



LESSON AT A GLANCE

- **Coordination entity:** It constitutes a central metal atom or ion bonded to a fixed number of ions or molecules, e.g. $[\text{CoCl}_3(\text{NH}_3)_3]$
- **Ligands:** It is a molecule or ion that donates an electron pair to central atom/cation in a coordination compound. A ligand may be *monodentate*, *bidentate*, *tridentate* or *polydentate* depending upon the number of donor sites.
- **Coordination number:** It is total number of coordinated bonds with which central atom is linked to ligand in a complex.
- **Coordination sphere:** The central metal atom/cation and the ligands attached to it, is called coordination sphere, e.g. $[\text{Cu}(\text{NH}_3)]\text{SO}_4$.
- **Coordination polyhedron:** The spatial arrangement of the ligand atoms which are directly attached to the central atom/ion defines a coordination polyhedron. Most common polyhedron are octahedral, tetrahedral, square planar etc.
- **VBT:** The valence bond theory explains with reasonable success, the formation magnetic behaviour and geometric shapes of coordination compounds.

TEXTBOOK QUESTIONS SOLVED

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

Ans. The main postulates of Werner's theory of coordination compounds are:

- (i) In coordination compounds metal shows two types of linkages (valences)—primary and secondary.

- (ii) The primary valences are normally ionisable and are satisfied by negative ions.
- (iii) The secondary valences are non-ionisable. These are satisfied by neutral molecules or negative ions. The secondary valence is equal to the coordination number and is fixed for a metal.
- (iv) The ions/groups bound by the secondary linkages to the metal have characteristic spatial arrangements corresponding to different coordination number.

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

Ans. FeSO₄ solution on mixing with (NH₄)₂SO₄ solution gives a double salt FeSO₄(NH₄)₂SO₄·6H₂O (Mohr's salt). This salt does not retain its identity in solution where it completely ionises to its respective ions. Thus it gives the test for Fe²⁺ ions. CuSO₄ solution with aqueous ammonia gives the coordination compound [Cu(NH₃)₄].SO₄ which does not ionise into Cu²⁺ ions so easily. Thus, it does not give the test for Cu²⁺ ions.

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

Ans. Coordination entity: This entity usually constitutes a central metal atom or ion, to which are attached a fixed number of other atoms or ions or groups by coordinate bonds. Examples are [Ni(CO)₄], [CoCl₃(NH₃)₃]. etc.

Ligands: It is an ion having at least one lone pair of electrons and capable of forming a coordinate bond with central atom/ion in the coordination entity.

Examples are: Cl⁻, (OH)⁻, (CN)⁻, etc.

Co-ordinate number: The total number of coordinate bonds with which central atom/ion is linked to ligands in the coordination entity is called coordination number of central atom/ion.

Coordination polyhedron: The spatial arrangement of the ligands which are directly attached to the central atom/ion defines a coordination polyhedron about the central atom.

Examples are: $[\text{Co}(\text{NH}_3)_6]^{3+}$ is octahedral,
 $[\text{Ni}(\text{CO})_4]$ is tetrahedral.

Homoleptic and heteroleptic: Complexes in which a metal is bound to only one kind of donor groups are known as homoleptic.

Example $[\text{Co}(\text{NH}_3)_6]^{3+}$.

Complex in which a metal is bound to more than one kind of donor groups are called heteroleptic. Example: $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]^+$.

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

Ans. **Unidentate ligand:** When a ligand is bound to a metal ion through a single donor atom as with Cl^- , H_2O the ligand is said to be unidentate.

Didentate ligand: When a ligand is bind through two donor atoms the ligand is said to be didentate.

Example: $\text{C}_2\text{O}_4^{2-}$ (Oxalate)

$\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2$ (ethanet, 2 diammine)

Ambidentate ligand: Ligand which can ligate through two different atoms is called ambidentate ligand.

Examples: $-\text{NO}_2-$ and SCN^- .

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

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

(iii) $[\text{PtCl}_4]^{2-}$ (iv) $\text{K}_3[\text{Fe}(\text{CN})_6]$

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

Ans. (i) Co, + 3 (ii) Co, + 3

(iii) Pt, + 2 (iv) Fe, + 3

(v) Cr, + 3

9.6 Using IUPAC norms write the formulas for the following:

(i) Tetrahydroxozincate(II)

(ii) Potassium tetrachloridopalladate(II)

(iii) Diamminedichloridoplatinum(II)

(iv) Potassium tetracyanonickelate(II)

(v) Pentaamminenitrito-O-cobalt(III)

(vi) Hexaamminecobalt(III) sulphate

(vii) Potassium tri(oxalato)chromate(III)

(viii) Hexaammineplatinum(IV)

(ix) Tetrabromidocuprate(II)

(x) Pentaamminenitrito-N-cobalt(III)

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

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

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

- Ans. (i) Hexaamminecobalt (III) chloride.
 (ii) Diamminechlorido (methylamine) platinum (II) chloride.
 (iii) Hexaaquatitanium (III) ion.
 (iv) Tetraamminechloridonitrito-N-cobalt (III) chloride.
 (v) Hexaaquamanganese (II) ion.
 (vi) Tetrachloridonickelate (II) ion
 (vii) Hexaamminenickel (II) chloride
 (viii) Tris (ethane-1, 2-diamine) cobalt (III) ion
 (ix) Tetracarbonylnickel(0)

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

Ans. Two principal types of isomerism are known among coordination compounds:

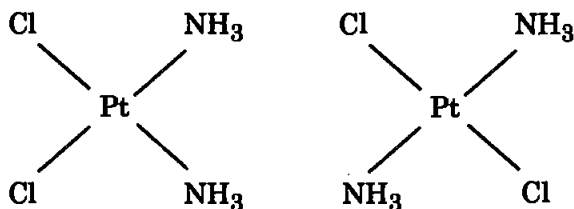
- (A) Stereo isomerism, (B) Structural isomerism.

Each of it can be further sub-divided as:

(A) Stereo isomerism

- (i) Geometrical isomerism. Type of isomerism arises in heteroleptic complexes due to different possible geometric arrangements of the ligands.

Example: $\text{Pt}(\text{NH}_3)_2\text{Cl}_2$



Geometrical isomers (cis & trans)

(ii) *Optical isomerism*. Common in octahedral complexes involving didentate ligands.

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

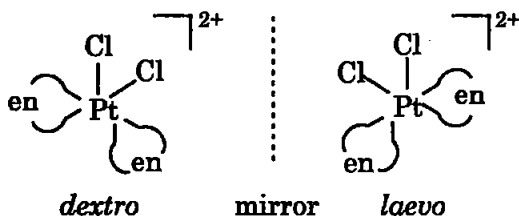


Fig. Optical isomers (*d* and *l*) of cis- $[\text{PtCl}_2(\text{en})_2]^{2+}$

(B) Structural isomerism

(i) *Linkage isomerism*.

Example: $[\text{CO}(\text{NH}_3)_5(\text{NO}_2)]\text{Cl}_2$

(ii) *Coordination isomerism*.

Example: $[\text{CO}(\text{NH}_3)_6][\text{Cr}(\text{CN})_6]$

(iii) *Ionisation isomerism*.

Example: $[\text{CO}(\text{NH}_3)_5\text{SO}_4]\text{Br}$ $[\text{CO}(\text{NH}_3)_5\text{Br}]\text{SO}_4$

(iv) *Solvate isomerism*.

Example: $[\text{Cr}(\text{H}_2\text{O})_6]\text{Cl}_3$ (violet) its solvate isomer
 $[\text{Cr}(\text{H}_2\text{O})_5\text{Cl}]\text{Cl}_2 \cdot \text{H}_2\text{O}$
 (grey-green)

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

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

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

Ans. (i) Nil

(ii) Two (*fac* and *mer*)

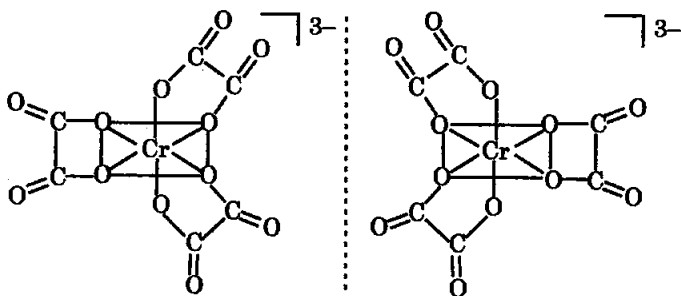
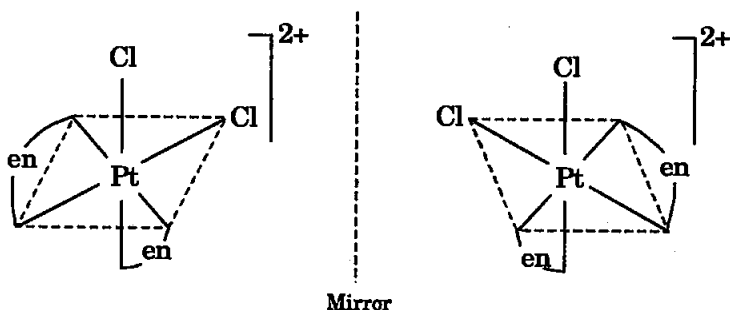
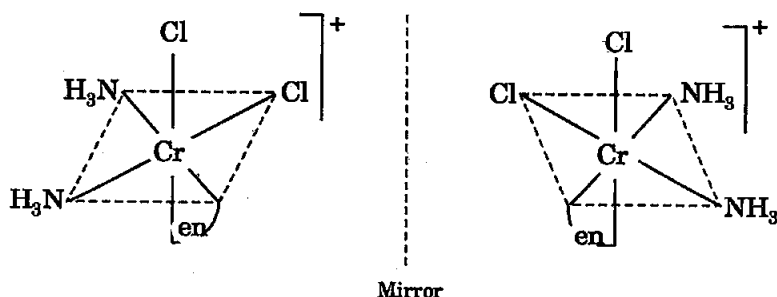
9.10 Draw the structures of optical isomers of:

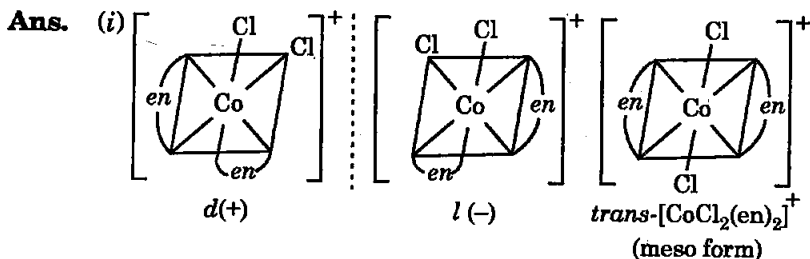
(i) $[\text{Cr}(\text{C}_2\text{O}_4)_3]^{3-}$

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

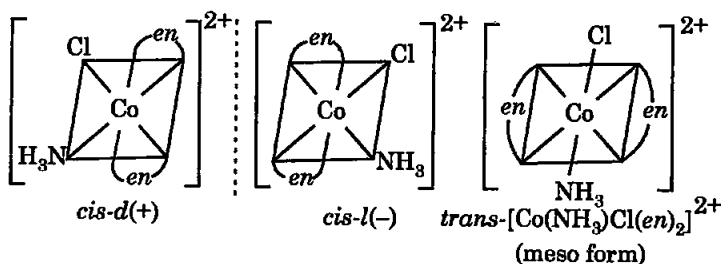
(iii) $[\text{Cr}(\text{NH}_3)_2\text{Cl}_2(\text{en})]^+$

Ans. (i)

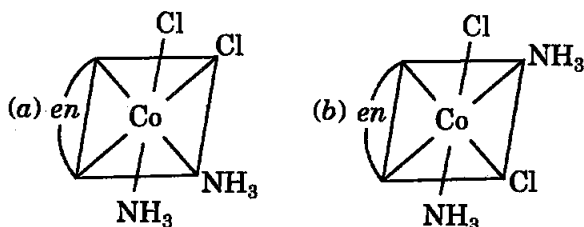
Optical isomers of $[\text{Cr}(\text{C}_2\text{O}_4)_3]^{3-}$ (ii) $[\text{PtCl}_2(\text{en})_2]^{2+}$ *cis*-isomer is optically active(iii) $[\text{Cr}(\text{NH}_3)_2\text{Cl}_2(\text{en})]^+$ *cis*-isomer is optically active**9.11** Draw all the isomers (geometrical and optical) of:(i) $[\text{CoCl}_2(\text{en})_2]^+$ (ii) $[\text{Co}(\text{NH}_3)\text{Cl}(\text{en})_2]^{2+}$ (iii) $[\text{Co}(\text{NH}_3)_2\text{Cl}_2(\text{en})]^+$



(ii) Optical isomers of $cis-[CoCl_2(en)_2]^+$

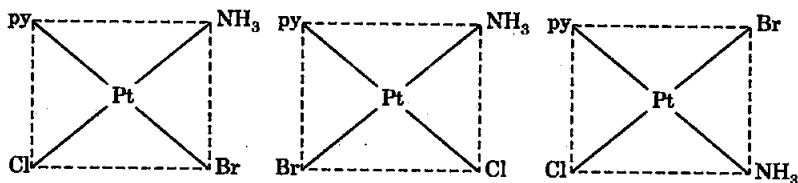


(iii) Optical isomers of $cis-[Co(NH_3)Cl(en)_2]^{2+}$



9.12 Write all the geometrical isomers of $[Pt(NH_3)(Br)(Cl)(py)]$ and how many of these will exhibit optical isomers?

Ans. $[Pt(NH_3)Br Cl(py)]$

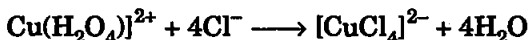
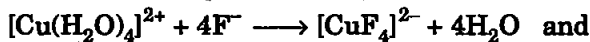


Optical isomerism is not shown by these complexes, in fact, square planar complexes show optical isomerism unless there is unsymmetrical chelating ligand.

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

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

Ans. The blue colour of $[\text{Cu}(\text{H}_2\text{O})_4]^{2+}$ ions change to green by the addition of either F^- or Cl^- ions is due to the fact that both F^- and Cl^- ions are weak field ligands which lie on the left of spectrochemical series. These ions create small splitting Δ , i.e., low energy light is required for small splitting. Thus light of red colour is absorbed and we see the green complexes $[\text{CuF}_4]^{2-}$ or $[\text{CuCl}_4]^{2-}$.



9.14 *What is the coordination entity formed when excess of aqueous KCN is added to an aqueous solution of copper sulphate? Why is it that no precipitate of copper sulphide is obtained when $\text{H}_2\text{S}(\text{g})$ is passed through this solution?*

Ans. An aqueous solution of CuSO_4 has $[\text{Cu}(\text{H}_2\text{O})_4]^{2+}$ as the coordination entity.

When aqueous KCN is added into the $\text{Cu}^{2+}(\text{aq})$ solution, water molecules as ligand are replaced by CN^- ions because they are stronger ligands and the stability of the copper complex with CN^- ion is very high.



In the formation of the cyano complex the oxidation number of copper also changes from +2 to +1.

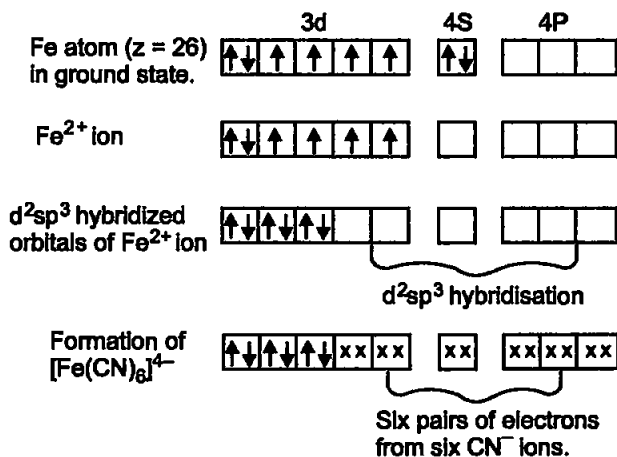
$[\text{Cu}(\text{CN})_4]^{3-}$ complex is very stable or inert and does not give free Cu^+ ions to be attacked by S^{2-} ions. It should be noted that even $\text{Cu}^+(\text{aq})$ is not stable and it is easily oxidised by air to $\text{Cu}^{2+}(\text{aq})$.

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

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

Ans. (i) In $[\text{Fe}(\text{CN})_6]^{4-}$

oxidation state of Fe = +2



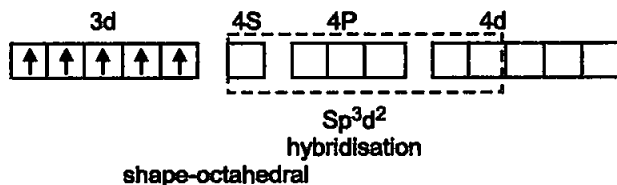
It has octahedral shape diamagnetic.

(ii) In $[\text{FeF}_6]^{3-}$: $[\text{Ar}]4\text{S}^23\text{d}^6$

Fe³⁺ : $[\text{Ar}] 4\text{S}^03\text{d}^5$

F⁻ is a weak ligand and does not cause pairing of electrons.

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

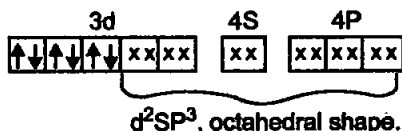


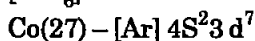
(iii) $[\text{Co}(\text{C}_2\text{O}_4)_3]^{3-}$:

Co(27): $[\text{Ar}] \text{AS}^2 3\text{d}^7$

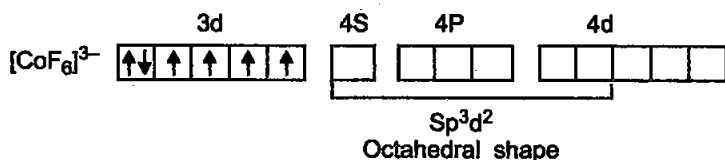
Co³⁺ : $[\text{Ar}] 4\text{S}^0 3\text{d}^6$

C₂O₄²⁻ is strong field ligand causes pairing of electrons.



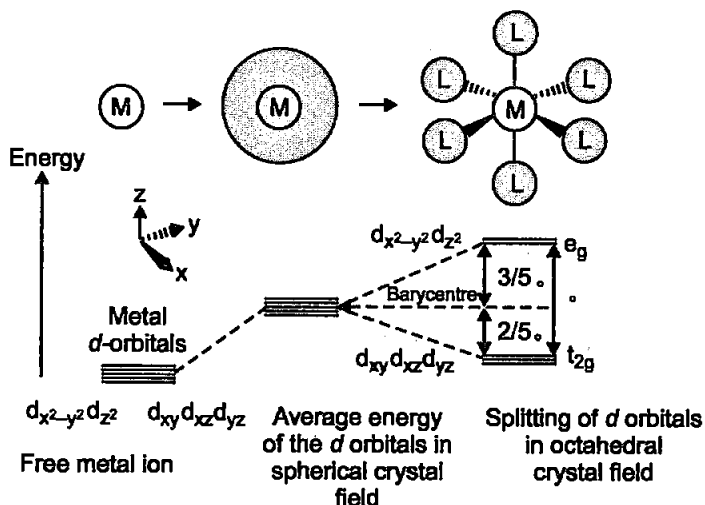


F^- is weak field ligand and does not cause pairing of electrons.



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

Ans.



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

Ans. **Spectrochemical series:** The arrangement of ligands in order of their increasing field strengths the increasing crystal field splitting energy (CFSE) values is called spectrochemical series.

The ligands with small value of CFSE (Δ_o) are called weak field ligands whereas those with large value of CFSE are called strong field ligands.

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

Ans. Ligands on approaching the metal ion, split d orbitals into two sets of orbitals t_{2g} and e_g orbitals. The energy difference between t_{2g} and e_g orbitals is called crystal field splitting energy (CFSE). For octahedral complexes, it is represented by Δ_o or $10 \Delta_q$.

Weak field ligands lying left to the spectrochemical series, keep the Δ_o magnitude small and the result is high spin or spin free complexes.

Strong field ligands, lying right to the spectrochemical series make Δ_o large and the complexes formed are low spin or spin paired ones.

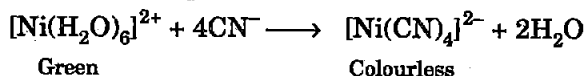
9.19 *$[\text{Cr}(\text{NH}_3)_6]^{3+}$ is paramagnetic while $[\text{Ni}(\text{CN})_4]^{2-}$ is diamagnetic. Explain why?*

Ans. $[\text{Cr}(\text{NH}_3)_6]$ is paramagnetic because NH_3 molecules are weak field ligands forming high spin complex. Δ_o in this case is low.

$[\text{Ni}(\text{CN})_4]^{2-}$ is tetrahedral low spin complex with Δ_t quite large.

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

Ans. The ligand displacement can be shown as



$[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$ is a high spin complex (Δ_o small) while $[\text{Ni}(\text{CN})_4]^{2-}$ is a low spin square planar complex. In $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$ $d-d$ transitions are easily taking place on absorbing low energy radiation (Red component of spectrum) showing green as the complementary colour.

In $[\text{Ni}(\text{CN})_4]^{2-}$ complex all the d^8 electrons are paired and also $d-d$ transitions do not take place in the visible region of spectrum and so appears colourless. (In such cases $d-d$ transitions take place in the UV region.)

[Note: Splitting of d orbitals in square planar complexes has not been described in this unit. However, the d orbitals splitting for square planar complexes is $d_{xz} = d_{yz} < d_{z^2} < d_{xy} < d_{x^2-y^2}$].

The energy gap between d_{xy} and $d_{x^2-y^2}$ is very high and is equal to Δ_0 i.e., same as for octahedral complex. So $d_{x^2-y^2}$ is seldom used for filling.

9.21 $[Fe(CN)_6]^{4-}$ and $[Fe(H_2O)_6]^{2+}$ are of different colours in dilute solutions. Why?

Ans. 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_0), they absorb different components of the visible light (VIBGYOR) for $d-d$ transition. Hence, the transmitted colours are different.

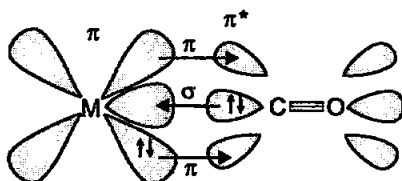
9.22 Discuss the nature of bonding in metal carbonyls.

Ans. (i) The metal-carbon bond in metal carbonyls possess both S & P character.

(ii) The M–C σ bond is formed by the donation of lone pair of electrons on the carbonyl carbon into a vacant orbital of the metal.

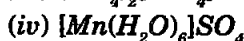
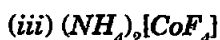
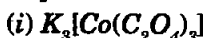
(iii) The M–C π bond is formed by the donation of a pair of electrons from a filled d orbital of metal into the vacant anti bonding π^* orbital of carbon monoxide.

(iv) The metal to ligand bonding creates a synergic which strengthens the bond between CO & the metal.



Synergic bonding

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



Ans.

S.No	Complex	Oxidation state of metal atom	Coordination number of central metal atom	d orbital occupation
(i)	$K_3[Co(C_2O_4)_3]$	+ 3	6	$Co^{3+} = 3d^6$, $(t_{2g})^6, (e_g)^0$
(ii)	<i>cis</i> - $[Cr(en)_2Cl_2]Cl$	+ 3	6	$Cr^{3+} = 3d^3$, $(t_{2g})^3$
(iii)	$(NH_4)_2 [CoF_4]$	+ 2	4	$Co^{2+} = 3d^7$, $(e_g)^4, (t_{2g})^3$
(iv)	$[Mn(H_2O)_6] SO_4$	+ 2	6	$Mn^{2+} = 3d^5$, $(t_{2g})^3, (e_g)^2$

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

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

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

Oxidation state of Cr = + 3; Coordination No. = 6

Name: potassium diaquadioxalatochromate (III) trihydrate

Stereochemistry: octahedral

E.C. of Cr^{3+} , $3d^3 = (t_{2g})^3 (e_g)^0$

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

$n = 3$ from $(t_{2g})^3$ unpaired electron

= $\sqrt{3(3+2)} = \sqrt{15}$ BM = 3.87 BM

(ii) $[Co(NH_3)_5Cl] Cl_2$

Oxidation state of Co = + 3, Coordination number = 6

Stereochemistry = octahedral

E.C. of $Co^{3+} = 3d^6 = (t_{2g})^6 (e_g)^0$

Magnetic moment: for $n = 0$, $\mu = 0$

(iii) $[\text{CrCl}_3(\text{Py})_3]$

Oxidation state of Cr = + 3, coordination No. = 6

Name: trichlorotripyridinechromium (III)

Stereochemistry: octahedral

E.C. of Cr^{3+} , $3d^3 = (t_{2g})^3 (e_g)^0$

Magnetic moment = 3.87 BM

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

Oxidation state of Fe = + 3; Coordination No. = 4

Stereochemistry = Tetrahedral

E.C. of $\text{Fe}^{3+} = 3d^5; (e_g)^2, (t_{2g})^3$

Magnetic moment (for $n = 5$)

$$= \sqrt{5(5+2)} \text{ BM} = \sqrt{35} \text{ BM} = 5.92 \text{ BM}$$

(v) $\text{K}_4 [\text{Mn}(\text{CN})_6]$

Oxidation state of Mn = + 2, Coordination No. = 6

Stereochemistry = octahedral

E.C. of $\text{Mn}^{2+} = 3d^5 = (t_{2g})^5 (e_g)^0$

Magnetic moment: for $n = 1$ (from $(t_{2g})^5$)

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

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

Ans. The stability of a complex in solution refers to the degree of association between the two species involved in the state of equilibrium. The magnitude of the equilibrium constant for the association, quantitatively express the stability.

Factors govern the stability of complex:

- (i) Smaller the size of cation, greater will be the stability of complex e.g. Fe^{3+} forms more stable complex than Fe^{2+} .
- (ii) Greater the charge on central metal ion, more stable will be the complex.
- (iii) Stronger the ligand, more stable will be the complex formed. e.g. CN^- forms more stable complex than NH_3 .

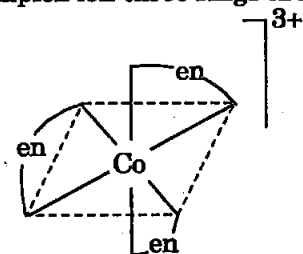
9.26 What is meant by the chelate effect? Give an example.

Ans. When didentate or other polydentate ligands form the complex, the process of the formation of complex is known as chelation and its effect on the stability of the complex is called chelate effect. During chelation, rings are formed with

the metal atom. More the number of rings, more stable is the complex.

Example: $[\text{Co}(\text{en})_3]^{3+}$ ion

Here en is a didentate ligand $\text{H}_2\text{N} - \text{CH}_2 - \text{CH}_2 - \text{NH}_2$ and in the complex ion three rings are formed:



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

- (i) biological systems
- (ii) medicinal chemistry and
- (iii) analytical chemistry
- (iv) extraction / metallurgy of metals

Ans. (i) **Biological systems:** Chlorophyll is a coordination compound of magnesium. Haemoglobin, the red pigment of blood which acts as oxygen carrier is a coordination compound of iron.

Vitamin B_{12} , cyanocobalamin the anti pernicious anaemia factor is a coordination compound of cobalt.

(ii) **Medicinal chemistry:** EDTA is used in the treatment of lead poisoning. Some coordination compounds of platinum effectively inhibit the growth of tumours.

Examples: cis-platin and related compounds.

(iii) **Analytical chemistry:** Hardness of water is estimated by simple titration with Na_2EDTA .

DMG, EDTA are used in qualitative and quantitative analysis.

(iv) **Extraction and metallurgy:** In the purification of metal.

For example, Nickel is converted to $[\text{Ni}(\text{CO})_4]$ which is decomposed to yield pure nickel.

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

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

Ans. The complex is $[\text{Co}(\text{NH}_3)_6]^{2+} (\text{Cl}^-)_2$. There are three ions formed, option is (iii)

9.29 Amongst the following ions which one has the highest magnetic moment value?

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

Ans. (i) $[\text{Cr}(\text{H}_2\text{O})_6]^{3+} : \text{Cr}^{3+} = 3d^3; n = 3; \mu = 3.87 \text{ BM}$

(ii) $[\text{Fe}(\text{H}_2\text{O})_6]^{2+} : \text{Fe}^{2+} = 3d^6; n = 4; \mu = 4.90 \text{ BM}$

(iii) $[\text{Zn}(\text{H}_2\text{O})_6]^{2+} : \text{Zn}^{2+} = 3d^{10}; n = 0; \mu = 0 \text{ BM}$

So (ii) has the highest value of μ .

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

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

Ans. Option (iii) is correct.

9.31 Amongst the following the most stable complex is

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

Ans. From the position of the ligands in the spectrochemical series $[\text{Fe}(\text{NH}_3)_6]^{3+}$ should be more stable. Since $\text{C}_2\text{O}_4^{2-}$ ions are didentate ligands they form chelates involving ring formation. In the complex $[\text{Fe}(\text{C}_2\text{O}_4)_3]^{3-}$, three rings are formed hence, it becomes more stable. The choice is (iii).

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

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

Ans. All the complex ions are derived from Ni^{2+} ion with different ligands. From the position of the ligands in the spectrochemical series the order of field strength is

$\text{H}_2\text{O} < \text{NH}_3 < \text{NO}_2^-$

That means Δ_0 for NO_2^- is maximum and so it would absorb the radiation of shorter wavelength having high energy. So, the order of absorption of the correct wavelength is

$[\text{Ni}(\text{H}_2\text{O})_6]^{2+} > [\text{Ni}(\text{NH}_3)_6]^{2+} > [\text{Ni}(\text{NO}_2)_6]^{4-}$
 (λ about 700 nm) (about 500 nm) (< 500 nm)

□□□