question : $CH_3 - Mg - Br$ is an organometallic compound due to :

- (1) π - bond between C and Mg (2) Mg - Br covalent bond
 (3) σ - bond between C and Br (4) σ - bond between C and Mg

Ans. (4)

Question : Which of the following is an organometallic compound :

- (1) $Ti(OCOCH_3)_4$ (2) $Ti(OC_6H_5)_4$ (3) $Ti(OC_2H_5)_3C_2H_5$ (4) $[Fe(CN)_6]^{4-}$

Ans. (3)

Question : Which of the following is organometallic compound :-

- (1) Lithium methoxide (2) Lithium acetate
 (3) Methyl lithium (4) Lithium carbonate

Ans. (3)

Level - 1

1. The charge on Iron in $[\text{Fe}(\text{CN})_6]^{3-}$ is
(A) -6 (B) +3
(C) -3 (D) +6
2. Co-ordination number of Co in $[\text{CoF}_6]^{-3}$ is
(A) 4 (B) 5
(C) 6 (D) 8
3. The neutral ligand is
(A) Chloro (B) Hydroxo
(C) Ammine (D) Oxalato
4. $\text{H}_2\text{N} - \text{CH}_2 - \text{CH}_2 - \text{NH}_2$ serves as :
(A) Monodentate ligand
(B) Chelating ligand
(C) Bridging ligand
(D) Cationic ligand
5. In the complex ion $[\text{Fe}(\text{EDTA})]^-$ the coordination number and oxidation state of central metal ion is :-
(A) C. N. = 6 O. N. = +3
(B) C. N. = 1 O. N. = -1
(C) C. N. = 4 O. N. = +2
(D) C. N. = 3 O. N. = +3
6. Which one of the following is not a condition for complex salt formation :-
(A) Small size
(B) Higher nuclear charge
(C) Availability of vacant d-orbitals
(D) Variable oxidation states
7. AgCl precipitate dissolves in NH_3 due to the formation of :-
(A) $[\text{Ag}(\text{NH}_4)_2]\text{OH}$
(B) $[\text{Ag}(\text{NH}_4)_2]\text{Cl}$
(C) $[\text{Ag}(\text{NH}_3)_2]\text{Cl}$
(D) $[\text{Ag}(\text{NH}_3)_2]\text{OH}$
8. The coordination number and oxidation number of the central metal ion in the complex $[\text{Pt}(\text{en})_2]^{+2}$ is :-
(A) C. N. = 2, O. N. = +2
(B) C. N. = 6, O. N. = +4
(C) C. N. = 4, O. N. = +4
(D) C. N. = 4, O. N. = +2
9. Which one of the following is not a complex compound ?
(A) $[\text{Cu}(\text{NH}_3)_4]\text{SO}_4 \cdot \text{H}_2\text{O}$
(B) $\text{K}_2[\text{PtCl}_6]$
(C) $\text{K}_2\text{SO}_4 \cdot \text{Al}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$
(D) $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$
10. The addition compounds, which retain their identity in solution are called.
(A) Double salts
(B) Complex compounds
(C) Coordination compounds
(D) (B) and (C) both
11. The formula of the complex tris (ethylene diamine) cobalt (III) sulphate is
(A) $[\text{Co}(\text{en})_2\text{SO}_4]$ (B) $[\text{Co}(\text{en})_3\text{SO}_4]$
(C) $[\text{Co}(\text{en})_3]\text{SO}_4$ (D) $[\text{Co}(\text{en})_3]_2(\text{SO}_4)_3$
12. The IUPAC name of $\text{Fe}(\text{CO})_5$ is
(A) Pentacarbonyl ferrate (0)
(B) Pentacarbonyl Ferrate (III)
(C) Pentacarbonyl Iron (0)
(D) Pentacarbonyl Iron (II)
13. The complex $\text{Hg}[\text{Co}(\text{CNS})_4]$ is correctly named as :
(A) Mercury tetrathiocyanato cobaltate (II)
(B) Mercury cobalt tetrasulphocyno(II)
(C) Mercury tetrasulphocyanide cobaltate(II)
(D) Mercury sulphocyanato cobalt (II)
14. The correct name of $(\text{CO})_3\text{Fe} \begin{array}{c} \diagup \text{CO} \diagdown \\ \text{CO} \\ \diagdown \text{CO} \diagup \end{array} \text{Fe}(\text{CO})_5$ is
(A) μ - tricarbonyl - Bis (tricarbonyl iron (0))
(B) Hexacarbonyl iron(III) μ - tricarbonyl ferrate(0)
(C) Tricarbonyl iron (0) μ - tricarbonyl iron (0) tricarbonyl
(D) Nona carbonyl Iron
15. The compound $\text{Na}_2[\text{Fe}(\text{CN})_5\text{NO}^+]$ is called -
(A) Sodium pentacyanonitrosonium ferrate (II)
(B) Sodium nitroprusside
(C) Sodium nitrosoferrocyanide
(D) 1 & 2 both
16. Which of the following is cationic complex
(A) Tetracarbonyl nickel (0)
(B) Hexachloroplatinante (III) ion
(C) Hexaaquairon (III) ion
(D) Tetraiodomercurate (II) ion
17. $\text{K}_3[\text{Fe}(\text{CN})_6]$ is :-
(a) Potassium hexacyno ferrate (II)
(b) Potassium hexacyno ferrate (III)
(c) Potassium ferri-cyanide
(d) Hexa cyno ferrate (III) potassium
Correct answer is :-
(A) Only (a) and (b) (B) Only (b) and (c)
(C) Only (a) and (c) (D) Only (b) and (d)

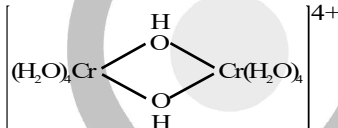
- 18.** The IUPAC name of the complex $[\text{CrCl}_2(\text{H}_2\text{O})_4]\text{NO}_3$ is :-
 (A) Dichlorotetraaqua chromium (III) nitrate
 (B) Tetraaquadichlorochromium (III) nitrate
 (C) Chromium tetra aqua dichloro nitrate
 (D) Dichlorotetraaqua chromium nitrate
- 19.** Name of $\text{Na}_3[\text{AlF}_6]$ is :-
 (a) Cryolite
 (b) Tri sodium hexa fluoroaluminium
 (c) Sodium hexafluoro aluminium(III)
 (d) Sodium hexafluoroaluminate (III)
 The correct answer is :-
 (A) Only a (B) a and d both
 (C) Only d (D) a and c both
- 20.** Give the IUPAC name of the complex compound $[\text{Co}(\text{NH}_3)_4(\text{H}_2\text{O})\text{Br}](\text{NO}_3)_2$.
 (A) Bromoaquatetraamine Cobalt (III) nitrate
 (B) Bromoaquatetraaminocobalt (III) nitrate
 (C) Bromoaquatetraammine cobalt (III) nitrate
 (D) Tetraammineaquabromo cobalt (III) nitrate
- 21.** Name the following compound according to IUPAC system
-
- (A) μ -chloro- μ -nitrooctaminedicobalt (III) sulphate
 (B) μ -chloro- μ -nitrooctaamminedicobalt (III) sulphate
 (C) μ -nitro- μ -chlorooctaamminedicobalt (III) sulphate
 (D) All of the above
- 22.** Chemical Name of "Turn bull's blue" is :-
 (A) Ferrous ferricyanide
 (B) Potassium ferrocyanide
 (C) Potassium cyanide
 (D) Potassium ferricyanide
- 23.** Which of the following complex is anion :-
 (A) Fluoro pentaammine cobalt (III)
 (B) Trioxalato ferrate (III)
 (C) Penta Carbonyl iron (0)
 (D) Dichloro diammine platinum
- 24.** The formula of dichloro bis (Urea) copper (II) is :-
 (A) $[\text{Cu}\{\text{O}=\text{C}(\text{NH}_2)_2\}_2]\text{Cl}_2$
 (B) $[\text{CuCl}_2\{\text{O}=\text{C}(\text{NH}_2)_2\}]$
 (C) $[\text{Cu}\{\text{O}=\text{C}(\text{NH}_2)_2\}\text{Cl}]\text{Cl}$
 (D) $[\text{CuCl}_2\{\text{O}=\text{C}(\text{NH}_2)_2\}_2]$
- 25.** The chloro-bis (ethylenediamine) nitro cobalt (III) ion is :-
 (A) $[\text{Co}(\text{NO}_2)_2(\text{en})_2\text{Cl}_2]^+$
 (B) $[\text{CoCl}(\text{NO}_2)_2(\text{en})_2]^+$
 (C) $[\text{Co}(\text{NO}_2)\text{Cl}(\text{en})_2]^+$
 (D) $[\text{Co}(\text{en})\text{Cl}_2(\text{NO}_2)_2]^-$
- 26.** The effective atomic number of Cr (atomic no. 24) in $[\text{Cr}(\text{NH}_3)_6]\text{Cl}_3$ is
 (A) 35 (B) 27
 (C) 33 (D) 36
- 27.** Which one of the following will give a white precipitate with AgNO_3 in aqueous medium ?
 (A) $[\text{Co}(\text{NH}_3)_5\text{Cl}](\text{NO}_3)_2$
 (B) $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$
 (C) $[\text{Pt}(\text{en})\text{Cl}_2]$
 (D) $[\text{Pt}(\text{NH}_3)_4]\text{Cl}_2$
- 28.** Which gives only 25% mole of AgCl , when reacts with AgNO_3 :-
 (A) $\text{PtCl}_2 \cdot 4\text{NH}_3$ (B) $\text{PtCl}_4 \cdot 5\text{NH}_3$
 (C) $\text{PtCl}_4 \cdot 4\text{NH}_3$ (D) $\text{PtCl}_4 \cdot 3\text{NH}_3$
- 29.** Which of the following will not give the chemical test for iron in aqueous solution
 (A) $\text{Fe}_4[\text{Fe}(\text{CN})_6]_3$
 (B) $\text{K}_2\text{Fe}_2(\text{SO}_4)_4 \cdot 24\text{H}_2\text{O}$
 (C) $\text{K}_3[\text{FeF}_6]$
 (D) $(\text{NH}_4)_2\text{SO}_4 \cdot \text{FeSO}_4 \cdot 6\text{H}_2\text{O}$
- 30.** In the metal carbonyls of general formula $\text{M}(\text{CO})_x$ (Which follows EAN rule) if M is Ni, Fe and Cr the value of x will be respectively:-
 (A) 6, 5, 6 (B) 4, 5, 6
 (C) 4, 4, 5 (D) 4, 6, 6
- 31.** In which of the following complexes central metal ion do not follows EAN rule :-
 (A) $\text{Fe}(\text{CO})_5$
 (B) $[\text{CoF}_6]^{3-}$
 (C) $[\text{HgI}_4]^{2-}$
 (D) $[\text{Cr}(\text{H}_2\text{O})_6]^{+3}$
- 32.** No. of moles of BaSO_4 precipitates when reagent $[\text{Cu}(\text{NH}_3)_4]\text{SO}_4$ treated with excess of BaCl_2 :-
 (A) 2 (B) 0
 (C) 1 (D) None of these
- 33.** Which of the following compound is paramagnetic
 (A) Tetracyanonickelate (II) ion
 (B) Tetraamminezinc (II) ion
 (C) Hexaamine chromium (III) ion
 (D) Diammine silver (I) ion
- 34.** The shape of the complex $[\text{Ag}(\text{NH}_3)_2]^+$ is :
 (A) Octahedral (B) Square planar
 (C) Tetrahedral (D) Linear

35. Hexafluoroferrate (III) ion is an outer orbital complex. The number of unpaired electrons are
(A) 1 (B) 5
(C) 4 (D) Unpredictable
36. Complex with CN^- ligands are usually
(A) High spin complexes
(B) Low spin complexes
(C) Both
(D) None
37. The structure of pentacarbonyl iron is
(A) Square planar (B) Trigonal bipyramid
(C) Triangular (D) None
38. The shape of $[\text{Cu}(\text{NH}_3)_4]\text{SO}_4$ is :
(A) Square planar (B) Pyramidal
(C) Octahedral (D) Tetrahedral
39. Which is low spin complex :
(A) $[\text{Fe}(\text{CN})_6]^{3-}$ (B) $[\text{Co}(\text{NO}_2)_6]^{3-}$
(C) $[\text{Mn}(\text{CN})_6]^{3-}$ (D) All
40. Complexes with halide ligands are generally :
(A) High spin complexes
(B) Low spin complexes
(C) Both
(D) None
41. Among the following ions, which one has the highest paramagnetism ?
(A) $[\text{FeF}_6]^{3-}$ (B) $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$
(C) $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ (D) $[\text{Zn}(\text{H}_2\text{O})_6]^{2+}$
42. In the complex ion ML_6^{n+} , M^{n+} has five d-electrons and L is weak field ligand. According to crystal field theory, the magnetic properties of the complex ion correspond to how many unpaired electrons
(A) 0 (B) 5
(C) 2 (D) 3
43. Among $\text{Ni}(\text{CO})_4$, $\text{Ni}(\text{CN})_4^{2-}$ and $[\text{Ni}(\text{Cl})_4]^{2-}$:
(A) $\text{Ni}(\text{CO})_4$ and NiCl_4^{2-} are diamagnetic and $\text{Ni}(\text{CN})_4^{2-}$ is paramagnetic
(B) NiCl_4^{2-} and $\text{Ni}(\text{CN})_4^{2-}$ are diamagnetic and $\text{Ni}(\text{CO})_4$ is paramagnetic
(C) $\text{Ni}(\text{CO})_4$ and $\text{Ni}(\text{CN})_4^{2-}$ are diamagnetic and NiCl_4^{2-} is paramagnetic
(D) $\text{Ni}(\text{CO})_4$ is diamagnetic and NiCl_4^{2-} and $\text{Ni}(\text{CN})_4^{2-}$ are paramagnetic
44. For $\text{K}_3[\text{CoF}_6]$, incorrect statement is :
(A) It is high spin complex
(B) Its magnetic moment is $\sqrt{24}$ BM
(C) Primary valency of Co is six
(D) Hybridisation state of CoF_6^{3-} is sp^3d^2
45. Which one of these ions absorbs energy from visible spectrum :-
(A) $[\text{Cu}(\text{NH}_3)_4]^+$ (B) $[\text{Cu}(\text{NH}_3)_4]^{+2}$
(C) $[\text{Zn}(\text{H}_2\text{O})_6]^{+2}$ (D) $[\text{Co}(\text{H}_2\text{O})_6]^{+3}$
46. A magnetic moment of 1.73 BM will be shown by one among of the following compounds .
(A) $[\text{Cu}(\text{NH}_3)_4]^{2+}$ (B) $[\text{Ni}(\text{CN})_4]^{2-}$
(C) TiCl_4 (D) $[\text{CoCl}_6]^{3-}$
47. The magnetic property and the shape of $[\text{Cr}(\text{NH}_3)_6]^{3+}$ complex ions are :
(A) Paramagnetic, Octahedral
(B) Diamagnetic, square planer
(C) Paramagnetic, tetrahedral
(D) None of the above
48. Amongst the following ions which one has the highest paramagnetism
(A) $[\text{Cr}(\text{H}_2\text{O})_6]^{2+}$ (B) $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$
(C) $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ (D) $[\text{Zn}(\text{H}_2\text{O})_6]^{2+}$
49. Which of the following complexes is an inner orbital complex ?
(A) $[\text{CoF}_6]^{3-}$ (B) $[\text{FeF}_6]^{3-}$
(C) $[\text{Cr}(\text{NH}_3)_6]^{3+}$ (D) $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$
50. Hexafluoro cobaltate (III) ion is found to be high spin complex, the probable hybrid state of cobalt in it, is:-
(A) dsp^2 (B) d^2sp^3
(C) sp^3d^2 (D) sp^3d
51. In the complex $[\text{Ni}(\text{H}_2\text{O})_2(\text{NH}_3)_4]^{+2}$ the magnetic moment (μ) of Ni is :-
(A) Zero (B) 2.83 BM
(C) 1.73 BM (D) 3.87 BM
52. Which of the following system has maximum number of unpaired electrones :-
(A) d^5 (Octahedral, low spin)
(B) d^8 (Tetrahedral)
(C) d^6 (Octahedral, low spin)
(D) d^3 (Octahedral)
53. Which of the following sets is/are example of co-ordination isomerism in complexes ?
(A) $[\text{Co}(\text{NH}_3)_6]$, $[\text{Cr}(\text{CN})_6]$ and $[\text{Cr}(\text{NH}_3)_6][\text{Co}(\text{CN})_6]$
(B) $[\text{Cr}(\text{H}_2\text{O})_5\text{Cl}]\text{Cl}_2 \cdot \text{H}_2\text{O}$ and $[\text{Cr}(\text{H}_2\text{O})_4\text{Cl}_2]\text{Cl} \cdot 2\text{H}_2\text{O}$
(C) $[\text{Co}(\text{NH}_3)_5\text{Br}]\text{SO}_3$ and $[\text{Cr}(\text{NH}_3)_5\text{SO}_4]\text{Br}$
(D) $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$ and $[\text{Pt}(\text{NH}_3)_4][\text{PtCl}_4]$
54. Which of the following does/do not exhibit optical isomerism
(A) Tetrahedral complexes
(B) Square planar complexes
(C) Octahedral complexes
(D) Polynuclear complexes
55. The number of geometrical isomers of $[\text{Co}(\text{NH}_3)_3(\text{NO}_3)_3]$ are :
(A) 0 (B) 2
(C) 3 (D) 4

56. A square planar complex is cis platin $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$, shows :
 (A) Geometrical isomerism
 (B) Optical isomerism
 (C) Linkage isomerism
 (D) None
57. The two compounds sulphato penta-ammine cobalt (III) bromide and sulphato penta-ammine cobalt (III) chloride represent :
 (A) Linkage isomerism
 (B) Ionisation isomerism
 (C) Co-ordination isomerism
 (D) No isomerism
58. The number of isomeric forms in which $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]^{1+}$ ion can occur is
 (A) 2 (B) 3
 (C) 4 (D) 1
59. Which of the following set of isomerism is wrong :
 (A) Cis- $[\text{Co}(\text{gly})_2\text{Cl}_2]^-$ – optical isomerism
 (B) $[\text{Zn}(\text{NH}_3)_3\text{Cl}]^+$ – Geometrical isomerism
 (C) $[\text{Fe}(\text{H}_2\text{O})_6]\text{Cl}_3$ – Hydrate isomerism
 (D) $[\text{Co}(\text{en})_2(\text{NCS})_2]\text{Cl}$ – Linkage isomerism
60. Which of the following will give maximum number of isomers :-
 (A) $[\text{Co}(\text{py})_3(\text{NH}_3)_3]^{3+}$
 (B) $[\text{Ni}(\text{en})(\text{NH}_3)_4]^{2+}$
 (C) $[\text{Fe}(\text{C}_2\text{O}_4)(\text{en})_2]^{2-}$
 (D) $[\text{Cr}(\text{NO}_2)_2(\text{NH}_3)_4]^+$
61. The total number of possible isomer for the complex comp. :- $[\text{Cu}(\text{NH}_3)_4][\text{PtCl}_4]$
 (A) 3 (B) 6
 (C) 5 (D) 4
62. The complexes $[\text{Co}(\text{NO}_2)(\text{NH}_3)_5]\text{Cl}_2$ and $[\text{Co}(\text{ONO})(\text{NH}_3)_5]\text{Cl}_2$ are the examples of
 (A) Coordination isomerism
 (B) Ionisation isomerism
 (C) Geometrical isomerism
 (D) Linkage isomerism
63. Which of the following is π -acid ligand
 (A) NH_3 (B) CO
 (C) gly. (D) ethylene diamine
64. Zeigler natta catalyst is :
 (A) Pt/PTO
 (B) $\text{Al}(\text{C}_2\text{H}_5)_3 + \text{TiCl}_4$
 (C) $\text{K}[\text{PtCl}_3(\eta^2 - \text{C}_2\text{H}_4)]$ (D) Pt/Rh
65. In which of the following process OMC is formed with the help of other OMC :
 (A) $\text{SnCl}_4 + \text{Butyl lithium} \longrightarrow \text{Bu}_4\text{Sn} + 4\text{LiCl}$
 (B) $\text{C}_2\text{H}_5\text{I} + 4\text{Pb}/\text{Na (alloy)} \longrightarrow (\text{C}_2\text{H}_5)_4\text{Pb} + 4\text{NaI} + 3\text{Pb}$
 (C) $\text{Ni} + 4\text{CO} \longrightarrow [\text{Ni}(\text{CO})_4]$
 (D) $\text{K}_2[\text{PtCl}_4] + \text{CH}_2 = \text{CH}_2 \longrightarrow \text{K}[\text{PtCl}_3(\text{C}_2\text{H}_4)] + \text{KCl}$
66. Which is/are organometallic compound :-
 (I) Grignard reagent (II) Sodium methoxide
 (III) trimethyl boron (IV) $\text{Al}_2(\text{CH}_3)_6$
 (A) Only I (B) I & II
 (C) I, II, IV (D) I, III, IV
67. $\text{CH}_3 - \text{Mg} - \text{Br}$ is an organometallic compound due to :
 (A) π – bond between C and Mg
 (B) Mg – Br covalent bond
 (C) σ – bond between C and Br
 (D) σ – bond between C and Mg
68. The brown ring test for nitrites and nitrates is due to the formation of a complex ion with formula :-
 (A) $[\text{Fe}(\text{H}_2\text{O})_5\text{NO}]^{2+}$ (B) $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$
 (C) $[\text{Fe}(\text{H}_2\text{O})(\text{NO})_5]^{2-}$ (D) $[\text{Fe}(\text{NO})(\text{CN})_5]^{2+}$
69. In a ferric salt on adding KCN a prussian blue is obtained which is :-
 (A) $\text{K}_3[\text{Fe}(\text{CN})_6]$ (B) $\text{Fe}_3[\text{Fe}(\text{CN})_6]_4$
 (C) $\text{FeSO}_4[\text{Fe}(\text{CN})_6]$ (D) $\text{Fe}_4[\text{Fe}(\text{CN})_6]_3$
70. Tollen's reagent is :-
 (A) $[\text{Ag}(\text{NH}_3)_2]^+$ (B) Ag_2O
 (C) $\text{Al}(\text{OH})_3$ (D) $[\text{Au}(\text{CN})_2]^-$
71. Nessler's reagent is :-
 (A) K_2HgI_4 (B) $\text{K}_2\text{HgI}_4 + \text{KOH}$
 (C) $\text{K}_2\text{HgI}_2 + \text{KOH}$ (D) $\text{K}_2\text{HgI}_4 + \text{Hg}$
72. Hypo is used in photography because it is :-
 (A) A strong reducing agent
 (B) A strong oxidising agent
 (C) A strong Complexing agent
 (D) Photo sensitive Compound
73. The image on an exposed and developed photography film is due to :-
 (A) AgBr (B) $[\text{Ag}(\text{S}_2\text{O}_3)_2]^{3+}$
 (C) Ag (D) Ag_2O
74. The solubility of AgBr in hypo solution is due to the formation of :-
 (A) Ag_2SO_3 (B) $\text{Ag}_2\text{S}_2\text{O}_3$
 (C) $[\text{Ag}(\text{S}_2\text{O}_3)]^-$ (D) $[\text{Ag}(\text{S}_2\text{O}_3)_2]^{3-}$
75. A compound which is used in photography is :-
 (A) AgCl (B) AgBr
 (C) AgNO_3 (D) Ag_2CO_3
76. $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$ is used in photography to :-
 (A) Reduce AgBr to metallic Ag
 (B) Remove reduced Ag
 (C) Remove undecomposed AgBr as a soluble complex
 (D) Converts metallic Ag to silver salt
77. Photo graphic films or plates have.....as an essential ingredient :-
 (A) Silver oxide (B) Silver bromide
 (C) Silver thio sulphate (D) Silver nitrate

Level - 2

- The total number of Ligands attached to the central metal ion through coordination (sigma) bond is called.
(A) Valency of the metal ion
(B) Oxidation state of the metal ion
(C) Coordination number of metal ion
(D) None of the above
- Select bidentate or didentate ligand from the following.
(A) CO (B) SCN⁻
(C) CH₃COO⁻ (D) C₂O₄²⁻
- The oxidation state of Ag in Tollen's reagent is
(A) 0 (B) +1
(C) +1.5 (D) +2
- The co-ordination number of a metal in co-ordination compound is
(A) Same as primary valency
(B) Sum of primary and secondary valencies
(C) Same as secondary valency
(D) None of the above
- For a stable complex, the value of ionic potential $\left(\frac{\text{ionic charge}}{\text{ionic radius}}\right)$ must be.
(A) Small (B) Large
(C) Zero (D) None of these
- The oxidation and coordination number of Pt in [Pt(C₂H₄)Cl₃]⁻ is respectively :-
(A) +1, 3 (B) +2, 4
(C) +3, 6 (D) +2, 5
- If thio-cyanide ion is added to potash-ferric alum then red colour appears. This colour is due to the formation of :-
(A) KSCN (B) Fe(SCN)₃
(C) Fe(SCN)₂ (D) Fe(SCN)
- The CN and ON of X in the compound [X(SO₄)(NH₃)₅] will be :-
(A) 10 and 3 (B) 1 and 6
(C) 6 and 4 (D) 6 and 2
- To form a coordination bond, one needs a ligand. Which of the following species cannot be a ligand
(i) NH₄⁺ (ii) NO⁺
(iii) C₅H₅ $\ddot{\text{N}}$
(A) i only (B) i & ii only
(C) i & iii only (D) i, ii & iii only
- The stability constants of the complexes formed by a metal ion M²⁺ with NH₃, CN⁻, H₂O are of the order of 10¹⁵, 10²⁷, 10¹¹ respectively. Then
(A) NH₃ is the strongest ligand
(B) CN⁻ is the strongest ligand
(C) These values cannot predict the strength of the ligand
(D) All the ligands are equally strong
- From the stability constant K (Hypothetical values) given below, predict which is strongest ligand:-
(A) $\text{Cu}^{2+} + 2\text{C}_2\text{O}_4^{2-} \rightleftharpoons [\text{Cu}(\text{C}_2\text{O}_4)_2]^{-2}$
 $K = 4.5 \times 10^{11}$
(B) $\text{Cu} + 4\text{CN}^- \rightleftharpoons [\text{Cu}(\text{CN})_4]^{-2}$
 $K = 2.0 \times 10^{27}$
(C) $\text{Cu}^{2+} + 2\text{en} \rightleftharpoons [\text{Cu}(\text{en})_2]^{2+}$
 $K = 3.0 \times 10^{15}$
(D) $\text{Cu}^{2+} + 4\text{F}^- \rightleftharpoons [\text{CuF}_4]^{-2}$
 $K = 9.5 \times 10^6$
- Which of the following statement is incorrect about [Fe(H₂O)₅NO]SO₄ :-
(A) It gives brown ring test for nitrates
(B) Oxidation state of Fe is +1
(C) It exhibits geometrical isomerism
(D) Charge on NO is +1
- Which of the following complexes is not a chelate
(A) bis (dimethylglyoximate) nickel(II)
(B) Potassium ethylenediaminetetrathiocyanato chromate(III)
(C) Tetrammine dichlorocobalt(III) nitrate
(D) Trans-diglycinatoplatinum(II)
- The correct IUPAC name of the complex Fe(C₅H₅)₂ is
(A) Cyclopentadienyl iron (II)
(B) Bis (cyclopentadienyl) iron (II)
(C) Dicyclopentadienyl ferrate (II)
(D) Ferrocene
- The correct name of [Pt(NH₃)₄Cl₂] [PtCl₄] is :-
(A) Tetraammine dichloro platinum (IV) tetrachloro platinate (II)
(B) Dichloro tetra ammine platinum (IV) tetrachloro platinate (II)
(C) Tetrachloro platinum (II) tetraammine platinate(IV)
(D) Tetrachloro platinum (II) dichloro tetraamine platinate (IV)

- 16.** The IUPAC name of $K_2[Cr(CN)_2O_2(O)_2(NH_3)]$ is :-
 (A) Potassiumamminedicyano dioxoperoxochromate(VI)
 (B) Potassiumamminecyanoperoxodioxo chromium (VI)
 (C) Potassiumamminecyanoperoxodioxo chromium (VI)
 (D) Potassiumamminecyanoperoxodioxo chromate (IV)
- 17.** The IUPAC name for $[Co(NH_3)_6][Cr(CN)_6]$ is :-
 (A) Hexaammine cobalt (III) hexacyanochromate (III)
 (B) Hexacyanochromium cobalt hexaammine (VI)
 (C) Hexaammine cobalt (III) hexacyanochromium (VI)
 (D) Hexacyanochromium (III) hexaammine cobalt (III)
- 18.** The IUPAC name for $[Co(NCS)(NH_3)_5]Cl_2$ is :-
 (A) Pentaammine (thiocyanato-N) cobalt (III) chloride
 (B) Pentaammine (thiocyanato-S) cobalt (III) chloride
 (C) Pentaammine (isothiocyanato-N,S)cobalt (III) chloride
 (D) Pentaammine (mercapto-N) cobalt (III) chloride
- 19.** IUPAC name of $K_2 [O_5Cl_5N]$ will be
 (A) Potassium pentachloroazido osmate (VIII)
 (B) Potassium pentachloroazido osmate (VI)
 (C) Potassium pentachloro nitrido osmate (VI)
 (D) Potassium nitro osmate (III)
- 20.** What is the oxidation number of chromium in the dimeric hydroxo bridged species :-

 (A) + 6 (B) + 4
 (C) + 3 (D) + 2
- 21.** The IUPAC name for $[(NH_3)_5Cr-OH-Cr(NH_3)_5]^{5+}$ is :-
 (A) μ -hydroxo-bis (pentaammine dichromium) (V+) ion
 (B) μ -hydroxo-bis (decaammine dichromium (V+) ion
 (C) μ -hydroxo-bis (octaammine chromium) (V+) ion
 (D) μ -hydroxo-bis (pentammine chromium) (III) ion
- 22.** The correct name of the compound $[Cu(NH_3)_4](NO_3)_2$, according to IUPAC system is :-
 (A) Cuprammonium nitrate
 (B) Tetraammine copper (II) dinitrate
 (C) Tetraammine copper (II) nitrate
 (D) Tetraammine copper (I) dinitrate
- 23.** $FeCl_3 \cdot 4H_2O$ is actually :
 (A) $[Fe(H_2O)_4]Cl_3$
 (B) $[Fe(H_2O)_3Cl]Cl_2 \cdot H_2O$
 (C) $[Fe(H_2O)_4Cl_2]Cl$
 (D) $[Fe(H_2O)_3Cl_2]Cl \cdot H_2O$
- 24.** Which of the following compound does not give test of sulphate ion in aqueous solution
 (A) $K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$
 (B) $[Cu(H_2O)_4]SO_4 \cdot H_2O$
 (C) $[CoSO_4(NH_3)_5]Br$
 (D) $FeSO_4 \cdot (NH_4)_2SO_4 \cdot 6H_2O$
- 25.** Which of the following is most likely formula of platinum complex, if $\frac{1}{4}$ of total chlorine of the compound is precipitated by adding $AgNO_3$ to its aqueous solution
 (A) $PtCl_4 \cdot 6H_2O$ (B) $PtCl_4 \cdot 5H_2O$
 (C) $PtCl_4 \cdot 2H_2O$ (D) $PtCl_4 \cdot 3H_2O$
- 26.** The EAN of Cr in $Cr(CO)_6$ is
 (A) 36 (B) 38 (C) 28 (D) 54
- 27.** According to the rule of effective atomic number, central atom acquires :
 (A) Inert gas configuration (B) Duplet
 (C) Octet (D) Quartet
- 28.** The EAN of iron in $K_4[Fe(CN)_6]$ is :
 (A) 35 (B) 34 (C) 36 (D) 38
- 29.** Which of the following has least conductivity in aqueous solution.
 (A) $Co(NH_3)_4Cl_3$ (B) $Co(NH_3)_3Cl_3$
 (C) $Co(NH_3)_5Cl_3$ (D) $Co(NH_3)_6Cl_3$
- 30.** If EAN of a central metal ion X^{+2} in a complex is 34. and atomic number of X is 28. The number of monodentet ligands present in complex are :-
 (A) 3 (B) 4 (C) 6 (D) 2
- 31.** The EAN of cobalt in the complex ion $[Co(en)_2Cl_2]^+$ is :-
 (A) 27 (B) 36 (C) 33 (D) 35
- 32.** For which of the d^n Configuration, both low and high spin complexes are possible :-
 (A) d^9 (B) d^3 (C) d^5 (D) d^2
- 33.** The wrong statement is :-
 (A) Halide ligands forms high spin complex
 (B) Strong ligands form low spin complex
 (C) $[FeF_6]^{-3}$ is inner orbital complex
 (D) $[NiCl_4]^{-2}$ is outer orbital complex
- 34.** The compound which does not shows paramagnetism is :-
 (A) $[Cu(NH_3)_4]Cl_2$ (B) $Fe(CO)_5$
 (C) NO (D) NO_2
- 35.** What is Incorrect for $K_4[Fe(CN)_6]$
 (A) O.N of Iron is +2
 (B) It exhibit diamagnetic character
 (C) It exhibit paramagnetic character
 (D) It involved d^2sp^3 hybridisation
- 36.** The complex $[Mn(CN)_6]^{4-}$ is :-
 (A) High spin complex
 (B) Diamagnetic ion
 (C) Having magnetic moment 1.73 BM
 (D) Outer orbital complex
- 37.** The complex ion which have no d-electrons in the central metal ion is (at No. Cr = 24, Mn = 25, V = 23, Fe = 26) :-
 (A) VO_4^{3-} (B) MnO_4^-
 (C) $[Fe(CN)_6]^{3-}$ (D) $[Cr(H_2O)_6]^{3+}$

38. In which of the following molecules, central atom used orbitals of different quantum number in the hybridisation :-
 (A) $[\text{Fe}(\text{CO})_5]$ (B) IF_7
 (C) $\text{Ni}(\text{CO})_4$ (D) XeO_4
39. What are the geometric shape and the oxidation number of the copper atom, respectively, for the complex ion, $[\text{Cu}(\text{NH}_3)_4(\text{OH}_2)_2]^{2+}$?
 (A) Tetrahedral; +2 (B) Square planar; -2
 (C) Linear; +3 (D) Octahedral; +2
40. For FeF_6^{3-} and $\text{Fe}(\text{CN})_6^{3-}$ magnetic moment of the fluoride complex is expected to be :-
 (A) The same as the magnetic moment of the cyanide complex
 (B) Larger than the magnetic moment of the cyanide complex because there are more unpaired electrons in the fluoride complex
 (C) Smaller than the magnetic moment of the cyanide complex because there are more unpaired electrons in the fluoride complex
 (D) Larger than the magnetic moment of the cyanide complex because there are fewer unpaired electrons in the fluoride complex
41. Which of the following contains one unpaired electron in the 4p orbitals :-
 (A) $[\text{Cu}(\text{NH}_3)_2]^+$ (B) $[\text{Cu}(\text{NH}_3)_4]^{2+}$
 (C) $[\text{Cu}(\text{CN})_4]^{3-}$ (D) $[\text{Ni}(\text{CN})_4]^{2-}$
42. In an octahedral crystal field, the t_{2g} orbitals are
 (A) Raised in energy by $0.4 \Delta_0$
 (B) Lowered in energy by $0.4 \Delta_0$
 (C) Raised in energy by $0.6 \Delta_0$
 (D) Lowered in energy by $0.6 \Delta_0$
43. If $\Delta_0 < P$, the correct electronic configuration for d^4 system will be :-
 (A) $t_{2g}^4 e_g^0$ (B) $t_{2g}^3 e_g^1$ (C) $t_{2g}^0 e_g^4$ (D) $t_{2g}^2 e_g^2$
44. Match List-I (Complex ions) with List-II (Number of Unpaired Electrons) and select the correct answer using the codes given below the lists :-
- | List -I
(Complex ions) | List II
(Number of Unpaired Electrons) |
|------------------------------------|---|
| A. $[\text{CrF}_6]^{4-}$ | i. One |
| B. $[\text{MnF}_6]^{4-}$ | ii. Two |
| C. $[\text{Cr}(\text{CN})_6]^{4-}$ | iii. Three |
| D. $[\text{Mn}(\text{CN})_6]^{4-}$ | iv. Four |
| | v. Five |
- Code :
- | | A | B | C | D |
|-----|----|---|-----|---|
| (A) | iv | i | ii | v |
| (B) | ii | v | iii | i |
| (C) | iv | v | ii | i |
| (D) | ii | i | iii | v |
45. For the $t_{2g}^6 e_g^2$ system, the value of magnetic moment (μ) is :
 (A) 2.83 B.M. (B) 1.73 B.M.
 (C) 3.87 B.M. (D) 4.92 B.M.
46. The species having tetrahedral shape is :-
 (A) $[\text{PdCl}_4]^{2-}$ (B) $[\text{Ni}(\text{CN})_4]^{2-}$
 (C) $[\text{Pd}(\text{CN})_4]^{2-}$ (D) $[\text{NiCl}_4]^{2-}$
47. Which of the following complexes are paramagnetic in nature :-
 I $[\text{Fe}(\text{CN})_6]^{3-}$ II $[\text{Fe}(\text{CN})_6]^{4-}$ III $[\text{CoF}_6]^{3-}$ IV $\text{Ni}(\text{CO})_4$
 (A) Only I (B) I and II
 (C) I and III (D) III and IV
48. Among the complex ions given below which is/are outer-orbital complex :
 I $[\text{Co}(\text{CN})_6]^{3-}$ II $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$ III $[\text{FeF}_6]^{3-}$ IV $[\text{CoF}_6]^{3-}$
 (A) II, III, IV (B) II, III only
 (C) I, IV only (D) II only
49. In which of 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) $[\text{Fe}(\text{CN})_6]^{3-}$, $[\text{Ni}(\text{CN})_4]^{2-}$
 (D) $[\text{CoF}_6]^{3-}$, $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$
50. The kind of isomerism exhibited by $[\text{Rh}(\text{en})_2\text{Cl}_2][\text{Rh}(\text{en})\text{Cl}_4]$ and $[\text{Rh}(\text{en})_3][\text{RhCl}_6]$ is
 (A) Linkage (B) Co-ordination
 (C) Ligand (D) Ionisation
51. Which of the following complex can not exhibit geometrical isomerism :-
 (A) $[\text{Pt}(\text{NH}_3)_2\text{ClNO}_2]$ (B) $[\text{Pt}(\text{gly})_2]$
 (C) $[\text{Cu}(\text{en})_2]^{+2}$ (D) $[\text{Pt}(\text{H}_2\text{O})(\text{NH}_3)\text{BrCl}]$
52. Which one of the following compounds will exhibit linkage isomerism :-
 (A) $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$ (B) $[\text{Co}(\text{NH}_3)_2\text{NO}_2]\text{Cl}_2$
 (C) $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]\text{Cl}$ (D) $[\text{Co}(\text{en})_2\text{Cl}_2]\text{Cl}$
53. Out of the following which complex will show geometrical isomerism ?
 (A) $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$ (B) $\text{Ni}(\text{CO})_4$
 (C) $\text{Na}_3[\text{Ni}(\text{CN})_4]$ (D) $\text{K}[\text{Ag}(\text{CN})_2]$
54. Which of the following complexes will show optical isomerism ?
 (A) $[\text{Cr}(\text{NH}_3)_6]^{2+}$ (B) $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$
 (C) $[\text{Pt}(\text{NH}_3)_3\text{Br}]\text{NO}_3$ (D) $[\text{Cr}(\text{en})_3]\text{Cl}_3$
55. The compound $[\text{Cr}(\text{H}_2\text{O})_6]\text{Cl}_3$ and $[\text{Cr}(\text{H}_2\text{O})_4\text{Cl}_2]\text{Cl} \cdot 2\text{H}_2\text{O}$ represent
 (A) Linkage isomerism (B) Hydration isomerism
 (C) Ligand isomerism (D) None of these

56. Which of the following will be able to show Cis-trans isomerism :-

- (a) Ma_3b (b) $\text{M}_{(\text{AA})_2}$
(c) $\text{M}_{\text{a}_2\text{b}_2}$ (d) $\text{M}_{(\text{AB})_2}$

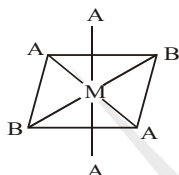
The Correct answer is

- (A) All (B) None
(C) a and c (D) c and d

[Where (AA) and (AB) are bidentate ligand with homo and hetero electron donating atoms.]

57. The isomer - can be marked as -

- (A) Cis isomer
(B) Leavo isomer
(C) Dextro isomer
(D) Trans isomer



58. One among the following complex ions will not show optical activity -

- (A) $[\text{Ph}(\text{Br})(\text{Cl})(\text{I})(\text{NO}_2)(\text{C}_2\text{H}_5\text{N})(\text{NH}_3)]$
(B) $\text{Cis}-[\text{Co}(\text{en})_2\text{Cl}_2]^+$
(C) $[\text{Co}(\text{en})(\text{NH}_3)_2\text{Cl}_2]^+$
(D) $[\text{Cr}(\text{NH}_3)_4\text{Cl}_2]^+$

59. A Planar Complex (Mabcd) gives :-

- (A) Two Optical isomer
(B) Two geometrical isomer
(C) Three optical isomer
(D) Three geometrical isomers

60. Out of the following which will not show geometrical isomerism :-

- (A) $[\text{Pt}(\text{NH}_3)_2(\text{H}_2\text{O})_2]^{+2}$
(B) $[\text{Cr}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$
(C) $[\text{Co}(\text{en})_2\text{Cl}_2]\text{Cl}$
(D) $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]\text{Cl}$

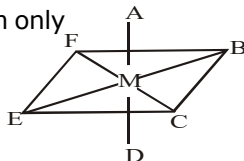
61. The Complexes given below are :-



- (A) Geometrical isomers (B) Position isomers
(C) Optical isomers (D) Identical

62. A complex shown below can exhibit :-

- (A) Geometrical isomerism only
(B) Optical isomerism only
(C) Both Optical and geometrical isomerism
(D) None



63. $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]\text{NO}_2$ and $[\text{Co}(\text{NH}_3)_4\text{Cl}\text{NO}_2]\text{Cl}$ are -

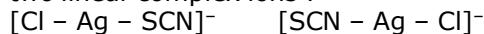
- (A) Geometrical isomers (B) Optical isomers
(C) Linkage isomers (D) Ionisation isomers

64. Theoretically the No. of geometrical isomers expected for octahedral complex $[\text{Mabcdef}]$ is:-
(A) Zero (B) 30 (C) 15 (D) 9

65. Which of the following has two geometrical isomers, and is also non ionisable :-

- (A) $\text{Pt}(\text{NH}_3)_2\text{Cl}_4$ (B) $\text{Pt}(\text{NH}_3)_3\text{Cl}_4$
(C) $\text{Pt}(\text{NH}_3)_4\text{Cl}_4$ (D) $\text{Pt}(\text{NH}_3)_6\text{Cl}_4$

66. What is the relationship between the following two linear complex ions ?



The complex ions are :-

- (A) Linkage isomers (B) Coordination isomers
(C) Geometric isomers (D) Optical isomers

67. Which of the following types of isomers can $[\text{Ag}(\text{NH}_3)_2]^+[\text{Ag}(\text{CN})_2]^-$ form :-

- (i) Coordination isomers
(ii) Geometric isomers
(iii) Optical isomers

- (A) (i) only (B) (i) & (ii)
(C) (iii) only (D) None of these

68. Which of the following common shapes (1-IV) can never exist as geometric isomers, regardless of the identity of the ligands :-

- (I) Linear (II) Square planar
(III) Tetrahedral (IV) Octahedral
(A) I only (B) I and II
(C) I and III (D) II and IV

69. Which of the following is an organometallic compound :

- (A) $\text{Ti}(\text{OCOCH}_3)_4$ (B) $\text{Ti}(\text{OC}_6\text{H}_5)_4$
(C) $\text{Ti}(\text{OC}_2\text{H}_5)_3\text{C}_2\text{H}_5$ (D) $[\text{Fe}(\text{CN})_6]^{4-}$

70. Which of the following is organometallic compound

- (A) Lithium methoxide (B) Lithium acetate
(C) Methyl lithium (D) Lithium carbonate

71. Which of the following statement is/are wrong:-

- (a) Al_4C_3 is an organometallic compound
(b) Metal carbonyls are organometallic compounds
(c) TEL is π bonded organometallic compound
(d) Frankland reagent is σ - bonded organometallic compound

The answer is:-

- (A) c and d (B) a and c
(C) a and b (D) All are correct

72. Compounds which contain one or more metal carbon bonds are called :

- (A) Organic compds. (B) Complex compds.
(C) Metal carbides (D) OMC compounds.

73. Which one of the following is used as a heterogeneous catalyst ?

- (A) Wilkinson's catalyst
(B) Tetraethyl lead
(C) Zeigler Natta catalyst
(D) Grignard's reagent

74. Which of the following statement is true
 (A) FeCO_3 and Fe_3C are organometallic compounds.
 (B) In ferrocene ligand is cyclopentadienyl.
 (C) $\text{Pb}(\text{C}_2\text{H}_5)_4$ is π -bonded OMC
 (D) In zeise salt central metal is Sp^3 hybridised.
75. Which of the following is not a σ -bonded organometallic compound ?
 (A) $(\text{C}_2\text{H}_5)_2\text{Zn}$ (B) $\text{Sn}(\text{C}_2\text{H}_5)_4$
 (C) $[(\text{CH}_3)_3\text{Al}]_2$ (D) $\text{Fe}(\eta^5\text{-C}_2\text{H}_5)_2$
76. Solution of TiCl_4 and trialkylaluminium used as a catalyst in polymerisation of olefins is called :-
 (A) Wilkinson's catalyst
 (B) Zeigler Natta catalyst
 (C) Homogeneous catalyst
 (D) Grignard reagent
77. Synergic bonding involves :-
 (A) The transference of electrons from ligands to metal
 (B) The transference of electrons from filled metal orbitals to anti-bonding orbitals of ligands
 (C) Both the above
 (D) None of these
78. Ferrocene is :-
 (A) $\text{Fe}(\eta^5\text{-C}_5\text{H}_5)_2$
 (B) $\text{Cr}(\eta^6\text{-C}_6\text{H}_6)_2$
 (C) $\text{K}[\text{PtCl}_3(\eta^2\text{-C}_2\text{H}_4)]$
 (D) $(\text{C}_2\text{H}_5)_4\text{Pb}$
79. OMC form during purification of a metal is :-
 (A) $\text{Ni}(\text{CO})_4$ (B) $\text{Pb}(\text{C}_2\text{H}_5)_4$
 (C) $\text{Li-C}_4\text{H}_9$ (D) $\text{Na}_2[\text{Ni}(\text{CN})_4]$
80. Which of the following is not an organo metallic compound :-
 (A) $(\text{C}_2\text{H}_5)_2\text{Zn}$ (B) $\text{CH}_3\text{B}(\text{OCH}_3)_2$
 (C) $\text{B}(\text{OCH}_3)_3$ (D) $\text{Ni}(\text{CO})_4$
81. Hypo is the aqueous solution of :-
 (A) Sodium sulphate (B) Sodium argentate
 (C) Sodium thiosulphate (D) Silver bromide
82. Silver halides are used in photography because it is :-
 (A) Photosensitive
 (B) Soluble in hypo solution
 (C) Soluble in NH_4OH
 (D) Insoluble in acids
83. Pick up the incorrect statement :-
 (A) Cisplatin is a complex of platinum
 (B) Vitamin B_{12} is a complex of cobalt
 (C) Chlorophyll is a complex of Manganese
 (D) Haemoglobin is a complex of iron
84. Which of the following is related to Nessler's reagent?
 (A) $\text{PtCl}_4 + \text{KCl} \rightarrow$ (B) $\text{AgCl} + \text{NH}_3 \rightarrow$
 (C) $\text{AgBr} + \text{Na}_2\text{S}_2\text{O}_3 \rightarrow$ (D) $\text{HgI}_2 + \text{KI} \rightarrow$
85. Baeyer's reagent is :-
 (A) $\text{KMnO}_4 + \text{H}_2\text{SO}_4$ (B) $\text{KMnO}_4 + \text{KOH}$
 (C) $\text{KMnO}_4 + \text{H}_2\text{O}$ (D) $\text{K}_2\text{Cr}_2\text{O}_7 + \text{KOH}$
86. $\text{K}_4[\text{Fe}(\text{CN})_6]$ reacts with FeCl_3 to form :-
 (A) $\text{K}_3\text{Fe}(\text{CN})_6$ (B) $\text{K}_4[\text{Fe}(\text{CN})_3\text{Cl}_3]$
 (C) $\text{K}_3[\text{Fe}(\text{CN})_5\text{Cl}]$ (D) $\text{KFe}[\text{Fe}(\text{CN})_6]$
87. A blue colouration is not obtained when :-
 (A) NH_4OH is added to CuSO_4
 (B) CuSO_4 solution reacts with $\text{K}_4[\text{Fe}(\text{CN})_6]$
 (C) FeCl_3 reacts with $\text{K}_4[\text{Fe}(\text{CN})_6]$
 (D) Anhydrous white CuSO_4 is dissolved in water
88. Match List I with List II and select the correct answer using the codes given below the lists :-
 List I
 A. Muscle contraction
 B. Blue-green algae
 C. Carboxypeptidase
 D. Cyanocobalamin
 List II
 i. Zinc
 ii. Cobalt
 iii. Calcium
 iv. Molybdenum
Code :
- | | A | B | C | D |
|-----|-----|-----|----|----|
| (A) | iv | iii | i | ii |
| (B) | iii | iv | ii | i |
| (C) | iv | iii | ii | i |
| (D) | iii | iv | i | ii |
89. A reagent used for identifying nickel ion is :-
 (A) Potassium ferrocyanide
 (B) Phenolphthalein
 (C) Dimethyl glyoxime
 (D) EDTA
90. Which of the following organometallic compound is used as fungicide in plant protection :-
 (A) $\text{C}_2\text{H}_5\text{HgCl}$ (B) $(\text{C}_2\text{H}_5)_2\text{Zn}$
 (C) $(\text{C}_2\text{H}_5)_4\text{Pb}$ (D) $(\text{C}_2\text{H}_5)_2\text{Cd}$
91. A person suffering from lead poisoning should be fed with :-
 (A) Hypo (B) Cis-platin
 (C) $[\text{Ca}(\text{EDTA})]^{2-}$ (D) DMG
92. Extraction of metals of other processes is through the complex formation :-
 I : cyanide process
 II : Mond's process
 III : Photographic fixing process
 Complexes formed in these methods are
- | I | II | III |
|---|--|--|
| (A) $[\text{Ag}(\text{NH}_3)_2]\text{Cl}$ | $\text{Ni}(\text{CO})_4$ | $\text{g}(\text{CN})_2^-$ |
| (B) $[\text{Cd}(\text{CN})_4]^{2-}$ | $\text{Ni}(\text{CO})_4$ | $[\text{Ag}(\text{S}_2\text{O}_3)_2]^{3-}$ |
| (C) $[\text{Ag}(\text{CN})_2]^-$ | $\text{Ni}(\text{CO})_4$ | $[\text{Ag}(\text{S}_2\text{O}_3)_2]^{3-}$ |
| (D) $[\text{Ag}(\text{CN})_2]^-$ | $[\text{Ag}(\text{S}_2\text{O}_3)_2]^{3-}$ | $\text{Ni}(\text{CO})_4$ |
93. Cu^{2+} and Cd^{2+} are distinguished through formation of complex $[\text{Cu}(\text{CN})_4]^{2-}$ and $[\text{Cd}(\text{CN})_4]^{2-}$ when H_2S gas is passed :
 (A) There is yellow precipitate due to CdS
 (B) There is precipitation of CuS and CdS together
 (C) There is black precipitate due to CuS
 (D) There is blue precipitate due to CuS

These questions consist of two statements each, printed as **Assertion** and **Reason**. While answering these Questions you are required to choose any one of the following four responses.

- A. If both **Assertion** & **Reason** are True & the **Reason** is a correct explanation of the **Assertion**.
 B. If both **Assertion** & **Reason** are True but **Reason** is not a correct explanation of the **Assertion**.
 C. If **Assertion** is True but the **Reason** is False.
 D. If both **Assertion** & **Reason** are False.

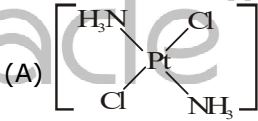
94. **Assertion** : $K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$ is a complex compound.
Reason : It ionises to give a complex ion.
95. **Assertion** : Tetrahedral complex do not exhibit geometrical isomerism.
Reason : In tetrahedral complex all the four positions are identical.
96. **Assertion** : $[Fe(CO)_5]$ is inner orbital complex.
Reason : In the given complex oxidation state of Iron is zero.
97. **Assertion** : $[Fe(CN)_6]^{3-}$ is paramagnetic in nature.
Reason : $[Fe(CN)_6]^{3-}$ is low spin complex.
98. **Assertion** : Hexachloroplatinate is a complex anion
Reason : Complex has negatively charged ligands
99. **Assertion** : $[Ni(CN)_4]^{2-}$ has zero unpaired electron while that of $[NiCl_4]^{2-}$ has two unpaired e^-
Reason : $[Ni(CN)_4]^{2-}$ has strong crystal field while $[NiCl_4]^{2-}$ has weak crystal field
100. **Assertion** : $K_2[PtCl_6]$ gives white ppt when reacts with $AgNO_3$
Reason : Chloride ion in the complex is ionisable
101. **Assertion** : Trans $[CoCl_2(en)_2]^+$ is optically inactive.
Reason : It has a plane of symmetry.
102. **Assertion** : Cu^+ is more stable than Cu^{+2}
Reason : ΔIP is greater than 16 eV
103. **Assertion** : In magnetic field weight of $MnSO_4$ increases
Reason : $MnSO_4$ is paramagnetic

104. **Assertion** : Cis - $[Fe(en)_2 Cl_2]^+$ can form racemic mixture.
Reason : Cis - $[Fe(en)_2 Cl_2]^+$ is square planar complex.
105. **Assertion** : Magnetic moment of d^7 is greater than d^2 electronic configuration.
Reason : d^7 has more electrons than d^2
106. **Assertion** : Square planar complex Ma_2b_2 has two optical isomers
Reason : Mirror image of Ma_2b_2 is non super imposable
107. **Assertion** : $[CoF_6]^{3-}$ is high spin complex.
Reason : F^- is strong field ligand.
108. **Assertion** : $CrCl_3 \cdot 3H_2O$ is non-conductive.
Reason : All the three Cl^- ions are in the coordination sphere.
109. **Assertion** : Ferrocene is π -bonded organometallic compound.
Reason : Ferrocene is a sandwich compound.
110. **Assertion** : NF_3 is weaker ligand than $N(CH_3)_3$.
Reason : NF_3 ionises to give F^- ions in aqueous solution.
111. **Assertion** : Potassium ferrocyanide is diamagnetic whereas potassium ferricyanide is paramagnetic.
Reason : Crystal field splitting in ferrocyanide ion is greater than that of ferricyanide ion.

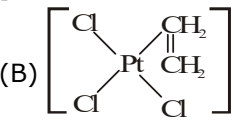
Level - 3

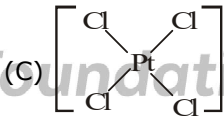
SECTION - A

- The number of water molecule in Mohr's salt –
(A) 7 (B) 5 (C) 6 (D) 8
- Amongst TiF_6^{2-} , CoF_6^{-3} , Cu_2Cl_2 and NiCl_4^{-2} colourless compound is
(A) Cu_2Cl_2 & NiCl_4^{-2}
(B) TiF_6^{-3} and CoF_6^{-3}
(C) CoF_6^{-3} and NiCl_4^{-2}
(D) TiF_6^{-2} and Cu_2Cl_2
- General formula of metal carbonyl is $\text{M}(\text{CO})_x$ (M = metal, $x = 4$). Metal is bonded with
(A) Oxygen (B) Carbon
(C) both (D) Triple bond of CO
- Geometrical isomer of $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$ are :
(A) 2 (B) 1 (C) 4 (D) 3
- Nessler's reagent is used in the test of –
(A) NH_4Cl (B) NH_3
(C) NH_4^+ (D) All of these
- Which of the following molecule or ions is a bidentate ligand ?
(A) $\text{C}_2\text{O}_4^{2-}$ (B) Br_2^+
(C) CH_3NH_2 (D) $\text{CH}_3-\text{C}\equiv\text{N}$
- Which of the following complex has square planar structure ?
(A) $[\text{Ni}(\text{CN})_4]^{2-}$ (B) $\text{Ni}(\text{CO})_4$
(C) $[\text{Zn}(\text{NH}_3)_4]^{+2}$ (D) $[\text{NiCl}_4]^{2-}$
- A complex compound of cobalt has molecular formula containing five NH_3 molecules, one nitro group and two chlorine atom for one cobalt atom. One mole of this compound produces three moles of ion in aqueous solution. On reaction with excess of AgNO_3 solution two moles of AgCl get precipitated. The Ionic formula of the compound.
(A) $[\text{Co}(\text{NH}_3)_4\text{NO}_2\text{Cl}]\text{NH}_3\text{Cl}$
(B) $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{ClNO}_2$
(C) $[\text{Co}(\text{NH}_3)_5\text{NO}_2]\text{Cl}_2$
(D) $[\text{Co}(\text{NH}_3)_5(\text{NO}_2)\text{Cl}]\text{Cl}$
- In the compound Lithium tetrahydridoaluminate, the ligand is –
(A) H (B) H^+
(C) H^- (D) F^-
- Number of isomers of $[\text{Pt}(\text{NH}_3)_4][\text{CuCl}_4]$ complex are :-
(A) 2 (B) 3
(C) 4 (D) 5
- The IUPAC name of $[\text{Co}(\text{NH}_3)_3\text{ClBrNO}_2]$ will be
(A) Triamminebromochloronitrocobaltate (III)
(B) Triamminebromochloronitrocobalt (III)
(C) Triamminebromonitrochlorocobalt (III)
(D) Triamminenitrochlorocobalt (III)
- Which one of the following shows maximum paramagnetic character ?
(A) $[\text{Fe}(\text{CN})_6]^{3-}$
(B) $[\text{Fe}(\text{CN})_6]^{4-}$
(C) $[\text{Cr}(\text{H}_2\text{O})_6]^{3+}$
(D) $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$
- Cr in $[\text{Cr}(\text{NH}_3)_6]\text{Br}_3$ has number of unpaired electron :-
(A) 4 (B) 3
(C) 1 (D) 2
- In quantitative analysis of second group in lab., H_2S gas is passed in acidic medium for ppt. When Cu^{+2} and Cd^{+2} react with KCN, than in which of the following condition, ppt 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) $\text{K}_3[\text{Cu}(\text{CN})_4]$ – Less stable
 $\text{K}_3[\text{Cd}(\text{CN})_4]$ – More stable
- Shape of $\text{Fe}(\text{CO})_5$ is :
(A) Octahedral
(B) Square planar
(C) Trigonal bipyramidal
(D) Square pyramidal
- Which complex compound will give four isomers
(A) $[\text{Fe}(\text{en})_3]\text{Cl}_3$
(B) $[\text{Co}(\text{en})_2\text{Cl}_2]\text{Cl}$
(C) $[\text{Fe}(\text{PPh}_3)_3\text{NH}_3\text{ClBr}]\text{Cl}$
(D) $[\text{Co}(\text{PPh}_3)_3\text{Cl}]\text{Cl}_3$
- In the formation of $[\text{Ni}(\text{CN})_4]^{2-}$, the type of hybridisation involved is
(A) sp^2 (B) sp^3d
(C) dsp^2 (D) sp^3d
- Which of the following will give maximum number

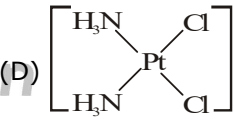
- of isomers :-
 (A) $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]^+$ (B) $[\text{Ni}(\text{en})(\text{NH}_3)_4]^{+2}$
 (C) $[\text{Ni}(\text{C}_2\text{O}_4)(\text{en})_2]^{-2}$ (D) $[\text{Cr}(\text{SCN})_2(\text{NH}_3)_4]^+$
19. Coordination number of Ni in $[\text{Ni}(\text{C}_2\text{O}_4)_3]^{-4}$ is
 (A) 3 (B) 6
 (C) 4 (D) 2
20. Which of following organometallic compound is σ and π bonded :-
 (A) $[\text{Fe}(\eta^5 - \text{C}_5\text{H}_5)_2]$ (B) $[\text{K}[\text{PtCl}_3(\eta^2 - \text{C}_2\text{H}_4)]]$
 (C) $[\text{Co}(\text{CO})_5\text{NH}_3]^{+2}$ (D) $\text{Fe}(\text{CH}_3)_3$
21. Which 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) $[\text{NiCl}_4]^{-2}$ - Tetrahedral, paramagnetic
22. Which of the following will exhibit maximum ionic conductivity :-
 (A) $\text{K}_4[\text{Fe}(\text{CN})_6]$ (B) $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$
 (C) $[\text{Cu}(\text{NH}_3)_4]\text{Cl}_2$ (D) $[\text{Ni}(\text{CO})_4]$
23. Atomic number of Cr and Fe are respectively 24 and 26, which of the following is paramagnetic due to the spin of electron :-
 (A) $[\text{Cr}(\text{CO})_6]$ (B) $[\text{Fe}(\text{CO})_5]$
 (C) $[\text{Fe}(\text{CN})_6]^{-4}$ (D) $[\text{Cr}(\text{NH}_3)_6]^{+3}$
24. The hypothetical complex chloro diaquatrimmine cobalt (III) chloride can be represented as :-
 (A) $[\text{CoCl}(\text{NH}_3)_3(\text{H}_2\text{O})_2]\text{Cl}_2$
 (B) $[\text{Co}(\text{NH}_3)_3(\text{H}_2\text{O})\text{Cl}_3]$
 (C) $[\text{Co}(\text{NH}_2)_3(\text{H}_2\text{O})_2\text{Cl}]$
 (D) $[\text{Co}(\text{NH}_3)_3(\text{H}_2\text{O})_3]\text{Cl}_3$
25. Which one of the following octahedral complexes will not show geometric isomerism ?
 (A and B are monodentate ligands)
 (A) $[\text{MA}_4\text{B}_2]$ (B) $[\text{MA}_5\text{B}]$
 (C) $[\text{MA}_2\text{B}_4]$ (D) $[\text{MA}_3\text{B}_3]$
26. According to IUPAC nomenclature of sodium nitroprusside is named as :
 (A) Sodium pentacyanonitrosyl ferrate (II)
 (B) Sodium pentacyanonitrosyl ferrate (III)
 (C) Sodium nitroferrocyanide
 (D) Sodium nitroferrocyanide
27. Among the following which is not the π -bonded organometallic compound ?
 (A) $\text{Cr}(\eta^6 - \text{C}_6\text{H}_6)_2$
 (B) $(\text{CH}_3)_4\text{Sn}$
 (C) $[\text{PtCl}_3(\eta^2 - \text{C}_2\text{H}_4)]$
 (D) $\text{Fe}(\eta^5 - \text{C}_5\text{H}_5)_2$
28. The number of unpaired electrons in the complex ion $[\text{CoF}_6]^{3-}$ is
 (A) 4 (B) Zero
 (C) 2 (D) 3
29. CN^- is a strong field ligand. This is due to the fact that
 (A) It forms high spin complexes with metal species
 (B) It gives negative charge
 (C) It is a pseudohalide
 (D) It can accept electrons from metal species
30. Considering H_2O as a weak field ligand, the number of unpaired electrons in $[\text{Mn}(\text{H}_2\text{O})_6]^{2+}$ will be (At. no. of Mn = 25) :-
 (A) Four (B) Three
 (C) Five (D) Two
31. Which of the following coordination compounds would exhibit optical isomerism ?
 (A) tris-(ethylenediamine) cobalt (III) bromide
 (B) pentaamminenitrocobalt (III) iodide
 (C) diamminedichloroplatinum (II)
 (D) trans-dicyanobis (ethylenediamine) chromium (III) chloride
32. Among $[\text{Ni}(\text{CO})_4]$, $[\text{Ni}(\text{CN})_4]^{2-}$, $[\text{NiCl}_4]^{2-}$ species, the hybridization states at the Ni atom are, respectively (At. no. of Ni = 28) :-
 (A) dsp^2 , sp^3 , sp^3 (B) sp^3 , dsp^2 , dsp^2
 (C) sp^3 , dsp^2 , sp^3 (D) sp^3 , sp^3 , dsp^2
33. Which of the following is considered to be an anticancer species ?
- 

(A)



(B)
- 

(C)



(D)
34. Which of the following does not have a metal-carbon bond ?
 (A) $\text{Ni}(\text{CO})_4$ (B) $\text{Al}(\text{OC}_2\text{H}_5)_3$
 (C) $\text{C}_2\text{H}_5\text{MgBr}$ (D) $[\text{K}[\text{Pt}(\text{C}_2\text{H}_4)_3\text{Cl}_3]]$
35. Which one of the following is an inner orbital complex as well as diamagnetic in behaviour :-
 (A) $[\text{Zn}(\text{NH}_3)_6]^{2+}$ (B) $[\text{Ni}(\text{NH}_3)_6]^{2+}$
 (C) $[\text{Cr}(\text{NH}_3)_6]^{3+}$ (D) $[\text{Co}(\text{NH}_3)_6]^{3+}$
 [Atomic number : Zn = 30, Cr = 24, Co = 27, Ni = 28]
36. The aqueous solution containing which one of the following ions will be colourless :-

- (A) Fe^{2+} (B) Mn^{2+}
(C) Ti^{3+} (D) Sc^{3+}
[Atomic number : Sc = 21, Fe = 26, Ti = 22, Mn = 25]
37. Which one of the following pairs represents stereoisomerism :-
(A) Linkage isomerism and Geometric isomerism
(B) Chain isomerism and Rotational isomerism
(C) Optical isomerism and Geometric isomerism
(D) Structural isomerism and Geometric isomerism
38. Which one of the following is expected to exhibit optical isomerism ?
(en = ethylenediamine)
(A) *cis* - $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$
(B) *cis* - $[\text{Co}(\text{en})_2\text{Cl}_2]$
(C) *trans* - $[\text{Co}(\text{en})_2\text{Cl}_2]$
(D) *trans* - $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$
39. In which of the following pairs both the complexes show optical isomerism ?
(A) *cis*- $[\text{Cr}(\text{C}_2\text{O}_4)_2\text{Cl}_2]^{3-}$, *cis*- $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]$
(B) $[\text{Co}(\text{en})_3] \text{Cl}_3$, *cis*- $[\text{Co}(\text{en})_2\text{Cl}_2]\text{Cl}$.
(C) $[\text{PtCl}(\text{dien})]\text{Cl}$, $[\text{NiCl}_2\text{Br}_2]^{2-}$.
(D) $[\text{Co}(\text{NO}_3)_3(\text{NH}_3)_3]$, *cis* - $[\text{Pt}(\text{en})_2\text{Cl}_2]$
40. The diamagnetic species is : [AIIMS-2005]
(A) $[\text{Ni}(\text{CN})_4]^{2-}$ (B) $[\text{NiCl}_4]^{2-}$
(C) $[\text{CoCl}_4]^{2-}$ (D) $[\text{CoF}_6]^{2-}$
41. The correct order for the wavelength of absorption in the visible region is :
(A) $[\text{Ni}(\text{NO}_2)_6]^{4-} < [\text{Ni}(\text{NH}_3)_6]^{2+} < [\text{Ni}(\text{H}_2\text{O})_6]^{2+}$
(B) $[\text{Ni}(\text{NO}_2)_6]^{4-} < [\text{Ni}(\text{H}_2\text{O})_6]^{2+} < [\text{Ni}(\text{NH}_3)_6]^{2+}$
(C) $[\text{Ni}(\text{H}_2\text{O})_6]^{2+} < [\text{Ni}(\text{NH}_3)_6]^{2+} < [\text{Ni}(\text{NO}_2)_6]^{4-}$
(D) $[\text{Ni}(\text{NH}_3)_6]^{2+} < [\text{Ni}(\text{H}_2\text{O})_6]^{2+} < [\text{Ni}(\text{NO}_2)_6]^{4-}$
42. The IUPAC name of the coordination compound $\text{K}_3[\text{Fe}(\text{CN})_6]$ is
(A) potassium hexacyanoferrate (II)
(B) potassium hexacyanoferrate (III)
(C) potassium hexacyanoiron (II)
(D) tripotassium hexacyanoiron (II)
43. Which of the following compounds shows 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) $[\text{Co}(\text{CN})_6]^{3-}$
44. Which one of the following cyano complexes would exhibit the lowest value of paramagnetic behaviour ?
(A) $[\text{Cr}(\text{CN})_6]^{3-}$ (B) $[\text{Mn}(\text{CN})_6]^{3-}$
(C) $[\text{Fe}(\text{CN})_6]^{3-}$ (D) $[\text{Co}(\text{CN})_6]^{3-}$
45. The value of the 'spin only' magnetic moment for one of the following configurations is 2.84 BM. The correct one is
- (A) d^4 (in strong ligand filed)
(B) d^4 (in weak ligand filed)
(C) d^3 (in weak as well as in strong fields)
(D) d^5 (in strong ligand filed)
46. In which of the following pairs are both the ions coloured in aqueous solution ?
(A) Ni^{2+} , Cu^+ (B) Ni^{2+} , Ti^{3+}
(C) Sc^{3+} , Ti^{3+} (D) Sc^{3+} , Co^{2+}
(At. no. : Sc = 21, Ti = 22, Ni = 28, Cu = 29, Co = 27)
47. $[\text{Co}(\text{NH}_3)_4(\text{NO}_2)_2]\text{Cl}$ exhibits
(A) linkage isomerism, geometrical isomerism and optical isomerism
(B) linkage isomerism, ionization isomerism and optical isomerism
(C) linkage isomerism, ionization isomerism and geometrical isomerism
(D) ionization isomerism, geometrical isomerism and optical isomerism
48. The pair in which both species have same magnetic moment (spin only value) is -
(A) $[\text{Cr}(\text{H}_2\text{O})_6]^{2+}$, $[\text{CoCl}_4]^{2-}$
(B) $[\text{Cr}(\text{H}_2\text{O})_6]^{2+}$, $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$
(C) $[\text{Mn}(\text{H}_2\text{O})_6]^{2+}$, $[\text{Cr}(\text{H}_2\text{O})_6]^{2+}$
(D) $[\text{CoCl}_4]^{2-}$, $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$
49. The colour imparted by $\text{Co}(\text{II})$ compounds to glass is -
(A) Green (B) Deep-Blue
(C) Yellow (D) Red
50. The number of possible isomers of an octahedral complex $[\text{Co}(\text{C}_2\text{O}_4)_2(\text{NH}_3)_2]^-$ is-
(A) 1 (B) 2
(C) 3 (D) 4
51. The ligands in anti cancer drug cisplatin are
(A) NH_3 , Cl (B) NH_3 , H_2O
(C) Cl , H_2O (D) NO , Cl
52. Among the following the species having square planar geometry for central atom are
(i) XeF_4 (ii) SF_4
(iii) $[\text{NiCl}_4]^{2-}$ (iv) $[\text{PdCl}_4]^{2-}$
(A) (i) and (iv) (B) (i) and (ii)
(C) (ii) and (iii) (D) (iii) and (iv)
53. Which of the following will give a pair of enantiomorphs
(A) $[\text{Cr}(\text{NH}_3)_6][\text{Co}(\text{CN})_6]$
(B) $[\text{Co}(\text{en})_2\text{Cl}_2]\text{Cl}$
(C) $[\text{Pt}(\text{NH}_3)_4][\text{PtCl}_6]$
(D) $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]\text{NO}_2$
54. The d electron configurations of Cr^{2+} , Mn^{2+} , Fe^{2+} and Ni^{2+} are $3d^4$, $3d^5$, $3d^6$ and $3d^8$ respectively which one of the following aqua

- complexes will exhibit the minimum paramagnetic behaviour
 (A) $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$ (B) $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$
 (C) $[\text{Cr}(\text{H}_2\text{O})_6]^{2+}$ (D) $[\text{Mn}(\text{H}_2\text{O})_6]^{2+}$
55. Which of the following complexes exhibits the highest paramagnetic behaviour?
 (A) $[\text{Co}(\text{OX})_2(\text{OH})_2]^-$
 (B) $[\text{Ti}(\text{NH}_3)_6]^{3+}$
 (C) $[\text{V}(\text{gly})_2(\text{OH})_2(\text{NH}_3)_2]^+$
 (D) $[\text{Fe}(\text{en})(\text{bpy})(\text{NH}_3)_2]^{2+}$
 Where gly = glycine, en = ethylenediamine and bpy = bipyridyl moities
56. In which of the following coordination entities the magnitude of Δ_o (CFSE in octahedral field) will be maximum?
 (A) $[\text{Co}(\text{CN})_6]^{3-}$ (B) $[\text{Co}(\text{C}_2\text{O}_4)_3]^{3-}$
 (C) $[\text{Co}(\text{H}_2\text{O})_6]^{3+}$ (D) $[\text{Co}(\text{NH}_3)_6]^{3+}$
57. Which of the following complex ions is expected to absorb visible light?
 (A) $[\text{Zn}(\text{NH}_3)_6]^{2+}$ (B) $[\text{Sc}(\text{H}_2\text{O})_3(\text{NH}_3)_3]^{3+}$
 (C) $[\text{Ti}(\text{en})_2(\text{NH}_3)_2]^{4+}$ (D) $[\text{Cr}(\text{NH}_3)_6]^{3+}$
58. Out of TiF_6^{2-} , CoF_6^{3-} , Cu_2Cl_2 and NiCl_4^{2-} colourless species are :
 (A) CoF_6^{3-} and NiCl_4^{2-}
 (B) TiF_6^{2-} and CoF_6^{3-}
 (C) Cu_2Cl_2 and NiCl_4^{2-}
 (D) TiF_6^{2-} and Cu_2Cl_2
59. Which of the following does not show optical isomerism?
 (A) $[\text{Co}(\text{en})_3]^{3+}$ (B) $[\text{Co}(\text{en})_2\text{Cl}_2]^+$
 (C) $[\text{Co}(\text{NH}_3)_3\text{Cl}_3]^0$ (D) $[\text{Co}(\text{en})\text{Cl}_2(\text{NH}_3)_2]^+$
60. Which one of the elements with the following outer orbital configurations may exhibit the largest number of oxidation states?
 (A) $3d^2 4s^2$ (B) $3d^3 4s^2$
 (C) $3d^5 4s^1$ (D) $3d^5 4s^2$
61. The pair of compounds that can exist together is
 (A) FeCl_3 , SnCl_2 (B) HgCl_2 , SnCl_2
 (C) FeCl_2 , SnCl_2 (D) FeCl_3 , KI
62. Among the following complexes, the one which show zero crystal field stabilisation energy (CFSE) is
 (A) $[\text{Mn}(\text{H}_2\text{O})_6]^{3+}$ (B) $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$
 (C) $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$ (D) $[\text{Co}(\text{H}_2\text{O})_6]^{3+}$
63. A magnetic moment of 1.73 BM will be shown by one among the following.
 (A) $[\text{Cu}(\text{NH}_3)_4]^{2+}$ (B) $[\text{Ni}(\text{CN})_4]^{2-}$
 (C) TiCl_4 (D) $[\text{CoCl}_6]^{4-}$
64. The complex used as an anticancer agent is
 (A) *meso*- $[\text{Co}(\text{NH}_3)_3\text{Cl}_3]$
- (B) *cis* - $[\text{PtCl}_2(\text{NH}_3)_2]$
 (C) *cis* - $\text{K}_2[\text{PtCl}_2\text{B}]$
 (D) Na_2CoCl_4
65. Which one of the following is an outer orbital complex and exhibits paramagnetic behaviour?
 (A) $[\text{Ni}(\text{NH}_3)_6]^{2+}$ (B) $[\text{Zn}(\text{NH}_3)_6]^{2+}$
 (C) $[\text{Cr}(\text{NH}_3)_6]^{3+}$ (D) $[\text{Co}(\text{NH}_3)_6]^{3+}$
66. Red precipitate is obtained when ethanol solution of dimethylglyoxime is added to ammoniacal Ni(II). Which of the following statements is not true?
- $$\begin{array}{c} \text{H}_3\text{C}-\text{C}=\text{N}-\text{OH} \\ | \\ \text{H}_3\text{C}-\text{C}=\text{N}-\text{OH} \end{array}$$
 dimethylglyoxime =
- (A) Red complex has a square planar geometry
 (B) Complex has symmetrical H-bonding
 (C) Red complex has a tetrahedral geometry
 (D) Dimethylglyoxime functions as bidentate ligand
67. The d-electron configuration of Cr^{2+} , Mn^{2+} , Fe^{2+} and Co^{2+} are d^4 , d^5 , d^6 and d^7 respectively. Which one of the following will exhibit minimum paramagnetic behaviour?
 (A) $[\text{Cr}(\text{H}_2\text{O})_6]^{2+}$ (B) $[\text{Mn}(\text{H}_2\text{O})_6]^{2+}$
 (C) $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$ (D) $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$
68. Which of the following complex ions is diamagnetic in nature?
 (A) $[\text{CoF}_6]^{3-}$ (B) $[\text{NiCl}_4]^{2-}$
 (C) $[\text{Ni}(\text{CN})_4]^{2-}$ (D) $[\text{CuCl}_2]^{2-}$
69. The complexes $[\text{Co}(\text{NH}_3)_6]$, $[\text{Cr}(\text{CN})_6]$ and $[\text{Cr}(\text{NH}_3)]$, $[\text{Co}(\text{CN})_6]$ are the examples of which type of isomerism?
 (A) Geometrical isomerism
 (B) Linkage isomerism
 (C) Ionisation isomerism
 (D) Coordination isomerism
70. The complex, $[\text{Pt}(\text{py})(\text{NH}_3)\text{BrCl}]$ will have how many geometrical isomers?
 (A) 2 (B) 3
 (C) 4 (D) 0
71. Crystal field stabilisation energy for high spin d^4 octahedral complex is
 (A) $-1.6 \Delta_o$ (B) $-1.8 \Delta_o$
 (C) $-1.6 \Delta_o + P$ (D) $-1.2 \Delta_o$
72. The existence of two different coloured complexes with the composition $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]^+$ is due to

- (A) Ionisation isomerism
 (B) Linkage isomerism
 (C) Geometrical isomerism
 (D) Coordination isomerism

73. Which of the following complex ion is not expected to absorb visible light ?

- (A) $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$ (B) $[\text{Ni}(\text{CN})_4]^{2-}$
 (C) $[\text{Cr}(\text{NH}_3)_6]^{3+}$ (D) $[\text{Fe}(\text{H}_2\text{I})_6]^{2+}$

SECTION-B

1. The secondary valency of Cr in the complex $[\text{Cr}(\text{H}_2\text{O})_4\text{Cl}_2]^+$ is –

- (A) 1 (B) 3
 (C) 5 (D) 6

2. Which of the following is expected to be a

paramagnetic complex ?

- (A) $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$ (B) $[\text{Ni}(\text{CO})_4]$
 (C) $[\text{Zn}(\text{NH}_3)_4]^{2+}$ (D) $[\text{Co}(\text{NH}_3)_6]^{3+}$

3. IUPAC name of $\text{Na}_3[\text{Co}(\text{NO}_2)_6]$ is

- (A) Sodium cobaltnitrite
 (B) Sodium hexanitrito cobaltate (III)
 (C) Sodium hexanitro cobalt (III)
 (D) Sodium hexanitro cobaltate (III)

4. A group of atoms can function as a ligand only when –

- (A) It is a small molecule
 (B) It has an unshared electron pair
 (C) It is a negatively charged ion
 (D) It is a positively charged ion

5. According to the postulates of Werner for coordination compounds –

- (A) Primary valency is ionizable
 (B) Secondary valency is ionizable
 (C) Primary and secondary valencies are non ionizable
 (D) Only primary valency is non-ionizable

6. The number of isomers exhibited by $[\text{Cr}(\text{NH}_3)_3\text{Cl}_3]$ is

- (A) 2 (B) 3
 (C) 4 (D) 5

7. For the square planar complex $[\text{M}(\text{a})(\text{b})(\text{c})(\text{d})]$ where M = central metal and a, b, c and d are monodentate ligands, the number of possible geometrical isomers are

- (A) 1 (B) 2
 (C) 3 (D) 4

8. Which of the following will exhibit optical isomerism ?

- (A) $[\text{Cr}(\text{en})_3]^{3+}$
 (B) trans - $[\text{Cr}(\text{en})_2\text{Cl}_2]^+$
 (C) $[\text{Cr}(\text{NH}_3)_6]^{3+}$
 (D) 1 and 2 both

9. A complex $\text{K}_n[\text{MnF}_6]$ has magnetic moment 4.9 BM what will be the oxidation state of Mn and the value of n ?

- (A) Mn (II), n = 4 (B) Mn (III) ; n = 3
 (C) Mn (IV) ; n = 2 (D) Mn (V) ; n = 1

10. The oxidation state of iron in $\text{K}_4[\text{Fe}(\text{CN})_6]$ is

- (A) 1 (B) 2
 (C) 3 (D) 4

11. The complex compounds $[\text{PtCl}_2(\text{NH}_3)_4]\text{Br}_2$ and $[\text{PtBr}_2(\text{NH}_3)_4]\text{Cl}_2$ constitutes a pair of

- (A) Coordination isomers
 (B) Linkage isomers
 (C) Ionization isomers
 (D) Hydration isomers

12. In $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$, the number of covalent bonds is

- (A) 3 (B) 6
 (C) 9 (D) 18

13. Which of the following compounds exhibits linkage isomerism ?

- (A) $[\text{Co}(\text{en})_3]\text{Cl}_3$ (B) $[\text{Co}(\text{NH}_3)_6][\text{Cr}(\text{en})_3]$
 (C) $[\text{Co}(\text{en})_2\text{NO}_2\text{Cl}]\text{Br}$ (D) $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{Br}_2$

14. The oxidation number of cobalt in $\text{K}[\text{Co}(\text{CO})_4]$

- (A) +1 (B) –1
 (C) +3 (D) –3

15. The shape of cupraammonium ion is

- (A) Octahedral (B) Tetrahedral

- (C) Trigonal (D) Square planar
16. The chemical formula for iron (III) hexacyanoferrate(II) is
(A) $\text{Fe}(\text{Fe}(\text{CN})_6)$ (B) $\text{Fe}_3[\text{Fe}(\text{CN})_6]$
(C) $\text{Fe}_3[\text{Fe}(\text{CN})_6]_4$ (D) $\text{Fe}_4[\text{Fe}(\text{CN})_6]_3$
17. The effective atomic number of iron in $[\text{Fe}(\text{CN})_6]^{3-}$ is
(A) 34 (B) 36
(C) 37 (D) 35
18. The geometry of the compound $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$ is
(A) Square planar (B) Pyramidal
(C) Tetrahedral (D) Octahedral
19. Which of the following group doesnot show linkage isomerism ?
(A) NO_2^- (B) SCN^-
(C) CN^- (D) NH_3
20. Which of the following form an octahedral complex ?
(A) d^7 (High spin) (B) d^8 (High spin)
(C) d^6 (high spin) (D) All
21. How many ions are produced in aqueous solution of $[\text{Co}(\text{H}_2\text{O})_6]\text{Cl}_2$
(A) 2 (B) 3
(C) 4 (D) 6
22. The type of isomerism present in nitropentamminechromium (III) Ion is
(A) Optical (B) Linkage
(C) Ionization (D) Polymerization
23. A square planar complex is formed by hybridization of which atomic orbitals
(A) s, p_x, p_y, d_{yz} (B) $s, p_x, p_y, d_{x^2-y^2}$
(C) s, p_x, p_y, d_{z^2} (D) s, p_x, p_y, d_{xy}
24. In $[\text{Cr}(\text{C}_2\text{O}_4)_3]^{3-}$, the isomerism shown is
(A) Ligand (B) Optical
(C) Geometrical (D) Ionization
25. In the complexes $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$, $[\text{Fe}(\text{CN})_6]^{3-}$, $[\text{Fe}(\text{C}_2\text{O}_4)_3]^{3-}$ and $[\text{FeCl}_6]^{3-}$, more stability is shown by
(A) $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$ (B) $[\text{Fe}(\text{CN})_6]^{3-}$
(C) $[\text{Fe}(\text{C}_2\text{O}_4)_3]^{3-}$ (D) $[\text{FeCl}_6]^{3-}$
26. The catalyst used for the polymerization of olefins is :-
(A) Ziegler-Natta catalyst
(B) Wilkinson's catalyst
(C) Pd - catalyst
(D) Zeolite
27. Both geometrical and optical isomerism are shown by -
(A) $[\text{Co}(\text{en})_2\text{Cl}_2]^+$ (B) $[\text{Co}(\text{NH}_3)_5\text{Cl}]^{2+}$
(C) $[\text{Co}(\text{C}_2\text{O}_4)_3]^{3-}$ (D) $[\text{Cr}(\text{ox})_3]^{3-}$
28. An example for a double salt is
(A) Cuprammonium sulphate
(B) Mohr's salt
(C) Potassium ferricyanide
(D) Cobalthexammine chloride
29. When AgNO_3 is added to a solution of $\text{Co}(\text{NH}_3)_5\text{Cl}_3$, the precipitate of AgCl shows two ionized chloride ions. This means :
(A) Two chlorine atoms satisfy primary valency and one secondary valency
(B) Two chlorine atom satisfies secondary valency
(C) Three chlorine atoms satisfy primary valency
(D) Three chlorine atoms satisfy secondary valency.
30. Which of the following species represent the example of dsp^2 hybridization ?
(A) $[\text{Fe}(\text{CN})_6]^{3-}$ (B) $[\text{Ni}(\text{CN})_4]^{2-}$
(C) $[\text{Ag}(\text{CN})_2]^-$ (D) $[\text{Co}(\text{CN})_6]^{3-}$
31. Which one of the following will not show geometrical isomerism ?
(A) $[\text{Cr}(\text{NH}_3)_4\text{Cl}_2]\text{Cl}$ (B) $[\text{Co}(\text{en})_2\text{Cl}_2]\text{Cl}$
(C) $[\text{Co}(\text{NH}_3)_5\text{NO}_2]\text{Cl}_2$ (D) $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$
32. According to Lewis, the ligands are
(A) Acidic in nature
(B) Basic in nature
(C) Neither acidic nor basic
(D) Some are acidic and others are basic
33. The most stable complex among the following is
(A) $\text{K}_3[\text{Al}(\text{C}_2\text{O}_4)_3]$ (B) $[\text{Pt}(\text{en})_2]\text{Cl}_2$
(C) $[\text{Ag}(\text{NH}_3)_2]\text{Cl}$ (D) $\text{K}_2[\text{Ni}(\text{EDTA})]$
34. In nessler reagent for the detection of ammonium ion the active species is :
(A) Hg_2Cl_2 (B) Hg^{+2}
(C) Hg_2I_2 (D) HgI_4^{-2}
35. One mole of the complex compound $\text{Co}(\text{NH}_3)_5\text{Cl}_3$, gives 3 moles of ions on dissolution in water. One mole of the same complex reacts with two moles of AgNO_3 solution to yield two moles of AgCl (s). The structure of the complex is
(A) $[\text{Co}(\text{NH}_3)_3\text{Cl}_3] \cdot 2\text{NH}_3$
(B) $[\text{Co}(\text{NH}_3)_4\text{Cl}_2] \cdot \text{Cl} \cdot \text{NH}_3$
(C) $[\text{Co}(\text{NH}_3)_4\text{Cl}] \cdot \text{Cl}_2 \cdot \text{NH}_3$

- (D) $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$
36. In the coordination compound $\text{K}_4[\text{Ni}(\text{CN})_4]$, the oxidation state of nickel is –
 (A) 0 (B) +1
 (C) +2 (D) –1
37. The coordination number of a central metal atom in a complex is determined by:
 (A) The number of ligands around a metal ion bonded by sigma and pi-bonds both
 (B) The number of ligands around a metal ion bonded by pi-bonds
 (C) The number of ligands around a metal ion bonded by sigma bonds
 (D) The number of only anionic ligands bonded to the metal ion
38. Which one of the following complexes is an outer orbital complex :-
 (A) $[\text{Co}(\text{NH}_3)_6]^{3+}$ (B) $[\text{Mn}(\text{CN})_6]^{4-}$
 (C) $[\text{Fe}(\text{CN})_6]^{4-}$ (D) $[\text{Ni}(\text{NH}_3)_6]^{2+}$
 (Atomic nos. : Mn = 25 ; Fe = 26 ; Co = 27 ; Ni = 28)
39. Coordination compounds have great importance in biological systems. In this context which of the following statements is incorrect ?
 (A) Cyanocobalamin is vitamin B_{12} and contains cobalt
 (B) Haemoglobin is the red pigment of blood and contains iron
 (C) Chlorophylls are green pigments in plants and contain calcium
 (D) Carboxypeptidase - A is an enzyme and contains zinc
40. Which one of the following has largest number of isomers ?
 (A) $[\text{Ir}(\text{PR}_3)_2\text{H}(\text{CO})]^{2+}$
 (B) $[\text{Co}(\text{NH}_3)_5\text{Cl}]^{2+}$
 (C) $[\text{Ru}(\text{NH}_3)_4\text{Cl}_2]^+$
 (D) $[\text{Co}(\text{en})_2\text{Cl}_2]^+$
 (R = alkyl group, en = ethylenediamine)
41. The correct order of magnetic moments (spin only values in B.M.) among is :-
 (A) $[\text{Fe}(\text{CN})_6]^{4-} > [\text{MnCl}_4]^{2-} > [\text{CoCl}_4]^{2-}$
 (B) $[\text{MnCl}_4]^{2-} > [\text{Fe}(\text{CN})_6]^{4-} > [\text{CoCl}_4]^{2-}$
 (C) $[\text{MnCl}_4]^{2-} > [\text{CoCl}_4]^{2-} > [\text{Fe}(\text{CN})_6]^{4-}$
 (D) $[\text{Fe}(\text{CN})_6]^{4-} > [\text{CoCl}_4]^{2-} > [\text{MnCl}_4]^{2-}$
 (Atomic nos. : Mn = 25, Fe = 26, Co = 27)
42. Which of the following does not have optical isomer ?
 (A) $[\text{Co}(\text{NH}_3)_3\text{Cl}_3]$ (B) $[\text{Co}(\text{en})_3]\text{Cl}_3$
 (C) $[\text{Co}(\text{en})_2\text{Cl}_2]\text{Cl}$ (D) $[\text{Co}(\text{en})(\text{NH}_3)_2\text{Cl}_2]\text{Cl}$
43. In which of the following oxidation state of Mn is six %&
 (A) K_2MnO_4 (B) MnO_2
 (C) KMnO_4 (D) MnO_4^{-1}
44. EDTA has coordination sites
 (A) 3 (B) 4
 (C) 5 (D) 6
45. What is the net charge on ferrous ion ?
 (A) +2 (B) +3
 (C) +4 (D) +5
46. When one mol of each of the following complex salts is treated with excess of AgNO_3 , which of them gives maximum amount of AgCl ?
 (A) $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$ (B) $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$
 (C) $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]\text{Cl}$ (D) $\text{Na}_2[\text{PtCl}_4]$
47. The correct order of hybridisation of the central atom in the following species :
 NH_3 , $[\text{PtCl}_4]^{2-}$, PCl_5 and BCl_3 is
 (A) dsp^2 , dsp^3 , sp^2 , sp^3
 (B) sp^3 , dsp^2 , dsp^3 , sp^2
 (C) dsp^2 , sp^2 , sp^3 , dsp^3
 (D) dsp^2 , sp^3 , sp^2 , sp^3
48. The IUPAC name for the complex $[\text{Co}(\text{NO}_2)(\text{NH}_3)_5]\text{Cl}_2$ is
 (A) pentaammine nitrito-N- cobalt (II) chloride
 (B) pentaammine nitrito-N- cobalt (III) chloride
 (C) nitrito-N- pentaamminecobalt (III) chloride
 (D) nitrito-N- pentaamminecobalt (II) chloride
49. Nickel (Z=28) combines with a uninegative monodentate ligand X^- to form a paramagnetic complex $[\text{NiX}_4]^{2-}$. The number of unpaired electron (s) in the nickel and geometry of this complex ion are, respectively.
 (A) one, square planar (B) two, square planar
 (C) one, tetrahedral (D) two, tetrahedral
50. In $\text{Fe}(\text{CO})_5$, the Fe–C bond possesses
 (A) ionic character
 (B) σ – character only
 (C) π – character only
 (D) both σ and π character
51. How many EDTA (ethylenediaminetetraacetic acid) molecules are required to make an octahedral complex with a Ca^{2+} ion ?
 (A) One (B) Two
 (C) Six (D) Three
52. The "spin-only" magnetic moment [in units of Bohr magneton, (μ_B)] of Ni^{2+} in aqueous solution would be (At. No. Ni= 28)
 (A) 0 (B) 1.73
 (C) 2.84 (D) 4.90
53. The coordination number of Ni^{+2} is = 4
 $\text{NiCl}_2 + \text{KCN (Complex)} \longrightarrow \text{A (Complex)}$
 $\text{A} + \text{Conc.HCl (Maximun)} \longrightarrow \text{B}$

- (Chloro complex)
- The IUPAC name of A and B are
 (A) potassium tetracyanonickelate(II),
 potassium tetrachloronickelate(II),
 (B) tetracyanopotassiumnickelate(II),
 tetrachloro potassiumnickelate (II),
 (C) tetracyanonickel (II), tetrachloronickel (II)
 (D) potassiumtetracyanonickel (II),
 potassiumtetrachloronickel (II).
54. Predict the magnetic nature of A and B
 (A) both are diamagnetic
 (B) A is diamagnetic and B is paramagnetic with one unpaired electron
 (C) A is diamagnetic and B is paramagnetic with two unpaired electrons
 (D) both are paramagnetic.
55. The hybridisation of A and B are
 (A) dsp^2 , sp^3 (B) sp^3 , sp^3
 (C) dsp^2 , dsp^2 (D) sp^3 , d^2 , d^2 , sp^3 .
56. Fac -Mer isomerism is associated with which one of the following complexes ? [M=central metal]
 (A) $[M(AA)_2]$ (B) $[MA_3B_3]$
 (C) $[M(AA)_3]$ (D) $[MABCD]$
 (E) $[MA_4B_2]$
57. Which one of the following is tridentate ligand
 (A) NO_2^- (B) oxalate ion
 (C) glycinate ion (D) dien
58. Which of the following statements is not correct
 (A) The complexes $[NiCl_4]^{2-}$ and $[Ni(CN)_4]^{2-}$ differ in the state of hybridization of nickel.
 (B) The complexes $[NiCl_4]^{2-}$ and $[Ni(CN)_4]^{2-}$ differ in the magnetic properties.
 (C) The complexes $[NiCl_4]^{2-}$ and $[Ni(CN)_4]^{2-}$ differ in geometry.
 (D) The complexes $[NiCl_4]^{2-}$ and $[Ni(CN)_4]^{2-}$ differ in primary valencies of nickel
59. Which of the following has a square planar geometry
 (A) $[PtCl_4]^{2-}$ (B) $[CoCl_4]^{2-}$
 (C) $[FeCl_4]^{2-}$ (D) $[NiCl_4]^{2-}$
60. The coordination number and the oxidation state of the element 'E' in the complex $[E(en)_2(C_2O_4)] NO_2$ (where (en) is ethylene diamine) are, respectively
 (A) 6 and 2 (B) 4 and 2
 (C) 4 and 3 (D) 6 and 3
61. In which of the following octahedral complexes of Co (at. number 27), will the magnitude of Δ_0 be the highest ?
 (A) $[Co(CN)_6]^{3-}$ (B) $[Co(C_2O_4)_3]^{3-}$
 (C) $[Co(H_2O)_6]^{3+}$ (D) $[Co(NH_3)_6]^{3+}$
62. The species having tetrahedral shape is :-
 (A) $[PdCl_4]^{2-}$ (B) $[Ni(CN)_4]^{2-}$
 (C) $[Pd(CN)_4]^{2-}$ (D) $[NiCl_4]^{2-}$
63. Transition metals show paramagnetism
 (A) due to characteristic configuration
 (B) high lattice energy
 (C) due to variable oxidation states
 (D) due to unpaired electrons.
64. Which of the following complexes have lowest molar conductance ?
 (A) $CoCl_3 \cdot 3NH_3$ (B) $CoCl_3 \cdot 4NH_3$
 (C) $CoCl_3 \cdot 5NH_3$ (D) $CoCl_3 \cdot 6NH_3$
65. Select the diamagnetic complex ion amongst the following complexes (Atomic number of Fe = 26, Co = 27)
 (A) $[K_3Fe(CN)_6]$ (B) $[Co(NH_3)_6]Cl_3$
 (C) $K_3[FeF_6]$ (D) $K_3[CoF_6]$
66. The hybridization of central metal ion in $K_2[Ni(CN)_4]$ and $K_2[NiCl_4]$ are respectively
 (A) dsp^2 , sp^3 (B) sp^3 , sp^3
 (C) dsp^2 , dsp (D) sp^3 , sp^3 , d^2
67. Which of the following compounds show optical isomerism ?
 I. $cis-[Co(NH_3)_4Cl_2]^+$ II. $trans-[Co(en)_2Cl]^+$
 III. $cis-[Co(en)_2Cl_2]^+$ IV. $[Co(en)_3]^{3+}$
 Choose the correct answer from the codes given below.
 (A) I and II (B) II and III
 (C) III and IV (D) I, III and IV
68. How many isomers are possible in $[Co(en)_2Cl_2]^+$?
 (A) 2 (B) 4
 (C) 6 (D) 1
69. A correct statement is
 (A) $[Co(NH_3)_6]^{2+}$ is paramagnetic
 (B) $[MnBr_4]^{2-}$ is tetrahedral
 (C) $[CoBr_2(en)_2]^-$ exhibits linkage isomerism
 (D) $[Ni(NH_3)_6]^{2+}$ is not an inner orbital complex
70. In which one of the pairs of ion given, there is an ion that forms a coordination compound with both aqueous sodium hydroxide and ammonia and an other ion that forms a coordination compound only with aqueous sodium hydroxide ?
 (A) Pb^{2+} , Cu^{2+} (B) Zn^{2+} , Al^{3+}
 (C) Cu^{2+} , Zn^{2+} (D) Al^{3+} , Cu^{2+}
71. The IUPAC name of the complex ion formed when gold dissolves in aqua-regia is
 (A) tetrachloridoaurate (III)
 (B) tetrachloridoaurate(I)

- (C) tetrachloridoaurate (II)
(D) dichloridoaurate (III)
72. In $[\text{CoF}_6]^{3-}$, Co^{3+} uses outer d-orbitals (4d) in $sp^3 d^2$ hybridisation. The number of unpaired electrons present in complex ion is
(A) 0 (B) 4
(C) 2 (D) 3
73. Crystal field theory does not explain which of the following property of coordination compound?
(A) The covalent character of the bond between metal and the ligand
(B) Magnetic property
(C) Colour
(D) Structure of coordination compounds
74. The coordination number of platinum in $[\text{Pt}(\text{NH}_3)_4 \text{Cl}_2]^{2+}$ ion is
(A) 2 (B) 4
(C) 6 (D) 8
75. Which of the following ligands is not a chelating agent?
(A) EDTA (B) en
(C) Oxalate (D) Pyridine
76. Which of the following salts is colourless?
(A) CdCl_2 (B) $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$
(C) $\text{MnSO}_4 \cdot 7\text{H}_2\text{O}$ (D) $\text{NiSO}_4 \cdot 7\text{H}_2\text{O}$
77. The oxidation number of Co in $[\text{Co}(\text{NH}_3)(\text{NO}_2)]$ is
(A) +3 (B) 0
(C) -3 (D) +6
78. IUPAC name of $[\text{K}_3\text{Fe}(\text{CN})_6]$ is
(A) potassium ferricyanide
(B) potassium hexacyanoferrate (I)
(C) potassium hexacyanoferrate (III)
(D) potassium hexacyanoferrate (II)
79. Compounds $[\text{PtCl}_2(\text{NH}_3)_4] \text{Br}_2$ and $[\text{PtBr}_2(\text{NH}_3)_4] \text{Cl}_2$, shows the following type of isomerism.
(A) Hydrate isomerism
(B) Ionisation isomerism
(C) Linkage isomerism
(D) Coordination position isomerism
80. The IUPAC name of $\text{K}_2[\text{Ni}(\text{CN})_4]$ is
(A) potassium tetracyanonickelate (II)
(B) potassium tetracyanonickelate (III)
(C) potassium tetracyanonickel (II)
(D) potassium tetracyanonickel (III)
81. Which of the following compounds shows optical isomerism?
(A) $[\text{Co}(\text{CN})_6]^{3-}$ (B) $[\text{Cr}(\text{C}_2\text{O}_4)_3]^{3+}$
(C) $[\text{ZnCl}_4]^{2-}$ (D) $[\text{Cu}(\text{NH}_3)_4]^{2+}$
82. In the brown ring complex $[\text{Fe}(\text{H}_2\text{O})_5(\text{NO})] \text{SO}_4$, nitric oxide behaves as
(A) NO^+
(B) neutral, no molecule
(C) NO^-
(D) NO^{2-}
83. Four transition metal octahedral complexes, (the choice given below) low spin electronic configuration arises only for
(A) d^1 to d^3 complexes
(B) d^4 to d^7 complexes
(C) d^7 to d^9 complexes
(D) d^1 , d^2 and d^8 complexes
84. The ligand $\text{N}(\text{CH}_2\text{CH}_2\text{NH}_2)_3$ is
(A) tridentate (B) pentadentate
(C) hexadentate (D) bidentate
85. Which can exist both as diastereoisomer and enantiomer?
(A) $[\text{Pt}(\text{en})_3]^{4+}$ (B) $[\text{Pt}(\text{en})_2\text{ClBr}]^{2+}$
(C) $[\text{Ru}(\text{NH}_3)_4\text{Cl}_2]^0$ (D) $[\text{PtCl}_2\text{Br}_2]^0$
86. Number of isomeric forms (constitutional and stereoisomers) for $[\text{Rh}(\text{en})_2(\text{NO}_2)(\text{SCN})]^+$ are
(A) three (B) six
(C) nine (D) twelve
87. Excess of silver nitrate solution is added to 100 ml. of 0.01 M pentaquachlorochromium (III) chloride solution. The mass of silver chloride obtained (in gram) is [Atomic mass of silver is 108]
(A) 287×10^{-3} (B) 43.5×10^{-3}
(C) 143.5×10^{-2} (D) 287×10^{-2}
88. The IUPAC name of the complex $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]\text{Cl}$ is
(A) dichlorotetraamminecobalt (III) chloride
(B) tetraamminedichlorocobalt (III) chloride
(C) tetraamminedichlorocobalt (II) chloride
(D) tetraammineferric (III) chloride
89. Ammonia gas does not evolve from the complex $\text{FeCl}_3 \cdot 4\text{NH}_3$ but it gives white precipitate with aqueous solution of AgNO_3 . Coordination number of central metal ion in the above complex is six. Given IUPAC name of the complex.
(A) Ammoniumtrichlorotriammineferric(III)
(B) Tetraammineferric (III) chloride
(C) Dichlorotetraammineferrate (II) chloride
(D) Dichlorotetraammineferric (III) chloride
90. In the complex ion $[\text{Co}(\text{NH}_3)_6]^{3+}$, the NH_3 molecules are linked to the central metal ion by
(A) ionic bonds (B) covalent bonds
(C) coordinate bonds (D) hydrogen bonds
91. $[\text{Co}(\text{NH}_3)_4\text{Cl}_2] \text{NO}_2$ and $[\text{Co}(\text{NH}_3)_4\text{ClNO}_2] \text{Cl}$ exhibit which type of isomerism?
(A) Geometrical (B) Optical
(C) Linkage (D) Ionisation
92. The name of the complex $[\text{Pt}(\text{NH}_3)_6]\text{Cl}_4$ is
(A) hexaammineplatinum (IV) chloride

- (B) hexaammineplatinum (II) chloride
(C) tetrachlorohexammineplatinum (IV)
(D) tetrachlorohexammineplatinum (II)
- 93.** The effective atomic number of Cr (atomic no. 24) in $[\text{Cr}(\text{NH}_3)_6]\text{Cl}_3$ is
(A) 35 (B) 27
(C) 33 (D) 36
- 94.** How many ions are produced from $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$ in solution ?
(A) 6 (B) 4
(C) 3 (D) 2
- 95.** In which of the following the magnetic character is not correct ?
(A) CuCl_4^{2-} — 1 unpaired electron
(B) $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$ — 5 unpaired electrons
(C) $[\text{Zn}(\text{NH}_3)_2]^{2+}$ — Diamagnetic
(D) $[\text{CoF}_6]^{3-}$ — 4 unpaired electrons
- 96.** EDTA has coordination number
(A) 3 (B) 4
(C) 5 (D) 6
- 97.** The IUPAC name of the complex $[\text{Pt}(\text{NH}_3)_3\text{Br}(\text{NO}_2)\text{Cl}]\text{Cl}$ is
(A) triamminechlorobromonitroplatinum (IV) chloride
(B) triamminebromonitrochloroplatinum(IV) chloride
(C) triamminebromochloronitroplatinum (IV) chloride
(D) triamminenitrochlorobromoplatinum (IV) chloride
- 98.** AgCl is dissolved in excess of each of NH_3 , KCN and $\text{Na}_2\text{S}_2\text{O}_3$. The complex ions produced in each case are
(A) $[\text{Ag}(\text{NH}_3)_2]^+$, $[\text{Ag}(\text{CN})_2]^+$ and $[\text{Ag}(\text{S}_2\text{O}_3)_2]^{3-}$
(B) $[\text{Ag}(\text{NH}_3)_2]^{2+}$, $[\text{Ag}(\text{CN})_2]^{3-}$ and $[\text{Ag}(\text{S}_2\text{O}_3)_2]^{2-}$
(C) $[\text{Ag}(\text{NH}_3)_4]^{2+}$, $[\text{Ag}(\text{CN})_2]^{3-}$ and $[\text{Ag}_2(\text{S}_2\text{O}_3)_2]^{2-}$
(D) $[\text{Ag}(\text{NH}_3)_2]^+$, $[\text{Ag}(\text{CN})_2]^-$ and $[\text{Ag}(\text{S}_2\text{O}_3)_2]^{3-}$
- 99.** The most stable complex among the following is
(A) $[\text{Pd}(\text{CN})_4]^{4-}$ (B) $[\text{Fe}(\text{CO})_5]$
(C) $[\text{Ni}(\text{CN})_4]^{4-}$ (D) $[\text{Ni}(\text{CN})_4]^{3-}$
- 100.** Choose the correct statement.
(A) $[\text{Co}(\text{NH}_3)_6]^{2+}$ is oxidised to diamagnetic $[\text{Co}(\text{NH}_3)_6]^{3+}$ by the oxygen in air
(B) Tetrahedral complexes are more stable than octahedral complexes
(C) $[\text{Fe}(\text{CN})_6]^{3-}$ is stable but $[\text{FeF}_6]^{3-}$ is unstable
(D) The $[\text{Cu}(\text{NH}_3)_4]^{2+}$ ion has a tetrahedral geometry and is diamagnetic
- 101.** Which one of the following is wrongly match ?
(A) $[\text{Cu}(\text{NH}_3)_4]^{2+}$ — Square planar
(B) $[\text{Ni}(\text{CO})_4]$ — Neutral ligand
(C) $[\text{Fe}(\text{CN})_6]^{3-}$ — $sp^3 d^2$
(D) $[\text{Co}(\text{en})_3]^{3+}$ — Follows EAN rule
- 102.** The correct order of magnetic moments (spin only values in BM) among the following is (Atomic number of Mn = 25, Fe = 26, Co = 27)
(A) $[\text{MnCl}_4]^{2-} > [\text{CoCl}_4]^{2-} > [\text{Fe}(\text{CN})_6]^{4-}$
(B) $[\text{MnCl}_4]^{2-} > [\text{Fe}(\text{CN})_6]^{4-} > [\text{CoCl}_4]^{2-}$
(C) $[\text{Fe}(\text{CN})_6]^{4-} > [\text{MnCl}_4]^{2-} > [\text{CoCl}_4]^{2-}$
(D) $[\text{Fe}(\text{CN})_6]^{4-} > [\text{CoCl}_4]^{2-} > [\text{MnCl}_4]^{2-}$
- 103.** Show the coordination number of the metal ion, its oxidation number, the number of electrons in d-orbitals and the number of unpaired electrons in d-orbitals respectively in complex $[\text{Co}(\text{H}_2\text{O})_4\text{SO}_3]\text{Cl}$.
(A) 6, 3, 6, 4 (B) 6, 3, 6, 0
(C) 5, 3, 6, 4 (D) 5, 3, 6, 0
- 104.** Which of the following 0.1 M complex compound solutions will have the minimum electrical conductivity ?
(A) Hexaammine platinum (IV) chloride
(B) Chloropentaammineplatinum (IV) chloride
(C) Dichlorotetraammineplatinum(IV) chloride
(D) Trichlorotriammineplatinum (IV) chloride
- 105.** $[\text{Sc}(\text{H}_2\text{O})_6]^{3+}$ ion is
(A) colourless and diamagnetic
(B) coloured and octahedral
(C) colourless and paramagnetic
(D) coloured and paramagnetic
- 106.** Zeigler-Natta catalyst is
(A) ZnCl_2
(B) $\text{Et}_3\text{Al} + \text{TiCl}_4$
(C) $\text{Cu} / \text{ZnO}-\text{Cr}_2\text{O}_3$
(D) Pt
(E) V_2O_5
- 107.** In $\text{Ni}(\text{CO})_4$, the nickel atom is hybridised by
(A) sp^2 (B) sp^3
(C) dsp^2 (D) sp^3d
- 108.** The IUPAC name of $\text{Ni}(\text{CO})_4$ is
(A) tetracarbonylnickelate (0)
(B) tetracarbonylnickel (II)
(C) tetracarbonylnickel (0)
(D) tetracarbonylnickelate (II)
- 109.** What is the oxidation number of Fe in $\text{Fe}(\text{CO})_5$?
(A) +3 (B) Zero
(C) +2 (D) +5
- 110.** The charge on the central metal ion in the complex $[\text{Ni}(\text{CO})_4]$ is
(A) +2 (B) +4
(C) 0 (D) +3
(E) +1
- 111.** The non-existent metal carbonyl among the following is
(A) $\text{Cr}(\text{CO})_6$ (B) $\text{Mn}(\text{CO})_5$
(C) $\text{Ni}(\text{CO})_4$ (D) $\text{Fe}(\text{CO})_5$
- 112.** In metal carbonyl (organometallic) complexes, the M — C bond is
(A) ionic



Answers

Level - 1

1	B	2	C	3	C	4	B	5	A	6	D	7	C
8	D	9	C	10	D	11	D	12	C	13	A	14	A
15	D	16	C	17	B	18	B	19	B	20	D	21	B
22	A	23	B	24	D	25	C	26	C	27	D	28	D
29	C	30	B	31	D	32	C	33	C	34	D	35	B
36	B	37	B	38	A	39	D	40	A	41	A	42	B
43	C	44	C	45	B	46	A	47	A	48	B	49	C
50	C	51	B	52	D	53	A	54	B	55	B	56	A
57	D	58	A	59	B	60	D	61	D	62	D	63	B
64	B	65	A	66	D	67	D	68	A	69	D	70	A
71	B	72	C	73	C	74	D	75	B	76	C	77	B

Level - 2

1	C	2	D	3	B	4	C	5	B	6	B	7	B
8	D	9	A	10	B	11	B	12	C	13	C	14	B
15	A	16	A	17	A	18	A	19	C	20	C	21	D
22	C	23	C	24	C	25	D	26	A	27	A	28	C
29	B	30	B	31	B	32	C	33	C	34	B	35	C
36	C	37	B	38	A	39	D	40	B	41	B	42	B
43	B	44	C	45	A	46	D	47	C	48	A	49	D
50	B	51	C	52	B	53	A	54	D	55	B	56	D
57	D	58	D	59	D	60	B	61	D	62	C	63	D
64	C	65	A	66	A	67	D	68	C	69	C	70	C
71	B	72	D	73	C	74	B	75	D	76	B	77	B
78	A	79	A	80	C	81	C	82	A	83	C	84	D
85	B	86	D	87	B	88	D	89	C	90	A	91	C
92	C	93	A	94	D	95	A	96	B	97	B	98	B
99	A	100	D	101	A	102	D	103	A	104	C	105	B
106	D	107	C	108	A	109	B	110	C	111	C		

Level - 3

SECTION – A

1.	C	2.	D	3.	B	4.	A	5.	D	6.	A	7.	A
8.	C	9.	C	10.	C	11.	B	12.	C	13.	B	14.	C
15.	C	16.	C	17.	C	18.	D	19.	B	20.	C	21.	A
22.	A	23.	D	24.	A	25.	B	26.	A	27.	B	28.	A
29.	D	30.	C	31.	A	32.	C	33.	D	34.	B	35.	D
36.	D	37.	C	38.	B	39.	B	40.	A	41.	A	42.	B
43.	C	44.	D	45.	A	46.	B	47.	C	48.	B	49.	B
50.	C	51.	A	52.	A	53.	B	54.	B	55.	A	56.	A
57.	D	58.	D	59.	C	60.	D	61.	C	62.	B	63.	A
64.	B	65.	A	66.	C	67.	D	68.	C	69.	D	70.	B
71.	A	72.	C	73.	B								

SECTION-B

1.	D	2.	A	3.	D	4.	B	5.	A	6.	A	7.	C
8.	A	9.	B	10.	B	11.	C	12.	D	13.	C	14.	B
15.	D	16.	D	17.	D	18.	A	19.	D	20.	D	21.	B
22.	B	23.	B	24.	B	25.	C	26.	A	27.	A	28.	B
29.	A	30.	B	31.	C	32.	B	33.	D	34.	D	35.	D
36.	A	37.	C	38.	D	39.	C	40.	D	41.	C	42.	A
43.	A	44.	D	45.	A	46.	A	47.	B	48.	B	49.	D
50.	D	51.	A	52.	C	53.	A	54.	C	55.	A	56.	B
57.	D	58.	D	59.	A	60.	D	61.	A	62.	D	63.	D
64.	A	65.	A, B	66.	A	67.	C	68.	B	69.	A, B	70.	B
71.	A	72.	B	73.	A	74.	C	75.	D	76.	A	77.	A
78.	A, C	79.	B	80.	A	81.	B	82.	A	83.	B	84.	C
85.	B	86.	D	87.	A	88.	B	89.	D	90.	C	91.	D
92.	A	93.	C	94.	B	95.	B	96.	D	97.	C	98.	D
99.	B	100.	A	101.	C	102.	A	103.	A	104.	D	105.	A
106.	B	107.	B	108.	C	109.	B	110.	C	111.	B	112.	D
113.	A	114.	A	115.	B	116.	A	117.	A				



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