

Chapter-9

Coordination Compounds

Class-XII

Subject-Chemistry

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

Answer 9.1

Werner's postulates: -

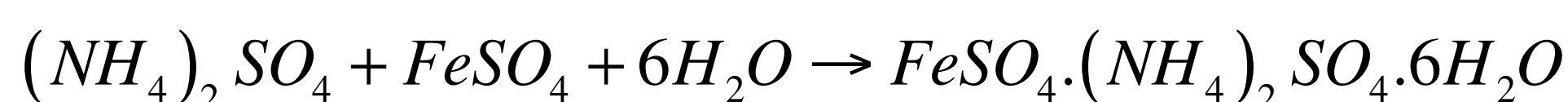
- a) A metal exhibits two types of valencies- primary and secondary. Primary valencies are satisfied by negative ions while secondary valencies are satisfied by both negative and neutral ions.

Primary valency can be calculated by oxidation number of the metal ion, whereas the secondary valency refers to the coordination number of the metal ion.

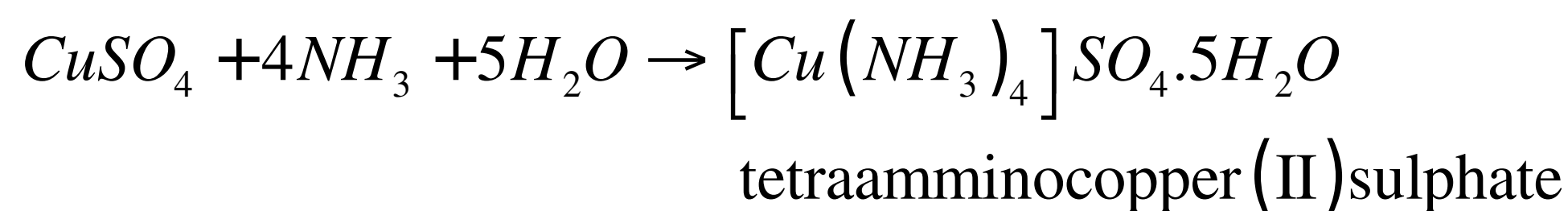
- b) Primary valencies are usually ionizable, while secondary valencies are non-ionizable.
- c) A metal ion has a definite number of secondary valencies around the central atom. This valency assigned the definite geometry of the coordination compound.

9.2 FeSO₄ solution mixed with (NH₄)₂SO₄ solution in 1:1 molar ratio gives the test of Fe²⁺ ion but CuSO₄ solution mixed with aqueous ammonia in 1:4 molar ratio does not give the test of Cu²⁺ ion. Explain why?

Answer 9.2



Mohr's salt



Both of the products are addition compounds in which mohr's salt is a double salt, while $[Cu(NH_3)_4]SO_4 \cdot 5H_2O$ is a coordination compound.

A double salt is stable in the solid state but it breaks into its constituent ions in the dissolved state. For e.g. $FeSO_4 \cdot (NH_4)_2 SO_4 \cdot 6H_2O$ breaks into Fe^{2+} , NH_4^+ , and SO_4^{2-} ions. Thus, it gives a positive test for Fe^{2+} ions.

On the other hand, a coordination compound retains its identity in the solid as well as in the dissolved state. Thus, individual properties of its constituents are lost. In case of $[Cu(NH_3)_4]SO_4 \cdot 5H_2O$, it doesn't break in copper ions & hence, it does not show the test for Cu^{2+} .

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

Answer 9.3

a) Coordination entity:

It is an electrically charged radical or species which carries a positive or negative charge.

In this, the central atom or ion is surrounded by neutral molecules or negative ions which are known as ligands). For example:



b) Ligands:-

These are the neutral molecules or negatively charged ions which surround the metal atom in a coordination entity. For example Cl^- , OH^-

Ligands are usually polar in nature and contain at least one unshared pair of valence electrons.

c) Coordination number:-

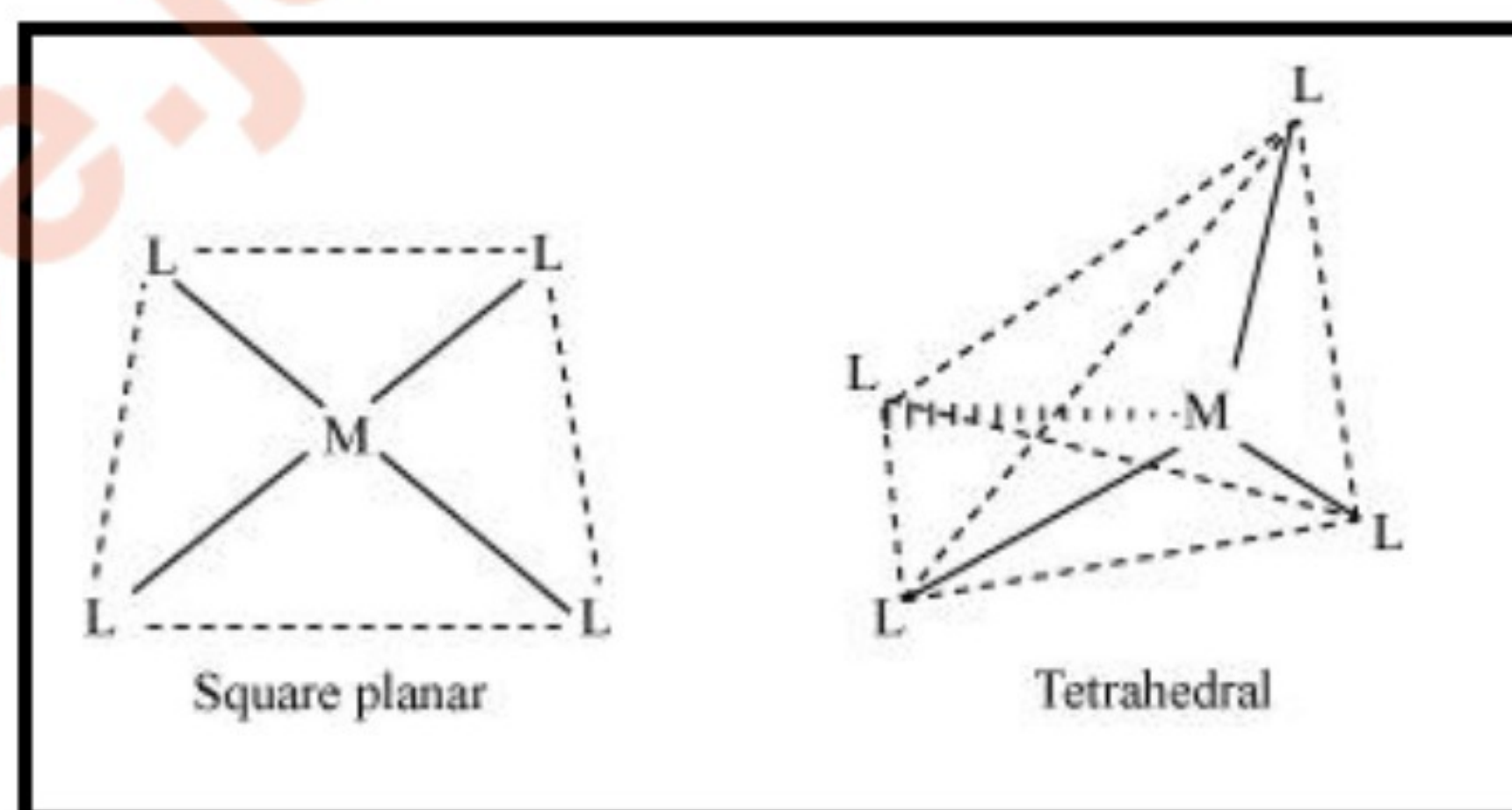
It is the total number of ligands which get attached to the central metal atom in the coordination sphere. For example:

- i. In the complex $[\text{Ni}(\text{NH}_3)_4]\text{Cl}_2$, the coordination number of the central atom (Ni) is 4.

d) Coordination polyhedron:-

It can be defined as the spatial arrangement of the ligands that are directly attached to the central metal ion in the coordination sphere.

For example:



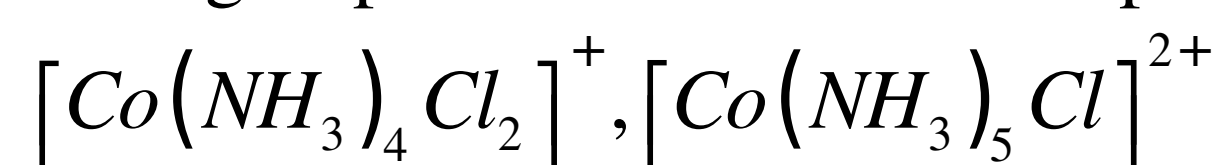
e) Homoleptic complexes:-

Complexes in which the metal ion is bound to only one kind of a donor group are known as homoleptic complexes. For

example: $[Pt(Cl)_4]^{2-}$, $[Co(NH_3)_6]^{3+}$ etc.

f) Heteroleptic complexes: -

Complexes where the central metal ion is bound to more than one type of a donor group are known as heteroleptic complexes. For example-



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

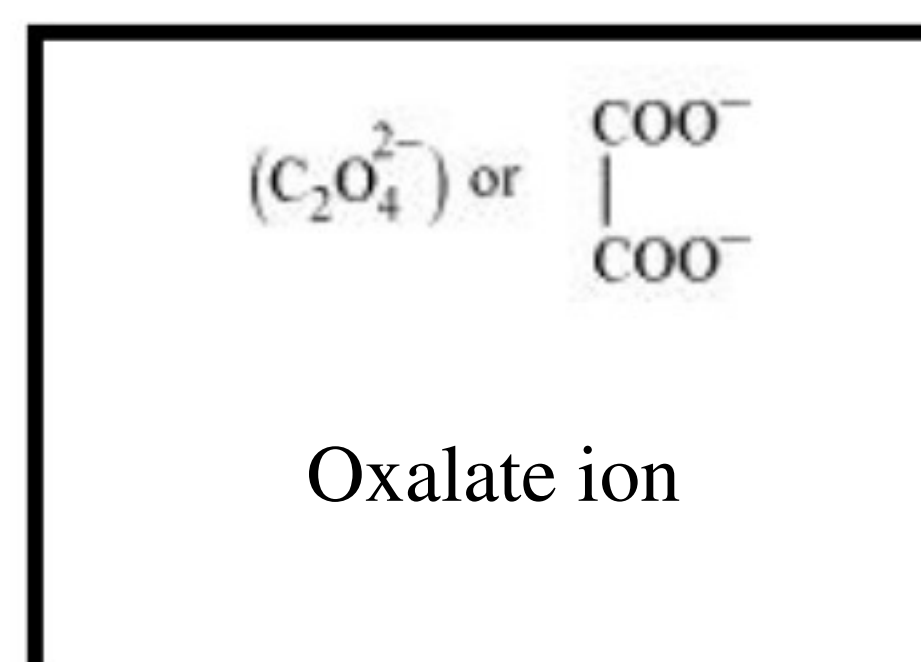
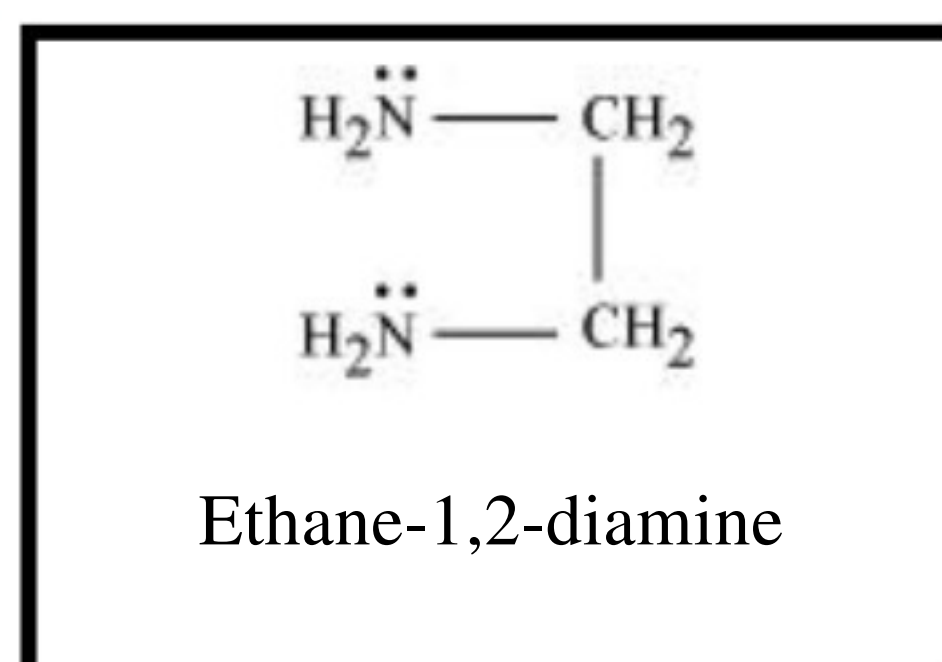
Answer 9.4

a) Unidentate ligands: -

Ligands which contain only one donor sites are known as unidentate ligands. For e.g., Cl^- , NH_3 etc.

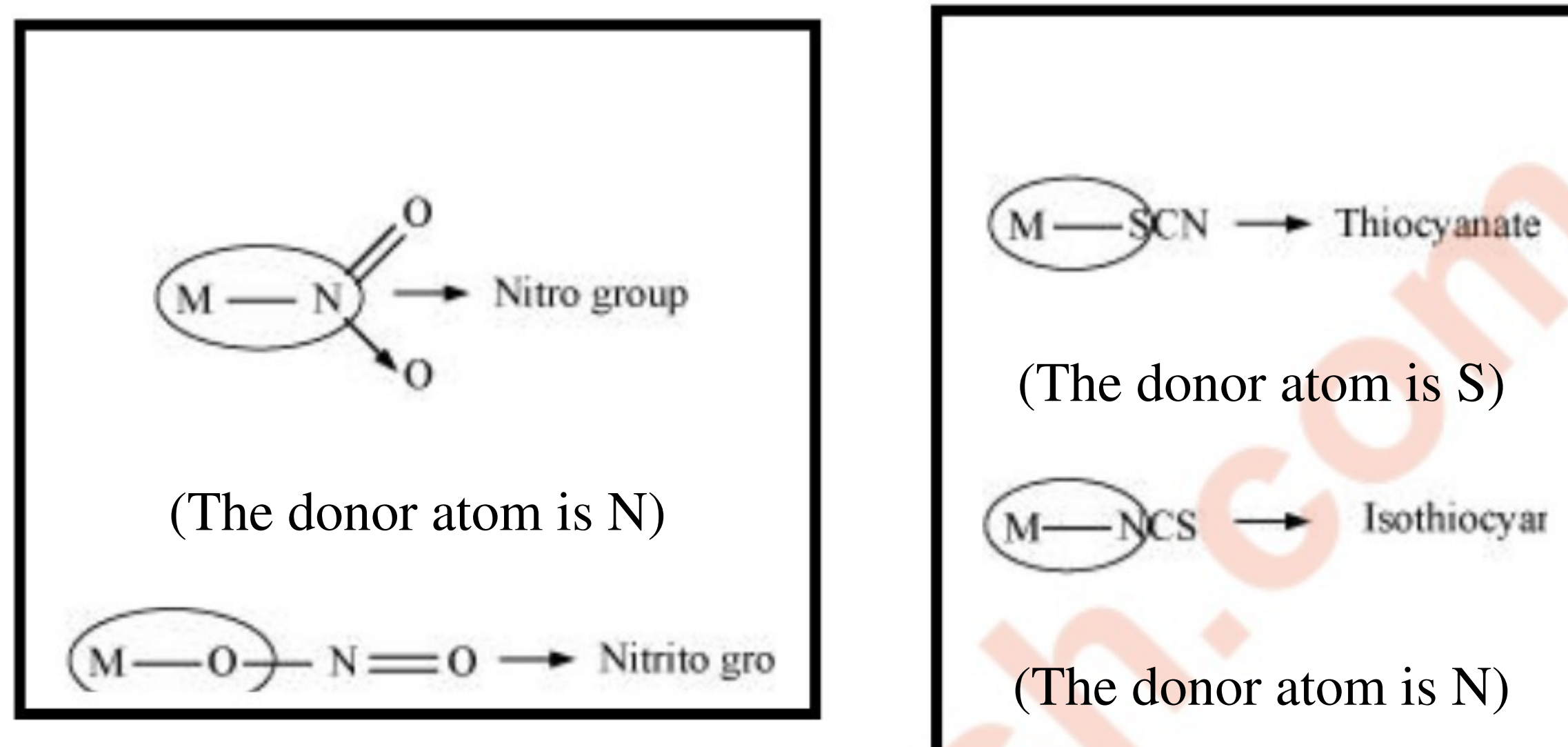
b) Didentate ligands: -

Ligands which contain two donor sites are known as didentate ligands. For example-



c) Ambidentate ligands: -

Ligands that can attack on central metal atom through two different atoms are called ambidentate ligands. For example:



9.5 Specify the oxidation numbers of the metals in the following coordination entities:

- $[\text{Co}(\text{H}_2\text{O})(\text{CN})(\text{en})_2]^{2+}$
- $[\text{CoBr}_2(\text{en})_2]^+$
- $[\text{PtCl}_4]^{2-}$
- $\text{K}_3[\text{Fe}(\text{CN})_6]$
- $[\text{Cr}(\text{NH}_3)_3\text{Cl}_3]$

Answer 9.4

- $[\text{Co}(\text{H}_2\text{O})(\text{CN})(\text{en})_2]^{2+}$

Let the oxidation number of Co = x

$$x + 0 - 1 + 2(0) = +2$$

$$x - 1 = 2$$

$$x = +3$$

- $[\text{PtCl}_4]^{2-}$

Let the oxidation number of Pt = x

$$x + 4(-1) = -2$$

$$x = +2$$



Let the oxidation number of Co = x

$$x + 2(-1) + 2(0) = +1$$

$$x - 2 = 1$$

$$x = +3$$



Let the oxidation number of Fe = x

$$x + 6(-1) = -3$$

$$x = +3$$



Let the oxidation number of Cr = x

$$x + 3(0) + 3(-1) = 0$$

$$x - 3 = 0$$

$$x = +3$$

9.6 Using IUPAC norms write the formulas for the following:

- i. Tetrahydroxozincate(II)
- ii. Potassium tetrachloridopalladate(II)
- iii. Diamminedichloridoplatinum(II)
- iv. Potassium tetracyanonickelate(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)

Answer 9.6

- i. $[\text{Zn}(\text{OH})]^{2-}$
- 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. $[\text{Co}(\text{ONO})(\text{NH}_3)_5]^{2+}$
- vi. $[\text{Co}(\text{NH}_3)_6]_2(\text{SO}_4)_3$
- vii. $\text{K}_3[\text{Cr}(\text{C}_2\text{O}_4)_3]$
- viii. $[\text{Pt}(\text{NH}_3)_6]^{4+}$
- ix. $[\text{Cu}(\text{Br})_4]^{2-}$
- x. $[\text{Co}(\text{NO}_2)(\text{NH}_3)_5]^{2+}$

9.7 Using IUPAC norms write the systematic names of the following:

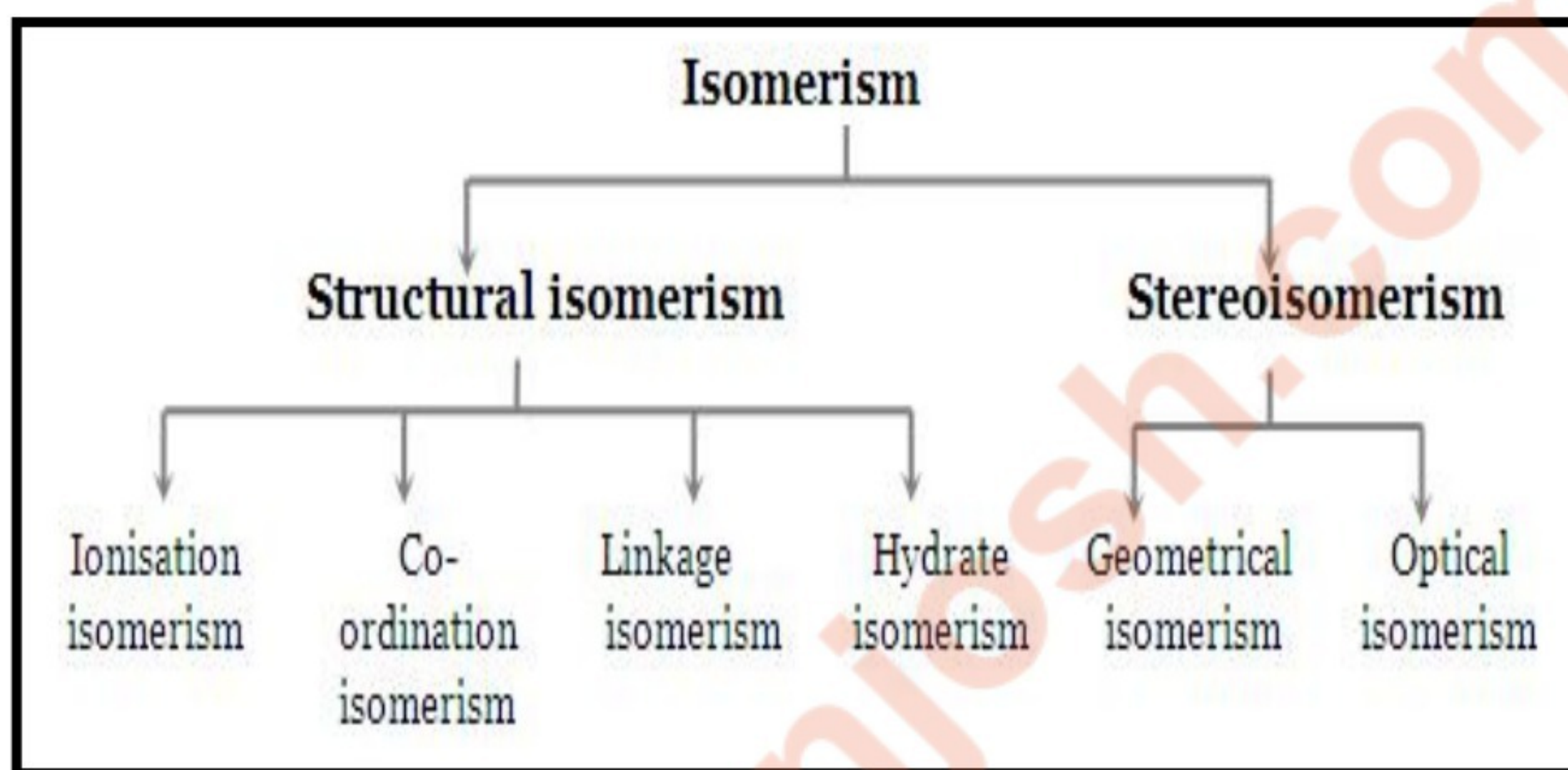
- i. $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$
- ii. $[\text{Pt}(\text{NH}_3)_2\text{Cl}(\text{NH}_2\text{CH}_3)]\text{Cl}$
- iii. $[\text{Ti}(\text{H}_2\text{O})_6]^{3+}$
- iv. $[\text{Co}(\text{NH}_3)_4\text{Cl}(\text{NO}_2)]\text{Cl}$
- v. $[\text{Mn}(\text{H}_2\text{O})_6]^{2+}$
- vi. $[\text{NiCl}_4]^{2-}$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

Answer 9.7

- i. Hexaamminecobalt(III) chloride
- ii. Diamminechlorido(methylamine) platinum(II) chloride
- iii. Hexaqua titanium(III) ion
- iv. Tetraamminichloridonitrito-N-Cobalt(III) chloride
- v. Hexaquamanganese(II) ion
- vi. Tetrachloridonickelate(II) ion
- vii. Hexaamminenickel(II) chloride
- viii. Tris(ethane-1, 2-diammine) cobalt(III) ion
- ix. Tetracarbonylnickel(0)

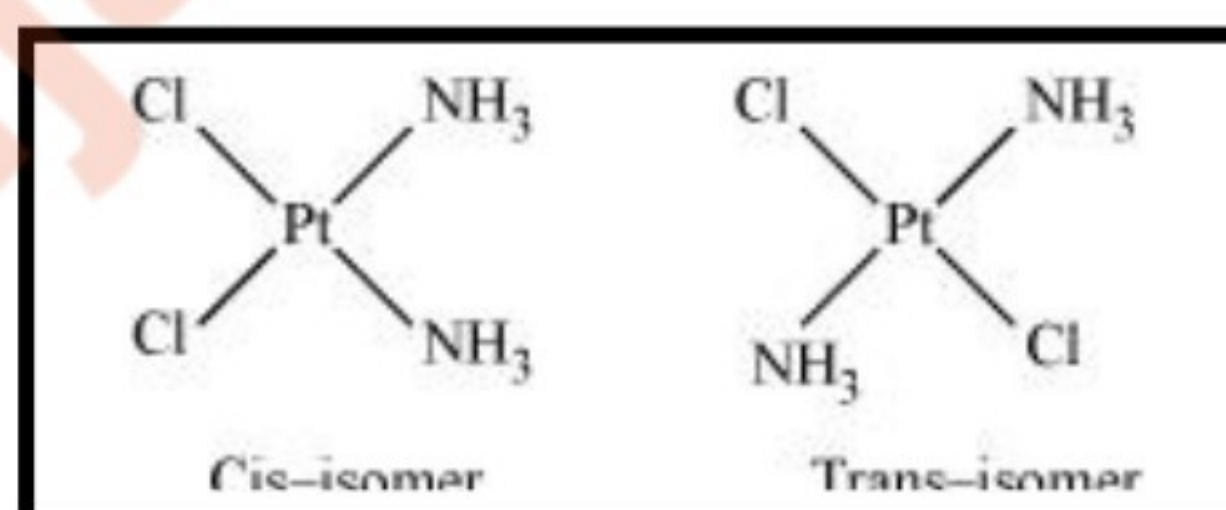
9.8 List various types of isomerism possible for coordination compounds, giving an example of each.

Answer 9.8



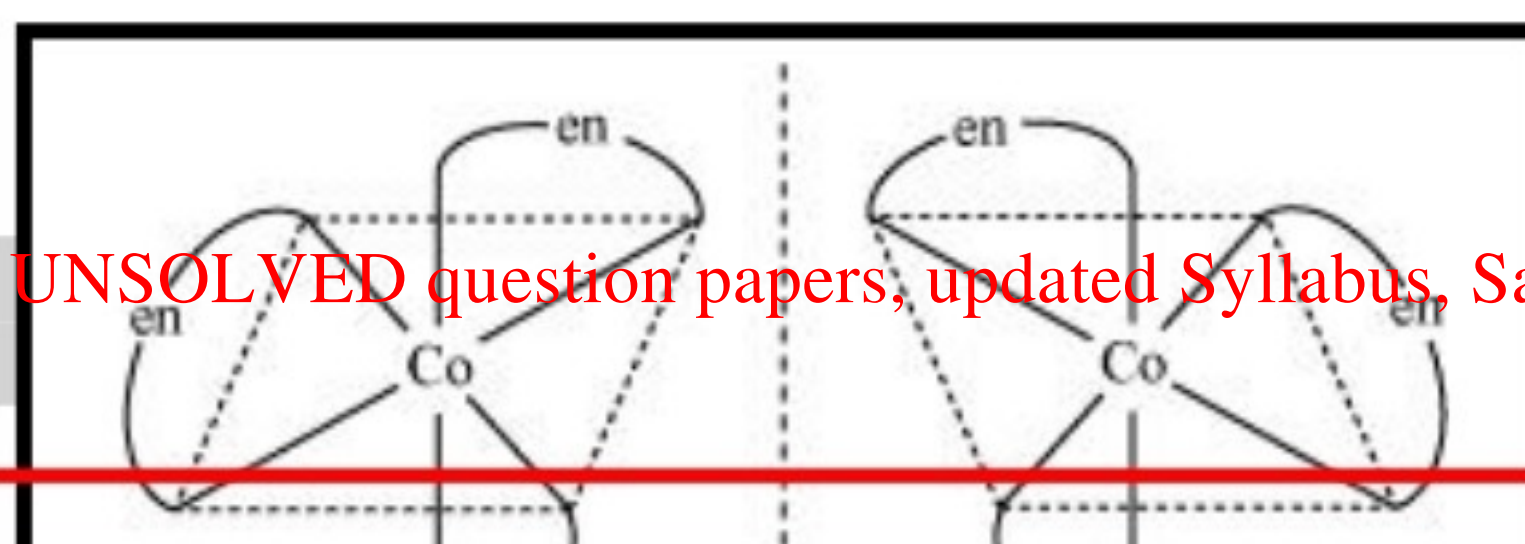
a) Geometric isomerism:

It is common in heteroleptic complexes. It arises due to the different possible geometric arrangements of the ligands. For example:



b) Optical isomerism: -

It arises in chiral molecules. These isomers are mirror images of each other and are non-superimposable.



c) Linkage isomerism: -

It is found in complexes that contain ambidentate ligands. For example:



d) Coordination isomerism: -

It arises when the ligands are interchanged between cationic and anionic entities of different metal ions present in the complex.



e) Ionization isomerism: -

It arises when a counter ion replaces a ligand within the coordination sphere. Thus, complexes that have the same composition, but furnish different ions when dissolved in water are called ionization isomers. For e.g.,
 $\text{Co}(\text{NH}_3)_5\text{SO}_4\text{Br}$ and $\text{Co}(\text{NH}_3)_5\text{Br}] \text{SO}_4$.

f) Solvate isomerism: -

These isomers differ by whether or not the solvent molecule is directly bonded to the metal ion or merely present as a free solvent molecule in the crystal lattice.



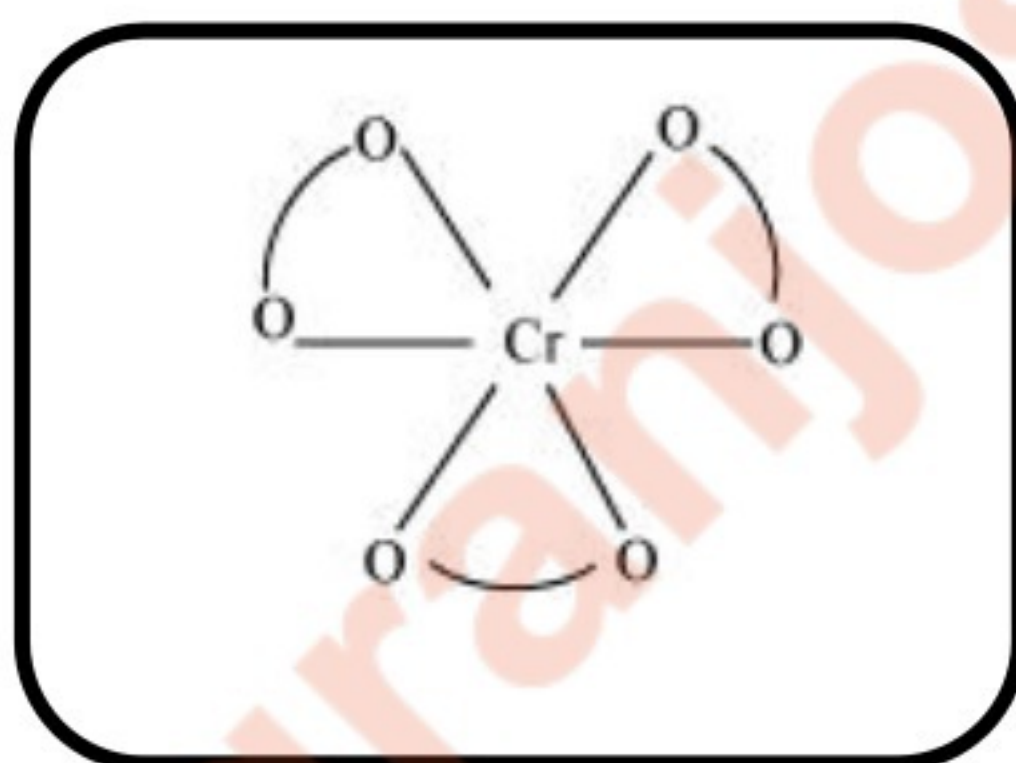
9.9 How many geometrical isomers are possible in the following coordination entities?

- i. $[\text{Cr}(\text{C}_2\text{O}_4)_3]^{3-}$
- ii. $[\text{Co}(\text{NH}_3)_3\text{Cl}_3]$

Answer 9.9

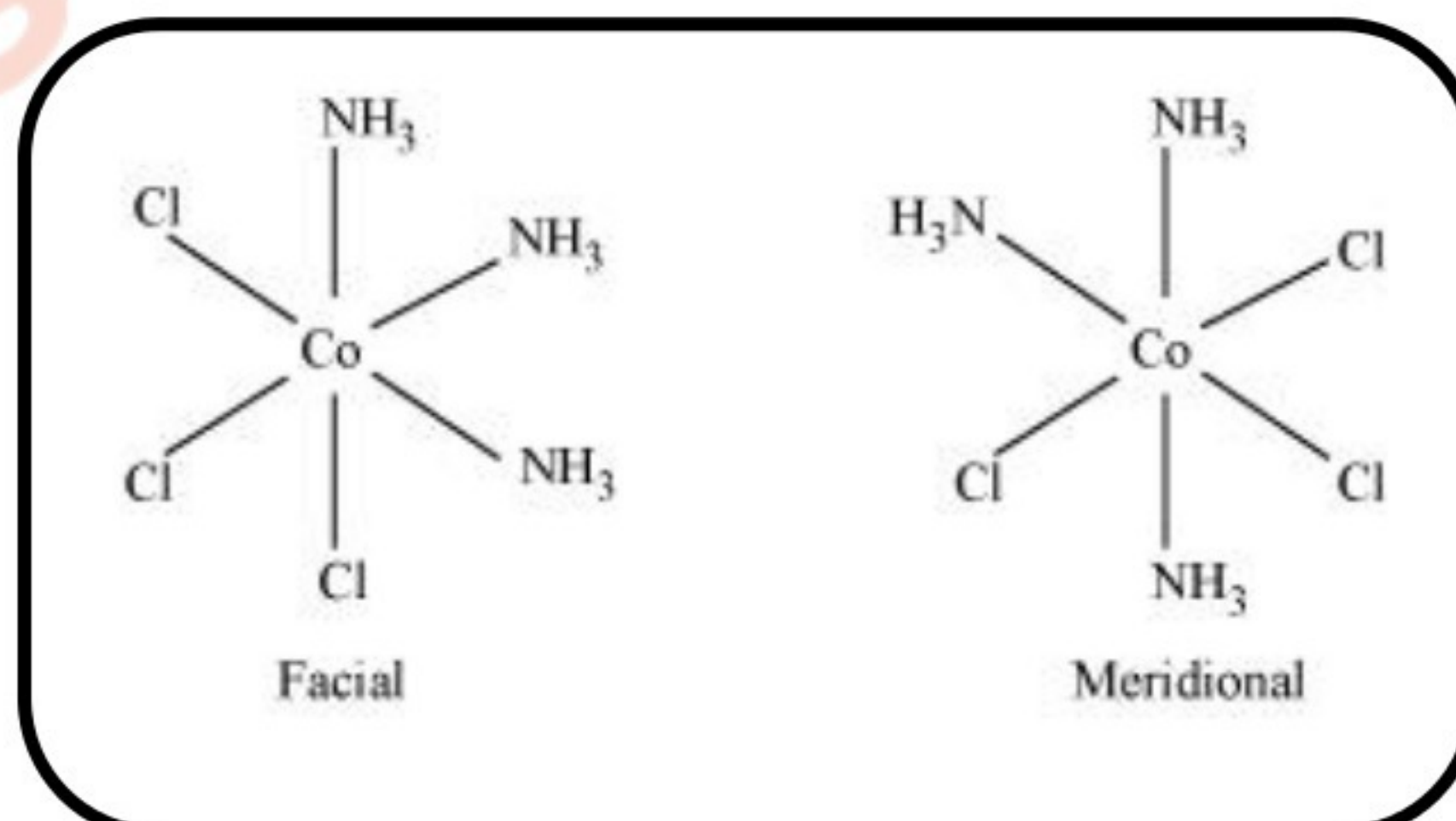
- i. For $[\text{Cr}(\text{C}_2\text{O}_4)_3]^{3-}$

No geometric isomer is possible in this case as it is a bidentate ligand.



- ii. $[\text{Co}(\text{NH}_3)_3\text{Cl}_3]$

Two geometrical isomers are possible here

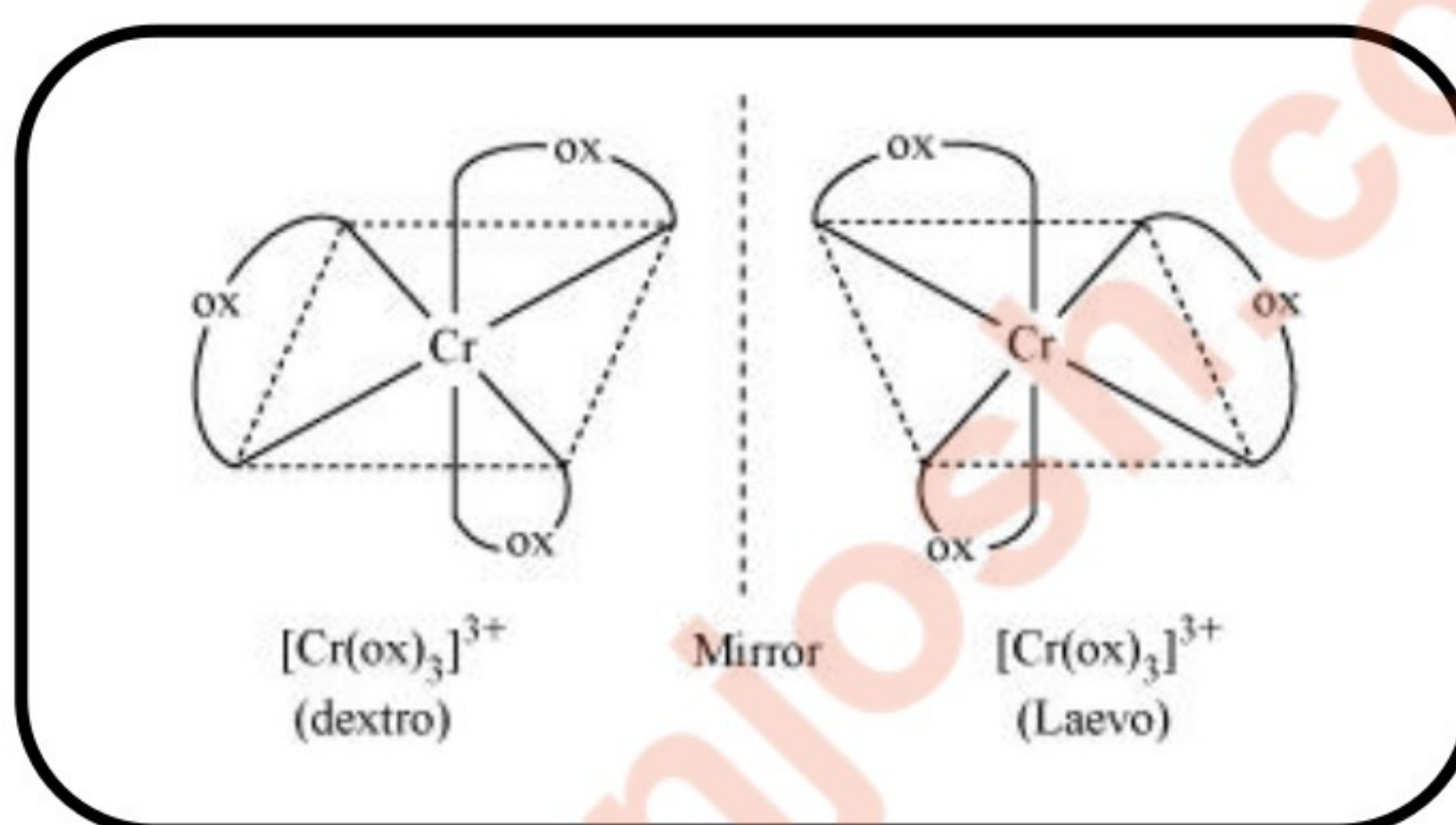


9.10 Draw the structures of optical isomers of:

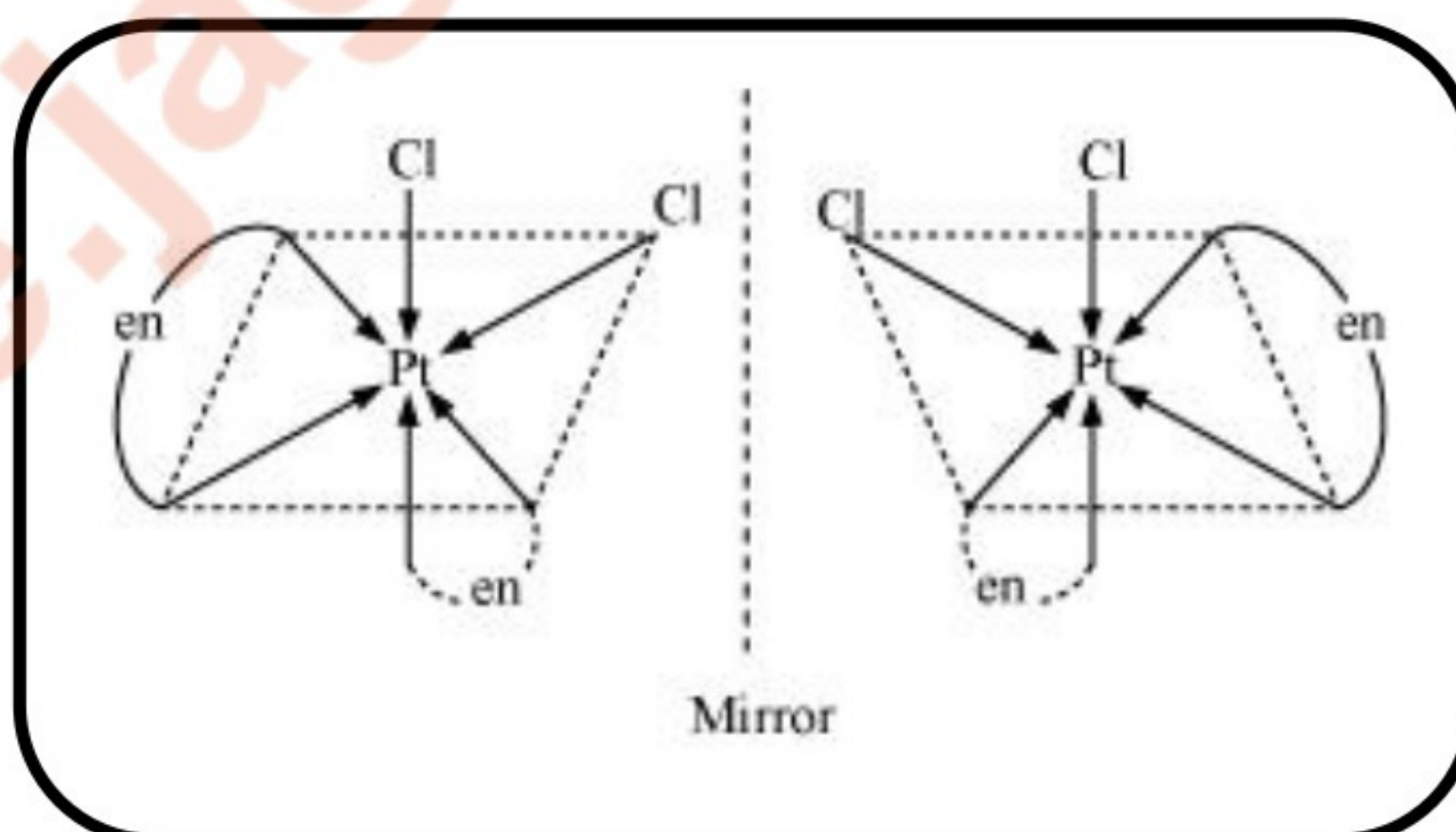
- $[\text{Cr}(\text{C}_2\text{O}_4)_3]^{3-}$
- $[\text{PtCl}_2(\text{en})_2]^{2+}$
- $[\text{Cr}(\text{NH}_3)_2\text{Cl}_2(\text{en})]^+$

Answer 9.10

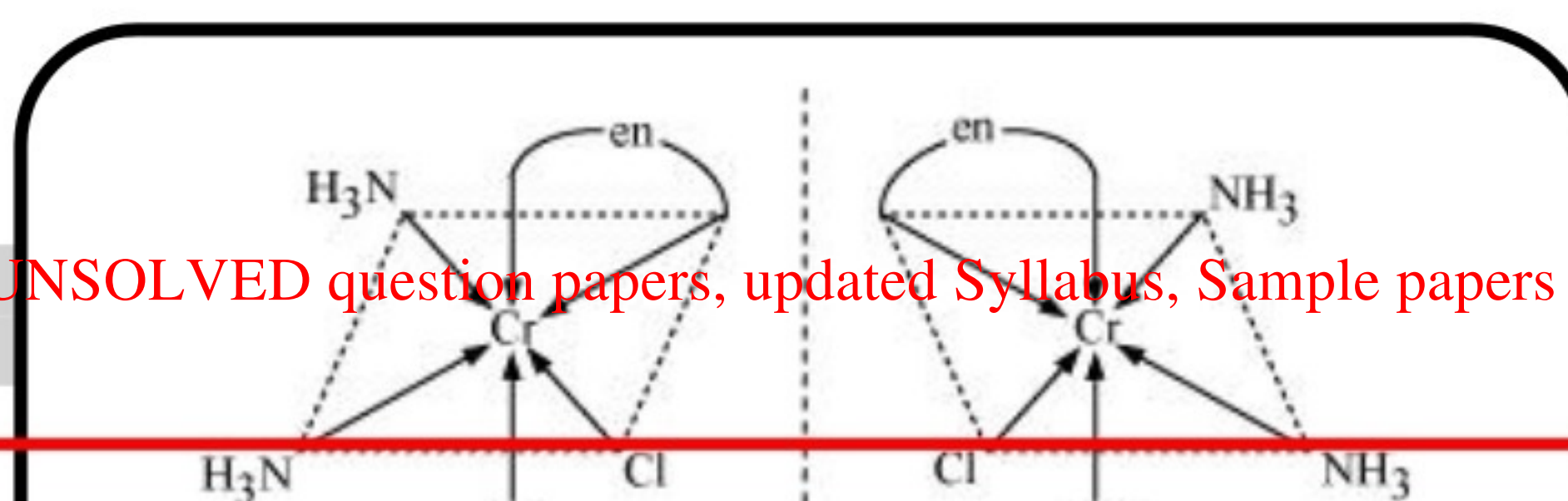
- $[\text{Cr}(\text{C}_2\text{O}_4)_3]^{3-}$

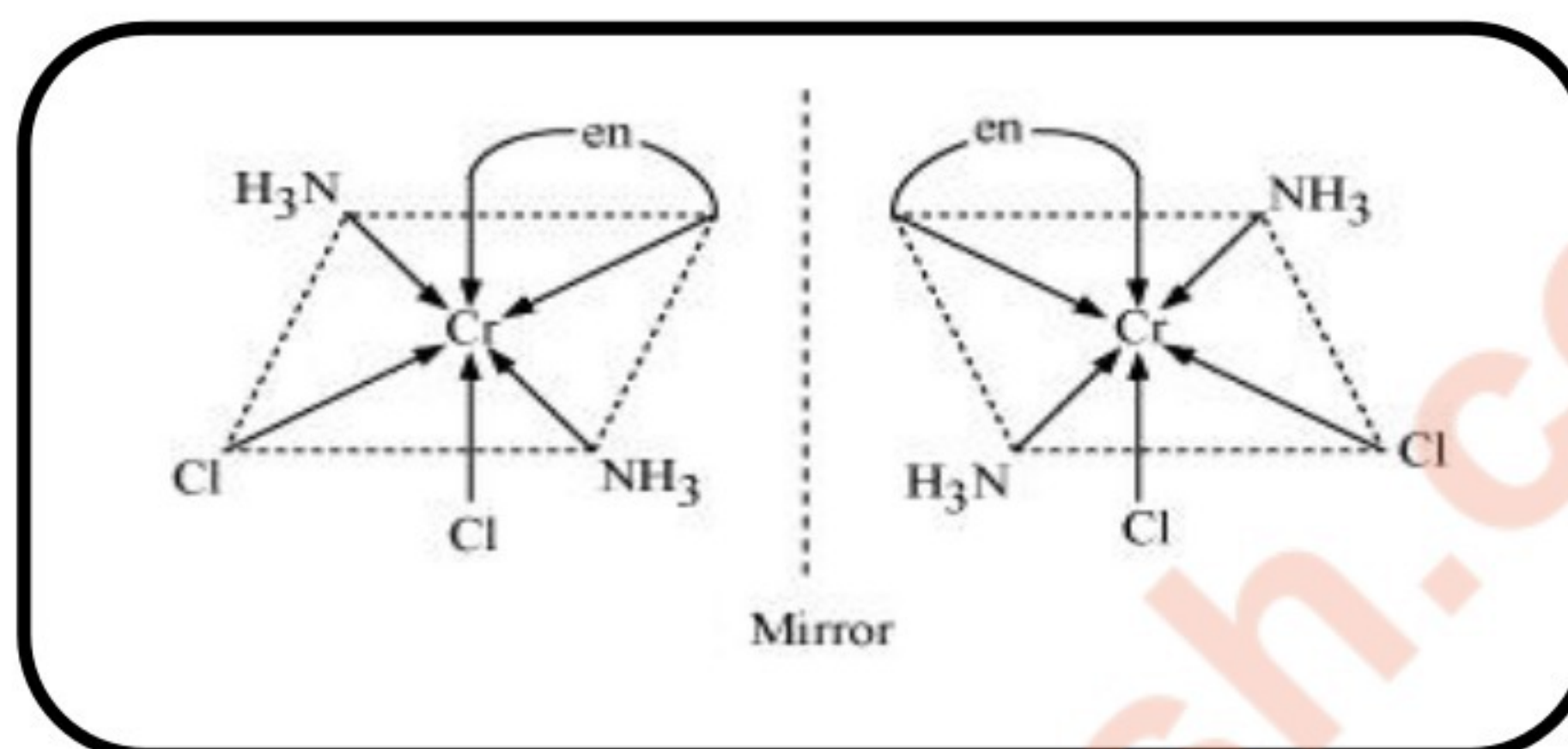


- $[\text{PtCl}_2(\text{en})_2]^{2+}$



- $[\text{Cr}(\text{NH}_3)_2\text{Cl}_2(\text{en})]^+$



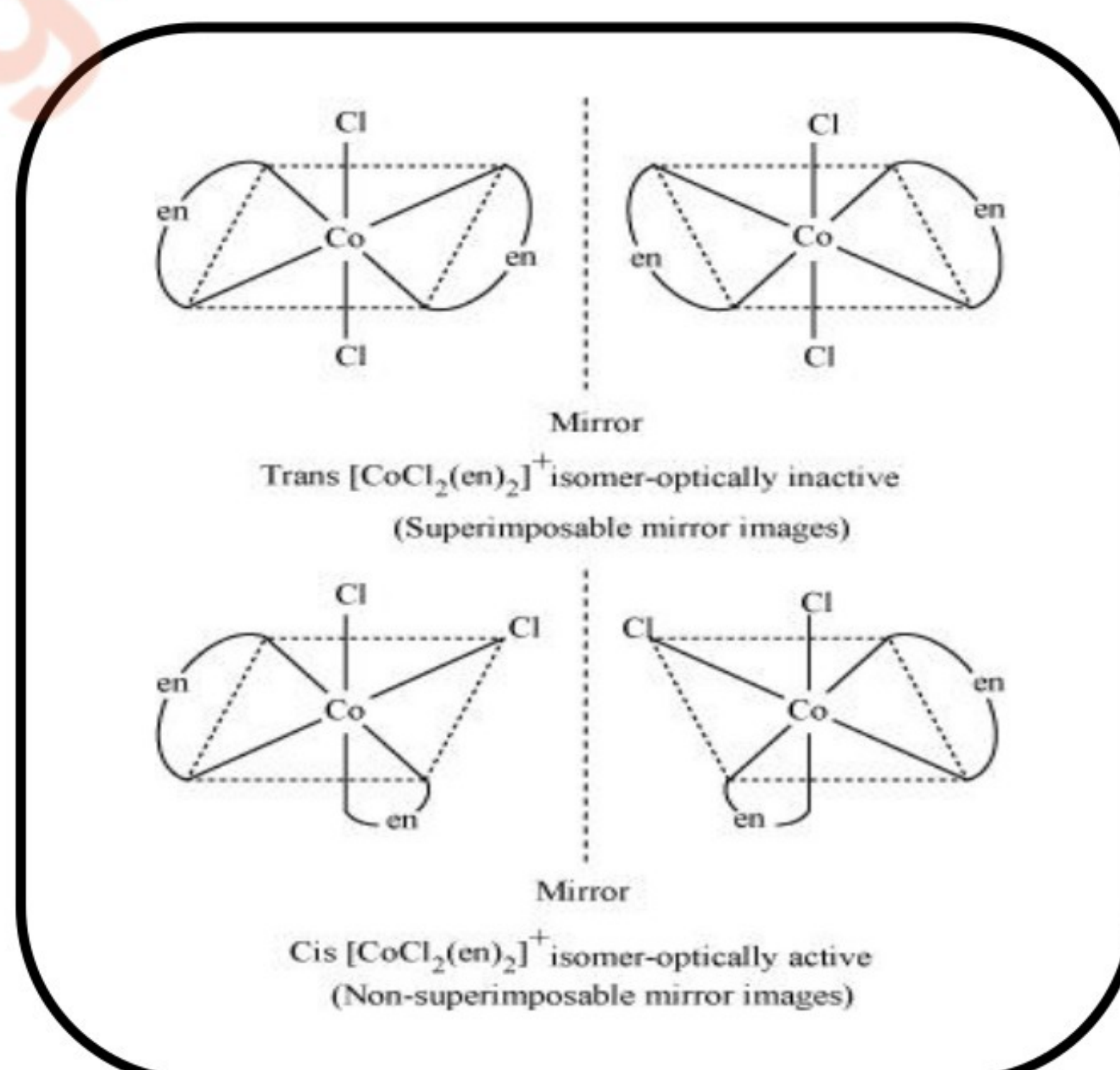


9.11 Draw all the isomers (geometrical and optical) of:

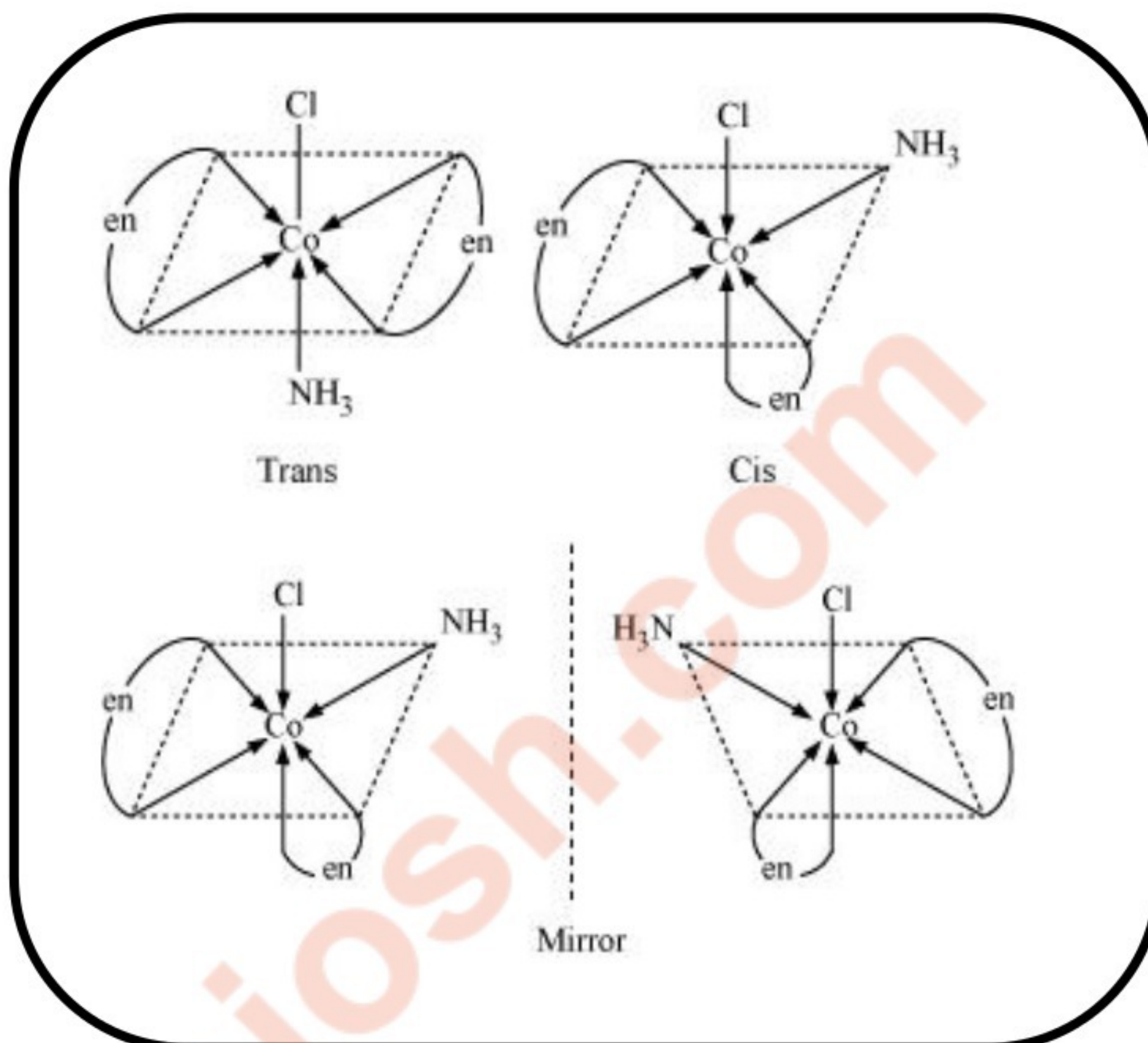
- i. $[\text{CoCl}_2(\text{en})_2]^+$
- ii. $[\text{Co}(\text{NH}_3)\text{Cl}(\text{en})_2]^{2+}$
- iii. $[\text{Co}(\text{NH}_3)_2\text{Cl}_2(\text{en})]^+$

Answer 9.11

- i. $[\text{CoCl}_2(\text{en})_2]^+$

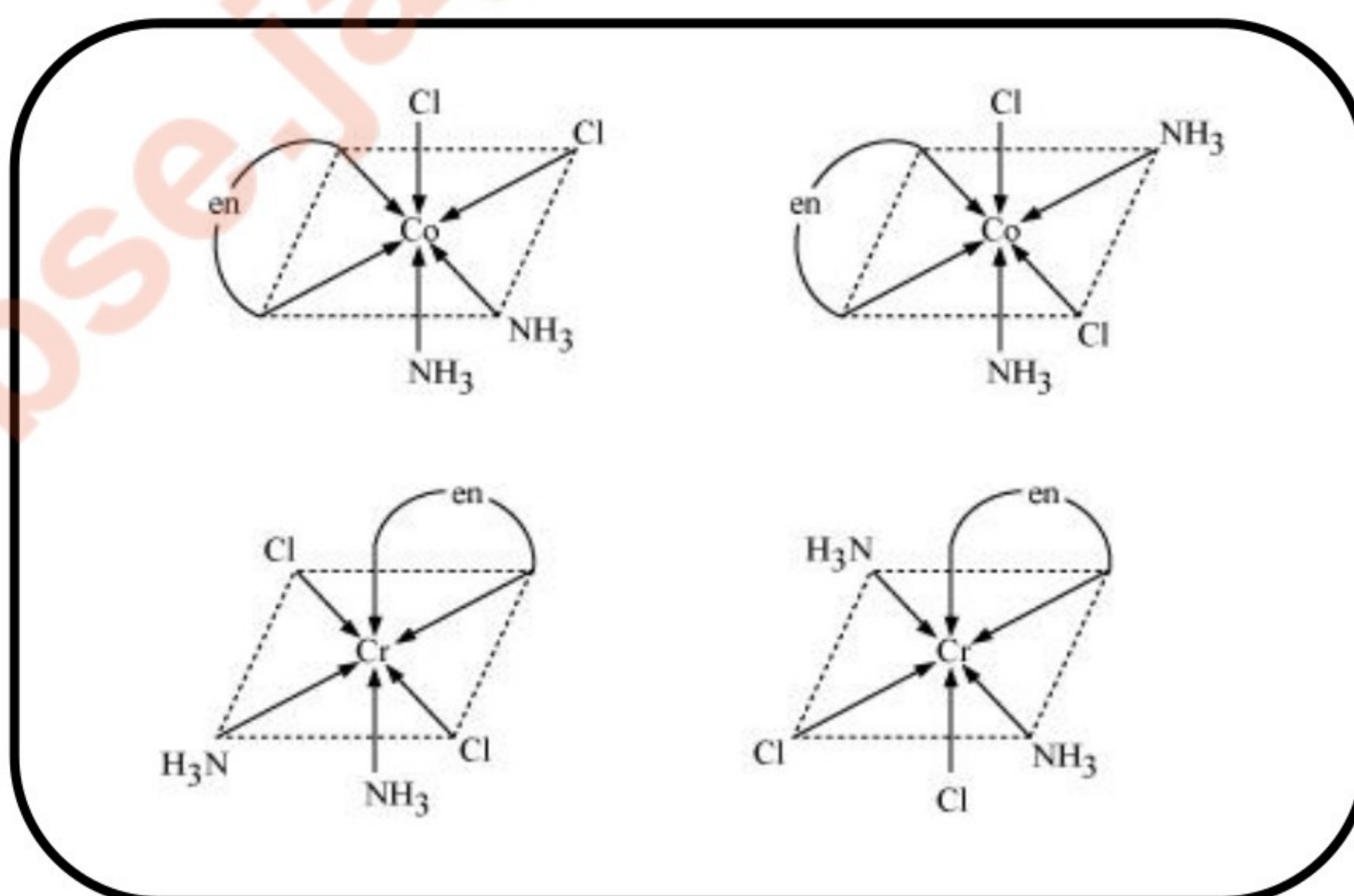


In total, three isomers are possible.



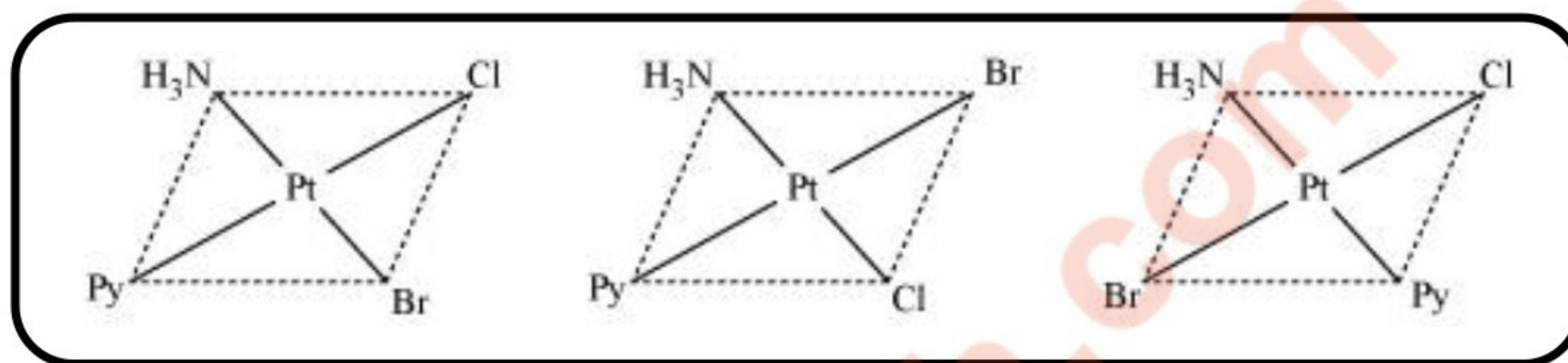
Trans-isomers are optically inactive.

Cis-isomers are optically active.



9.12 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 isomers?

Answer 9.12



None will exhibit optical isomers. Tetrahedral complexes rarely show optical isomerization. Tetrahedral complexes show optical isomerization only in the presence of unsymmetrical chelating agents.

9.13 Aqueous copper sulphate solution (blue in colour) gives:

- a green precipitate with aqueous potassium fluoride, and
- a bright green solution with aqueous potassium chloride

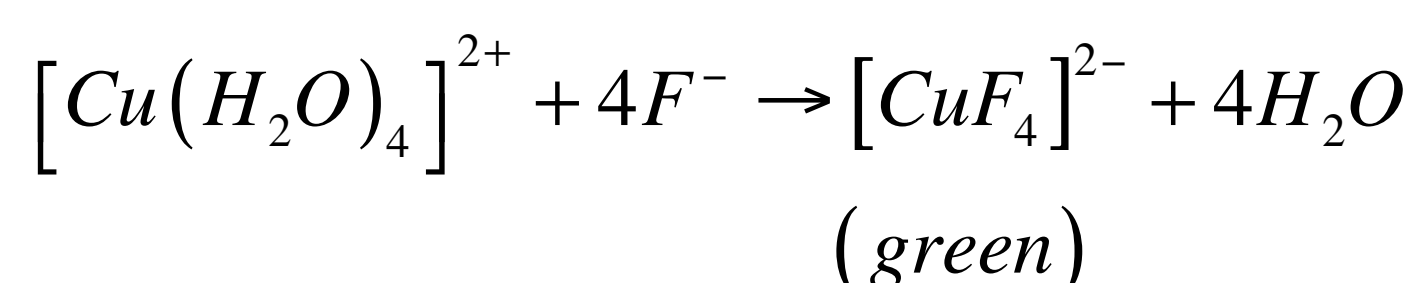
Explain these experimental results.

Answer 9.13

Aqueous CuSO_4 exists as $[\text{Cu}(\text{H}_2\text{O})_4]\text{SO}_4$. It is blue in colour due to the presence of

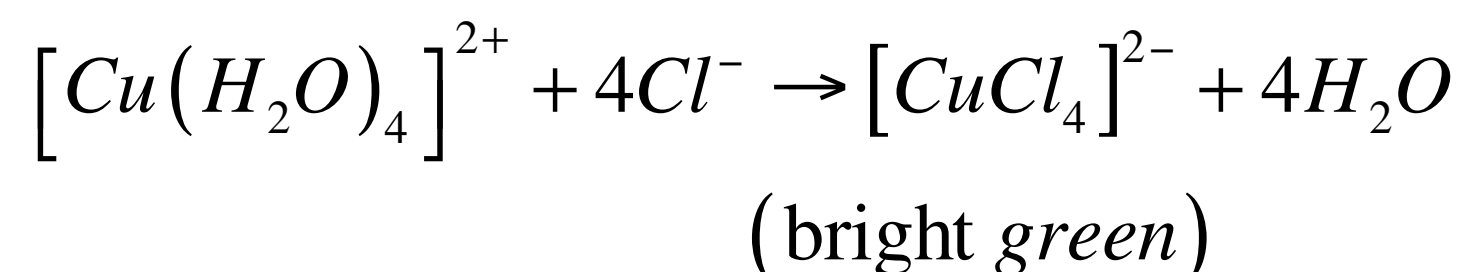
$[\text{Cu}(\text{H}_2\text{O})_4]^{2+}$ ions.

- When KF is added:



Here, weak field ligand water is replaced by the F^- and Cl^- ions

ii. When KCl is added:

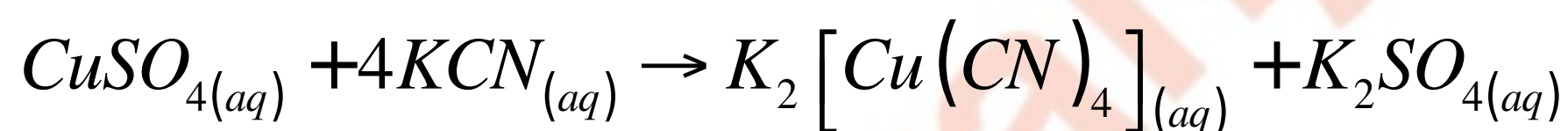


Here, the weak field ligand water is replaced by the F^- and Cl^- ions.

9.14 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 9.14

When copper sulphate is reacted with excess of KCN, following reaction takes place:



Here, the coordination entity formed in the process is $K_2[Cu(CN)_4]$. It is a very stable complex, which does not ionize to give Cu^{2+} ions when added to water. Thus, Cu^{2+} ions are not precipitated when $H_2S_{(g)}$ is passed through the solution.

9.15 Discuss the nature of bonding in the following coordination entities on the basis of valence bond theory:

- i. $[Fe(CN)_6]^{4-}$
- ii. $[FeF_6]^{3-}$
- iii. $[Co(C_2O_4)_3]^{3-}$
- iv. $[CoF_6]^{3-}$

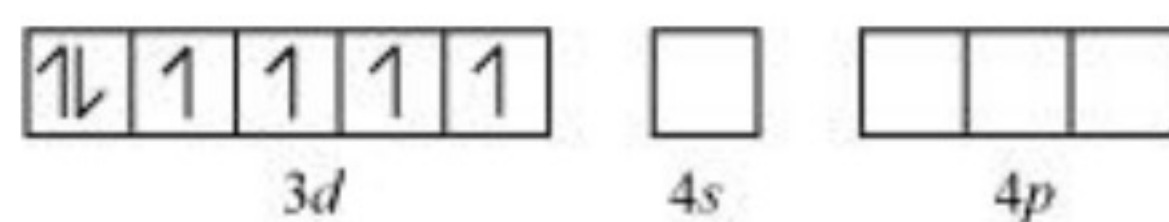
Answer 9.15

- i. $[Fe(CN)_6]^{4-}$

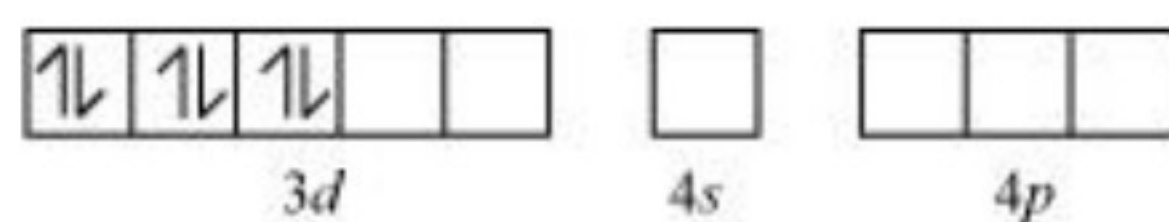
In this complex, oxidation state of iron is +2

Electronic configuration of $\text{Fe}^{2+} = 3d^6$

Orbitals of Fe^{2+} ion:

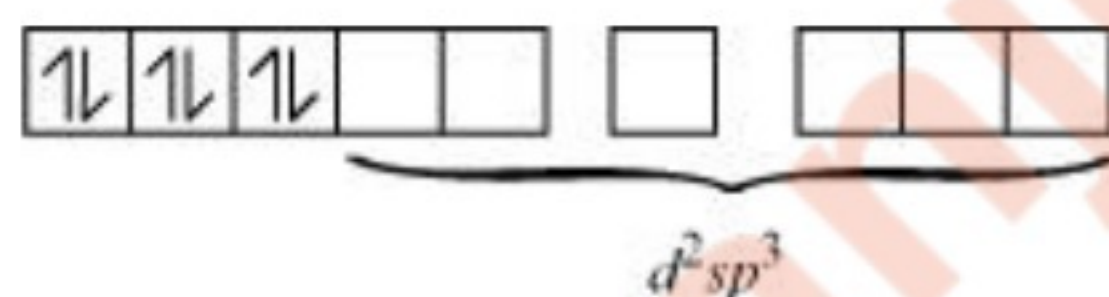


As a strong field ligand, CN^- causes the pairing of the unpaired $3d$ electrons



Because of six ligands, Fe shows d^2sp^3 hybridization

d^2sp^3 hybridized orbitals of Fe^{2+} are:



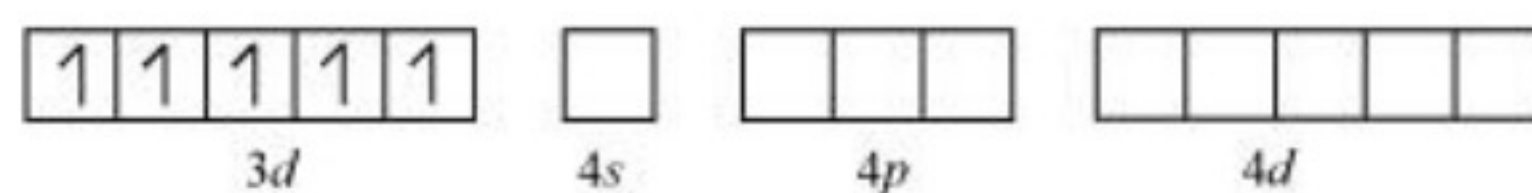
6 electron pairs from CN^- ions occupy the six hybrid d^2sp^3 orbitals.

Hence, the geometry of the complex is octahedral and the complex is diamagnetic.

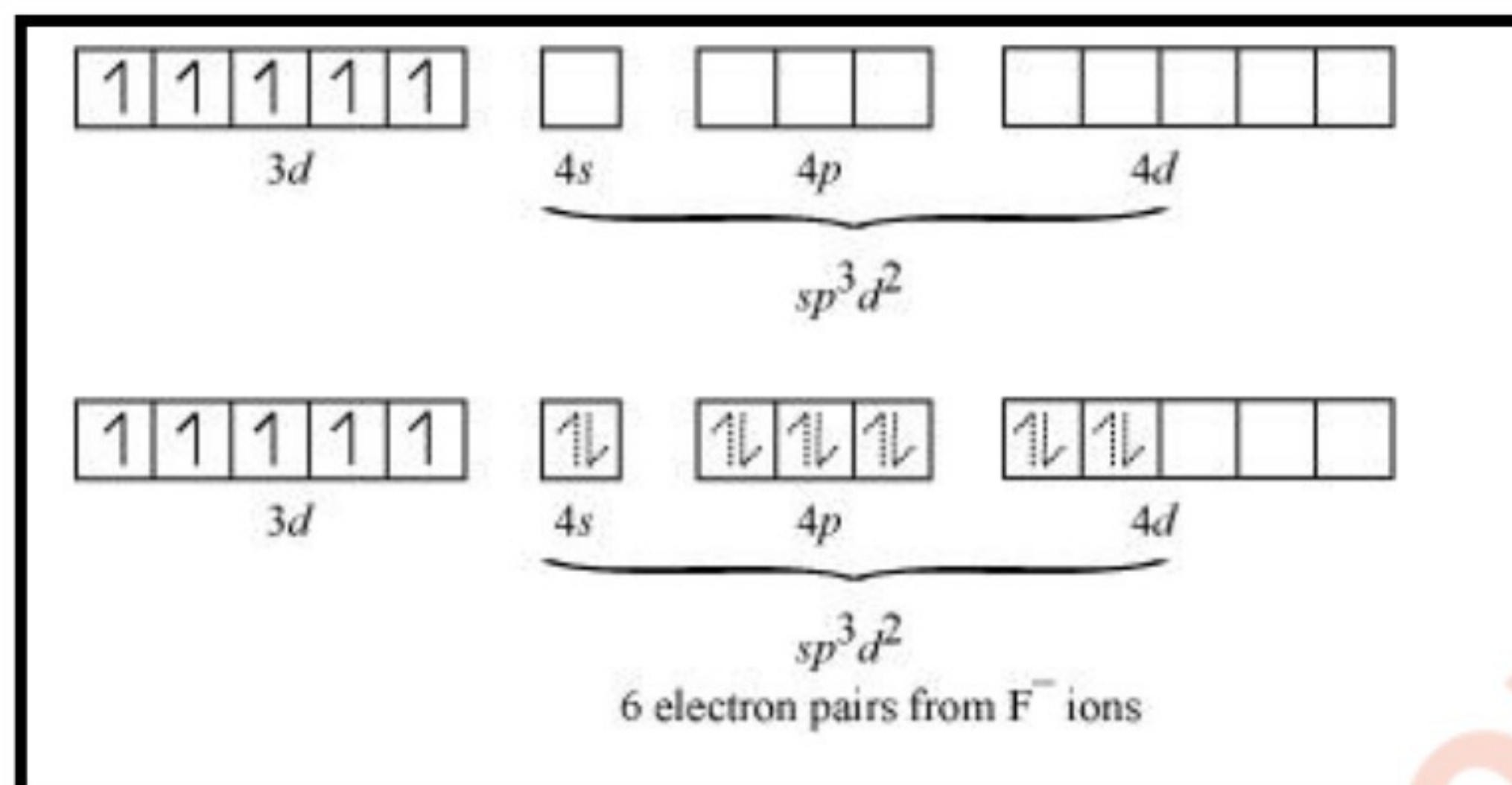
ii. $[\text{FeF}_6]^{3-}$

In this complex, the oxidation state of Fe = +3

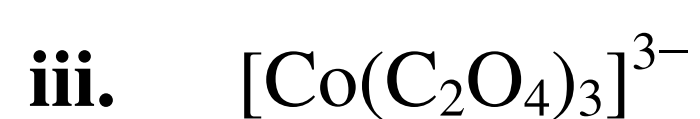
Orbitals of Fe^{+3} ion are:



As F^- is a weak field ligand, it does not cause the pairing of the electrons in the $3d$ orbital. Thus, the most feasible hybridization state of iron will be sp^3d^2 .



Thus, the geometry of the complex is octahedral.



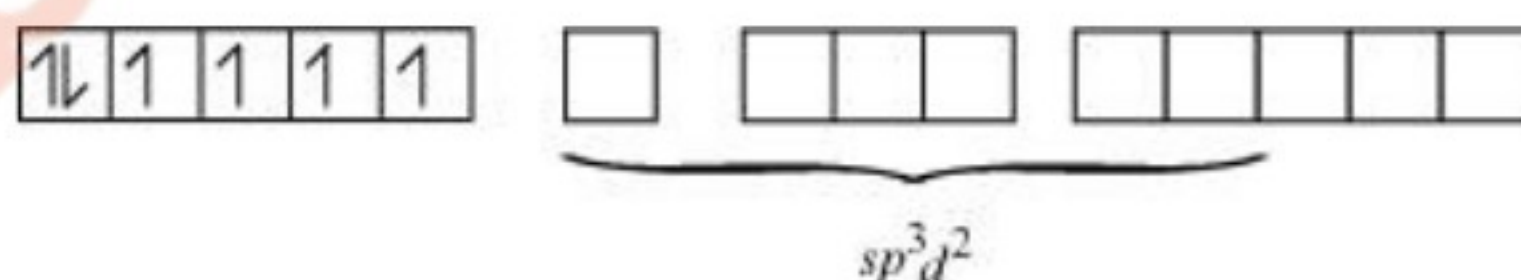
Oxidation state of cobalt = +3

Orbitals of Co^{3+} ion:

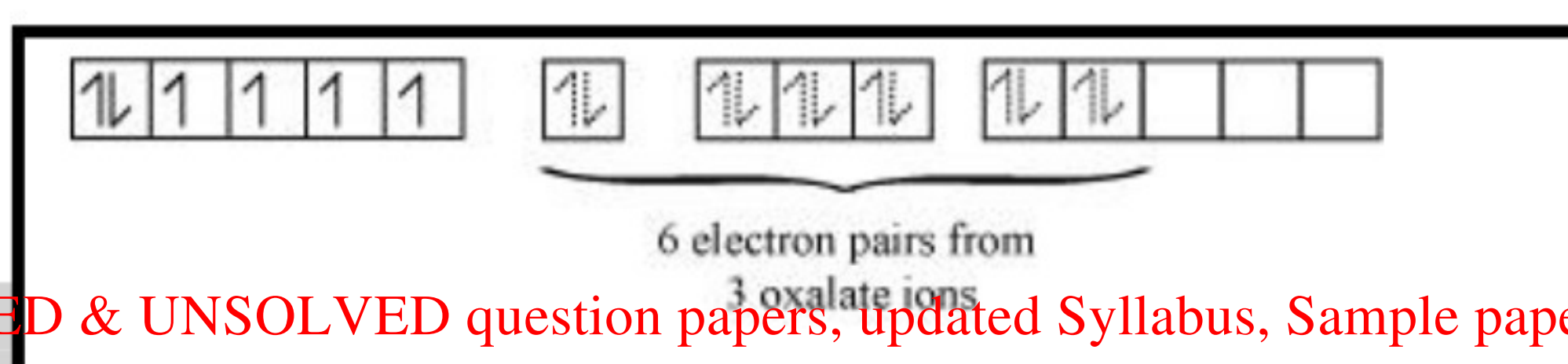


Oxalate is a weak field ligand. Thus, cobalt shows sp^3d^2 hybridization.

sp^3d^2 hybridization of Co^{3+}



The 6 electron pairs from the 3 oxalate ions occupy these sp^3d^2 orbitals.

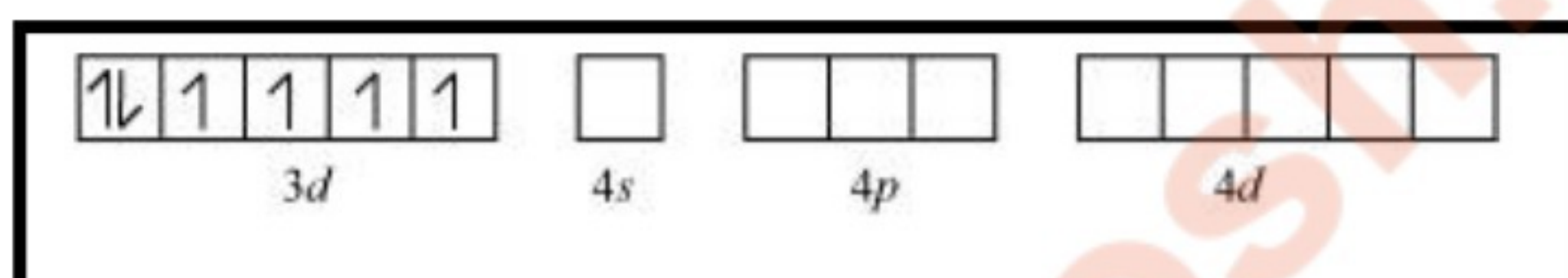


Hence, the geometry of the given complex is octahedral.

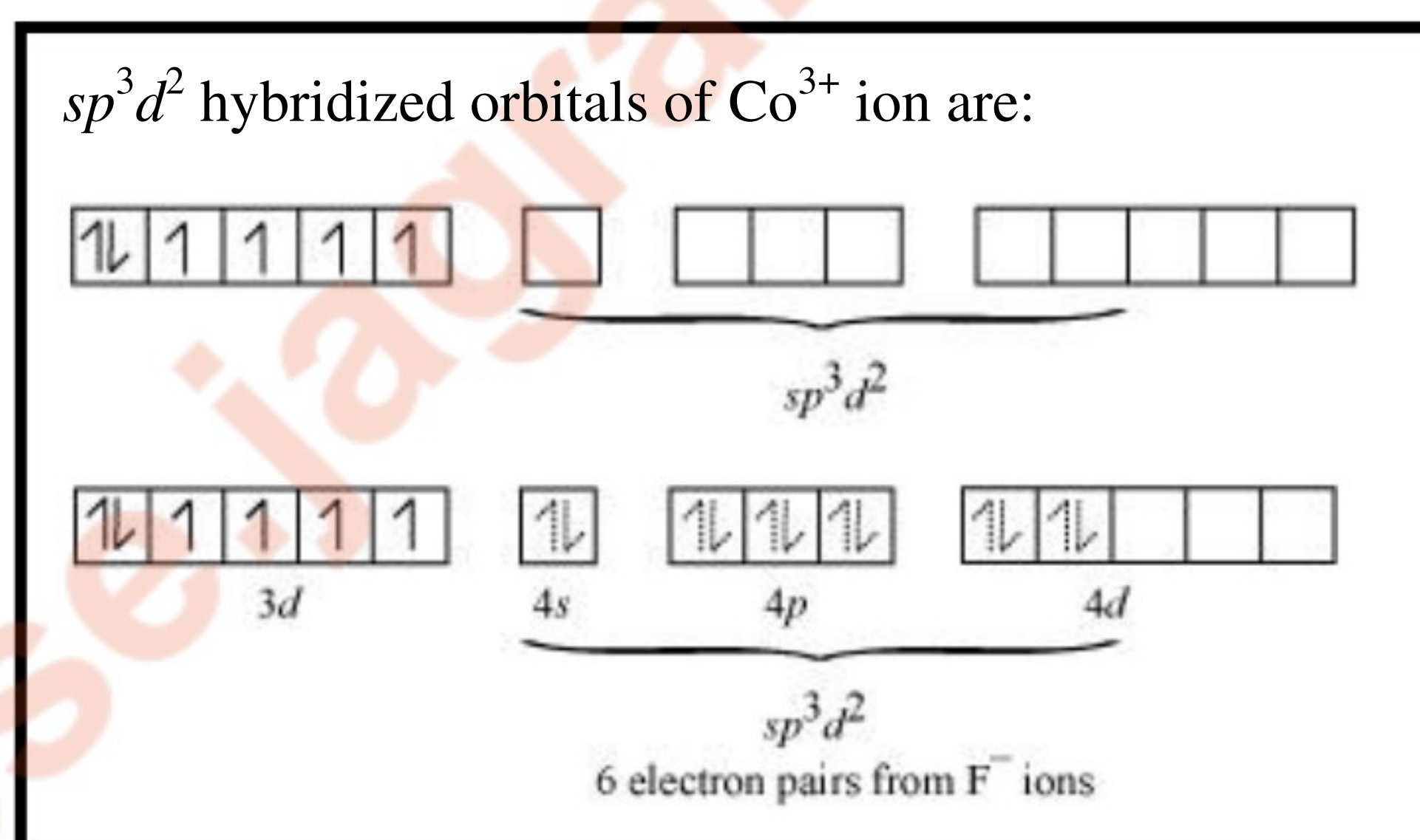
iv. $[\text{CoF}_6]^{3-}$

Cobalt exists in the +3 oxidation state.

Orbitals of Co^{3+} ion:



Because of weak field ligand, fluoride ion cannot cause the pairing of the $3d$ electrons. Thus, the Co^{3+} ion will undergo sp^3d^2 hybridization.

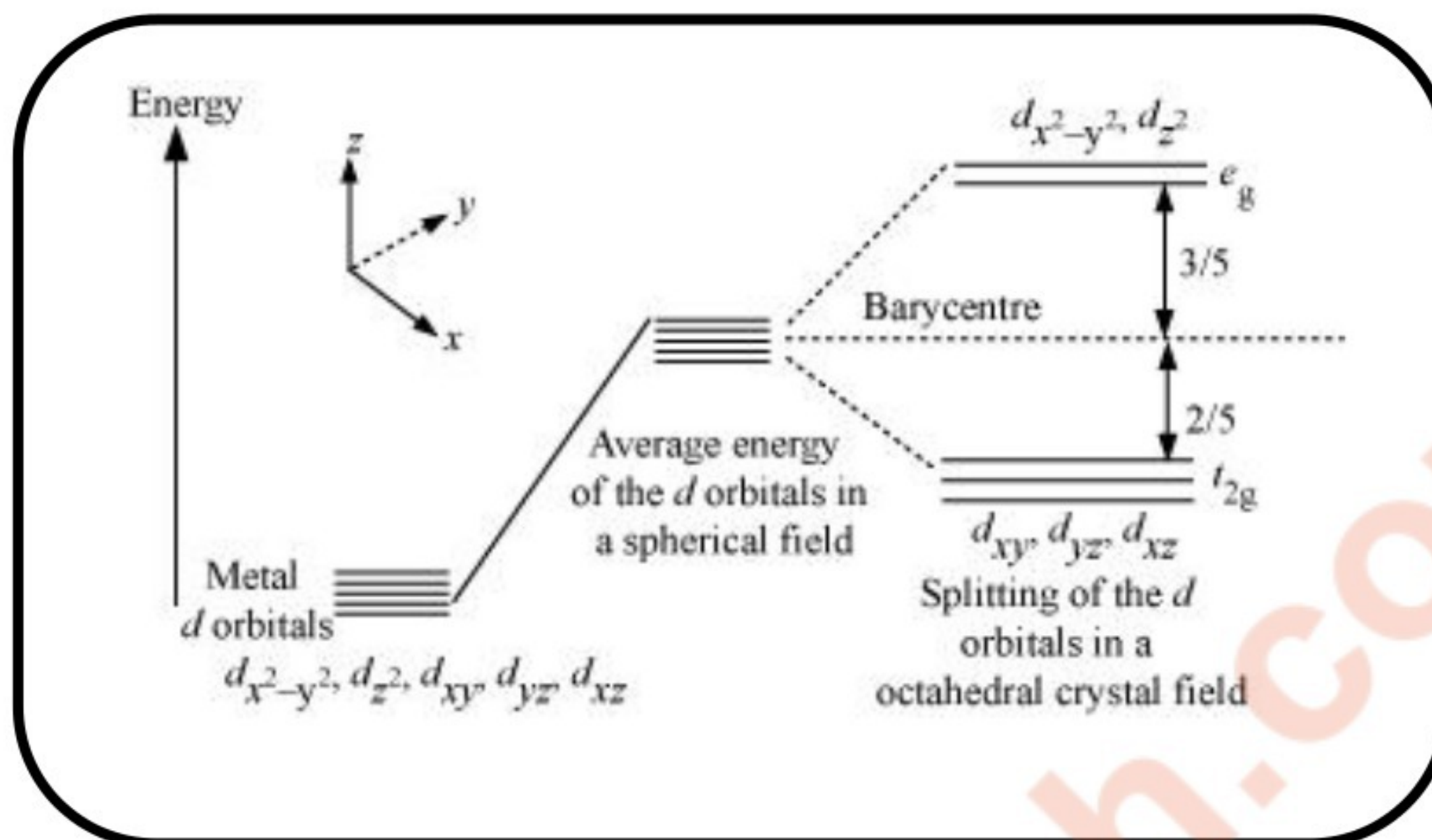


Hence, the geometry of the given complex is octahedral and paramagnetic.

9.16 Draw figure to show the splitting of d orbitals in an octahedral crystal field.

Answer 9.16

The splitting of the d orbitals in an octahedral field: -

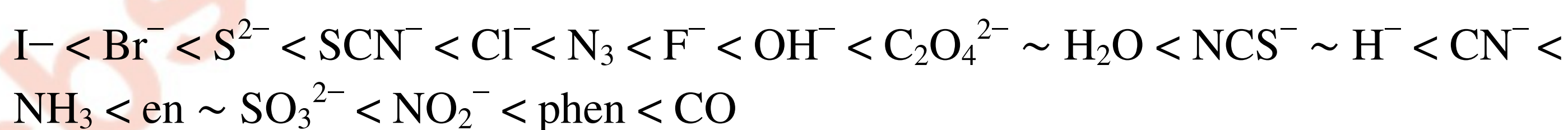


9.17 What is spectrochemical series? Explain the difference between a weak field ligand and a strong field ligand.

Answer 9.17

Spectrochemical series: -

It is the arrangement of common ligands in the increasing order of their crystal-field splitting energy (CFSE) values. Strong field ligands cause higher splitting in the d orbitals than weak field ligands.



9.18 What is crystal field splitting energy? How does the magnitude of Δ_o decide the actual configuration of d -orbitals in a coordination entity?

Answer 9.18

Crystal-field splitting energy: -

We know that d-orbital is degenerate which split into two levels- e_g and t_{2g} in the presence of ligands. This splitting is due to the presence of ligands. This is called the crystal-field splitting & the energy difference between the two levels (e_g and t_{2g}) is called the crystal-field splitting energy, Δ_o .

Filling of the electrons takes place, after splitting of orbitals. After 1 electron (each) has been filled in the three t_{2g} orbitals, the filling of the fourth electron takes place in two ways. It can enter the e_g orbital or the pairing of the electrons can take place in the t_{2g} orbitals.

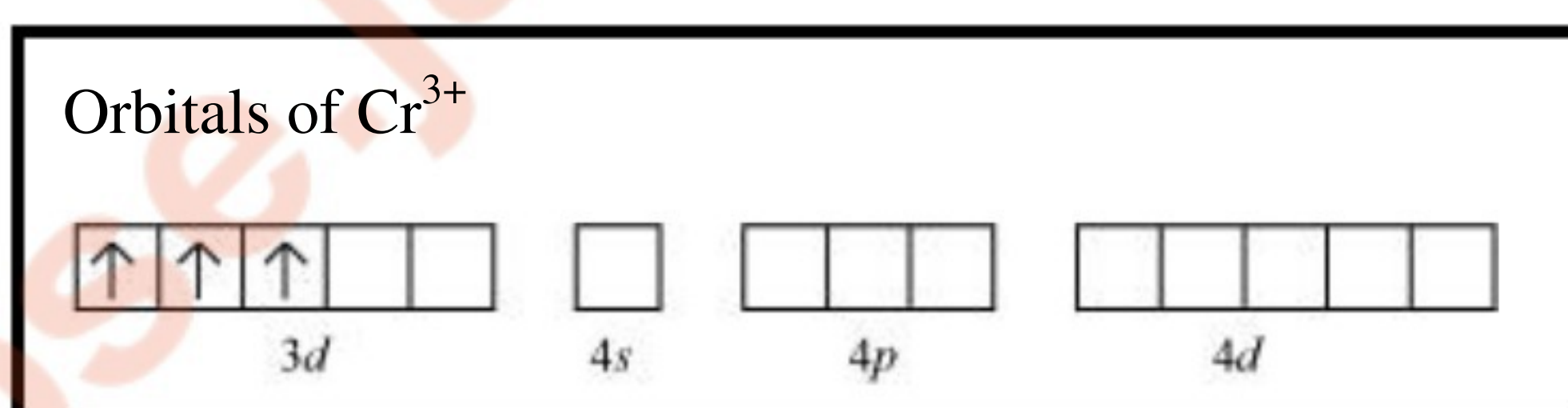
If the Δ_o value of a ligand is less than the pairing energy (P), then the electrons enter the e_g orbital. On the other hand, if the Δ_o value of a ligand is more than the pairing energy (P), then the electrons enter the t_{2g} orbital.

9.19 $[\text{Cr}(\text{NH}_3)_6]^{3+}$ is paramagnetic while $[\text{Ni}(\text{CN})_4]^{2-}$ is diamagnetic. Explain why?

Answer 9.19

Oxidation state of Cr = +3

NH_3 is a weak field ligand & it does not cause the pairing of the electrons in the 3d orbital.

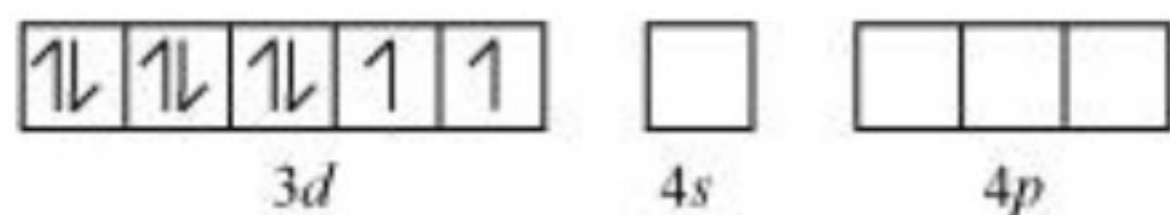


Thus, chromium shows d^2sp^3 hybridization and the electrons in the 3d orbitals remain unpaired. Hence, it is paramagnetic in nature.

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

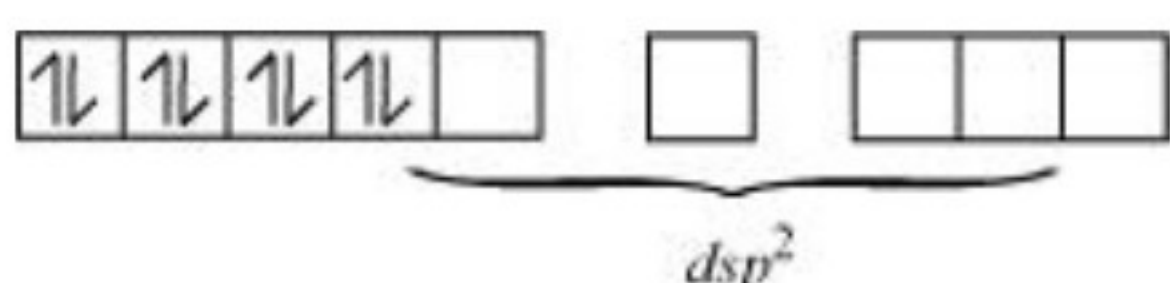
Oxidation state of nickel = +2

Orbitals of Ni^{2+}



CN^- is a strong field ligand & causes the pairing of the $3d$ orbital electrons.

Thus, Ni^{2+} shows dsp^2 hybridization



As there are no unpaired electrons, it is diamagnetic.

9.20 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 9.20

In $[\text{Ni}(\text{CN})_4]^{2-}$, CN^- is a strong field ligand. Thus electrons are all paired. Therefore, $d-d$ transition is not possible in this case. Hence, it is colourless.

In $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$, water is a weak field ligand. Thus, there are unpaired electrons in Ni^{2+} . In this complex, the d electrons from the lower energy level can be excited to the higher energy level. Thus, we can say that, possibility of $d-d$ transition is present here. Hence, $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$ is coloured.

9.21 $[\text{Fe}(\text{CN})_6]^{4-}$ and $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$ are of different colours in dilute solutions. Why?

Answer 9.21

Colour of coordination compounds depends on the value of crystal-field splitting energy, Δ , which in turn depends on the nature of the ligand.

In case of $[\text{Fe}(\text{CN})_6]^{4-}$ and $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$, both compounds have different CFSE value. In first compound, CN^- is a strong field ligand which has a higher CFSE value as compared to the CFSE value of water. Thus, we can say that the absorption energy for the intra $d-d$ transition also differs. Hence, the transmitted colour is also differs.

9.22 Discuss the nature of bonding in metal carbonyls.

Answer 9.22

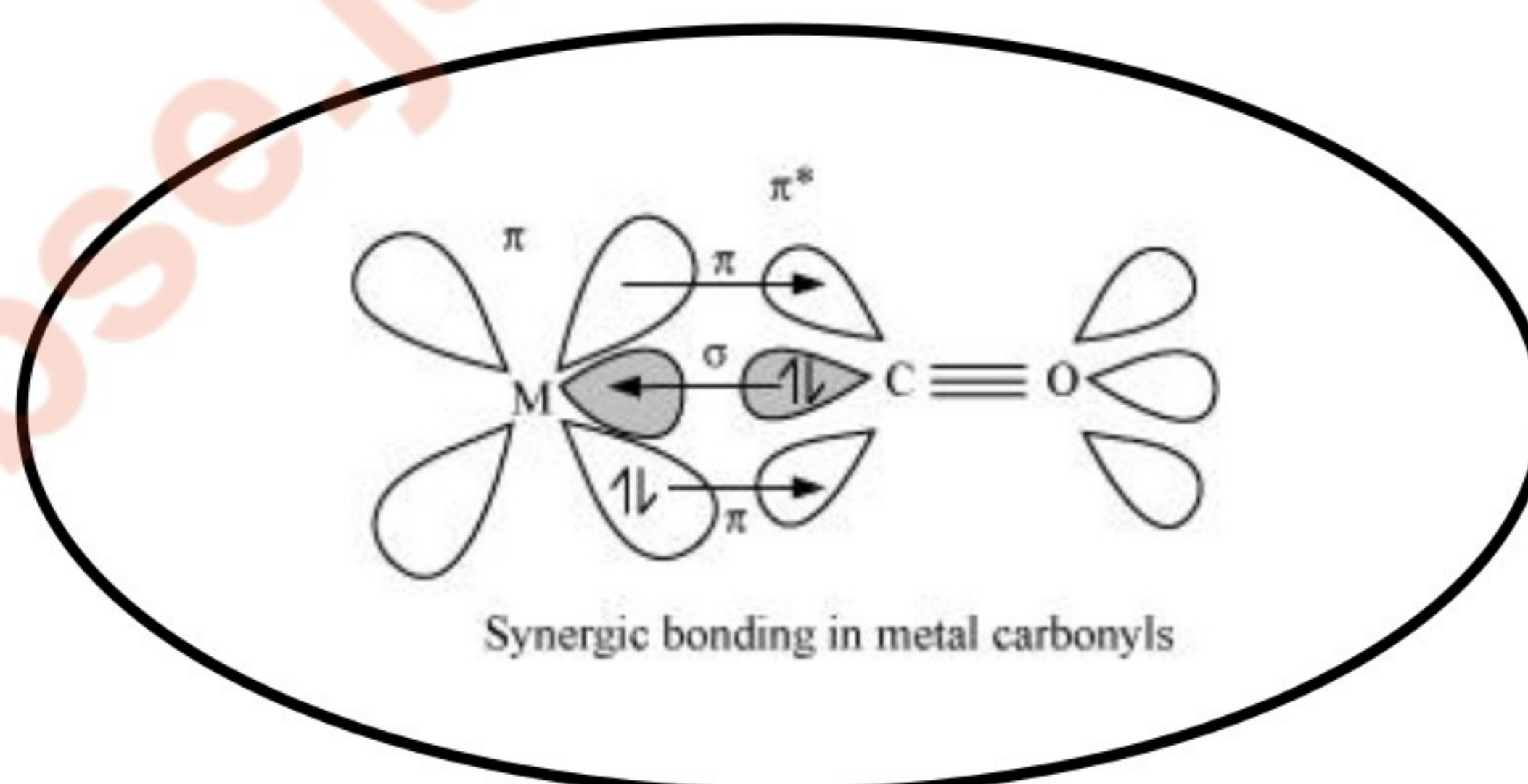
Bonding in metal carbonyls: -

In this, the metal-carbon bonds have both σ and π characters.

σ bond is formed when the carbonyl carbon donates a lone pair of electrons to the vacant orbital of the metal.

π bond is formed by the donation of a pair of electrons from the filled metal d orbital into the vacant anti-bonding π^* orbital.

The σ bond strengthens the π bond and vice-versa. Thus, a synergic effect is created due to this metal-ligand bonding. This synergic effect strengthens the bond between CO and the metal.



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

- i. $\text{K}_3[\text{Co}(\text{C}_2\text{O}_4)_3]$
- ii. $\text{cis-}[\text{Cr}(\text{en})_2\text{Cl}_2]\text{Cl}$
- iii. $(\text{NH}_4)_2[\text{CoF}_4]$
- iv. $[\text{Mn}(\text{H}_2\text{O})_6]\text{SO}_4$

Answer 9.23

- i. $\text{K}_3[\text{Co}(\text{C}_2\text{O}_4)_3]$

The central metal ion - Co

Coordination number - 6

The oxidation state can be calculated as:

$$x - 6 = -3$$

$$x = +3$$

The *d* orbital occupation for Co^{3+} - $t_{2g}^6 e_g^0$

- ii. $\text{cis-}[\text{Cr}(\text{en})_2\text{Cl}_2]\text{Cl}$

The central metal ion - Cr

The coordination number - 6

The oxidation state can be calculated as:

$$x + 2(0) + 2(-1) = 1$$

$$x + 0 - 2 = 1$$

$$x = +3$$

The d orbital occupation for $\text{Cr}^{3+} - t_{2g}^3$

iii. $(\text{NH}_4)_2[\text{CoF}_4]$

The central metal ion - Co

The coordination number - 4

The oxidation state can be calculated as:

$$x - 4 = -2$$

$$x = +2$$

The d orbital occupation for $\text{Co}^{2+} - e_g^4 t_{2g}^3$

iv. $[\text{Mn}(\text{H}_2\text{O})_6]\text{SO}_4$

The central metal ion - Mn

The coordination number - 6

The oxidation state can be calculated as:

$$x + 0 = +2$$

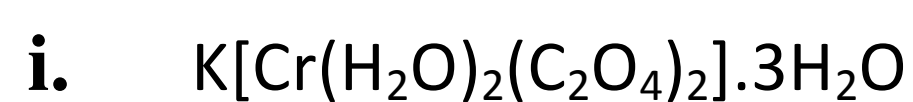
$$x = +2$$

The d orbital occupation for Mn - $t_{2g}^3 e_g^2$

9.24 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:

- i. $\text{K}[\text{Cr}(\text{H}_2\text{O})_2(\text{C}_2\text{O}_4)_2] \cdot 3\text{H}_2\text{O}$
- ii. $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$
- iii. $\text{CrCl}_3(\text{py})_3$
- iv. $\text{Cs}[\text{FeCl}_4]$
- v. $\text{K}_4[\text{Mn}(\text{CN})_6]$

Answer 9.24



IUPAC name: Potassium diaquadioxalatochromate (III) trihydrate

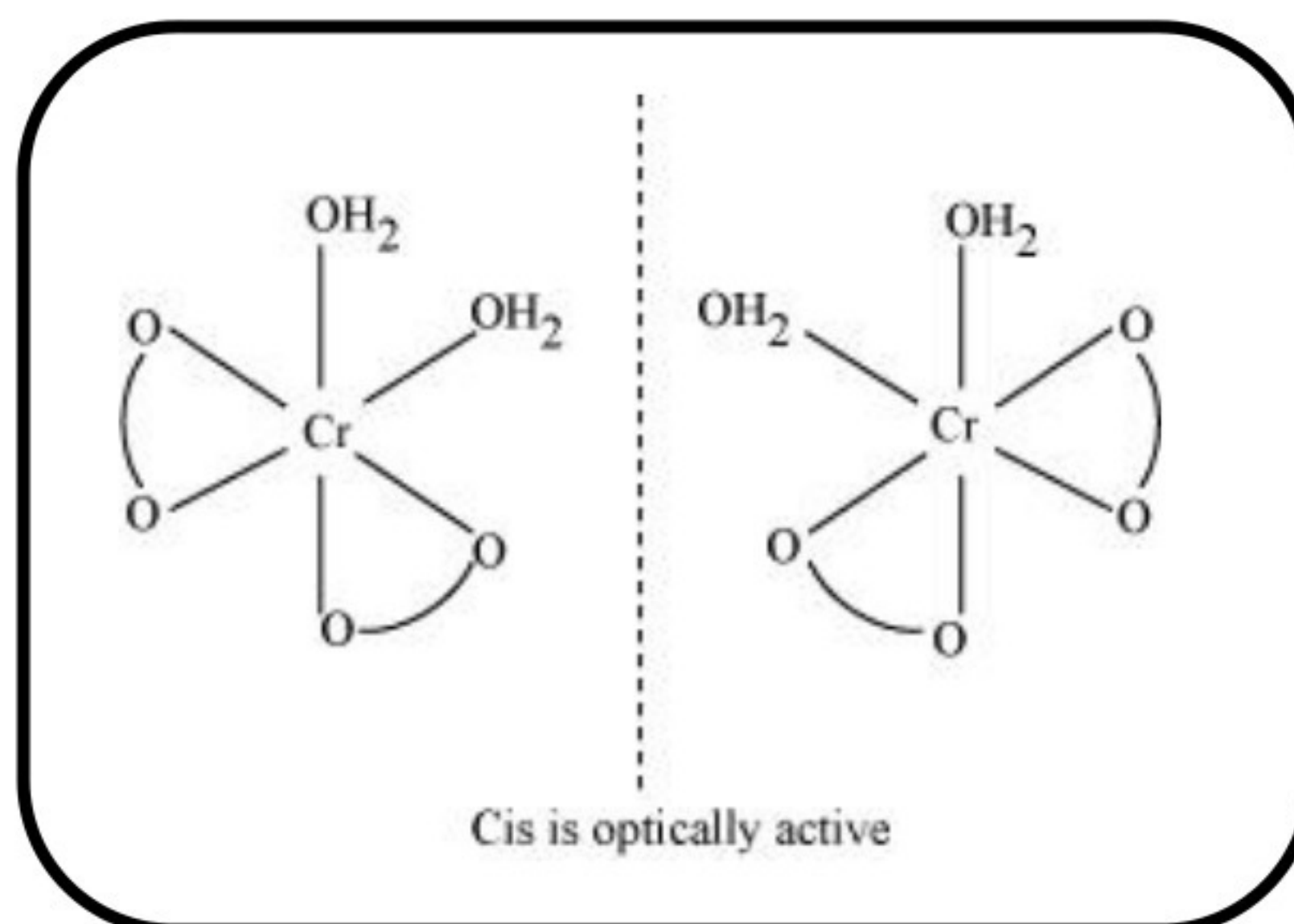
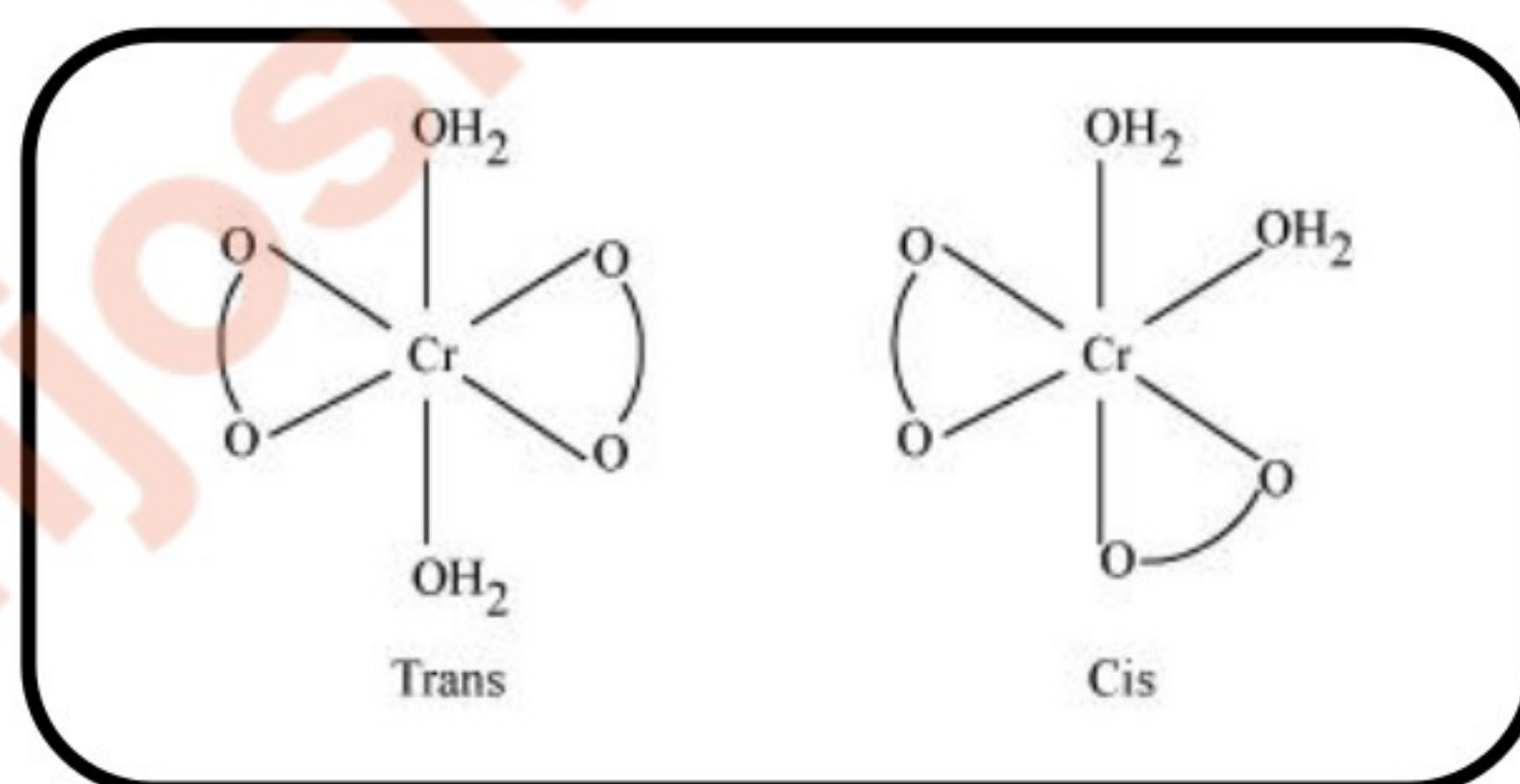
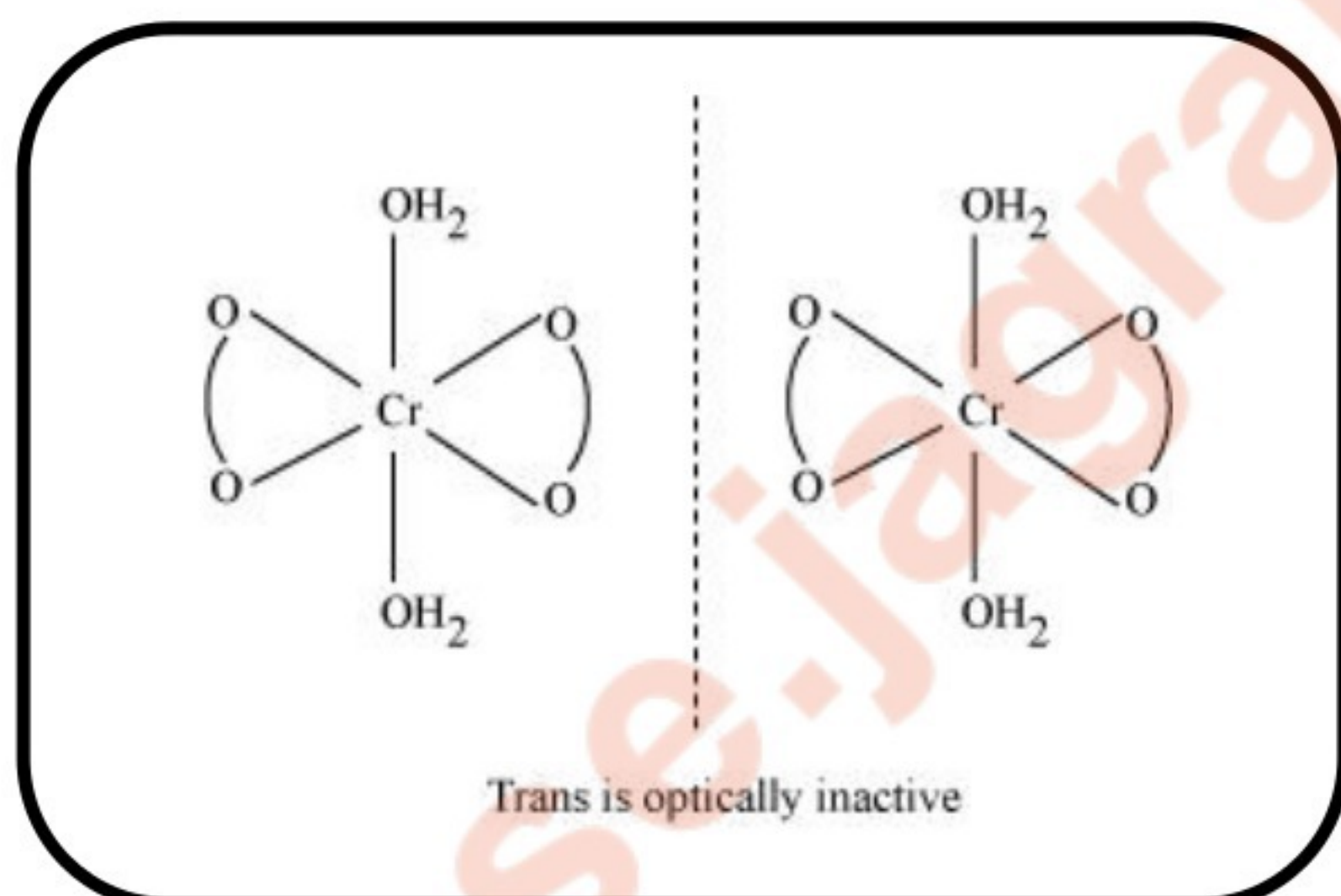
Oxidation state of chromium = 3

Electronic configuration = $3d^3: t_{2g}^3$

Coordination number = 6

Shape = octahedral

Stereochemistry:



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

$$\begin{aligned} &= \sqrt{3(3+2)} \\ &= \sqrt{15} \\ &< 4 \text{ BM} \end{aligned}$$



IUPAC name: Pentaamminechloridocobalt(III) chloride

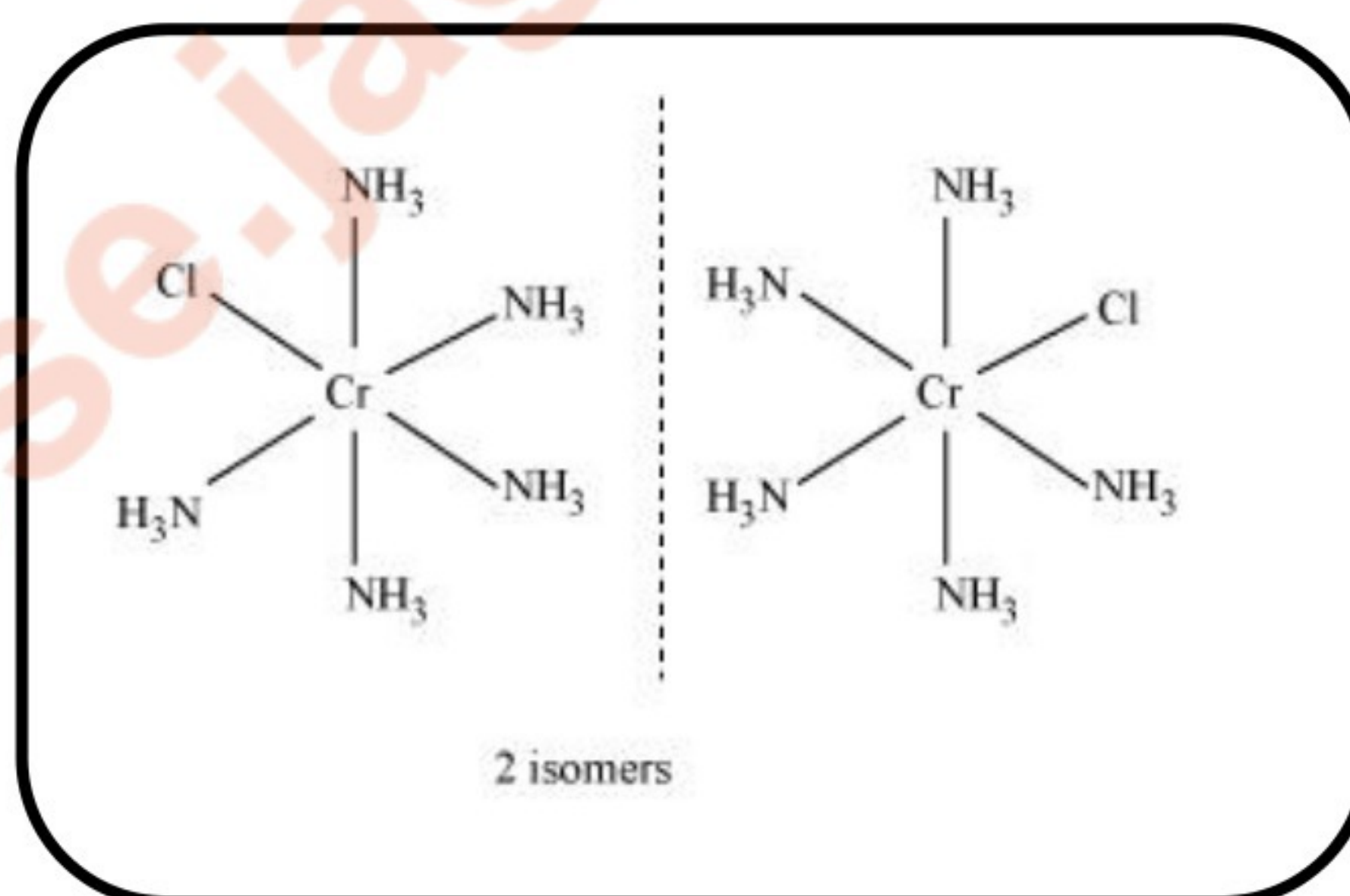
Oxidation state of Co = +3

Coordination number = 6

Shape: octahedral

Electronic configuration: $d^6: t_{2g}^6$

Stereochemistry:



Magnetic Moment = 0



IUPAC name: Trichloridotripyridinechromium (III)

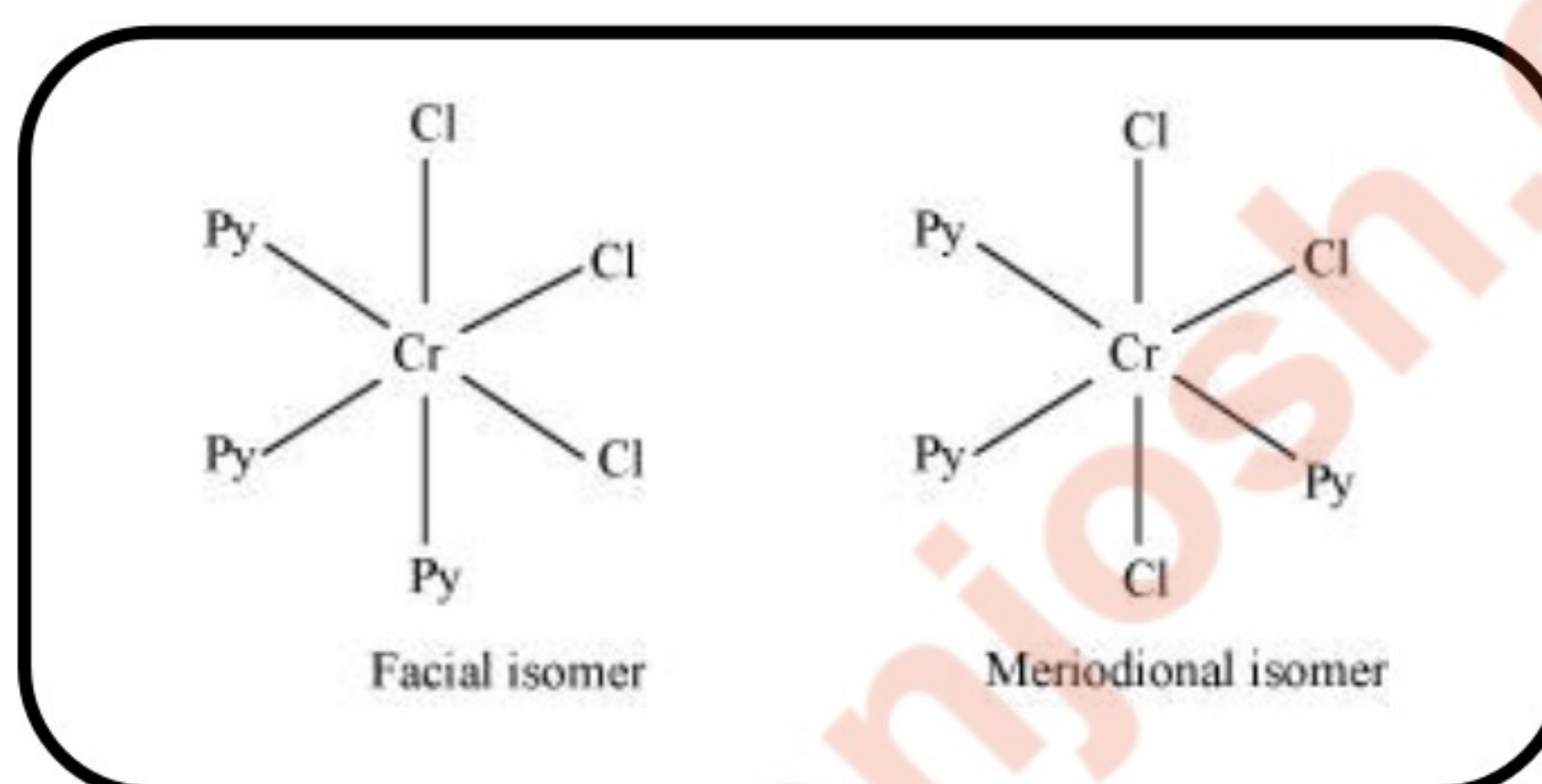
Oxidation state of chromium = +3

Electronic configuration for $d^3 = t_{2g}^3$

Coordination number = 6

Shape: octahedral

Stereochemistry:



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

$$\begin{aligned}\text{Magnetic moment, } \mu &= \sqrt{n(n+2)} \\ &= \sqrt{3(3+2)} \\ &= \sqrt{15} \\ &: 4 \text{ BM}\end{aligned}$$

iv. $\text{Cs}[\text{FeCl}_4]$

IUPAC name: Caesium tetrachloroferrate (III)

Oxidation state of Fe = +3

Electronic configuration of $d^6 = e_g^2 t_{2g}^3$

Coordination number = 4

Shape = tetrahedral

Stereochemistry = optically inactive

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

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

$$= \sqrt{35}$$

$$: 6BM$$



IUPAC name = Potassium hexacyanomanganate(II)

Oxidation state of manganese = +2

Electronic configuration = $d^{5+}: t_{2g}^5$

Coordination number = 6

Shape = octahedral

Stereochemistry = optically inactive

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

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

$$= \sqrt{3}$$

$$= 1.732 \text{ BM}$$

9.25 What is meant by stability of a coordination compound in solution? State the factors which govern stability of complexes.

Answer 9.25

Stability of a complex in a solution: -

It is the degree of association between the two species involved in a state of equilibrium. Stability can be expressed quantitatively in terms of stability constant.



$$\text{Stability constant, } \beta = \frac{[ML_2]}{[M][L]^2}$$

Greater is the value of the stability constant, the greater will be product in the solution.

Two types of stability are:

- Thermodynamic stability:** - The extent to which the complex will be formed at the point of equilibrium is determined by thermodynamic stability.
- Kinetic stability:** - it helps in determining the speed with which the transformation will occur to attain the state of equilibrium.

Factors that affect the stability of a complex are:

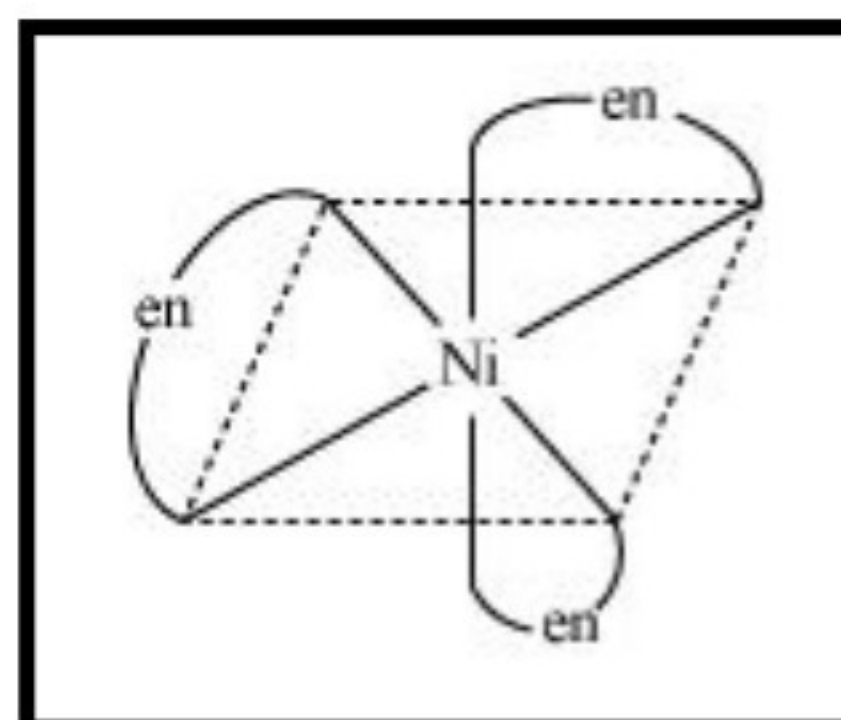
- Charge on the central metal ion – The greater the charge on the central metal ion, the greater is the stability of the complex.
- Presence of chelate rings - Chelation increases the stability of complexes
- Nature of the ligand - A more basic ligand will form a more stable complex

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

Answer 9.26 Chelate effect: -

When a ligand is attached to the metal ion in such a manner that it forms a ring, then the metal- ligand association is more stable. This is known as the chelate effect.

For example:



9.27 Discuss briefly giving an example in each case the role of coordination compounds in:

- i. Biological system**
- ii. Medicinal chemistry**
- iii. Analytical chemistry**
- iv. Extraction/metallurgy of metals**

Answer 9.23

i. Biological systems:

- Chlorophyll pigment is necessary for photosynthesis. This pigment is a coordination compound of magnesium.
- Haemoglobin acts as an oxygen-carrier of blood which is a coordination compound of iron.

ii. Medicinal chemistry:

cis-platin, a coordination compounds of platinum is used for inhibiting the growth of tumours.

iii. Analytical chemistry:

- In salt analysis- various radicals are detected because of the colour changes they exhibit with different reagents. These colour changes are a result of the coordination compounds or complexes that the basic radicals form with different ligands.

iv. Extraction or metallurgy of metals:

- In extraction of some of the metals from their ores, some complexes are formed. For example, in aqueous solution, gold combines with cyanide ions to form $[\text{Au}(\text{CN})_2]$. From this solution, gold is later extracted by the addition of zinc metal.

9.28 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 9.23

Complex is $[\text{Co}(\text{NH}_3)_6]\text{Cl}_2$

Hence, $[\text{Co}(\text{NH}_3)_6]^+$ along with two Cl^- ions are produced.

9.29 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 9.29

i. No. of unpaired electrons in $[\text{Cr}(\text{H}_2\text{O})_6]^{3+} = 3$

$$\text{Now, } \mu = \sqrt{n(n+2)}$$

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

$$= \sqrt{15}$$

$$: 4 \text{ BM}$$

ii. No. of unpaired electrons in $[\text{Fe}(\text{H}_2\text{O})_6]^{2+} = 4$

$$\text{Now, } \mu = \sqrt{n(n+2)}$$

$$= \sqrt{4(4+2)}$$

$$= \sqrt{24}$$

$$: 5 \text{ BM}$$

iii. No. of unpaired electrons in $[\text{Zn}(\text{H}_2\text{O})_6]^{2+} = 0$

Thus, $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$ has the highest magnetic moment value.

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

- i. +1
- ii. +3
- iii. -1
- iv. -3

Answer 9.30

It is known that, CO is a neutral ligand and K carries a charge of +1.

Thus, the complex can be written as $\text{K}^+[\text{Co}(\text{CO})_4]^-$.

Oxidation number of Co in the given complex is = -1

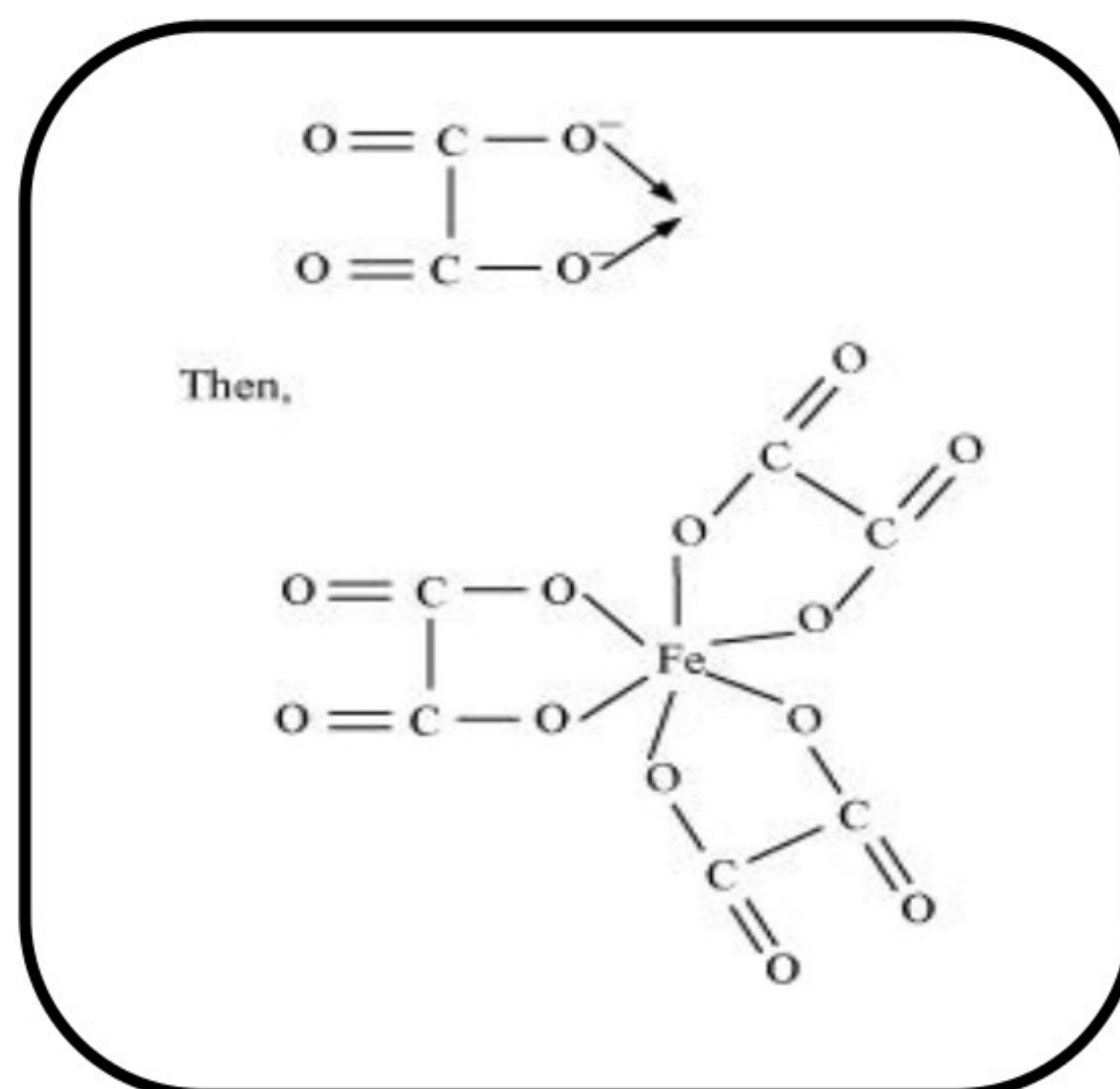
Hence, option (iii) is correct.

9.31 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 9.31

The stability of a complex increases by chelation. Thus, the most stable complex is $[\text{Fe}(\text{C}_2\text{O}_4)_3]^{3-}$.



9.32 What will be the correct order for the wavelengths of absorption in the visible region for the following?



Answer 9.32

We can observe that, central metal ion in all the three complexes is the Nickel. Thus, absorption in the visible region will depend on the ligands.

The order of the CFSE values of the ligands is:



Thus, the wavelengths of absorption in the visible region will be in the order:

