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Coordination Compounds — CBSE Class 12 Chemistry Chapter Test

FREE CHAPTER TEST · CLASS XII · CHEMISTRY (043) · PATTERN OF THE CBSE SAMPLE QUESTION PAPER 2026-27

TIME ALLOWED	MAXIMUM MARKS	QUESTIONS	NAME / ROLL NO.
1½ hours	37	17 (A 8 · B 3 · C 3 · D 1 · E 2)	

GENERAL INSTRUCTIONS

Read the following instructions very carefully and strictly follow them:

1. This question paper contains 17 questions. All questions are compulsory.
2. This question paper is divided into five sections: A, B, C, D and E.
3. Section A (Q1–8) contains 6 multiple choice questions and 2 assertion-reason based questions of 1 mark each.
4. Section B (Q9–11) contains short answer questions of 2 marks each.
5. Section C (Q12–14) contains short answer questions of 3 marks each.
6. Section D (Q15) contains case-based questions of 4 marks each, with sub-parts of 1, 1 and 2 marks.
7. Section E (Q16–17) contains long answer questions of 5 marks each.
8. There is no overall choice. However, an internal choice has been provided in 1 question in Section B, 1 question in Section C, 1 question in Section D, 2 questions in Section E. Attempt only one of the alternatives in such questions.
9. Use of log tables and calculators is not allowed.
10. This chapter test follows the section structure, question types and marks per question of the CBSE Class XII Chemistry (043) Sample Question Paper 2026-27, at about half the length of the 70-mark board paper: 37 marks in 1½ hours.
11. The answer key and the marking scheme are at the end of this booklet. Attempt the paper in 1½ hours before you look at them.

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Chapter: Coordination Compounds · **Topics:** Werner's theory and definitions · Nomenclature · Isomerism · Valence bond theory · Crystal field theory · Importance and applications

SECTION A

This section comprises 8 questions of 1 mark each: 6 multiple choice questions (MCQs) and 2 assertion-reason based questions.

1. The oxidation state of cobalt in $Na_3[Co(NO_2)_6]$ is 1

(A) +2 (B) +3

(C) +1 (D) +6

2. Which of the following is an ambidentate ligand? 1

(A) NH_3 (B) $H_2NCH_2CH_2NH_2$

(C) H_2O (D) SCN^-

3. The IUPAC name of $[Cr(NH_3)_3(H_2O)_3]Cl_3$ is 1

(A) triamminetriaquachromium(III) chloride (B) triaquatriamminechromium(III) chloride

(C) triamminetriaquachromate(III) chloride (D) triamminetriaquachromium(II) chloride

4. The number of ions produced in solution by one formula unit of $[Ni(NH_3)_6]Cl_2$ is 1

(A) 2 (B) 4

(C) 3 (D) 7

5. The hybridisation of zinc in the tetrahedral ion $[Zn(NH_3)_4]^{2+}$ is 1

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

(C) d^2sp^3 (D) sp^3

6. Which of the following ligands produces the largest crystal field splitting? 1

(A) CN^- (B) H_2O

(C) F^- (D) I^-

7. **Assertion (A) :** $[Cr(NH_3)_6]^{3+}$ is an inner orbital complex. 1

Reason (R) : Chromium is a member of the first transition series.

(A) Both A and R are true, and R is the correct explanation of A.

(B) Both A and R are true, and R is not the correct explanation of A.

(C) A is true but R is false.

(D) A is false but R is true.

8. **Assertion (A) :** $[Ni(CO)_4]$ is diamagnetic. 1

Reason (R) : CO is a weak-field ligand.

(A) Both A and R are true, and R is the correct explanation of A.

(B) Both A and R are true, and R is not the correct explanation of A.

(C) A is true but R is false.

(D) A is false but R is true.

SECTION B

This section comprises 3 short answer questions of 2 marks each.

9. Write the formulas of (i) tetraamminediaquacobalt(III) chloride and (ii) potassium tetrahydroxidozincate(II). 2

10. (a) Explain linkage isomerism and ionisation isomerism, giving one example of each. 2

OR

(b) How many geometrical isomers does square planar $[Pt(NH_3)_2Cl_2]$ have? Describe them. Is $[Co(en)_3]^{3+}$ optically active?

11. One mole of the platinum(IV) complex $PtCl_4 \cdot 4NH_3$ gives two moles of AgCl when treated with excess $AgNO_3$ solution. Write the formula of the complex according to Werner, and state the coordination number of platinum. 2

SECTION C

This section comprises 3 short answer questions of 3 marks each.

12. (a) Using valence bond theory, explain the hybridisation, shape and magnetic behaviour of $[Co(NH_3)_6]^{3+}$ and $[CoF_6]^{3-}$. 3

OR

(b) Using valence bond theory, explain why $[Ni(CN)_4]^{2-}$ is square planar and diamagnetic, while $[NiCl_4]^{2-}$ is tetrahedral and paramagnetic.

13. What are the crystal field splitting energy Δ_o and the pairing energy P? Write the electronic configuration of a d^4 ion in an octahedral field (i) when $\Delta_o > P$ and (ii) when $\Delta_o < P$ (P = pairing energy), and give the number of unpaired electrons in each case. 3

14. How many stereoisomers does each of the following have? State which of them are optically active. 3
(i) $[Co(NH_3)_4Cl_2]^+$ (ii) $[CoCl_2(en)_2]^+$ (iii) $[Co(NH_3)_3Cl_3]$

SECTION D

This section comprises 1 case-based question of 4 marks, with sub-parts of 1, 1 and 2 marks.

15. Anhydrous copper(II) sulphate is a white powder. It turns blue when water is added, and the solution is pale blue. When excess ammonia solution is added, the solution turns deep blue. The colours of such complexes arise from d–d transitions, and depend on how strongly the ligands split the d orbitals.

(I) Why is anhydrous copper(II) sulphate white? [1]

(II) Write the formula of the ion responsible for the deep blue colour. [1]

(III) Explain, in terms of the spectrochemical series, why the colour changes when ammonia replaces water as the ligand. [2]

OR

(III) What is the oxidation state of copper in the deep blue ion, and what is its spin-only magnetic moment? (Z of Cu = 29) [2]

SECTION E

This section comprises 2 long answer questions of 5 marks each.

16. (a) (i) State the main postulates of Werner's theory of coordination compounds. 5

(ii) The complexes $CoCl_3 \cdot 6NH_3$, $CoCl_3 \cdot 5NH_3$ and $CoCl_3 \cdot 4NH_3$ give 3, 2 and 1 mole of AgCl respectively per mole with excess $AgNO_3$. Write their formulas according to Werner, and the number of ions each gives in solution.

OR

(b) (i) Describe the splitting of the d orbitals in an octahedral and in a tetrahedral crystal field. Why are tetrahedral complexes almost always high spin?

(ii) Explain why $[Fe(CN)_6]^{4-}$ is diamagnetic while $[Fe(H_2O)_6]^{2+}$ is paramagnetic, and find the spin-only magnetic moment of the latter. (Z of Fe = 26)

17. (a) (i) Explain with one example each: (I) chelating ligand, (II) denticity, (III) homoleptic and heteroleptic complexes. 5

(ii) Write the IUPAC names of: (I) $[Pt(NH_3)_2Cl(NO_2)]$ (N-bonded nitrite), (II) $K_3[Cr(C_2O_4)_3]$, (III) $[CoCl_2(en)_2]Cl$.

OR

(b) (i) Give four examples of the importance of coordination compounds in analysis, metallurgy, biology or medicine.

(ii) State one limitation of valence bond theory.

(iii) Predict the hybridisation and the spin-only magnetic moment of $[Fe(CN)_6]^{3-}$. (Z of Fe = 26)

END OF THE QUESTION PAPER

ANSWER KEY — SECTION A

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
(B)	(D)	(A)	(C)	(D)	(A)	(B)	(C)

MARKING SCHEME AND WORKED SOLUTIONS

Marks for each step are shown in brackets, as in the CBSE marking scheme. Any correct alternative method earns full marks.

Q1. Answer (B). The complex ion is $[Co(NO_2)_6]^{3-}$: $x + 6(-1) = -3$, so $x = +3$.

Q2. Answer (D). SCN^- can bind through S (thiocyanato-S) or through N (thiocyanato-N).

Q3. Answer (A). Ligands in alphabetical order (ammine before aqua); a cationic complex keeps the name chromium; $x + 0 + 0 = +3$, so Cr is +3.

Q4. Answer (C). $[Ni(NH_3)_6]^{2+} + 2Cl^-$: three ions (the NH_3 ligands stay bound).

Q5. Answer (D). Zn^{2+} is $3d^{10}$: no 3d orbital is free, so one 4s and three 4p orbitals are used: sp^3, tetrahedral, diamagnetic.

Q6. Answer (A). Spectrochemical series: $I^- < F^- < H_2O < NH_3 <$ en $< CN^- <$ CO.

Q7. Answer (B). Both are true. Cr^{3+} ($3d^3$) always has two empty 3d orbitals, so it uses d^2sp^3 (inner orbital); being in the first series does not explain this. Answer B.

Q8. Answer (C). Ni(0) is $3d^8 4s^2$; the strong-field CO ligands pair all the electrons into the 3d orbitals, giving sp^3 (tetrahedral) with no unpaired electrons: A is true. CO is one of the strongest-field ligands, so R is false. Answer C.

Q9. (2 marks) Answer: $[Co(NH_3)_4(H_2O)_2]Cl_3$; $K_2[Zn(OH)_4]$.
(i) $[Co(NH_3)_4(H_2O)_2]Cl_3$. [1]
(ii) $K_2[Zn(OH)_4]$. [1]

Q10. (2 marks) Answer: (a) e.g. NO_2/ONO; SO_4/Br; (b) cis and trans; yes.
(a) Linkage isomerism: an ambidentate ligand binds through different atoms, e.g. $[Co(NH_3)_5(NO_2)]Cl_2$ (N-bonded, yellow) and $[Co(NH_3)_5(ONO)]Cl_2$ (O-bonded, red). [1] Ionisation isomerism: a ligand inside and an ion outside the coordination sphere exchange places, so different ions are produced in solution, e.g. $[Co(NH_3)_5(SO_4)]Br$ and $[Co(NH_3)_5Br]SO_4$. [1]
OR (b) Two geometrical isomers: cis, with the two Cl on adjacent corners of the square, and trans, with them on opposite corners. [1] $[Co(en)_3]^{3+}$ is optically active: it exists as two non-superimposable mirror images (d and l forms). [1]

Q11. (2 marks) Answer: $[Pt(NH_3)_4Cl_2]Cl_2$; 6.
Two Cl^- are outside the coordination sphere (ionisable) and two are ligands: $[Pt(NH_3)_4Cl_2]Cl_2$. [1]
Coordination number = 4 NH_3 + 2 Cl = 6. [1]

Q12. (3 marks) Answer: (a) d^2sp^3, diamagnetic; sp^3d^2, paramagnetic; (b) dsp^2 square planar; sp^3 tetrahedral.
(a) Co^{3+} is $3d^6$. [½] In $[Co(NH_3)_6]^{3+}$ the NH_3 ligands pair the six d electrons into three 3d orbitals; two empty 3d, one 4s and three 4p orbitals give d^2sp^3 hybridisation: octahedral, inner orbital, diamagnetic. [1½]
In $[CoF_6]^{3-}$ the electrons stay unpaired (4 unpaired); 4s, 4p and two 4d orbitals give sp^3d^2: octahedral, outer orbital, paramagnetic. [1]
OR (b) Ni^{2+} is $3d^8$. [½] With CN^- the electrons pair up, leaving one 3d orbital empty: dsp^2, square planar, diamagnetic. [1½]
With Cl^- (weak field) the two unpaired electrons remain: sp^3, tetrahedral, paramagnetic (two unpaired electrons). [1]

Q13. (3 marks) Answer: (i) t_{2g}^4, 2 unpaired; (ii) $t_{2g}^3e_g^1$, 4 unpaired.

Δ_o is the energy gap between the e_g and t_{2g} sets of d orbitals in an octahedral field; P is the energy needed to pair two electrons in one orbital. [1]

(i) $\Delta_o > P$ (strong field): $t_{2g}^4e_g^0$, 2 unpaired electrons (low spin). [1]

(ii) $\Delta_o < P$ (weak field): $t_{2g}^3e_g^1$, 4 unpaired electrons (high spin). [1]

Q14. (3 marks) Answer: (i) 2; (ii) 3 (cis pair optically active); (iii) 2.

(i) Two (cis and trans); neither is optically active. [1]

(ii) Three: trans (optically inactive) and the cis form, which exists as a pair of enantiomers (optically active). [1]

(iii) Two (fac and mer); neither is optically active. [1]

Q15. (4 marks) Answer: (I) no d–d transition; (II) $[Cu(NH_3)_4]^{2+}$; (III) NH_3 stronger field, or +2 and 1.73 BM.

(I) Without water molecules as ligands there is (practically) no crystal field splitting of the right size, so no d–d transition in the visible region: the solid appears white. [1]

(II) $[Cu(NH_3)_4]^{2+}$. [1]

(III) NH_3 is a stronger-field ligand than H_2O, so it splits the d orbitals more (larger Δ). [1] The complex absorbs light of higher energy (shorter wavelength), and the colour seen (the complementary colour) changes to deep blue. [1]

OR (III) +2 (NH_3 is neutral). [1] Cu^{2+} is $3d^9$ with 1 unpaired electron: $\mu = \sqrt{3} \approx 1.73$ BM. [1]

Q16. (5 marks) Answer: (a) primary and secondary valence; 4, 3 and 2 ions; (b) $\Delta t = (4/9)\Delta o$; 0 and 4.90 BM.

(a) (i) The metal shows two kinds of valence: primary (ionisable, satisfied by negative ions, the oxidation state) and secondary (non-ionisable, the coordination number, satisfied by neutral molecules or negative ions). [1] The secondary valences are directed in fixed directions in space, giving definite shapes (octahedral, tetrahedral, square planar). [1]

(ii) $[Co(NH_3)_6]Cl_3$: 4 ions. [1] $[Co(NH_3)_5Cl]Cl_2$: 3 ions. [1] $[Co(NH_3)_4Cl_2]Cl$: 2 ions. [1]

OR (b) (i) Octahedral: the e_g orbitals, pointing at the ligands, are raised and the t_{2g} lowered (gap Δ_o). [1] Tetrahedral: the order is reversed, e below t_2, and the splitting is smaller, $\Delta_t = (4/9)\Delta_o$. [1] Because Δ_t is usually smaller than the pairing energy, tetrahedral complexes are high spin. [1]

(ii) Fe^{2+} is $3d^6$. With CN^- (strong field): t_{2g}^6, no unpaired electrons, diamagnetic. [1] With H_2O (weak field): $t_{2g}^4e_g^2$, 4 unpaired electrons, $\mu = \sqrt{24} \approx 4.90$ BM. [1]

Q17. (5 marks) Answer: (a) names: diamminechloridonitrito-N-platinum(II), potassium trioxalatochromate(III), dichloridobis(ethane-1,2-diamine)cobalt(III) chloride; (b) d^2sp^3, 1.73 BM.

(a) (i) A chelating ligand binds through two or more donor atoms to the same metal, forming a ring (e.g. en, $C_2O_4^{2-}$). [½] Denticity is the number of donor atoms of a ligand bound to the metal (NH_3 1, en 2, $EDTA^{4-}$ 6). [½] Homoleptic: only one kind of ligand ($[Co(NH_3)_6]^{3+}$); heteroleptic: more than one kind ($[Co(NH_3)_4Cl_2]^+$). [1]

(ii) (I) diamminechloridonitrito-N-platinum(II). [1] (II) potassium trioxalatochromate(III). [1] (III) dichloridobis(ethane-1,2-diamine)cobalt(III) chloride. [1]

OR (b) (i) Any four [2]: EDTA titration to estimate the hardness of water (Ca^{2+}, Mg^{2+}); extraction of gold and silver as cyanide complexes; chlorophyll (Mg), haemoglobin (Fe) and vitamin B_{12} (Co) are coordination compounds; cisplatin is used against cancer; EDTA removes excess lead from the body.

(ii) Any one: it does not explain the colours of complexes; it gives no quantitative account of magnetic data or of the stability; it cannot predict whether a 4-coordinate complex is tetrahedral or square planar; it does not distinguish weak and strong ligands. [1]

(iii) Fe^{3+} is $3d^5$; CN^- pairs the electrons into three 3d orbitals (one unpaired), leaving two 3d orbitals for d^2sp^3 hybridisation: octahedral, inner orbital, $\mu = \sqrt{3} \approx 1.73$ BM. [2]

All questions are original and © Master Testing Agency. Free to download and use for personal practice; not for resale. Every oxidation state, ion count and magnetic moment in this paper was checked independently by computer, and every isomer count by enumerating all arrangements of the ligands on an octahedron under rotation and reflection.