CHAPTER

18 Coordination Compounds

1. The oxidation states of Cr in $[Cr(H_2O)_6]Cl_3$, $[Cr(C_6H_6)_2]$ and $K_2[Cr(CN)_2(O)_2(O_2)(NH_3)]$ respectively are
(a) +3, +4 and +6 (b) +3, +2 and +4
(c) +3, 0 and +6 (d) +3, 0 and +4 *(2018)*

2. Consider the following reaction and statements :
$[Co(NH_3)_4Br_2]^+ + Br^- \rightarrow [Co(NH_3)_3Br_3] + NH_3$
(I) Two isomers are produced if the reactant complex ion is a *cis*-isomer.
(II) Two isomers are produced if the reactant complex ion is a *trans*-isomer.
(III) Only one isomer is produced if the reactant complex ion is a *trans*-isomer.
(IV) Only one isomer is produced if the reactant complex ion is a *cis*-isomer.
The correct statements are
(a) (I) and (II) (b) (I) and (III)
(c) (III) and (IV) (d) (II) and (IV) *(2018)*

3. The correct combination is
(a) $[Ni(CN)_4]^{2-}$ – tetrahedral; $[Ni(CO)_4]$ – paramagnetic
(b) $[NiCl_4]^{2-}$ – paramagnetic; $[Ni(CO)_4]$ – tetrahedral
(c) $[NiCl_4]^{2-}$ – diamagnetic; $[Ni(CO)_4]$ – square-planar
(d) $[NiCl_4]^{2-}$ – square-planar; $[Ni(CN)_4]^{2-}$ – paramagnetic
(Online 2018)

4. The total number of possible isomers for square planar $[Pt(Cl)(NO_2)(NO_3)(SCN)]^{2-}$ is
(a) 16 (b) 8
(c) 24 (d) 12
(Online 2018)

5. The correct order of spin-only magnetic moments among the following is
(Atomic number : Mn = 25, Co = 27, Ni = 28, Zn = 30)
(a) $[ZnCl_4]^{2-} > [NiCl_4]^{2-} > [CoCl_4]^{2-} > [MnCl_4]^{2-}$
(b) $[CoCl_4]^{2-} > [MnCl_4]^{2-} > [NiCl_4]^{2-} > [ZnCl_4]^{2-}$
(c) $[MnCl_4]^{2-} > [CoCl_4]^{2-} > [NiCl_4]^{2-} > [ZnCl_4]^{2-}$
(d) $[NiCl_4]^{2-} > [CoCl_4]^{2-} > [MnCl_4]^{2-} > [ZnCl_4]^{2-}$
(Online 2018)

6. Which of the following complexes will show geometrical isomerism?
(a) Potassium amminetrichloroplatinate(II)
(b) Aquachlorobis(ethylenediamine)cobalt(II) chloride
(c) Potassium tris(oxalato)chromate(III)
(d) Pentaaquachlorochromium(III) chloride
(Online 2018)

7. In Wilkinson's catalyst, the hybridisation of central metal ion and its shape are respectively
(a) dsp^2, square planar (b) sp^3d, trigonal bipyramidal
(c) sp^3, tetrahedral (d) d^2sp^3, octahedral.
(Online 2018)

8. On treatment of 100 mL of 0.1 M solution of $CoCl_3.6H_2O$ with excess $AgNO_3$, 1.2×10^{22} ions are precipitated. The complex is
(a) $[Co(H_2O)_6]Cl_3$ (b) $[Co(H_2O)_5Cl]Cl_2.H_2O$
(c) $[Co(H_2O)_4Cl_2]Cl.2H_2O$ (d) $[Co(H_2O)_3Cl_3].3H_2O$
(2017)

9. $[Co_2(CO)_8]$ displays
(a) one Co — Co bond, four terminal CO and four bridging CO
(b) one Co — Co bond, six terminal CO and two bridging CO
(c) no Co — Co bond, four terminal CO and four bridging CO
(d) no Co — Co bond, six terminal CO and two bridging CO.
(Online 2017)

. The pair having the same magnetic moment is
[At. No.: Cr = 24, Mn = 25, Fe = 26, Co = 27]
(a) $[Cr(H_2O)_6]^{2+}$ and $[CoCl_4]^{2-}$
(b) $[Cr(H_2O)_6]^{2+}$ and $[Fe(H_2O)_6]^{2+}$
(c) $[Mn(H_2O)_6]^{2+}$ and $[Cr(H_2O)_6]^{2+}$
(d) $[CoCl_4]^{2-}$ and $[Fe(H_2O)_6]^{2+}$ *(2016)*

11. Which one of the following complexes shows optical isomerism?
(a) $[Co(NH_3)_3Cl_3]$
(b) *cis*$[Co(en)_2Cl_2]Cl$
(c) *trans*$[Co(en)_2Cl_2]Cl$
(d) $[Co(NH_3)_4Cl_2]Cl$ (*en* = ethylenediamine) *(2016)*

12. Which one of the following complexes will consume more equivalents of aqueous solution of $AgNO_3$?
(a) $Na_2[CrCl_5(H_2O)]$ (b) $Na_3[CrCl_6]$
(c) $[Cr(H_2O)_5Cl]Cl_2$ (d) $[Cr(H_2O)_6]Cl_3$
(Online 2016)

13. Identify the correct trend given below :
(Atomic no. : Ti = 22, Cr = 24 and Mo = 42)
(a) Δ_o of $[Cr(H_2O)_6]^{2+} > [Mo(H_2O)_6]^{2+}$ and Δ_o of $[Ti(H_2O)_6]^{3+} > [Ti(H_2O)_6]^{2+}$
(b) Δ_o of $[Cr(H_2O)_6]^{2+} > [Mo(H_2O)_6]^{2+}$ and Δ_o of $[Ti(H_2O)_6]^{3+} < [Ti(H_2O)_6]^{2+}$
(c) Δ_o of $[Cr(H_2O)_6]^{2+} < [Mo(H_2O)_6]^{2+}$ and Δ_o of $[Ti(H_2O)_6]^{3+} > [Ti(H_2O)_6]^{2+}$
(d) Δ_o of $[Cr(H_2O)_6]^{2+} < [Mo(H_2O)_6]^{2+}$ and Δ_o of $[Ti(H_2O)_6]^{3+} < [Ti(H_2O)_6]^{2+}$ *(Online 2016)*

14. The transition metal ions responsible for colour in ruby and emerald are, respectively
(a) Co^{3+} and Cr^{3+} (b) Co^{3+} and Co^{3+}
(c) Cr^{3+} and Cr^{3+} (d) Cr^{3+} and Co^{3+}
(Online 2016)

15. Which of the following is an example of homoleptic complex?
(a) $[Co(NH_3)_6]Cl_3$ (b) $[Pt(NH_3)_2Cl_2]$
(c) $[Co(NH_3)_4Cl_2]$ (d) $[Co(NH_3)_5Cl]Cl_2$
(Online 2016)

16. Which of the following compounds is not yellow coloured?
(a) $(NH_4)_3[As(Mo_3O_{10})_4]$ (b) $BaCrO_4$
(c) $Zn_2[Fe(CN)_6]$ (d) $K_3[Co(NO_2)_6]$ *(2015)*

17. The number of geometric isomers that can exist for square planar $[Pt(Cl)(py)(NH_3)(NH_2OH)]^+$ is (*py* = pyridine)
(a) 4 (b) 6
(c) 2 (d) 3 *(2015)*

18. The correct statement on the isomerism associated with the following complex ions,
(1) $[Ni(H_2O)_5(NH_3)]^{2+}$ (2) $[Ni(H_2O)_4(NH_3)_2]^{2+}$ and
(3) $[Ni(H_2O)_3(NH_3)_3]^{2+}$ is
(a) (1) and (2) show only geometrical isomerism
(b) (1) and (2) show geometrical and optical isomerism
(c) (2) and (3) show geometrical and optical isomerism
(d) (2) and (3) show only geometrical isomerism.
(Online 2015)

19. Which molecule/ion among the following cannot act as a ligand in complex compounds?
(a) CO (b) CN^-
(c) CH_4 (d) Br^- *(Online 2015)*

20. When concentrated HCl is added to an aqueous solution of $CoCl_2$, its colour changes from reddish pink to deep blue. Which complex ion gives blue colour in this reaction?
(a) $[CoCl_6]^{4-}$ (b) $[CoCl_6]^{3-}$
(c) $[CoCl_4]^{2-}$ (d) $[Co(H_2O)_6]^{2+}$
(Online 2015)

21. Which of the following complex ions has electrons that are symmetrically filled in both t_{2g} and e_g orbitals?
(a) $[CoF_6]^{3-}$ (b) $[Co(NH_3)_6]^{2+}$
(c) $[Mn(CN)_6]^{4-}$ (d) $[FeF_6]^{3-}$ *(Online 2015)*

22. The octahedral complex of a metal ion M^{3+} with four monodentate ligands L_1, L_2, L_3 and L_4 absorbs wavelengths in the region of red, green, yellow and blue, respectively. The increasing order of ligand strength of the four ligands is
(a) $L_1 < L_2 < L_4 < L_3$ (b) $L_4 < L_3 < L_2 < L_1$
(c) $L_1 < L_3 < L_2 < L_4$ (d) $L_3 < L_2 < L_4 < L_1$ *(2014)*

23. Which of the following complex species is not expected to exhibit optical isomerism?
(a) $[Co(en)(NH_3)_2Cl_2]^+$ (b) $[Co(en)_3]^{3+}$
(c) $[Co(en)_2Cl_2]^+$ (d) $[Co(NH_3)_3Cl_3]$ *(2013)*

24. Which among the following will be named as dibromidobis (ethylene diamine) chromium (III) bromide?
(a) $[Cr(en)_2Br_2]Br$ (b) $[Cr(en)Br_4]^-$
(c) $[Cr(en)Br_2]Br$ (d) $[Cr(en)_3]Br_3$ *(2012)*

25. The magnetic moment (spin only) of $[NiCl_4]^{2-}$ is
(a) 1.82 BM (b) 5.46 BM
(c) 2.82 BM (d) 1.41 BM *(2011)*

26. Which of the following facts about the complex $[Cr(NH_3)_6]Cl_3$ is wrong?
(a) The complex involves d^2sp^3 hybridisation and is octahedral in shape.
(b) The complex is paramagnetic.
(c) The complex is an outer orbital complex.
(d) The complex gives white precipitate with silver nitrate solution.
(2011)

27. Which one of the following has an optical isomer?
(a) $[Zn(en)_2]^{2+}$ (b) $[Zn(en)(NH_3)_2]^{2+}$
(c) $[Co(en)_3]^{3+}$ (d) $[Co(H_2O)_4(en)]^{3+}$ *(2010)*

28. A solution contains 2.675 g of $CoCl_3 \cdot 6NH_3$ (molar mass = 267.5 g mol^{-1}) is passed through a cation exchanger. The chloride ions obtained in solution were treated with excess of $AgNO_3$ to give 4.78 g of AgCl (molar mass = 143.5 g mol^{-1}). The formula of the complex is (At. mass of Ag = 108 u)
(a) $[CoCl(NH_3)_5]Cl_2$ (b) $[Co(NH_3)_6]Cl_3$
(c) $[CoCl_2(NH_3)_4]Cl$ (d) $[CoCl_3(NH_3)_3]$ *(2010)*

29. Which of the following pairs represents linkage isomers?
(a) $[Cu(NH_3)_4][PtCl_4]$ and $[Pt(NH_3)_4][CuCl_4]$
(b) $[Pd(PPh_3)_2(NCS)_2]$ and $[Pd(PPh_3)_2(SCN)_2]$
(c) $[Co(NH_3)_5(NO_3)]SO_4$ and $[Co(NH_3)_5(SO_4)]NO_3$
(d) $[PtCl_2(NH_3)_4]Br_2$ and $[PtBr_2(NH_3)_4]Cl_2$ *(2009)*

30. Which of the following has an optical isomer?
(a) $[Co(NH_3)_3Cl]^+$ (b) $[Co(en)(NH_3)_2]^{2+}$
(c) $[Co(H_2O)_4(en)]^{3+}$ (d) $[Co(en)_2(NH_3)_2]^{3+}$
(2009)

31. The coordination number and the oxidation state of the element *E* in the complex $[E(en)_2(C_2O_4)]NO_2$ (where (*en*) is ethylene diamine) are, respectively
(a) 6 and 3 (b) 6 and 2
(c) 4 and 2 (d) 4 and 3 *(2008)*

32. Which of the following has a square planar geometry?
(a) $[PtCl_4]^{2-}$ (b) $[CoCl_4]^{2-}$
(c) $[FeCl_4]^{2-}$ (d) $[NiCl_4]^{2-}$.
(At. nos.: Fe = 26, Co = 27, Ni = 28, Pt = 78) *(2007)*

33. How many EDTA (ethylenediaminetetraacetic acid) molecules are required to make an octahedral complex with a Ca^{2+} ion?
(a) Six (b) Three
(c) One (d) Two *(2006)*

34. In $Fe(CO)_5$, the Fe – C bond possesses
(a) π-character only (b) both σ and π characters
(c) ionic character (d) σ-character only. *(2006)*

35. The IUPAC name for the complex $[Co(NO_2)(NH_3)_5]Cl_2$ is
(a) nitrito-N-pentaamminecobalt(III) chloride
(b) nitrito-N-pentaamminecobalt(II) chloride
(c) pentaammine nitrito-N-cobalt(II) chloride
(d) pentaammine nitrito-N-cobalt(III) chloride. *(2006)*

36. The value of the 'spin only' magnetic moment for one of the following configurations is 2.84 BM. The correct one is
(a) d^4 (in strong ligand field)
(b) d^4 (in weak ligand field)
(c) d^3 (in weak as well as in strong fields)
(d) d^5 (in strong ligand field) *(2005)*

37. Which one of the following cyano complexes would exhibit the lowest value of paramagnetic behaviour?
(a) $[Cr(CN)_6]^{3-}$ (b) $[Mn(CN)_6]^{3-}$
(c) $[Fe(CN)_6]^{3-}$ (d) $[Co(CN)_6]^{3-}$ *(2005)*

38. Which of the following compounds shows optical isomerism?
(a) $[Cu(NH_3)_4]^{2+}$ (b) $[ZnCl_4]^{2-}$
(c) $[Cr(C_2O_4)_3]^{3-}$ (d) $[Co(CN)_6]^{3-}$ *(2005)*

39. The IUPAC name of the coordination compound $K_3[Fe(CN)_6]$ is
(a) potassium hexacyanoferrate (II)
(b) potassium hexacyanoferrate (III)
(c) potassium hexacyanoiron (II)
(d) tripotassium hexacyanoiron (II) *(2005)*

40. The oxidation state of Cr in $[Cr(NH_3)_4Cl_2]^+$ is
(a) +3 (b) +2
(c) +1 (d) 0 *(2005)*

41. Which one of the following has largest number of isomers?
(a) $[Ru(NH_3)_4Cl_2]^+$ (b) $[Co(NH_3)_5Cl]^{2+}$
(c) $[Ir(PR_3)_2H(CO)]^{2+}$ (d) $[Co(en)_2Cl_2]^+$
(R = alkyl group, en = ethylenediamine) *(2004)*

42. Coordination compounds have great importance in biological systems. In this context which of the following statements is incorrect?
(a) Chlorophylls are green pigments in plants and contain calcium.
(b) Haemoglobin is the red pigment of blood and contains iron.
(c) Cyanocobalamine is B_{12} and contains cobalt.
(d) Carboxypeptidase-A is an enzyme and contains zinc. *(2004)*

43. Which one of the following complexes is an outer orbital complex?
(a) $[Fe(CN)_6]^{4-}$ (b) $[Mn(CN)_6]^{4-}$
(c) $[Co(NH_3)_6]^{3+}$ (d) $[Ni(NH_3)_6]^{2+}$
[Atomic nos.: Mn = 25, Fe = 26, Co = 27, Ni = 28] *(2004)*

44. The coordination number of a central metal atom in a complex is determined by
(a) the number of ligands around a metal ion bonded by sigma bonds
(b) the number of ligands around a metal ion bonded by pi-bonds
(c) the number of ligands around a metal ion bonded by sigma and pi-bonds both
(d) the number of only anionic ligands bonded to the metal ion. *(2004)*

45. One mole of the complex compound $Co(NH_3)_5Cl_3$, gives 3 moles of ions on dissolution in water. One mole of the same complex reacts with two moles of $AgNO_3$ solution to yield two moles of AgCl (*s*). The structure of the complex is
(a) $[Co(NH_3)_5Cl]Cl_2$ (b) $[Co(NH_3)_3Cl_2]\cdot 2NH_3$
(c) $[Co(NH_3)_4Cl_2]Cl\cdot NH_3$ (d) $[Co(NH_3)_4Cl]Cl_2\cdot NH_3$ *(2003)*

46. Ammonia forms the complex ion $[Cu(NH_3)_4]^{2+}$ with copper ions in alkaline solutions but not in acidic solutions. What is the reason for it?
(a) In acidic solutions hydration protects copper ions.
(b) In acidic solutions protons coordinate with ammonia molecules forming NH_4^+ ions and NH_3 molecules are not available.
(c) In alkaline solutions insoluble $Cu(OH)_2$ is precipitated which is soluble in excess of any alkali.
(d) Copper hydroxide is an amphoteric substance. *(2003)*

47. In the coordination compound, $K_4[Ni(CN)_4]$, the oxidation state of nickel is
(a) –1 (b) 0 (c) +1 (d) +2 *(2003)*

48. The type of isomerism present in nitropentamine chromium (III) chloride is
(a) optical (b) linkage
(c) ionization (d) polymerisation. *(2002)*

49. CH_3 – Mg – Br is an organometallic compound due to
(a) Mg – Br bond (b) C – Mg bond
(c) C – Br bond (d) C – H bond. *(2002)*

ANSWER KEY

1. (c)	**2.** (b)	**3.** (b)	**4.** (d)	**5.** (c)	**6.** (b)	**7.** (a)	**8.** (b)	**9.** (b)	**10.** (b)	**11.** (b)	**12.** (d)
13. (c)	**14.** (c)	**15.** (a)	**16.** (c)	**17.** (d)	**18.** (d)	**19.** (c)	**20.** (c)	**21.** (d)	**22.** (c)	**23.** (d)	**24.** (a)
25. (c)	**26.** (c)	**27.** (c)	**28.** (b)	**29.** (b)	**30.** (d)	**31.** (a)	**32.** (a)	**33.** (c)	**34.** (b)	**35.** (d)	**36.** (a)
37. (d)	**38.** (c)	**39.** (b)	**40.** (a)	**41.** (d)	**42.** (a)	**43.** (d)	**44.** (a)	**45.** (a)	**46.** (b)	**47.** (b)	**48.** (b)
49. (b)											

Explanations

1. (c) : $[Cr(H_2O)_6]Cl_3 : x + 6 \times 0 + 3 \times -1 = 0 \Rightarrow x = +3$

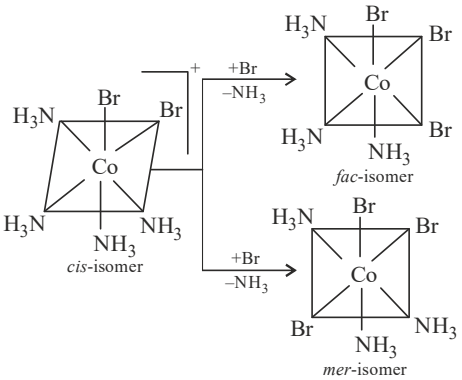
$[Cr(C_6H_6)_2] : x + 2 \times 0 \Rightarrow x = 0$

$K_2[Cr(CN)_2(O)_2(O_2)(NH_3)] :$

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

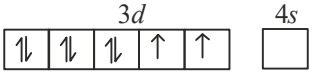
$2 + x - 2 - 4 - 2 = 0 \Rightarrow x = +6$

2. (b) :



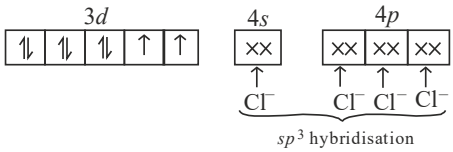
3. (b) : $[NiCl_4]^{2-}$: Oxidation state of Ni in $[NiCl_4]^{2-} = +2$

Ni^{2+} : [Ar] 3*d* 4*s*



Cl^- is a weak field ligand and cannot take part in pairing of electrons.

$[NiCl_4]^{2-}$: [Ar]

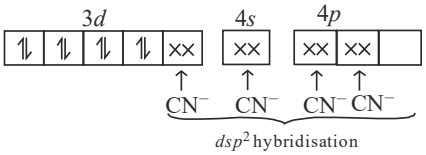


Hence, the complex is tetrahedral and paramagnetic with two unpaired electrons.

$[Ni(CN)_4]^{2-}$: Oxidation state of Ni is $[Ni(CN)_4]^{2-} = +2$

CN^- is a strong field ligand, thus pairing of electrons takes place in *d*-orbitals.

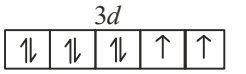
$[Ni(CN)_4]^{2-}$: [Ar]



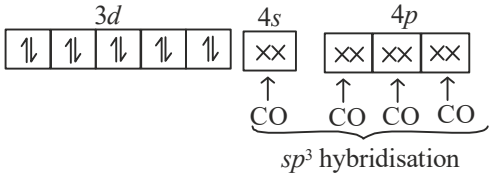
Hence, the complex is square planar and diamagnetic.

$[Ni(CO)_4]$: Oxidation state of Ni in $[Ni(CO)_4]$ is zero. CO is a strong field ligand.

Ni : [Ar] 3*d* 4*s*



$[Ni(CO)_4]$: [Ar]



Hence, the complex is tetrahedral and diamagnetic.

4. (d) : $[Pt(Cl)(NO_2)(NO_3)(SCN)]^{2-}$: This complex will show linkage isomerism as $-NO_2$ and –SCN are bidentate ligand. These are :

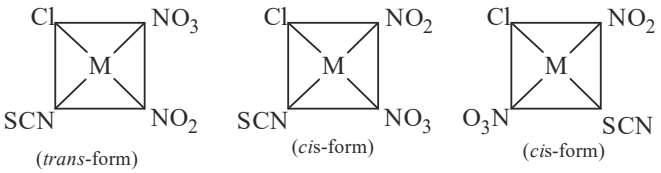
$[Pt(Cl)(NO_2)(NO_3)(NCS)]^{2-}$

$[Pt(Cl)(ONO)(NO_3)(NCS)]^{2-}$

$[Pt(Cl)(ONO)(NO_3)(SCN)]^{2-}$

$[Pt(Cl)(NO_2)(NO_3)(SCN)]^{2-}$

It exhibits geometrical isomerism also



All four linkage isomers give three geometrical isomers each. Thus, total 12 isomers are possible.

5. (c) : Spin-only magnetic moment $(\mu) = \sqrt{n(n+2)}$ B.M.

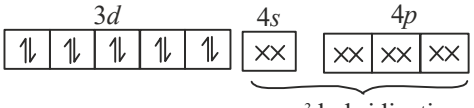
Where, *n* is the number of unpaired electron(s).

As Cl^- is a weak field ligand, no pairing of electrons takes place.

(i) $[ZnCl_4]^{2-}$:

Zn^{2+} : [Ar]$3d^{10}$

$[ZnCl_4]^{2-}$:

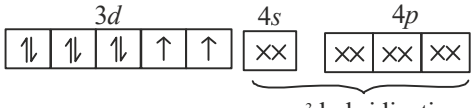


$n = 0, \therefore \mu = 0$

(ii) $[NiCl_4]^{2-}$:

Ni^{2+} : [Ar]$3d^8$

$[NiCl_4]^{2-}$:

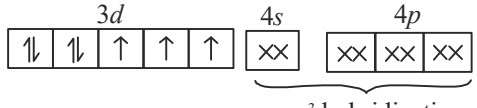


$n = 2, \therefore \mu = \sqrt{2(2+2)} = 2.83$ B.M.

(iii) $[CoCl_4]^{2-}$:

Co^{2+} : [Ar]$3d^7$

$[CoCl_4]^{2-}$:

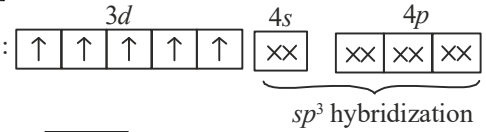


$n = 3, \therefore \mu = \sqrt{3(3+2)} = 3.87$ B.M.

(iv) $[MnCl_4]^{2-}$:

Mn^{2+} : [Ar]$3d^5$

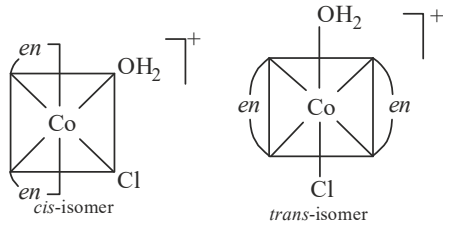
$[MnCl_4]^{2-}$:



$n = 5, \therefore \mu = \sqrt{5(5+2)} = 5.91$ B.M.

6. (b) : (a) $K[Pt(NH_3)Cl_3]$: This complex is $[MAB_3]$ type, which does not show geometrical isomerism.

(b) $[Co(H_2O)Cl\ (en)_2]Cl$: This complex shows geometrical isomerism.



(c) $K_3[Cr(ox)_3]$: This complex is $[M(AA)_3]$ type, it does not show geometrical isomerism.

(d) $[Cr(H_2O)_5Cl]\ Cl_2$: This complex is $[MA_5B]$ type.

It does not show geometrical isomerism.

7. (a) : Wilkinson's catalyst is $[RhCl(PPh_3)_3]$.

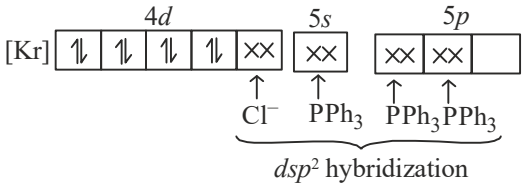
Oxidation state of Rh in $[RhCl(PPh_3)_3]$ = +1

Electronic configuration of Rh = $[Kr]4d\ ^85s^1$

Electronic configuration of Rh^+ = $[Kr]4d^8$

As Rh(4*d*) always forms low spin complex,

Hence, $[RhCl(PPh_3)_3]$:



Thus, complex is square planar.

8. (b) : Number of moles of complex $= \frac{M \times V(mL)}{1000}$

$= \frac{0.1 \times 100}{1000} = 0.01$

Moles of ions precipitated with excess of $AgNO_3$

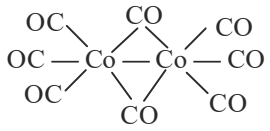
$= \frac{1.2 \times 10^{22}}{6.022 \times 10^{23}} = 0.01992 \approx 0.02$

Now, number of Cl^- ions present in ionisation sphere

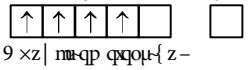
$= \frac{\text{Moles of ions precipitated with excess } AgNO_3}{\text{Moles of complex}} = \frac{0.02}{0.01} = 2$

Hence, the formula of complex is $[Co(H_2O)_5Cl]Cl_2 \cdot H_2O$.

9. (b) :

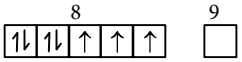


10. (b) : $[Cr(H_2O)_6]^{2+}$: $Cr^{2+} \rightarrow [Ar]3d^44s^0$



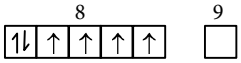
9 ×z| mu+qp qxqou+{z-

$[CoCl_4]^{2-}$: $Co^{2+} \rightarrow [Ar]3d^74s^0$



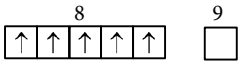
8 ×z| mu+qp qxqou+{z-

$[Fe(H_2O)_6]^{2+}$: $Fe^{2+} \rightarrow [Ar]3d^64s^0$



9 ×z| mu+qp qxqou+{z-

$[Mn(H_2O)_6]^{2+}$: $Mn^{2+} \rightarrow [Ar]3d^54s^0$

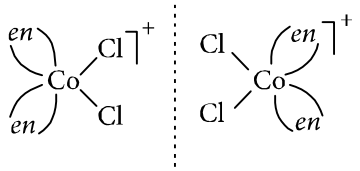


: ×z| mu+qp qxqou+{z-

Hence, $[Cr(H_2O)_6]^{2+}$ and $[Fe(H_2O)_6]^{2+}$ have same number of unpaired electrons *i.e.*, same magnetic moment.

11. (b) : $[Co(NH_3)_3Cl_3]$ has two geometrical isomers but both are optically inactive due to plane of symmetry.

cis$[Co(en)_2Cl_2]Cl$ is optically active.



Non-superimposable

trans$[Co(en)_2Cl_2]Cl$ is optically inactive due to plane of symmetry.

$[Co(NH_3)_4Cl_2]Cl$ has two geometrical isomers but both are optically inactive due to plane of symmetry.

12. (d) : Chloride ions outside the coordination sphere are ionisable only. Hence, $[Cr(H_2O)_6]Cl_3$ will give 3 Cl^- ions in aqueous solution which consume more equivalents of $AgNO_3$.

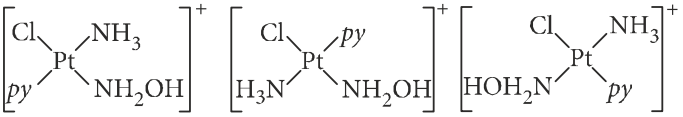
13. (c) : Δ_o increases from 3*d*-series to 4*d*-series. Thus, $[Cr(H_2O)_6]^{2+}$ has lower Δ_o value than that of $[Mo(H_2O)_6]^{2+}$. Also, for a metal ion having lesser number of *d*-electrons, Δ_o value increases. Thus, $[Ti(H_2O)_6]^{3+}$ has greater Δ_o value than that of $[Ti(H_2O)_6]^{2+}$.

14. (c) : Red colour of ruby (Al_2O_3) arises due to Cr^{3+} replaces Al^{3+} ions in octahedral sites. Green colour of emerald ($Be_3Al_2(SiO_3)_6$) arises due to Cr^{3+} replaces Al^{3+} ions in octahedral sites.

15. (a) : Homoleptic complexes have only one type of ligands. In complex $[Co(NH_3)_6]Cl_3$, NH_3 serves as the only ligand.

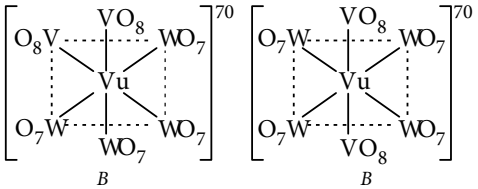
16. (c) : $Zn_2[Fe(CN)_6]$ is bluish white while all others are yellow coloured.

17. (d) : The number of geometrical isomers for square planar are 3.

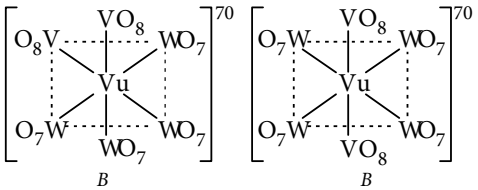


18. (d) : Octahedral complexes of the type Ma_4b_2 and Ma_3b_3 exhibit geometrical isomerism only.

Geometrical isomers :



gVu+O7W.9-VO8.7i70



gVu+O7W.9-VO8.7i70

19. (c) : Ligand donates electron to metal. In methane there is no electron to donate, it is stable with complete octet.

20. (c) : $\underset{\text{Pink}}{[Co(H_2O)_6]^{2+}} + 4Cl^- \longrightarrow \underset{\text{Blue}}{[CoCl_4]^{2-}} + 6H_2O$

21. (d) : $[CoF_6]^{3-}$: Co^{3+} : $3d^6$, F^- is a weak field ligand. $t^4_{2g}\, e_g^2$

$[Co(NH_3)_6]^{2+}$: Co^{2+} : $3d^7$, NH_3 is a strong field ligand. $t^6_{2g}\, e^1_g$

$[Mn(CN)_6]^{4-}$: Mn^{2+} : $3d^5$, CN^- is a strong field ligand. $t^5_{2g}\, e^0_g$

$[FeF_6]^{3-}$: Fe^{3+} : $3d^5$, F^- is a weak field ligand. $t^3_{2g}\ \ e_g^2$

22. (c) : $\underset{\text{Wavelength increasing } (\lambda)}{\overset{V\ I\ B\ G\ Y\ O\ R}{\longrightarrow}}$

According to the spectrochemical series, more the absorption frequency, stronger is the ligand.

or, Δ or CFSE $\propto$ Strength of ligands $\propto \frac{1}{\lambda}$

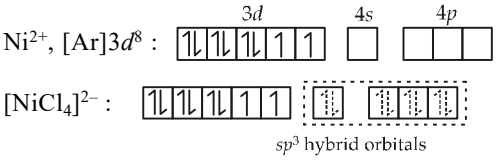
Hence, the increasing order of ligand strength is,

$\underset{\text{(Red)}}{L_1} < \underset{\text{(Yellow)}}{L_3} < \underset{\text{(Green)}}{L_2} < \underset{\text{(Blue)}}{L_4}$

23. (d) : $[Co(NH_3)_3Cl_3]$ will not exhibit optical isomerism due to presence of plane of symmetry.

24. (a)

25. (c) : In the paramagnetic and tetrahedral complex $[NiCl_4]^{2-}$, the nickel is in +2 oxidation state and the ion has the electronic configuration $3d^8$. The hybridisation scheme is as shown in figure.

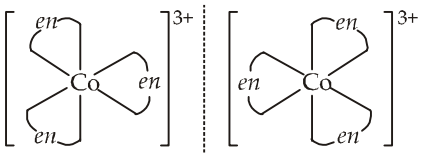


$\mu = \sqrt{n(n+2)}$ BM $= \sqrt{(2(2+2)} = \sqrt{8} = 2.82$ BM

26. (c) : The complex $[Cr(NH_3)_6]Cl_3$ involves d^2sp^3 hybridization as it involves $(n-1)d$ orbitals for hybridization. It is an inner orbital complex.

27. (c) : Optical isomers rarely occur in square planar complexes due to the presence of axis of symmetry.

Optical isomerism is common in octahedral complexes of the general formula, $[Ma_2b_2c_2]^{n\pm}$, $[Mabcdef]^{n\pm}$, $[M(AA)_3]^{n\pm}$, $[M(AA)_2a_2]^{n\pm}$, $[M(AA)_2ab]^{n\pm}$ and $[M(AB)_3]^{n\pm}$. Thus, among the given options, only $[Co(en)_3]^{3+}$ shows optical isomerism.



28. (b) : No. of moles of $CoCl_3 \cdot 6NH_3 = \frac{2.675}{267.5} = 0.01$

No. of moles of AgCl $= \frac{4.78}{143.5} = 0.03$

Since 0.01 moles of the complex $CoCl_3 \cdot 6NH_3$ gives 0.03 moles of AgCl on treatment with $AgNO_3$, it implies that 3 chloride ions are ionisable, in the complex. Thus, the formula of the complex is $[Co(NH_3)_6]Cl_3$.

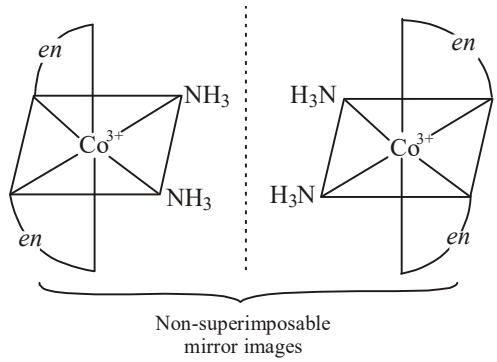
29. (b) : Linkage isomerism is exhibited by compounds containing ambidentate ligand.

In$[Pd(PPh_3)_2(NCS)_2]$, the linkage of NCS and Pd is through N.

In $[Pd(PPh_3)_2(SCN)_2]$, the linkage of SCN and Pd is through S.

30. (d) : Optical isomerism is usually exhibited by octahedral compounds of the type $[M(AA)_2B_2]$, where (AA) is a symmetrical bidentate ligand. Square planar complexes rarely show optical isomerism on accout of presence of axis of symmetry.

Thus among the given options, $[Co(en)_2(NH_3)_2]^{3+}$ exhibits optical isomerism.



31. (a) : In the given complex $[E(en)_2(C_2O_4)]^+NO_2^-$ ethylene diamine is a bidentate ligand and $(C_2O_4^{2-})$ oxalate ion is also bidentate ligand. Therefore co-ordination number of the complex is 6 *i.e.*, it is an octahedral complex.

Oxidation number of E in the given complex is

$x + 2 \times 0 + 1 \times (-2) = +1 \Rightarrow x = 3$

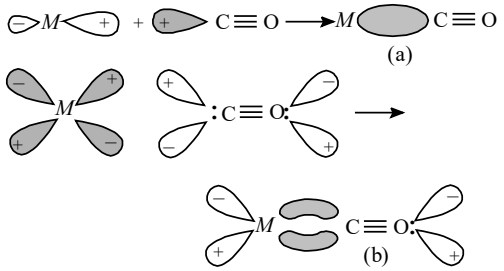
32. (a) : In 4-coordinate complexes Pt, the four ligands are arranged about the central 2-valent platinum ion in a square planar configuration.

33. (c) : EDTA, which has four donor oxygen atoms and two donor nitrogen atoms in each molecule forms complex with Ca^{2+} ion. The free acid H_4EDTA is insoluble and the disodium salt Na_2H_2EDTA is the most used reagent.

$Ca^{2+} + [H_2EDTA]^{2-} \rightarrow [Ca(EDTA)]^{2-} + 2H^+$

34. (b) : In a metal carbonyl, the metal carbon bond possesses both the σ- and π-character. A σ-bond between metal and carbon atom is formed when a vacant hybrid bond of the metal atom overlaps with an orbital of C atom of carbon monoxide containing a lone pair of electrons.

Formation of π-bond is caused when a filled orbital of the metal atom overlaps with a vacant antibonding π^* orbital of C atom of CO. This overlap is also called back donation of electrons by metal atom to carbon.



(a) The formation of the metal ← carbon σ-bond using an unshared pair of the C atom. (b) The formation of the metal → carbon π-bond.

The π-overlap is perpendicular to the nodal plane of σ-bond.

35. (d) : $[Co(NO_2)(NH_3)_5]Cl_2$: Pentaaminenitrito-N-cobalt(III) chloride

36. (a) : Spin only magnetic moment $= \sqrt{n(n+2)}$ B.M.
Where n = no. of unpaired electron.

Given, $\sqrt{n(n+2)} = 2.84$

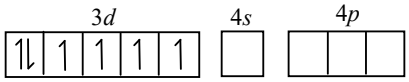
or, $n\,(n+2) = 8.0656 \Rightarrow n = 2$

In an octahedral complex, for a d^4 configuration in a strong field ligand, number of unpaired electrons = 2

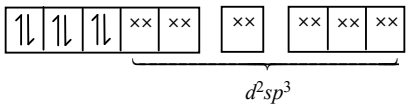
37. (d) : $[Co(CN)_6]^{3-}$

$Co \rightarrow [Ar]\ 3d^7\ 4s^2$

$Co^{3+} \rightarrow [Ar]\ 3d^6\ 4s^0$

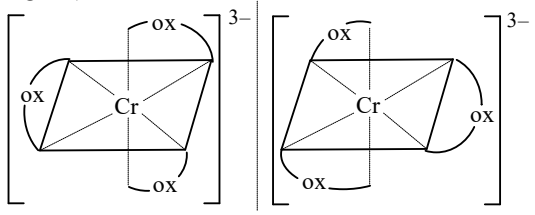


In presence of strong field ligand CN^- pairing of electrons takes place.



There is no unpaired electron, so the lowest value of paramagnetic behaviour is observed.

38. (c) : Optical isomers rarely occur in square planar complexes on account of the presence of axis of symmetry. Optical isomerism is very common in octahedral complexes having general formulae: $[Ma_2b_2c_2]^{n\pm}$, $[Mabcdef]^{n\pm}$, $[M(AA)_3]^{n\pm}$, $[M(AA)_2a_2]^{n\pm}$, $[M(AA)_2ab]^{n\pm}$ and $[M(AB)_3]^{n\pm}$
(where AA = symmetrical bidentate ligand and AB = unsymmetrical bidentate ligand).



39. (b) : $K_3[Fe(CN)_6]$: Potassium hexacyanoferrate(III)

40. (a) : Let the oxidation state of Cr in $[Cr(NH_3)_4Cl_2]^+ = x$

$x + 4(0) + 2(-1) = +1 \Rightarrow x - 2 = +1 \Rightarrow x = +1 + 2 = +3$

41. (d) : $[Co(en)_2Cl_2]^+$ shows geometrical as well as optical isomerism.

42. (a) : Chlorophyll are green pigments in plants and contains magnesium instead of calcium.

43. (d) :

Complex ion	Hybridization of central ion
$[Fe(CN)_6]^{4-}$	d^2sp^3 (inner)
$[Mn(CN)_6]^{4-}$	d^2sp^3 (inner)
$[Co(NH_3)_6]^{3+}$	d^2sp^3 (inner)
$[Ni(NH_3)_6]^{2+}$	sp^3d^2 (outer)

44. (a) : The number of atoms of the ligands that are directly bound to the central metal atom or ion by coordinate bonds is known as the coordination number of the metal atom or ion. Coordination number of metal = number of σ bonds formed by metal with ligands.

45. (a) : Given reactions can be explained as follows:

$[Co(NH_3)_5Cl]Cl_2 \rightleftharpoons [Co(NH_3)_5Cl]^{2+} + 2Cl^- \Rightarrow 3$ ions.

$[Co(NH_3)_5Cl]Cl_2 + 2AgNO_3 \rightarrow [Co(NH_3)_5Cl](NO_3)_2 + 2AgCl$

46. (b) : In acidic solution, NH_3 forms a bond with H^+ to give NH_4^+ ion which does not have a lone pair on N atom. Hence it cannot act as a ligand.

47. (b) : Let the oxidation number of Ni in $K_4[Ni(CN)_4] = x$

$1 \times 4 + x \times (-1) \times 4 = 0 \Rightarrow 4 + x - 4 = 0 \Rightarrow x = 0$

48. (b) : The nitro group can attach to metal through nitrogen as ($-NO_2$) or through oxygen as nitrito (–ONO).

49. (b) : Compounds that contain at least one carbon-metal bond are called organometallic compounds.