

CHAPTER 5

Coordination Compounds

VEDA
ACADEMY

CLASS 12TH

NCERT EXERCISE AND SOLUTIONS - CHEMISTRY

Q. 1. Explain the bonding in coordination compounds in terms of Werner's postulates.

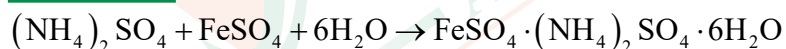
ANSWER:-

Werner's postulates describe the bonding in coordination compounds as follows:

- A metal has two types of valencies: primary and secondary valencies. The primary valencies are fulfilled by negative ions, while the secondary valencies are satisfied by both negative and neutral ions. (In modern terms, the primary valency corresponds to the metal's oxidation state, and the secondary valency corresponds to the coordination number.)
- A metal ion has a specific number of secondary valencies around it. These valencies are directed in particular spatial orientations, determining the geometry of the coordination compound.
- Primary valencies are typically ionizable, while secondary valencies are non-ionizable.

Q. 2. FeSO_4 solution mixed with $(\text{NH}_4)_2\text{SO}_4$ solution in 1:1 molar ratio gives the test of Fe^{2+} ion but CuSO_4 solution mixed with aqueous ammonia in 1:4 molar ratio does not give the test of Cu^{2+} ion. Explain why?

ANSWER:-



Mohr's salt



tetraamminocopper (II) sulphate

Both compounds i.e. $\text{FeSO}_4 \cdot (\text{NH}_4)_2\text{SO}_4 \cdot 6\text{H}_2\text{O}$ & $[\text{Cu}(\text{NH}_3)_4]\text{SO}_4 \cdot 5\text{H}_2\text{O}$ are classified as addition compounds, with one key difference: the former is a double salt, while the latter is a coordination compound. A double salt is an addition compound that remains stable in the solid state but dissociates into its constituent ions when dissolved. These compounds display the distinct properties of their individual components. For e.g., $\text{FeSO}_4 \cdot (\text{NH}_4)_2\text{SO}_4 \cdot 6\text{H}_2\text{O}$ breaks into Fe^{2+} , NH_4^+ & SO_4^{2-} ions. Hence, it gives a positive test for Fe^{2+} ions.

A coordination compound is an addition compound that maintains its identity both in the solid state and when dissolved. However, the individual properties of its components are lost because $[\text{Cu}(\text{NH}_3)_4]\text{SO}_4 \cdot 5\text{H}_2\text{O}$ does not show the test for Cu^{2+} . The ions present in the $[\text{Cu}(\text{NH}_3)_4]\text{SO}_4 \cdot 5\text{H}_2\text{O}$ are $[\text{Cu}(\text{NH}_3)_4]^{2+}$ & SO_4^{2-} .

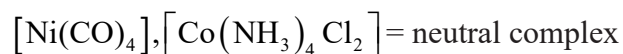
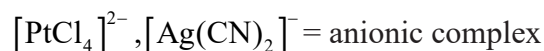
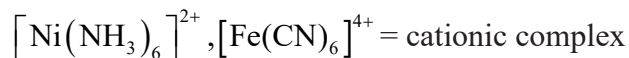


Q. 3. Explain with two examples each of the following: coordination entity, ligand, coordination number, coordination polyhedron, homoleptic and heteroleptic.

ANSWER:-

Coordination entity

A coordination entity is a charged species or radical that carries either a positive or negative charge. In this entity, the central atom or ion is surrounded by a specific number of neutral molecules or negatively charged ions, known as ligands.



Ligand

The neutral molecules or negatively charged ions that surround the metal atom in a coordination entity or complex are referred to as ligands.

E.g. $\text{NH}_3, \text{H}_2\text{O}, \text{Cl}^-, -\text{OH}$. Ligands are typically polar and contain at least one lone pair of valence electrons.

Coordination number:

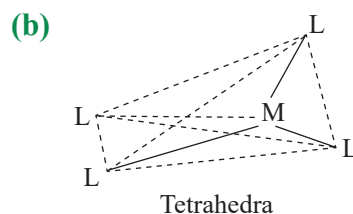
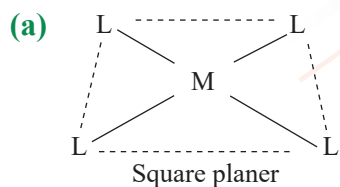
The coordination number of the central metal atom in a coordination entity refers to the total number of ligands (whether neutral molecules or negative ions) that are attached to it within the coordination sphere. This is also known as the metal atom's ligancy.

For example

- (a) In the complex $\text{K}_2[\text{PtCl}_6]$, six chloride ions are bonded to the platinum atom in the coordination sphere, giving Pt a coordination number of 6.
- (b) Similarly, in the complex $[\text{Ni}(\text{NH}_3)_4]\text{Cl}_2$, the coordination number of the central nickel atom (Ni) is 4.

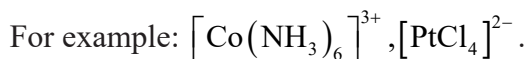
Coordination polyhedron:

Coordination polyhedra around the central atom refer to the three-dimensional arrangement of the ligands directly bonded to the central metal ion within the coordination sphere. For example:



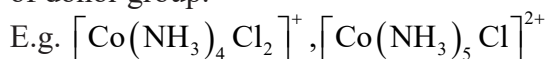
Homoleptic complexes:

These are complexes in which the metal ion is bonded to only one type of donor group.



Heteroleptic complexes:

Heteroleptic complexes are those in which the central metal ion is coordinated to more than one type of donor group.



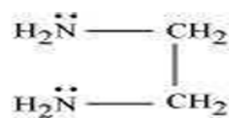
Q. 4. What is meant by unidentate, didentate and ambidentate ligands? Give two examples for each.

ANSWER:-

Unidentate ligands: Ligands that have only one donor site are referred to as unidentate ligands. E.g. NH_3 , Cl^- etc

Didentate Ligands: Ligands that have two donor sites are called didentate ligands. For e.g.,

(a) Ethane – 1, 2- diamine



(b) Oxalate ion

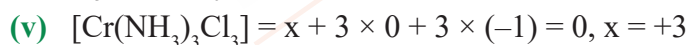
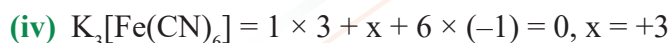
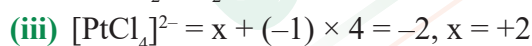
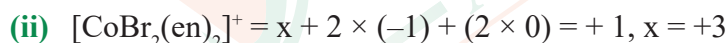
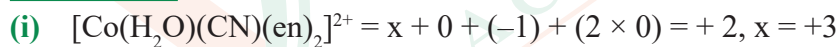


Ambidentate ligands: Ligands that can bind to the central metal atom through two different atoms are known as ambidentate ligands. For example: NO_2^- , SCN^- ions.

Q. 05. Specify the oxidation numbers of the metals in the following coordination entities:



ANSWER:-



Q. 6. Using IUPAC norms write the formulas for the following:

(i) Tetrahydrozincate(II)

(ii) Potassium tetrachloridopalladate(II)

(iii) Diamminedichloridoplatinum(II)

(iv) Potassium tetracyanonicklate (II)

(v) Pentaamminenitrito-O-cobalt(III)

(vi) Hexaaminecobalt(III) sulphate

(vii) Potassium trioxalatochromate(III)



- (viii) Hexaammineplatinum (IV)
 (ix) Tetrabromidocuprate (II)
 (x) Pentaamminenitrito-N-cobalt (III).

ANSWER:-

- | | | |
|--|---|--|
| (i) $[\text{Zn}(\text{OH})_4]^{2-}$ | (ii) $\text{K}_2[\text{PdCl}_4]$ | (iii) $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$ |
| (iv) $\text{K}_2[\text{Ni}(\text{CN})_4]$ | (v) $[\text{Co}(\text{NH}_3)_5\text{ONO}]^{2+}$ | (vi) $[\text{Co}(\text{NH}_3)_6]_2(\text{SO}_4)_3$ |
| (vii) $\text{K}_3[\text{Cr}(\text{Ox})_3]$ | (viii) $[\text{Pt}(\text{NH}_3)_6]^{4+}$ | (ix) $[\text{Cu}(\text{Br})_4]^{2-}$ |
| (x) $[\text{Co}(\text{NH}_3)_5\text{NO}_2]^{2+}$ | | |

Q. 7. Using IUPAC norms write the systematic names of the following:

- | | |
|--|---|
| (i) $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$, | (ii) $[\text{Pt}(\text{NH}_3)_2\text{Cl}(\text{NH}_2\text{CH}_3)]\text{Cl}$ |
| (iii) $[\text{Ti}(\text{H}_2\text{O})_6]^{3+}$ | (iv) $[\text{Co}(\text{NH}_3)_4\text{Cl}(\text{NO}_2)]\text{Cl}$ |
| (v) $\text{Mn}(\text{H}_2\text{O})_6]^{2+}$ | (vi) $[\text{NiCl}_4]^{2-}$ |
| (vii) $[\text{Ni}(\text{NH}_3)_6]\text{Cl}_2$ | (viii) $[\text{Co}(\text{en})_3]^{3+}$ |
| (ix) $[\text{Ni}(\text{CO})_4]$ | |

ANSWER:-

- (i) Hexaammine cobalt (III) chloride.
 (ii) Diammine chlorido (methylamine) platinum (II) chloride.
 (iii) Hexaaquatitanium (III) ion.
 (iv) Tetraammine chlorido nitrito-N-cobalt (IV) chloride.
 (v) Hexaaquamanganese (II) ion.
 (vi) Tetrachloridonickelate (II) ion.
 (vii) Hexaammine nickel (II) chloride.
 (viii) Tris (ethane -1, 2-diamine) cobalt (III) ion.
 (ix) Tetra carbonyl nickel (0).

Q. 8. List various types of isomerism possible for coordination compounds, giving an example of each.

ANSWER:-

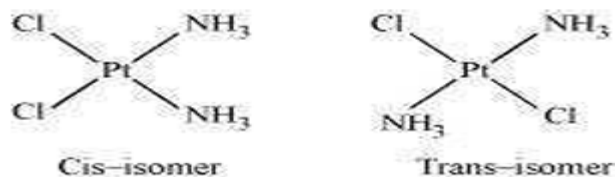
Isomerism in coordination compound is of two types :

- (1) Structural isomerism, (2) Stereo isomerism
 (1) Structural isomerism: It is of 4 types:
 (i) Linkage isomerism $[\text{Co}(\text{NH}_3)_5\text{NO}_2]\text{Cl}_2$ and $[\text{Co}(\text{NH}_3)_5\text{ONO}]\text{Cl}_2$
 (ii) Coordination isomerism $[\text{Co}(\text{NH}_3)_6][\text{Cr}(\text{CN})_6]$ and $[\text{Cr}(\text{NH}_3)_6][\text{Co}(\text{CN})_6]$
 (iii) Ionisation isomerism $[\text{Co}(\text{NH}_3)_5\text{SO}_4]\text{Br}$ and $[\text{Co}(\text{NH}_3)_5\text{Br}]\text{SO}_4$
 (iv) Solvate or hydrate isomerism $[\text{Cr}(\text{H}_2\text{O})_6]\text{Cl}_2$ and $[\text{Cr}(\text{H}_2\text{O})_5\text{Cl}]\text{Cl}\cdot\text{H}_2\text{O}$

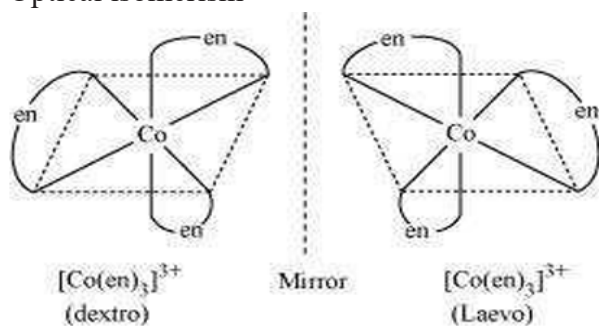


(2) Stereoisomerism: It is of 2 types

(i) Geometrical isomerism



(ii) Optical isomerism

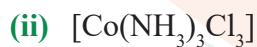
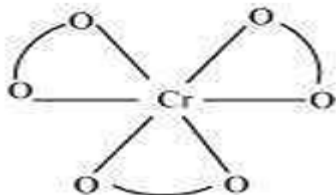


Q. 9. How many geometrical isomers are possible in the following coordination entities?

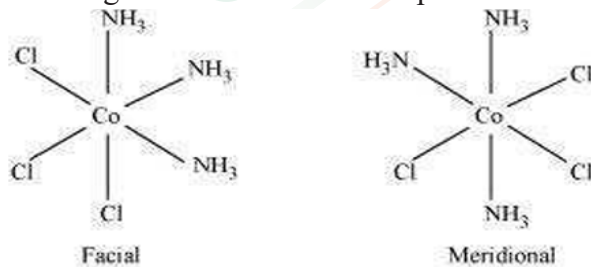


ANSWER:-

(i) For $[\text{Cr}(\text{C}_2\text{O}_4)_3]^{3-}$, no geometric isomer is possible as it is a bidentate ligand.



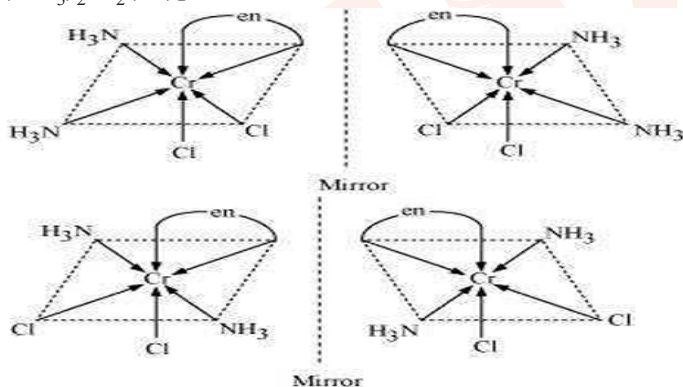
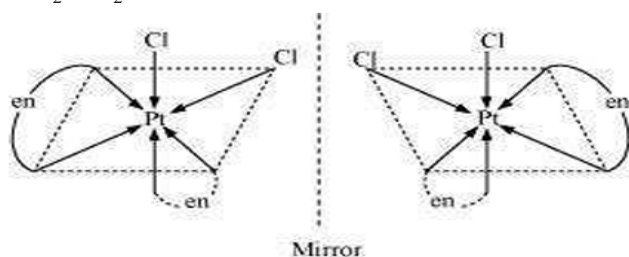
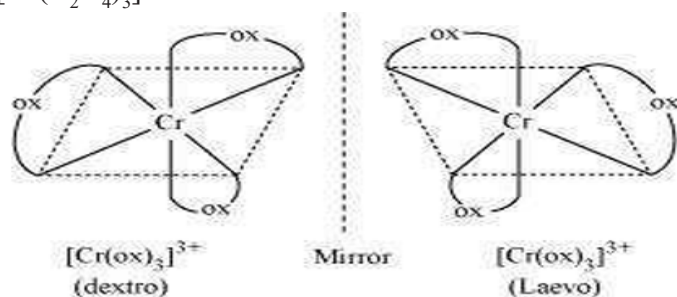
Two geometrical isomers are possible.



Q. 10. Draw the structures of optical isomers of



ANSWER:-

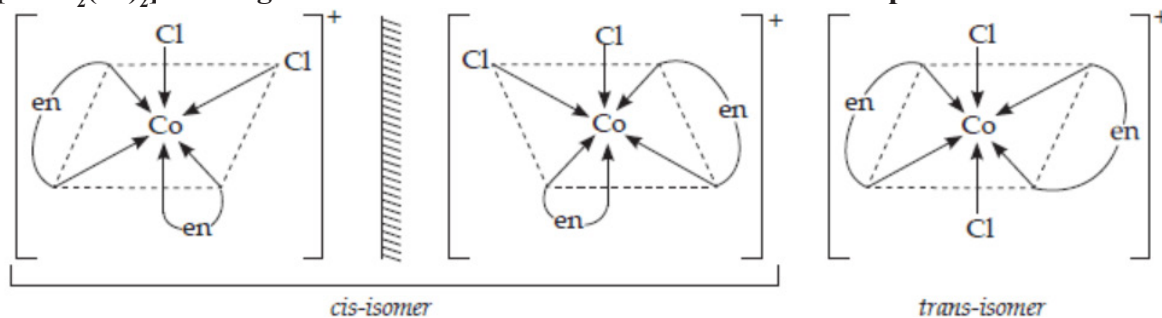


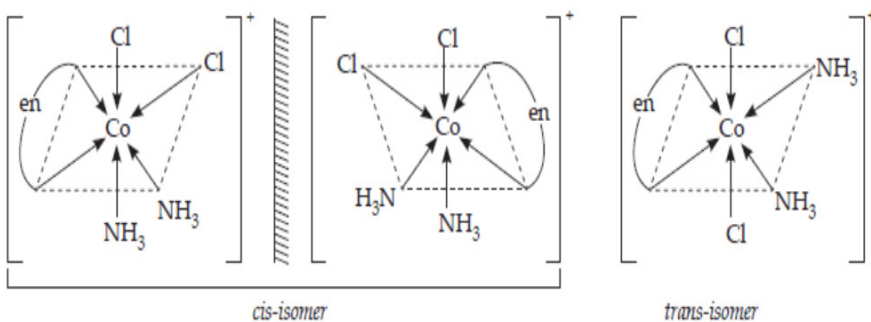
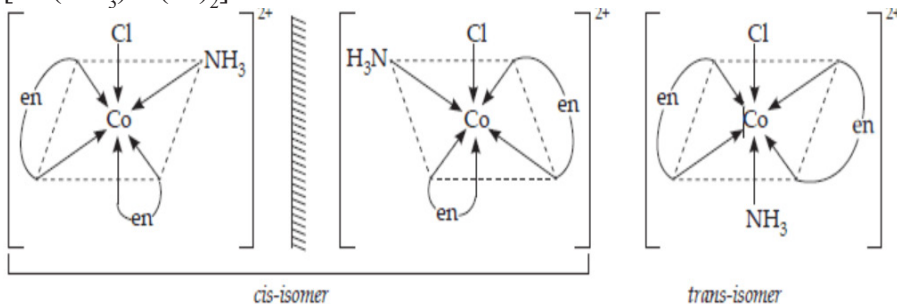
Q. 11. Draw all the isomers (geometrical and optical) of:



ANSWER:-

(i) $[\text{CoCl}_2(\text{en})_2]^+$ has 2 geometrical isomers. Further cis-form shows optical isomerism.

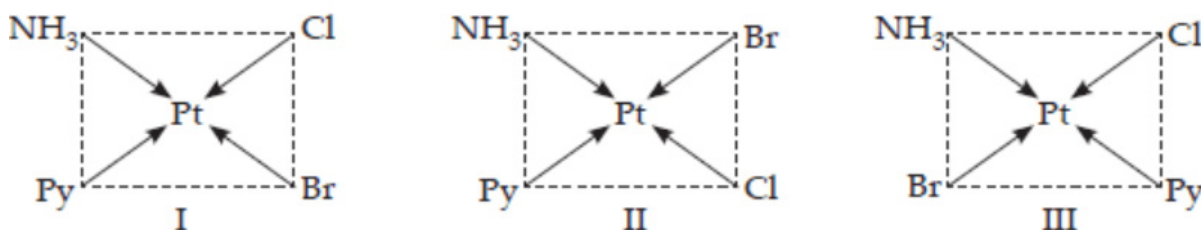




Q. 12. Write all the geometrical isomers of $[\text{Pt}(\text{NH}_3)(\text{Br})(\text{Cl})(\text{py})]$ and how many of these will exhibit optical isomerism?

ANSWER:-

Three geometrical isomers of $[\text{Pt}(\text{NH}_3)(\text{Br})(\text{Cl})(\text{py})]$ are possible



These are formed by keeping the position of one ligand, such as NH_3 , fixed while rotating the positions of the others. These types of isomers do not exhibit optical isomerism. Optical isomerism is rare in square planar or tetrahedral complexes, and even then, it only occurs when the complexes contain unsymmetrical chelating ligands.

Q. 13. Aqueous copper sulphate solution (blue in colour) gives:

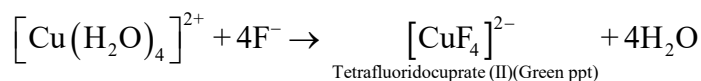
- (i) A green precipitate with aqueous potassium fluoride and
- (ii) A bright green solution with aqueous potassium chloride. Explain these experimental results.

ANSWER:-

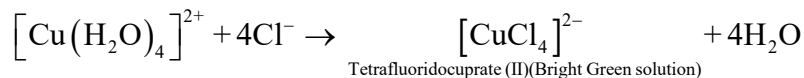
Aqueous CuSO_4 solution exists as $[\text{Cu}(\text{H}_2\text{O})_4]\text{SO}_4$ which has blue colour due to $[\text{Cu}(\text{H}_2\text{O})_4]^{2+}$ ions. When KF is added, the weak H_2O ligands are replaced by F^- ligands forming $[\text{CuF}_4]^{2-}$ ions which is



a green precipitate.



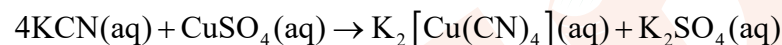
When KCl is added, Cl^- ligands replace the weak H_2O ligands forming $[\text{CuCl}_4]^{2-}$ ion which has bright green colour.



Q. 14. What is the coordination entity formed when excess of aqueous KCN is added to an aqueous solution of copper sulphate? Why is it that no precipitate of copper sulphide is obtained when H_2S (g) is passed through this solution?

ANSWER:-

When an excess of KCN(aq) is added to CuSO_4 (aq), a complex called Potassium tetra cyanocuprate(II) is formed. Since CN^- ions are strong ligands, the complex is highly stable, as demonstrated by its stability constant value ($K = 2.0 \times 10^{27}$). $\text{K}_2[\text{Cu}(\text{CN})_4]$ which does not ionize to give Cu^{2+} ions when added to water. Hence, Cu^{2+} ions are not precipitated when H_2S (g) is passed through the solution.

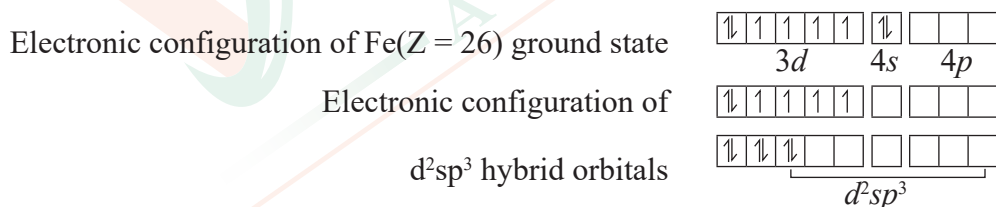


Q. 15. Discuss the nature of bonding in the following coordination entities on the basis of valence bond theory:

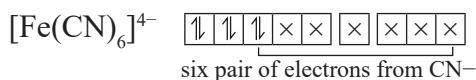
- (i) $[\text{Fe}(\text{CN})_6]^{4-}$ (ii) $[\text{FeF}_6]^{3-}$ (iii) $[\text{Co}(\text{C}_2\text{O}_4)_3]^{3-}$ (iv) $[\text{CoF}_6]^{3-}$

ANSWER:-

- (i) $[\text{Fe}(\text{CN})_6]^{4-}$: In this complex Fe is present as Fe^{2+}

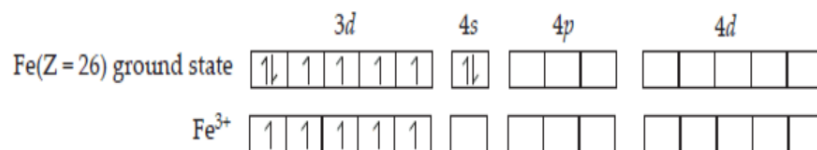


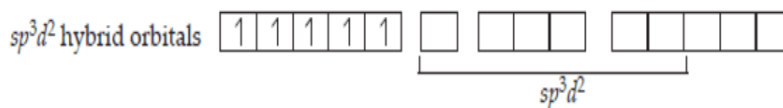
Pairing of electrons occurs due to strong CN^- ligand.



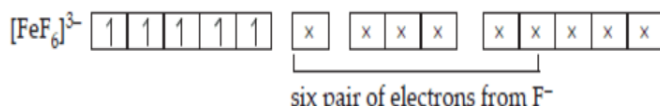
Since, all the electrons are paired, the complex is diamagnetic moreover $(n - 1)$ d-orbitals are involved in bonding, so, it is an inner orbital or low spin complex.

- (ii) $[\text{FeF}_6]^{3-}$: In this complex Fe is present as Fe^{3+}



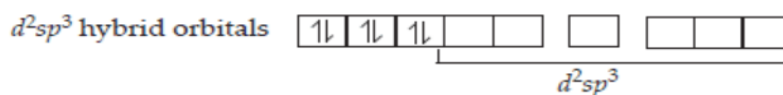
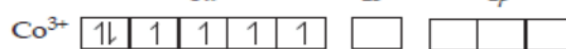
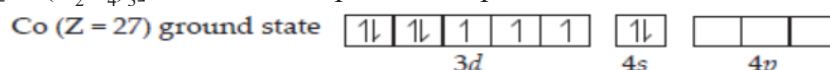


As F^- ions are weak ligands, no pairing of electrons occurs

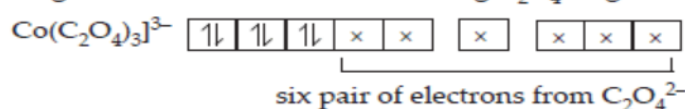


Because of the presence of 4 unpaired electrons, the complex is paramagnetic. Moreover, nd-orbitals are involved in bonding, so it is an outer orbital or high spin complex.

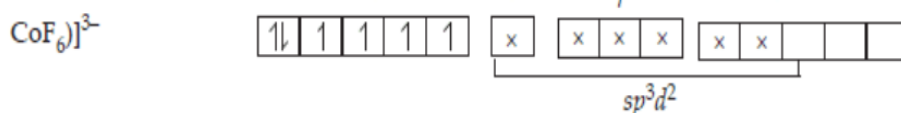
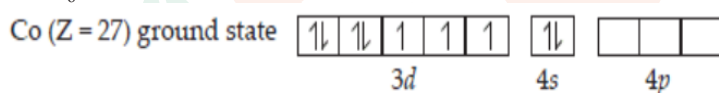
(iii) $[Co(C_2O_4)_3]^{3-}$: In this complex, Co is present as Co^{3+}



Pairing of electrons occurs due to strong $C_2O_4^{2-}$ ligands



(iv) $[CoF_6]^{3-}$ In this complex Co is present as Co^{3+}

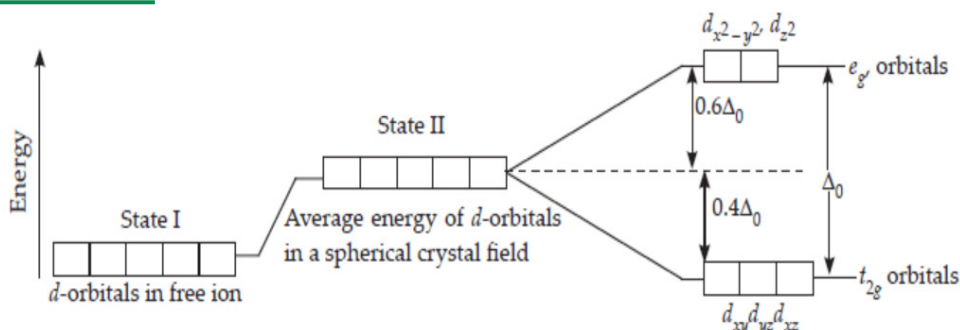


As F^- ions are weak ligands, pairing of electrons does not take place.

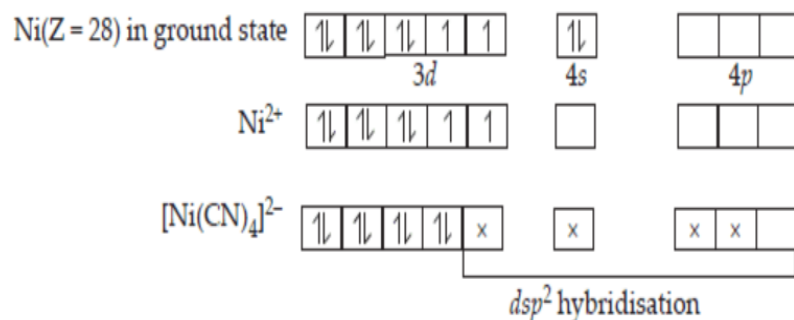
Because of the presence of 4 unpaired electrons, complex is paramagnetic. Since, nd orbitals take part in bonding. It is an outer orbital complex or high spin complex.

Q. 16. Draw figure to show the splitting of d-orbitals in an octahedral crystal field.

ANSWER:-



In $[\text{Ni}(\text{CN})_4]^{2-}$, the Ni present as Ni^{2+}



Pairing of electrons occurs due to strong CN^- ligand.

In $[\text{Cr}(\text{NH}_3)_6]^{3+}$, there are unpaired electrons, making it paramagnetic in nature. In contrast, in $[\text{Ni}(\text{CN})_4]^{2-}$, electron pairing takes place, resulting in a diamagnetic nature.

Q. 20. A solution of $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$ is green but a solution of $[\text{Ni}(\text{CN})_4]^{2-}$ is colourless. Explain.

ANSWER:-

In $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$, Ni is in the +2 oxidation state with a $3d^8$ electronic configuration, which includes two unpaired electrons that do not pair up in the presence of the weak H_2O ligand. As a result, the complex is colored. The d-d transition absorbs red light, and the complementary green light is emitted.

In $[\text{Ni}(\text{CN})_4]^{2-}$, Ni is also in the +2 oxidation state with a $3d^8$ configuration. However, in the presence of the strong CN^- ligand, the two unpaired electrons in the 3d orbitals pair up. As a result, there are no unpaired electrons, and the complex is colorless.

Q. 21. $[\text{Fe}(\text{CN})_6]^{4-}$ and $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$ are of different colours in dilute solutions. Why?

ANSWER:-

In both complexes, Fe is in the +2 oxidation state with a $3d^6$ configuration, which means it has four unpaired electrons. With weak H_2O ligands, the unpaired electrons remain unpaired, whereas with the strong CN^- ligand, the electrons pair up. This difference in the number of unpaired electrons results in the complex ions having different colors.

Q. 22. Discuss the nature of bonding in metal carbonyls.

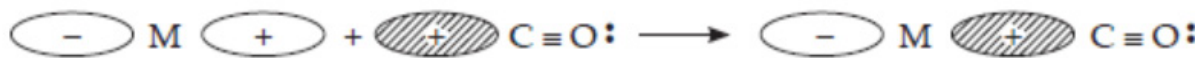
ANSWER:-

In metal carbonyls, the metal-carbon (M–C) bond exhibits both σ and π bond character. The bonding occurs through the overlap of atomic orbitals from the metal and the carbon atom of carbon monoxide in the following sequence:

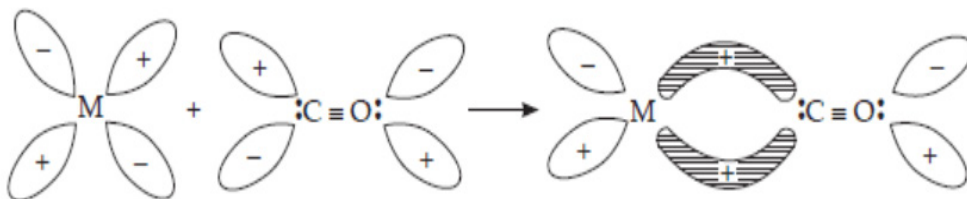
- (a) A σ -bond is initially formed between the metal and carbon, where a vacant d-orbital of the metal overlaps with the lone pair of electrons on the carbon atom of carbon monoxide ($:\text{C}=\text{O}:$).
- (b) In addition to the σ -bond in metal carbonyls, electrons from the filled d-orbitals of the transition metal atom/ion are back-donated into the anti-bonding π -orbitals of carbon monoxide. This



back donation stabilizes the metal-ligand bonding. These two concepts are illustrated in the following figure:



σ -overlap: Donation of lone pair of electrons on carbon into a vacant orbital on the metals.



π -overlap: Donation of electrons from a filled metal d-orbital into a vacant antibonding p-orbital of CO.

Q. 23. Give the oxidation state, d-orbital occupation and coordination number of the central metal ion in the following complexes:



ANSWER:-



The central atom is Co. The oxidation state

$$\Rightarrow 1 \times 3 + x + 3(-2) = 0$$

$$x = +3$$

d orbital occupation $\Rightarrow 3d^6 : t_{2g}^6 e_g^0$

Coordination number $\Rightarrow 3 \times \text{denticity of } \text{C}_2\text{O}_4^-$

$$= 3 \times 2 = 6$$



The central atom is Cr

$$\text{oxidation number} \Rightarrow x + 2 \times 0 + 2(-1) = +1$$

$$x = +3$$

d-orbital occupation $\Rightarrow 3d^3 : t_{2g}^3$

Coordination number = $3 \times \text{denticity of en}$

$$= 3 \times 2 = 6$$



The central atom is Co

$$\text{oxidation number} \Rightarrow 1 \times 2 + x(-1) \times 4 = 0$$

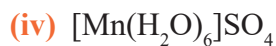
$$x = +2$$



d orbital occupation $\Rightarrow 3d^7 : t_{2g}^5 e_g^2$

N Coordination number = $2 \times \text{denticity}$

$$= 2 \times 2 = 4$$



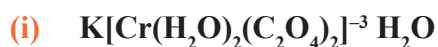
The central atom is Mn

oxidation number $\Rightarrow x + 6 \times 0 + (-2) = +2$

d orbital occupation $\Rightarrow 3d^5 : t_{2g}^3 e_g^2$

Coordination number = $3 \times 2 = 6$

Q. 24. 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:



ANSWER:-



IUPAC name is Potassiumdiaquadioxalatochromate (III) hydrate.

Oxidation state of Cr : $1 \times 1 + x + 2(0) + 2(-2) + 3(0) = 0$

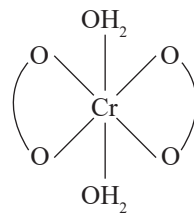
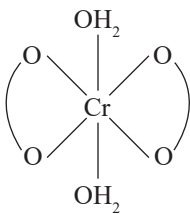
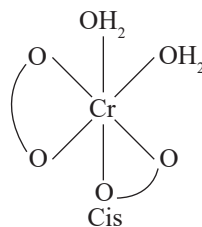
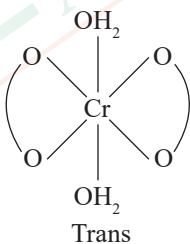
$$x = +3$$

Shape is octahedral

Electronic configuration of $\text{Cr}^{3+} = 3d^3 = t_{2g}^3 e_g^0$.

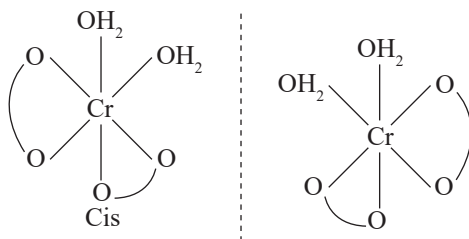
Coordination number = 6

Stereochemistry : cis and trans isomers



Trans is optically inactive





Cis is optically active

Magnetic moment

$$\mu = \sqrt{n(n+2)} = \sqrt{3(3+2)} = 3.87 \text{ BM}$$

(ii) $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$

IUPAC name is Pentaamminechloridocobalt (III) chloride

Coordination number of Co = 6

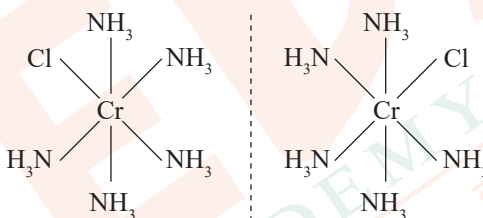
Shape is octahedral

Oxidation state of Co, $x + 5(0) + (-1) + 2(-1) = 0$

$x = +3$

Electronic configuration of $\text{Co}^{3+} = 3d^6 = t_{2g}^6 e_g^0$ $n = 0, \mu = 0$.

Stereochemistry



(iii) $\text{CrCl}_3(\text{Py})_3$. IUPAC name is trichloridotripyridine chromium (III).

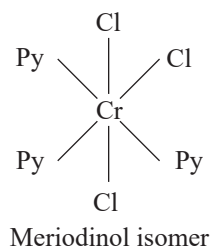
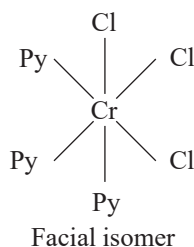
Oxidation state of Cr, $x + (-1) \times 3 + 0 \times 3 = 0$

$x = +3$

Electronic configuration of $\text{Cr}^{3+} = 3d^3 = t_{2g}^3 e_g^0$

Coordination number of Cr = 6

Stereochemistry = face and mer isomers



Magnetic moment

$$\mu = \sqrt{n(n+2)} = \sqrt{3(3+2)} = 3.87 \text{ BM}$$

(iv) $\text{Cs}[\text{FeCl}_4]$

IUPAC name is Cesium tetrachloridoferrate (III)

Oxidation number of Fe, $1 + x + (-1) \times 4 = 0$



$$x = +3$$

Electronic configuration of $\text{Fe}^{3+} = t_{2g}^3 e_g^2$

Coordination number of Fe is 4

Stereochemistry = No stereoisomer

Magnetic moment

$$\mu = \sqrt{n(n+2)} = \sqrt{5(5+2)} = 5.92\text{BM}$$



IUPAC name is Potassium hexacyanomanganate (II)

Oxidation state of Mn is $(+1) \times 4 + x(-1) \times 6 = 0$

$$x = +2$$

Electronic configuration of $\text{Mn}^{2+} = 3d^5 = t_{2g}^5 e_g^0$

Coordination number of Mn = 6

Stereochemistry = No stereoisomers

Magnetic moment

$$\mu = \sqrt{n(n+2)} = \sqrt{1(1+2)} = \sqrt{3} = 1.73\text{BM}$$

Q. 25. Explain the violet colour of the complex $[\text{Ti}(\text{H}_2\text{O})_6]^{3+}$ on the basis of crystal field theory.

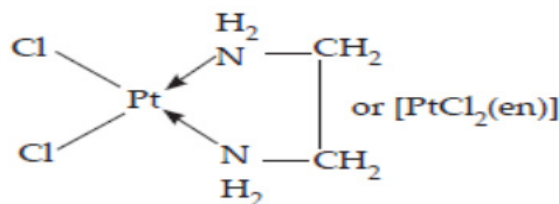
ANSWER:-

In its ground state, Ti has 23 electrons with the electronic configuration $3d^3 4s^2$. The oxidation state of Ti in the given compound is +3, which results in the configuration $3d^2$. Since it has 2 unpaired electrons and the ability to undergo d-d transitions, the complex appears violet in color.

Q. 26. What is meant by the chelate effect? Give an example

ANSWER:-

The chelate effect occurs when a didentate or polydentate ligand has donor atoms arranged in such a way that, upon coordinating with the central metal ion, a five- or six-membered ring is formed. For example,



Q. 27. Discuss briefly giving an example in each case the role of coordination compounds in :

- (i) Biological systems,
- (ii) Analytical chemistry,
- (iii) Medicinal chemistry, and
- (iv) Extraction/Metallurgy of metals.



ANSWER:-

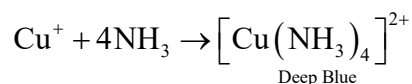
(i) Biological systems

- (a) Hemoglobin, the oxygen-carrying molecule in blood, is a coordination compound of iron.
 (b) Chlorophyll in plants, which is essential for photosynthesis, is a coordination compound of magnesium.
 (c) Vitamin B12, the anti-pernicious anemia factor, is a coordination compound of cobalt.

(ii) Analytical chemistry

(a) Qualitative analysis:

The detection of Cu^{2+} is based on the formation of a blue tetraamine copper(II) ion.



(b) Quantitative analysis:

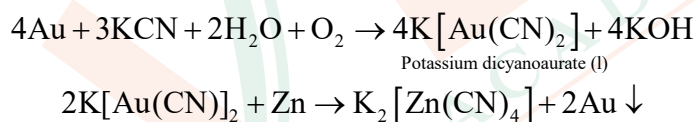
The gravimetric estimation of Ni^{2+} is performed by precipitating Ni^{2+} as a red nickel dimethylglyoxime complex in the presence of ammonia.

(iii) Medicinal chemistry

- (a) Cisplatin, the $[\text{cis}-[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]]$ complex of platinum, is used in cancer treatment.
 (b) The EDTA complex of calcium is utilized in the treatment of lead poisoning.

(iv) Extraction/Metallurgy of metals.

The extraction of various metals from their ores involves the formation of complexes. For example, silver and gold are extracted from their ores by forming cyanide complexes.



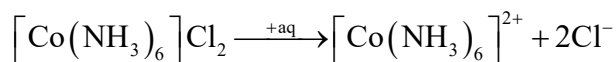
Q. 28. How many ions are produced from the complex $\text{Co}(\text{NH}_3)_6\text{Cl}_2$ in solution?

- (i) 6 (ii) 4 (iii) 3 (iv) 2

ANSWER:-

(i) Coordination number of cobalt = 6

Hence, the complex is $[\text{Co}(\text{NH}_3)_6]\text{Cl}_2$. It ionizes in the solution as follows:



Thus, three ions are produced. Hence, the correct option is (iii).

Q. 29. Amongst the following ions? Which one has the highest magnetic moment value:

- (i) $[\text{Cr}(\text{H}_2\text{O})_6]^{3+}$ (ii) $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$ (iii) $[\text{Zn}(\text{H}_2\text{O})_6]^{2+}$



ANSWER:-

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

Electronic configuration of $\text{Cr}^{3+} = 3d^3$, unpaired electrons = 3 $\Rightarrow \mu = \sqrt{3(3+2)} = 2.83\text{BM}$

Electronic configuration of $\text{Fe}^{2+} = 3d^6$, unpaired electrons = 4 $\Rightarrow \mu = \sqrt{4(4+2)} = 3.16\text{BM}$

Electronic configuration of $\text{Zn}^{2+} = 3d^{10}$, unpaired electrons = 0 $\Rightarrow \mu = \sqrt{0(0+2)} = 0\text{BM}$

Q. 30. The oxidation number of cobalt in $\text{K}[\text{Co}(\text{CO})_4]$ is:

- (i) +1 (ii) +3 (iii) -1 (iv) -3

ANSWER:-

$\text{K}[\text{Co}(\text{CO})_4]$

\therefore Oxidation number $\Rightarrow 1 + x + 4 \times 0 = 0$

$x = -1$

Hence, (iii) is the correct option.

Q. 31. Amongst the following, the most stable complex is:

- (i) $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$ (ii) $[\text{Fe}(\text{NH}_3)_6]^{3+}$ (iii) $[\text{Fe}(\text{C}_2\text{O}_4)_3]^{3-}$ (iv) $[\text{FeCl}_6]^{3-}$

ANSWER:-

In each of the given complexes, Fe is in the +3 oxidation state. Since $\text{C}_2\text{O}_4^{2-}$ is a didentate chelating ligand, it forms chelate rings, making complex (iii) the most stable among those listed.

Q. 32. What will be the correct order for the wavelengths of absorption in the visible region for the following: $[\text{Ni}(\text{NO}_2)_6]^{4+}$, $[\text{Ni}(\text{NH}_3)_6]^{2+}$, $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$?

ANSWER:-

Since the metal ion is fixed, the field strengths of the ligands, reflected by the CFSE values from the spectrochemical series, increase in the order: $\text{H}_2\text{O} < \text{NH}_3 < \text{NO}_2^-$.

Therefore, the energies absorbed for excitation will follow this order:

$[\text{Ni}(\text{H}_2\text{O})_6]^{2+} < [\text{Ni}(\text{NH}_3)_6]^{2+} < [\text{Ni}(\text{NO}_2)_6]^{4+}$.

As $E = \frac{hc}{\lambda}$ the wavelengths absorbed will be in the opposite order.

$[\text{Ni}(\text{H}_2\text{O})_6]^{2+} > [\text{Ni}(\text{NH}_3)_6]^{2+} > [\text{Ni}(\text{NO}_2)_6]^{4+}$.

