Co-ordination Compounds (2015-2025)

CBSE 2025

1. The diamagnetic species is :

(A) $[Ni(CN)_4]^{2-}$ (B) $[NiCl_4]^{2-}$

(C) $[Fe(CN)_6]^{3-}$ (D) $[CoF_6]^{3-}$

[At. No. Co = 27, Fe = 26, Ni = 28]

2. The complex ions $[Co(NH_3)_5(NO_2)]^{2+}$ and $[Co(NH_3)_5(ONO)]^{2+}$ are called

(A) Ionization isomers (B) Linkage isomers

(C) Co-ordination isomers (D) Geometrical isomers

3. Explain $[Co(NH_3)_6]^{3+}$ is an inner orbital complex whereas $[Ni(NH_3)_6]^{2+}$ is an outer orbital complex. [At. No. Co = 27, Ni = 28] 2

4. Write IUPAC names of the following coordination entities : 3

(a) $[Fe(en)_2Cl_2]^+$

(b) $[Co(NH_3)_4(H_2O)Br]SO_4$

(c) $[Ni(CN)_4]^{2-}$

5. **Assertion (A): $[Cr(H_2O)_6]Cl_2$ and $[Fe(H_2O)_6]Cl_2$ are examples of homoleptic complexes.**

Reason (R): All the ligands attached to the metal are the same.

6. **(A) Answer the following:**

(a) Low spin tetrahedral complexes are not known.

(b) Co^{2+} is easily oxidized to Co^{3+} in the presence of a strong ligand (At. No. of Co = 27).

(c) What type of isomerism is shown by the complex [Co(NH)][Cr(CN)]?

(d) Why is a solution of $[Ni(H_2O)_6]^{+2}$ green while a solution of $[Ni(CN)_6]^{-2}$ is colourless? (At. No. of Ni = 28)

(e) Write the IUPAC name of the following complex: [Co(NH)(CO)]Cl.

CBSE 2024

1. Write the IUPAC names of the following coordination compounds (any **three**):
   (*a*) $[Co(NH_3)_4Cl(NO_2)]Cl$
   (*b*) $[Ni(NH_3)_6]Cl_2$
   (*c*) $K_3[Cr(C_2O_4)_3]$
   (*d*) $[Co(en)_2Br_2]^+$

2. **The following questions are case-based questions. Read the case carefully and answer the questions that follow:**

The oxidation number of the central atom in a complex is defined as the charge it would carry if all the ligands are removed along with the electron pairs that are shared with the central atom. Similarly the charge on the complex is the sum of the charges of the constituent parts i.e. the sum of the charges on the central metal ion and its surrounding ligands. Based on this, the complex is called neutral if the sum of the charges of the constituents is equal to zero. However, for an anion or cationic complex, the sum of the charges of the constituents is equal to the charge on the coordination sphere.

Based on the above information, answer the following questions:

(*a*) Define ambidentate ligand with an example. **1**

(*b*) What type of isomerism is shown by $[Co(NH_3)_5Cl]SO_4$ and $[Co(NH_3)_5SO_4]Cl$? **1**

(*c*) Define Chelate effect. How it affects the stability of complex? **2**

OR

(*c*) Find the coordination number and oxidation state of chromium in $Na_3[Cr(C_2O_4)_3]$. **2**

3. Which of the following is diamagnetic in nature ?

(A) Co^{3+}, octahedral complex with strong field ligand

(B) Co^{3+}, octahedral complex with weak field ligand

(C) Co^{3+}, in a square planar complex

(D) Co^{3+}, in a tetrahedral complex

[Atomic number : Co = 27]

4. Attempt any ***five*** of the following : *5×1=5*

(a) Write the IUPAC name of the complex :

$[Co(H_2O)(CN)(en)_2]^{2+}$

(b) Why is geometrical isomerism not possible in tetrahedral complexes having two different types of unidentate ligands coordinated with the central metal ion ?

(c) Arrange the following complex ions in increasing order of their crystal field splitting energy (Δ_o) :

$[Co(NH_3)_6]^{3+}$, $[CoF_6]^{3-}$, $[Co(CN)_6]^{3-}$

(d) Write the hybridization and magnetic character of the complex $[Ni(CO)_4]$ on the basis of valence bond theory.

[Atomic No. : Ni = 28]

(e) Out of $[CoF_6]^{3-}$ and $[Co(C_2O_4)_3]^{3-}$, which one complex is :

(i) more stable ?

(ii) the high spin complex ?

(f) What is the difference between an ambidentate ligand and bidentate ligand ?

(g) Write the electronic configuration of d^5 in terms of t_{2g} and e_g in an octahedral field when :

(i) $\Delta_o > P$, and (ii) $\Delta_o < P$

CBSE 2023

1. What is the secondary valency of cobalt in $[Co(en_2)Cl_2]^+$?

(*a*) 6 (*b*) 4 (*c*) 2 (*d*) 8

2. The formula of the complex dichloridobis (ethane –1, 2-diamine) platinum(IV) nitrate is

(*a*) $[PtCl_2(en)_2 (NO_3)_2]$ (*b*) $[PtCl_2(en)_2] (NO_3)_2$

(*c*) $[PtCl_2(en)_2 (NO_3)] NO_3$ (*d*) $[Pt(en)_2 (NO_3)_2] Cl_2$

3. (*a*) Write the IUPAC names of the following:

(*i*) $[Co(NH_3)_5(ONO)]^{2+}$ (*ii*) $K_2[NiCl_4]$

OR

(*b*) (*i*) What is a chelate complex? Give one example.

(*ii*) What are heteroleptic complexes? Give one example.

4. (*a*) Draw the geometrical isomers of $[Co(en)_2Cl_2]^{2+}$. Which geometrical isomer of $[Co(en)_2Cl_2]^{2+}$ is not optically active and why? **2+1**

(*b*) Write the hybridisation and magnetic behaviour of $[CoF_6]^{3-}$.

[Given : Atomic number of Co = 27]

5. The compounds $[Co(SO_4) (NH_3)_5] Br$ and $[Co(Br) (NH_3)_5] SO_4$ represent :

(a) optical isomerism (b) linkage isomerism

(c) ionisation isomerism (d) coordination isomerism

6. *Assertion (A) :* Low spin tetrahedral complexes are rarely observed.
Reason (R) : Crystal field splitting energy is less than pairing energy for tetrahedral complexes.

7. In coordination compounds, metals show two types of linkages, primary and secondary. Primary valencies are ionisable and are satisfied by negatively charged ions. Secondary valencies are non-ionisable and are satisfied by neutral or negative ions having lone pair of electrons. Primary valencies are non-directional while secondary valencies decide the shape of the complexes.

(i) If $PtCl_2 \cdot 2NH_3$ does not react with $AgNO_3$, what will be its formula ?

(ii) What is the secondary valency of $[Co(en)_3]^{3+}$?

(iii) (1) Write the formula of Iron(III)hexacyanidoferrate(II).

(2) Write the IUPAC name of $[Co(NH_3)_5Cl]\ Cl_2$.

OR

(iii) Write the hybridization and magnetic behaviour of $[Ni(CN)_4]^{2-}$.
[Atomic number : Ni = 28]

CBSE 2021

1. (a) (i) On the basis of crystal field theory, write the electronic configuration for d^4 ion if $\Delta_0 < P$.

(ii) Using valence bond theory, predict the hybridization and magnetic character of $[Ni(CN)_4]^{2-}$.

(Atomic number of Ni = 28)

(iii) Write the formula of the following complex using IUPAC norms :
Dichloridobis (ethane-1,2-diamine) cobalt (III) **1 × 3 = 3**

OR

(b) When a co-ordination compound $NiCl_2 \cdot 6H_2O$ mixed with $AgNO_3$, 2

OR

(b) When a co-ordination compound $NiCl_2 \cdot 6H_2O$ mixed with $AgNO_3$, 2 moles of $AgCl$ are precipitated per mole of the compound. Write

(i) Structural formula of the complex.

(ii) Secondary valency of 'Ni' in the complex.

(iii) IUPAC name of the complex. **1 × 3 = 3**

CBSE-2021

CBSE 2020

1. **The oxidation state of Ni in $[Ni(CO)_4]$ is** CBSE-2020

(a) 0 **(b) 2**

(c) 3 **(d) 4**

Ans. (a) $[Ni(CO)_4]$ $x + 0 = 0 \Rightarrow x = 0$

2. **Assertion (A): Low spin tetrahedral complexes are rarely observed.** CBSE-2020

Reason (R): Crystal field splitting energy is less than pairing energy for tetrahedral complexes.

Ans. (A) Both 'A' and 'R' are correct and 'R' is correct reason of 'A'.

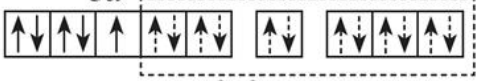
3. **(a) Write the IUPAC name and hybridisation of the complex $[Fe(CN)_6]^{3-}$. (Given: Atomic number of Fe = 26)** CBSE-2020

(b) What is the difference between an ambidentate ligand and a chelating ligand? 1+1=2

Ans. (a) Hexacyanido ferrate (III) or Hexacyano ferrate (III)

CN^- is a strong field ligand, therefore, it causes pairing of electrons, forms low spin.

$[Fe(CN)_6]^{3-}$:



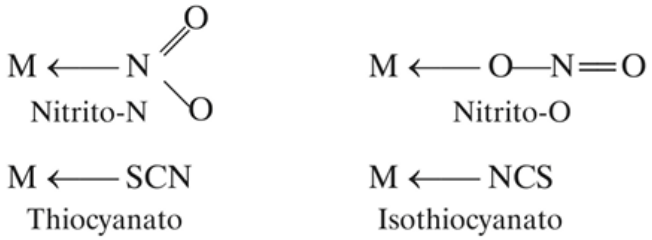
d^2sp^3 hybridisation

$[Fe(CN)_6]^{3-}$ has d^2sp^3 hybridization, weakly paramagnetic due to presence of one unpaired electron, therefore, low spin complex.

(b) Chelating ligands form cyclic complex where as ambidentate ligands form non-cyclic ligands.

or

Ambidentate ligand: Ligands which can ligate (link) through two different atoms present in it are called *ambidentate ligands*, e.g. NO_2^-, SCN^-, CNO^- and CN^-. NO_2^- can link through 'N' as well as oxygen while SCN^- can link through 'S' as well as 'N' atoms.



Chelating or Polydentate ligand: The ligand which can form two or more σ bond with central metal atom or ion, e.g., $\begin{matrix} COO^- \\ | \\ COO^- \end{matrix}$

Polydentate ligand are also called chelating agents.

4. **Which of the following will give a white precipitate upon reacting with $AgNO_3$?** CBSE-2020

(a) $K_2[Pt(en)_2Cl_2]$ **(b) $[Co(NH_3)_3Cl_3]$** **(c) $[Cr(H_2O)_6]Cl_3$** **(d) $[Fe(H_2O)_3Cl_3]$**

Ans. (c) $[Cr(H_2O)_6]\,Cl_3$

6. **Discuss the nature of bonding in metal carbonyls.** CBSE-2020 **2**

Ans. It involves both σ bond as well as π-bond. σ bond is formed by donation of lone pair of electron to the vacant *d*-orbitals of transition metals.

π-bond is formed by back donation of pair of electrons from transition metal to antibonding molecular orbital of CO.

It makes bond between metal and CO very strong.

6. **Out of *Cis* – $[Pt(en)_2Cl_2]^{2+}$ and *Trans* – $[Pt(en_2)Cl_2]^{2+}$, Which one is optically active?**

Ans. *Cis* $[Pt\ (en)_2Cl_2]^{2+}$ CBSE-2020

CBSE 2019

1. **Define ambidient nucleophile with an example.** CBSE-2019

Ans. **Ambidient nucleophiles:** Those nucleophiles which can form bond through either of the two atoms are called ambident nucleophiles, *e.g.* CN^- can link through 'C' or 'N' to form cyanide or isocyanide as follows:

$$C_2H_5Cl + KCN \longrightarrow C_2H_5C{\equiv}N + KCl$$

$$C_2H_5Br + AgCN \longrightarrow C_2H_5N{=}C + AgBr$$

2. **Write IUPAC name of the complex $[Pt(en)_2Cl_2]$. Draw structures of geometrical isomers for this complex.**

OR

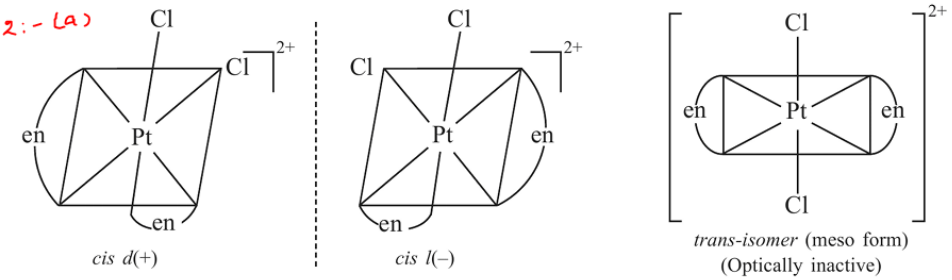
CBSE-2019

Using IUPAC norms write the formulae for the following:

(*i*) Hexaamminecobalt(III) sulphate

(*ii*) Potassium trioxalatochromate(III).

Ans. 2:- (a)



cis d(+) *cis l*(–) *trans-isomer* (meso form) (Optically inactive)

Dichlorido bis (ethane 1, 2-diamine) platinum II

OR

OR

(*i*) $[Co(NH_3)_6]_2(SO_4)_3$

(*ii*) $K_3[Cr(C_2O_4)_3]$

3. **Out of $[CoF_6]^{3-}$ and $[Co(en)_3]^{3+}$, which one complex is** CBSE-2019

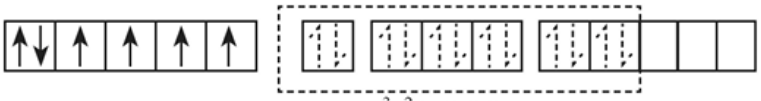
(*i*) paramagnetic **(*ii*) more stable**

(*iii*) inner orbital complex and **(*iv*) high spin complex**

(Atomic number of Co = 27)

Ans. (*i*) $[CoF_6]^{3-}$ is paramagnetic.

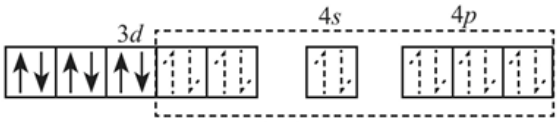
$[CoF_6]^{3-}$:



sp^3d^2 hybridisation

(*ii*) $[Co(en)_3]^{3+}$ is more stable.

(*iii*) $[Co(en)_3]^{3+}$ is inner orbital complex.



d^2sp^3 hybridisation

(*iv*) $[CoF_6]^{3-}$ is high spin complex.

4. **Write IUPAC name of the complex $[Cr(NH_3)_4Cl_2]^+$. Draw structures of geometrical isomers for this complex.**

OR

Using IUPAC norms write the formulae for the following:

(*i*) Pentaamminenitrito-O-cobalt(III) chloride

(*ii*) Potassium tetracyanidonickelate(II)

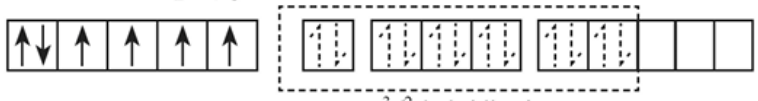
5. **Out of $[CoF_6]^{3-}$ and $[Co(C_2O_4)_3]^{3-}$, which one complex is** CBSE-2019

(*i*) diamagnetic **(*ii*) more stable**

(*iii*) outer orbital complex **(*iv*) low spin complex?**

Ans. (*i*) $[CoF_6]^{3-}$ is paramagnetic and $[Co(C_2O_4)_3]^{3-}$ is diamagnetic.

$[CoF_6]^{3-}$:



sp^3d^2 hybridisation

(*ii*) $[Co(C_2O_4)_3]^{3-}$ is more stable.

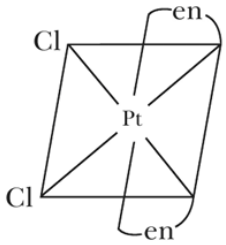
(*iii*) $[CoF_6]^{3-}$ is outer orbital complex.

(*iv*) $[Co(C_2O_4)_3]^{3-}$ is low spin complex.

CBSE 2018

1. **Write the coordination number and oxidation state of Platinum in the complex $[Pt(en)_2Cl_2]$.** CBSE-2018 **1**

Ans. Coordination number of Pt is 6 because 'en' is bidentate ligand, there are two bidentane ligands and two mono dentate ligands. Therefore, coordination number is 6 as shown below.



Oxidation State

$[Pt(en)_2Cl_2]$

$x + 2\times0 + 2\times(-1) = 0$

$x - 2 = 0$

$\boxed{x = +2}$

2. **(a) Write the formula of the following coordination compound:** CBSE-2018
Iron(III) hexacyanoferrate(II)

(b) What type of isomerism is exhibited by the complex $[Co(NH_3)_5Cl]SO_4$?

(c) Write the hybridisation and number of unpaired electrons in the complex $[CoF_6]^{3-}$. (Atomic No. of Co = 27) **3**

CBSE 2017

1. **Write the structures of the following:** CBSE-2017

(a) Sodium dicyanidoaurate(I)

(b) Tetraamminechloridonitrito-N-platinum(IV) sulphate

Ans (a) $Na[Au(CN)_2]$

(b) $[Pt(NH_3)_4ClNO_2]SO_4$

2. **(a) What type of isomerism is shown by the complex $[Co(NH_3)_5(SCN)]^{2+}$?**

(b) Why is $[NiCl_4]^{2-}$ paramagnetic while $[Ni(CN)_4]^{2-}$ is diamagnetic? (Atomic number of Ni = 28)

(c) Why are low spin tetrahedral complexes rarely observed? **[3]**

CBSE 2016

1. **When a co-ordination compound $CoCl_3.4NH_3$ is mixed with $AgNO_3$, 1 mole of AgCl is precipitated per mole of the compound. Write**

(i) Structural formula of the complex CBSE-2016

(ii) IUPAC name of the complex. **[2]**

(i) $[Co(NH_3)_4Cl_2]Cl$

(ii) Tetraamminedichloridocobalt(III)chloride.

2. **(a) For the complex $[Fe(CO)_5]$, write the hybridization, magnetic character and spin of the complex. (At. number: Fe = 26)** CBSE-2016

(b) Define crystal field splitting energy. **[3]**

Hint- (a) It has dsp^3 hybridization and diamagnetic. It is low spin complex.

(b) The energy used to split degenerate *d*-orbital due to the presence of ligands in a definite geometry is called crystal field splitting energy.

CBSE 2015

1. (*i*) Write down the IUPAC name of the following complex: $[Co(NH_3)_5Cl]^{2+}$ CBSE-2015

(*ii*) Write the formula for the following complex:
Potassium tetrachloridonickelate (II)

Ans. (*i*) Pentaamminechlorido cobalt (III)

(*ii*) $K_2[NiCl_4]$

2. (*i*) What type of isomerism is shown by the complex $[Cr(H_2O)_6]Cl_3$?

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

(*iii*) Write the hybridization and shape of $[CoF_6]^{3-}$. CBSE-2015
(Atomic number of Co = 27) 3