Coordination Compounds

Class 12 Chemistry · 24 NEET MCQs with answers & explanations

Coordination Compounds covers Werner's theory, IUPAC nomenclature of complexes, isomerism (geometric, optical, ionisation, linkage), crystal field theory (CFT), spectrochemical series and bonding in complexes. NEET tests nomenclature, determining hybridisation and geometry, magnetic behaviour prediction, and isomerism identification.

Key Coordination Chemistry

Concept	Key Fact
Coordination number	Number of ligand atoms directly bonded to metal; CN 4 → tetrahedral or square planar; CN 6 → octahedral
IUPAC naming	Cation first, then anion; ligands in alphabetical order; metal oxidation state in Roman numerals
CFT splitting	Octahedral: t_2g and eg; tetrahedral: e and t_2; Δoct > Δtet
Spectrochemical series	I^- < Br^- < Cl^- < F^- < OH^- < H_2O < NH_3 < en < CN^- < CO (weak → strong field)
Geometric isomerism	cis-trans in square planar and octahedral; fac-mer in octahedral
Magnetic behaviour	Strong field ligand → low spin (paired); weak field → high spin (unpaired)

Questions

Q1. Which of the following species is correctly identified as an ambidentate ligand?

(A) NH3
(B) en
(C) NO2−
(D) OH−

Q2. Which of the following is a homoleptic coordination compound?

(A) K3[Al(C2O4)3]
(B) [Pt(NH3)2Cl2]
(C) [Co(NH3)5Cl]Cl
(D) [Cr(NH3)3(H2O)3]Cl

Q3. For [Co(NH3)5Cl]Cl2, the total number of ions produced per formula unit on complete ionisation in water is:

(A) 2
(B) 3
(C) 4
(D) 5

Q4. Which pair of complexes represents linkage isomerism?

(A) [Co(NH3)5NO2]Cl2 and [Co(NH3)5ONO]Cl2
(B) [Co(NH3)5Br]SO4 and [Co(NH3)5SO4]Br
(C) [Co(NH3)6][Cr(CN)6] and [Cr(NH3)6][Co(CN)6]
(D) cis-[Pt(NH3)2Cl2] and trans-[Pt(NH3)2Cl2]

Q5. What are the primary and secondary valences of Co in [Co(NH3)6]Cl3?

(A) Primary 6 and secondary 3
(B) Primary 6 and secondary 6
(C) Primary 3 and secondary 6
(D) Primary 3 and secondary 3

Q6. Which of the following complexes has the highest crystal-field splitting energy?

(A) [Co(NH3)6]3+
(B) [CoF6]3-
(C) [Co(H2O)6]3+
(D) [CoCl6]3-

Q7. Which isomerism arises due to exchange of ions between coordination and ionisation spheres?

(A) Ionisation isomerism
(B) Geometrical isomerism
(C) Optical isomerism
(D) Linkage isomerism

Q8. Which type of isomerism is exhibited by complexes containing ambidentate ligands?

(A) Ionisation isomerism
(B) Linkage isomerism
(C) Optical isomerism
(D) Coordination isomerism

Q9. Which hybridisation is shown by inner orbital octahedral complexes?

(A) d^2sp^3
(B) sp^3d^2
(C) sp^3
(D) dsp^2

Q10. Which of the following forms an inner orbital octahedral complex?

(A) $[CoF_6]^{3-}$
(B) $[Co(NH_3)_6]^{3+}$
(C) $[NiCl_4]^{2-}$
(D) $[ZnCl_4]^{2-}$

Q11. Which of the following is the weakest field ligand in the spectrochemical series?

(A) I^-
(B) Br^-
(C) F^-
(D) Cl^-

Q12. Which segment of the spectrochemical series is arranged in the correct increasing order of field strength?

(A) $NH_3 < en < H_2O < CN^-$
(B) $CN^- < CO < en < NH_3$
(C) $en < NH_3 < F^- < H_2O$
(D) $F^- < H_2O < NH_3 < en$

Q13. Which of the following ligands is bidentate and capable of forming a chelate ring?

(A) NH3
(B) en
(C) CO
(D) H2O

Q14. Which of the following ligands is hexadentate?

(A) Oxalate
(B) en
(C) EDTA
(D) dien

Q15. Which statement correctly represents primary valency according to Werner's theory?

(A) Ionisable and equals oxidation state
(B) Non-ionisable and directional
(C) Satisfied only by anions inside coordination sphere
(D) Determines geometry of complex

Q16. How many total ions does $[Co(NH_3)_6]Cl_3$ produce in aqueous solution?

(A) 1
(B) 4
(C) 3
(D) 2

Q17. Crystal field theory explains the splitting of which orbitals of the central metal ion?

(A) d orbitals
(B) p orbitals
(C) s orbitals
(D) f orbitals

Q18. In an octahedral crystal field, the five d orbitals split into which two sets?

(A) t_2g (lower) and eg (higher)
(B) eg (lower) and t_2g (higher)
(C) t_2g and eg at equal energy
(D) dxy set and dz^2 set

Q19. Which reagent forms a red precipitate with Ni^{2+} ions in qualitative analysis?

(A) Dimethylglyoxime
(B) EDTA
(C) Potassium ferrocyanide
(D) Ammonium thiocyanate

Q20. EDTA is widely used in complexometric titrations because it acts as a:

(A) Oxidising agent
(B) Complexing agent
(C) Reducing agent
(D) Precipitating agent

Q21. Which of the following d-configurations has zero CFSE in an octahedral high-spin field?

(A) d^3
(B) d^8
(C) d^5
(D) d^6

Q22. Which d-configuration gives a CFSE of −1.2Δo in an octahedral high-spin field?

(A) d^3
(B) d^5
(C) d^6
(D) d^8

Q23. Which of the following correctly explains why secondary valency determines the geometry of a complex?

(A) Secondary valency is directional and fixes spatial arrangement of ligands
(B) Secondary valency equals the oxidation state of the metal
(C) Secondary valency is satisfied by ionisable anions
(D) Secondary valency is non-directional like primary valency

Q24. Which complex will NOT give a precipitate with $AgNO_3$ solution?

(A) $[Co(NH_3)_6]Cl_3$
(B) $[Co(NH_3)_5Cl]Cl_2$
(C) $[Co(NH_3)_4Cl_2]Cl$
(D) $[Co(NH_3)_3Cl_3]$

Answer key

1-C	**2-A**	**3-B**	**4-A**	**5-C**	**6-A**	**7-A**	**8-B**
9-A	**10-B**	**11-A**	**12-D**	**13-B**	**14-C**	**15-A**	**16-B**
17-A	**18-A**	**19-A**	**20-B**	**21-C**	**22-A**	**23-A**	**24-D**

Answers with explanations

Q1 — Answer: (C) NO2−
NO2− can coordinate through nitrogen (nitro mode) or through oxygen (nitrito mode) and is therefore ambidentate. NH3 has only one donor atom and is monodentate. OH− coordinates only through oxygen. en is bidentate, not ambidentate, because it uses two different donor atoms simultaneously rather than offering alternative donor sites.

Q2 — Answer: (A) K3[Al(C2O4)3]
A homoleptic complex contains only one type of ligand in its coordination sphere. In K3[Al(C2O4)3], all three ligands are oxalate. The coordination spheres of the remaining three compounds each contain at least two different ligand types. Counter-ions are not considered when determining homoleptic character.

Q3 — Answer: (B) 3
[Co(NH3)5Cl]Cl2 ionises to give one complex cation [Co(NH3)5Cl]2+ and two free Cl- ions. Total ions = 3. The chloride inside the coordination sphere does not ionise.

Q4 — Answer: (A) [Co(NH3)5NO2]Cl2 and [Co(NH3)5ONO]Cl2
NO2- is an ambidentate ligand that can bind through N (nitro) or O (nitrito), producing linkage isomers. Option B is ionisation isomerism, Option C is coordination isomerism, and Option D is geometrical isomerism.

Q5 — Answer: (C) Primary 3 and secondary 6
Primary valence equals the oxidation state. Co is +3, so primary valence = 3. Secondary valence equals the coordination number = 6 (six NH3 donor atoms directly bonded). The three Cl- counter-ions satisfy the primary valence; the six NH3 ligands satisfy the secondary valence.

Q6 — Answer: (A) [Co(NH3)6]3+
All four complexes contain Co3+ so Δo depends only on ligand-field strength. The spectrochemical series gives NH3 > H2O > F- > Cl- among these ligands. Therefore [Co(NH3)6]3+ has the largest Δo.

Q7 — Answer: (A) Ionisation isomerism
Ionisation isomers differ in which ion is inside the coordination sphere vs outside as counter ion — e.g. $[Co(NH_3)_5Cl]SO_4$ and $[Co(NH_3)_5SO_4]Cl$. Option D is the trap — linkage isomerism involves ambidentate ligands, not ion exchange.

Q8 — Answer: (B) Linkage isomerism
Ambidentate ligands (e.g. NO_2^-, SCN^-) can coordinate through two different donor atoms — this gives linkage isomers. Option A is the trap — ionisation isomerism involves ion exchange, not donor atom switching.

Q9 — Answer: (A) d^2sp^3
Inner orbital octahedral complexes use (n−1)d orbitals for hybridisation, giving d^2sp^3. Outer orbital complexes use nd orbitals and show sp^3d^2 instead. The key distinction is which d orbitals are involved.

Q10 — Answer: (B) $[Co(NH_3)_6]^{3+}$
Co^{3+} is d^6; NH_3 (strong field) causes pairing of electrons into three 3d orbitals, freeing two 3d orbitals for d^2sp^3 hybridisation. $[CoF_6]^{3-}$ uses weak-field F^- and remains outer orbital (sp^3d^2).

Q11 — Answer: (A) I^-
I^- causes the minimum crystal field splitting among all common ligands — it sits at the extreme weak-field end of the spectrochemical series. Among halides, field strength decreases as $F^- > Cl^- > Br^- > I^-$, making Br^- the second-weakest option here.

Q12 — Answer: (D) $F^- < H_2O < NH_3 <$ en
The correct order is $F^- < H_2O < NH_3 <$ en — en (ethylenediamine) is a stronger field ligand than NH_3 due to the chelate effect and greater donor strength. CN^- and CO sit above en. Option A wrongly places H_2O above en.

Q13 — Answer: (B) en
en (ethylenediamine) has two $-NH_2$ donor atoms that coordinate simultaneously to a metal, forming a five-membered chelate ring. NH_3, CO, and H_2O are all monodentate — they bind through only one donor atom and cannot form rings.

Q14 — Answer: (C) EDTA
EDTA (ethylenediaminetetraacetic acid) donates through two N and four O atoms — six donor sites total, making it hexadentate. Oxalate is bidentate, en is bidentate, and dien is tridentate.

Q15 — Answer: (A) Ionisable and equals oxidation state
Primary valency = oxidation state; it is ionic and satisfied by counter ions outside the coordination sphere. Secondary valency (not primary) is non-ionisable and directional. Option C confuses primary with secondary valency roles.

Q16 — Answer: (B) 4
$[Co(NH_3)_6]Cl_3$ dissociates into $[Co(NH_3)_6]^{3+}$ (1 ion) + 3 Cl^- = 4 ions total. Option C (3) is the trap — students confuse number of Cl^- ions with total ion count. All NH_3 ligands remain inside the coordination sphere.

Q17 — Answer: (A) d orbitals
CFT explains how degenerate d orbitals of the central metal ion split into sets of different energies when surrounded by ligands. p, s, and f orbitals are not involved in this splitting in transition metal complexes.

Q18 — Answer: (A) t_2g (lower) and eg (higher)
In octahedral field, ligands approach along axes. The dxy, dxz, dyz orbitals (t_2g) point between axes and experience less repulsion (lower energy); dx^2-y^2 and dz^2 (eg) point directly at ligands and experience greater repulsion (higher energy).

Q19 — Answer: (A) Dimethylglyoxime
Ni^{2+} reacts with dimethylglyoxime (dmgH) to form a characteristic bright red chelate precipitate — this is the standard spot test for Ni^{2+}. EDTA forms colourless complexes. Potassium ferrocyanide and thiocyanate are used for Fe and Co detection respectively.

Q20 — Answer: (B) Complexing agent
EDTA forms highly stable 1:1 complexes with most metal ions regardless of charge, making it ideal for complexometric titrations. It does not oxidise, reduce, or precipitate the metal — it sequesters it as a soluble chelate.

Q21 — Answer: (C) d^5
d^5 high-spin has the configuration $t_2g^3eg^2$, with each orbital singly occupied. CFSE = $3(-0.4\Delta o) + 2(+0.6\Delta o) = -1.2 + 1.2 = 0$. d^6 high-spin is the trap — it gives $-0.4\Delta o$, not zero.

Q22 — Answer: (A) d^3
d^3 high-spin: $t_2g^3eg^0$; CFSE = $3(-0.4\Delta o) = -1.2\Delta o$. d^5 high-spin is the trap — it also has 3 electrons in t_2g but gains 2 in eg, cancelling to zero. d^3 has no eg electrons so the full $-1.2\Delta o$ is retained.

Q23 — Answer: (A) Secondary valency is directional and fixes spatial arrangement of ligands
Secondary valency (coordination number) is directional — ligands attach at fixed angles around the metal, directly determining geometry. Primary valency is non-directional. Option D is the key trap — students confuse which valency is directional.

Q24 — Answer: (D) $[Co(NH_3)_3Cl_3]$
In $[Co(NH_3)_3Cl_3]$, all three Cl^- ions are inside the coordination sphere satisfying secondary valency — none are free in solution to react with Ag^+. Options A, B, C each have 3, 2, 1 ionisable Cl^- respectively.

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