

Coordination Compounds — NEET Chemistry PYQ (2005-2021)

Class 12 Chemistry · 45 real NEET & AIPMT questions, year-tagged · answers checked by RankUp

NEET 2021

1. Ethylene diaminetetraacetate (EDTA) ion is :

- (A) Hexadentate ligand with four "O" and two "N" donor atoms
- (B) Unidentate ligand
- (C) Bidentate ligand with two "N" donor atoms
- (D) Tridentate ligand with three "N" donor atoms

NEET 2021

2. Match List - I with List - II.

List - I | List - II

(a) $[\text{Fe}(\text{CN})_6]^{3-}$ | (i) 5.92 BM

(b) $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$ | (ii) 0 BM

(c) $[\text{Fe}(\text{CN})_6]^{4-}$ | (iii) 4.90 BM

(d) $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$ | (iv) 1.73 BM

Choose the correct answer from the options given below.

- (A) (a)-(iv), (b)-(ii), (c)-(i), (d)-(iii)
- (B) (a)-(ii), (b)-(iv), (c)-(iii), (d)-(i)
- (C) (a)-(i), (b)-(iii), (c)-(iv), (d)-(ii)
- (D) (a)-(iv), (b)-(i), (c)-(ii), (d)-(iii)

NEET 2020 · Q116

3. Which of the following is the correct order of increasing field strength of ligands to form coordination compounds ?

- (A) $\text{SCN}^- < \text{F}^- < \text{C}_2\text{O}_4^{2-} < \text{CN}^-$
- (B) $\text{SCN}^- < \text{F}^- < \text{CN}^- < \text{C}_2\text{O}_4^{2-}$
- (C) $\text{F}^- < \text{SCN}^- < \text{C}_2\text{O}_4^{2-} < \text{CN}^-$
- (D) $\text{CN}^- < \text{C}_2\text{O}_4^{2-} < \text{SCN}^- < \text{F}^-$

NEET 2019 · Q75

4. What is the correct electronic configuration of the central atom in $\text{K}_4[\text{Fe}(\text{CN})_6]$ based on crystal field theory?

- (A) $t_2g^4 e_g^2$
- (B) $t_2g^6 e_g^0$
- (C) $e^3 t_2^3$
- (D) $e^4 t_2^2$

NEET 2018 · Q71

5. Iron carbonyl, $\text{Fe}(\text{CO})_5$ is

- (A) trinuclear
- (B) mononuclear
- (C) tetranuclear
- (D) dinuclear

NEET 2018 · Q72

6. The type of isomerism shown by the complex $[\text{CoCl}_2(\text{en})_2]$ is

- (A) Ionization isomerism
- (B) Coordination isomerism
- (C) Geometrical isomerism
- (D) Linkage isomerism

NEET 2018 · Q73

7. The geometry and magnetic behaviour of the complex $[\text{Ni}(\text{CO})_4]$ are

- (A) square planar geometry and paramagnetic
- (B) tetrahedral geometry and diamagnetic
- (C) square planar geometry and diamagnetic
- (D) tetrahedral geometry and paramagnetic

NEET 2017 · Q11

8. Correct increasing order for the wavelengths of absorption in the visible region for the complexes of Co^{3+} is:

- (A) $[\text{Co}(\text{en})_3]^{3+}$, $[\text{Co}(\text{NH}_3)_6]^{3+}$, $[\text{Co}(\text{H}_2\text{O})_6]^{3+}$
- (B) $[\text{Co}(\text{H}_2\text{O})_6]^{3+}$, $[\text{Co}(\text{en})_3]^{3+}$, $[\text{Co}(\text{NH}_3)_6]^{3+}$
- (C) $[\text{Co}(\text{H}_2\text{O})_6]^{3+}$, $[\text{Co}(\text{NH}_3)_6]^{3+}$, $[\text{Co}(\text{en})_3]^{3+}$
- (D) $[\text{Co}(\text{NH}_3)_6]^{3+}$, $[\text{Co}(\text{en})_3]^{3+}$, $[\text{Co}(\text{H}_2\text{O})_6]^{3+}$

NEET 2017 · Q12

9. The correct order of the stoichiometries of AgCl formed when AgNO_3 in excess is treated with the complexes: $\text{CoCl}_3 \cdot 6\text{NH}_3$, $\text{CoCl}_3 \cdot 5\text{NH}_3$, $\text{CoCl}_3 \cdot 4\text{NH}_3$ respectively is:

- (A) 1 AgCl , 3 AgCl , 2 AgCl
- (B) 3 AgCl , 1 AgCl , 2 AgCl
- (C) 3 AgCl , 2 AgCl , 1 AgCl
- (D) 2 AgCl , 3 AgCl , 1 AgCl

NEET 2017 · Q26

10. An example of a sigma bonded organometallic compound is:

- (A) Ruthenocene
- (B) Grignard's reagent
- (C) Ferrocene
- (D) Cobaltocene

NEET 2017 · Q29

11. Pick out the correct statement with respect to $[\text{Mn}(\text{CN})_6]^{3-}$:

- (A) It is sp^3d^2 hybridised and octahedral
- (B) It is sp^3d^2 hybridised and tetrahedral
- (C) It is d^2sp^3 hybridised and octahedral
- (D) It is dsp^2 hybridised and square planar

NEET 2017 (Gujarati paper) · Q1

12. The electron distribution in d^n coordination complexes depends on magnitude of crystal field splitting, (Δ_o) and pairing energy (P). The condition which favours formation of high spin complexes is:

- (A) $\Delta_o > P$
- (B) $\Delta_o < P$
- (C) $\Delta_o = P$
- (D) $t_{2g}^4 e_g^0$

NEET 2017 (Gujarati paper) · Q4

13. Which one of the following ions is not tetrahedral in shape?

- (A) NH_4^+
- (B) BF_4^-
- (C) $[\text{Cu}(\text{NH}_3)_4]^{2+}$
- (D) $[\text{NiCl}_4]^{2-}$

NEET 2017 (Gujarati paper) · Q14

14. The $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$ ion has three unpaired electrons. The hybridization of Co in $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$ is:

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

NEET 2017 (Gujarati paper) · Q16

15. For the tetrahedral complex $[\text{MnBr}_4]^{2-}$, the spin only magnetic moment value is: [At. no. of Mn = 25]

- (A) 1.7
- (B) 5.9
- (C) 4.8
- (D) 2.4

NEET 2017 (Gujarati paper) · Q24

16. Which of the following complex ions is not diamagnetic?

- (A) $[\text{Ti}(\text{en})_2(\text{NH}_3)_2]^{4+}$
- (B) $[\text{Cr}(\text{NH}_3)_6]^{3+}$
- (C) $[\text{Zn}(\text{NH}_3)_6]^{2+}$
- (D) $[\text{Sc}(\text{H}_2\text{O})_3(\text{NH}_3)_3]^{3+}$

NEET 2016 Phase 2 · Q75

17. Jahn-Teller effect is not observed in high spin complexes of

- (A) d^7
- (B) d^8
- (C) d^4
- (D) d^9

NEET 2016 Phase 1 · Q74

18. Which of the following has longest C-O bond length? (Free C-O bond length in CO is 1.128 Å.)

- (A) $\text{Ni}(\text{CO})_4$
- (B) $[\text{Co}(\text{CO})_4]^-$
- (C) $[\text{Fe}(\text{CO})_4]^{2-}$
- (D) $[\text{Mn}(\text{CO})_6]^+$

AIPMT 2015

19. Which of these statements about $[\text{Co}(\text{CN})_6]^{3-}$ is true?

- (A) $[\text{Co}(\text{CN})_6]^{3-}$ has no unpaired electrons and will be in a high-spin configuration
- (B) $[\text{Co}(\text{CN})_6]^{3-}$ has no unpaired electrons and will be in a low-spin configuration
- (C) $[\text{Co}(\text{CN})_6]^{3-}$ has four unpaired electrons and will be in a low-spin configuration
- (D) $[\text{Co}(\text{CN})_6]^{3-}$ has four unpaired electrons and will be in a high-spin configuration

AIPMT 2015

20. Cobalt(III) chloride forms several octahedral complexes with ammonia. Which of the following will not give test for chloride ions with silver nitrate at 25°C?

- (A) $\text{CoCl}_3 \cdot 6\text{NH}_3$
- (B) $\text{CoCl}_3 \cdot 3\text{NH}_3$
- (C) $\text{CoCl}_3 \cdot 4\text{NH}_3$
- (D) $\text{CoCl}_3 \cdot 5\text{NH}_3$

AIPMT 2014

21. Which of the following complexes is used to be as an anticancer agent?

- (A) $\text{cis-}[\text{PtCl}_2(\text{NH}_3)_2]$
- (B) $\text{cis-}[\text{K}_2[\text{PtCl}_2\text{Br}_2]]$
- (C) Na_2CoCl_4
- (D) $\text{mer-}[\text{Co}(\text{NH}_3)_3\text{Cl}_3]$

AIPMT 2014

22. Among the following complexes the one which shows Zero crystal field stabilization energy (CFSE) is:

- (A) $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$
- (B) $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$
- (C) $[\text{Co}(\text{H}_2\text{O})_6]^{3+}$
- (D) $[\text{Mn}(\text{H}_2\text{O})_6]^{3+}$

NEET 2013

23. A magnetic moment of 1.73 BM will be shown by one among the following

- (A) $[\text{Cu}(\text{NH}_3)_4]^{2+}$
- (B) $[\text{Ni}(\text{CN})_4]^{2-}$
- (C) TiCl_4
- (D) $[\text{CoCl}_6]^{4-}$

NEET 2013

24. An excess of AgNO_3 is added to 100 mL of a 0.01 M solution of dichlorotetraaquachromium(III) chloride. The number of moles of AgCl precipitated would be

- (A) 0.001
- (B) 0.002
- (C) 0.003
- (D) 0.01

AIPMT 2012 Prelims

25. Which one of the following is an outer orbital complex and exhibits paramagnetic behaviour?

- (A) $[\text{Co}(\text{NH}_3)_6]^{3+}$
- (B) $[\text{Ni}(\text{NH}_3)_6]^{2+}$
- (C) $[\text{Zn}(\text{NH}_3)_6]^{2+}$
- (D) $[\text{Cr}(\text{NH}_3)_6]^{3+}$

AIPMT 2011 Mains

26. Which of the following complex compounds will exhibit highest paramagnetic behaviour? (At. No. Ti = 22, Cr = 24, Co = 27, Zn = 30)

- (A) $[\text{Co}(\text{NH}_3)_6]^{3+}$
- (B) $[\text{Zn}(\text{NH}_3)_6]^{2+}$
- (C) $[\text{Ti}(\text{NH}_3)_6]^{3+}$
- (D) $[\text{Cr}(\text{NH}_3)_6]^{3+}$

AIPMT 2011 Mains

27. Which of the following carbonyls will have the strongest C - O bond?

- (A) $\text{V}(\text{CO})_6^-$
- (B) $\text{Fe}(\text{CO})_5$
- (C) $\text{Mn}(\text{CO})_6^+$
- (D) $\text{Cr}(\text{CO})_6$

AIPMT 2011 Prelims

28. The complex $[\text{Pt}(\text{Py})(\text{NH}_3)\text{BrCl}]$ will have how many geometrical isomers?

- (A) 2
- (B) 3
- (C) 4
- (D) 0

AIPMT 2011 Prelims

29. The complexes $[\text{Co}(\text{NH}_3)_6][\text{Cr}(\text{CN})_6]$ and $[\text{Cr}(\text{NH}_3)_6][\text{Co}(\text{CN})_6]$ are the examples of which type of isomerism?

- (A) Geometrical isomerism
- (B) Linkage isomerism
- (C) Ionization isomerism
- (D) Coordination isomerism

AIPMT 2011 Prelims

30. The d-electron configurations of Cr^{2+} , Mn^{2+} , Fe^{2+} and Co^{2+} are d^4 , d^5 , d^6 and d^7 respectively. Which one of the following will exhibit minimum paramagnetic behaviour? (At. nos. Cr = 24, Mn = 25, Fe = 26, Co = 27)

- (A) $[\text{Cr}(\text{H}_2\text{O})_6]^{2+}$
- (B) $[\text{Mn}(\text{H}_2\text{O})_6]^{2+}$
- (C) $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$
- (D) $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$

AIPMT 2011 Prelims

31. Of the following complex ions, which is diamagnetic in nature?

- (A) $[\text{CoF}_6]^{3-}$
- (B) $[\text{NiCl}_4]^{2-}$
- (C) $[\text{Ni}(\text{CN})_4]^{2-}$
- (D) $[\text{CuCl}_4]^{2-}$

AIPMT 2010 Mains · Q111

32. Which one of the following complexes is not expected to exhibit isomerism?

- (A) $[\text{Ni}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}$
- (B) $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$
- (C) $[\text{Ni}(\text{NH}_3)_2\text{Cl}_2]$
- (D) $[\text{Ni}(\text{en})_3]^{2+}$

AIPMT 2010 Prelims · Q76

33. The existence of two different coloured complexes with the composition of $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]^+$ is due to

- (A) Ionization isomerism
- (B) Linkage isomerism
- (C) Geometrical isomerism
- (D) Coordination isomerism

AIPMT 2010 Prelims · Q80

34. Crystal field stabilization energy for high spin d^4 octahedral complex is

- (A) $-0.6 \Delta_o$
- (B) $-1.8 \Delta_o$
- (C) $-1.6 \Delta_o + P$
- (D) $-1.2 \Delta_o$

AIPMT 2009 Prelims · Q181

35. Out of TiF_6^{2-} , CoF_6^{3-} , Cu_2Cl_2 and NiCl_4^{2-} (Z of Ti = 22, Co = 27, Cu = 29, Ni = 28) the colourless species are:

- (A) Cu_2Cl_2 and NiCl_4^{2-}
- (B) TiF_6^{2-} and Cu_2Cl_2
- (C) CoF_6^{3-} and NiCl_4^{2-}
- (D) TiF_6^{2-} and CoF_6^{3-}

AIPMT 2009 Prelims · Q185

36. Which of the following does not show optical isomerism?

- (A) $[\text{Co}(\text{NH}_3)_3\text{Cl}_3]^0$
- (B) $[\text{Co}(\text{en})\text{Cl}_2(\text{NH}_3)_2]^+$
- (C) $[\text{Co}(\text{en})_3]^{3+}$
- (D) $[\text{Co}(\text{en})_2\text{Cl}_2]^+$ (en = ethylenediamine)

AIPMT 2009 Prelims · Q196

37. Which of the following complex ions is expected to absorb visible light? (At. no. Zn = 30, Sc = 21, Ti = 22, Cr = 24)

- (A) $[\text{Ti}(\text{en})_2(\text{NH}_3)_2]^{4+}$
- (B) $[\text{Cr}(\text{NH}_3)_6]^{3+}$
- (C) $[\text{Zn}(\text{NH}_3)_6]^{2+}$
- (D) $[\text{Sc}(\text{H}_2\text{O})_3(\text{NH}_3)_3]^{3+}$

AIPMT 2008 Prelims · Q80

38. In which of the following coordination entities the magnitude of Δ_o (CFSE in octahedral field) will be maximum? (at. no. Co = 27)

- (A) $[\text{Co}(\text{C}_2\text{O}_4)_3]^{3-}$
- (B) $[\text{Co}(\text{H}_2\text{O})_6]^{3+}$
- (C) $[\text{Co}(\text{NH}_3)_6]^{3+}$
- (D) $[\text{Co}(\text{CN})_6]^{3-}$

AIPMT 2007 Prelims · Q76

39. Which of the following will give a pair of enantiomorphs? (en = $\text{NH}_2\text{CH}_2\text{CH}_2\text{NH}_2$)

- (A) $[\text{Cr}(\text{NH}_3)_6][\text{Co}(\text{CN})_6]$
- (B) $[\text{Co}(\text{en})_2\text{Cl}_2]\text{Cl}$
- (C) $[\text{Pt}(\text{NH}_3)_4][\text{PtCl}_6]$
- (D) $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]\text{NO}_2$

AIPMT 2007 Prelims · Q78

40. The d electron configurations of Cr^{2+} , Mn^{2+} , Fe^{2+} and Ni^{2+} are $3d^4$, $3d^5$, $3d^6$ and $3d^8$ respectively. Which one of the following aqua complexes will exhibit the minimum paramagnetic behaviour? (At. No. Cr = 24, Mn = 25, Fe = 26, Ni = 28)

- (A) $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$
- (B) $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$
- (C) $[\text{Cr}(\text{H}_2\text{O})_6]^{2+}$
- (D) $[\text{Mn}(\text{H}_2\text{O})_6]^{2+}$

AIPMT 2006 Prelims · Q61

41. Copper sulphate dissolves in excess of KCN to give :

- (A) CuCN
- (B) $[\text{Cu}(\text{CN})_4]^{3-}$
- (C) $[\text{Cu}(\text{CN})_4]^{2-}$
- (D) $\text{Cu}(\text{CN})_2$

AIPMT 2006 Prelims · Q79

42. $[\text{Co}(\text{NH}_3)_4(\text{NO}_2)_2]\text{Cl}$ exhibits :

- (A) linkage isomerism, ionization isomerism and optical isomerism
- (B) linkage isomerism, ionization isomerism and geometrical isomerism
- (C) ionization isomerism, geometrical isomerism and optical isomerism
- (D) linkage isomerism, geometrical isomerism and optical isomerism

43. $[\text{Cr}(\text{H}_2\text{O})_6]\text{Cl}_3$ (at. no. of Cr = 24) has a magnetic moment of 3.83 BM, the correct distribution of 3d electrons in the chromium of the complex is :

- (A) $3d^1(x^2-y^2)$, $3d^1(z^2)$, $3d^1(xz)$
- (B) $3d^1(xy)$, $3d^1(x^2-y^2)$, $3d^1(yz)$
- (C) $3d^1(xy)$, $3d^1(zx)$, $3d^1(xz)$
- (D) $3d^1(xy)$, $3d^1(yz)$, $3d^1(z^2)$

44. Which one of the following is an inner orbital complex as well as diamagnetic in behaviour ? (Atomic no. : Zn = 30, Cr = 24, Co = 27, Ni = 28)

- (A) $[\text{Zn}(\text{NH}_3)_6]^{2+}$
- (B) $[\text{Cr}(\text{NH}_3)_6]^{3+}$
- (C) $[\text{Co}(\text{NH}_3)_6]^{3+}$
- (D) $[\text{Ni}(\text{NH}_3)_6]^{2+}$

45. Which one of the following is expected to exhibit optical isomerism ? (en = ethylenediamine)

- (A) cis- $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$
- (B) trans- $[\text{Co}(\text{en})_2\text{Cl}_2]$
- (C) trans- $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$
- (D) cis- $[\text{Co}(\text{en})_2\text{Cl}_2]$

Answer key and explanations

1. Answer: (A) Hexadentate ligand with four "O" and two "N" donor atoms

EDTA⁴⁻ donates through its two amine nitrogen atoms and four carboxylate oxygen atoms, so it is a hexadentate ligand. Ethylenediamine (en), not EDTA, is the bidentate ligand with two N donors.

2. Answer: (D) (a)-(iv), (b)-(i), (c)-(ii), (d)-(iii)

$[\text{Fe}(\text{CN})_6]^{3-}$: Fe^{3+} (d^5) low spin, 1 unpaired electron, 1.73 BM. $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$: high spin d^5 , 5 unpaired, 5.92 BM. $[\text{Fe}(\text{CN})_6]^{4-}$: Fe^{2+} (d^6) low spin, 0 unpaired, 0 BM. $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$: high spin d^6 , 4 unpaired, 4.90 BM.

3. Answer: (A) $\text{SCN}^- < \text{F}^- < \text{C}_2\text{O}_4^{2-} < \text{CN}^-$

In the spectrochemical series $\text{SCN}^- < \text{F}^- < \text{C}_2\text{O}_4^{2-} < \text{CN}^-$, with cyanide one of the strongest-field ligands. Placing oxalate above cyanide, or fluoride below thiocyanate, contradicts that series.

4. Answer: (B) $t_2g^6 e_g^0$

Fe is +2 (d^6) in an octahedral field; CN^- is a strong-field ligand causing pairing, so the configuration is $t_2g^6 e_g^0$ (low spin, diamagnetic). $t_2g^4 e_g^2$ is the high-spin arrangement with weak-field ligands, and e/t_2 labels belong to tetrahedral fields.

5. Answer: (B) mononuclear

$\text{Fe}(\text{CO})_5$ contains a single Fe atom bonded to five CO ligands, so it is mononuclear (trigonal bipyramidal). $\text{Fe}_2(\text{CO})_9$ is the dinuclear and $\text{Fe}_3(\text{CO})_{12}$ the trinuclear carbonyl.

6. Answer: (C) Geometrical isomerism

The octahedral $[\text{MA}_2(\text{AA})_2]$ complex can have the two Cl ligands cis or trans, so it shows geometrical isomerism (the cis form is also optically active). It has no counter-ion exchange, no complex cation-anion pair and no ambidentate ligand, so the other types do not apply.

7. Answer: (B) tetrahedral geometry and diamagnetic

Ni is in the 0 state ($3d^8 4s^2$); the strong-field CO ligands pair all electrons into $3d^{10}$, and sp^3 hybridisation gives a tetrahedral, diamagnetic complex. Square planar dsp^2 geometry is for Ni^{2+} with strong-field ligands like CN^- .

8. Answer: (A) $[\text{Co}(\text{en})_3]^{3+}$, $[\text{Co}(\text{NH}_3)_6]^{3+}$, $[\text{Co}(\text{H}_2\text{O})_6]^{3+}$

Field strength follows the spectrochemical series $\text{en} > \text{NH}_3 > \text{H}_2\text{O}$, so Δ_o is largest for the en complex. Absorbed wavelength is inversely related to Δ_o ($\lambda = hc/\Delta_o$), so the order of increasing wavelength is $[\text{Co}(\text{en})_3]^{3+} < [\text{Co}(\text{NH}_3)_6]^{3+} < [\text{Co}(\text{H}_2\text{O})_6]^{3+}$. Writing the reverse order confuses increasing Δ_o with increasing wavelength.

9. Answer: (C) 3 AgCl, 2 AgCl, 1 AgCl

The complexes are $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$, $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$ and $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]\text{Cl}$. Only chloride outside the coordination sphere is precipitated by Ag^+ , giving 3, 2 and 1 mol AgCl respectively.

10. Answer: (B) Grignard's reagent

In a Grignard reagent RMgX the alkyl carbon is joined to magnesium by a single σ bond. Ferrocene, ruthenocene and cobaltocene are sandwich compounds in which the metal is π -bonded to cyclopentadienyl rings.

11. Answer: (C) It is d^2sp^3 hybridised and octahedral

Mn^{3+} is $3d^4$. CN^- is a strong-field ligand, so the four electrons pair into three $3d$ orbitals, leaving two inner $3d$ orbitals free; with $4s$ and $4p$ they give d^2sp^3 hybridisation and an octahedral (inner-orbital) complex. sp^3d^2 would apply to a weak-field outer-orbital complex.

12. Answer: (B) $\Delta_o < P$

When the crystal field splitting is smaller than the pairing energy, it costs less energy to put electrons in the higher e_g set than to pair them in t_{2g} , so electrons stay unpaired and a high spin complex forms.

When Δ_o exceeds P , pairing is preferred and a low spin complex results.

13. Answer: (C) $[\text{Cu}(\text{NH}_3)_4]^{2+}$

$[\text{Cu}(\text{NH}_3)_4]^{2+}$ is a d^9 dsp^2 complex and is square planar. NH_4^+ and BF_4^- are sp^3 tetrahedral, and $[\text{NiCl}_4]^{2-}$ with the weak-field Cl^- ligand is sp^3 tetrahedral.

14. Answer: (C) sp^3d^2

Co^{2+} is $3d^7$. Three unpaired electrons means the weak-field water ligands do not force pairing, so the inner $3d$ orbitals are not free and the six ligands use $4s$, $4p$ and $4d$ orbitals: sp^3d^2 (outer orbital, octahedral). d^2sp^3 would need pairing down to one unpaired electron.

15. Answer: (B) 5.9

Mn^{2+} is $3d^5$, and in a tetrahedral field with weak Br^- ligands all five electrons stay unpaired. $\mu = \sqrt{n(n+2)} = \sqrt{5(5+2)} = \sqrt{35} \approx 5.9 \text{ BM}$.

16. Answer: (B) $[\text{Cr}(\text{NH}_3)_6]^{3+}$

Cr^{3+} is $3d^3$, with three unpaired electrons in t_{2g} , so $[\text{Cr}(\text{NH}_3)_6]^{3+}$ is paramagnetic. Ti^{4+} and Sc^{3+} are d^0 and Zn^{2+} is d^{10} , so those complexes have no unpaired electrons and are diamagnetic.

17. Answer: (B) d^8

High-spin d^8 in an octahedral field is $t_{2g}^6e_g^2$, with symmetrically filled degenerate sets, so there is no Jahn-Teller distortion. High-spin d^4 ($t_{2g}^3e_g^1$) and d^9 ($t_{2g}^6e_g^3$) have unevenly filled e_g orbitals and show strong distortion; d^7 high spin ($t_{2g}^5e_g^2$) has an uneven t_{2g} set.

18. Answer: (C) $[\text{Fe}(\text{CO})_4]^{2-}$

These carbonyls are isoelectronic, but the more negative the metal centre, the more electron density it back-donates into the π^* orbitals of CO , weakening and lengthening the C-O bond. $[\text{Fe}(\text{CO})_4]^{2-}$ carries the highest negative charge, so it has the longest C-O bond, while the cationic $[\text{Mn}(\text{CO})_6]^+$ has the shortest.

19. Answer: (B) $[\text{Co}(\text{CN})_6]^{3-}$ has no unpaired electrons and will be in a low-spin configuration

Co^{3+} is $3d^6$. CN^- is a strong-field ligand, so the electrons pair up as $t_{2g}^6e_g^0$ (d^2sp^3 , inner orbital): low spin with no unpaired electrons. Four unpaired electrons would occur only with a weak-field ligand such as F^- .

20. Answer: (B) $\text{CoCl}_3 \cdot 3\text{NH}_3$

Octahedral Co(III) needs six ligands. With only three NH_3 the complex is $[\text{Co}(\text{NH}_3)_3\text{Cl}_3]$, all three Cl^- inside the coordination sphere, so no Cl^- ions are free to precipitate with AgNO_3 . The 6, 5 and 4 NH_3 complexes have 3, 2 and 1 ionisable Cl^- .

21. Answer: (A) cis- $[\text{PtCl}_2(\text{NH}_3)_2]$

cis- $[\text{PtCl}_2(\text{NH}_3)_2]$ (cisplatin) binds DNA and is used in cancer chemotherapy. The trans isomer and the other complexes listed do not have this use.

22. Answer: (A) $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$

Fe^{3+} is $3d^5$, and with weak-field H_2O it is high spin $t_{2g}^3e_g^2$: $\text{CFSE} = 3(-0.4\Delta_o) + 2(+0.6\Delta_o) = 0$. Co^{2+} (d^7), Co^{3+} (d^6) and Mn^{3+} (d^4) all have non-zero CFSE.

23. Answer: (A) $[\text{Cu}(\text{NH}_3)_4]^{2+}$

$1.73 \text{ BM} = \sqrt{n(n+2)}$ with $n = 1$ unpaired electron. Cu^{2+} ($3d^9$) in $[\text{Cu}(\text{NH}_3)_4]^{2+}$ has one unpaired electron. $[\text{Ni}(\text{CN})_4]^{2-}$ is square planar and diamagnetic, TiCl_4 has Ti^{4+} ($3d^0$), and $[\text{CoCl}_6]^{4-}$ has high-spin Co^{2+} ($3d^7$) with three unpaired electrons.

24. Answer: (A) 0.001

Dichlorotetraaqua chromium(III) chloride is $[\text{Cr}(\text{H}_2\text{O})_4\text{Cl}_2]\text{Cl}$, with only one chloride outside the coordination sphere. Moles of complex = $0.01 \times 0.100 = 0.001$ mol, giving 0.001 mol AgCl. Coordinated chlorides are not precipitated, so 0.003 is wrong.

25. Answer: (B) $[\text{Ni}(\text{NH}_3)_6]^{2+}$

Ni^{2+} is d^8 ; in an octahedral complex the two remaining inner d orbitals are not vacant, so it uses $4s4p^34d^2$ (sp^3d^2 , outer orbital) and keeps two unpaired electrons, making it paramagnetic. $[\text{Co}(\text{NH}_3)_6]^{3+}$ is inner orbital and diamagnetic, $[\text{Zn}(\text{NH}_3)_6]^{2+}$ is outer orbital but diamagnetic (d^{10}), and $[\text{Cr}(\text{NH}_3)_6]^{3+}$ is inner orbital (d^2sp^3).

26. Answer: (D) $[\text{Cr}(\text{NH}_3)_6]^{3+}$

Cr^{3+} is d^3 with 3 unpaired electrons in octahedral complexes. Co^{3+} (d^6) with NH_3 is low spin with no unpaired electrons, Zn^{2+} is d^{10} with none, and Ti^{3+} is d^1 with one. So $[\text{Cr}(\text{NH}_3)_6]^{3+}$ is the most paramagnetic.

27. Answer: (C) $\text{Mn}(\text{CO})_6^+$

Back-donation from metal d orbitals into CO π^* orbitals weakens the C-O bond. The positive charge in $\text{Mn}(\text{CO})_6^+$ holds the metal electrons tightly, so back-bonding is least and the C-O bond is strongest. The anion $\text{V}(\text{CO})_6^-$ has the most back-bonding and the weakest C-O bond.

28. Answer: (B) 3

$[\text{Pt}(\text{py})(\text{NH}_3)\text{BrCl}]$ is square planar of type $[\text{Mabcd}]$. Fixing one ligand, any of the other three can be trans to it, giving 3 geometrical isomers. Two isomers is the answer only for $[\text{Ma}_2\text{b}_2]$ -type complexes.

29. Answer: (D) Coordination isomerism

Both compounds have the same formula, but the ligands are exchanged between the cobalt and chromium centres of the cationic and anionic complexes. This is coordination isomerism. Ionisation isomerism would involve exchange of an ion between the coordination sphere and the counter-ion.

30. Answer: (D) $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$

H_2O is a weak-field ligand, so all are high-spin: d^4 (Cr^{2+}) has 4 unpaired electrons, d^5 (Mn^{2+}) 5, d^6 (Fe^{2+}) 4 and d^7 (Co^{2+}) 3. Fewest unpaired electrons means least paramagnetism, so the cobalt complex. The manganese complex is the most paramagnetic.

31. Answer: (C) $[\text{Ni}(\text{CN})_4]^{2-}$

Ni^{2+} is d^8 ; strong-field CN^- pairs all electrons and gives a dsp^2 square planar complex with no unpaired electrons, so $[\text{Ni}(\text{CN})_4]^{2-}$ is diamagnetic. $[\text{NiCl}_4]^{2-}$ is tetrahedral sp^3 with 2 unpaired electrons, $[\text{CoF}_6]^{3-}$ has 4 and $[\text{CuCl}_4]^{2-}$ (d^9) has 1.

32. Answer: (C) $[\text{Ni}(\text{NH}_3)_2\text{Cl}_2]$

$[\text{Ni}(\text{NH}_3)_2\text{Cl}_2]$ is tetrahedral, and an MA_2B_2 tetrahedral complex shows no geometrical or optical isomers. $[\text{Ni}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}$ (octahedral MA_4B_2) and square planar $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$ show cis-trans isomerism, and $[\text{Ni}(\text{en})_3]^{2+}$ is optically active.

33. Answer: (C) Geometrical isomerism

$[\text{Co}(\text{NH}_3)_4\text{Cl}_2]^+$ is octahedral MA_4B_2 , which exists as cis (violet) and trans (green) isomers: geometrical isomerism. Ionisation and linkage isomerism need different ions or an ambidentate ligand, which are absent here.

34. Answer: (A) $-0.6 \Delta_o$

High-spin d^4 in an octahedral field is $t_{2g}^3 e_g^1$. CFSE = $3(-0.4\Delta_o) + 1(+0.6\Delta_o) = -0.6\Delta_o$. $-1.6\Delta_o + P$ is the low-spin t_{2g}^4 value.

35. Answer: (B) TiF_6^{2-} and Cu_2Cl_2

Ti^{4+} in TiF_6^{2-} is $3d^0$ and Cu^+ in Cu_2Cl_2 is $3d^{10}$, so no d-d transition is possible and both are colourless. Co^{3+} ($3d^6$) and Ni^{2+} ($3d^8$) have partly filled d orbitals and are coloured.

36. Answer: (A) $[\text{Co}(\text{NH}_3)_3\text{Cl}_3]^0$

$[\text{Co}(\text{NH}_3)_3\text{Cl}_3]$ is an MA_3B_3 octahedral complex; both its fac and mer forms have a mirror plane, so it is not optically active. $[\text{Co}(\text{en})_3]^{3+}$, cis- $[\text{Co}(\text{en})_2\text{Cl}_2]^+$ and one isomer of $[\text{Co}(\text{en})\text{Cl}_2(\text{NH}_3)_2]^+$ are chiral.

37. Answer: (B) $[\text{Cr}(\text{NH}_3)_6]^{3+}$

Cr^{3+} is $3d^3$, so d-d transitions are possible and the complex absorbs visible light. Ti^{4+} and Sc^{3+} are $3d^0$ and Zn^{2+} is $3d^{10}$, so they have no d-d transitions and are colourless.

38. Answer: (D) $[\text{Co}(\text{CN})_6]^{3-}$

For the same metal ion (Co^{3+}), Δ_o depends on the ligand's place in the spectrochemical series, where CN^- is the strongest-field ligand here, well above NH_3 , H_2O and oxalate. So $[\text{Co}(\text{CN})_6]^{3-}$ has the largest splitting. $[\text{Co}(\text{NH}_3)_6]^{3+}$ is a strong-field complex too, but ammonia splits less than cyanide.

39. Answer: (B) $[\text{Co}(\text{en})_2\text{Cl}_2]\text{Cl}$

$\text{cis}-[\text{Co}(\text{en})_2\text{Cl}_2]^+$ has no plane of symmetry and exists as a pair of enantiomers. The other complexes show coordination or geometrical isomerism but no optical isomers ($[\text{Co}(\text{NH}_3)_4\text{Cl}_2]^+$ cis/trans are both achiral).

40. Answer: (B) $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$

H_2O is a weak-field ligand, so the ions stay high-spin: Cr^{2+} (d^4) 4, Mn^{2+} (d^5) 5, Fe^{2+} (d^6) 4 and Ni^{2+} (d^8) 2 unpaired electrons. $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$ has the fewest, so it is least paramagnetic; $[\text{Mn}(\text{H}_2\text{O})_6]^{2+}$ is the most.

41. Answer: (B) $[\text{Cu}(\text{CN})_4]^{3-}$

CN^- reduces Cu^{2+} to Cu^+ ($2\text{Cu}^{2+} + 4\text{CN}^- \rightarrow 2\text{CuCN} + (\text{CN})_2$), and CuCN dissolves in excess cyanide to give the stable tetracyanidocuprate(I) ion, $[\text{Cu}(\text{CN})_4]^{3-}$. The Cu(II) complex $[\text{Cu}(\text{CN})_4]^{2-}$ is not the product, and CuCN is only the intermediate before excess KCN acts.

42. Answer: (B) linkage isomerism, ionization isomerism and geometrical isomerism

NO_2^- can bind through N (nitro) or O (nitrito), giving linkage isomers. Exchanging Cl^- with a coordinated NO_2^- gives ionisation isomers, and the two NO_2 ligands can be cis or trans, giving geometrical isomers. Neither cis nor trans $[\text{Co}(\text{NH}_3)_4(\text{NO}_2)_2]^+$ is chiral, because each has mirror planes, so optical isomerism is absent.

43. Answer: (C) $3d^1(xy)$, $3d^1(zy)$, $3d^1(xz)$

$\mu = \sqrt{n(n+2)} = 3.83 \text{ BM}$ gives $n = 3$ unpaired electrons, matching Cr^{3+} ($3d^3$). In the octahedral field of six water ligands these three electrons occupy the lower t_{2g} set, d_{xy} , d_{yz} and d_{zx} , one each. Any set that includes $d_{x^2-y^2}$ or d_{z^2} places an electron in the higher e_g level.

44. Answer: (C) $[\text{Co}(\text{NH}_3)_6]^{3+}$

Co^{3+} is $3d^6$; with NH_3 the electrons pair up in t_{2g} , leaving two $3d$ orbitals for d^2sp^3 (inner orbital) hybridisation with no unpaired electrons, so it is diamagnetic. $[\text{Cr}(\text{NH}_3)_6]^{3+}$ is inner orbital but has 3 unpaired electrons; the Zn^{2+} and Ni^{2+} complexes are outer orbital.

45. Answer: (D) cis- $[\text{Co}(\text{en})_2\text{Cl}_2]$

$\text{cis}-[\text{Co}(\text{en})_2\text{Cl}_2]^+$ has no plane of symmetry and exists as non-superimposable mirror images, so it is optically active. The trans isomer has a mirror plane through the Cl-Co-Cl axis, and square planar $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$ isomers are planar and achiral.

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