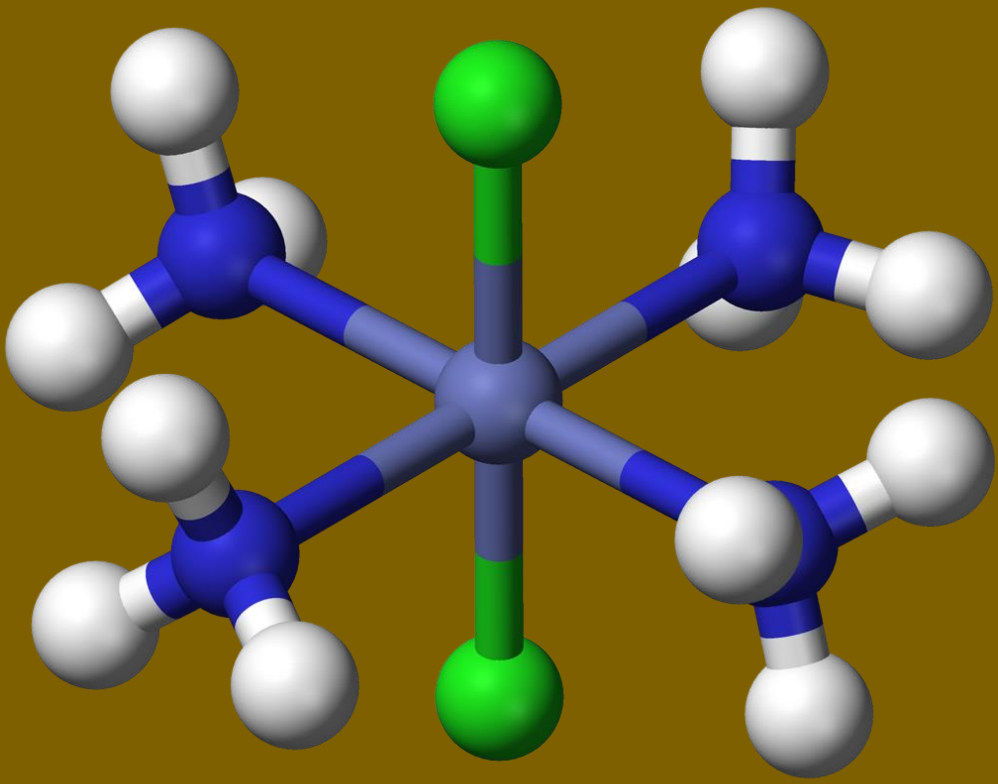
9. COORDINATION COMPOUNDS



Chemistry Smart Booklet

Theory + NCERT MCQs + Topic Wise Practice MCQs + NEET PYQs

COORDINATION COMPOUNDS

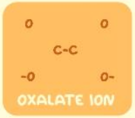
Counter ion — Central Metal Atom — Coordination Sphere

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

LIGAND

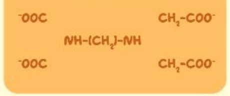
MONODENTATE

CN^-, H^2O, NH^3, Cl^-, Br^- etc



OXALATE ION

POLYDENTATE



$$\begin{matrix} {}^-OOC & & CH_2\text{-}COO^- \\ & NH\text{-}(CH_2)\text{-}NH & \\ {}^-OOC & & CH_2\text{-}COO^- \end{matrix}$$

AMBIDENTATE

M ← SCN Thiocyanate

M ← NCS Isothiocyanate

STABILITY

$M^- + NL^{x-} \longrightarrow (ML_N)^{y-}$

Stability constant $K = \frac{(ML_N)^{y-}}{(M^+)(L^{x-})^N}$

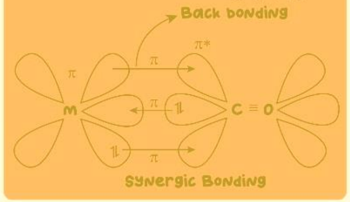
FACTOR AFFECTING STABILITY

Charge density on the central metal ion.

Nature of ligands.

METAL CABONYL

Metal Carboxyl posses both S and P bond.



EDTA is used in estimation of hardness of water

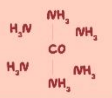
EDTA is used in estimation of hardness of water

EDTA is used in estimation of hardness of water

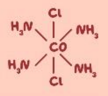
COMPLEX SALT

Doesn't dissociate completely into the ion

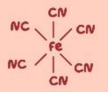
HOMOLEPTIC COMPLEX



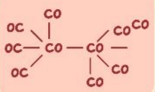
HETEROLEPTIC COMPLEX



HOMONUCLEAR COMPLEX



HETRONUCLEAR COMPLEX



NOMENCLATURE

Naming of Mononuclear Complex

Naming of mononucelar complex

Cation is named first

Naming of ligands in alphabetical order

Anionic ligands end in -o.

Neutral and cationic are same.

Prefixes mono, di, tri, etc are used.

Followed by roman numeral in parenthesis.

Example: Triamminetriaqua chromium (III) chloride [Cr(NH3)3(H2O)3]Cl3

Formula of Mononuclear Complex

Central atom is listed first.

Ligands is alphabetical order.

Formula is enclosed in square bracket.

No space between ligand and metal.

Charge is indicated outside brackets.

Charge on cotton(s) balanced by charge of anion(s)

Example:

SPECTRO CHEMICAL SERIES

$I^- < Br^- < SCN^- < Cl^- < S^{2-} < F^- < C_2O_4^{2-} < H_2O < NCS^- < EDTA^{4-} < NH^3 < EN < CN^- < CO$

Shape	Coordination Number	Hybridisation	Example
Tetrahedral	4	sp^3	$[CuCl_4]^{2-}$
Square Planar	4	dsp^2	$[Ni(CN)_4]^{2-}$
Trigonal Bipyramidal	5	sp^3d	PF_5
Square Pyramidal	5	sp^3d^2	BrF_5
Octahedral	6	sp^3d^2 d^2sp^3	SF_6 $[Co(NH_3)_6]^{3+}$

VALENCE BOND THEORY

COLOUR IN COMPLEX

Caused by d-d transition. colour is complementary to wavelength absorbed.

MAGNETIC PROPERTY

Magnetic moment = $\sqrt{N(N+2)}$ BM

PARAMAGNETIC

Ex- $[CoF_6]^{-3}$

One or more than one unpaired e^- present

Ex- $[CoF6_6]^{3-}$

DIAMAGNETIC

No unpared electron present

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

HIGH SPIN COMPLEX

Δ_0 < Pairing Energy

Ex: $[CrCl_6]^{3-}$

LOW SPIN COMLEX

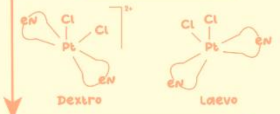
Δ_0 < Pairing Energy

Ex: $[Cr(Cl)_6]^{3-}$

ISOMERISM

STERIO ISOMERS

OPTICAL ISOMERS



Dextro Laevo

GEOMETRICAL ISOMERS

(i) COORDINATION NUMBER 4

(cis-platin) (tran-platin)

(ii) Coordination number 6

(cis-isomer) (trans-isomer)(fac-isomer) (mer-isomer)

LINKAGE ISOMR

Occurs in ambidentate ligands

Ex: $[CO(NH_3)_5(NO_2)]$ and $[CO(NH_3)_5(ONO)]$

Cordination enttites are different.

Ex: [CO(NH3)6][Cr(CN)6] and [CO(CN)6][Cr(NH3)6]

STRUCTURAL ISOMERS

Ionisation isomer

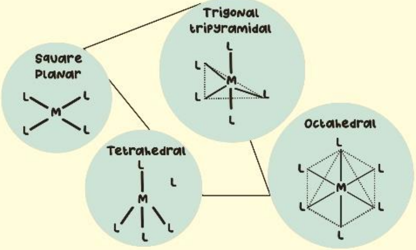
Different ions are produced in aqueous solution.

Ex: [CO(NH3)5(SO4)]

Solvate isomer

Different in number of water molecules attached.

Ex: [Cr(H2O)6)]Cl3 and [Cr(H2O)5-Cl)Cl3.H2O



WARNERS THEORY

Central metal ion shows primary and secondary valances

Primary valances are ionisable.

Secondary valances are non-ionisable.

Ions bonded to metal via secondary linkages have different spatial arrangement

Limitation

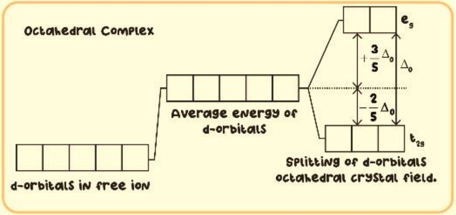
Only certain elements form coordination complex

Why coordination bonds have directional property

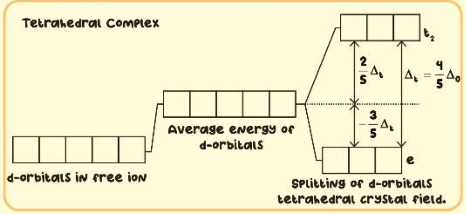
Couldn't explain magnetic and optical properties of complex.

BONDING THEORY

CRYSTAL FIELD THEORY



Splitting of d-orbitals octahedral crystal field.



Splitting of d-orbitals tetrahedral crystal field.

COORDINATION COMPOUNDS

COORDINATION COMPOUNDS

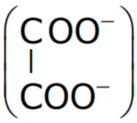
- **Differences between coordination compound and double bond**

Coordination compound	Double salt
A coordination compound contains a central metal atom or ion surrounded by several oppositely charged ions or neutral molecules. These ions or molecules re-bonded to the metalatom or ion by a coordinate bond.	When two salts in stoichiometric ratio are crystallised together from their saturated solution, they are called double salts.
Example: $K_4[Fe(CN)_6]$	**Example:** $FeSO_4.(NH_4)_2SO_4.6H_2O$ (Mohr's salt)
They do not dissociate into simpleions when dissolved in water.	They dissociate into simple ions when dissolved in water.

- **Coordination entity:** A coordination entity constitutes a central metal atom or ion bonded to a fixednumber of ions or molecules. Example: In $K_4[Fe(CN)_6]$, $[Fe(CN)_6]^{4-}$ represents a coordination entity.
- **Central atom or ion:** In a coordination entity, the atom/ion to which a fixed number of ions/groups are bound in a definite geometrical arrangement is called the central atom or ion. Example: In $K_4[Fe(CN)_6]$,Fe^{2+} is the central metal ion.
- **Ligands:** A molecule, ion or group which is bonded to the metal atom or ion in a complex or coordination compound by a coordinate bond is called a ligand. It may be neutral, positively ornegatively charged. Examples: H_2O, CN^-, NO^+ etc.
- **Donor atom:** An atom of the ligand attached directly to the metal is called the donor atom. Example:In the complex $K_4[Fe(CN)_6]$, carbon is a donor atom.
- **Coordination number:** The coordination number (CN) of a metal ion in a complex can be defined asthe number of ligand donor atoms to which the metal is directly bonded. Example: In the complex $K_4[Fe(CN)_6]$, the coordination number of Fe is 6.
- **Coordination sphere**: The central atom/ion and the ligands attached to it are enclosed in squarebracket and is collectively termed the coordination sphere. Example: In the complex $K_4[Fe(CN)_6]$,$[Fe(CN)_6]^{4-}$ is the coordination sphere.
- **Counter ions:** The ions present outside the coordination sphere are called counter ions. Example: Inthe complex $K_4[Fe(CN)_6]$, K^+ is the counter ion.
- **Coordination polyhedron:** The spatial arrangement of the ligand atoms which are directly attached tothe central atom/ion defines a coordination polyhedron about the central atom. The most common coordination polyhedra are octahedral, square planar and tetrahedral. Examples: $[PtCl_4]^{2-}$ is square planar, $Ni(CO)_4$ is tetrahedral and $[Cu(NH_3)_6]^{3+}$ is octahedral.
- **Charge on the complex ion:** The charge on the complex ion is equal to the algebraic

sum of thecharges on all the ligands coordinated to the central metal ion.

- **Denticity:** The number of ligating (linking) atoms present in a ligand is called denticity.
- **Unidentate ligands:** The ligands whose only donor atom is bonded to a metal atom are calledunidentate ligands. Examples: H_2O, NH_3, CO, CN^-
- **Didentate ligands:** The ligands which contain two donor atoms or ions through which they are bonded to the metal ion. Example: Ethylene diamine ($H_2NCH_2CH_2NH_2$) has two nitrogen atoms, and oxalate ion has two oxygen atoms which can bind with the metal atom.



$$\begin{pmatrix} COO^- \\ | \\ COO^- \end{pmatrix}$$

- **Polydentate ligand:** When several donor atoms are present in a single ligand, the ligand is called a polydentate ligand. Example: In $N(CH_2CH_2NH_2)_3$, the ligand is said to be polydentate. Ethylenediaminetetraacetate ion ($EDTA^{4-}$) is an important hexadentate ligand. It can bind through twonitrogen and four oxygen atoms to a central metal ion.
- **Chelate:** An inorganic metal complex in which there is a close ring of atoms caused by attachment ofa ligand to a metal atom at two points. An example is the complex ion formed between ethylene diamine and cupric ion $[Cu(NH_2CH_2NH_2)_2]^{2+}$.
- **Ambidentate ligands:** Ligands which can ligate (link) through two different atoms present in it are called ambidentate ligands. Examples: NO^- and SCN^-. NO^- can link through N as well as O, while SCN^- can link through S as well as N.
- **Werner's coordination theory:** Werner was able to explain the nature of bonding in complexes. The postulates of Werner's theory are
  - Metal shows two kinds of valencies—primary valence and secondary valence.

Primary valence	Secondary valence
This valence is normally ionisable.	This valence is non-ionisable.
It is equal to the positive chargeon the central metal atom.	The secondary valency equals to the number of ligand atoms coordinated to the metal. It is also called the coordination number of the metal.
These valencies are satisfied by negatively charged ions.	It is commonly satisfied by neutral and negatively charged, sometimes by positively charged ligands.
Example: In $CrCl_3$, the primaryvalency is three. It is equal to the oxidation state of the centralmetal ion.	

  - The ions/groups bound by secondary linkages to the metal have characteristic spatial arrangements corresponding to different coordination numbers.
  - The most common geometrical shapes in coordination compounds are octahedral, square planarand tetrahedral.
- **Oxidation number of the central atom:** The oxidation number of the central atom

in a complex is defined as the charge it would carry if all the ligands are removed along with the electron pairs whichare shared with the central atom.

- **Homoleptic complexes:** Those complexes in which metal or ion is coordinately bonded to only onekind of donor atom. Example: $[Co(NH_3)_6]^{3+}$
- **Heteroleptic complexes:** Those complexes in which metal or ion is coordinately bonded to more thanone kind of donor atom. Example: $[CoCl_2(NH_3)_4]^+$, $[Co(NH_3)_5Br]^{2+}$
- **Isomers:** Two or more compounds which have the same chemical formula but different arrangementof atoms are called isomers.
- Types of isomerism
  - Structural isomerism
    - Linkage isomerism
    - Solvate isomerism or hydrate isomerism
    - Ionisation isomerism
    - Coordination isomerism
  - Stereoisomerism
    - Geometrical isomerism
    - Optical isomerism
- **Structural isomerism:** This type of isomerism arises due to the difference in structures of coordination compounds. Structural isomerism, or constitutional isomerism, is a form of isomerism inwhich molecules with the same molecular formula have atoms bonded together in different orders.
  - **Ionisation isomerism:** This form of isomerism arises when the counter ion in a complex salt isitself a potential ligand and can displace a ligand which can then become the counter ion.

    Examples: $[Co(NH_3)_5Br]\ SO_4$ and $[Co(NH_3)_5\ SO_4]\ Br$
  - **Solvate isomerism:** It is isomerism in which the solvent is involved as the ligand. If the solvent iswater, then it is called hydrate isomerism. Example: $[Cr(H_2O)_6]Cl_3$ and $[Crcl_2(H_2O)_4]\ Cl_2.2H_2O$
  - **Linkage isomerism:** Linkage isomerism arises in a coordination compound containing an ambidentate ligand. In the isomerism, a ligand can form linkage with metal through different atoms.

    Examples: $[Co(NH_3)_5ONO]Cl_2$ and $[Co(NH_3)_5NO_2]Cl_2$
  - **Coordination isomerism:** This type of isomerism arises from the interchange of ligands betweencationic and anionic entities of different metal ions present in a complex. Examples: $[Co(NH_3)_6][Cr(C_2O_4)_3]$ and $[Cr(NH_3)_6][Co(C_2O_4)_3]$
- **Stereoisomerism:** This type of isomerism arises because of different spatial arrangement.
  - **Geometrical isomerism:** It arises in heteroleptic complexes due to different possible geometricalarrangements of ligands.
  - **Optical isomerism:** Optical isomers are those isomers which are non-superimposable mirrorimages.

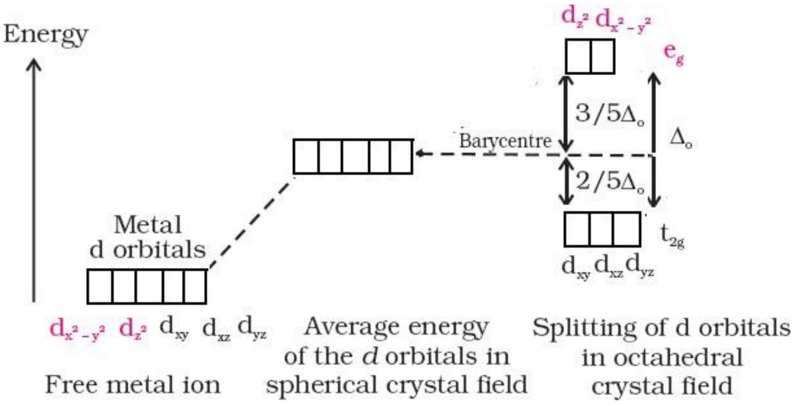
- **Valence bond theory:**

  According to this theory, the metal atom or ion under the influence of ligands can use its (n − 1)d, ns, np or ns, np or nd orbitals for hybridization to yield a set of equivalent orbitals of definite geometry such as octahedral, tetrahedral and square planar.These hybridised orbitals are allowed to overlap with ligand orbitals which can donate electron pairs for bonding.

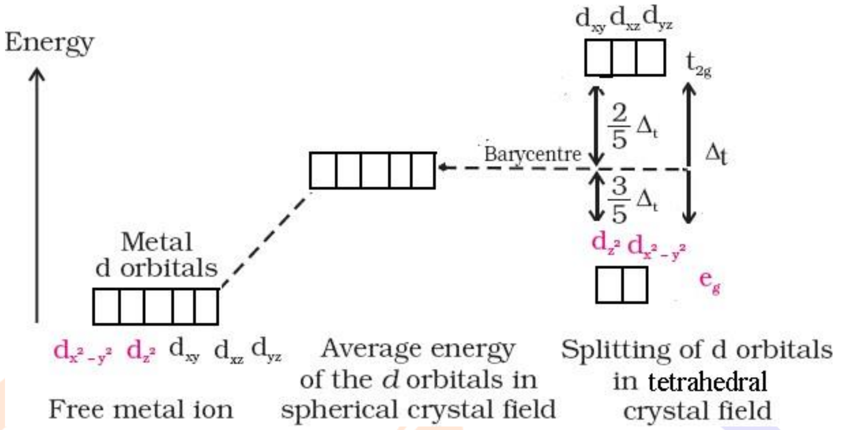
Coordinatio nnumber	Type of hybridisation	Distribution of hybridorbitals in space
4	sp^3	Tetrahedral
4	dsp^2	Square planar
5	sp^3d	Trigonal bipyramidal
6	sp^3d^2 (nd orbitals are involved; outer orbital complex or high-spin or spin-free complex)	Octahedral
6	d^2sp^3 [(n − 1)d orbitals are involved; inner orbital complex or low-spin or spin-paired complex]	Octahedral

- **Magnetic properties of coordination compounds:** A coordination compound is paramagnetic in nature if it has unpaired electrons and diamagnetic if all the electrons in the coordination compoundare paired.

  Magnetic moment $\mu = \sqrt{n(n+2)}$ where n is the number of unpaired electrons.
- **Crystal Field Theory:** It assumes the ligands to be point charges and there is an electrostatic force ofattraction between ligands and the metal atom or ion. It is a theoretical assumption.
- Crystal field splitting in octahedral coordination complexes



- **Crystal field splitting in tetrahedral coordination complexes**



- For the same metal, the same ligands and metal–ligand distances, the difference in energy between $e_g$and t_{2g} level is

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

- **Metal carbonyls:** Metal carbonyls are homoleptic complexes in which carbon monoxide (CO) acts asthe ligand. Example: $Ni(CO)_4$
  The metal–carbon bond in metal carbonyls possesses both σ and π characters. The metal–carbon bond in metal carbonyls possess both *s* and *p* characters. The M–C σ bond is formed by the donation of a lone pair of electrons from the carbonyl carbon into a vacant orbital of the metal. The M–C π bond is formed by the donation of a pair of electrons from a filled *d* orbital of metal into the vacant anti-bonding π^* orbital of carbon monoxide. The metal to ligand bonding creates a synergic effect which strengthensthe bond between CO and the metal.

NCERT LINE BY LINE QUESTIONS

(1.) Which of the following coordination compound is also known as heteroleptic complex? **[Page: 240]**

(a.) $\left[\mathrm{Co(NH_3)_6}\right]^{3+}$ (b.) $\left[\mathrm{Co(NH_3)_4Cl_2}\right]^{+}$

(c.) $\left[\mathrm{PtCl_4}\right]^{2-}$ (d.) $\left[\mathrm{Cu(CN)_4}\right]^{3-}$

(2.) The crystal field stabilisation energy (CFSE) for $\left[\mathrm{COCl0}\right]^{4-}$ is $15000\,\mathrm{cm^{-1}}$. The CFSE for $\left[\mathrm{CoCl_4}\right]^{2-}$ will be **[Odisha NEET-2019, Page: 252]**

(a.) $6000\,\mathrm{cm^{-1}}$ (b.) $16000\,\mathrm{cm^{-1}}$

(c.) $18000\,\mathrm{cm^{-1}}$ (d.) $8000\,\mathrm{cm^{-1}}$

(3.) Match the Column I with Column II and select the correct codes given below.

Column I	Column II
Complex	**IUPAC name**
(P) $[\mathrm{Co(H_2NCH_2CH_2NH_2)_3}]_2\mathrm{SO_4}$	(i) Pentaaminine carbonatocobalt (III) chloride
(Q) $\left[\mathrm{Co(NH_3)_5(CO_3)}\right]\mathrm{Cl}$	(ii) Tris(ethane-1,2 -diammine) cobalt (III) sulphate
(R) $\left[\mathrm{CoCl_2(en)_2}\right]\mathrm{Cl}$	(iii) Dichloridobis (ethane-1,2-diammine) cobalt (III) chloride
(S) $\left[\mathrm{CoCl_2(en)_2}\right]^{+}$	(iv) Dichloridobis (ethane-1,2-diammione) cobalt (III)

(a.) P-(i),Q-(ii),R-(iii),S-(iv) (b.) P-(iv),Q-(iii),R-(ii),S-(i)

(c.) P-(ii),Q-(i),R-(iii),S-(iv) (d.) P-(iii),Q-(ii),R-(i),S-(iv) **[Page: 241]**

(4.) Due to the presence of ambidentate ligands coordination compounds show isomerism. Palladium complexes of the type $\left[\mathrm{Pd(C_6H_5)_2(SCN)_2}\right]$ and $\left[\mathrm{Pd(C_6H_5)_2(NCS)_2}\right]$ are

[QR code, NCERT Exemplar, Page: 245, HOTS]

(a.) linkage isomers (b.) coordination isomers

(c.) ionisation isomers (d.) geometrical isomers

(5.) Which of the following formula belongs to Mohr's salt?

(a.) $\mathrm{KCl\cdot MgCl_2\cdot 6H_2O}$ (b.) $\mathrm{FeSO_4\cdot (NH_4)_2SO_4\cdot 6H_2O}$

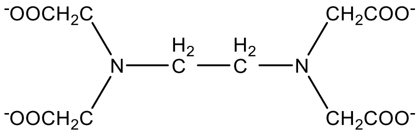
(c.) $\mathrm{KAI(SO_4)_2\cdot 12H_2O}$ (d.) None of these

(6.) Match the column I with column II and select the correct code given below. **[Page: 247]**

Column I	Column II
Hybridisation	**Geometry**
(P) sp^3	(i) Tetrahedral
(Q) dsp2	(ii) Square planar
(R) sp^3d	(iii) Trigonal bipyramidal
(S) sp^3d^2	(iv) Octahedral

(a.) P-(i),Q-(ii),R-(iii),S-(iv) (b.) P-(i),Q-(iii),R-(iv),S-(ii)

(c.) P-(iii),Q-(iv),R-(ii),S-(i) (d.) P-(ii),_O-(i),R-(iii),S-(iv)

(7.)  **[Page: 241]**

The given compounds is

(a.) hexadenate ligand.

(b.) pentadentate ligand.

(c.) tetradentate ligand.

(d.) didenate ligand.

(8.) What is the oxidation state of the compound tetracarbonyl nickel? **[Page: 242]**

(a.) Zero

(b.) One

(c.) Two

(d.) Four

(9.) Which of the metal carbonyl have metal (M) – metal (M) bond?

(a.) $[\mathrm{Fe(CO)_5}]$

(b.) $[\mathrm{Cr(CO)_6}]$

(c.) $[\mathrm{Ni(CO)_4}]$

(d.) $[\mathrm{Mn_2(CO)_{10}}]$

(10.) Some statements are given below regarding coordination complexes. Select the correct statement. **[Page: 249]**

(I) $[\mathrm{MnCl_6}]^{3-}$ has outer orbital complex.

(II) $[\mathrm{FeF_6}]^{3-}$ involve sp^3d^2 hybridisation.

(III) $[\mathrm{CoF_6}]^{3-}$ has paramagnetic in nature.

(a.) I, II and III

(b.) II and III

(c.) I and III

(d.) I and II

(11.) Which of the following compounds show linkage isomerism **[Page: 244]**

(a.) $[\mathrm{Co(NH_3)_5(NO_2)}]\mathrm{Cl_2}$

(b.) $[\mathrm{Co(NH_3)_6}][\mathrm{Cr(CN)_6}]$

(c.) $[\mathrm{Co(NH_3)_5SO_4}]\mathrm{Br}$

(d.) $[\mathrm{Cr(H_2O)_6}]\mathrm{Cl_3}$

(12.) What are the coordination number of d^2sp^3 and sp^3d^2 hybridised complex respectively?

(a.) 2 and 6

(b.) 4 and 6

(c.) 6 and 6

(d.) 6 and 4

(13.) What is the coordination number of the complex $[\mathrm{Fe(C_2O_4)_3}]^{3-}$?

(a.) 4

(b.) 6

(c.) 2

(d.) 0

(14.) IUPAC name of the complex $[\mathrm{Cr(NH_3)_3(H_2O)_3}]\mathrm{Cl_3}$ is **[Page: 24l]**

(a.) triamminetriaquachromium(II) chloride

(b.) hexaamminerriaquachromium(III) chloride

(c.) diamminetriamminechromium(II) chloride

(d.) triamminetriaquachromium(III) chloride

(15.) 1 mol of $\mathrm{CoCl_3 \cdot 6NH_3}$ gave how many mol of AgCl precipitate when it is treated with excess silver nitrate solution? **[Page: 238]**

(a.) 3 mol of AgCl
(b.) 2 mol of AgCl
(c.) 1 mol of AgCl
(d.) 4 mol of AgCl

(16.) Match the metal ions given in column I with the spin magnetic moments of the given in column II and assign the correct code: **[NEET-2O18, Page: 252]**

Column I	**Column II**
(P) Co^{3+}	(i) $\sqrt{8}$B.M.
(Q) Cr^{3+}	(ii) $\sqrt{35}$B.M.
(R) Fe^{3+}	(iii) $\sqrt{3}$B.M.
(S) Ni^{2+}	(iv) $\sqrt{24}$B.M.
	(v) $\sqrt{15}$B.M.

	P	Q	R	S
(a.)	(iv)	(v)	(ii)	(i)
(b.)	(i)	(ii)	(iii)	(iv)
(c.)	(iv)	(i)	(ii)	(iii)
(d.)	(iii)	(v)	(i)	(ii)

(17.) Which of the following ligands form a chelate? **[Page: 24O]**

(a.) Acetate
(b.) Oxalate
(c.) Cyanide
(d.) Ammonia

(18.) Which of the following statement is correct with respect to $\left[Ni(CO)_4\right]$ and $\left[NiCl_4\right]^{2-}$ **[Page: 248]**

(a.) $\left[Ni(CO)_4\right]$ and $\left[NiCl_4\right]^{2-}$ both are square planar

(b.) $\left[Ni(CO)_4\right]$ and $\left[NiCl_4\right]^{2-}$ both are tetrahedral

(c.) $\left[Ni(CO)_4\right]$ is tetrahedral while $\left[NiCl_4\right]^{2-}$ is square planar

(d.) $\left[Ni(CO)_4\right]$ is square planar while $\left[NiCl_4\right]^{2-}$ is tetrahedral

(19.) Which of the following ligands is also considered as ambidentate ligand)

(a.) $C_2O_4^{2-}$
(b.) NO_2^-
(c.) NH_3
(d.) H_2O

(20.) Select the incorrect statement **[Page: 246]**

(a.) Stereoisomerism have the same chemical formula and chemical bonds bur they have different spatial arrangement.

(b.) $\left[Pt(NH_3)_2Cl_2\right]$ has cis and trans isomerism.

(c.) $\left[Co(NH_3)_4Cl_2\right]^+$ has only cis isomerism.

(d.) Ionisation isomerism is a type of structural isomerism.

(21.) Crystal field theory explains

(a.) electrostatic model which considers the metal – ligand bond to be ionic.

(b.) electrostatic model which considers the metal-ligand bond to be covalent.

(c.) electrostatic model which considers the metal-ligand bond to be ionic and covalent.
(d.) none of these.

(22.) The correct IUPAC name of $\left[Pt(NH_3)_2Cl_2\right]$ is **[QR code, NCERT Exemplar, Page: 243, HOTS]**

(a.) diamminedichloridoplatinum (II)
(b.) diamminedichloridoplatinum (IV)
(c.) diamminedichloridoplatinum (0)
(d.) dichloridodiammineplatinum (IV)

(23.) Which of the following arrangement for spectrochemical series is incorrect? **[Page: 251]**

(a.) $I^- < Br^- < SCN^- < Cl^-$
(b.) $S^{2-} < F^- < OH^- < C_2O_4^{2-}$
(c.) $en < CN^- < CO < NCS^-$
(d.) $edta^{4-} < NH_3 < en < CN^-$

(24.) What is the correct IUPAC name of $\left[Ag(NH_3)_2\right]\left[Ag(CN)_2\right]$?

(a.) Diammine silver(II) dicyanoargentate(II)
(b.) Diammine silver(I) dicyanoargentate(I)
(c.) Diammine silver(0) dicyanosilver(II)
(d.) Diammine silver(II) dicyanoargentate(0)

(25.) Assertion: $\left[Cu(H_2O)_4\right]^{2+}$ absorb green light.

Reason: $\left[Co(NH_3)_5(H_2O)\right]^{3+}$ complementary colour is yellow. **[Page: 252]**

(a.) Both Assertion and Reason are true and Reason is the best explanation of Assertion.
(b.) Both Assertion and Reason are true but Reason is not the correct explanation of Assertion.
(c.) Assertion is true but Reason is false.
(d.) Both Assertion and Reason are false.

(26.) How many ions are produced from the complex $\left[Co(NH_3)_6Cl_2\right]$ in solution?

(a.) 6
(b.) 4
(c.) 3
(d.) 2

(27.) The colour of the coordination compounds depends on the crystal field splitting. What will be the correct order of absorption of wavelength of light in the visible region, for the complexes,

$\left[Co(NH_3)_6\right]^{3+}, \left[Co(CN)_6\right]^{3-}, \left[Co(H_2O)_6\right]^{3+}$

[QR code, NCERT Exemplar, Page: 252, HOTS]

(a.) $\left[Co(CN)_6\right]^{3-} > \left[Co(NH_3)_6\right]^{3+} > \left[Co(H_2O)_6\right]^{3+}$
(b.) $\left[Co(NH_3)_6\right]^{3+} > \left[Co(H_2O)_6\right]^{3+} > \left[Co(CN)_6\right]^{3-}$
(c.) $\left[Co(H_2O)_6\right]^{3+} > \left[Co(NH_3)_6\right]^{3+} > \left[Co(CN)_6\right]^{3-}$
(d.) $\left[Co(NH_3)_6\right]^{3+} > \left[Co(CN)_6\right]^{3-} > \left[Co(H_2O)_6\right]^{3+}$

(28.) Which of the following will not show geometrical isomerism? **[Page: 244]**

(a.) $\left[Cr(NH_3)_4Cl_2\right]Cl$
(b.) $\left[Co(en)_2Cl_2\right]Cl$
(c.) $\left[Co(NH_3)_5NO_2\right]Cl_2$
(d.) $\left[Pt(NH_3)_2C\right]_2]$

(29.) Given below some coordinate complexes with IUPAC name. Identify the incorrect name with their complex. **[Page: 242]**

(I) $\left[NiC1_2\left(PPh_3\right)_2\right]$: Dichloridobis(triphenyl phosphine)nickel(III)

(II) $\left[Cr\left(NH_3\right)_3\left(H_2O\right)_3\right]Cl_3$: Triamminetriaqua chromium(III) chloride

(III) $Hg\left[Co\left(SCN\right)_4\right]$: Mercury tetrathiocynato cobaltate(II)

(a.) I and II
(b.) I and III
(c.) II and III
(d.) I, II and III

(30.) Which one of the following ions exhibits d-d transition and paramagnetism as well? **[NEET-2018, Page: 252]**

(a.) CrO_4^{2-}
(b.) $Cr_2O_7^{2-}$
(c.) MnO_{4^-}
(d.) MnO_4^{2-}

(31.) Which of the following option is correct with respect to the inner and outer orbital complex?

(a.) $\left[Co\left(NH_3\right)_6\right]^{3+}$ is inner orbital complex and $\left[Ni\left(NH_3\right)_6\right]^{2+}$ is outer orbital complex.
(b.) $\left[Ni\left(NH_3\right)_6\right]^{2+}$ is inner orbital complex and $\left[Co\left(NH_3\right)_6\right]^{3+}$ is outer orbital complex.
(c.) Both $\left[Co\left(NH_3\right)_6\right]^{3+}$ and $\left[Ni\left(NH_3\right)_6\right]^{2+}$ are inner orbital complex.
(d.) Both $\left[Co\left(NH_3\right)_6\right]^{3+}$ and $\left[Ni\left(NH_3\right)_6\right]^{2+}$ are outer orbital complex.

(32.) The spin only magnetic moment of $\left[MnBr_4\right]^{2-}$ is 5.9 B.M. What is the geometry of the complexion? **[Page: 249]**

(a.) Tetrahedral
(b.) Square planar
(c.) Trigonal planar
(d.) None of these

(33.) Which isomer in the molecule $\left[PtCl_2\left(en\right)_2\right]^{2+}$ shows optical activity? **[Page: 245]**

(a.) Both cis and trans
(b.) Neither cis nor trans
(c.) Only cis
(d.) Only trans

(34.) Chlorophyll, hemoglobin and vitamin B_{12} are coordination compounds of

(a.) cobalt, iron and magnesium respectively
(b.) magnesium, cobalt and iron respectively
(c.) magnesium, iron and cobalt respectively
(d.) iron, cobalt and magnesium respectively.

(35.) When 1 mol $CrCl_3 \cdot 6H_2O$ is treated with excess of $AgNO_3$, 3 mol of AgCl are obtained. The formula of the complex is **[QR code, NCERT Exemplar, Page: 240, HOTS]**

(a.) $\left[CrCl_3\left(H_2O\right)_3\right]\cdot 3H_2O$
(b.) $\left[CrCl_2\left(H_2O\right)_4\right]\cdot 2H_2O$
(c.) $\left[CrCl\left(H_2O\right)_5\right]Cl_2 \cdot H_2O$
(d.) $\left[Cr\left(H_2O\right)_6\right]Cl_3$

(36.) Which of the following conditions is necessary for t^3e^1 configuration and what is the nature of ligands?

(a.) $\Delta_o < P$, weak field ligand
(b.) $\Delta_o < P$, strong field ligand
(c.) $\Delta_o > P$, weak field ligand
(d.) $\Delta_o > P$, strong field ligand

(37.) **Assertion:** IUPAC name of $\left[Co(NH_3)_4(H_2O)Cl\right]Cl_2$ is tetraammineaquachloridocobalt(III) chloride.

Reason: Chlorine is the central element in the compound $\left[Co(NH_3)_4(H_2O)Cl\right]Cl_2$. **[Page: 242]**

(a.) Both Assertion and Reason are true and Reason is the best explanation of Assertion.

(b.) Both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

(c.) Assertion is true bur Reason is false.

(d.) Both Assertion and Reason are false.

(38.) Which of the following complex is also known as Wilkinson catalyst? **[Page: 252]**

(a.) $\left[Ag(S_2O_3)_2\right]^{3-}$

(b.) $\left[(Ph_3P)_3RhCl\right]$

(c.) $\left[Ni(CO)_4\right]$

(d.) $\left[Co(C_2O_4)_3\right]^{3-}$

(39.) What are the geometry of $\left[Ni(CO)_4\right], Fe(CO)_5]$ and $[Cr(CO)_6]$ respectively? **[Page: 255]**

(a.) Trigonal bipyramidal, tetrahedral, octahedral

(b.) Tetrahedral, trigonal bipyramidal, octahedral

(c.) Octahedral, trigonal bipyramidal, tetrahedral

(d.) Tetrahedral, octahedral, trigonal bipyramidal

(40.) The type of isomerism shown by the complex $\left[CoCl_2(en)_2\right]$ is **[NEET-2018, Page: 245]**

(a.) geometrical isomerism

(b.) coordination isomerism

(c.) ionisation isomerism

(d.) linkage isomerism

(41.) $\left[Co(NH_3)_6\right]\left[Cr(CN)_6\right]$, which type of isomerism arises in the given complex?

(a.) Linkage isomerism

(b.) Coordination isomerism

(c.) Ionisation isomerism

(d.) Solvate isomerism

(42.) Which of the following is the correct chemical formula of Mohr's salt? **[Page: 239]**

(a.) $KAl(SO_4)_2 \cdot 12H_2O$

(b.) $KCl \cdot MgCl_2 \cdot 6H_2O$

(c.) $FeSO_4 \cdot (NH_4)_2SO_4 \cdot 6H_2O$

(d.) None of these

(43.) Which of the following ligands are didentate ligand?

(a.) $C_2O_4^{2-}$

(b.) $H_2NCH_2CH_2NH_2$

(c.) Both **(a)** and **(b)**

(d.) Neither **(a)** nor **(b)**

(44.) Which of the following statements regarding primary and secondary valences is correct? **[Page: 238]**

(a.) Primary valences are ionisable while secondary valences are non-ionisable.

(b.) Primary valences are non-ionisable while secondary valences are ionisable.

(c.) Both primary and secondary valences are non-ionisable.

(d.) Both primary and secondary valences are ionisable.

(45.) Select the compound which shows ionization isomerism. **[Page: 246]**

(a.) $\left[Co(NH_3)_5(SCN)\right]Cl_2$

(b.) $\left[Co(NH_3)_5Cl\right]SO_4$

(c.) $\left[Co(NH_3)_6\right]\left[Co(CN)_6\right]$

(d.) $\left[Co(NH_3)_5(NO_2)\right](NO_3)_2$

(46.) Hexaamminenickel(II) hexanitrocobaltate(III) can be written as **[Page: 242]**

(a.) $\left[Ni\left(NH_3\right)_6\right]_2\left[Co\left(NO_2\right)_6\right]_3$

(b.) $\left[Ni\left(NH_3\right)_6\right]_3\left[Co\left(NO_2\right)_6\right]_2$

(c.) $\left[Ni\left(NH_3\right)_6\right]\left[Co\left(NO_2\right)_6\right]$

(d.) $\left[Ni\left(NH_3\right)_6\left(NO_2\right)_6\right]Co$

(47.) Out of the following two coordination entities, which is chiral (optically active) . **[Page: 244]**

(I) cis $-\left[CrCl_2\left(Ox\right)_2\right]^{3-}$

(II) trans $-\left[CrCl_2\left(Ox\right)_2\right]^{3-}$

(a.) Only I

(b.) Only II

(c.) Both I and II

(d.) None of these

(48.) Which of the following has longest C-O bond length? **[NEET-2O16, Page: 252]**

(Free $C-O$ bond length in CO is 1.128Å)

(a.) $\left[Ni\left(CO\right)_4\right]$

(b.) $\left[Co\left(CO\right)_4\right]^-$

(c.) $\left[Fe\left(CO\right)_4\right]^{2-}$

(d.) $\left[Mn\left(CO\right)_6\right]^+$

(49.) What is the primary valency of the given compounds $CrCl_3, CoCl_2$ and $PdCl_2$ respectively? **[Page: 238]**

(a.) 2, 2 and 3

(b.) 3, 2 and 2

(c.) 2, 3 and 2

(d.) 3,2 and 3

(50.) Select the correct statement

(a.) The secondary valences are ionisable.

(b.) The primary valences are ionisable.

(c.) The primary and secondary valences both are non-ionisable.

(d.) None of these.

TOPIC WISE PRACTICE QUESTIONS

TOPIC 1: Coordination Number, Nomenclature and Isomerism

1. Select the correct IUPAC name for

$[Pt(C_5H_5N)_4]$ both same $[PtCl_4]$ complex:

1) Tetrapyridineplatinate (II) tetrachloridoplantinate(II)

2) Tetrapyridineplatinum (II) tetrachloridoplantinum(II)

3) Tetrapyridineplatinate (II) tetrachloridoplantinum(II)

4) Tetrapyridineplatinum (II) tetrachloridoplantinate(II)

2. $[Pt(NH_3)_4Cl_2]\ Br_2$ complex can show :

1) Hydrated as well as ionization isomerism

2) Ionization as well as geometrical isomerism

3) Linkage as well as geometrical isomerism

4) Ionization as well as optical isomerism

3. The complex ion $[Pt\ (NO_2)(Py)\ (NH_3)\ (NH_2OH)]^+$ will give

1) 2 isomers (Geometrical)

2) 3 isomers (Geometrical)

3) 6 isomers (Geometrical)

4) 4 isomers (Geometrical)

4. The geometry of $Ni(CO)_4$ and $Ni(PPh_3)_2Cl_2$ are

1) both square planar

2) tetrahedral and square planar

3) both tetrahedral

4) None of these

5. In the reactions

$[CoCl_2(NH_3)_4]^+ + Cl^- \rightarrow [CoCl_3(NH_3)_3] + NH3$ two isomers of the product are obtained. The initial complex is

1) *cis* isomer 2) *trans* isomer 3) *cis* or *trans* isomers 4) None of these

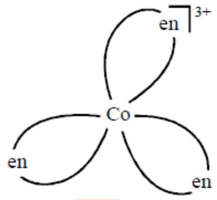
6. Possible isomerism in complexes $[Co(NH_3)_3(NO_2)_3]$ and $[Co(NH_3)_5(NO_2)]Cl_2$, respectively are:

1) Linkage and optical 2) Geometrical and linkage
3) Optical and ionization 4) Linkage and geometrical

7. Both geometrical and optical isomerisms are shown by

1) $[Co(en)_2Cl_2]^+$ 2) $[Co(NH_3)_5Cl]^{2+}$ 3) $[Co(NH_3)_4Cl_2]^+$ 4) $[Cr(ox)_3]^{3-}$

8. The complex given is



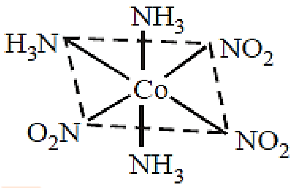
(i) non-superimposable on its mirror images (ii) optically inactive
(iii) rotate plane polarised light (iv) planar

1) (i) and (ii) 2) (i) and (iv) 3) (i), (ii) and (iii) 4) (ii) only

9. An example of double salt is

1) Bleaching powder 2) $K_4[Fe(CN)_6]$ 3) Hypo 4) Potash alum

10. Which of the following type of isomerism is shown by given complex compound?



1) Facial 2) Meridional 3) Cis 4) Both b and c

11. The tetrahedral complex [M1)2)(X)(Y)], where A,B,X and Y are different ligands and M is a metal ion is

1) optically inactive 2) rotate plane polarized light
3) incomplete information 4) can't be said

12. Which of the following will give maximum number of isomers?

1) $[Ni(C_2O_4)(en)_2]^{2-}$ 2) $[Ni(en)(NH_3)_4]^{2+}$ 3) $[Cr(SCN)_2(NH_3)_4]^+$ 4) $[Co(NH_3)_4Cl_2]$

13. Which of the following compounds shows optical isomerism?

1) $\left[Co(CN)_6\right]^{3-}$ 2) $\left[Cr(C_2O_4)_3\right]^{3-}$ 3) $\left[ZnCl_4\right]^{2-}$ 4) $\left[Cu(NH_3)_4\right]^{2+}$

14. The ionisation isomer of $[Cr(H_2O)_4Cl(NO_2)]Cl$ is

1) $[Cr(H_2O)_4(O_2N)]Cl_2$ 2) $[Cr(H_2O)_4Cl_2](NO_2)$
3) $[Cr(H_2O)_4Cl(ONO)]Cl$ 4) $[Cr(H_2O)_4Cl_2(NO_2)].H_2O$

15. A bidenate ligand always

1) has bonds formed to two metals ions 2) has a charge of +2 or – 2
3) forms complex ions with a charge of +2 or –2
4) has two donor atoms forming simultaneously two sigma (s) bonds.

16. Which one of the following complexes is not expected to exhibit isomerism?

1) $\left[Ni(en)_3\right]^{2+}$ 2) $\left[Ni(NH_3)_4(H_2O)_2\right]^{2+}$ 3) $\left[Pt(NH_3)_2Cl_2\right]$ 4) $\left[Ni(NH_3)_2Cl_2\right]$

17. The complexes $[Co(NH_3)_6][Cr(CN)_6]$ and $[Cr(NH_3)_6][Co(CN)_6]$ are the examples of which type of isomerism?

1) Linkage isomerism 2) Ionization isomerism

3) Coordination isomerism 4) Geometrical isomerism

18. For which value of the x, and y, the following square planar compound shows geometrical isomers $[Pt(Cl)_x(Br)_y]^{2-}$

1) 1, 3 2) 3, 1 3) 2, 2 4) 1, 1

19. The structure of which of the following chloro species can be explained on the basis of *dsp*^{2} hybridization?

1) $PdCl_4^{2-}$ 2) $FeCl_4^{2-}$ 3) $CoCl_4^{2-}$ 4) $NiCl_4^{2-}$

20. Which of the following is not chelating agent?

1) thiosulphato 2) oxalate 3) glycinato 4) ethylene diamine

21. A similarity between optical and geometrical isomerism is that

1) each gives equal number of isomers for a given compound
2) if in a compound one is present then so is the other
3) both are included in stereoisomerism
4) they have no similarity

22. Which is the pair of ambidentate ligand?

1) CN^-, NO_2^- 2) NO_3^-, SCN^- 3) N_3^-, NO_2^- 4) $NCS^-, C_2O_4^{2-}$

23. Number of water molecules acting as ligands in $CuSO_4.5H_2O$, $ZnSO_4.5H_2O$, $FeSO_4.7H_2O$ respectively are

1) 5, 5, 7 2) 4, 5, 4 3) 4, 4, 6 4) 4, 4, 7

24. The number of ions formed on dissolving one molecule of $FeSO_4(NH_4)_2SO_4.6H_2O$ in water is:

1) 4 2) 5 3) 3 4) 6

25. In octaamine-μ-dihydroxodiiron(III) sulphate, the number of bridging ligands is

1) 2 2) 1 3) 3 4) None of these

TOPIC 2: Magnetic Moment, Valence Bond Theory and Crystal Field Theory

26. The crystal field splitting energy for octahedral (Δ_0) and tetrahedral (Δ_t) complexes is related as

1) $\Delta_t = -\frac{1}{2}\Delta_0$ 2) $\Delta_t = -\frac{4}{9}\Delta_0$ 3) $\Delta_t = -\frac{3}{4}\Delta_0$ 4) $\Delta_t = -\frac{2}{5}\Delta_0$

27. Ammonia will not form complex with

1) Ag^{2+} 2) Pb^{2+} 3) Cu^{2+} 4) Cd^{2+}

28. Which of the following complex compound is low spin, inner orbital, diamagnetic complex?

1) $[Ni(NH_3)_6]Cl_2$ 2) $K_3[Fe(CN)_6]$ 3) $K_2[PtCl_6]$ 4) $[Cr(H_2O)_6]Cl_3$

29. As aqueous solution of titanium bromide shows zero magnetic moment. Assuming the complex as octahedral in aqueous solution, the formula of the complex is

1) $[TiBr_6]^{3-}$ 2) $[Ti(H_2O)_6]Br_4$ 3) $[TiBr_6]^{2-}$ 4) $[Ti(H_2O)_4Br_2]$

30. Which of the following option is having maximum number of unpaired electrons –

1) A tetrahedral d^6 ion 2) $[Co(NH_3)_6]^{3+}$
3) A square planar d^7 ion 4) A co-ordination compound with magnetic moment of 5.92 B.M.

31. The degeneracy of *d*-orbitals is lost under :

(I) Strong field ligand (II) Weak field ligand
(III) Mixed field ligand (IV) Chelated ligand field

1) I, II and IV 2) I and II 3) I, II, III and IV 4) I, II and III

32. Relative to the average energy in the spherical crystal field, the t_{2g} orbitals in tetrahedral field is

1) raised by (2/5) Δ_t 2) lowered by (2/5) Δ_t
3) raised by (3/5) Δ_t 4) lowered by (1/5) Δ_t

33. Which of the following outer orbital complex has highest magnetic moment?

1) $[Mn(NH_3)_6]Cl_2$ 2) $[Cr(NH_3)_6]Cl_3$ 3) $[Ni(NH_3)_6]Cl_2$ 4) $[Co(NH_3)_6]Cl_3$

34. Which of the following are inner orbital complex (i.e., involving *d2sp3* hybridisation) and is paramagnetic in nature?
1) $[Mn(CN)_6]^{3-}$, $[Fe(CN)_6]^{3-}$, $[Co(C_2O_4)_3]^{3-}$ 2) $[MnCl_6]^{3-}$, $[FeF_6]^{3-}$, $[CoF_6]^{3-}$
3) $[Mn(CN)_6]^{3-}$, $[Fe(CN)_6]^{3-}$ 4) $[MnCl_6]^{3-}$, $[Fe(CN)_6]^{3-}$, $[Co(C_2O_4)_3]^{3-}$

35. Mn^{2+} forms a complex with Br^- ion. The magnetic moment of the complex is 5.92 B.M. What would be the probable formula and geometry of the complex?
1) $[MnBr_6]^{4-}$, octahedral 2) $[MnBr_4]^{2-}$, square planar
3) $[MnBr_4]^{2-}$, tetrahedral 4) $[MnBr_5]^{3-}$, trigonal bipyramidal

36. Which of the following hydrate is diamagnetic?
1) $[Mn(H_2O)_6]^{2+}$ 2) $[Cu(H_2O)_6]^{3+}$ 3) $[Co(NH_3)_6]^{3+}$ 4) $[Co(H_2O)_6]^{2+}$

37. Which one of the following will show paramagnetism corresponding to 2 unpaired electrons? (Atomic numbers : Ni = 28, Fe = 26)
1) $[FeF_6]^{3-}$ 2) $[NiCl_4]^{2-}$ 3) $[Fe (CN)_6]^{3-}$ 4) $[Ni (CN)_4]^{2-}$

38. CN– is a strong field ligand. This is due to the fact that
1) it carries negative charge 2) it is a pseudohalide
3) it can accept electrons from metal species 4) it forms high spin complexes with metal species

39. When pink complex, $[Co(H_2O)_6]^{2+}$ is dehydrated the colour changes to blue. The correct explanation for the change is :
1) The octahedral complex becomes square planar. 2) A tetrahedral complex is formed.
3) Distorted octahedral structure is obtained.
4) Dehydration results in the formation of polymeric species.

40. The crystal field stabilization energy (CFSE) is the highest for
1) $[CoF_4]^{2-}$ 2) $[Co(NCS)_4]^{2-}$ 3) $[Co(NH_3)_6]^{3+}$ 4) $[CoCl_4]^{2-}$

41. Which of the following complex ion is not expected to absorb visible light ?
1) $\left[Ni(CN)_4\right]^{2-}$ 2) $\left[Cr(NH_3)_6\right]^{3+}$ 3) $\left[Fe(H_2O)_6\right]^{2+}$ 4) $\left[Ni(H_2O)_6\right]^{2+}$

42. Crystal field stabilization energy for high spin d^4 octahedral complex is:
1) $-1.8\ \Delta_0$ 2) $-1.6\ \Delta_0 + P$ 3) $-1.2\ \Delta_0$ 4) $-0.6\ \Delta_0$

43. Which of the following is incorrect regarding spectrochemical series?
1) $NH_3 > H_2O$ 2) $F^- > C_2O_4^{2-}$ 3) $NCS^- > SCN^-$ 4) en > $edta^{4-}$

44. Of the following complex ions, which is diamagnetic in nature?
1) $[NiCl_4]^{2-}$ 2) $[Ni(CN)_4]^{2-}$ 3) $[CuCl_4]^{2-}$ 4) $[CoF_6]^{3-}$

45. The *d*-electron configurations 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?
1) $[Mn(H_2O)_6]^{2+}$ 2) $[Fe(H_2O)_6]^{2+}$ 3) $[Co(H_2O)_6]^{2+}$ 4) $[Cr(H_2O)_6]^{2+}$
(At, nos. Cr = 24, Mn = 25, Fe = 26, Co = 27)

46. Which of the following complex compounds will exhibit highest paramagnetic behaviour? (At. No. : Ti = 22, Cr = 24, Co = 27, Zn = 30)
1) $[Ti (NH_3)_6]^{3+}$ 2) $[Cr (NH_3)_6]^{3+}$ 3) $[Co (NH_3)_6]^{3+}$ 4) $[Zn (NH_3)_6]^{2+}$

47. Which one of the following is an outer orbital complex and exhibits paramagnetic behaviour ?
1) $[Ni(NH_3)_6]^{2+}$ 2) $[Zn(NH_3)_6)]^{2+}$ 3) $[Cr(NH_3)_6]^{3+}$ 4) $[Co(NH_3)_6]^{3+}$

48. Which of the following is the limitation of valence bond theory?
1) It does not distinguish between weak and strong ligands.
2) It does not give quantitative interpretation of magnetic data.
3) It does not explain the colour exhibited by coordination compounds
4) All of these

49. Low spin complex of d^6-cation in an octahedral field will have the following energy :

1) $\frac{-12}{5}\Delta_0 + P$ 2) $\frac{-12}{5}\Delta_0 + 3P$ 3) $\frac{-2}{5}\Delta_0 + 2P$ 4) $\frac{-2}{5}\Delta_0 + P$

(Δ_0 = Crystal Field Splitting Energy in an octahedral field, P = Electron pairing energy)

50. Among the following complexes the one which shows zero crystal field stabilization energy (CFSE):

1) $[Mn(H_2O)_6]^{3+}$ 2) $[Fe(H_2O)_6]^{3+}$ 3) $[Co(H_2O)_6]^{2+}$ 4) None of these

51. $[Sc(H_2O)_6]^{3+}$ ion is

1) colourless and diamagnetic 2) coloured and octahedral
3) colourless and paramagnetic 4) coloured and paramagnetic

52. One mole of the complex compound $Co(NH_3)5Cl_3$, 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 formula of the complex is

1) $[Co(NH_3)_3Cl_3]$. 2 NH_3 2) $[Co(NH_3)_4Cl_2]$ Cl . NH_3
3) $[Co(NH_3)_4Cl]$ Cl_2. NH_3 4) $[Co(NH_3)_5Cl]$ Cl_2

53. How many EDTA (ethylenediaminetetraacetic acid) molecules are required to make an octahedral complex with a Ca^{2+} ion?

1) One 2) Two 3) Six 4) Three

54. The molar ionic conductances of the octahedral complexes:

(I) $PtCl_4.5NH_3$ (II) $PtCl_4.4NH_3$ (III) $PtCl_4.3NH_3$ (IV) $PtCl_4.2NH_3$

Follow the order

1) I < II < III < IV 2) IV < III < II < I 3) III < IV < II < I 4) IV < III < I < II

55. The most stable complex among the following is

1) $K_3[Al(C_2O_4)_3]$ 2) $[Pt(en)_2]Cl$ 3) $[Ag(NH_3)_2]Cl$ 4) $K_2[Ni(EDTA)]$

56. Consider the following complex $[Co(NH_3)_5CO_3]ClO_4$. The coordination number, oxidation number, number of *d*-electrons and number of unpaired *d*-electrons on the metal are respectively.

1) 6, 3, 6, 0 2) 7, 2, 7, 1 3) 7, 1, 6, 4 4) 6, 2, 7, 3

57. Nickel (Z = 28) combines with a uninegative monodentate ligand to form a diamagnetic complex $[NiL_4]^{2-}$. The hybridisation involved and the number of unpaired electrons present in the complex are respectively:

1) sp^3, two 2) dsp^2, zero 3) dsp^2, one 4) sp^3, zero

TOPIC 3: Organometallic Compounds

58. The formula of ferrocene is

1) $[Fe(CN)_6]^{4-}$ 2) $[Fe(CN)_6]^{3-}$ 3) $[Fe(CO)_5]$ 4) $[(C_5H_5)_2Fe]$

59. The organometallic compound is :

1) $Ti(OCOCH_3)_4$ 2) $Ti(C_2H_4)_4$ 3) $Ti(OC_6H_5)_4$ 4) $Ti(OC_2H_5)_4$

60. Which of the following does not have a metal- carbon bond?

1) $Al(OC_2H_5)_3$ 2) C_2H_5MgBr 3) $K[Pt(C_2H_4)Cl_3]$ 4) $Ni(CO)_4$

61. Which of the following is an organometallic compound?

1) Lithium methoxide 2) Lithium acetate 3) Lithium dimethylamide 4) Methyl lithium

62. In $Fe(CO)_5$, the Fe – C bond possesses

1) ionic character 2) σ-character only 3) π-character 4) both σ and π characters

63. Which of the following may be considered to be an organometallic compound?

1) Nickel tetracarbonyl 2) Chlorophyll 3) $K_3[Fe(C_2O_4)_3]$ 4) $[Co(en)_3]Cl_3$

64. $CH_3 – Mg – Br$ is an organometallic compound due to

1) Mg – Br bond 2) C – Mg bond 3) C – Br bond 4) C – H bond.

65. Oxidation state of “V” in $Rb_4K[HV_{10}O_{28}]$ is

1) + 5 2) + 6 3)+7/5 4) + 4

66. For $[Co_2(CO)_8]$, what is the total number of metal – carbon bonds and number of metal–metal bonds.

1) 10 ,1 2) 8, 2 3) 8, 1 4) 10, 0

67. Coordination compounds have great importance in biological systems. In this context which of the following statements is incorrect?
1) Cyanocobalamin is B_{12} and contains cobalt
2) Haemoglobin is the red pigment of blood and contains iron
3) Chlorophylls are green pigments in plants and contain calcium
4) Carboxypeptidase - A is an exzyme and contains zinc.

68. An organometallic compound amongst the following is
1) Ferrocene 2) Diethyl zinc3) Tetraethyl lead (TEL) 4) All of these

69. Which of the following carbonyls will have the strongest C – O bond ?
1) $[Mn(CO)_6]^+$ 2) $[Cr(CO)_6]$ 3) $[V(CO)_6]^-$ 4) $[Fe(CO)_5]$

70. An example of a sigma bonded organometallic compound is :
1) Grignard's reagent 2) Ferrocene 3) Cobaltocene 4) Ruthenocene

NEET PREVIOUS YEARS QUESTIONS

1. Iron carbonyl, $Fe(CO)_5$ is [2018]
1) Tetranuclear 2) Mononuclear 3) Dinuclear 4) Trinuclear

2. The type of isomerism shown by the complex $[CoCl_2(en)_2]$ is [2018]
1) Geometrical isomerism 2) Coordination isomerism
3) Linkage isomerism 4) Ionization isomerism

3. The geometry and magnetic behaviour of the complex $[Ni(CO)_4]$ are [2018]
1) Square planar geometry and diamagnetic 2) Tetrahedral geometry and diamagnetic
3) Tetrahedral geometry and paramagnetic 4) Square planar geometry and paramagnetic

4. An example of a sigma bonded organometallic compound is : [2017]
1) Grignard's reagent 2) Ferrocene 3) Cobaltocene 4) Ruthenocene

5. The correct order of the stoichiometries of AgCl formed when $AgNO_3$ in excess is treated with the complexes : $CoCl_3.6NH_3$, $CoCl_3.5NH_3$, $CoCl_3.4NH_3$ respectively is : [2017]
1) 3 AgCl, 1 AgCl, 2 AgCl 2) 3 AgCl, 2 AgCl, 1 AgCl
3) 2 AgCl, 3 AgCl, 1 AgCl 4) 1 AgCl, 3 AgCl, 2 AgCl

6. Correct increasing order for the wavelengths of absorption in the visible region for the complexes of Co^{3+} is : [2017]
1) $[Co(H_2O)_6]^{3+}$, $[Co(en)_3]^{3+}$, $[Co(NH_3)_6]^{3+}$ 2) $[Co(H_2O)_6]^{3+}$, $[Co(NH_3)_6]^{3+}$, $[Co(en)_3]^{3+}$
3) $[Co(NH_3)_6]^{3+}$, $[Co(en)_3]^{3+}$, $[Co(H_2O)_6]^{3+}$ 4) $[Co(en)_3]^{3+}$, $[Co(NH_3)_6]^{3+}$, $[Co(H_2O)_6]^{3+}$

7. Pick out the correct statement with respect to $[Mn(CN)_6]^{3-}$ [2017]
1) It is sp^3d^2 hybridised and tetrahedral 2) It is d^2sp^3 hybridised and octahedral
3) It is dsp^2 hybridised and square planar 4) It is sp^3d^2 hybridised and octahedral

8. Which of the following has longest C–O bond length? (Free C–O bond length in CO is 1.128Å) [2016]
1) $Ni(CO)_4$ 2) $[Co(CO)_4]^-$ 3) $[Fe(CO)_4]^{2-}$ 4) $[Mn(CO)_6]^+$

9. The sum of coordination number and oxidation number of the metal M in the complex $[M(en)_2(C_2O_4)]Cl$ (where *en* is ethylenediamine) is: [2015]
1) 9 2) 6 3) 7 4) 8

10. The name of complex ion, $[Fe(CN)_6]^{3-}$ is : [2015]
1) Hexacyanoiron (III) ion 2) Hexacyanitoferrate (III) ion
3) Tricyanoferrate (III) ion 4) Hexacyanidoferrate (III) ion

11. The hybridization involved in complex $[Ni(CN)_4]^{2-}$ is (At. No. Ni = 28) [2015]
1) dsp^2 2) sp^3 3) d^2sp^2 4) d^2sp^3

12. Number of possible isomers for the complex $[Co(en)_2Cl_2]Cl$ will be (en = ethylenediamine) [2015]
1) 2 2) 1 3) 3 4) 4

13. Cobalt (III) chloride forms several octahedral complexes with ammonia. Which of the following will not give test of chloride ions with silver nitrate at 25 °C? [2015]
1) $CoCl_3{\cdot}4NH_3$ 2) $CoCl_3{\cdot}5NH_3$ 3) $CoCl_3{\cdot}6NH_3$ 4) $CoCl_3{\cdot}3NH_3$

14. Which of these statements about $[Co(CN)_6]^{3-}$ is true? [2015]
1) $[Co(CN)_6]^{3-}$ has four unpaired electrons and will be in a low-spin configuration.

2) $[Co(CN)_6]^{3-}$ has four unpaired electrons and will be in a high spin configuration.
3) $[Co(CN)_6]^{3-}$ has no unpaired electrons and will be in a high-spin configuration.
4) $[Co(CN)_6]^{3-}$ has no unpaired electrons and will be in a low-spin configuration.

15. Among the following complexes the one which shows zero crystal field stabilization energy (CFSE): [2014]
1) $[Mn(H_2O)_6]^{3+}$ 2) $[Fe(H_2O)_6]^{3+}$ 3) $[Co(H_2O)_6]^{2+}$ 4) $[Co(H_2O)_6]^{3+}$

16. Which of the following complexes is used as an anti-cancer agent: [2014]
1) *mer*-$[Co(NH_3)_3Cl_3]$ 2) *cis*-$[PtCl_2(NH_3)_2]$ 3) *cis*-$K_2[PtCl_2Br_2]$ 4) Na_2CoCl_4

17. What is the correct electronic configuration of the central atom in $K_4[Fe(CN)_6]$ based on crystal field theory? [2019]
(1) $t_{2g}^4e_g^2$ (2) $t_{2g}^6e_g^0$ (3) $e^3t_2^3$ (4) $e^4t_2^2$

18. The Crystal Field Stabilisation Energy (CFSE) for $[CoCl_6]^{4-}$ is 18000 cm^{-1}. The CFSE for $[CoCl_4]2^{-}$ will be- [2019- ODISSA]
(1) 6000 cm^{-1} (2) 16000 cm^{-1} (3) 18000 cm^{-1} (4) 8000 cm^{-1}

19. Match the coordination number and type of hybridisation with distribution of hybrid orbitals in space based on Valence bond theory. [2020-COVID-19]

Coordination number and type of hybridisation	**Distribution of hybrid orbitals in space**
1) 4, sp^3	(i) trigonal bipyramidal
2) 4, dsp^2	(ii) octahedral
3) 5, sp^3d	(iii) tetrahedral
4) 6, d^2sp^3	(iv) square planar

Select the correct option :
(1) 1)-(ii) 2)-(iii) 3)-(iv) 4)-(i) (2) 1)-(iii) 2)-(iv) 3)-(i) 4)-(ii)
(3) 1)-(iv) 2)-(i) 3)-(ii) 4)-(iii) (4) 1)-(iii) 2)-(i) 3)-(iv) 4)-(ii)

20. Which of the following is the correct order of increasing field strength of ligands to form coordination compounds? [2020]

1. $CN^- < C_2O_4^{2-} < SCN^- < F^-$ 2. $SCN^- < F^- < C_2O_4^{2-} < CN^-$
3. $SCN^- < F^- < CN^- < C_2O_4^{2-}$ 4. $F^- < SCN^- < C_2O_4^{2-} < CN^-$

21. Ethylene diaminetetraacetate (EDTA) ion is **[NEET-2021]**
1) Unidentate ligand 2) Bidentate ligand with two “N” donor atoms
3) Tridentate ligand with three “N” donor atoms
4) Hexadentate ligand with four “O” and two “N” donor atoms

22. **Match List – I with List – II.** **[NEET-2021]**

List – I	**List – II**
a) $\left[Fe(CN)_6\right]^{3-}$	i) 5.92 BM
b) $\left[Fe(H_2O)_6\right]^{3+}$	ii) 0 BM
c) $\left[Fe(CN)_6\right]^{4-}$	iii) 4.90 BM
d) $\left[Fe(H_2O)_6\right]^{2+}$	iv) 1.73 BM

23. The IUPAC name of the complex – **[NEET-2022]**
$[Ag(H_2O)_2][Ag(CN)_2]$ is:
1) dicyanidosilver(II) diaquaargentate(II)
2) diaquasilver(II) dicyanidoargentate(II)
3) dicyanidosilver(I) diaquaargentate(I)
4) diaquasilver(I) dicyanidoargentate(I)

24. The order of energy absorbed which is responsible for the color of complexes **[NEET-2022]**

A) $\left[Ni\left(H_2O\right)_2(en)_2\right]^{2+}$ **B)** $\left[Ni\left(H_2O\right)_4(en)\right]^{2+}$ **and c)** $\left[Ni(en)_3\right]^{2+}$ **is**

1)A > B > C 2) C > B > A 3) C > A > B 4) B > A > C

NCERT LINE BY LINE QUESTIONS – ANSWERS

(1.)	b	**(2.)**	d	**(3.)**	c	**(4.)**	a	**(5.)**	b
(6.)	a	**(7.)**	a	**(8.)**	a	**(9.)**	d	**(10.)**	a
(11.)	a	**(12.)**	c	**(13.)**	b	**(14.)**	d	**(15.)**	a
(16.)	a	**(17.)**	b	**(18.)**	b	**(19.)**	b	**(20.)**	c
(21.)	a	**(22.)**	a	**(23.)**	c	**(24.)**	b	**(25.)**	d
(26.)	c	**(27.)**	c	**(28.)**	c	**(29.)**	b	**(30.)**	d
(31.)	a	**(32.)**	a	**(33.)**	c	**(34.)**	c	**(35.)**	d
(36.)	a	**(37.)**	c	**(38.)**	b	**(39.)**	b	**(40.)**	a
(41.)	b	**(42.)**	c	**(43.)**	c	**(44.)**	a	**(45.)**	b
(46.)	b	**(47.)**	a	**(48.)**	c	**(49.)**	b	**(50.)**	b

TOPIC WISE PRACTICE QUESTIONS - ANSWERS

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

NEET PREVIOUS YEARS QUESTIONS-ANSWERS

1) 2	2) 1	3) 2	4) 1	5) 2	6) 4	7) 2	8) 3	9) 1	10) 4
11) 1	12) 3	13) 4	14) 4	15) 2	16) 2	17) 2	18) 4	19) 2	20) 2
21) 4	22) 3	23) 4	24) 3						

NCERT LINE BY LINE QUESTIONS – SOLUTIONS

(1.) (b) Complexes in which a metal is bound to more than one kind of donor groups, e.g., $\left[Co\left(NH_3\right)_4Cl_2\right]^+$ are known as heteroleptic. Complexes in which a metal is bound to only one kind of donor groups, e.g., $\left[Co\left(NH_3\right)_6\right]^{3+}$ are known as homoleptic.

(2.) (d) $\Delta\ \text{tetrahedral} = \frac{4}{9} \times \Delta\text{octahedral}$

$= \frac{4}{9} \times 18000 = 8000\,cm^{-1}$

(3.) (c) Correct match is, P-(ii),Q-(i),R-(iii),S-(iv) .

(4.) (a) Linkage isomers

(6.) (a)

Coordination number	**Type of hybridisation**	**Distribution of hybrid orbitals in space**
4	sp^3	Tetrahedral
4	dsp^2	Square planar
5	sp^3d	Trigonal bipyramidal
6	sp^3d^2	Octahedral

6	d^2sp^3	Octahedral

(7.) (a) The given compound is ethylenediaminetetraacetate ion $(EDTA)^{4-}$ is hexadentate ligand.

(8.) (a) $[Ni(CO)_4]$ – Terracarbonylnicke1(0) .

(10.) (a) $[MnCl_6]^{3-}, [FeF_6]^{3-}$ and $[CoF_6]^{3-}$ areouterorbital complexes involving sp^3d^2 hybridisation and paramagnetic corresponding to four, five and four unpaired electrons.

(11.) (a) $[Co(NH_3)_5(NO_2)]Cl_2$ shows linkage isomerism. $[Co(NH_3)_5(NO_2)]Cl_2$, which is obtained as the red form, in which the nitrite ligands is bound through oxygen $(-ONO)$, and as the yellow form, in which the nitrite ligand is bound through nitrogen $(-NO_2)$.

(14.) (d) $[Cr(NH_3)_3(H_2O)_3]Cl_3$: Triamminetriaqua chromium(III) chloride.

(15.) (a) 1mo1 $CoCl_3 \cdot 6NH_3$ (yellow) gave 3 mol of AgCl when it is treated with excess silver nitrate solution.

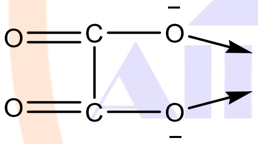
(16.) (a) $Co^{3+}, n = 4, \mu = \sqrt{4(4+2)} = \sqrt{24}$ B.M.

$Cr^{3+}, n = 3, \mu = \sqrt{3(3+2)} = \sqrt{15}$ B.M.

$Fe^{3+}, n = 5, \mu = \sqrt{5(5+2)} = \sqrt{35}$ B.M.

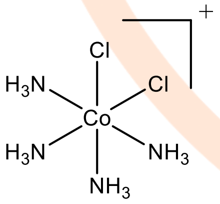
$Ni^{3+}, n = 2, \mu = \sqrt{2(2+2)} = \sqrt{8}$ B.M.

(17.) (b) Among the given ligands oxalate is a bidentate ligand hence forms a chelate.

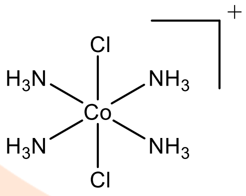


(18.) (b) Both $[Ni(CO)_4]$ and $[NiCl_4]^{2-}$ are tetrahedral geometry.

(20.) (c) $[Co(NH_3)_4Cl_2]^+$ has geometrical isomers, cis and trans.



trans



cis

(22.) (a) The correct IUPAC name of $[Pr(NH_3)_2Cl_2]$ is diamminedichloridoplatinum(II).

(23.) (c) In general, ligands can be arranged in a series in the order of increasing field strength as given below:

$I^- < Br^- < SCN^- < Cl^- < S^{2-} < F^{\leftarrow} < OH^- < C_2O_4^{2-} < H_2O < NCS^- < edra^{4-} < NH_3 < en < CN^- < CO$

(25.) (d) $[Cu(H_2O)_4]^{2+}$ absorb red colour and its complementary colour is blue. $[Co(NH_3)_5H_2O]^{3+}$ absorb blue green colour and its complementary colour is red.

(27.) (c) The CPSE of the ligands is in the order: $H_2O < NH_3 < CN^-$ Therefore, excitation energies are in the order:

$[Co(H_2O)_6]^{3+} < [Co(NH_3)_6]^{3+} < [Co(CN)_6]^{3-}$

From the reaction $E = \dfrac{hc}{\lambda}$

Hence, $E \propto \dfrac{1}{\lambda}$

The order of absorption of wavelength of light in the visible region is:

$[Co(H_2O)_6]^{3+} > [Co(NH_3)_6]^{3+} > [Co(CN)_6]^{3-}$

(28.) (c) Octahedral complex of type $[MA_5B_2]$ cannot show geometrical isomerism.

(29.) (b) $[NiCl_2(PPh_3)_2]$: Dichloridobis (triphenyl phosphine) nickel (II)

$Hg[Co(SCN)_4]$: Mercury tetrathiocynato cobaltate(III)

(30.) (d)

CrO_4^{2-} Cr^{6+} – Diamagnetic

CrO_7^{2-} Cr^{6+} – Diamagnetic

MnO_4^- Mn^{7+} – Diamagnetic

MnO_4^{2-} Mn^{6+} – Paramagnetic

In MnO_4^{2-} unpaired electron is present, therefore d-d transition is possible.

(32.) (a) Since the coordination number of Mn^{2+} ion in the complex ion is 4, it will be either tetrahedral (sp^3 hybridisation) or square planar (dsp^2 hybridisation). But the fact that the magnetic moment of the complex ion is 5.9 B.M., it should be tetrahedral in shape rather than square planar because of the presence of five unpaired electrons in the d-orbitals.

(33.) (c) In a coordination entity of the type $[PtCl_2(en)_2]^{2+}$, only the cis-isomer shows optical activity.

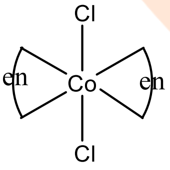
(35.) (d) As 3 moles of AgCl are obtained when 1 mol of $CrCl_3 \cdot 6H_2O$ is treated with excess of $AgNO_3$ which shows that one molecule of the complex gives three chloride ions in solution. Hence, formula of the complex is $[Cr(H_2O)_6]Cl_3$.

(37.) (c) Cobalt (Co) is the central metal in the complex $[Co(NH_3)_4(H_2O)Cl]Cl_2$.

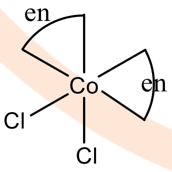
(38.) (b) Coordination compounds are used as catalysts for many industrial processes. Examples include rhodium complex, $[(Ph_3P)_3RhCl]$ a Wilkinson catalyst is used for the hydrogenation of alkenes.

(39.) (b) Tetracarbonyl nickel(O) is tetrahedral, pentacarbonyl iron (0) is trigonal bipyramidal while hexacarbonyl chromium (0) is octahedral.

(40.) (a) $[CoCl_2(en)_2]$ has geometrical isomerism.



trans



cis

(42.) (c) Mohr's salt: $FeSO_4 \cdot (NH_4)_2SO_4 \cdot 6H_2O$

(44.) (a) The primary valences are normally ionisable and are satisfied by negative ions while secondary valences are non-ionisable. These are satisfied by neutral molecules or negative ions. The secondary valence is equal to the coordination number and is fixed a metal.

(45.) (b) Ionisation isomerism arises when the counter ion in a complex salt is itself a potential ligand and can displace a ligand which can then become the counter ion. An example is provided by the ionisation isomers $[Co(NH_3)_5Cl]SO_4$ and $[Co(NH_3)_5SO_4]Cl$.

(46.) (b) Hexaamminenickel(II) hexanitrocobaltate(III) can be written as $[Ni(NH_3)_6]_3[Co(NO_2)_6]_2$.

(47.) (a) Out of cis $-[CrCl_2(Ox)_2]^{3-}$ and trans - $[CrCl_2(Ox)_2]^{3-}$, cis-isomer is chiral (optically active).

(48.) (c) $[Fe(CO)_4]^{2-}$

Since metal atom is carrying maximum negative change therefore it would show maximum synergic bonding as a result $C-O$ bond length would be maximum.

(49.) (b) Primary compounds such as $CrCl_3, CoCl_2$ or $PdCl_2$ have primary valency of 3, 2 and 2 respectively.

TOPIC WISE PRACTICE QUESTIONS - SOLUTIONS

1. 4)

2. 2) $[Pt(NH_3)_4Cl_2]Br_2$

Ionization isomer

$[Pt(NH_3)_4ClBr]Cl.Br$

Geometrical isomers

3. 2)

4. 3)

	$Ni(CO)_4$	$Ni(PPh_3)_2Cl_2$
O.S.	Ni^0	Ni^{2+}
E.C.	$[Ar]3d^8 4s^2$	$[Ar]3d^8 4s^0$
	Pairing of e^-	No pairing of e^-
Hybridization	sp^3 (tetrahedral)	sp^3 (tetrahedral)

5. 1) The initial complex must have two Cl^- ions in cis position as the third Cl^- ion could replace an ammonia cis to both or trans to one giving two isomers. If two Cl^- ions were in the trans positions, the other four positions which could be replaced are equivalent and only one isomer of the product would be obtained.

6. 2) $[Co(NH_3)_3(NO_2)_3]Cl_2$ complex exhibits geometrical isomerism (G.I.)

Geometrical isomers = 2 (1 cis + 1 trans)

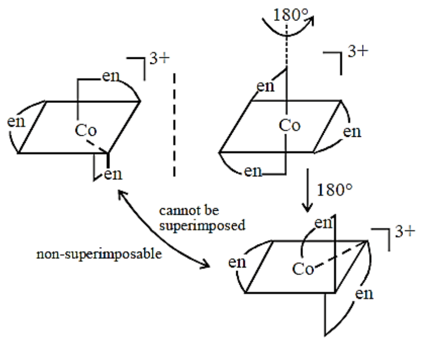
Optical isomers = 0

Space isomers = 2

$[Co(NH_3)_5(NO_2)]Cl_2$ complex shows linkage and ionization isomerism.

7. 1) The compounds of the type $M(AA)_2B_2$ exhibit both geometrical and optical isomerism

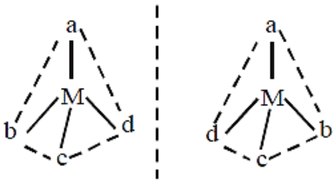
8. (3) Complex is not superimposable on its mirror image hence optically active i.e., rotate plane polarized light.



9. 4)

10. 2)Given compound shows meridional isomerism.

11. (2) Non –superimposable mirror images are optically active, hence rotate plane polarized light.



12. 3) $\left[Cr(SCN)_2(NH_3)_4\right]^+$ shows linkage, geometrical and optical isomerism. Hence produces maximum no. of isomers.

13. 2)

14. 2) Ionisation isomer of $\left[Cr(H_2O)_4Cl(NO_2)\right]Cl$ is $\left[Cr(H_2O)_4Cl_2\right]NO_2$

15. 4)

16. 4) $\left[Ni(NH_3)_2Cl_2\right]$, Ni^{2+} is in sp^3 hybridisation, thus tetrahedral in shape. Hence the four ligands are not different to exhibit optical isomerism. In tetrahedral geometry all the positions are adjacent to one another

$\therefore$ geometrical isomerism also is not possible.

17. (3) Coordination isomerism occurs when cationic and anionic complexes of different metal ions are present in a salt. The two isomers differ in the distribution of ligands in cation and anion e.g.

$\left[Co(NH_3)_6\right]\left[Cr(CN)_6\right]$ is an isomer of $\left[Co(CN)_6\right]\left[Cr(NH_3)_6\right]$

18. 3) Geometrical isomers of following type of square planar complexes is possible. Ma_2b_2 type, Ma_2bc type and Mabcd type.

19. (1) $[PdCl_4]^{2-}$ is dsp^2 hybridized and square planar in shape.

20. (1) $S_2O_3^{2-}$ is a monodentate ligand whereas other ligands are bidentate.

21. (3) Similarity between optical and geometrical isomerism is that both are included in stereo isomerism.

22. (1)

23. 3) Coordination number of Cu^{2+}, Zn^{2+} and Fe^{2+} are 4, 4 and 6 respectively.

i. $[Cu(H_2O)_4]SO_4.H_2O$; ii. $[Zn(H_2O)_4]SO_4.H_2O$; iii. $[Fe(H_2O)_6]SO_4.H_2O$

24. (2) It is a double salt: $FeSO_4.(NH_4)_2SO_4.6H_2O \rightarrow Fe^{2+} + 2SO_4^{2-} + 2NH_4^+$

25. 1)

26. 2)

26. (2) The crystal field splitting in tetrahedral complexes is lower than that in octahedral complexes, and

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

27. (2) The complex formation is a characteristic of *d*-block elements. Lead is a *p*-block element hence does not forms complex compounds.

28. (3) $[Ni(NH_3)_6]Cl_2$ paramagnetic, outer orbital complex, sp^3d^2

$K_3[Fe(CN)_6]$ paramagnetic, inner orbital complex, d^2sp^3

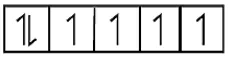
$K_2[PtCl_6]$ diamagnetic, inner orbital complex, d^2sp^3

$[Cr(H_2O)_6]Cl_3$ paramagnetic, inner orbital, d^2sp^3

29. (2)

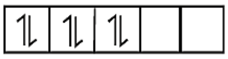
30. (4)

(a) For tetrahedral d^6 ion,



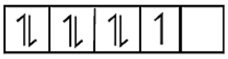
4 unpaired electrons

(b) For $[Co(NH_3)_6]^{3+}$,



0 unpaired electrons

(c) For square planar d^7 ion,



1 unpaired electrons

(d) B.M. = $\sqrt{n(n+2)}$, n = unpaired electrons

5.92 B.M. = $\sqrt{n(n+2)}$

n = 5 unpaired electrons

31. 3) Degenerate d-orbitals undergo splitting under ligand field created by strong, weak or mixed ligands.

32. 1) t_{2g} orbitals have higher energy by $(2/5)\Delta_t$

33. 1) $[Mn(NH_3)_6]Cl_2$

It is a outer orbital complex ; $Mn^{2+}(d^5)$

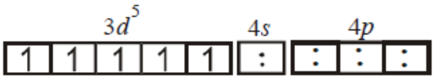
sp^3d^2–hyd.

M.M = $\sqrt{35}$ B.M

34. 3) $[Mn(CN)_6]^{3-}$ and $[Fe(CN)_6]^{3-}$ are inner orbital complexes and paramagnetic while $[Co(C_2O_4)_3]^{3-}$ is diamagnetic in nature

35. 3) Magnetic moment, $\sqrt{n(n+2)} = 5.92$ B.M $\Rightarrow$ n (unpaired electrons) = 5

Mn^{2+} :



sp^3 hybridization (tetrahedral)

36. 3)

Mn^{2+}	Cu^{3+}	Co^{3+}	Co^{2+}
$[Ar]3d^5$	$[Ar]3d^8$	$[Ar]3d^6$	$[Ar]3d^7$
No pairing of e^-	No pairing of e^-	Pairing of e^-	No pairing of e^-

Paramagnetic Paramagnetic Diamagnetic Paramagnetic

37. 2) In $[NiCl_4]^{-2}$ chloride ion, being a weak ligand, is not able to pair the electrons in *d* orbital.

38. 2) CN^- is a strong field ligand as it is a pseudohalide ion. These ions are strong coordinating ligands and hence have the tendency to form σ-bond (from the pseudo halide to the metal) and π-bond (from the metal to pseudo halide)

39. 2) Hydrated $CoCl_2.6H_2O$ is pink coloured and contains octahedral $\left[Co(H_2O)_6\right]^{2+}$ ions. If this is partially dehydrated by heating, then blue coloured tetrahedral ions $\left[Co(H_2O)_4\right]^{2+}$ are formed

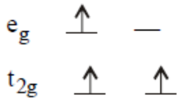
$$\underset{\text{pink}}{[Co(H_2O)_6]^{2+}} \rightleftharpoons \underset{\text{blue}}{[Co(H_2O)_4]^{2+}} + 2H_2O$$

40. 3) Higher the oxidation state of the metal, greater the crystal field splitting energy. In options 1), 2) and 4), Co is present in + 2 oxidation state and in 3) it is present in + 3 oxidation state and hence has a higher value of CFSE.

41. 1)

42. 4)

d^4 in high spin octahedral complex



$CFSE = (-0.4x + 0.6y)\Delta_0$

Where, $x \rightarrow$ electrons in t_{2g} orbital

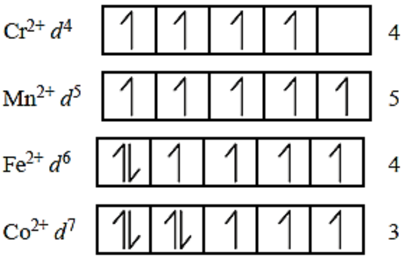
$y \rightarrow$ electrons in e_g orbital

$CFSE = [0.6 \times 1] + [-0.4 \times 3] = -0.6\ \Delta_0$

43. 2) According to spectrochemical series $C_2O_4^{2-} > F^-$

44. 2)

45. 3)



Minimum paramagnetic behaviour = $[Co\ (H_2O)_6]^{2+}$

46. 2)

47. 1) $\left[Ni(NH_3)_6\right]^{2+}$

$Ni^{2+} = 3d^8$, according to CFT = $t_2^6e_g^2$ therefore, hybridisation is sp^3d^2 and complex is paramagnetic.

48. 4)

49. 2) $d^6 : t_{2g}{}^{2,2,2}e_g{}^{0,0}$ (in low spin)

$$C.F.S.E = -0.4 \times 6\Delta_0 + 3P = -\frac{12}{5}\Delta_0 + 3P$$

50. 4) Due to d^5 configuration CFSE is zero

51. 1) $Sc=[Ar]3d^1,4s^2$

Oxidation state of Sc in $[Sc(H_2O)_6]^{3+}$ is Sc^{3+}

$Sc^{3+}=[Ar]3d^0,4s^0$

Thus Sc^{3+} does not have unpaired electron, hence it is diamagnetic and colourless.

52. 4)

$Co(NH_3)_5Cl_3 \rightleftharpoons [Co(NH_3)_5Cl]^{+2}+2Cl^-$

∴ Structure is $[Co(NH_3)_5Cl]Cl_2$.

Now $[Co(NH_3)_5Cl]Cl_2+2AgNO_3 \longrightarrow$

$[Co(NH_3)_5Cl](NO_3)_2+2AgCl$

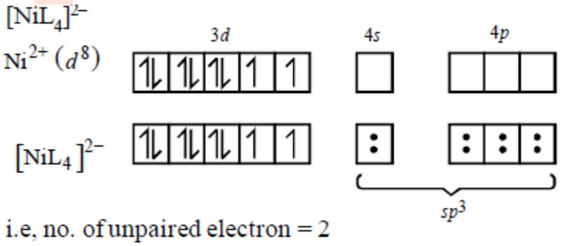
53. 1) EDTA has hexadentate four donor O atoms and 2 donor N atoms and for the formation of octahedral complex one molecule is required

54. 2)

55. 4) $K_2[Ni(EDTA)]$ Since EDTA is hexadentate and chelating and coordinates from six sides forming more stable complex.

56. 1) $[Co(NH_3)_5CO_3]ClO_4$ Six monodentate ligands are attached to Co hence C.N. of Co = 6; O.N. = $x+5\times(0)+1\times(-2)+1\times(-1)=0 \therefore x=+3$; electronic configuration of Co^{3+} $[Ar]3d^6 4s^0$ hence number of d electrons is 6. All *d* electrons are paired due to strong ligand hence unpaired electron is zero.

57. 1)



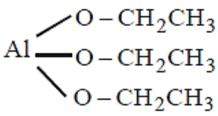
i.e, no. of unpaired electron = 2

hybridization – sp^3.

58. 4)

59. 2) Organometallic compound is 2) as it contains metalcarbon bonds. In others, direct link of carbon with metal is not present

60. 1) Triethoxyaluminium has no Al – C linkage



61. (4) Compounds that contain at least one carbon metal bond are called organometallic compounds. Hence, based on above definition methyl lithium is an organometallic compound. In other chemical compounds, carbon is not linked with metal.

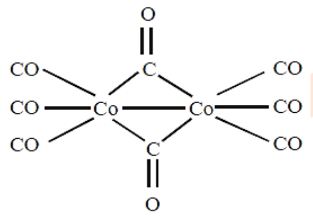
62. (4)

63. (2) Organometallic compounds are those compounds in which a metal is bonded directly to a carbon atom of a molecule. In chlorophyll there is bond between carbon and Mg.

64. (2) Compounds that contain at least one carbon metal bond are known as organometallic compounds. In CH_3-Mg-Br (Grignard's reagent) a bond is present between carbon and Mg (Metal) hence it is an organometallic compound.

65. (1)

66. (1) Structure of $\left[Co_2(CO)_8\right]$



67. (3) The chlorophyll molecule plays an important role in photosynthesis, contain porphyrin ring and the metal Mg not Ca.

68. (4)

69. 1) As positive charge on the central metal atom increases, the less readily the metal can donate electron density into the π^* orbitals of CO ligand (donation of electron density into π^* orbitals of CO result in weakening of C – O bond). Hence, the C – O bond would be strongest in $[Mn(CO)_6]^+$.

70. 1) Grignard's reagent (RMgX) is a σ-bonded organometallic compound.

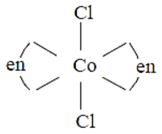
NEET PREVIOUS YEARS QUESTIONS-EXPLANATIONS

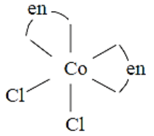
1. 2) $Fe(CO)_5$

EAN = Z – O.N.+2(C.N) = 26-0+2(5) = 26 + 10 = 36

Only one central metal atom/ion is present and it follows EAN rule, so it is mononuclear.

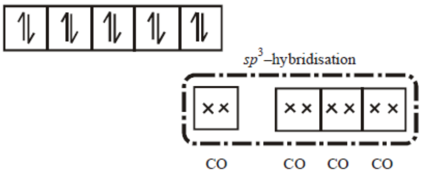
2. 1) In the given complex, the CN of Co is 6, and the complex has octahedral geometry.





3. 2) $Ni(28):[Ar]3d^8 4s^2$

$\because$ CO is a strong field ligand, so unpaired electrons get paired. Hence, configuration would be:



For, four 'CO'ligands hybridisation would be sp^3 and thus the complex would be diamagnetic and of tetrahedral geometry.

4. 1) Grignard's reagent (RMgX) is a s-bonded organometallic compound.

5. 2)

$$\left[Co(NH_3)_6\right]Cl_3 \xrightarrow{AgNO_3} 3\text{mol of AgCl}$$

$$\left[Co(NH_3)_5Cl\right]Cl_2 \xrightarrow{AgNO_3} 2\text{mol of AgCl}$$

$$\left[Co(NH_3)_4Cl_2\right]Cl \xrightarrow{AgNO_3} 1\text{mol of AgCl}$$

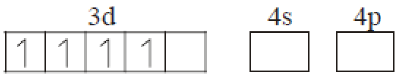
6. 4) The order of the ligand in the spectrochemical series $H_2O < NH_3 <$ en Hence, the wavelength of the light observed will be in the order

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

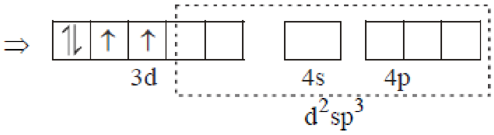
Thus, wavelength absorbed will be in the opposite order

i.e., $[Co(en)_3]^{3+}$, $[Co(NH_3)_6]^{3+}$, $[Co(H_2O)_6]^{3+}$

7. 2) In the complex $\left[Mn(CN)_6\right]^{3-}$, O.S. of Mn is +3 E.C. of $Mn^{+3} \rightarrow 3d^4$

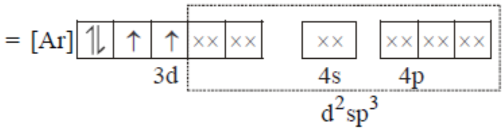


The presence of a strong field ligand CN^- causes pairing of electrons.



As, coordination number of Mn = 6, so it will form an octahedral complex.

$\therefore \left[Mn(CN)_6\right]^{3-}$



8. 3) $\left[Fe(CO)_4\right]^{2-}$ Since metal atom is carrying maximum –ve charge therefore it would show maximum synergic bonding as a resultant C—O bond length would be maximum.

9. $\left[M(en)_2(C_2O_4)\right]Cl$

C_2O_4 = bidentate ligand, carry – 2 charge

en = bidentate ligand, carry 0 charge

$\therefore$ M carry + 3 charge;

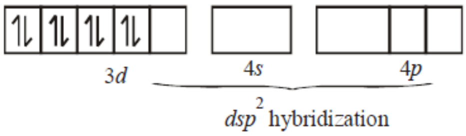
coordination number = 6

$\therefore$ Sum = + 3 + 6 = 9

10. (4) Carbocation Hexacyanidoerrate (III) ion.

11. 1) $Ni^{2+} = [Ar]^{18}\, 4s^0 3d^8$

Valence bond theory can be used to predict shape.

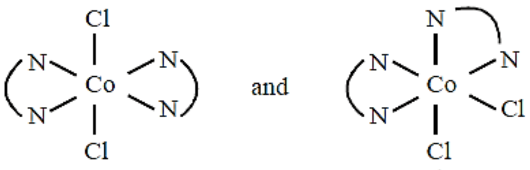


(In presence of ligand, pairing of electron occurs)

$\therefore$ Square planar.

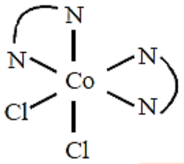
12. 3)

$[Co(en)_2Cl_2]Cl$



trans (I) cis (II)

Mirror image of (II)



13. 4) $CoCl_3.3NH_3$ will not give test for chloride ions with silver nitrate due to absence of ionisable chloride atoms.

$$CoCl_3.3NH_3 \Rightarrow \left[Co\left(NH_3\right)_3 Cl_3\right]$$

$$\left[Co\left(NH_3\right)_3 Cl_3\right] \xrightarrow{AgNO_3} \text{no ppt}$$

14. 4) In $\left[Co\left(CN\right)_6\right]^{-3}$ O.N. of Co is +3

$\therefore Co^{+3} = 3d^6 4s^0$

CN^- is a strong field ligand

$\therefore$ Pairing of electrons occurs so in this complex no unpaired electron is present and it is low spin complex.

15. 2) Due to d^5 configuration CFSE is zero.

16. 2)

17. 2)

In $K_4[Fe(CN)_6]$

$Fe(26) = 3d^6\ 4s^2$

$Fe^{+2} = 3d^6$

in presence of SFL $3d^6 \rightarrow t_{2g}^6 e_g^0$

18. 4)

$$\Delta_{tetrahedral} = \frac{4}{9} \times \Delta_{octahedral}$$

$$= \frac{4}{9} \times 18000$$

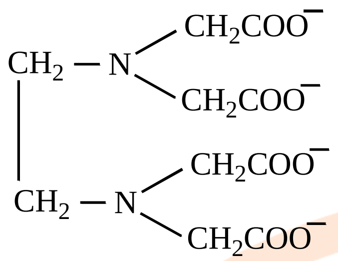
$$= 8000\ cm^{-1}$$

19. 2) sp^3 - tetrahedral, dsp^2 - square planar

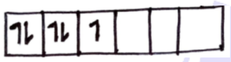
sp^3d - trigonal bipyramidal, d^2sp^3-octahedral

20. 2) According to spectro chemical series . $SCN^- < F^- < C_2O_4^{2-} < CN^-$

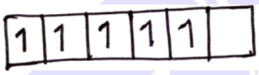
21. 4)



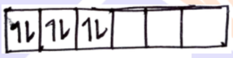
22. 3) $\left[Fe(CN)_6\right]^{3-}$ $Fe^{3+}-d^5$ Sn = 1 $\mu=\sqrt{n(n+2)}=1.73\,BM$



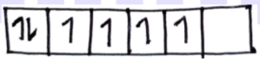
$\left[Fe(H_2O)_6\right]^{3+}$ $Fe^{3+}-d^5$ n = 5 $\mu=\sqrt{n(n+2)}=5.92\,BM$



$\left[Fe(CN)_6\right]^{4-}$ $Fe^{2+}-d^6$ n = 0 $\mu=\sqrt{n(n+2)}=0\,BM$



$\left[Fe(H_2O)_6\right]^{2+}$ $Fe^{2+}-d^6$ n = 4 $\mu=\sqrt{n(n+2)}=4.90\,BM$



23. IUPAC name of cpx $\left[Ag(H_2O)_2\right]\left[Ag(CN)_2\right]$ diaquasilver(1) dicyanidoargentate(1)

24. Energy absorbed by complex is directly proportional to strength of ligand