

coordination compounds-CBSE(solutions)

☑ Explanations

1. Double salt is a combination of (+)ve and (-)ve ions, which completely dissociates into its ions, when dissolved in water. Whereas complex is a salt, in which molecular structure of complex ion retain itself in aqueous solution, i.e., do not dissociates into its ions completely. (1)

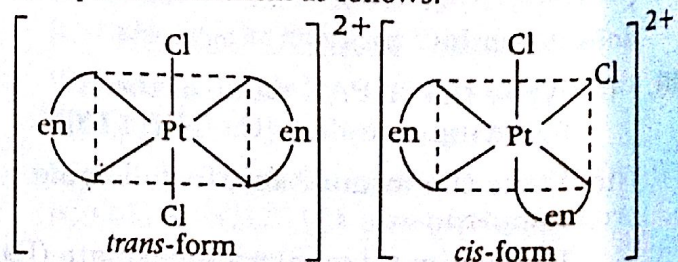
2. $[\text{Pt}(\text{NH}_3)_4][\text{CuCl}_4]$. (1)

3. Coordination number of platinum in the complex, $[\text{Pt}(\text{en})_2\text{Cl}_2]$ is 6 as en is a bidentate ligand. Let the oxidation state of Pt is x .

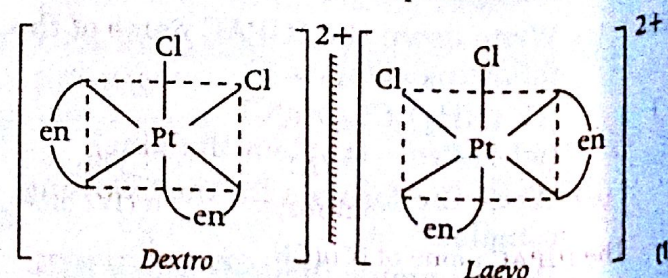
$$\therefore x + 0 + 2(-1) = 0 \Rightarrow x = +2$$

Thus, oxidation state of Pt be +2 (1)

4. IUPAC name of $[\text{Pt}(\text{en})_2\text{Cl}_2]^{2+}$ is dichlorobis(ethane 1, 2-diamine) platinum (IV) ion. The given complex show geometrical isomerism and optical-isomerism as follows.

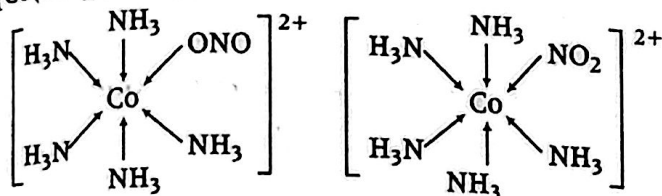


cis-form is optically active



5. The IUPAC name of the complex, $[\text{Ni}(\text{NH}_3)_6]\text{Cl}_2$ is hexaamminenickel (II) chloride. (1)

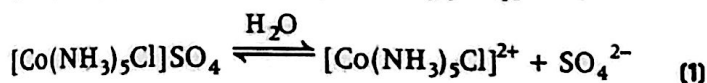
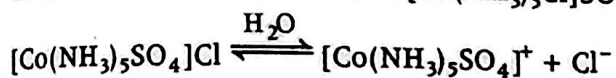
6. The complex, $[\text{Co}(\text{NH}_3)_5\text{NO}_2]^{2+}$ exhibits linkage isomerism as NO_2 group being an ambidentate ligand can bind to a metal atom either through N or O atom and, hence two different isomers are formed. These are: $[\text{Co}(\text{ONO})(\text{NH}_3)_5]^{2+}$ and $[\text{Co}(\text{NO}_2)(\text{NH}_3)_5]^{2+}$.



Pentaamminenitrito-O-cobalt (III) ion (Red) $[\text{Co}(\text{ONO})(\text{NH}_3)_5]^{2+}$ Pentaamminenitrito-N-cobalt (III) ion (Yellow) $[\text{Co}(\text{NO}_2)(\text{NH}_3)_5]^{2+}$ (1)

7. The complex, $[\text{Co}(\text{NH}_3)_5\text{SO}_4]\text{Cl}$ exhibits ionisation isomerism as it gives two different ions when dissolve in water.

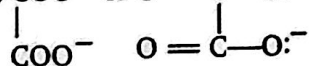
Its another ionisation isomer is $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{SO}_4$.



8. The complex, $[\text{Co}(\text{NH}_3)_6][\text{Cr}(\text{CN})_6]$ shows coordination isomerism which is caused by the interchange of ligands between the two complex ions. Its another coordination isomer is $[\text{Cr}(\text{NH}_3)_6][\text{Co}(\text{CN})_6]$. (1)

9. The number of coordinating or ligating sites present in a ligand is called the denticity of that ligand. e.g.

Oxalate ion (ox), COO^- or $\text{O}=\text{C}-\text{O}^-$ has a



denticity of two. (1)

10. The IUPAC name of the complex, $\text{K}_3[\text{CrF}_6]$ is potassium hexafluorochromate (III). (1)

11. The IUPAC name of the complex, $[\text{PtCl}(\text{NH}_2\text{CH}_3)(\text{NH}_3)_2]\text{Cl}$ is diamminechlorido methylamine platinum (II) chloride. (1)

12. The IUPAC name of the complex, $[\text{Pt}(\text{NH}_3)_4\text{Cl}_2]\text{Cl}_2$ is tetraamminedichlorido platinum (IV) chloride. (1)

13. The IUPAC name of $[\text{Cr}(\text{NH}_3)_6][\text{Co}(\text{CN})_6]$ is hexaamminechromium (III) hexacyano cobaltate (III). (1)

14. The IUPAC name of $[\text{Pt}(\text{NH}_3)_3(\text{NO})\text{Cl}_2]\text{Br}_2$ is triamminedichloridonitrosylplatinum (IV) bromide. (1)

15. The IUPAC name of $[\text{Co}(\text{CN})_2(\text{NH}_3)_4]\text{Cl}$ is tetraamminedicyanocobalt (III) chloride. (1)

16. The IUPAC name of $[\text{Cr}(\text{NH}_3)_5(\text{NCS})][\text{ZnCl}_4]$ is pentaammineisothiocyanato chromium (III) tetrachlorozincate (II). (1)

17. $[\text{Co}(\text{NH}_3)_5(\text{NO}_2)]\text{Cl}_2$ and $[\text{Co}(\text{NH}_3)_5(\text{ONO})]\text{Cl}_2$ are examples of linkage isomerism. (1)

18. Coordination isomerism occurs when cation and anion both are complex ions and differ in the distribution of ligands in the cation and anion. e.g.

(i) $[\text{Co}(\text{NH}_3)_6][\text{Cr}(\text{CN})_6]$ and $[\text{Cr}(\text{NH}_3)_6][\text{Co}(\text{CN})_6]$

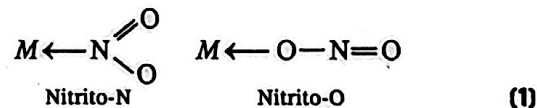
(ii) $[\text{Cr}(\text{NH}_3)_6][\text{Co}(\text{C}_2\text{O}_4)_3]$ and $[\text{Co}(\text{NH}_3)_6][\text{Cr}(\text{C}_2\text{O}_4)_3]$ (1)

19. $[\text{Co}(\text{en})_3][\text{Cr}(\text{CN})_6]$ and $[\text{Cr}(\text{en})_3][\text{Co}(\text{CN})_6]$ is an example of coordination isomerism. (1)

20. $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{SO}_4$ and $[\text{Co}(\text{NH}_3)_5(\text{SO}_4)]\text{Cl}$ is an example of ionisation isomerism. (1)

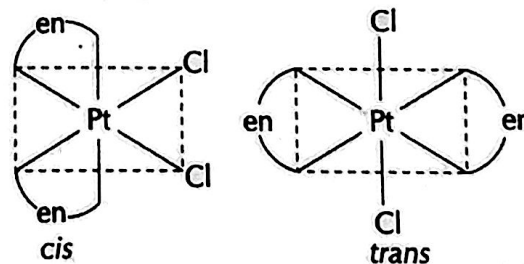
21. The IUPAC name of $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$ is pentaamminechloridocobalt (III) chloride. (1)

22. **Ambidentate ligand** Ligands which can ligate through two different atoms (with any one at a time) present in it are called ambidentate ligands. e.g. NO_2^- , SCN^- , CNO^- , etc. NO_2^- can ligate through two sites, e.g.



23. $[\text{Pt}(\text{en})_2\text{Cl}_2]$

IUPAC name : dichloridobis(ethylenediamine) platinum(II). Geometrical isomers of $[\text{Pt}(\text{en})_2\text{Cl}_2]$ are



24. (i) Hexaamminecobalt(III) sulphate $[\text{Co}(\text{NH}_3)_6]_2(\text{SO}_4)_3$

(ii) Potassium trioxalatochromate (III) $\text{K}_3[\text{Cr}(\text{Ox})_3]$ or $\text{K}_3[\text{Cr}(\text{C}_2\text{O}_4)_3]$

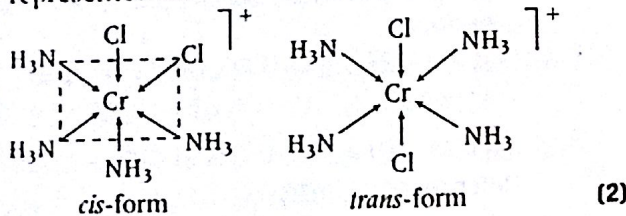
25. (i) Potassium trioxalatoaluminate (III) $\text{K}_3[\text{Al}(\text{C}_2\text{O}_4)_3]$ (1)

(ii) Dichloridobis(ethane-1, 2-diamine)cobalt (III) $[\text{CoCl}_2(\text{en})_2]^+$ (1)

26. (i) Sodium dicyanidoaurate (I)- $\text{Na}[\text{Au}(\text{CN})_2]$ (1)
 (ii) Tetraamminechlorido nitrito-N-platinum (IV) sulphate $[\text{Pt}(\text{NH}_3)_4\text{Cl}(\text{NO}_2)]\text{SO}_4$ (1)

27. IUPAC name is tetraamminedichlorido chromium (III) ion.

Isomerism It shows geometrical isomerism and has two isomers *cis* and *trans* that can be represented as:



28. (i) The IUPAC name of the complex, $[\text{Co}(\text{NH}_3)_5\text{Cl}]^{2+}$ is pentaamminechloridocobalt (III) ion. (1)

(ii) The formula for the complex, potassium tetrachloridonickelate (II) is $\text{K}_2[\text{NiCl}_4]$. (1)

29. (i) The IUPAC name of $[\text{Cr}(\text{NH}_3)_2\text{Cl}_2(\text{en})]\text{Cl}$ is diamminedichlorido (ethane-1, 2- diamine) chromium (III) chloride. (1)

(ii) The formula for the complex, pentaamminenitrito-O-cobalt ion is $[\text{Co}(\text{NH}_3)_5(\text{ONO})]^{2+}$. (1)

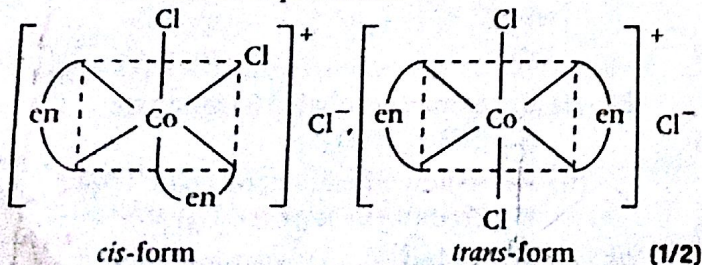
30. (i) The IUPAC name of the complex, $[\text{Cr}(\text{en})_3]\text{Cl}_3$ is *tris* (ethane-1,2- diamine) chromium (III) chloride. (1)

(ii) The formula for the complex, potassiumtrioxalatochromate (III) is $\text{K}_3[\text{Cr}(\text{C}_2\text{O}_4)_3]$. (1)

31. (i) $[\text{CoCl}_2(\text{en})_2]\text{Cl}$

IUPAC name Dichlorido *bis*-(ethane-1, 2-diamine) cobalt (III) chloride (1/2)

Structures There are two possible structures of $[\text{CoCl}_2(\text{en})_2]\text{Cl}$, one is *cis* and other is *trans* that can be represented as:



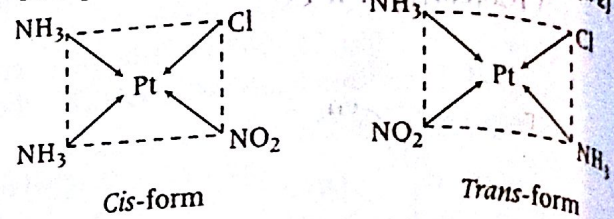
(ii) $[\text{Pt}(\text{NH}_3)_2\text{Cl}(\text{NO}_2)]$

IUPAC name

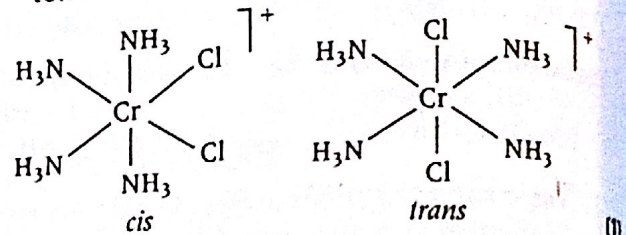
Diamminechloridonitrito-N-platinate (II). (1/2)

Structures

There are two structures of $[\text{Pt}(\text{NH}_3)_2\text{Cl}(\text{NO}_2)]$, one is *cis* form and other is *trans*-form that can be represented as:



32. (i) IUPAC name of $[\text{Cr}(\text{NH}_3)_4\text{Cl}_2]^+$ is tetraammine dichloride chromium(III)

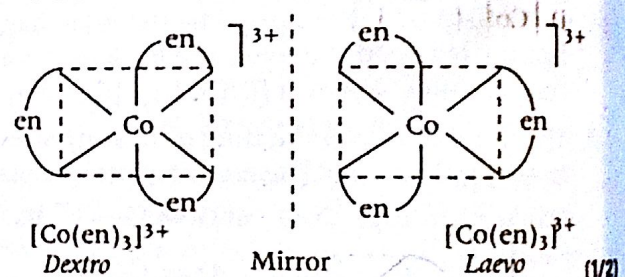


(ii) $[\text{Co}(\text{en})_3]^{3+}$

IUPAC name

Tris-(ethane-1,2- diamine) cobalt (III) ion. (1/2)

Structure There are two optical isomers of $[\text{Co}(\text{en})_3]^{3+}$, one is *dextro* and other is *laevo* whose structures are:



33. IUPAC name of the following coordination compounds are:

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

Tetraammineaquachloridocobalt (III) chloride (1)

(ii) $[\text{CrCl}_2(\text{en})_2]\text{Cl}$:

Dichlorido *bis*-(ethane-1,2- diamine) chromium (III) chloride. (1)

34. (i) Refer to solution 5.

(ii) $\text{K}_3[\text{Fe}(\text{CN})_6]$: Potassium hexacyano ferrate (III).

(iii) Refer to solution 32 (ii).

35. The IUPAC name of the following complexes is

(i) $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$:

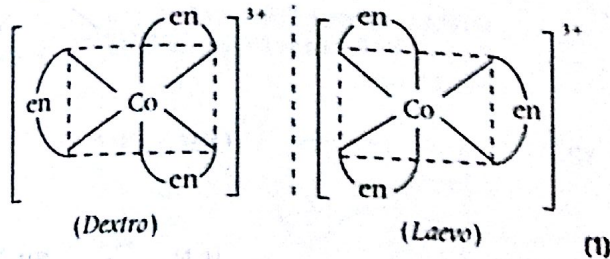
Hexaamminecobalt (III) chloride (1)

(ii) $[\text{NiCl}_4]^{2-}$: Tetrachloridonickelate (II) ion (1)

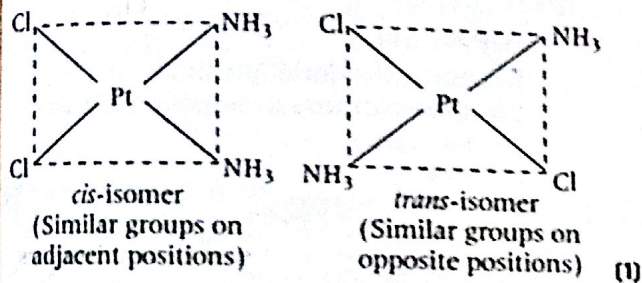
(iii) $K_3[Fe(CN)_6]$
Potassium hexacyanoferrate (III). (1)

(i) $[Co(NH_3)_5(NO_2)]^{2+}$: It exhibits linkage isomerism. [For structures refer to solution 6.] (1)

(ii) $[Co(en)_3]Cl_3$: It exhibits optical isomerism and exists in two forms: *dextro* and *laevo* that can be represented as:

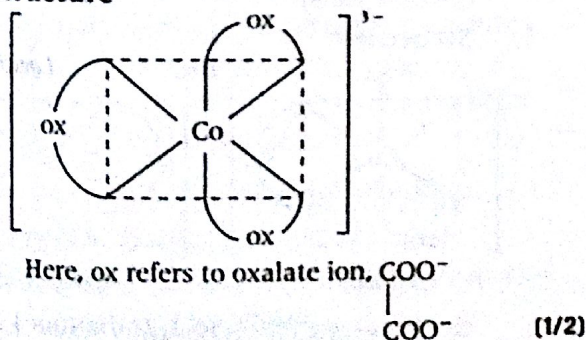


(iii) $[Pt(NH_3)_2Cl_2]$ It exhibits geometrical isomerism and exists in two geometrical forms, *cis* and *trans*. Their structures are:



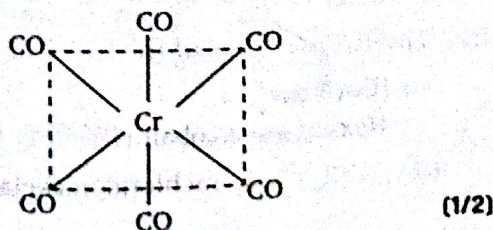
(i) $[Co(COO)_3]^{3-}$
IUPAC name Trioxalatocobaltate (III) ion (1/2)

Structure

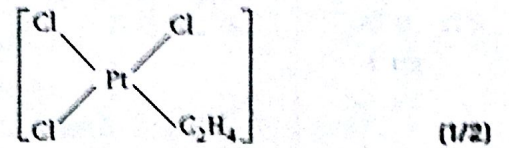


(ii) $[Cr(CO)_6]$
IUPAC name Hexacarbonylchromium(0) (1/2)

Structure



(iii) $[PtCl_3(C_2H_4)]$
IUPAC name: Trichloridoetheneplatinum (IV)
Structure (1/2)



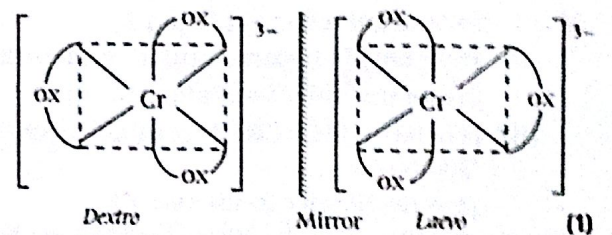
38. The IUPAC name of the following given complexes are:

(i) $[Co(NH_3)_5Cl]Cl_2$: Pentaamminechloridocobalt (III) chloride (1)

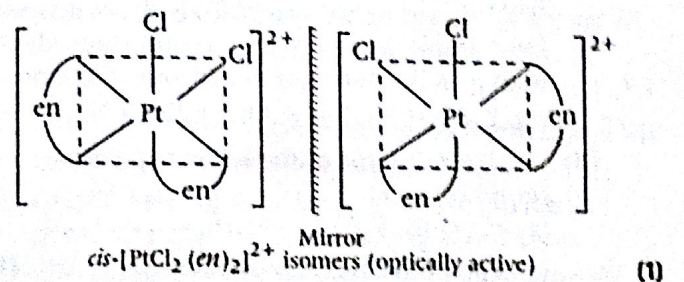
(ii) $K_3[Fe(CN)_6]$
Refer to solution 35 (iii). (1)

(iii) $[NiCl_4]^{2-}$
Refer to solution 35 (ii). (1)

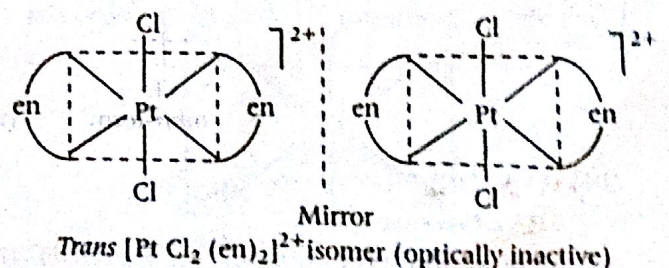
39. (i) $[Cr(C_2O_4)_3]^{3-}$
It exhibits two optical forms *dextro* and *laevo*, whose structures are:



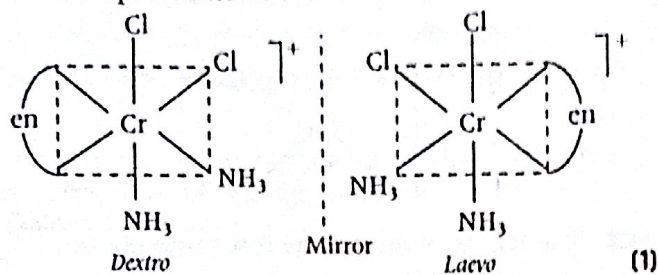
(ii) $[PtCl_2(en)_2]^{2+}$
It has two geometrical isomers, *cis* and *trans* isomers among which only *cis*-isomer shows optical isomerism. Their structures are:



NOTE The structure of *trans* $[PtCl_2(en)_2]^{2+}$ isomer is optically inactive due to superimposable mirror images.



(iii) $[\text{Cr}(\text{NH}_3)_2\text{Cl}_2(\text{en})]^+$: Its two optical isomers may be represented as:



40. The IUPAC name of the following given compounds is:

(i) $[\text{Cr}(\text{NH}_3)_3\text{Cl}_3]$ (1)

Triamminetrichloridochromium (III)

(ii) $\text{K}_3[\text{Fe}(\text{CN})_6]$ (1)

Refer to solution 34 (ii).

(iii) $[\text{CoBr}_2(\text{en})_2]^+$ (1)

Dibromido bis-(ethane - 1, 2 diamine) cobalt (III) ion.

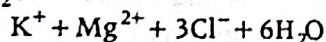
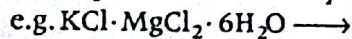
41. (i) $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{SO}_4$: It exhibits ionisation isomer. [For detail refer to solution 7] (1)

(ii) $[\text{Co}(\text{en})_3]^{3+}$: It shows optical isomerism.

[For detail refer to solution 36 (ii).]

(iii) $[\text{Co}(\text{NH}_3)_6][\text{Cr}(\text{CN})_6]$: It exhibit coordination isomerism [For detail refer to solution 8]. (1)

42. (i) Double salts dissociate completely into their constituent simple ions when dissolve in water, i.e they lose their identity in aqueous solution.



While coordination compounds do not dissociate into simple ions, i.e. they retain their identity both in solid state and in aqueous solutions.

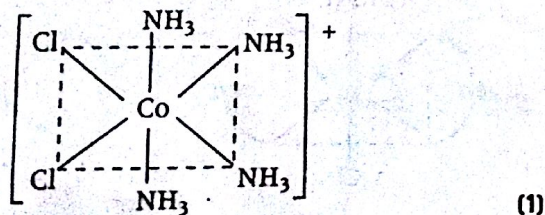


(ii) The IUPAC name of the following given complexes are:

(a) $\text{K}_3[\text{Fe}(\text{C}_2\text{O}_4)_3]$: Potassiumtrioxalatoferate (III) (1/2)

(b) $[\text{Pt}(\text{NH}_3)_6]\text{Cl}_4$: Hexaammineplatinum (IV) chloride (1/2)

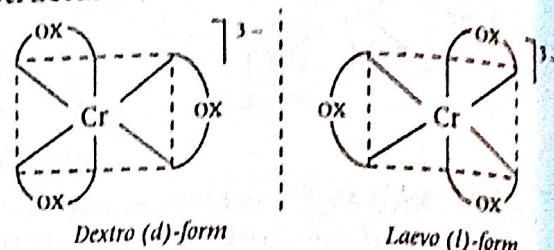
(iii) The structure of *cis*-isomer of $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]^+$ ion is:



43. Geometrical isomers are *cis* - and *trans* forms, optical isomers are *d*- and *l*- forms (mirror images). $[\text{M}(\text{AA})_3]$ type complex does not exhibit geometrical isomerism, they show optical isomerism.

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

IUPAC name Trioxalatochromate (III) ion
Possible Isomers Optical Isomers (*d* and *l*)
Structure



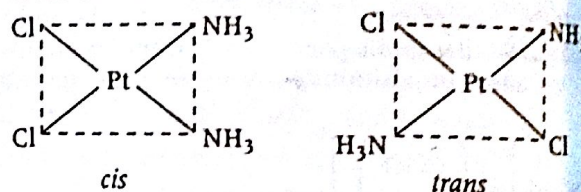
(ii) $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$

IUPAC name

Diamminedichloridoplatinum (II)

Possible isomers Geometrical isomers (*cis* and *trans*)

Structure



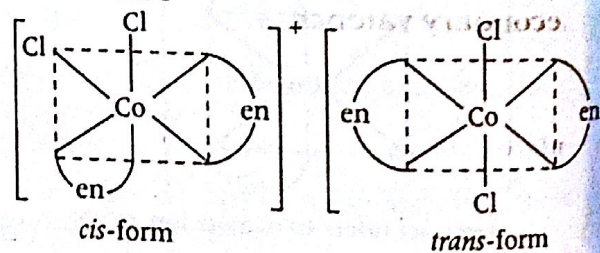
(iii) $[\text{Co}(\text{en})_2\text{Cl}_2]^+$

IUPAC name Dichlorido bis -

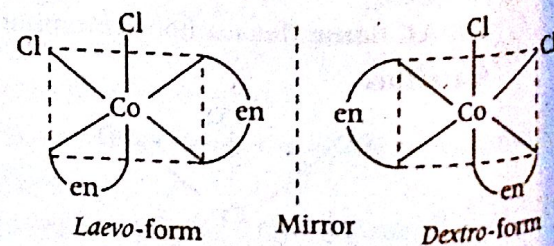
(ethane - 1, 2 diamine) cobalt (III) ion

Possible isomers Geometrical isomers (*cis* and *trans*)

Structure



cis - $[\text{Co}(\text{en})_2\text{Cl}_2]^+$ is optically active and exists in *dextro* (*d*) and *laevo* (*l*) forms.



44. (i) Refer to solution 43 (iii).

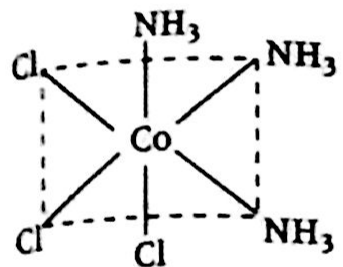
(ii) Refer to solution 43 (i)

(iii) $[\text{Co}(\text{NH}_3)_3\text{Cl}_3]$

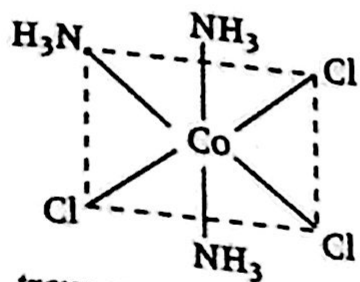
IUPAC name Triamminetrichloridocobalt (III)

Possible isomers Geometrical isomers
[i.e. shows *cis* and *trans* isomers]

Structure



cis or facial isomer



trans or meridional isomer

45. (i) $[\text{Co}(\text{en})_3]\text{Cl}_3$:

IUPAC name : *Tris* - (ethane-1,2-diamine)
cobalt (III) chloride.

(1)

(1)

Isomers optical isomers (*dextro* and *laevo* forms)

Structure Refer to solution 36 (ii).

(ii) $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$ Refer to solution 43 (ii).

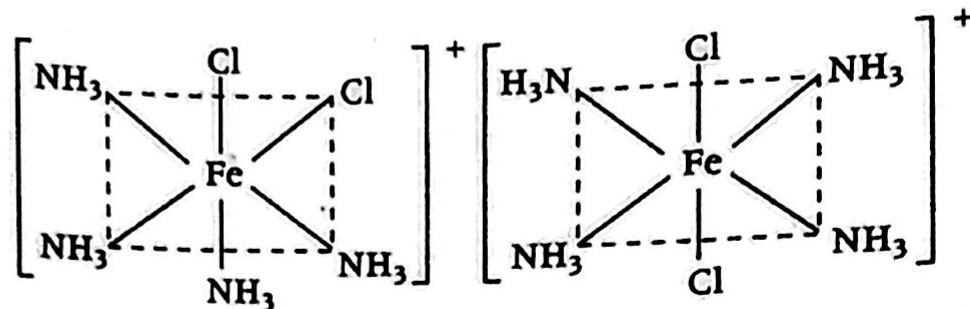
(iii) $[\text{Fe}(\text{NH}_3)_4\text{Cl}_2]\text{Cl}$

IUPAC name

Tetraamminedichloridoiron (III) chloride

Isomers Geometrical isomers (*cis* and *trans*)

Structure



cis-form

trans-form

(1)

Explanations

1. When one mole of $\text{CrCl}_3 \cdot 6\text{H}_2\text{O}$ is mixed with AgNO_3 , two moles of AgCl are precipitated which indicates that two ionisable chloride ions in the complex are present. Hence, its structural formula is $[\text{Cr}(\text{H}_2\text{O})_5\text{Cl}]\text{Cl}_2 \cdot \text{H}_2\text{O}$. (1)

2. When one mole of $\text{CoCl}_3 \cdot 6\text{NH}_3$ is mixed with AgNO_3 , three moles of AgCl are precipitated which indicates that three ionisable chloride ions in the complex are present. Hence, its structural formula is $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$. (1)

3. When a didentate or a polydentate ligand containing donor atoms positioned in such a way that, they coordinate with the central metal ion forming a five or six membered ring the effect is called **chelate effect**.

As a result of chelate effect, the stability of the complex increases. (1)

4. $[\text{Co}(\text{en})_3]^{3+}$ is more stable complex because of chelation. (1)

5. In both the complexes, Fe is in +2 state with the configuration $3d^6$, i.e. it has four unpaired electrons. As the ligands H_2O and CN^- possess different crystal field splitting energy (Δ_o) they absorb different components of visible light (VIBGYOR) for $d-d$ transition. Hence, the transmitted colours are different. (1)

6. Ligand such as CO has empty π -orbitals which overlap with the filled d -orbitals (t_{2g} orbitals) of transition metals forming π -bonds (back bonding). Hence, CO is a π -acceptor ligand which can accept the electron density from the metal atom into their π^* orbitals. These π

π interactions increase the value of Δ_o . This accounts for the position of this ligand as strong field ligand. Whereas Cl^- cannot form π bonds by back bonding. Hence, it is a weak field ligand. (1)

7. (i) Refer to solution 1. (1)

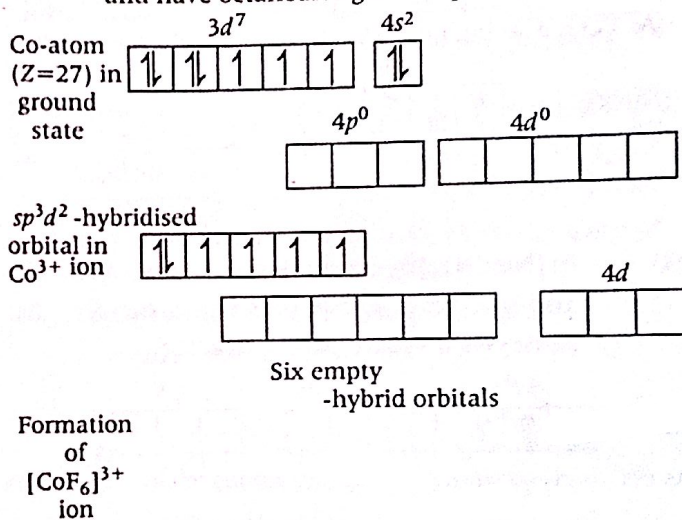
(ii) IUPAC name of the complex

$[\text{Cr}(\text{H}_2\text{O})_5\text{Cl}]\text{Cl}_2 \cdot \text{H}_2\text{O}$ is pentaquachloridochromium (III) chloride. (1)

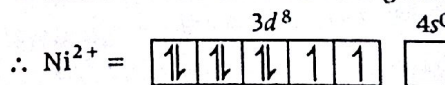
8. (i) Refer to solution 2. (1)

(ii) IUPAC name of the complex $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$ is hexaamminecobalt (III) chloride. (1)

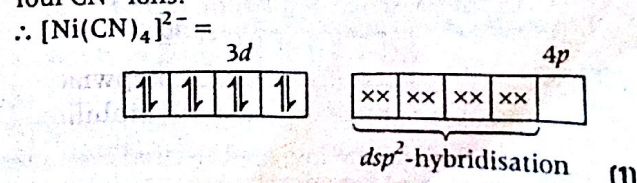
9. (i) In $[\text{CoF}_6]^{3-}$, cobalt is in +3 oxidation state. F^- is a weak field ligand. It does not cause pairing. Therefore, cobalt undergoes sp^3d^2 -hybridisation and has octahedral geometry. (1)



(ii) In $[\text{Ni}(\text{CN})_4]^{2-}$, nickel is in +2 oxidation state and has the electronic configuration $3d^8 4s^0$. (1)



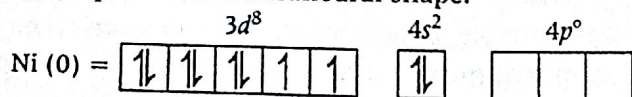
As CN^- is a strong field ligand, pairing of electrons takes place and resulting in empty one $3d$ orbital, one $4s$ orbital and two $4p$ orbitals which undergoes hybridisation to form four dsp^2 -hybrid orbitals. These hybrid orbitals occupied by electron pairs of four CN^- ions.



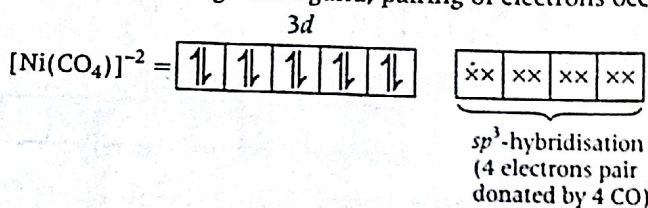
Thus, the hybridisation involved is dsp^2 and therefore, complex is square planar. (1)

10. (i) As CO is a good σ -sigma donor and a good π -acceptor ligand, there exists a back bonding in CO complexes in which CO accepts an appreciable amount of electron density from the filled d -orbitals of metal atom into their empty π or π^* orbitals. These π interactions increase the value of Δ_o . Whereas NH_3 can form only σ -bonds and no π -bonds with metals, therefore CO is a better complexing reagent than NH_3 . (1)

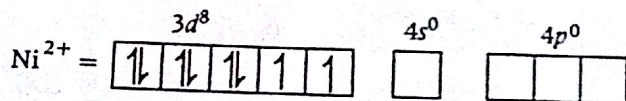
(ii) In $[\text{Ni}(\text{CO})_4]$, Ni has oxidation state equal to zero and involves sp^3 -hybridisation hence possesses a tetrahedral shape. (1)



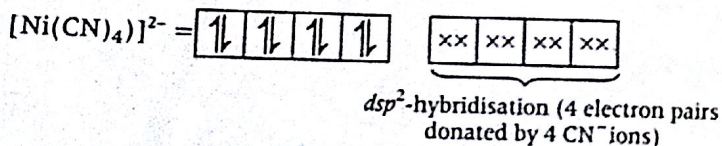
As CO is a strong field ligand, pairing of electrons occurs



In $[\text{Ni}(\text{CN})_4]^{2-}$, the oxidation state of Ni is +2 and it involves dsp^2 -hybridisation, hence, possesses a square planar structure.

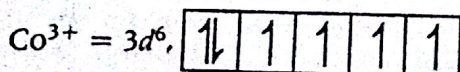


As CN^- is also a strong field ligand, pairing of electrons occurs

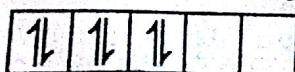


11. (i) First find the electronic configuration of Co^{3+} and Co^{2+} . Then do pairing.

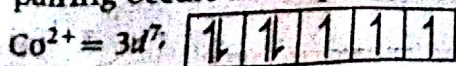
The electronic configuration of Co^{3+} is $3d^6 4s^0$. So, pairing occurs in the presence of a strong ligand. Thus, there are no unpaired electrons and it is highly stable.



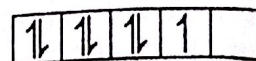
In the presence of a strong ligand,



However, in Co^{2+} , electronic configuration is $3d^7$, there is one unpaired electron even after pairing occurs in the presence of a strong ligand.



In the presence of a strong ligand



This unpaired electron can be easily lost and shows an oxidation state of +3

Hence, Co^{2+} is oxidised to more stable Co^{3+} . (1)

(ii) Refer to solution 10 (i).

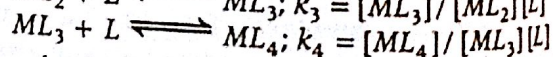
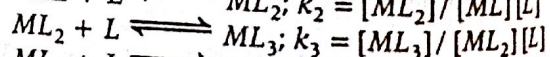
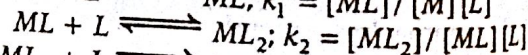
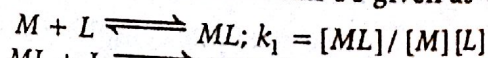
12. When ligands approach a transition metal in a definite geometry, the degenerate d -orbitals splits into two sets, one with lower energy and the other with higher energy. The difference of energy between the two sets of d -orbitals is called **crystal field splitting energy**. It is denoted by Δ_o (for octahedral complexes) and Δ_t (for tetrahedral complexes). (1)

The magnitude of splitting decide the actual configuration of d -orbital in an octahedral field for a coordination entity as follows. (1)

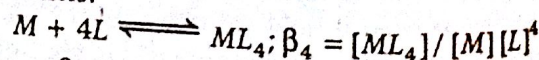
If $\Delta_o < P$ (P is the energy required for pairing of electrons) then fourth electron enters one of the e_g orbitals giving the configuration $t_{2g}^3 e_g^1$. It means first four orbitals are singly occupied and no pairing will take place, forming high spin complexes. Such ligands for which $\Delta_o < P$ are called **weak field ligands**.

If $\Delta_o > P$, the 4th electron pairs up in one of the t_{2g} orbitals giving the configuration $t_{2g}^4 e_g^0$ thereby forming low spin complexes. Such ligands for which $\Delta_o > P$ are called **strong field ligands**. (1)

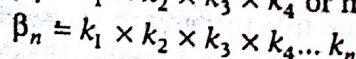
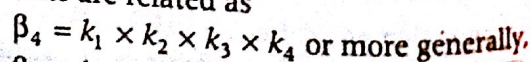
13. The equilibrium constant of each step of a complex reaction is called **stepwise stability constant**. **Overall stability constant** is the equilibrium constant for net reaction. The stepwise stability constant can be given as



where, k_1, k_2 etc. are referred as stepwise stability constants. (1)



where, β_4 is the overall stability constant. Thus, stepwise stability constants and overall constants are related as

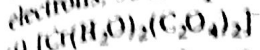


14. For shape Refer to solution 9 (ii)

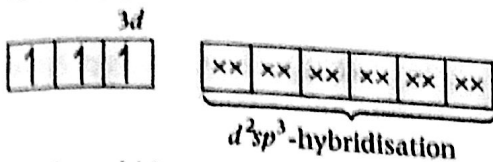
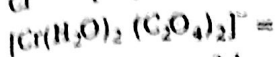
Magnetic behaviour As all the electrons are paired, so it is diamagnetic in nature.

For shape Refer to solution 9 (1)

Magnetic behaviour As there are four unpaired electrons, so it is paramagnetic in nature.



In this complex, Cr is present as Cr^{3+} .
 $\text{Cr}^{3+} = [\text{Ar}] 3d^3 4s^0$



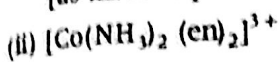
[∴ Oxalate is a bidentate ligand, one oxalate occupies two orbitals].

Thus, **hybridisation** - d^2sp^3

Structure Octahedral

Magnetic behaviour Paramagnetic

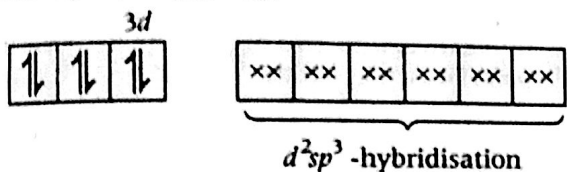
[as three unpaired electrons are present]. (1)



Here, Co is present as Co^{3+} ($3d^6$).

(en and NH_3 are strong field ligands and thus, pair up the electrons of $3d$ -orbitals).

Thus, $[\text{Co}(\text{NH}_3)_2(\text{en})_2]^{3+} =$



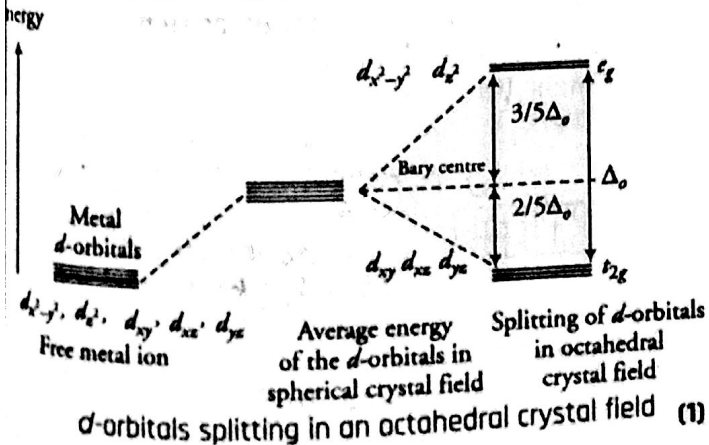
Hybridisation - d^2sp^3

Structure Octahedral

Magnetic nature Diamagnetic (as all the electrons are paired). (1)

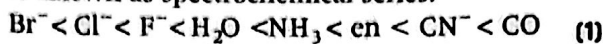
Note en is also a bidentate ligand.

17. (i) **Crystal field splitting** In a free transition metal ion, all the five d -orbitals are degenerate (having equal energies). But when ligand approaches a metal ion, this degeneracy splits due to repulsion of electrons of ligands and electrons of metal ions.

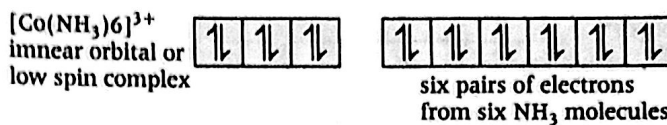
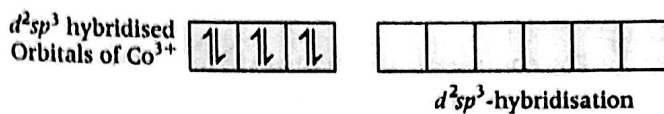
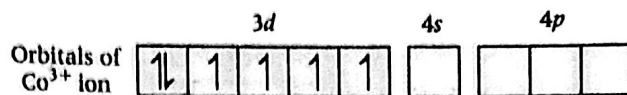


Thus, the splitting of degenerate levels (or orbitals) due to the presence of ligands in a definite geometry is known as **crystal field splitting** in an octahedral complex.

(ii) **Spectrochemical series** The arrangement of ligands in the order of increasing field strengths, i.e. increasing crystal field splitting energy values is known as spectrochemical series.

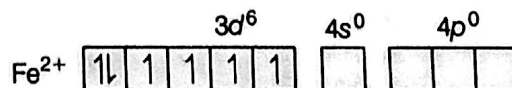
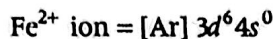


18.

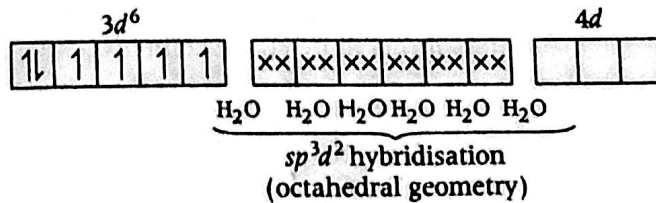
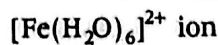


Magnetic behaviour Because of the absence of unpaired electrons it is **diamagnetic**. (2)

19. (i) $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$: outer configuration of ${}_{26}\text{Fe}$ atom = $[\text{Ar}] 3d^6 4s^2$

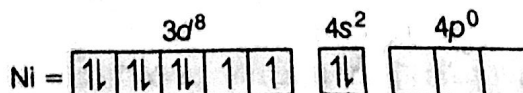


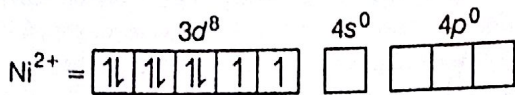
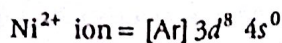
(H_2O being weak field ligands, they do not cause electron pairing).



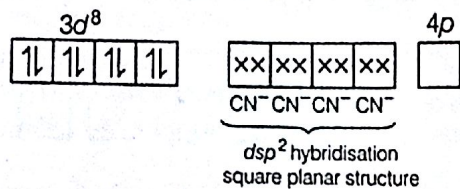
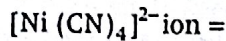
The complex is **paramagnetic** in nature as it has **four unpaired electrons**.

(ii) $[\text{Ni}(\text{CN})_4]^{2-}$: Outer configuration of ${}_{28}\text{Ni}$ atom = $[\text{Ar}] 3d^8 4s^2$

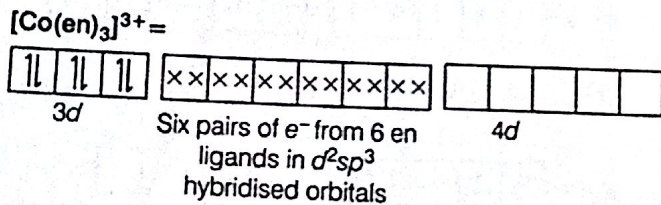
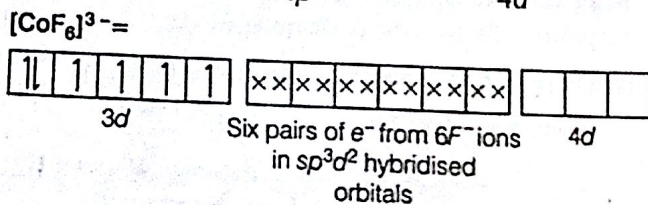
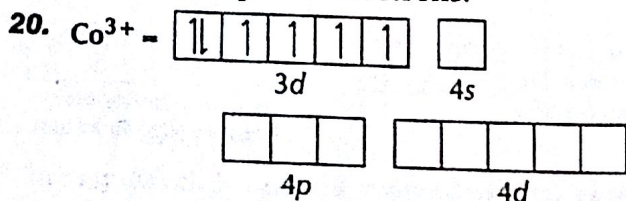




(CN^- being strong field ligand pair up the d -electrons of metal atom.)

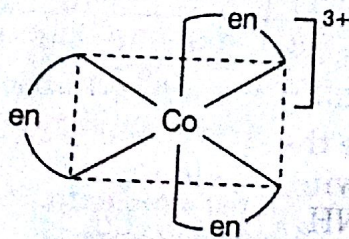


The complex is **diamagnetic** in nature as it has **no unpaired electrons**.



(i) $[\text{CoF}_6]^{3-}$ is paramagnetic since it contains 4 unpaired electrons.

(ii) $[\text{Co}(\text{en})_3]^{3+}$ is more stable since ethylenediamine (en) is a chelating ligand and thus forms more stable complex.



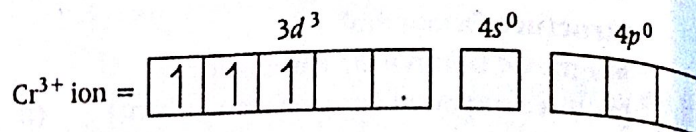
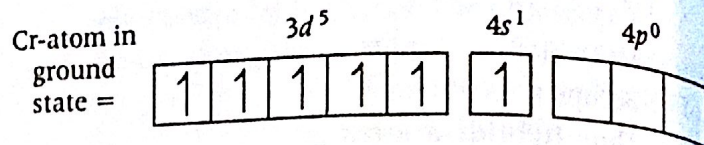
(iii) $[\text{Co}(\text{en})_3]^{3+}$ forms inner orbital complex since ethylenediamine (en) is a strong ligand which pairs up the electrons of Co^{3+} .

(iv) $[\text{CoF}_6]^{3-}$ forms high spin complex as F^- could not pair up the electrons of Co^{3+} being a weak ligand.

21. Crystal field splitting energy Refer to solution 12.

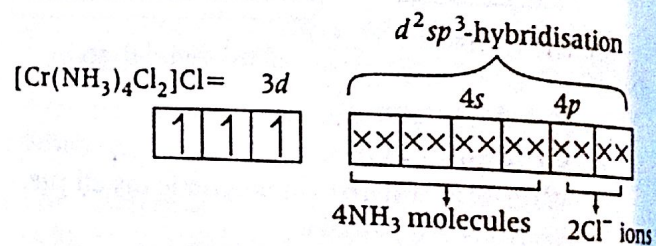
- (i) $\Delta_o > P$, (pairing energy), the 4th electron pair up in one of the t_{2g} orbitals giving the configuration $t_{2g}^4 e_g^0$
- (ii) If $\Delta_o < P$ the 4th electron enters one of the e_g orbitals giving the configuration $t_{2g}^3 e_g^1$.

22. (i) In $[\text{Cr}(\text{NH}_3)_4\text{Cl}_2]\text{Cl}$, Cr is present as Cr^{3+} . Its formation can be depicted as



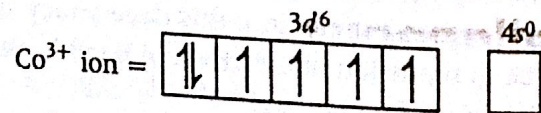
As Cl^- is a weak field so no pairing of electrons takes place. Thus, two $3d$, one $4s$ and three $4p$ -orbitals undergo hybridisation to form d^2sp^3 -hybrid orbitals.

Among six d^2sp^3 -hybrid orbitals, four orbitals occupied by electron pairs of four NH_3 molecules, and two are occupied by electron pairs of two Cl^- -ions.

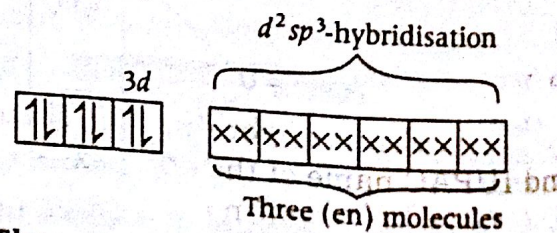


Thus, the shape of the complex is octahedral. Because of the presence of three unpaired electrons, it is paramagnetic in nature.

(ii) In $[\text{Co}(\text{en})_3]\text{Cl}_3$, Co is present as Co^{3+} .

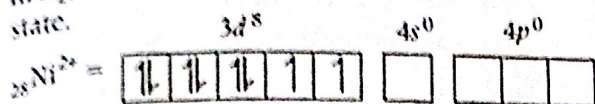


en being a strong field ligand, pair up the electrons of $3d$ -orbital. Thus, $[\text{Co}(\text{en})_3]\text{Cl}_3$ =

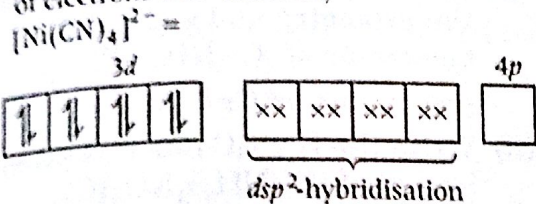


Shape Octahedral
Magnetic nature Diamagnetic
(as all the electrons are paired)

(iii) $K_2[Ni(CN)_4]$
 In $K_2[Ni(CN)_4]$ Ni is present in +2 oxidation state.



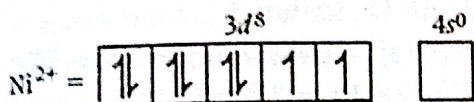
(CN^- is a strong field ligand. It causes pairing of electrons in d -orbitals.)



Shape Square planar

Magnetic nature Diamagnetic (1)

13. (i) In case of Ni, electronic configuration of Ni = $3d^8 4s^2$ and when it forms Ni^{2+} ion its electronic configuration becomes $3d^8 4s^0$.

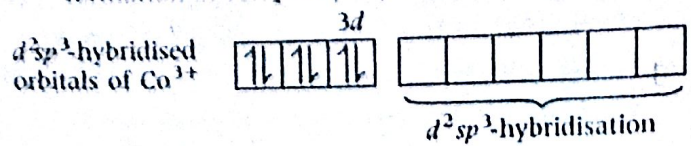


For low spin complexes, electrons get paired up. Thus, will produce only one empty d -orbital. Hence, d^2sp^3 -hybridisation is not possible in Ni to form octahedral complexes. (1)

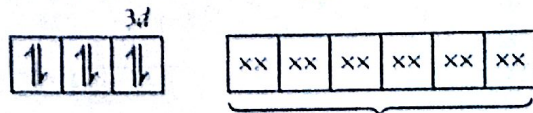
(ii) The transition metals/ions have empty d -orbitals into which the electron pairs can be donated by ligands containing π -electrons (e.g. $CH_2 = CH_2$ and C_6H_6 , etc.) while, the other metals do not have empty d -orbitals, hence, complexes are formed only by transition metal atom/ion. (1)

(iii) Refer to solution 11 (i) (1)

electron pairs of six NH_3 molecules resulting in the formation of complex $[\text{Co}(\text{NH}_3)_6]^{3+}$ ion.



Formation of $[\text{Co}(\text{NH}_3)_6]^{3+}$ ion



Six pairs of electrons from six NH_3 molecules, d^2sp^3 -hybridisation (1)

It is inner orbital, low spin complex due to d^2sp^3 -hybridisation.

Thus, its shape is **octahedral**

(as it is d^2sp^3 -hybridised).

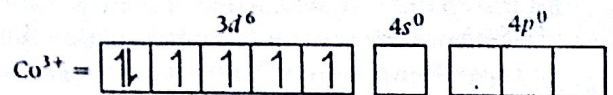
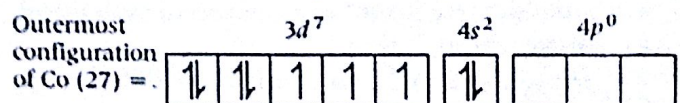
(1/2)

IUPAC name is : Hexaamminecobalt (III) ion. (2)

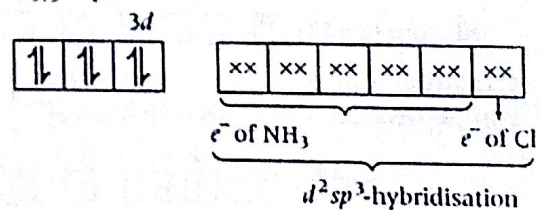
3. (i) $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$

IUPAC name Pentaamminechloridocobalt (III) chloride.

Stereochemistry and magnetic behaviour



$[\text{Co}(\text{NH}_3)_5\text{Cl}]^{2+}$ =



In $[\text{Co}(\text{NH}_3)_5\text{Cl}]^{2+}$, NH_3 being a strong field ligand causes pairing of electrons in d -orbitals of Co^{3+} ion.

Hence, the compound has d^2sp^3 -hybridisation and octahedral shape. Since, all the electrons are paired, the complex $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$ is diamagnetic. (1)

(ii) $\text{K}_2[\text{Ni}(\text{CN})_4]$

IUPAC Name

Potassium tetracyanonickelate (III)

Stereochemistry and magnetic behaviour

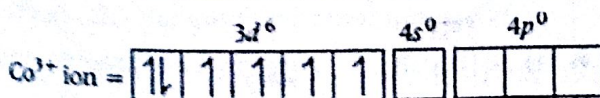
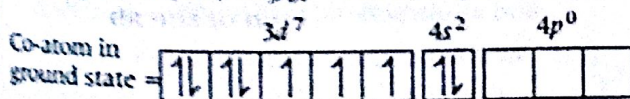
$[\text{COF}_6]^{3-}$ Refer to solution 9(ii) of topic 2. (1)

Explanations

1. For hybridisation and shape, refer to solution 9 of topic 2.

IUPAC name is : Hexafluorocobaltate (III) ion. (2)

2. In $[\text{Co}(\text{NH}_3)_6]^{3+}$, Co exists as Co^{3+} ion. The formation of $[\text{Co}(\text{NH}_3)_6]^{3+}$ can be explained as

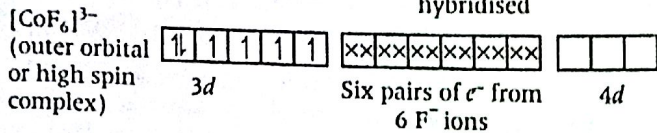
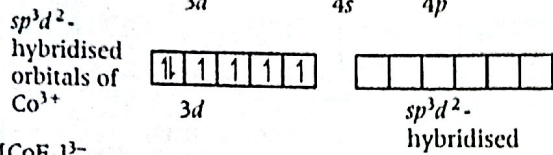
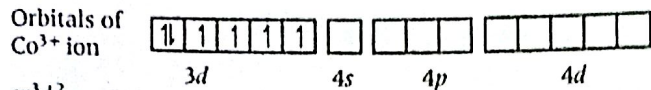


NH_3 being a strong field ligand causes pairing of $3d^6$ electrons resulting in empty two $3d$, one $4s$ and three $4p$ -orbitals which undergoes hybridisation to give six d^2sp^3 -hybrid orbitals. These six empty d^2sp^3 -hybrid orbitals would be accommodated by

4. (a) Iron (III) hexacyanoferrate (II) has formula—
 $\text{Fe}_4[\text{Fe}(\text{CN})_6]_3$ (1)

(b) $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{SO}_4$ exhibit ionisation isomers.
 Its ionisation isomer is $[\text{Co}(\text{NH}_3)_5\text{SO}_4]\text{Cl}$ (1)

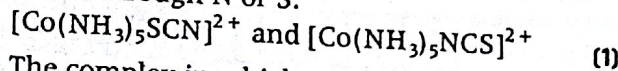
(c) $[\text{CoF}_6]^{3-}$: Oxidation state of cobalt is +3.



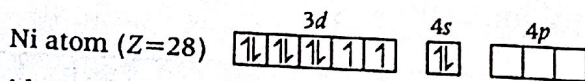
Six pairs of electrons one from each F^- ion occupy the six hybrid orbitals. Thus, the complex has octahedral geometry (sp^3d^2). (1)

5. Linkage isomerism arises in a coordination compound containing ambidentate ligand. Hence,

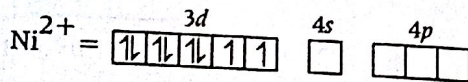
(i) $[\text{Co}(\text{NH}_3)_5(\text{SCN})]^{2+}$ exhibit linkage isomerism due to presence of SCN which is an ambidentate ligand and can linked with metal either through N or S.



(ii) The complex in which one or more unpaired electrons are present is paramagnetic while, those which does not contain any unpaired electron is diamagnetic.



Oxidation state of Ni is + 2 in both the complexes i.e. $[\text{NiCl}_4]^{2-}$ and $[\text{Ni}(\text{CN})_4]^{2-}$.

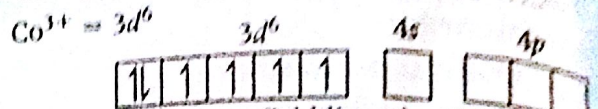
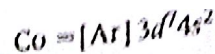


In case of $[\text{NiCl}_4]^{2-}$, Cl^- is a weak field ligand so pairing of electrons in 3d-orbital does not occur, hence compound is paramagnetic with two unpaired electrons. In $[\text{Ni}(\text{CN})_4]^{2-}$, CN^- is a strong field ligand, hence pairing occurs and $[\text{Ni}(\text{CN})_4]^{2-}$ is diamagnetic. (1)

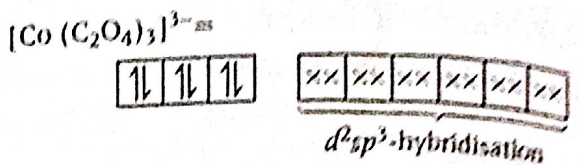
(iii) For tetrahedral complexes, the crystal field stabilisation energy is lower than pairing energy, so they are rarely formed in low spin state. (1)

6. (i) Refer to solution 36 (ii) of topic 1. (1)

(ii) In $[\text{Co}(\text{C}_2\text{O}_4)_3]^{3-}$, cobalt is in +3 oxidation state



As C_2O_4 is a strong field ligand, pairing of electrons will occur

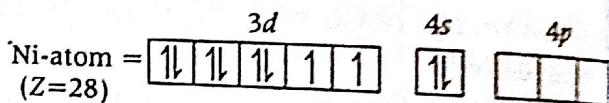


Magnetic character = Diamagnetic (all electrons are paired)

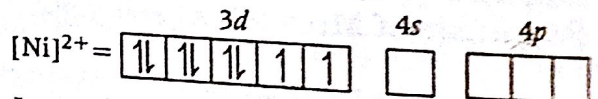
(iii) IUPAC name of the complex $[\text{Cr}(\text{NH}_3)_3\text{Cl}_3]$ Triamminetrichlorochromium (III).

7. (i) The type of isomerism exhibited by the $[\text{Co}(\text{NH}_3)_6][\text{Cr}(\text{CN})_6]$ is **coordination isomerism**. Here, both the positive and negative ions are complex ions. Isomerism may be caused by the interchange of ligands between the anion and cation. The two isomers are $[\text{Co}(\text{NH}_3)_6][\text{Cr}(\text{CN})_6]$ and $[\text{Cr}(\text{NH}_3)_6][\text{Co}(\text{CN})_6]$

(ii) Electronic configuration of Ni ($Z = 28$) = $[\text{Ar}] 3d^8 4s^2$



Oxidation state of Ni is +2 in both $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$ and $[\text{Ni}(\text{CN})_4]^{2-}$.



In case of $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$, H_2O is a weak field ligand so pairing of electrons in 3d-orbital does not occur. These unpaired electrons get excited from a lower energy d-orbital to a higher energy d-orbital. Due to d-d transition, $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$ possess green colour, whereas

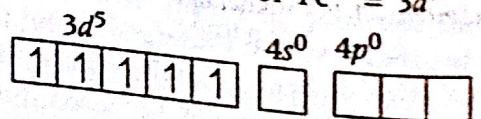
CN^- is a strong field ligand so pairing occurs and a solution of $[\text{Ni}(\text{CN})_4]^{2-}$ is colourless. (1)

(iii) The IUPAC name of the complex $[\text{Co}(\text{NH}_3)_5(\text{CO}_3)]\text{Cl}$ is pentaamminecarbonatocobalt (III) chloride. (1)

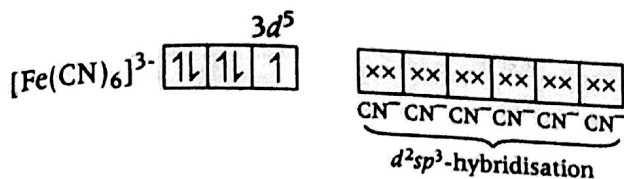
8. (i) In $[\text{Fe}(\text{CN})_6]^{3-}$ complex, Fe is present as Fe^{3+} .

Configuration of Fe = $[\text{Ar}] 3d^6 4s^2 4p^0$

Outer configuration of $\text{Fe}^{3+} = 3d^5$



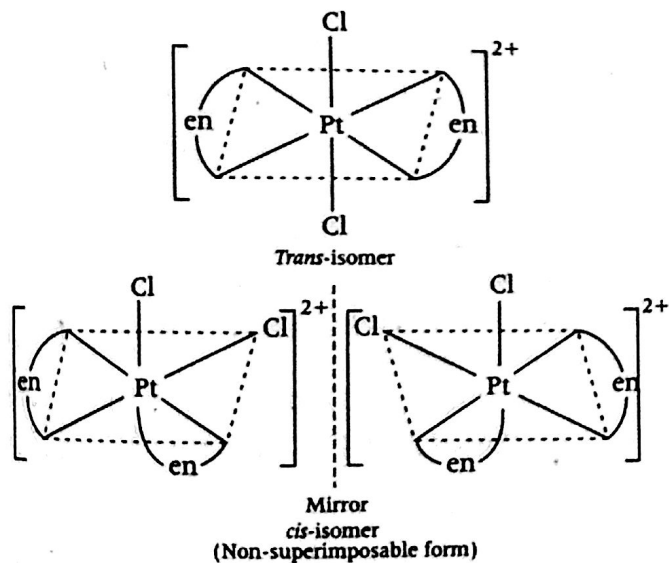
CN⁻ being strong field ligand, pair up the unpaired *d*-electrons. Thus, two 3*d*-orbitals are now available for CN⁻ ions.



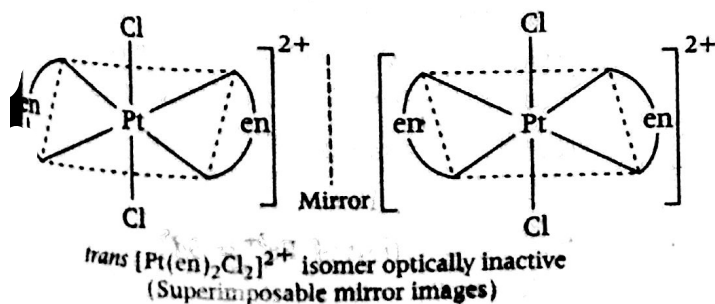
Since, one electron remains unpaired, the complex is paramagnetic.

Moreover, $(n-1)$ *d*-orbitals are involved in bonding. So, it is an inner orbital or low spin complex. (1½)

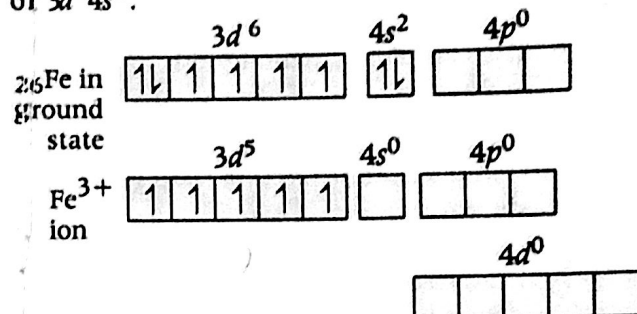
- (ii) The complex, [Pt(en)₂Cl₂]²⁺ contains two symmetrical didentate ligands, ethylenediamine (*en*) and exists in two geometrical isomers, *cis* and *trans*. *Trans* isomer being symmetrical does not show optical isomerism and hence, this isomer is optically inactive. While *cis* being unsymmetrical shows optical isomerism.



Hence, the structure of geometrical isomer (i.e. *trans* isomer) of the complex [Pt(en)₂Cl₂]²⁺ which is optically inactive is as follows:



9. (i) In [Fe(H₂O)₆]³⁺, Fe exists in +3 oxidation state having a valence shell electronic configuration of 3*d*⁵4*s*⁰.



As H₂O is a weak field ligand, electrons in 3*d*-subshell of Fe (III) ion will not pair up. Fe (III) ion uses its one 4*s*, three 4*p* and two 4*d* vacant orbitals for hybridisation and forms six *sp*³*d*²-hybrid orbitals which accommodates electrons from six H₂O molecules, thus, forming [Fe(H₂O)₆]³⁺ complex.

The complex, [Fe(H₂O)₆]³⁺ involves *sp*³*d*²-hybridisation and thus, it is **octahedral in shape**.

Since, the complex possesses five unpaired electrons in 3*d*-orbitals of Fe, therefore, the complex [Fe(H₂O)₆]³⁺ is **paramagnetic in nature**. Further, Fe forms an outer orbital complex by using its outer 4*d*-orbitals for *sp*³*d*²-hybridisation. As H₂O is weak field ligand, pairing of electrons will not occur which means Δ₀ < P, hence, it is a high spin complex.

Thus, for the complex, [Fe(H₂O)₆]³⁺,

Hybridisation - *sp*³*d*²

Magnetic character Paramagnetic

Spin High spin complex

- (ii) Refer to solution 8 (ii).

(1½)

(1½)

10. (i) The isomerism shown by the complex [Cr(H₂O)₆]Cl₃ is hydrate or solvate isomerism. The hydrate isomers of the given complex are

(a) [Cr(H₂O)₅Cl]Cl₂ · H₂O

Blue green (two ionisable chlorine)

(b) [Cr(H₂O)₄Cl₂]Cl · H₂O

Dark green (one ionisable chlorine)

Both isomers differ in the number of molecules of water in the coordination sphere.

(1)

- (ii) Refer to solution 21 (i) of topic 2

(1)

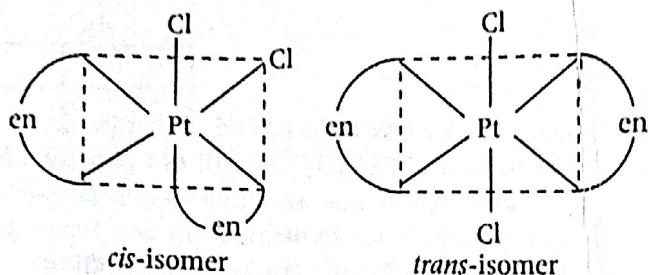
- (iii) Refer to solution 9 (i) of topic 2

(1)

11. (i) Refer to solution 36 (iii) of topic 1 (1)
 (ii) Refer to solution 21 (ii) of topic 2 (1)
 (iii) **For shape and hybridisation** Refer to solution 10 (ii) of topic 2.

The complex is diamagnetic as all the electrons are paired. (1)

12. (i) The complex $[\text{Pt}(\text{en})_2\text{Cl}_2]^{2+}$ has two geometrical isomers that are *cis* and *trans* which can be shown as



NOTE *cis*-isomer shows optical isomerism.

- (ii) Refer to solution 21 (i) of topic 2. (1)
 (iii) Refer to solution 9 (ii) of topic 2. (1)

13. (i) $[\text{Cr}(\text{NH}_3)_4\text{Cl}_2]\text{Cl}$

IUPAC name

Tetraamminedichlorido chromium (III) chloride. (1)

- (ii) Refer to solution 32 (ii) of topic 1. (1)

- (iii) In the complex $[\text{NiCl}_4]^{2-}$, Ni is in +2 oxidation state and has the configuration $3d^8 4s^0$. The Cl^- ion being a weak field ligand cannot pair up the two unpaired electrons present in the two unpaired $3d$ -orbitals. That means, $3d$ -orbitals are not involved in hybridisation. Thus, the complex is sp^3 -hybridised (tetrahedral) and is paramagnetic in nature. (1)

In the complex $[\text{Ni}(\text{CO})_4]$ the oxidation state of nickel is zero and outer electronic configuration is $3d^8 4s^2$. In the presence of strong field ligand CO, the $4s$ -electrons shifts to the two half-filled $3d$ -orbitals and make all the electrons paired. The valence $4s$ and $4p$ -orbitals are involved in hybridisation. Thus, the complex is tetrahedral but diamagnetic in nature. (1)

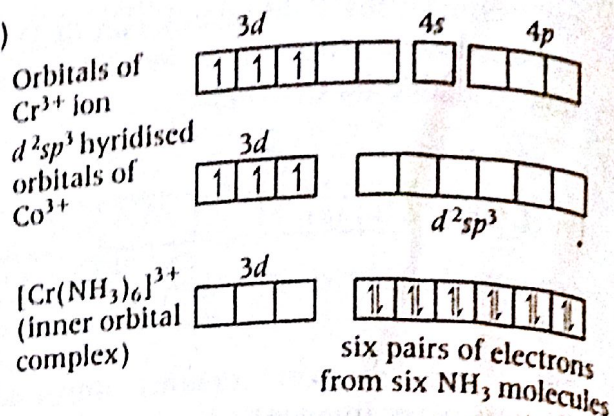
4. (i) The IUPAC name of $[\text{NiCl}_4]^{2-}$ is tetrachloridonickelate (II) ion. (1)

- (ii) sp^3 hybridisation (1)

[For detail refer to solution 13 (iii)] (1)

- (iii) **Shape** Due to sp^3 -hybridisation, its shape is tetrahedral. (1)

15. (i)



Geometry Octahedral geometry due to d^2sp^3 -hybridisation.

Magnetic behaviour Paramagnetic

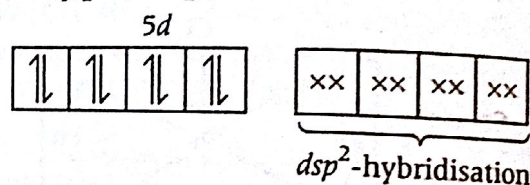
- (ii) The ionisation isomer of $[\text{Ni}(\text{NH}_3)_3\text{NO}_3]\text{Cl}$ is $[\text{Ni}(\text{NH}_3)_3\text{Cl}]\text{NO}_3$. Its IUPAC name is triamminechloridonickel (II) nitrate. (1)

16. (i) $[\text{Pt}(\text{NH}_3)_2\text{Cl}(\text{NO}_2)]$

IUPAC name

Diamminechloridonitrito-N-platinum (II)

$[\text{Pt}(\text{NH}_3)_2\text{Cl}(\text{NO}_2)]$



Structure Square planar

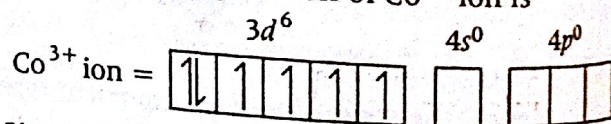
Magnetic behaviour Diamagnetic (as all the electrons are paired).

- (ii) $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]\text{Cl}$

IUPAC name

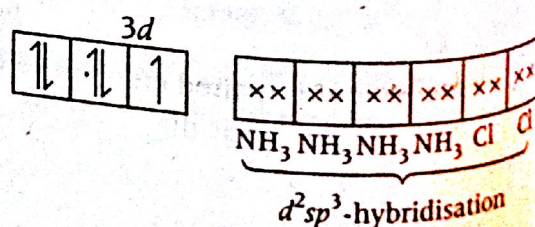
Tetraamminedichloridocobalt (III) chloride

In $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]^+$, Co exists as Co^{3+} ion. The electronic configuration of Co^{3+} ion is

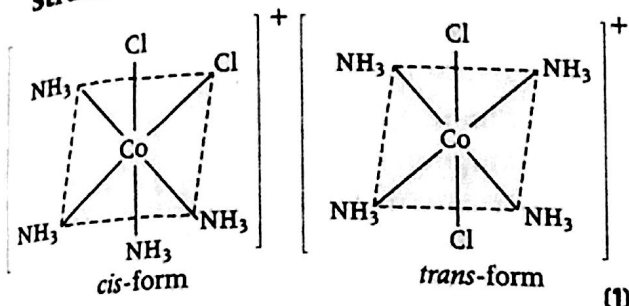


Since, NH_3 is a strong field ligand, so pairing of electrons takes place and the empty two $3d$ -orbitals, one $4s$ and three $4p$ -orbitals undergo d^2sp^3 -hybridisation. Among the $6d^2sp^3$ -hybrid orbitals, four are occupied by NH_3 molecules and two chlorine ions.

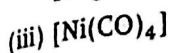
$[\text{Co}(\text{NH}_3)_4\text{Cl}_2]^+ =$



Structure Octahedral



Magnetic behaviour Diamagnetic.

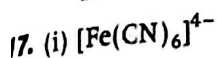


IUPAC name Tetracarbonylnickel (0)

For structure and magnetic behaviour

Refer to solution 10 (ii) of topic 2.

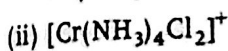
(1)



IUPAC name Hexacyanoferrate (II) ion

Structure Octahedral complex due to d^2sp^3 -hybridisation.

(1)



IUPAC name

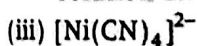
Tetraamminedichloridochromium (III) ion

Structure

Octahedral complex due to d^2sp^3 hybridisation.

Inner orbital complex (as inner d -orbital is involve in hybridisation) [For detail refer to solution 22 (i) of topic 2]

(1)



IUPAC name Tetracyanonickelate (II) ion

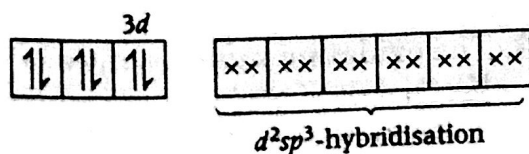
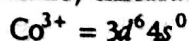
Structure Square planar complex due to dsp^2 hybridisation.

(1)

18. (i) The formula of the cationic complex is written as [metal symbol + ligand (with their number as subscript)] counter ion satisfying the valency of metal or oxidation state of complex.



IUPAC name Ammine bis (ethane-1, 2-diamine) chloridocobalt (III) ion (1/2)



Number of unpaired electrons = 0

So, the complex is diamagnetic.

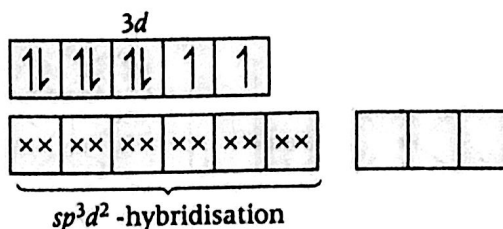
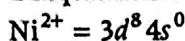
(1/2)

NOTE The formula of the anionic complex is written as counter ion satisfying valency of metal [metal symbol + ligand (with their number as subscript)].



IUPAC name

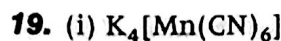
Diaquadioxalatonickelate (II) ion (1/2)



Number of unpaired electrons = 2

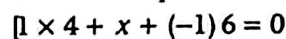
So, the complex is paramagnetic.

(1/2)

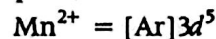


IUPAC name

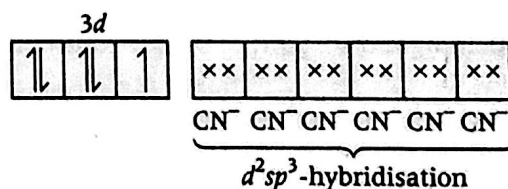
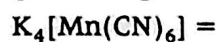
Potassium hexacyano manganate (II)



Stereochemistry In this complex Mn is present as Mn^{2+} .



[CN^- being strong field ligand, causes pairing]



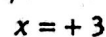
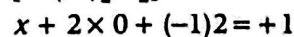
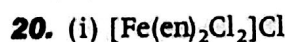
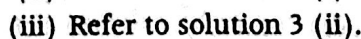
\Rightarrow low spin, inner orbital complex

Thus, the structure of this complex is **octahedral**.

Magnetic behaviour Paramagnetic

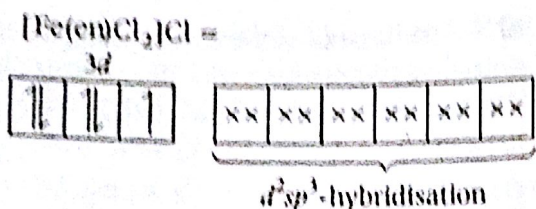
(as one unpaired electron is present in the above orbital formula).

(1)



Thus, the oxidation number of iron = + 3 (1/2)

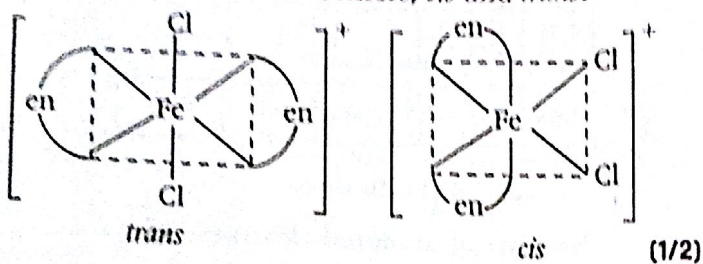
- (ii) In this complex, Fe is present as Fe^{3+} and en being a strong field ligand, causes pairing.



d^2sp^3 , octahedral geometry. (1/2)

(iii) Paramagnetic (as it contains one unpaired electron) (1/2)

(iv) Two geometrical isomers, *cis* and *trans*.



(v) Yes, *cis* isomer will have optical isomers, due to the non-superimposable mirror images. (1/2)

(vi) Dichlorido bis-(ethane 1, 2-diamine) iron (III) chloride. (1/2)

21. (i) Refer to solution 21 of topic 1. (1)

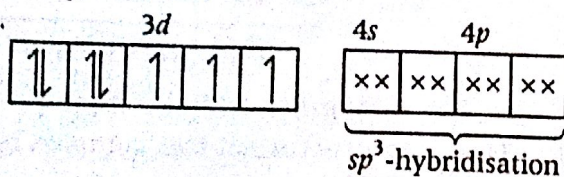
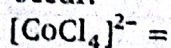
(ii) Refer to solution 9 of topic 1. (1)

(iii) Refer to solution 21 of topic 2. (1)

22. (i) $[\text{CoCl}_4]^{2-}$

IUPAC name Tetrachloridocobalt (II) ion

In $[\text{CoCl}_4]^{2-}$, Co is in +2 state and has an outer electronic configuration of $3d^7$. Cl^- is a weak field ligand so, pairing of electrons will not occur.



Four pairs of electrons one from each Cl^- ion occupy the four sp^3 -hybrid orbitals. Therefore, the complex has **tetrahedral** geometry and **paramagnetic** nature as it contains three unpaired electrons.

Thus,

Hybridisation - sp^3

Shape - Tetrahedral

Magnetic nature - Paramagnetic (1)

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

IUPAC name Tetracyanonickelate (II) ion

Hybridisation - dsp^2

Shape Square planar

Magnetic nature Diamagnetic

[For detail structure-refer to solution 14 of topic 2.]

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

IUPAC name

Diaquadioxalatochromate III ion

Hybridisation - d^2sp^3

Shape Octahedral

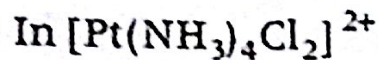
Magnetic behaviour Paramagnetic

[For detailed structure, refer to sc¹ ition 16 (i) of topic 2]

23. Refer to solution 19 (i).

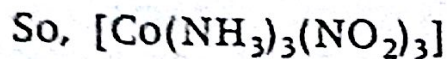
[Thus, $[\text{Cu}(\text{NH}_3)_4]^{2+}$ is the complex that exhibits a magnetic moment of 1.73 BM.]

3. (c) Coordination number = number of monodentate ligands.



Number of monodentate ligands = $4\text{NH}_3 + 2\text{Cl}^- = 6$

4. (a) Oxidation state of $\text{NH}_3 = 0$ and $\text{NO}_2 = -1$



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

$$x - 3 = 0 \Rightarrow x = +3$$

5. (c) The IUPAC name of $\text{K}_3\text{Fe}(\text{CN})_6$ is potassium ferricyanide or potassium hexacyanoferrate (III).

6. (a) The IUPAC name of $\text{K}_2[\text{Ni}(\text{CN})_4]$ is potassium tetracyanonickelate (II).

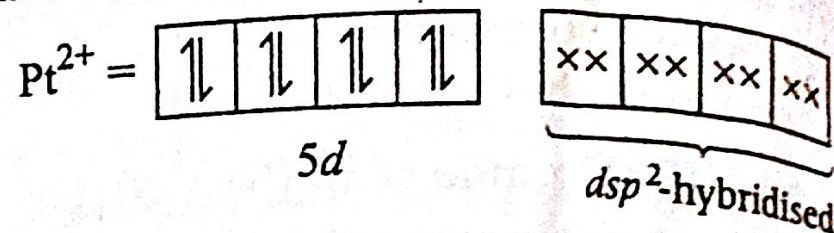
7. (c) The existence of two different coloured complexes is due to geometrical isomerism as *cis* and *trans* forms are present.

8. (b) $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3 \rightleftharpoons [\text{Co}(\text{NH}_3)_6]^{3+} + 3\text{Cl}^-$

Hence, four ions are produced in the solution.

9. (a) Outer electronic configuration of Pt is $5d^9, 6s^1$.

Outer electronic configuration of Pt^{2+} is $5d^8$.
As CN^- is strong field ligand, so pairing will take place.



Hence, there is no unpaired electron in the square planar $[\text{Pt}(\text{CN})_4]^{2-}$ ion.

10. (b) $[\text{Fe}(\text{CN})_6]^{3-}$

Let the oxidation number of Fe in $[\text{Fe}(\text{CN})_6]^{3-}$

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

$$x - 6 = -3$$

$$x = +3$$

IUPAC name is hexacyanoferrate (III) ion.

11. (a) The IUPAC name of $[\text{Co}(\text{NH}_3)_5\text{ONO}]^{2+}$ is pentaamminenitritocobalt (III) ion.

12. (c) $\text{Ni}(\text{CO})_4$ and $\text{Ni}(\text{PPh}_3)_2\text{Cl}_2$ are tetrahedral in geometrical shape, because coordination number of Ni is 4 in both cases.