OPEN STUDENT FOUNDATION
STD:12th Chemistry
Practice Sheet Day -5

Chapters: 5

Section A

- **Choose correct answer from the given options. [Each carries 1 Mark]** **[8]**

1. Ethylene diaminetetraacetate (EDTA) ion is :

(A) Hexadentate ligand with four "O" and two "N" donor atoms

(B) Unidentate ligand

(C) Bidentate ligand with two "N" donor atoms

(D) Tridentate ligand with three "N" donor atoms

2. What is the correct electronic configuration of the central atom in $K_4[Fe(CN)_6]$ based on crystal field theory ?

(A) $t_{2g}^4 e_g^2$ (B) $t_{2g}^6 e_g^0$ (C) $e^3 t_2^3$ (D) $e^4 t_2^2$

3. The correct order of the stoichiometries of AgCl formed when $AgNO_3$ in excess is treated with the complexes : $CoCl_3 \cdot 6NH_3$, $CoCl_3 \cdot 5NH_3$, $CoCl_3 \cdot 4NH_3$ respectively is _________.

(A) 2 AgCl, 3 AgCl, 1 AgCl (B) 1 AgCl, 3 AgCl, 2 AgCl

(C) 3 AgCl, 1 AgCl, 2 AgCl (D) 3 AgCl, 2 AgCl, 1 AgCl

4. The hybridization and magnetic behaviour of cobalt ion in $[Co(NH_3)_6]^{3+}$ complex, respectively is

(A) d^2sp^3 and paramagnetic (B) sp^3d^2 and diamagnetic

(C) sp^3d^2 and paramagnetic (D) d^2sp^3 and diamagnetic

5. Match List-I with List-II :

List-I (Complexes)		List-II (Hybridisation)	
A.	$[Ni(CO)_4]$	I.	sp^3
B.	$[Cu(NH_3)_4]^{2+}$	II.	dsp^2
C.	$[Fe(NH_3)_6]^{2+}$	III.	sp^3d^2
D.	$[Fe(H_2O)_6]^{2+}$	IV.	d^2sp^3

(A) A - II, B - I, C - IV, D - III (B) A - I, B - II, C - IV, D - III

(C) A - I, B - II, C - III, D - IV (D) A - II, B - I, C - III, D - IV

6. Which of the following is correct order of ligand field strength ?

(A) $NH_3 < en < CO < S^{2-} < C_2O_4^{2-}$ (B) $S^{2-} < NH_3 < en < CO < C_2O_4^{2-}$

(C) $S^{2-} < C_2O_4^{2-} < NH_3 < en < CO$ (D) $CO < en < NH_3 < C_2O_4^{2-} < S^{2-}$

7. Which is correct formula of wilkinson calatyst ?

(A) $[Ph_3As)_3RhCl]$ (B) $[(Me_3P)_3RhCl]$ (C) $[(Ph_3P)_3RhCl]$ (D) $[(Me_3As)_3RhCl]$

8. Which one of the following complex ion possess ionisation isomerism ?

(A) $[Pt(NH_3)_4Cl_2]Br_2$ (B) $[Pt{\cdot}Cl_2{\cdot}(en)_2]^{2+}$ (C) $[Cr(C_2O_4)_3]^{3-}$ (D) $[Cr{\cdot}Cl_2{\cdot}(NH_3)_2{\cdot}(en)]^+$

Section B

- **Write the answer of the following questions. [Each carries 2 Marks]** **[8]**

1. What is the Difference between a double salt and a complex

2. What is Chelate ligand ? Explain Chelate Complex.

3. What are isomers ? Explain the types of isomerism.

4. Write down limitation of Crystal field.

Section C

- **Write the answer of the following questions. [Each carries 3 Marks]** **[12]**

5. Using IUPAC norms write the formulas for the following :

(i) Tetrahydroxidozincate(II)
(ii) Potassium tetrachloridopalladate(II)
(iii) Diamminedichloridoplatinum(II)
(iv) Potassium tetracyanidonickelate(II)
(v) Pentaamminenitrito-O-cobalt(III)
(vi) Hexaamminecobalt(III) sulphate
(vii) Potassium tri(oxalato)chromate(III)
(viii) Hexaammineplatinum(IV)
(ix) Tetrabromidocuprate(II)
(x) Pentaamminenitrito-N-cobalt(III)

6. Draw the structures of optical isomers of :

(i) $[Cr(C_2O_4)_3]^{3-}$
(ii) $[PtCl_2(en)_2]^{2+}$
(iii) $[Cr(NH_3)_2Cl_2(en)]^+$

7. Give the oxidation state, d orbital occupation and coordination number of the central metal ion in the following complexes :

(i) $K_3[Co(C_2O_4)_3]$
(ii) cis–$[CrCl_2(en)_2]Cl$
(iii) $(NH_4)_2[CoF_4]$
(iv) $[Mn(H_2O)_6]SO_4$

8. Explain with two examples each of the following : coordination entity, ligand, coordination number, coordination polyhedron, homoleptic and heteroleptic.

Section D

- **Write the answer of the following questions. [Each carries 4 Marks]** **[12]**

9. Write down the IUPAC name for each of the following complexes and indicate the oxidation state electronic configuration and coordination number. Also give stereochemistry and magnetic moment of the complex :

(i) $K[Cr(H_2O)_2(C_2O_4)_2].3H_3O$
(ii) $[Co(NH_3)_5Cl]Cl_2$
(iii) $[CrCl_3(py)_3]$
(iv) $Cs[FeCl_4]$
(v) $K_4[Mn(CN)_6]$

10. Indicate the types of isomerism exhibited by the following complexes and draw the structures for these isomers :

(i) $K[Cr(H_2O)_2(C_2O_4)_2]$
(ii) $[Co(en)_3]Cl_3$
(iii) $[Co(NH_3)_5(NO_2)(NO_3)_2$
(iv) $[Pt(NH_3)(H_2O)Cl_2]$

11. $[Fe(H_2O)_6]^{3+}$ is strongly paramagnetic where as $[Fe(CN)_6]^{3-}$ is weakly paramagnetic. Explain.

OPEN STUDENT FOUNDATION

Chapters: 5

STD:12th Chemistry

Practice Sheet Day -5

Section A

- **Choose correct answer from the given options. [Each carries 1 Mark]** **[8]**

1. Ethylene diaminetetraacetate (EDTA) ion is :

(A) Hexadentate ligand with four “O” and two “N” donor atoms

(B) Unidentate ligand

(C) Bidentate ligand with two “N” donor atoms

(D) Tridentate ligand with three “N” donor atoms

➠ Ans : (A)

2. What is the correct electronic configuration of the central atom in $K_4[Fe(CN)_6]$ based on crystal field theory ?

(A) $t_{2g}^4 e_g^2$ (B) $t_{2g}^6 e_g^0$ (C) $e^3 t_2^3$ (D) $e^4 t_2^2$

➠ Ans : (B)

3. The correct order of the stoichiometries of AgCl formed when $AgNO_3$ in excess is treated with the complexes : $CoCl_3 \cdot 6NH_3$, $CoCl_3 \cdot 5NH_3$, $CoCl_3 \cdot 4NH_3$ respectively is ________.

(A) 2 AgCl, 3 AgCl, 1 AgCl (B) 1 AgCl, 3 AgCl, 2 AgCl

(C) 3 AgCl, 1 AgCl, 2 AgCl (D) 3 AgCl, 2 AgCl, 1 AgCl

Ans. (D)

➪ Complexes are respectively $[Co(NH_3)_6]Cl_3$, $[Co(NH_3)_5Cl]Cl_2$ and $[Co(NH_3)_4Cl_2]Cl$

4. The hybridization and magnetic behaviour of cobalt ion in $[Co(NH_3)_6]^{3+}$ complex, respectively is

(A) d^2sp^3 and paramagnetic (B) sp^3d^2 and diamagnetic

(C) sp^3d^2 and paramagnetic (D) d^2sp^3 and diamagnetic

➠ Ans : (D)

5. Match List-I with List-II :

List-I (Complexes)		List-II (Hybridisation)	
A.	$[Ni(CO)_4]$	I.	sp^3
B.	$[Cu(NH_3)_4]^{2+}$	II.	dsp^2
C.	$[Fe(NH_3)_6]^{2+}$	III.	sp^3d^2
D.	$[Fe(H_2O)_6]^{2+}$	IV.	d^2sp^3

(A) A - II, B - I, C - IV, D - III (B) A - I, B - II, C - IV, D - III

(C) A - I, B - II, C - III, D - IV (D) A - II, B - I, C - III, D - IV

➠ Ans : (B)

6. Which of the following is correct order of ligand field strength ?

(A) $NH_3 < en < CO < S^{2-} < C_2O_4^{2-}$ (B) $S^{2-} < NH_3 < en < CO < C_2O_4^{2-}$

(C) $S^{2-} < C_2O_4^{2-} < NH_3 < en < CO$ (D) $CO < en < NH_3 < C_2O_4^{2-} < S^{2-}$

➠ Ans : (C)

7. Which is correct formula of wilkinson calatyst ?

(A) $[Ph_3As)_3RhCl]$ (B) $[(Me_3P)_3RhCl]$ (C) $[(Ph_3P)_3RhCl]$ (D) $[(Me_3As)_3RhCl]$

➠ Ans : (C)

8. Which one of the following complex ion possess ionisation isomerism ?

(A) $[Pt(NH_3)_4Cl_2]Br_2$ (B) $[Pt \cdot Cl_2 \cdot (en)_2]^{2+}$ (C) $[Cr(C_2O_4)_3]^{3-}$ (D) $[Cr \cdot Cl_2 \cdot (NH_3)_2 \cdot (en)]^+$

➠ Ans : (A)

Section B

● **Write the answer of the following questions. [Each carries 2 Marks]** **[8]**

1. What is the Difference between a double salt and a complex

➪ Both double salts as well as complexes are formed by the combination of two or more stable compounds in stoichiometric ratio.

➪ They differ in the fact that double salts such as carnallite, $KCl. MgCl_2. 6H_2O$, Mohr's salt, $FeSO_4. (NH_4)_2SO_4. 6H_2O$, potash alum, $KAl(SO_4)_2. 12H_2O$, etc. Dissociate into simple ions completely when dissolved in water.

➪ However complex ions such as $[Fe(CN)_6]^{4-}$ of $K_4 [Fe(CN)_6]$ do not dissociate into Fe^{2+} and CN^- ions.

On the basis of the following observations made with aqueous solutions, assign Secondary valences to metals in the following compounds : Example 9.1

Formula	**Moles of AgCl precipitated per mole of the compounds with excess $AgNO_3$**
(i) $PdCl_2.4NH_3$	2
(ii) $NiCl_2.6H_2O$	2
(iii) $PtCl_4.2HCl$	0
(iv) $CoCl_2.4NH_3$	1
(v) $PtCl_2.2NH_3$	0

(i) $[Pd(NH_3)_4]\ Cl_2 \rightarrow [Pd(NH_3)_4]^{2+} + 2Cl$ secondary valences = 4

(ii) $[Ni(H_2O)_6]\ Cl_2 \rightarrow [Ni(H_2O)_6]^{2+} + 2Cl^-$ secondary valences = 6

(iii) $H_2[PtCl_6] \rightarrow 2H^+ + [PtCl_6]^{2-}$ secondary valences = 6

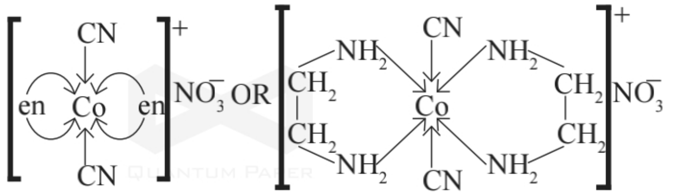
(iv) $[Co(NH_3)_4Cl_2]\ Cl \rightarrow [Co(NH_3)_4Cl_2]^+ + Cl^-$ secondary valences = 6

(v) $[Pt(NH_3)_2Cl_2] \rightarrow$ No Ionization secondary valences = 4

2. What is Chelate ligand ? Explain Chelate Complex.

➪ When multidentate ligands like en, OX^{2-}, pn, ptn, $(EDTA)^{4-}$ form coordinate covalent bond with metal ion, it results into cyclic structure involving central metal ion. Thus, the complex compound formed by ligand and metal ion having cyclic structure is called chelate complex and the ligand is known as chelate ligand.

➪ The stability of such chelate compounds is more than the stability of simple complex compounds



3. What are isomers ? Explain the types of isomerism.

➪ Isomers are two or more compounds that have the same chemical formula but a different arrangement of atoms.

➪ the different arrangement of atoms, they differ in one or more physical or chemical properties.

➪ Two principal types of isomerism are known among coordination compounds.

isomerism

↓

1. Stereoisomerism	**2. Structural isomerism**
(i) Geometrical isomerism	(i) Linkage isomerism
(ii) Optical isomerism	(ii) Coordination isomerism
	(iii) Ionisation isomerism
	(iv) Solvate isomerism

➪ Stereoisomers have the same chemical formula and chemical bonds but they have different spatial arrangement.

➪ Structural isomers have different bonds.

4. Write down limitation of Crystal field.

➪ The Crystal field model is successful in explaining the formation, structures, colour and magnetic properties of coordination compounds to a large extent.

➪ However, from the assumptions that the ligands are point charges, it follows that anionic ligands should exert the greatest splitting effect. The anionic ligands actually are found at the low end of the spectrochemical series.

➪ Further, it does not take into account the covalent character of bonding between the ligand and the central atom. These are some of the weaknesses of CFT,

Section C

● **Write the answer of the following questions. [Each carries 3 Marks]** **[12]**

5. Using IUPAC norms write the formulas for the following :

(i) Tetrahydroxidozincate(II) (ii) Potassium tetrachloridopalladate(II)

(iii) Diamminedichloridoplatinum(II) (iv) Potassium tetracyanidonickelate(II)

(v) Pentaamminenitrito-O-cobalt(III) (vi) Hexaamminecobalt(III) sulphate

(vii) Potassium tri(oxalato)chromate(III) (viii) Hexaammineplatinum(IV)

(ix) Tetrabromidocuprate(II) (x) Pentaamminenitrito-N-cobalt(III)

➪ (i) $[Zn(OH)_4]^{2-}$ (ii) $K_2[PdCl_4]$

(iii) $[Pt(NH_3)_2Cl_2]$ (iv) $K_2[Ni(CN)_4]$

(v) $[Co(NH_3)_5(ONO)]^{2+}$ (vi) $[Co(NH_3)_6]_2(SO_4)_3$

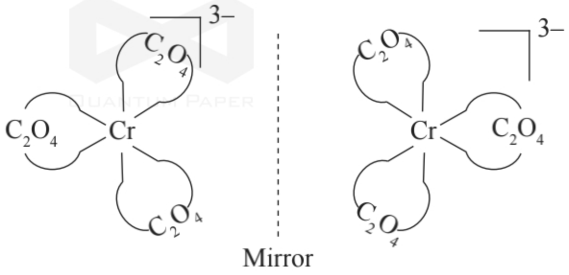
(vii) $K_3[Cr(C_2O_4)_3]$ (viii) $[Pt(NH_3)_6]^{4+}$

(ix) $[CuBr_4]^{2-}$ (x) $[Co(NH_3)_5(NO_2)]^{2+}$

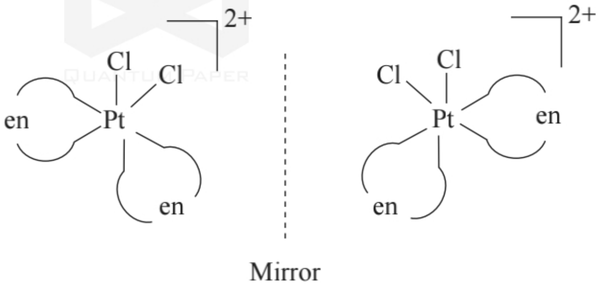
6. Draw the structures of optical isomers of :

(i) $[Cr(C_2O_4)_3]^{3-}$ (ii) $[PtCl_2(en)_2]^{2+}$ (iii) $[Cr(NH_3)_2Cl_2(en)]^+$

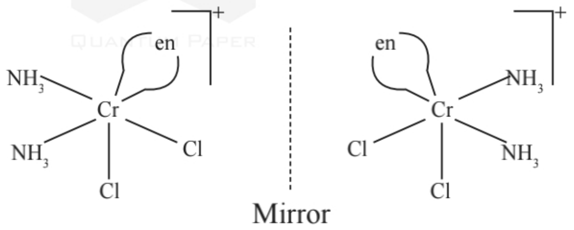
➪ (i) $[Cr(C_2O_4)_3]^{3-}$



➪ (ii) $[PtCl_2(en)_2]^{2+}$



➪ (iii) $[Cr(NH_3)_2Cl_2(en)]^+$



7. Give the oxidation state, d orbital occupation and coordination number of the central metal ion in the following complexes :

(i) $K_3[Co(C_2O_4)_3]$ (iii) $(NH_4)_2[CoF_4]$

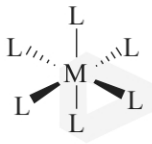
(ii) cis–$[CrCl_2(en)_2]Cl$ (iv) $[Mn(H_2O)_6]SO_4$

➪

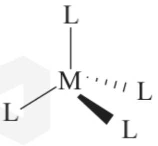
No	Complex	oxidation Number	coordination Number of Metal	Filling of obrital
1.	$K_3[Co(C_2O_4)_3]$	+3	6	$[Ar]\ 3d^6 \rightarrow t_{2g}^6 e_g^0$
2.	cis–$[CrCl_2(en)_2]Cl$	+3	6	$[Ar]\ 3d^3 \rightarrow t_{2g}^3 e_g^0$
3.	$(NH_4)_2[CoF_4]$	+2	4	$[Ar]\ 3d^7 \rightarrow e_g^4 t_{2g}^3$
4.	$[Mn(H_2O)_6]SO_4$	+2	6	$[Ar]\ 3d^5 \rightarrow t_{2g}^3 e_g^2$

8. Explain with two examples each of the following : coordination entity, ligand, coordination number, coordination polyhedron, homoleptic and heteroleptic.

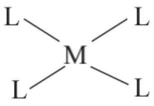
- **(1) Coordination entity :**
  - A coordination entity constitutes a central metal atom or ion bonded to a fixed number of ions or molecules.
  - For example, $[CoCl_3(NH_3)_3]$ is a coordination entity in which the cobalt ion is surrounded by three ammonia molecules and three chloride ions.
  - Other examples are $[Ni(CO)_4]$, $[PtCl_2(NH_3)_2]$, $[Fe(CN)_6]^{4-}$, $[Co(NH_3)_6]^{3+}$
- **(2) Ligand :**
  - The neutral molecules or negatively charged ions that surround the metal atom in a coordination entity or a coordination complex are known as ligands. For example, $\dot{N}H_3$, $H_2\dot{O}$, Cl^-, ^-OH. Ligands are usually polar in nature and possess at least one unshared pair of valence electrons.
- **(3) Co-ordination Number :**
  - The coordination number (CN) of a metal ion in a complex can be defined as the number of ligand donor atoms to which the metal is directly bonded.
  - For example, in the complex ions, $[PtCl_6]^{2-}$ and $[Ni(NH_3)_4]^{2+}$, the coordination number of Pt and Ni are 6 and 4 respectively.
  - Similarly, in the complex ions, $[Fe(C_2O_4)_3]^{3-}$ and $[Co(en)_3]^{3+}$, the coordination number of both. Fe and Co, is 6 because $C_2O_4^{2-}$ and en (ethane - 1, 2 - diamine) are didentate ligands.
- **(4) Coordination Polyhedron :**
  - Coordination polyhedrons about the central atom can be defined as the spatial arrangement of the ligands that are directly attached to the central metal ion in the coordination sphere.
  - The most common coordination polyhedra are octahedral, square planar and tetrahedral.
  - For example, $[Co(NH_3)_6]^{3+}$ is octahedral, $[Ni(CO)_4]$ is tetrahedral and $[PtCl_4]^{2-}$ is square planar.



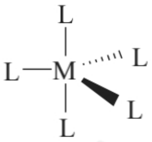
Octahedral



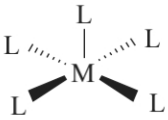
Tetrahedral



Square Planar



Trigonal bipyramidal



Square pyramidal

- **(5) Homoleptic and heteroleptic complexes :**
  - Complexes in which a metal is bound to only one kind of donor groups are known as homoleptic.

    e.g. : $[Co(NH_3)_6]^{3+}$
  - Complexes in which a metal is bound to more than one kind of donor groups are known as heteroleptic.

    e.g. : $[Co(NH_3)_4\ Cl_2]^+$

Section D

- **Write the answer of the following questions. [Each carries 4 Marks]** **[12]**

9. Write down the IUPAC name for each of the following complexes and indicate the oxidation state electronic configuration and coordination number. Also give stereochemistry and magnetic moment of the complex :

(i) $K[Cr\ (H_2O)_2(C_2O_4)_2].3H_3O$ (ii) $[Co(NH_3)_5Cl]Cl_2$

(iii) $[CrCl_3(py)_3]$ (iv) $Cs[FeCl_4]$

(v) $K_4[Mn(CN)_6]$

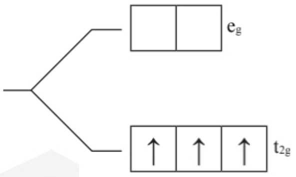
➪ (i) $K[Cr(H_2O)_2(C_2O_4)_2].3H_2O$

➠ IUPAC Name : Potassium diaquadioxalatochromate (III) trihydrate.

➠ Oxidation state of chromium = 3

➠ Electronic configuration :

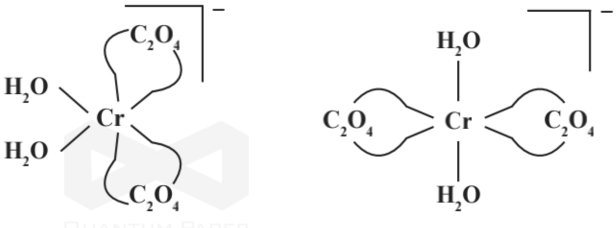
$3d^3 : t_{2g}^3\ e_g^0$



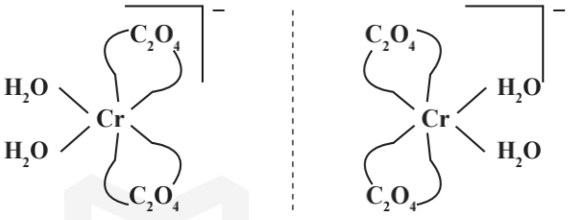
➠ Coordination number = 6

➠ Shape : octahedral

➠ Stereochemistry :



cis **Trans**



dextro **Mirror** **laevo**

➠ Magnetic Moment $\mu = \sqrt{n(n+2)}$

$= \sqrt{3(3+2)}$

$= \sqrt{15}$

$= 3.87$ B.M.

➪ (ii) $[Co(NH_3)_5Cl\_]Cl_2$

➠ IUPAC Name : Pentaamminechloridocobalt(III) chloride

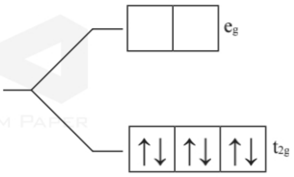
➠ Oxidation state of Co = 3

➠ Coordination number = 6

➠ Shape : octahedral

- Electronic configuration :

d^6 : $t_{2g}6$ e_g^0

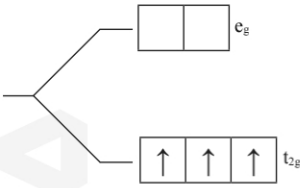


- Stereochemistry : Do not show stereoisomerism.
- Magnetic Moment (μ) = 0 BM.

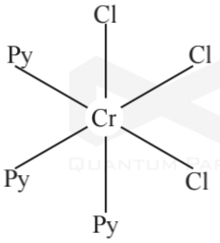
(iii) $[CrCl_3(py)_3]$

- IUPAC Name : Trichloridotripyridinechromium(III)
- Oxidation state of Chromium = +3
- Electronic configuration for :

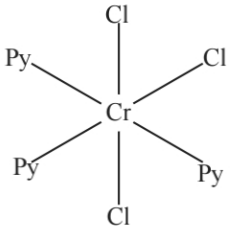
d^3 : $t_{2g}3$ e_g^0



- Coordination number = 6
- Shape : octahedral
- Stereochemistry :



Facial isomer



Meriodional isomer

Both isomer are optically active. Therefore, a total of 4 isomers exist.

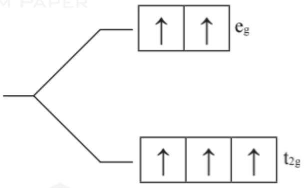
- Mugnetic Moment $\mu = \sqrt{n(n+2)}$

$$= \sqrt{3(3+2)}$$
$$= \sqrt{15}$$
$$= 3.87 \text{ B.M.}$$

(iv) $Cs[FeCl_4]$

- IUPAC Name : Caesium tetrachloroferrate(III)
- Oxidation state of Fe = +3
- Electronic configuration for :

d^6 : t_{2g}^3 eg^2



- Coordination number = 4
- Shape : tetrahedral
- Stereochemistry : optically inactive

➠ Magnetic Moment Number of Upaired electrons

$$\mu = \sqrt{n(n+2)}$$
$$= \sqrt{5(5+2)}$$
$$= \sqrt{35}$$
$$= 5.91 \text{ B.M.}$$

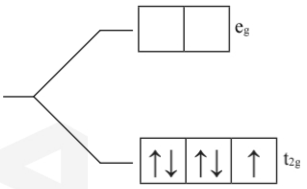
➪ (v) $K_4[Mn(CN)_6]$

➠ IUPAC Name : Potassium hexacyanomanganate(II)

➠ Oxidation state of manganese = +2

➠ Electronic configuration :

d^5 : $t_{2g}5$ $e_g{}^0$



➠ Coordination number = 6

➠ Shape : octahedral

➠ Stereochemistry : optically inactive

➠ Mugnetic Moment $\mu = \sqrt{n(n+2)}$

$$= \sqrt{1(1+2)}$$
$$= \sqrt{3}$$
$$= 1.732 \text{ B.M.}$$

10. Indicate the types of isomerism exhibited by the following complexes and draw the structures for these isomers :

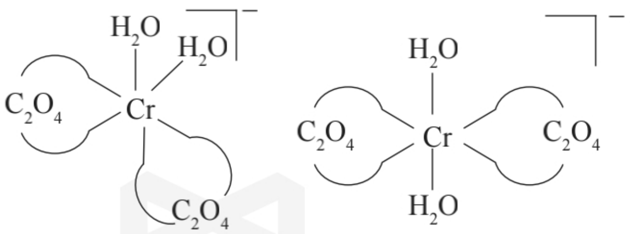
(i) $K[Cr(H_2O)_2(C_2O_4)_2]$ (ii) $[Co(en)_3]Cl_3$

(iii) $[Co(NH_3)_5(NO_2)\ (NO_3)_2$ (iv) $[Pt\ (NH_3)(H_2O)Cl_2]$

➪ **Solution :**

(i) $K[Cr(H_2O)_2(C_2O_4)_2]$

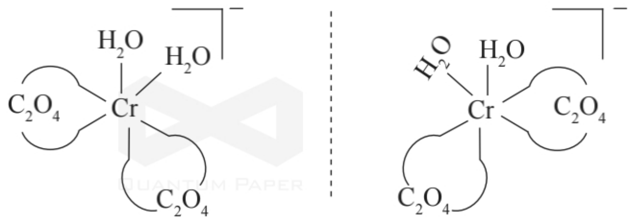
➪ Both geometrical (cis–, trans–) and optical isomers for cis can exist.



cis trans

Geometrical isomers

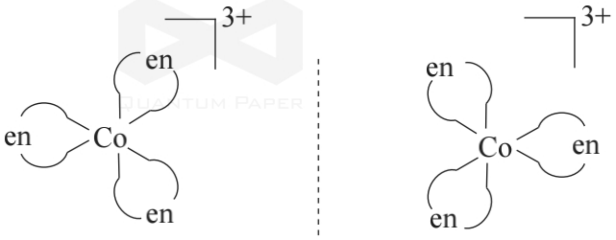
➪ Trans-isomer is optically inactive. On the other hand, cis-isomer is optically active.



dextro mirror laevo

(ii) $[Co(en)_3]Cl_3$

➪ Two optical isomers can exist.



dextro mirror laevo

(iii) $[Co(NH_3)_5(NO_2)](NO_3)_2$

➪ It Show Linkage and ionization isomerism.

(1) Linkage isomerism.

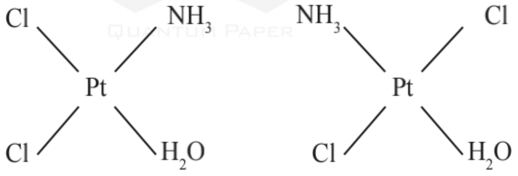
$[CO(NH_3)_5(NO_2)]\ (NO_3)_2$ and $[CO(NH_3)_5(ONO)](NO_3)_2$

(2) Ionization isomerism.

$[Co(NH_3)_5(NO_2)]\ (NO_3)_2$ and $[CO(NH_3)_5(NO_3)](NO_3)(NO_2)$

(iv) $[Pt(NH_3)(H_2O)Cl_2]$

➪ Geometrical (cis–, trans–) isomers can exist.

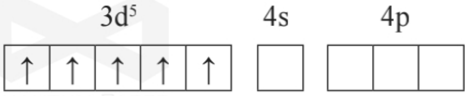


cis trans

11. $[Fe(H_2O)_6]^{3+}$ is strongly paramagnetic where as $[Fe(CN)_6]^{3-}$ is weakly paramagnetic. Explain.

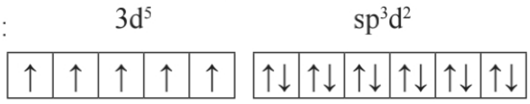
➪ In $[Fe(H_2O)_6]^{3+}$ oxidation state of Fe is +3 and Electronic configuration of Fe^{3+} ion.

Fe^{3+} : [Ar]



➪ In $[Fe(H_2O)_6]^{3+}$ H_2O is a weak field ligand. Therefore, it cannot cause the pairing of electrons. This means that the number of unpaired electrions. is 5.

$[Fe(H_2O)]^{3+}$:



Six pairs of electrons
form six H_2O molecules

Therefore,

$\mu = \sqrt{n(n+2)}$ Where n = No, of unpaired electron = 5

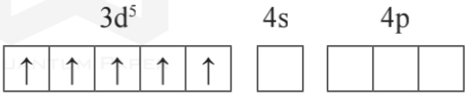
$= \sqrt{5(5+2)}$

$= \sqrt{35}$

$\simeq$ 6BM

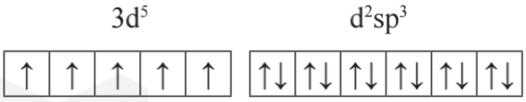
- In $[Fe(CN)_6]^{3-}$ oxidation state of Fe is +3 and Electronic configuration of Fe^{3+} ion.

Fe^{3+} : [Ar]



- On the other hand, CN^- is a strong field ligand, it causes the pairing of unpaired electrons. Therefore, there is only one unpaired electron left in the d-orbital.

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



Six pairs of electrons
fron six CN^- ion.

Therefore,

$\mu = \sqrt{n(n+2)}$ Where n = No, of unpaired electrone. = 1

$= \sqrt{1(1+2)}$

$= \sqrt{3}$

$= 1.732$ BM

- Thus, it is evident that $[Fe(H_2O)_6]^{3+}$ is strongly paramagnetic whereas $[Fe(CN)_6]^{3-}$ is weak paramagnetic.