

Short Answer Questions-II

Short Answer Questions-II (PYQ)

Q.1. Giving a suitable example for each, explain the following:

Q. Crystal field splitting

Ans. Crystal field splitting: When the ligands approach the central metal ion, the electrons in the d -orbitals of central metal ion will be repelled by the lone pairs of the ligands. Because of these interactions the degeneracy of d -orbitals of the metal ion is lost and these split into two sets of orbitals having different energies. This is known as

crystal field splitting, e.g., for d^4 , configuration is $t_{2g}^3 e_g^1$, in the presence of weak field ligand.

Q. Linkage isomerism

Ans. Linkage isomerism: The isomers which have same molecular formula but differ in the linkage of ligand atom to the central metal atom are called linkage isomers, e.g.,



Q. Ambidentate ligand

[CBSE (AI) 2009]

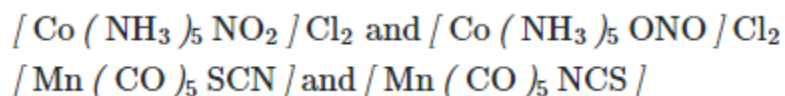
Ans. Ambidentate ligand: A unidentate ligand which can bind to the central metal atom through any of the two donor atoms present in it is called ambidentate ligand, e.g.,

NO_2 can bind to metal either through nitro-N ($\leftarrow \text{N} \begin{smallmatrix} \text{O} \\ \parallel \end{smallmatrix} \text{O}$) or through oxygen atom, i.e., as nitrito-O ($\leftarrow \text{O}-\text{N}=\text{O}$)

Q.2. Explain the following giving an example in each case:

Q. Linkage isomerism

Ans. Linkage isomerism: This type of isomerism arises due to the presence of an ambidentate ligand in a coordination compound. Some examples of linkage isomers are:



Q. An outer orbital complex

Ans. Outer orbital complex: When ns , np and nd orbitals are involved in hybridisation, outer orbital complex is formed, e.g., $[\text{CoF}_6]^{2-}$ in which cobalt is sp^3d^2 hybridised.

Q. A bidentate ligand

[CBSE (F) 2009]

Ans.

Bidentate ligand: When a ligand is bound to a metal ion through two donor atoms, it is said to be bidentate ligand, e.g., $\text{H}_2\ddot{\text{N}}-\text{CH}_2-\text{CH}_2-\ddot{\text{N}}\text{H}_2$ (ethane-1, 2-diamine), $\text{C}_2\text{O}_4^{2-}$ (oxalate), etc.

Q.3. Answer the following questions:

Q. What type of isomerism is shown by the complex $[\text{Cr}(\text{H}_2\text{O})_6]\text{Cl}_3$?

Ans. Hydration isomerism is shown by complex $[\text{Cr}(\text{H}_2\text{O})_6]\text{Cl}_3$.

Q. On the basis of crystal field theory, write the electronic configuration for d^4 ion if $\Delta_0 > P$.

Ans.

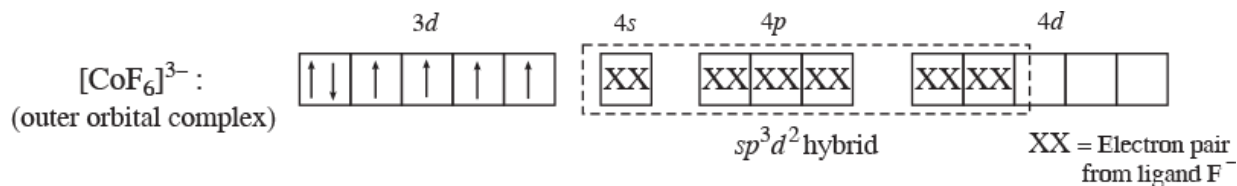
If $\Delta_0 > P$, electronic configuration becomes $t_{2g}^4 e_g^0$.

Q. Write the hybridisation and shape of $[\text{CoF}_6]^{3-}$.

(Atomic number of Co = 27)

[CBSE Allahabad 2015]

Ans. $\text{Co}^{3+} : 3d^6 4s^0$

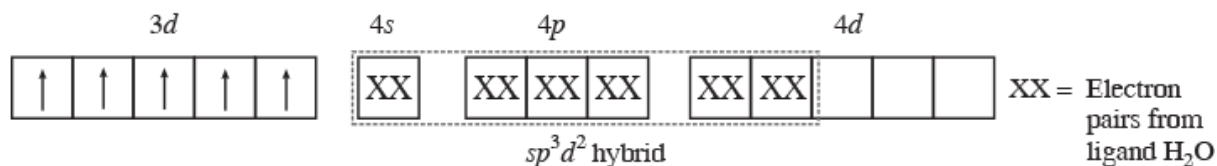


Hybridisation = sp^3d^2 ; Shape = Octahedral

Q.4. Answer the following questions:

Q. For the complex $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$, write the hybridisation, magnetic character and spin of the complex. (At. number: Fe = 26)

Ans.

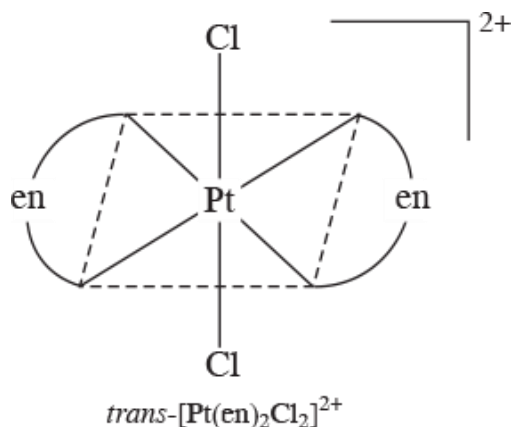


Hybridisation	sp^3d^2
Magnetic character	Paramagnetic
Spin of the complex	High spin complex

Q. Draw one of the geometrical isomers of the complex $[\text{Pt}(\text{en})_2\text{Cl}_2]^{2+}$ which is optically inactive.

[CBSE Central 2016]

Ans. (ii).



Q.5. Write the name, stereochemistry and magnetic behaviour of the following:

(At. nos. Mn = 25, Co = 27, Ni = 28)

- $\text{K}_4[\text{Mn}(\text{CN})_6]$
- $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$
- $\text{K}_2[\text{Ni}(\text{CN})_4]$

Ans.

S. No.	Name of the complex	Hybridisation of metal ion involved	Geometry of complex	Magnetic behaviour
(i)	Potassium hexacyano manganate (II)	d^2sp^3	Octahedral	Paramagnetic
(ii)	Pentaamminechloridocobalt (III) chloride	d^2sp^3	Octahedral	Diamagnetic
(iii)	Potassium tetra cyanonickelate (II)	dsp^2	Square planar	Diamagnetic

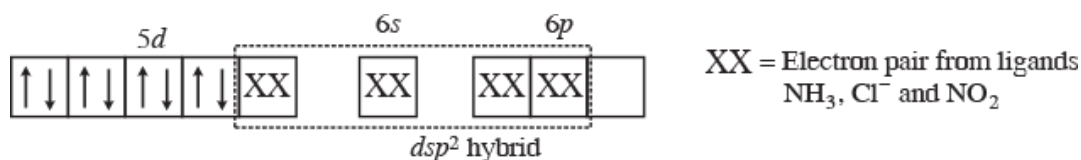
Q.6. Write the name, the structure and the magnetic behaviour of each one of the following complexes:

- $[\text{Pt}(\text{NH}_3)_2\text{Cl}(\text{NO}_2)]$
- $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]\text{Cl}$
- $[\text{Ni}(\text{CO})_4]$

(At. nos. Co = 27, Ni = 28, Pt = 78)

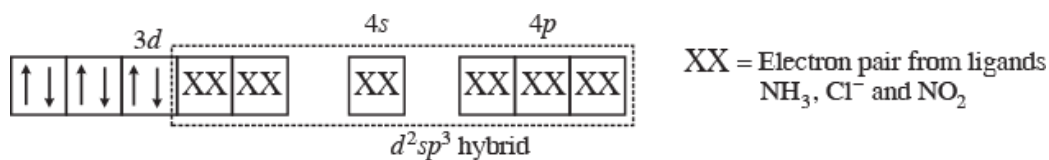
Ans.

- i. $[\text{Pt}(\text{NH}_3)_2\text{ClNO}_2]$: Diamminechloridonitrito-N-platinum (II); $\text{Pt}^{2+} = 5d^8$



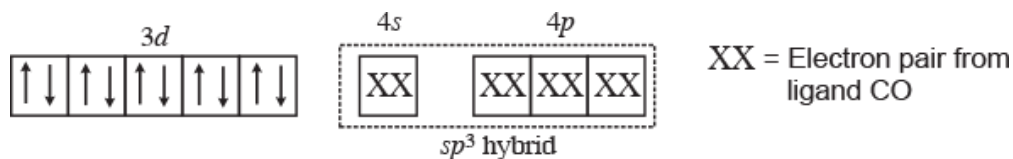
Structure = Square planar; Magnetic behaviour : Diamagnetic

- ii. $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]\text{Cl}$: Tetraamminedichloridocobalt (III) chloride; $\text{Co}^{3+} = 3d^6$



Structure = Octahedral; Magnetic behaviour : Diamagnetic

iii. $[\text{Ni}(\text{CO})_4]$: Tetracarbonyl nickel(0); $\text{Ni} = 3d^8 4s^2$



Structure = Tetrahedral; Magnetic behaviour : Diamagnetic

Q.7. Name the following coordination entities and describe their structures:

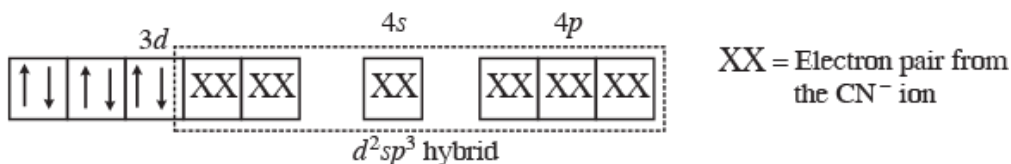
- i. $[\text{Fe}(\text{CN})_6]^{4-}$
- ii. $[\text{Cr}(\text{NH}_3)_4\text{Cl}_2]^+$
- iii. $[\text{Ni}(\text{CN})_4]^{2-}$

(Atomic Numbers: Fe = 26, Cr = 24, Ni = 28)

[CBSE (AI) 2012]

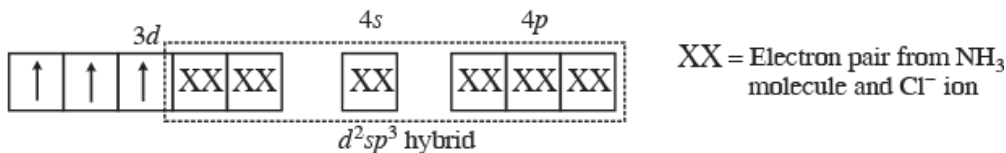
Ans.

- i. $[\text{Fe}(\text{CN})_6]^{4-}$ = Hexacyanoferrate (II) ion; $\text{Fe}^{2+}(3d^6)$



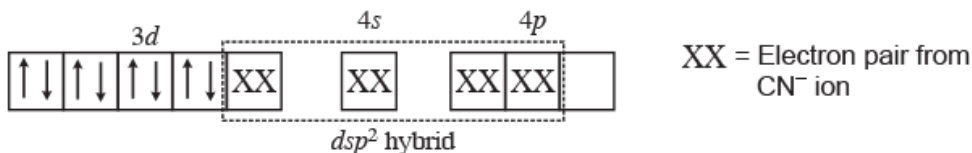
d^2sp^3 hybridisation in $[\text{Fe}(\text{CN})_6]^{4-}$ leads to octahedral structure.

- ii. $[\text{Cr}(\text{NH}_3)_4\text{Cl}_2]^+$ = Tetraamminedichloridochromium (III) ion; $\text{Cr}^{3+}(3d^3)$



d^2sp^3 hybridisation in $[\text{Cr}(\text{NH}_3)_4\text{Cl}_2]^+$ leads to octahedral structure.

- iii. $[\text{Ni}(\text{CN})_4]^{2-}$ = Tetracyanonickelate(II)ion; $\text{Ni}^{2+}(\text{II}) (3d^8)$



dsp^2 hybridisation in $[\text{Ni}(\text{CN})_4]^{2-}$ leads to square planar structure.

Q.8. Give the name, the stereochemistry and the magnetic behaviour of the following complexes:

- i. $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$
- ii. $\text{K}_2[\text{Ni}(\text{CN})_4]$

[CBSE (F) 2011]

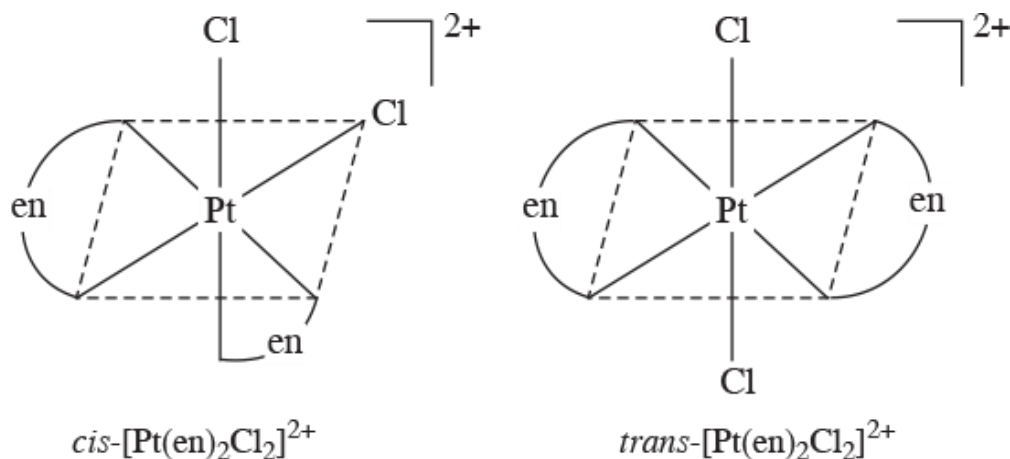
Ans. (i). $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$: Pentaamminechloridocobalt(III) chloride
 Co(III): $[\text{Ar}] 3d^6 4s^0 \rightarrow d^2sp^3$ hybridisation leads to octahedral shape.
 Magnetic behaviour: Diamagnetic.

(ii). $\text{K}_2[\text{Ni}(\text{CN})_4]$: Potassium tetracyanonickelate (II)
 Ni(II): $[\text{Ar}] 3d^8 4s^0 \rightarrow dsp^2$ hybridisation leads to square planar shape.
 Magnetic behaviour: Diamagnetic.

Q.9. Answer the following questions:

Q. Draw the geometrical isomers of complex $[\text{Pt}(\text{en})_2\text{Cl}_2]^{2+}$.

Ans.



Q. On the basis of crystal field theory, write the electronic configuration for d^4 ion, if $\Delta_0 > P$

Ans.



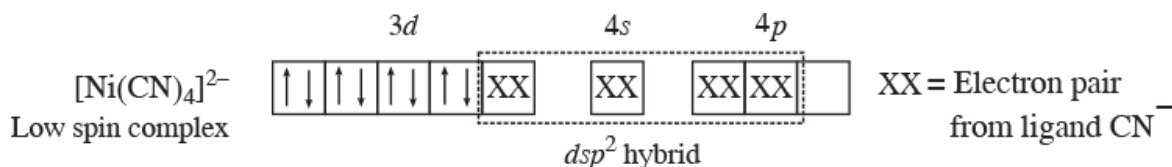
Q. Write the hybridization type and magnetic behaviour of the complex $[\text{Ni}(\text{CN})_4]^{2-}$

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(Atomic number of Ni = 28).

[CBSE (AI) 2015]

Ans. $\text{Ni}^{2+} : 3d^8 4s^0$



Hybridisation = dsp^2

Magnetic behaviour = Diamagnetic

Q.10. Answer the following questions:

Q. What type of isomerism is shown by the complex $[\text{Co}(\text{NH}_3)_6][\text{Cr}(\text{CN})_6]$?

Ans. Coordination isomerism.

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

(At no. of Ni = 28)

Ans. In $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$, Ni is in + 2 oxidation state with the configuration $3d^8 4s^0$, i.e., it has two unpaired electrons which do not pair up in the presence of weak H_2O ligand. The $d-d$ transition absorbs red light and the complementary green light is emitted.

On the other hand, in $[\text{Ni}(\text{CN})_4]^{2-}$, Ni is again in +2 oxidation state with the electronic configuration $3d^8$. In the presence of strong CN^- ligand the two unpaired electrons in the $3d$ orbitals pair up. As there is no unpaired electron in $[\text{Ni}(\text{CN})_4]^{2-}$ therefore the complex is colourless.

Q. Write the IUPAC name of the following complex: $[\text{Co}(\text{NH}_3)_5(\text{CO}_3)]\text{Cl}$.

[CBSE Delhi 2017]

Ans. Pentaamminecarbonatocobalt(III)chloride

Q.11. Answer the following questions:

Q. What type of isomerism is shown by $[\text{Co}(\text{NH}_3)_5\text{ONO}]\text{Cl}_2$?

Ans. Linkage isomerism and the linkage isomer is $[\text{Co}(\text{NH}_3)_5\text{NO}_2]\text{Cl}_2$.

Q. On the basis of crystal field theory, write the electronic configuration for d^4 ion, if $\Delta_0 < P$.

Ans.

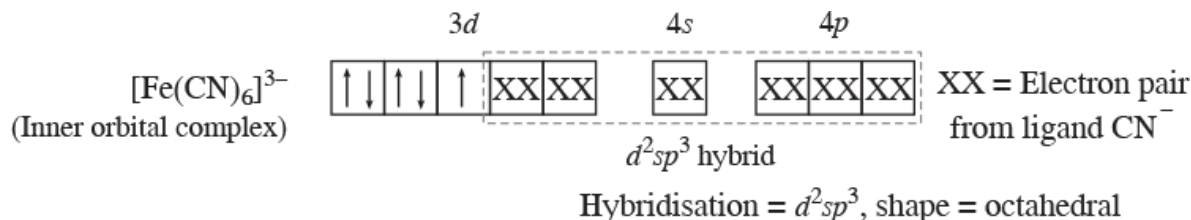
If $\Delta_0 < P$, the fourth electron enters one of two e_g orbitals giving the configuration $t_{2g}^3 e_g^1$.

Q. Write the hybridisation and shape of $[\text{Fe}(\text{CN})_6]^{3-}$.

(Atomic number of Fe = 26)

[CBSE Ajmer 2015]

Ans. $\text{Fe}^{3+} : 3d^5 4s^0$



Q.12. Answer the following questions:

Q. What type of isomerism is shown by the complex $[\text{Co}(\text{NH}_3)_5(\text{SCN})]^{2+}$?

Ans. Linkage isomerism.

Q. Why is $[\text{NiCl}_4]^{2-}$ paramagnetic while $[\text{Ni}(\text{CN})_4]^{2-}$ is diamagnetic?

(Atomic number of Ni = 28)

Ans. In both $[\text{NiCl}_4]^{2-}$ and $[\text{Ni}(\text{CN})_4]^{2-}$, Ni is in +2 oxidation state with configuration $3d^8$ and it contains two unpaired electrons. In $[\text{NiCl}_4]^{2-}$ due to presence of weak ligand Cl^- no pairing takes place and hence paramagnetic whereas in $[\text{Ni}(\text{CN})_4]^{2-}$, CN^- is a strong field ligand and pairing occurs and hence diamagnetic.

Q. Why are low spin tetrahedral complexes rarely observed?

[CBSE (AI) 2017]

Ans. This is due to very low CFSE which is not able to pair up the electrons.

Q.13. Answer the following questions:

Q. Define crystal field splitting energy. On the basis of crystal field theory, write the electronic configuration for d^4 ion if $\Delta_0 < P$.

Ans. When ligand approach a transition metal ion, the d -orbitals split into two sets, one with lower energy and the other with higher energy. The difference of energy between the two sets of orbitals is called crystal field splitting energy.

If $\Delta_0 < P$, the fourth electron enters one of the e_g orbitals giving the configuration $t_{2g}^3 e_g^1$.

Q. $[\text{Ni}(\text{CN})_4]^{2-}$ is colourless whereas $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$ is green. Why?

(At. no. of Ni = 28)

[CBSE (F) 2017]

Ans. In $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$, Ni is in + 2 oxidation state with the configuration $3d^8 4s^0$, i.e., it has two unpaired electrons which do not pair up in the presence of weak H_2O ligand. The $d-d$ transition absorbs red light and the complementary green light is emitted.

On the other hand, in $[\text{Ni}(\text{CN})_4]^{2-}$, Ni is again in +2 oxidation state with the electronic configuration $3d^8$. In the presence of strong CN^- ligand the two unpaired electrons in the $3d$ orbitals pair up. As there is no unpaired electron in $[\text{Ni}(\text{CN})_4]^{2-}$ therefore the complex is colourless.

Short Answer Questions-II (OIQ)

Q.1. Explain with two examples each of the following:

Q. Coordination entity

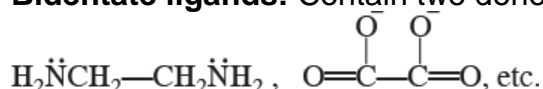
Ans. Coordination Entity: A coordination entity constitutes a central metal atom or ion bonded to a fixed number of molecules or ions (ligands), e.g., $[\text{Co}(\text{NH}_3)_3\text{Cl}_3]$, $[\text{Fe}(\text{CN})_6]^{4-}$, $[\text{Cu}(\text{NH}_3)_4]^{2+}$, etc.

Q. Ligand

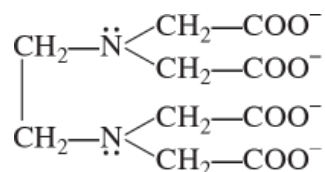
Ans. Ligands: Ligands are the atoms, molecules or ions which donate a pair of electrons to central metal atom or ion and form a coordinate bond with it. Depending upon the number of donor atoms available for coordination, the ligands may be classified as:

- **Unidentate ligands:** Contain one donor atom, e.g., NH_3 , Cl^- , etc.

- **Bidentate ligands:** Contain two donor atoms, *e.g.*,

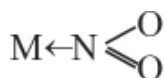


- **Polydentate ligands:** Contain several donor atoms, *e.g.*,

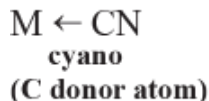
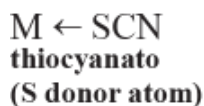


Ethylenediaminetetraacetate ion (EDTA^{4-}) (Hexadentate)

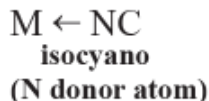
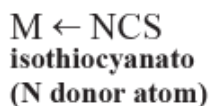
- **Ambidentate ligand:** A ligand which contains two donor atoms but only one of them forms a coordinate bond at a time with central metal atom/ion is called an ambidentate ligand. Some common examples are given below:



nitrito—N
(N donor atom)



nitrito—O
(O donor atom)



- **Chelating ligand:** When a bidentate or a polydentate ligand uses its two or more donor atoms to bind a single metal ion, then a ring-like structure is obtained. It is called chelate and the ligand is known as chelating ligand. The chelating ligands form more stable complexes than the unidentate ligands. This is because when chelation occurs entropy increases and the process becomes more favourable.

Q. Coordination number

Ans. Coordination Number (CN): The coordination number of a metal ion in a complex may be defined as the total number of ligand donor atoms to which the metal ion is directly bonded. For example, in the complex ions, $[\text{Co}(\text{NH}_3)_6]^{3+}$ and $[\text{Fe}(\text{C}_2\text{O}_4)_3]^{3-}$, the coordination numbers of both Co and Fe is 6.

Q.2. Explain with two examples each of the following:

Q. Coordination polyhedron

Ans. Coordination Polyhedron: The spatial arrangement of the ligand atoms which are directly attached to the central atom/ion is known as the coordination polyhedron around the central atom/ion. Tetrahedral, square planar, octahedral, square pyramidal and trigonal bipyramidal are common shapes of coordination polyhedra.

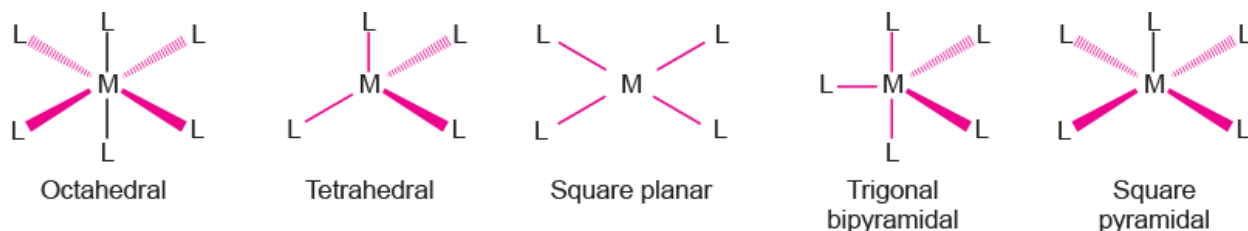


Fig. 9.1: Shapes of different coordination polyhedra.
M represents the central atom/ion and L, a unidentate ligand

Q. Homoleptic complex

Ans. Homoleptic Complex: The complex in which metal atom is bound to only one kind of donor groups, e.g., $[\text{Cu}(\text{CN})_4]^{3-}$.

Q. Heteroleptic complex

Ans. Heteroleptic Complex: The complex in which metal atom is bound to more than one kind of donor groups, e.g., $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]^+$.

Q.3. Differentiate between weak field and strong field coordination entity.

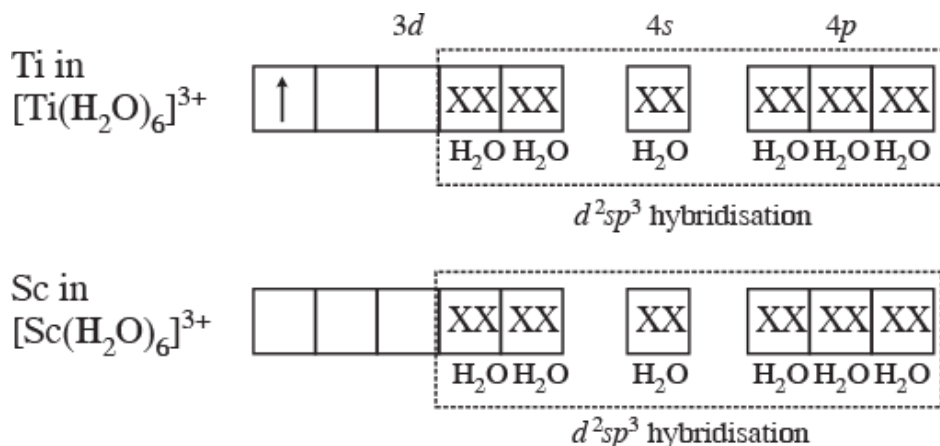
Ans.

S.No.	Weak field coordination entity	Strong field coordination entity
(i)	They are formed when the crystal field stabilisation energy (Δ_o) in octahedral complexes is less than the energy required for an electron pairing in a single orbital (P).	They are formed when the crystal field stabilisation energy (Δ_o) is greater than the P.
(ii)	They are also called high spin complexes.	They are called low spin complexes.
(iii)	They are mostly paramagnetic in nature.	They are mostly diamagnetic or less paramagnetic than weak field.
(iv)	Never formed by CN^- ligands.	Formed by CN^- like ligands.

Q.4. How would you account for the following?

Q. $[\text{Ti}(\text{H}_2\text{O})_6]^{3+}$ is coloured while $[\text{Sc}(\text{H}_2\text{O})_6]^{3+}$ is colourless.

Ans. The outer electronic structure of $[\text{Ti}(\text{H}_2\text{O})_6]^{3+}$ and $[\text{Sc}(\text{H}_2\text{O})_6]^{3+}$ are given below:

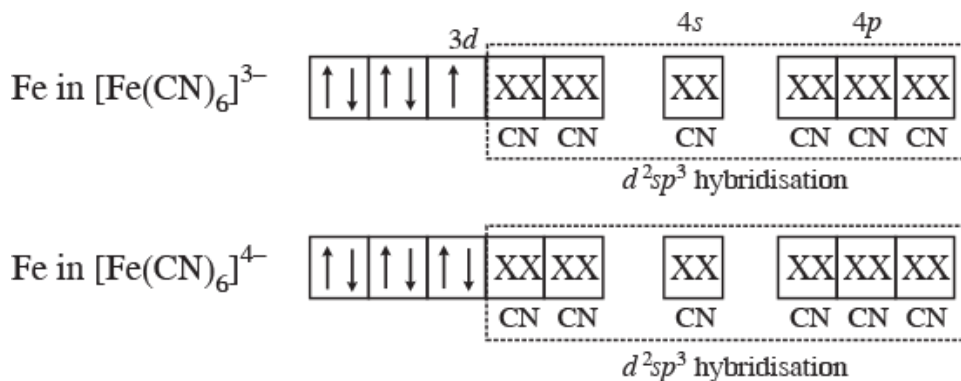


Due to the presence of one electron in $3d$ -subshell in $[\text{Ti}(\text{H}_2\text{O})_6]^{3+}$ complex $d-d$ transition takes place by the absorption of visible light. Hence, the complex appears coloured.

On the other hand, $[\text{Sc}(\text{H}_2\text{O})_6]^{3+}$ does not possess any unpaired electron. Hence, $d-d$ transition (which is responsible for colour) in this complex is not possible. Therefore, it is colourless.

Q. $[\text{Fe}(\text{CN})_6]^{3-}$ is weakly paramagnetic while $[\text{Fe}(\text{CN})_6]^{4-}$ is diamagnetic.

Ans. Paramagnetism is attributed to the presence of unpaired electrons. Greater the number of unpaired electrons, greater is the paramagnetism.

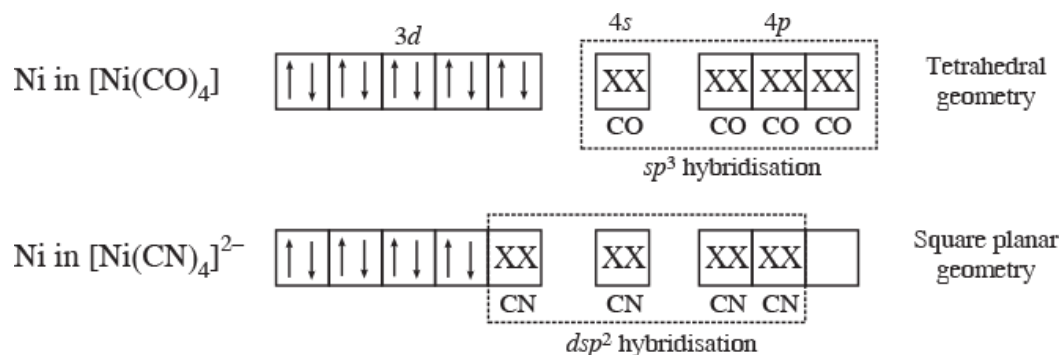


Due to the presence of one unpaired electron in the $3d$ subshell in $[\text{Fe}(\text{CN})_6]^{3-}$, it is weakly paramagnetic. On the other hand, $[\text{Fe}(\text{CN})_6]^{4-}$ is diamagnetic because all the electrons are paired.

Q. $[\text{Ni}(\text{CO})_4]$ possesses tetrahedral geometry while $[\text{Ni}(\text{CN})_4]^{2-}$ is square planar.

Ans. Ni in $[\text{Ni}(\text{CO})_4]$ is sp^3 hybridised. Hence, it is tetrahedral.

In $[\text{Ni}(\text{CN})_4]^{2-}$, the Ni^{2+} is dsp^2 hybridised. Hence, it has square planar geometry.

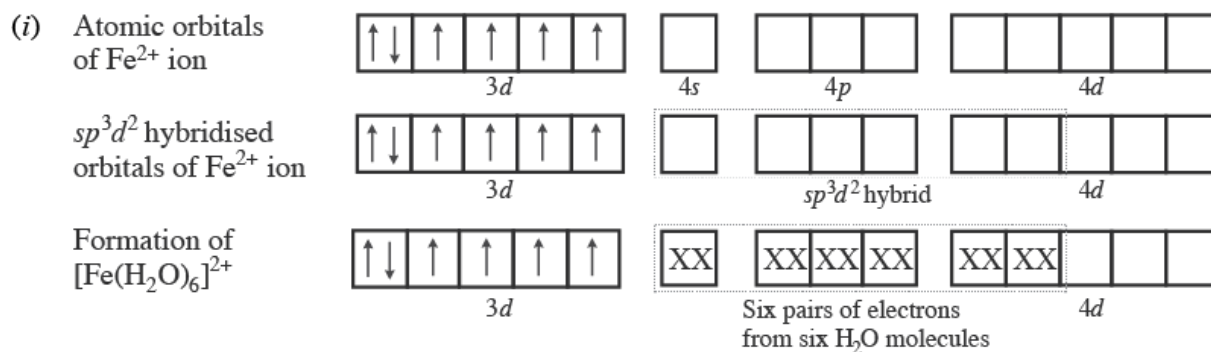


Q.5. Describe for any two of the following complex ions, the type of hybridisation, shape and magnetic property:

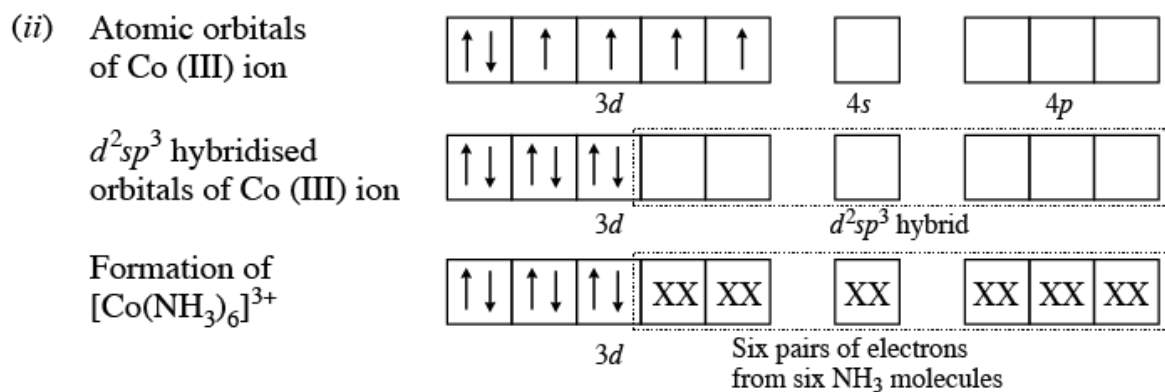
- $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$
- $[\text{Co}(\text{NH}_3)_6]^{3+}$
- $[\text{NiCl}_4]^{2-}$

(At. Nos. Fe = 26, Co = 27, Ni = 28)

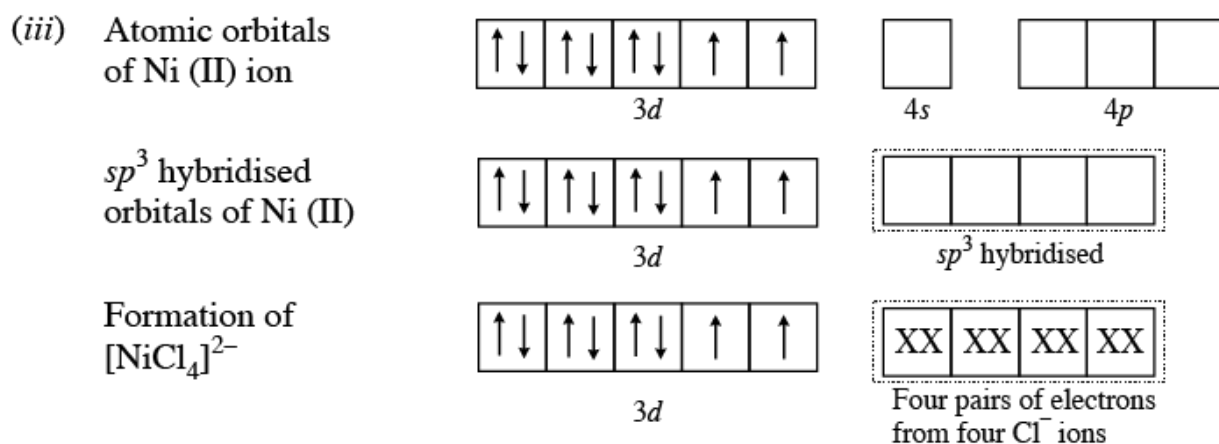
Ans.



Octahedral because of sp^3d^2 hybridisation. Paramagnetic, as there are four unpaired electrons present in the complex ion.



d^2sp^3 hybridisation leads to octahedral geometry. Diamagnetic, as there is no unpaired electron present in the complex.



sp^3 hybridisation leads to tetrahedral geometry. Paramagnetic, as there are two unpaired electrons.

(any two)

Q.6. Write IUPAC names of the following coordination compounds:

- $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$
- $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$
- $\text{K}_3[\text{Fe}(\text{CN})_6]$

Ans.

- Hexaamminecobalt(III) chloride
- Pentaamminechloridocobalt(III) chloride
- Potassium hexacyanoferrate(III)

Q.7. Answer the following questions:

Q. Write the formulae for the following coordination compounds:

- a. Tetraammineaquachloridocobalt (III) chloride
- b. Potassiumtetracyanonickelate (II)

Ans.

- a. $[\text{Co}(\text{NH}_3)_4(\text{H}_2\text{O})\text{Cl}]\text{Cl}_2$
- b. $\text{K}_2[\text{Ni}(\text{CN})_4]$

Q. Write the hybridisation of the complex $[\text{NiCl}_4]^{2-}$.

(Atomic number of Ni = 28)

Ans. sp^3 hybridisation.

Q.8. Write the formulae of the following coordination compounds:

- i. Amminebromidochloridonitrito-N-platinate(II)
- ii. Dichloridobis(ethane-1, 2-diamine)platinum(IV) nitrate
- iii. Iron(III)hexacyanoferrate(II)

Ans.

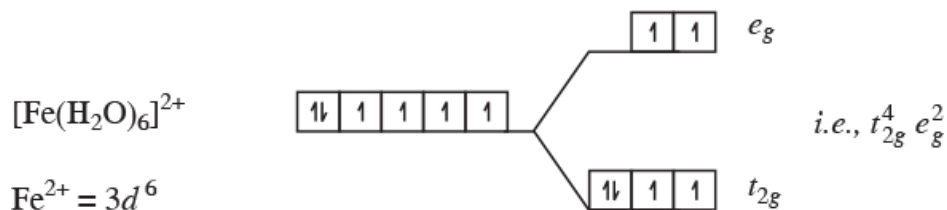
- i. $[\text{Pt}(\text{NH}_3)\text{BrCl}(\text{NO}_2)]^-$
- ii. $[\text{PtCl}_2(\text{en})_2](\text{NO}_3)_2$
- iii. $\text{Fe}_4[\text{Fe}(\text{CN})_6]_3$

Q.9. Using crystal field theory, draw energy level diagram, write electronic configuration of the central metal atom/ion and determine the magnetic moment value in the following;

$[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$,

[NCERT Exemplar]

Ans.



Number of unpaired electrons (n) = 4

$$\text{Magnetic moment } (\mu) = \sqrt{4(4+2)} = \sqrt{24} = 4.9 \text{ BM}$$

Q.10. Answer the following questions:

Q. What is the coordination number of central metal ion in $[\text{Fe}(\text{C}_2\text{O}_4)_3]^{3-}$?

Ans. Six

Q. Write the formula of Pentamminechloridoplatinum (IV).

Ans. $[\text{Pt}(\text{NH}_3)_5\text{Cl}]\text{Cl}_3$

Q.10. Arrange following complex ions in increasing order of crystal field splitting energy (Δ_0):

$[\text{Cr}(\text{Cl})_6]^{3-}$, $[\text{Cr}(\text{CN})_6]^{3-}$, $[\text{Cr}(\text{NH}_3)_6]^{3+}$

[NCERT Exemplar]

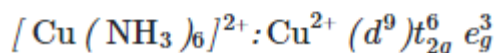
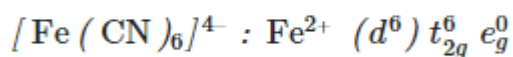
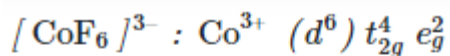
Ans. Crystal field splitting energy increases in the order $[\text{Cr}(\text{Cl})_6]^{3-} < [\text{Cr}(\text{NH}_3)_6]^{3+} < [\text{Cr}(\text{CN})_6]^{3-}$.

Q.11. Give the electronic configuration of the following complexes on the basis of crystal field splitting theory.

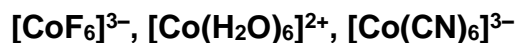
$[\text{CoF}_6]^{3-}$, $[\text{Fe}(\text{CN})_6]^{4-}$ and $[\text{Cu}(\text{NH}_3)_6]^{2+}$.

[NCERT Exemplar]

Ans.



Q.12. Using crystal field theory, draw energy level diagram, write electronic configuration of the central metal atom/ion and determine the magnetic moment value in the following:

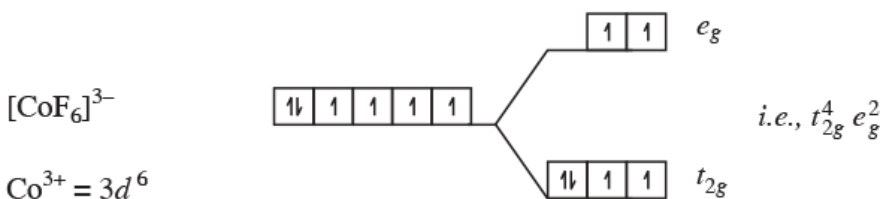


[NCERT Exemplar]

Ans.

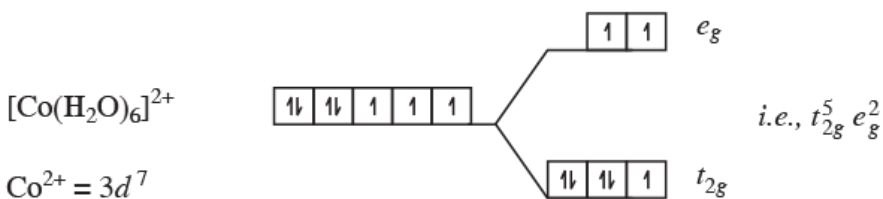
Magnetic moment, $\mu = \sqrt{n(n+2)}$

where, n = Number of unpaired electrons



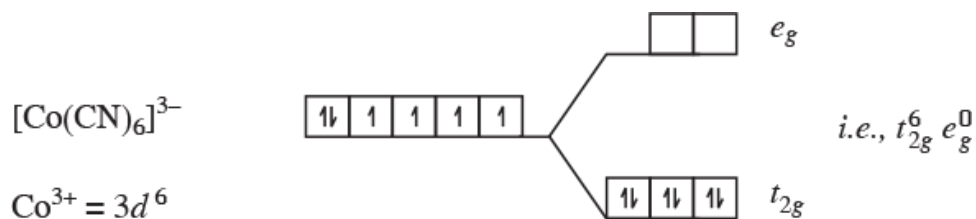
Number of unpaired electrons (n) = 4

Magnetic moment = $\sqrt{n(n+2)} = \sqrt{4(4+2)} = \sqrt{24} = 4.9 \text{ BM}$



Number of unpaired electrons (n) = 3

Magnetic moment = $\sqrt{n(n+2)} = \sqrt{3(3+2)} = \sqrt{15} = 3.87 \text{ BM}$



No unpaired electrons, so it is diamagnetic.

Q.13. Give the number of unpaired electrons in the following complex ions:

FeF_6^{4-} and $[\text{Fe}(\text{CN})_6]^{4-}$

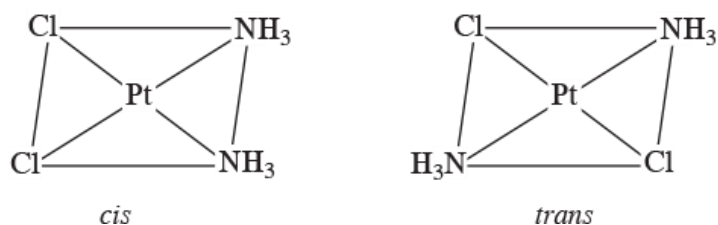
Ans. $[\text{FeF}_6]^{4-}$ has 4 unpaired electrons as F^- is a weak field ligand.

$[\text{Fe}(\text{CN})_6]^{4-}$ has no unpaired electrons as CN^- is a strong field ligand.

Q.14. Answer the following questions:

Q. Draw the geometrical isomers of complex $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$.

Ans.



Geometrical isomers of $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$

Q. On the basis of crystal field theory, write the electronic configuration for d^4 ion if $\Delta_0 < P$.

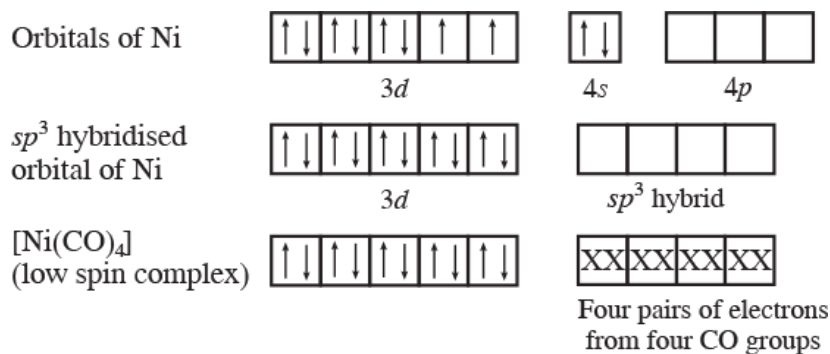
Ans.

If $\Delta_0 < P$ then fourth electron enters one of the e_g orbitals giving the configuration $t_{2g}^3 e_g^1$.

Q. Write the hybridisation and magnetic behaviour of the complex $[\text{Ni}(\text{CO})_4]$.

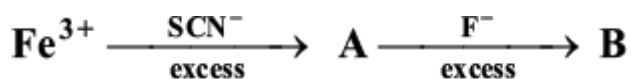
(At. no. of Ni = 28)

Ans. The complex $[\text{Ni}(\text{CO})_4]$ involves sp^3 hybridisation.



The complex is diamagnetic as evident from the absence of unpaired electrons.

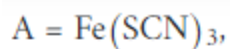
Q.15.



What are A and B? Give IUPAC names of A and B. Find spin only magnetic moment of B.

[HOTS]

Ans.



Trithiocyanato iron(III)

Hexafluoridoferrate(III) ion

EC of $\text{Fe}(\text{III}) = d^5$,

unpaired electrons (n) = 5

Spin only magnetic moment of B = $\sqrt{n(n+2)}$

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

$$= 5.916 \text{ BM}$$

Q.16. Explain the following:

[HOTS]

Q. Low spin octahedral complexes of nickel are not known.

Ans.

Orbitals of Ni^{2+}



For the formation of low spin complex, electrons present in $3d$ electrons of Ni^{2+} should pair up. This will produce only one empty d orbit. Hence, d^2sp^3 hybridisation in nickel is not possible to form low spin octahedral complex.

Q. Co^{2+} is easily oxidised to Co^{3+} in the presence of a strong ligand.

Ans. With the electronic configuration $3d^7 4s^0$, Co^{2+} has three unpaired electrons. H_2O being a weak ligand, the unpaired electrons present in $3d$ orbitals of Co (II) do not pair up. In the presence of strong ligands, two unpaired electrons in $3d$ orbitals pair up and the third unpaired electron shifts to higher energy orbital from where it can be easily lost and hence shows an oxidation state of III.

Q. CO is a stronger complexing reagent than NH_3 .

Ans. CO has empty π -orbitals which overlap with filled d -orbitals (t_{2g} orbitals) of transition metals and form π -bonds by back bonding. These π -interactions increase the value of crystal field stabilisation energy (Δ_0).

As NH_3 cannot form π bonds by back bonding, therefore, CO is stronger ligand than NH_3 .

Q.17. Answer the following questions:

[HOTS]

Q. Give the electronic configuration of the d -orbitals of Ti in $[\text{Ti}(\text{H}_2\text{O})_6]^{3+}$ ion in an octahedral crystal field.

Ans.

In $[\text{Ti}(\text{H}_2\text{O})_6]^{3+}$ ion, Ti is in +3 oxidation state. There is one electron in d -orbital and the electronic configuration is $t_{2g}^1 e_g^0$.

Q. Why is this complex coloured? Explain on the basis of distribution of electrons in the d -orbitals.

Ans. Due to $d-d$ transition, the electron present in t_{2g} absorbs green and yellow radiation of white light for excitation to e_g and the configuration becomes e_g^1 . The complementary colour is purple.

Q. How does the colour change on heating $[\text{Ti}(\text{H}_2\text{O})_6]^{3+}$ ion?

Ans. On heating, H_2O is lost. In the absence of ligand, crystal field splitting does not occur hence the substance becomes colourless.

Q.18. A metal ion M^{n+} having d^4 valence electronic configuration combines with three bidentate ligands to form a complex compound. Assuming $\Delta_0 > P$:

[HOTS]

Q. Explain orbital splitting during this complex formation.

Ans. As $\Delta_0 > P$ pairing will occur in the t_{2g} orbitals and e_g orbitals will remain vacant.

Q. Write the electronic configuration of the valence electrons of the metal M^{n+} ion in terms of t_{2g} and e_g .

Ans.



Q. What type of hybridisation will M^{n+} ion have?

Ans. As there are three bidentate ligands to combine therefore hybridisation will be d^2sp^3 .

Q. Name the type of isomerism exhibited by this complex.

Ans. Optical isomerism.

Q.19. Write the correct formulae for the following coordination compounds:

- $\text{CrCl}_3 \cdot 6\text{H}_2\text{O}$ (violet with 3 chloride ions precipitated as AgCl)
- $\text{CrCl}_3 \cdot 6\text{H}_2\text{O}$ (light green colour, with 2 chloride ions precipitated as AgCl)
- $\text{CrCl}_3 \cdot 6\text{H}_2\text{O}$ (dark green colour, with 1 chloride ion precipitated as AgCl)

[CBSE Sample Paper 2017]

Ans.

- $[\text{Cr}(\text{H}_2\text{O})_6]\text{Cl}_3$
- $[\text{Cr}(\text{H}_2\text{O})_5\text{Cl}]\text{Cl}_2 \cdot \text{H}_2\text{O}$
- $[\text{Cr}(\text{H}_2\text{O})_4\text{Cl}_2]\text{Cl} \cdot 2\text{H}_2\text{O}$

Q.20. $\text{CoSO}_4\text{Cl} \cdot 5\text{NH}_3$ exists in two isomeric forms 'A' and 'B'. Isomer 'A' reacts with AgNO_3 to give white precipitate, but does not react with BaCl_2 . Isomer 'B' gives

white precipitate with BaCl_2 but does not react with AgNO_3 . Answer the following questions:

Q. Identify 'A' and 'B' and write their structural formulae.

Ans. $\text{A} = [\text{Co}(\text{NH}_3)_5\text{SO}_4]\text{Cl}$

$\text{B} = [\text{Co}(\text{NH}_3)_5\text{Cl}]\text{SO}_4$

Q. Name the type of isomerism involved.

Ans. Ionisation isomerism

Q. Give the IUPAC name of 'A' and 'B'.

[NCERT Exemplar]

Ans.

A. – Pentaamminesulphatocobalt(III) chloride

B. – Pentaamminechloridocobalt(III) sulphate