Additional Problems For Self Practice (APSP)

✍ Marked Questions may have for Revision Questions.

This Section is not meant for classroom discussion. It is being given to promote self-study and self testing amongst the Resonance students.

PART - I : PRACTICE TEST-1 (IIT-JEE (MAIN Pattern))

Max. Marks : 100 **Max. Time : 1 Hr.**

Important Instructions

A. General :

1. The test is of 1 hour duration.
2. The Test Booklet consists of 25 questions. The maximum marks are 100.

B. Question Paper Format :

3. Each part consists of Two sections.
4. Section-1 contains 20 multiple choice questions. Each question has four choices (1), (2), (3) and (4) out of which **ONE** is correct.
5. Section-2 contains 5 questions. The answer to each of the questions is a **Numerical Value**.

C. Marking Scheme :

6. For each question in Section-1, you will be awarded 4 marks if you given the corresponding to the correct answer and zero mark if no given answers. In all other cases, minus one (– 1) mark will be awarded.
7. For each question in Section-2, you will be awarded 4 marks if you given the corresponding to the correct answer and zero mark if no given answers. No negative marks will be answered for incorrect answer in this section.

SECTION-1 : (Only One option correct Type)

This section contains **20** multiple choice questions. Each questions has four choices (1), (2), (3) and (4) out of which **Only ONE** option is correct.

1.✍ The IUPAC name of $K_2[Cr(CN)_2O_2(O)_2(NH_3)]$ is :
(1) Potassium amminedicyanodioxoperoxochromate(VI)
(2) Potassium amminecyanoperoxodioxochromium(VI)
(3) Potassium amminedicyanoperoxooxochromium(VI)
(4) Potassium amminecyanodiperoxodioxochromate(VI)

2. Which one of the following high-spin complexes has the largest CFSE (Crystal field stabilization energy)?
(1) $[Mn(H_2O)_6]^{2+}$ (2) $[Cr(H_2O)_6]^{2+}$ (3) $[Mn(H_2O)_6]^{3+}$ (4) $[Cr(H_2O)_6]^{3+}$

3.✍ Which of the following complex will show optical activity ?
(1) trans-$[Co(NH_3)_4Cl_2]^+$ (2) $[Cr(H_2O)_6]^{3+}$
(3) cis-$[Co(NH_3)_2(en)_2]^{3+}$ (4) trans-$[Co(NH_3)_2(en)_2]^{3+}$

4. Which kind of isomerism is shown by the complex $[Co(NH_3)_5(ONO)]SO_4$?
1. Ionisation isomerism 2. Linkage isomerism
3. Geometrical isomerism 4. Optical isomerism
(1) 1, 2, 3 and 4 are correct (2) 1, 3 and 4 are correct only
(3) 1 and 2 are correct only (4) 2, 3 and 4 are correct only

5. Which of the following statements is correct for complex $[Cr(NH_3)(CN)_4(NO)]^{2-}$ (given that n = 1)?
(1) It is d^2sp^3 hybridised .
(2) The chromium is in +1 oxidation state
(3) It is heteroleptic complex and its aqueous solution is coloured
(4) All of these.

6. Consider the following statements

S_1 : $[Cr(NH_3)_6]^{3+}$ is a inner orbital complex with crystal field stabilization energy equal to $-1.2\ \Delta_o$

S_2 : The complex formed by joining the CN^- ligands to Fe^{3+} ion has theoretical value of 'spin only' magnetic moment equal to 1.73 B.M.

S_3 : $Na_2S + Na_2[Fe(CN)_5NO] \longrightarrow Na_4[Fe(CN)_5NOS]$, In reactant and product the oxidation states of iron are same

and arrange in the order of true/false.

(1) F T F (2) T T F (3) T T T (4) F F F

7. A complex of certain metal has the magnetic moment of 4.91 BM whereas another complex of the same metal with same oxidation state has zero magnetic moment. The metal ion could be :

(1) Co^{2+} (2) Mn^{2+} (3) Fe^{2+} (4) Fe^{3+}

8.✍ Aqueous solution of nickel sulphate on treating with pyridine and then adding a solution of sodium nitrite gives dark blue crystals of :

(1) $[Ni(py)_4]SO_4$ (2) $[Ni(py)_2(NO_2)_2]$ (3) $[Ni(py)_4](NO_2)_2$ (4) $[Ni(py)_3(NO_2)]_2SO_4$

9. In the compound lithiumtetrahydroaluminate, the ligand is :

(1) H^+ (2) H (3) H^- (4) None of these

10. The magnitude of crystal field stabilisation energy (CFSE of Δ_t) in tetrahedral complexes is considerably less than that in the octahedral field. Because

(1) There are only four ligands instead of six so the ligand field is only 2/3 in tetrahedral complex

(2) The direction of the orbitals does not coincide with the direction of the ligands. This reduces the crystal field stabilization energy (Δ) by further 2/3

(3) Both points (1) and (2) are correct

(4) Both points (1) and (2) are wrong

11. Other than the X-ray diffractions, how could be the following pairs of isomers be distinguished from one another by ;

$[Cr(NH_3)_6]\ [Cr(NO_2)_6]$ and $[Cr(NH_3)_4(NO_2)_2]\ [Cr(NH_3)_2(NO_2)_4]$

(1) cryoscopic method (2) measurement of molar conductance

(3) measuring magnetic moments (4) observing their colours

12. $[Fe(en)_2(H_2O)_2]^{2+} + en \longrightarrow$ complex(X). The correct statement about the complex (X) is :

(1) it is a low spin complex. (2) it is diamagnetic.

(3) it shows geometrical isomerism. (4) (1) and (2) both.

13. Which of the following pairs will show the same magnetic moment ('spin only')?

(1) $[Cr(H_2O)_6]^{3+}$ and $[Fe(H_2O)_5NO]^{2+}$ (2) $[Mn(CN)_6]^{4-}$ and $[Fe(CN)_6]^{3-}$

(3) $[Ni(CO)_4]$ and $[Zn(NH_3)_4]^{2+}$ (4) All of these.

14. Which of the following statements about $Fe(CO)_5$ is correct?

(1) It is paramagnetic and high spin complex

(2) It is diamagnetic and high spin complex

(3) It is diamagnetic and low spin complex

(4) It is paramagnetic and low spin complex

15.✍ The crystal field-splitting for Cr^{3+} ion in octahedral field changes for ligands I^-, H_2O, NH_3, CN^- and the increasing order is :

(1) $I^- < H_2O < NH_3 < CN^-$ (2) $CN^- < I^- < H_2O < NH_3$

(3) $CN^- < NH_3 < H_2O < I^-$ (4) $NH_3 < H_2O < I^- < CN^-$

16. Which of the following complex ion is not expected to absorb visible light ?

(1) $[Ni(H_2O)_6]^{2+}$ (2) $[Zn(NH_3)_4]^{2+}$ (3) $[Cr(NH_3)_6]^{3+}$ (4) $[Fe(H_2O)_6]^{2+}$

17. Of the following complex ions, the one that probably has the largest overall formation constant, K_f, is :

(1) $[Co(NH_3)_6]^{3+}$ (2) $[Co(H_2O)_6]^{3+}$ (3) $[Co(NH_3)_2(H_2O)_4]^{3+}$ (4) $[Co(en)_3]^{3+}$

18. The correct structure of $Fe(CO)_5$ is :

(1) octahedral (2) tetrahedral (3) square pyramidal (4) trigonal bipyramidal

19.✍ Arrange the following in order of decreasing number of unpaired electrons :

I : $[Fe(H_2O)_6]^{2+}$ II : $[Fe(CN)_6]^{3-}$ III : $[Fe(CN)_6]^{4-}$ IV : $[Fe(H_2O)_6]^{3+}$

(1) IV, I, II, III (2) I, II, III, IV (3) III, II, I, IV (4) II, III, I, IV

20.✍ Match List-**I** (Complexes) with List-**II** (Hybridization) of central atom and select the correct answer using the codes given below the lists :

	List-I		**List-II**
A	$Ni(CO)_4$	1.	sp^3
B	$[Ni(CN)_4]^{2-}$	2.	dsp^2
C	$[Fe(CN)_6]^{4-}$	3.	sp^3d^2
D	$[MnF_6]^{4-}$	4.	d^2sp^3

Code:

	A	B	C	D		A	B	C	D
(1)	1	3	2	4	(2)	5	2	4	3
(3)	5	3	2	4	(4)	1	2	4	3

Section-2 : (Numerical Value)

This section contains **5** questions. Each question, when worked out will result in **Numerical Value**.

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21. The EAN of platinum in potassium hexachloroplatinate (IV) is :

22. If excess of $AgNO_3$ solution is added to 100 mL of a 2.4 M solution of dichlorobis(ethylenediamine) cobalt (**III**) chloride. How many moles of AgCl be precipitated ?

23. Oxidation number of Fe in violet coloured complex $Na_4[Fe(CN)_5(NOS)]$ is :

24.✍ What will be the theoretical value of 'spin only' magnetic moment (in BM) when $Fe(SCN)_3$ reacts with a solution containing F^- ions to yield a colourless complex ?

25. Coordination number of Ni in $[Ni(C_2O_4)_3]^{4-}$ is :

Practice Test-1 (IIT-JEE (Main Pattern))

OBJECTIVE RESPONSE SHEET (ORS)

Que.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Ans.										
Que.	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Ans.										
Que.	**21**	**22**	**23**	**24**	**25**					
Ans.										

PART - II : JEE (MAIN) OFFLINE PROBLEMS (PREVIOUS YEARS)

1. One mole of $Co(NH_3)_5Cl_3$ gives 3 moles of ions on dissolution in water. One mole of this reacts with two moles of $AgNO_3$ to give two moles of AgCl. The complex is : **[AIEEE 2003, 3/225]**

(1) $[Co(NH_3)_4Cl_2]Cl.NH_3$ (2) $[Co(NH_3)_4Cl]Cl_2.NH_3$

(3) $[Co(NH_3)_5Cl]Cl_2$ (4) $[Co(NH_3)_3Cl_3].2NH_3$

2. Ammonia forms the complex $[Cu(NH_3)_4]^{2+}$ with copper ions in alkaline solution but not in acid solution. The reason for it is : **[AIEEE 2003, 3/225]**

(1) in alkaline solution $Cu(OH)_2$ is precipitated which is soluble in excess of alkali.

(2) copper hydroxide is amphoteric.

(3) in acidic solution hydration protects Cu^{2+} ions.

(4) in acidic solution protons coordinates with ammonia molecule forming NH_4^+ ions and NH_3 molecules are not available.

3. In the coordination compound $K_4[Ni(CN)_4]$, the oxidation state of nickel is : **[AIEEE 2003, 3/225]**
(1) – 1 (2) 0 (3) + 1 (4) + 2

4. The co-ordination number of a central metal atom in a complex is determined by : **[AIEEE 2004, 3/225]**
(1) the number of only anionic ligands bonded to metal ion
(2) the number of ligands around a metal ion bonded by pi bonds
(3) the number of ligands around a metal ion bonded by sigma and pi bonds
(4) the number of ligands around a metal ion bonded by sigma bonds

5. Which one is an outer orbital complex ? **[AIEEE 2004, 3/225]**
(1) $[Ni(NH_3)_6]^{2+}$ (2) $[Mn(CN)_6]^{4-}$ (3) $[Co(NH_3)_6]^{3+}$ (4) $[Fe(CN)_6]^{4-}$

6. Co-ordination compounds have great importance in biological systems. In this context, which statement is incorrect ? **[AIEEE 2004, 3/225]**
(1) Carboxypeptidase–A is an enzyme and contains zinc.
(2) Haemoglobin is the red pigment of blood and contains iron.
(3) Cyanocobalmin is B_{12} and contains cobalt.
(4) Chlorophylls are green pigments in plants and contain calcium.

7. Which one has largest number of isomers ? **[AIEEE 2004, 3/225]**
(1) $[Co(en)_2Cl_2]^+$ (2) $[Co(NH_3)_5Cl]^{2+}$ (3) $[Ir(PhR_3)_2H(CO)]^{2+}$ (4) $[Ru(NH_3)_4Cl_2]^+$

8. The correct order of magnetic moments (only spin value in BM) among is : **[AIEEE 2004, 3/225]**
(1) $Fe(CN)_6^{4-} > [CoCl_4]^{2-} > [MnCl_4]^{2-}$ (2) $[MnCl_4]^{2-} > [Fe(CN)_6]^{4-} > [CoCl_4]^{2-}$
(3) $[Fe(CN)_6]^{4-} > [MnCl_4]^{2-} > [CoCl_4]^{2-}$ (4) $[MnCl_4]^{2-} > [CoCl_4]^{2-} > [Fe(CN)_6]^{4-}$

9. The oxidation state of Cr in $[Cr(NH_3)_4Cl_2]^+$ is : **[AIEEE 2005, 1½/225]**
(1) 0 (2) +1 (3) +2 (4) +3

10. The IUPAC name of $K_3Fe(CN)_6$ is : **[AIEEE 2005, 3/225]**
(1) Potassium hexacyanoferrate(II) (2) Potassium hexacyanoferrate(III)
(3) Potassium hexacyanoiron(II) (4) Tripotassium hexacyanoiron(II)

11. Which of the following will show optical isomerism ? **[AIEEE 2005, 3/225]**
(1) $[Cu(NH_3)_4]^{2+}$ (2) $[ZnCl_4]^{2-}$ (3) $[Cr(C_2O_4)_3]^{3-}$ (4) $[Co(CN)_6]^{3-}$

12. Which one of the following complexes would exhibit the lowest value of paramagnetic behaviour ? **[AIEEE 2005, 3/225]**
(1) $[Co(CN)_6]^{3-}$ (2) $[Fe(CN)_6]^{3-}$ (3) $[Mn(CN)_6]^{3-}$ (4) $[Cr(CN)_6]^{3-}$

13. The value of 'spin only' magnetic moment for one of the following configurations is 2.84 BM. The correct one is: (Assuming octahedral complex) **[AIEEE 2005, 4½/225]**
(1) d^4 (in strong field ligand) (2) d^4 (in weak field ligand)
(3) d^3 (in weak as well as strong field ligand) (4) d^5 (in strong field ligand)

14. Nickel (Z = 28) combines with a uninegative monodentate ligand X^- to form a paramagnetic complex $[NiX_4]^{2-}$. The number of unpaired electron(s) in the nickel and geometry of this complex ion are, respectively : **[AIEEE 2006, 3/165]**
(1) one, tetrahedral (2) two, tetrahedral
(3) one, square planar (4) two, square planar

15. The IUPAC name for the complex $[Co(NH_3)_5(NO_2)]Cl_2$ is : **[AIEEE 2006, 3/165]**
(1) Nitrito-N-pentaamminecobalt(III) chloride (2) Nitrito-N-pentaamminecobalt(II) chloride
(3) Pentaamminenitrito-N-cobalt(II) chloride (4) Pentaamminenitrito-N-cobalt(III) chloride

16. In $Fe(CO)_5$, the Fe – C bond possesses : **[AIEEE 2006, 3/165]**
(1) π-character only (2) both σ and π characters
(3) ionic character only (4) σ-character only

17. How many EDTA (ethylenediaminetetraacetic acid) molecules are required to make an octahedral complex with a Ca^{2+} ion ? **[AIEEE 2006, 3/165]**
(1) Six (2) Three (3) One (4) Two

18. Which one of the following has a square planar geometry? **[AIEEE 2007, 2/120]**
(1) $[NiCl_4]^{2-}$ (2) $[PtCl_4]^{2-}$ (3) $[CoCl_4]^{2-}$ (4) $[FeCl_4]^{2-}$
(At. no. Co = 27, Ni = 28, Fe = 26, Pt = 78)

19. The coordination number and the oxidation state of the element 'E' in the complex $[E(en)_2(C_2O_4)]\ NO_2$ (when 'en' is ethylene diamine) are, respectively, **[AIEEE 2008, 3/105]**
(1) 4 and 2 (2) 4 and 3 (3) 6 and 3 (4) 6 and 2

20. In which of the following octahedral complexes of Co (at no. 27), will the magnitude of Δ_0 be the highest? **[AIEEE 2008, 3/105]**
(1) $[Co(C_2O_4)_3]^{3-}$ (2) $[Co(H_2O)_6]^{3+}$ (3) $[Co(NH_3)_6]^{3+}$ (4) $[Co(CN)_6]^{3-}$

21. Which of the following has an optical isomer ? **[AIEEE 2009, 4/144]**
(1) $[Co(en)(NH_3)_2]^{2+}$ (2) $[Co(H_2O)_4(en)]^{3+}$ (3) $[Co(en)_2(NH_3)_2]^{3+}$ (4) $[Co(NH_3)_3Cl]^{+}$

22. Which of the following pairs represents linkage isomers ? **[AIEEE 2009, 4/144]**
(1) $[Pd(PPh_3)_2(NCS)_2]$ and $[Pd(PPh_3)_2(SCN)_2]$ (2) $[Co(NH_3)_5NO_3]SO_4$ and $[Co(NH_3)_5(SO_4)]NO_3$
(3) $[PtCl_2(NH_3)_4]Br_2$ and $[PtBr_2(NH_3)_4]Cl_2$ (4) $[Cu(NH_3)_4][PtCl_4]$ and $[Pt(NH_3)_4][CuCl_4]$

23. A solution containing 2.675 g of $CoCl_3.6NH_3$ (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) **[AIEEE 2010, 8/144]**
(1) $[Co(NH_3)_6]Cl_3$ (2) $[CoCl_2(NH_3)_4]Cl$ (3) $[CoCl_3(NH_3)_3]$ (4) $[CoCl(NH_3)_5]Cl_2$

24. Which one of the following has an optical isomer ? **[AIEEE 2010, 4/144]**
(1) $[Zn(en)(NH_3)_2]^{2+}$ (2) $[Co(en)_3]^{3+}$ (3) $[Co(H_2O)_4(en)]^{3+}$ (4) $[Zn(en)_2]^{2+}$
(en = ethylenediamine)

25. Which of the following facts about the complex $[Cr(NH_3)_6]Cl_3$ is **wrong** ? **[AIEEE 2011, 4/144]**
(1) The complex involves d^2sp^3 hybridisation and is octahedral in shape.
(2) The complex is paramagnetic.
(3) The complex is an outer orbital complex.
(4) The complex gives white precipitate with silver nitrate solution.

26. The magnetic moment (spin only) of $[NiCl_4]^{2-}$ is : **[AIEEE 2011, 4/144]**
(1) 1.82 BM (2) 5.46 BM (3) 2.82 BM (4) 1.41 BM

27. Which among the following will be named as dibromidobis (ethylene diamine) chromium (III) bromide? **[AIEEE 2012, 4/144]**
(1) $[Cr(en)_3]Br_3$ (2) $[Cr(en)_2Br_2]Br$ (3) $[Cr(en)Br_4]^-$ (4) $[Cr(en)Br_2]Br$

28. Which of the following complex species is not expected to exhibit optical isomerism ? **[JEE(Main) 2013, 4/120]**
(1) $[Co(en)_3]^{3+}$ (2) $[Co(en)_2Cl_2]^+$ (3) $[Co(NH_3)_3Cl_3]$ (4) $[Co(en)(NH_3)_2Cl_2]^+$

29. The octahedral complex of a metal ion M^{3+} with four monodentate ligands L_1, L_2, L_3 and L_4 absorb wavelengths in the region of red, green, yellow and blue, respectively. The increasing order of ligand strength of the four ligands is : **[JEE(Main) 2014, 4/120]**
(1) $L_4 < L_3 < L_2 < L_1$ (2) $L_1 < L_3 < L_2 < L_4$ (3) $L_3 < L_2 < L_4 < L_1$ (4) $L_1 < L_2 < L_4 < L_3$

30. The number of geometric isomers that can exist for square planar $[Pt(Cl)(py)(NH_3)(NH_2OH)]^+$ is (py = pyridine) : **[JEE(Main) 2015, 4/120]**
(1) 2 (2) 3 (3) 4 (4) 6

31. The pair having the same magnetic moment is : [At. No.: Cr = 24, Mn = 25, Fe = 26, Co = 27] **[JEE(Main) 2016, 4/120]**
(1) $[Cr(H_2O)_6]^{2+}$ and $[Fe(H_2O)_6]^{2+}$ (2) $[Mn(H_2O)_6]^{2+}$ and $[Cr(H_2O)_6]^{2+}$
(3) $[CoCl_4]^{2-}$ and $[Fe(H_2O)_6]^{2+}$ (4) $[Cr(H_2O)_6]^{2+}$ and $[CoCl_4]^{2-}$

32. Which one of the following complexes shows optical isomerism ? **[JEE(Main) 2016, 4/120]**
(1) *cis*$[Co(en)_2Cl_2]Cl$ (2) *trans*$[Co(en)_2Cl_2]Cl$
(3) $[Co(NH_3)_4Cl_2]Cl$ (4) $[Co(NH_3)_3Cl_3]$
(en = ethylenediamine)

33. 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 : **[JEE(Main) 2017, 4/120]**
(1) $[Co(H_2O)_3Cl_3].3H_2O$ (2) $[Co(H_2O)_6]Cl_3$
(3) $[Co(H_2O)_5Cl]Cl_2.H_2O$ (4) $[Co(H_2O)_4Cl_2]Cl.2H_2O$

34. 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 *tran*-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 : **[JEE(Main) 2018, 4/120]**
(1) (III) and (IV) (2) (II) and (IV) (3) (I) and (II) (4) (I) and (III)

35.^ 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 : **[JEE(Main) 2018, 4/120]**
(1) +3, 0 and +6 (2) +3, 0 and +4 (3) +3, +4 and +6 (4) +3, +2 and +4

PART-III : NATIONAL STANDARD EXAMINATION IN CHEMISTRY (NSEC) STAGE-I

1. The angle between the bonding orbitals of a molecule AX_3 with zero dipole moment is **[NSEC-2000]**
(A) 120º (B) 109º (C) 104º (D) 180º

2. In which of the following compounds, the oxidation number of the stated transition metal is zero. **[NSEC-2000]**
(A) $[Ni(CO)_4]$ (B) $[Pt(C_2H_4)Cl_3]$ (C) $[Co(NH_3)_6]Cl_2$ (D) $[Fe(H_2O)_3](OH)_2$

3. Ligands contain : **[NSEC-2001]**
(A) lone pair of electron (B) incomplete octet
(C) unpaired electron (D) shared pair of electron

4. e_g orbitals include **[NSEC-2002]**
(A) d_{xy} and d_{yz} (B) d_{yz} and d_{xz} (C) d_{yz} and d_{xz} (D) $d_{x_2 - y_2}$ and d_{z_2}

5. Dimethyl glyoxime forms a square planar complex with Ni^{2+}. This complex should be **[NSEC-2003]**
(A) diamagnetic (B) paramagnetic having 1 unpaired electron
(C) paramagnetic having 2 unpaired electrons (D) ferromagnetic.

6. A $[M(H_2O)_6]^{2+}$ complex typically absorbs at around 600 nm. It is allowed to react with ammonia to form a new complex $[M(NH_3)_6]^{2+}$ that should have absorption at **[NSEC-2003]**
(A) 800nm (B) 580nm (C) 620nm (D) 320nm.

7. The least stable metal carbonyl as per the bonding considerations should be **[NSEC-2003]**
(A) $Cr(CO)_6$ (B) $Mn(CO)_6$ (C) $Fe(CO)_5$ (D) $Ni(CO)_4$.

8. A coordination complex of type MX_2Y_2 [M = metal ion; X, Y = monodentate ligands], can have either a tetrahedral or a square planar geometry. The maximum number of possible isomers in these two cases are respectively **[NSEC-2003]**
(A) 0 and 2 (B) 2 and 1 (C) 1 and 3 (D) 3 and 2

9. The compound in which nickel has the lowest oxidation number is **[NSEC-2004]**
(A) $Ni(CO)_4$ (B) $(CH_3COO)_2Ni$ (C) NiO (D) $NiCl_2(PPh_3)_2$.

10. IUPAC name for $K_3[A\ell(C_2O_4)_3]$ is **[NSEC-2004]**
(A) potassium trioxalatoaluminate (III) (B) potassium aluminiumoxalate
(C) potassium trioxalatealuminium (II) (D) potassium trioxalatealuminium (III)

11. Geometrical isomerism would be expected for which of the following compounds **[NSEC-2005]**
(A) $[Zn(NH_3)_4]^{2+}$ (B) $[Pt(NH_3)_2C1_2]$ (C) $[Pt(NH_3)_3Cl]^+$ (D) $K_2[CuCl_4]$

12. Co-ordination compounds $[Pt(NH_3)_3(SCN)]$ and $[Pt(NH_3)_3(NCS)]$ are examples of **[NSEC-2005]**
(A) co-ordination isomerism (B) linkage isomerism
(C) optical isomerism (D) hydrate isomerism.

13. The highest molar conductivity will be exhibited by the complex **[NSEC-2005]**
(A) $[Cr(NH_3)_6]Cl_3$ (B) $[Cr(NH_3)_6Cl]Cl_2$ (C) $[Cr(NH_3)_6Cl_2]Cl$ (D) $[Cr(NH_3)_6Cl_3]$.

14. How many isomers are possible for the complex $[Co(en)_2Cl_2]$ (en = ethylene diamine) **[NSEC-2006]**
(A) 4 (B) 2 (C) 6 (D) 3

15. Which of the following complex ions does satisfy the effective atomic number (EAN) rule ? **[NSEC-2006]**
(A) $[Pt(NH_3)_4]^{2+}$ (B) $[PtCl_4]^{2-}$ (C) $[PtCl_6]^{2-}$ (D) $[Fe(CN)_6]^{3-}$.

16. In which of the following compounds is the oxidation number of the transition metal zero? **[NSEC-2007]**
(A) $[Ni(CO)_4]$ (B) $[Pt(C_2H_4)Cl_3$ (C) $[Co(NH_3)_6]Cl_2$ (D) $[Fe(H_2O)_3](OH)_2$

17. $[NiCl_4]^{2-}$ is paramagnetic and therefore its geometry is : **[NSEC-2007]**
(A) pyramidal (B) bi-pyramidal (C) tetrahedral (D) square planar

18. dsp^2 hybridization represents **[NSEC-2007]**
(A) octahedral geometry (B) square-planar geometry
(C) trigonal-bipyramidal geometry (D) square-pyramidal geometry

19. Which isomerism is exhibited by$[Co(NH_3)_6][Cr(CN)_6]$ and $[Cr(NH_3)_6][Co(CN)_6]$? **[NSEC-2007]**
(A) Ionization (B) Linkage (C) Coordination (D) Polymerization

20. The complex pentaaminecarbonatocobalt (III) chlorides is: **[NSEC-2007]**
(A) $[Co(NH_3)_5CO_3]$ Cl (B) $[Co(NH_2)_5CO_3]Cl$ (C) $[Co(NH_2)_5CO_2]Cl$ (D) $[Co(NH_3)_5CO_2]Cl$

21. According to the Crystal Field Theory, the energy of d_{xy} orbital is lower than $d_{x^2-y^2}$ in an octahedral complex because **[NSEC-2007]**
(A) the d_{xy} orbital near the ligands.
(B) the repulsion between the d_{xy} electrons and ligand electrons is less than that between $d_{x^2-y^2}$ and ligand electrons.
(C) the repulsion between the d_{xy} electrons and ligand electrons is more than that between $d_{x^2-y^2}$ and ligand electrons.
(D) the $d_{x^2-y^2}$ orbital is away the ligands.

22. The orbitals of iron involved in the hybrdization in $Fe(CO)_5$ are **[NSEC-2007]**
(A) s, p_x, p_y, p_z and $d_{x^2-y^2}$ (B) s, p_x, p_y, d_{z^2} and $d_{x^2-y^2}$
(C) s, px, py, pz and d_{z^2} (D) s, p_x, p_z, d_{xy} and $d_{x^2-y^2}$

23. The crystal field stabilization energy (CFSE) in $[Co(SCN)_6]^{3-}$ is : **[NSEC-2007]**
(A) 24 Δq (B) 18 Δq (C) 4 Δq (D) 0 Δq

24. How many isomers are possible for a compound with formula, $[Rh(en)_2Cl(NO_2)]$? **[NSEC-2007]**
(A) 2 (B) 4 (C) 6 (D) 8

25. Metal carbonyls have the metal ions in zero or unusually lower oxidation states. This is because : **[NSEC-2007]**
(A) carbonyl ligand is reducing in nature. (B) carbonyl is a highly electron rich ligand.
(C) carbonyl is a strongly o-bonding ligand. (D) carbonyl is a strongly p-acidic ligand.

26. Among the following, the chiral complex is : **[NSEC-2009]**
(A) $[Cr(OX)_3]^{3-}$ (B) cis-$[PtCl_2(en)]$ (C) cis-$[RhCl_2(NH_3)_4]^+$ (D) trans-$[PtCl_2(en)]$

27. The species having tetrahedral shape is : **[NSEC-2009]**
(A) $[PdCl_4]^{2-}$ (B) $[Ni(CN)_4]^{2-}$ (C) $[Pd(CN)_4]^{2-}$ (D) $[Ni(Cl)_4]^{2-}$

28. The types of isomerism shown by $Co(NH_3)_4Br_2Cl$ are : **[NSEC-2009]**
(A) Geometrical and ionization (B) Optical and ionization
(C) Geometrical and optical (D) Geometrical only

29. The formula of tetraammineaquachlorocobalt(III) chloride is : **[NSEC-2010]**
(A) $[Co(NH_2)_4(H_2O)Cl]Cl_2$ (B) $[Co(NH_2)_4(H_2O)Cl]Cl$
(C) $[Co(NH_3)_4(H_2O)Cl]Cl_2$ (D) $[Co(NH_3)_4(OH)Cl_2]\ Cl$

30. The oxidation number and co-ordination number of chromium in complex ion $[Cr(C_2O_4)_2(H_2O)_2]^-$ are **[NSEC-2010]**
(A) 3,6 (B) 2,6 (C) 2,8 (D) 3,8

31. The complex that exhibits Co-ordination isomerism is **[NSEC-2010]**
(A) $[Cr(NCS)(H_2O)_5]^{2+}$ (B) $[Cr(NH_3)_6]Cl_3$
(C) $[Cr(NH_3)_6][Co(CN)_6]$ (D) $[CoCl_2(NH_3)_4]Cl.H_2O$

32. The strong field ligand is : **[NSEC-2010]**
(A) SCN^- (B) NO_2^- (C) I^- (D) S^{2-}

33. The correct formula for hexaaminecobalt (III) nitrate is **[NSEC-2011]**
(A) $[Co_3(NH_3)](NO_3)_3$ (B) $[Co_3(NH_3)_6](NO_3)_3$ (C) $[Co(NO_3)_3].6NH_3$ (D) $[Co(NH_3)_6](NO_3)_3$

34. The IUPAC name of complex $[Cu(en)_2(H_2O)_2]^{2+}$ is **[NSEC-2011]**
(A) ethylene diamine Cu(II) dihydrate (B) diaquobis(ethylenediamine) Cu(II) ion
(C) diaquobisdiethylamine Cu(II) ion (D) diaquobis(ethylenediamine) cuprate(II)

35. The electronic spectrum of $[Ni(H_2O)_6]^{++}$ shows a band at 8500 cm^{-1} due to d-d transition. $[Ph_4As]_2[NiCl_4]$ will have such a transition in cm^{-1} at **[NSEC-2011]**
(A) 3778 (B) 8500 (C) 4250 (D) 850

36. In the coordination compound, $Na_2[Pt(CN)_4]$ the Lewis acid is **[NSEC-2011]**
(A) $[Pt(CN)_4]^{2-}$ (B) Na^+ (C) Pt^{2+} (D) CN^-

37. The 'd' orbitals will be split under square planar geometry into **[NSEC-2011]**
(A) two levels (B) three levels (C) four levels (D) five levels

38. Dimethyl glyoxime forms a square planar complex with Ni^{2+}. This complex should be: **[NSEC-2011]**
(A) diamagnetic (B) paramagnetic having 1 unpaired electron
(C) paramagnetic having 2 unpaired electrons (D) ferromagnetic

39. The formula of the isothiocyanate ion is **[NSEC-2011]**
(A) OCN^- (B) SCN^- (C) ONC^- (D) NCS^-

40. The bond order for a species with the configuration $\sigma 1s^2\ \sigma^*1s^2\ \sigma 2s^2\ \sigma^*2s^2\ \sigma\ p_x^1$ will be **[NSEC-2012]**
(A) 1 (B) $\frac{1}{2}$ (C) Zero (D) 3/2

41. Which of the following compounds has the least tendency to form hydrogen bonds between molecules? **[NSEC-2012]**
(A) NH_3 (B) H_2NOH (C) HF (D) CH_3F

42. The species in which the central atom uses sp^2 hybrid orbitals is **[NSEC-2012]**
(A) PH_3 (B) NH_3 (C) CH_3^+ (D) SbH_3

43. In which of the following ion/molecule, the 'S' atom does not assume sp^3 hybridization ? **[NSEC-2012]**
(A) SO_4^{2-} (B) SF_4 (C) SF_2 (D) S_8

44. Which of the following contain maximum number of electrons in the antibonding molecular orbitals **[NSEC-2012]**
(A) O_2^{2-} (B) O_2 (C) O_2^{-1} (D) O_2^+

45. Lattice energy for an ionic compound is calculated by using **[NSEC-2012]**
(A) Kirchoff's equation (B) Markownikoff's rule (C) Born Haber cycle (D) Carnot cycle

46. The IUPAC name of $[Co(ONO)(NH_3)_5Cl_2]$ is : **[NSEC-2012]**
(A) pentamminenitrocobalt(II)chloride (B) pentamminenitrosocobalt(III)chloride
(C) pentamminenitritocobalt(III)chloride (D) pentammineoxo-nitrocobalt(III)chloride

47. The metal carbonyl which is paramagnetic is **[NSEC-2013]**
(A) $Ni(CO)_4$ (B) $V(CO)_6$ (C) $Cr(CO)_6$ (D) $Fe(CO)_5$

48. High spin complexes having coordination number '6' are usually formed through **[NSEC-2013]**
(A) sp^3d^2 hybridisation (B) d^2sp^3 hybridisation (C) sp^3 hybridisation (D) sp^3d hybridization

49. The complex having zero crystal field stabilization energy is **[NSEC-2014]**
(A) $[Mn(H_2O)_6]^{3+}$ (B) $[Fe(H_2O)_6]^{3+}$ (C) $[Co(H_2O)_6]^{2+}$ (D) $[Co(H_2O)_6]^{3+}$

50. When any solution passes through a cation exchange resin that is in acidic form, H ion of the resin is replaced by cations of the solution. A solution containing 0.319 g of an isomer with molecular formula $CrCl_3.6H_2O$ is passed through a cation exchange resin in acidic form. The eluted solution requires 19 cm^3 of 0.125 N NaOH. The isomer is **[NSEC-2015]**
(A) triaquatrichloro chromium (III) chloride trihydrate
(B) hexaaqua chrominum (III) chloride
(C) pentaaquamonochloro chromium (III) chloride monohydrate
(D) tetraaquadichloro chromium (III) chloride dihydrate

51. A person having osteoporosis is suffering from lead poisoning. Ethylene diamine tetra acetic acid (EDTA) is administered for this condition. The best form of EDTA to be used for such administration is - **[NSEC-2015]**
(A) EDTA (B) tetrasodium salt (C) disodium salt (D) calcium dihydrogen salt

52. Four statements for the following reaction are given below **[NSEC-2015]**
$[CoCl_2(NH_3)_4]^+ + Cl^- \rightarrow [CoCl_3(NH_3)_3] + NH_3$
(i) only one isomer is produced if the reactant complex ion is a trans isomer
(ii) three isomers are produce if the reactant complex ion is a cis isomer
(iii) two isomers are produced if the reactant complex ion is a trans isomer
(iv) two isomers are produced if the reactant complex ion is cis isomer
The correct statements are
(A) I and II (B) III and IV (C) I and IV (D) II and III

53. The complex that shows optical activity is **[NSEC-2015]**
(A) *trans*-$[CoCl_2(en)_2]^+$ (B) *cis*-$[CoCl_2(en)_2]^+$
(C) *trans*-$[PtCl_2(NH_3)_2]$ (D) $[CoCl_2(NH_3)_2(en)]^+$

54. For $[FeF_6]^{3-}$ and $[CoF_6]^{3-}$, the statement that is correct is : **[NSEC-2015]**
(A) both are colored (B) both are colorless
(C) $[FeF_6]^{3-}$ is colored and $[CoF_6]^{3-}$ is colorless (D) $[FeF_6]^{3-}$ is colorless and $[CoF_6]^{3-}$ is colored

55. Which of the following statements about ammonium cerium (IV) nitrate, $(NH_4)_2[Ce(NO_3)_6]$ is **false**? **[NSEC-2016]**
(A) NO_3^- acts as a monodentate ligand. (B) The Ce atom has a coordination number of 12.
(C) The shape of the complex ion is icosahedron (D) The solution is used as oxidizing agent.

56. Which one of the following reactions is correct ? **[NSEC-2016]**
(A) $[Fe(CO)_5] + 2NO \rightarrow [Fe(CO)_2(NO)_2] + 3CO$ (B) $[Fe(CO)_5] + 2NO \rightarrow [Fe(CO)_3(NO)_2] + 2CO$
(C) $[Fe(CO)_5] + 3NO \rightarrow [Fe(CO)_2(NO)_3] + 3CO$ (D) $[Fe(CO)_5] + 3NO \rightarrow [Fe(CO)_3(NO)_3] + 2CO$

57. How many isomers are possible for complex $[Co(ox)_2Cl_2]^+$? **[NSEC-2016]**
(A) 1 (B) 3 (C) 2 (D) 4

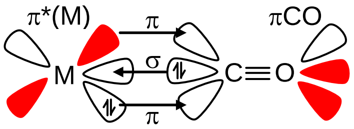
58. In which of the following complexes the metal ion has the lowest ionic radius ? **[NSEC-2016]**
(A) $[Ti(H_2O)_6]^{2+}$ (B) $[V(H_2O)_6]^{2+}$ (C) $[Cr(H_2O)_6]^{2+}$ (D) $[Mn(H_2O)_6]^{2+}$

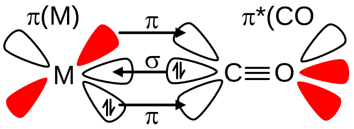
59. Which of the complex has the magnetic moment of 3.87 B.M.? **[NSEC-2016]**
(A) $[Co(NH_3)_6]^{3+}$ (B) $[CoF_6]^{3-}$
(C) $[CoCl_4]^{2-}$ (D) $[Co(dmg)_2]$ square planar complex (dmg = dimethyl glyoxime)

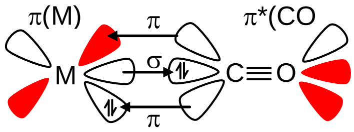
60. IUPAC name of complex ion $[CrCl_2(ox)_2]^{3-}$ is **[NSEC-2017]**
(A) dichlorodioxalatochromium (III) (B) dioxalatodichlorochromate(III)
(C) dichlorodioxalatochromate(III) (D) bisoxalaeodichlorochromate(III)

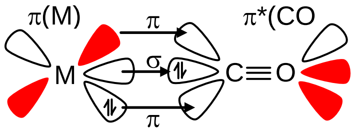
61. The type of isomerism that $Co(NH_3)_4Br_2Cl$ can exhibit is/are **[NSEC-2017]**
(A) geometric and ionisation (B) ionisation
(C) Optical and ionisation (D) Optical, ionisation and geometric

62. Metal 'M' forms a carbonly compound in which it is present in its lower valance state. Which of the following bonding is possible in this metal carbonyl ? **[NSEC-2017]**

(A)


(B)


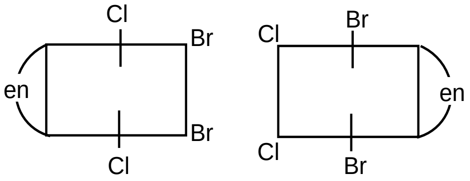
(C)


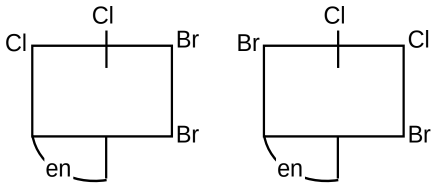
(D)


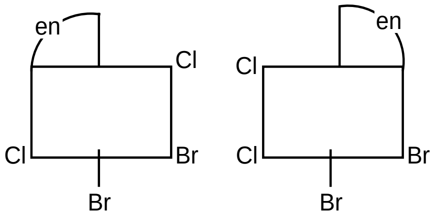
63. An appropriate reagent for the conversion of 1-propanol to 1-propanal is **[NSEC-2017]**
(A) acidified potassium dichromate
(B) alkaline potassium permanganate
(C) pyridinium chlorochromate
(D) acidified CrO_3

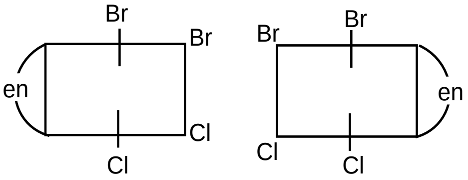
64. The complex ion that does not have d electrons in the metal atom is **[NSEC-2017]**
(A) $[MnO_4]^-$ (B) $[Co(NH_3)_6]^{3+}$ (C) $[Fe(CN)_6]^{3-}$ (D) $Cr(H_2O)_6]^{3+}$

65. The complex $[M(en)Br)_2(Cl)_2]$ has two optical isomers. Their configurations can be represented as **[NSEC-2018]**

(A)


(B)


(C)


(D)


66. The IUPAC name of the complex $[Pt(en)(NH_3)(Cl)_2(ONO)][Ag(CN)_2]$ is **[NSEC-2018]**
(A) monoamminedichlorido(ethane-1,2-diammine)nitritoplatinum(IV) dicyanoargentate(I)
(B) monoaminebischlorido(ethane-1,2-diamine)nitroplatinate(IV) dicyanosilver(I)
(C) monoaminebischlorido(ethane-1,2-diammine)nitritoplatinate(IV) dicyanoargentate(I)
(D) monoamminedichlorido(ethane-1,2-diammine)nitritoplatinum(IV) dicyanoargentate(I)

67. The C–O bond length is the shortest in : **[NSEC-2018]**
(A) $[Cr(CO)_6]$ (B) $[Mo(CO)_6]$ (C) $[Mn(CO)_6]^+$ (D) $[V(CO)_6]^-$

68. The spin-only magnetic moments of $[Fe(NH_3)_6]^{3+}$ and $[FeF_6]^{3-}$ (in units of BM) respectively are **[NSEC-2018]**
(A) 1.73 and 1.73 (B) 5.92 and 1.73 (C) 1.73 and 5.92 (D) 5.92 and 5.92

69. The alkene ligand ($\pi - C_2R_4$) is both a 'σ' donoar and a 'π' acceptor, similar to the CO ligand in metal carbonyls, and exhibits synergic bonding with metals. Correct order of C–C bond length in $K[PtCl_3(\pi\text{–}C_2R_4)]$ complexes in which R = H, F or CN is **[NSEC-2019]**
(A) H > F > CN (B) H > CN > F (C) CN > F > H (D) F > H > CN

70. The correct order of CFSE among $[Zn(NH_3)_4]^{2+}$ and $[Co(NH_3)_6]^{2+}$ and $[Co(NH_3)_6]^{3+}$ is **[NSEC-2019]**
(A) $[Co(NH_3)_6]^{3+} > [Co(NH_3)_6]^{2+} > [Zn(NH_3)_4]^{2+}$
(B) $[Zn(NH_3)_4]^{2+} > [Co(NH_3)_6]^{2+} > [Co(NH_3)_6]^{3+}$
(C) $[Co(NH_3)_6]^{3+} > [Zn(NH_3)_4]^{2+} > [Co(NH_3)_6]^{2+}$
(D) $[Co(NH_3)_6]^{2+} > [Co(NH_3)_6]^{3+} > [Zn(NH_3)_4]^{2+}$

71. The number of stereoisomers is maximum for **[NSEC-2019]**
(A) $[Co(en)_3]^{3+}$ (B) $[Co(en)_2ClBr]^+$ (C) $[Co(NH_3)_4Cl_2]^+$ (D) $[Co(NH_3)_4ClBr]^+$

72. $MnCl_2.4H_2O$ (molar mass = 198 g mol^{-1}) when dissolved in water forms a complex of Mn^{2+}. An aqueous solution containing 0.400 g of $MnCl_2.4H_2O$ was passed through a column of a cation exchange resin and the acid solution coming out was neutralized with 10 mL of 0.20 M NaOH. The formula of the complex formed is **[NSEC-2019]**

(A) $[Mn(H_2O)_4Cl_2]$ (B) $[Mn(H_2O)_6]Cl_2$ (C) $[Mn(H_2O)_5Cl]Cl$ (D) $Na[Mn(H_2O)_3Cl_3]$

73. The correct IUPAC name of the compound, $[Pt(py)_4][Pt(Br)_4]$ is **[NSEC-2019]**

(A) tetrapyridineplatinum(II) tetrabromidoplatinate(II)
(B) tetrabromidoplatinum(IV) tetrapyridineplatinate(II)
(C) tetrabromidoplatinate(II) tetrapyridineplatinum(II)
(D) tetrapyridineplatinum(IV) tetrabromidoplatinate(IV)

74. Among the following, the complex ion/s that will have a magnetic moment of 2.82 B.M. is/are **[NSEC-2019]**

I. $[Ni(CO)_4]$ II. $[NiCl_4]^{2-}$ III. $[Ni(H_2O)_6]^{2+}$ IV. $[Ni(CN)_4]^{2-}$

(A) I and IV (B) II only (C) II and III (D) II, III and IV

PART - IV : ADDITIONAL PROBLEMS

THEORY

Introduction :

(a) The concept of co-ordination compounds arises from the complex formation tendency of transition elements.

(b) These compounds play a vital role in our lives, as chlorophyll of plants, vitamin B_{12} and haemoglobin of animal blood are the co-ordination compounds of Mg, Co and Fe respectively.

(c) The co-ordination compounds play important role in analytical chemistry, polymerisation reactions, metallurgy and refining of metals, photography, water purification etc.

(d) Co-ordination compounds also find many applications in electroplating, textile dyeing and medicinal chemistry.

Addition Compounds:

They are formed by the combination of two or more stable compounds in stoichiometric ratio.

Addition Compounds

Double salts **Coordination compounds (Complexes)**

Double salts:

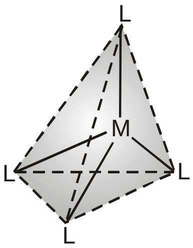
D1 Those addition compounds which lose their identity in solutions are called **double salts**. For example, when K_2SO_4 solution is added to $Al_2(SO_4)_3$ solution, the species formed when dissolved in water gives tests of K^+, Al^{3+} and SO_4^{2-} ions.

$$K_2SO_4 + Al_2(SO_4)_3 + 24H_2O \rightarrow K_2SO_4.Al_2(SO_4)_3.24H_2O\ (aq.) \xrightleftharpoons{(aq.)} 2K^+\ (aq.) + 2Al^{+3}\ (aq.) + 4SO_4^{2-}\ (aq.)$$

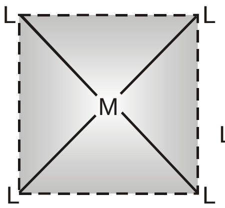
Other examples are carnallite ($KCl.\ MgCl_2.6H_2O$), Mohr's salt $[FeSO_4.(NH_4)_2SO_4.6H_2O]$,
potash alum $[KAl(SO_4)_2.12H_2O]$ or $[K_2SO_4.Al_2(SO_4)_3.24H_2O]$ etc.

D9 Coordination Polyhedron:

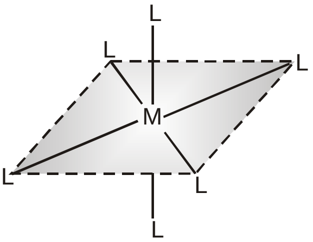
The spatial arrangement of the ligand atoms which are directly attached to the central atom/ion gives a coordination polyhedron about the central atom. Figure below shows the shapes of tetrahedral, square planar, octahedral, square pyramidal and trigonal bipyramidal coordination polyhedra. $[Co(NH_3)_6]^{3+}$ has an octahedral geometry, while $[PtCl_4]^{2-}$ and $Ni(CO)_4$, are square planar and tetrahedral, respectively.



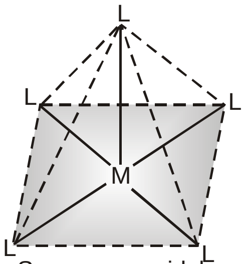
Tetrahedral entity



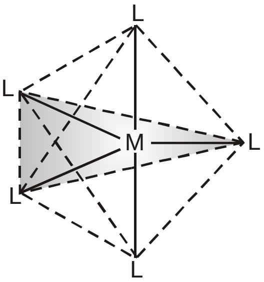
Square planar entity



Octahedral entity



Square pyramidal entity



Trigonal bipyramidal entity

Writing the name of Polynuclear Coordination Compounds:

(i) **Ist case:** The name of a bridge complex is prefixed by μ–.

If the situation on both sides of the bridge is symmetrical then we can write the name of remaining complex at one place like

$$\left[(NH_3)_5Cr-OH-Cr(NH_3)_5\right]^{5+}Cl_5$$

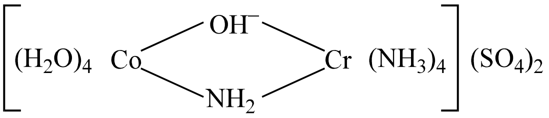
μ–Hydroxidobis(pentaamminechromium(III)) chloride

OR we could also have written the name of one side of the bridge ligand and then the name of bridge ligand and then the other side of the bridge, like

$$\left[(NH_3)_5Cr-OH-Cr(NH_3)_5\right]^{5+}Cl_5$$

Pentaamminechromium(III)–μ–hydroxidopentaamminechromium(III) chloride

(ii) **IInd case:** If the compound is unsymmetrical on both sides of the bridge then we have to follow the second rule, i.e. write the name of one side then that of the bridge and then that of the second side, like



$$\left[(H_2O)_4\,Co\overset{OH^-}{\underset{NH_2}{\rightleftharpoons}}Cr\,(NH_3)_4\right](SO_4)_2$$

Tetraaquacobalt(III)–μ–amido–μ–hydroxidotetramminechromium(III) sulphate

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SUBJECTIVE QUESTIONS

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1. What is the coordination number and the oxidation state of the metal in each of the following complexes?

(a) $[ZrF_8]^{4-}$; (b) $K_3[Cr(C_2O_4)_2Cl_2]$

2. Write the name of the following ligands and classify their denticity

(a) o-phen (b) NOS^-

3. Name the $K[PtCl_3(\eta^2\text{–}C_2H_4)]$ compound.

4. Write down the formulae of the following compounds

(a) tetraamminecobalt(III)-μ-amido-μ-hydroxidobis(ethylenediamine)cobalt(III) chloride

(b) bis(η^5-cyclopentadienyl)iron(II)

(c) tetraammineaquacobalt(III)-μ-cyanidotetraamminebromidocobalt(III)

5. Calculate the EAN of central atom in the following complexes

(a) $[Fe(CO)_2(NO)_2]$ (b) $[Fe(C_5H_5)_2]$

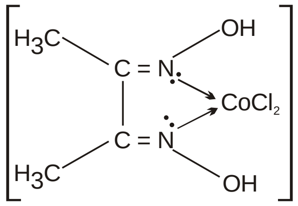
6. Complete the following table (using concepts of VBT).

	Complex	Geometry	Hybridisation	Number of unpaired electrons(n)	Mag. moment
	CN =2				
(a)	$[Ag(NH_3)_2]^+$			0	
(b)	$[Cu(CN)_2]^-$	Linear			
(c)	$[AuCl_2]^-$				0
	CN = 4				
(d)	$[PtCl_2(NH_3)_2]$			0	
(e)	$[Zn(CN)_4]^{2-}$			0	
(f)	$[Cu(CN)_4]^{3-}$			0	
(g)	$[MnBr_4]^{2-}$			5	
(h)	$[Cu(NH_3)_4]^{2+}$	Square Planar			
(i)	$[CoI_4]^{2-}$			3	
	CN = 6				
(j)	$[Mn(CN)_6]^{3-}$			2	
(k)	$[Cr(NH_3)_6]^{3+}$			3	
(l)	$[Fe(CN)_6]^{3-}$			1	
(m)	$[Ir(NH_3)_6]^{3+}$			0	
(n)	$[V(CO)_6]$			1	
(o)	$[Fe(H_2O)_6]^{2+}$			4	
(p)	$[MnCl_6]^{3-}$			4	

7. Draw the structures of the following metal carbonyls
(a) $[Co_2(CO)_8]$ (b) $[Fe_2(CO)_9]$

ONLY ONE OPTION CORRECT TYPE

8. The correct IUPAC name of the complex is :



(A) Dichloridodimethylglyoximecobalt(II) (B) Bis(dimethyglyoxime)dichloridocobalt(II)
(C) Dimethylglyoximecobalt(II) chloride (D) Dichlorido(dimethylglyoximato)cobalt(II)

9. A co-ordination complex has the formula $PtCl_4.2KCl$. Electrical conductance measurements indicate the presence of three ion in one formula unit. Treatment with $AgNO_3$ produces no precipitate of AgCl. What is the co-ordination number of Pt in this complex ?
(A) 5 (B) 6 (C) 4 (D) 3

10. Which of the following complexes produces three moles of silver chloride when its one mole is treated with excess of silver nitrate ?
(A) $[Cr(H_2O)_3Cl_3]$ (B) $[Cr(H_2O)_4Cl_2]Cl$ (C) $[Cr(H_2O)_5Cl]Cl_2$ (D) $[Cr(H_2O)_6]Cl_3$

11. The number of chloride ions which would be precipitated when one mole of the complex $PtCl_4.4NH_3$ is treated with silver nitrate is: (here coordination number of platinum is 6).
(A) four (B) one (C) three (D) two

12. A coordination compound of cobalt has the molecular formula containing five ammonia molecules, one nitro group and two chlorine atoms for one cobalt atom. One mole of this compound produces three moles of ions in an aqueous solution. The aqueous solution on treatment with an excess of $AgNO_3$ gives two moles of AgCl as a precipitate. The formula of this complex would be
(A) $[Co(NH_3)_4(NO_2)Cl]\ [(NH_3)Cl]$ (B) $[Co(NH_3)_5Cl]\ [Cl\ NO_2]$
(C) $[Co(NH_3)_5(NO_2)]Cl_2$ (D) $[Co\ (NH_3)_5]\ [(NO_2)_2Cl_2]$

13. From the stability constant (hypothetical values), given below, predict which is the most stable complex?

(A) $Cu^{2+} + 4NH_3 \longrightarrow [Cu(NH_3)_4]^{2+}$, $K = 4.5 \times 10^{11}$
(B) $Cu^{2+} + 4CN^- \longrightarrow [Cu(CN)_4]^{3-}$, $K = 2.0 \times 10^{27}$
(C) $Cu^{2+} + 2en \longrightarrow [Cu(en)_2]^{2+}$, $K = 3.0 \times 10^{15}$
(D) $Cu^{2+} + 4H_2O \longrightarrow [Cu(H_2O)_4]^{2+}$, $K = 9.5 \times 10^{8}$

14. In Ziesses salt C = C bond length is:

$$\text{Note :} \begin{Bmatrix} C-C & \text{bond} & \text{length} & \text{in} & \text{ethane} & \text{is} & 1.54\text{Å} \\ C=C & \text{bond} & \text{length} & \text{in} & \text{ethene} & \text{is} & 1.34\text{Å} \\ C\equiv C & \text{bond} & \text{length} & \text{in} & \text{ethyne} & \text{is} & 1.20\text{Å} \end{Bmatrix}$$

(A) 1.37Å (B) 1.19Å (C) 1.87Å (D) 1.34 Å

15. Which is not a π-bonded complex?
(A) Zeise's salt (B) Ferrocene
(C) bis(benzene) chromium (D) Tetraethyl lead

16. What is wrong about the compound $K [Pt (\eta^2 - C_2H_4) Cl_3]$?
(A) It is called Zeise's salt. (B) It is π bonded complex.
(C) Oxidation number of Pt is +4. (D) Four ligands surround the platinum atom.

17. Which of the following are bidentate monoanion ligands ?
(a) Dimethylglyoximato (b) Oxalato ion (c) Bis(ethane-1,2-diamine)
Select the correct answer using the codes given below :
(A) a only (B) a and c only (C) c only (D) b and c only

18. Diethylenetriamine is :
(A) chelating agent (B) tridentate neutral molecule
(C) tridentatemonoanion (D) (A) and (B) both

19. In $K_4[Fe(CN)_6]$, Fe is in the form of
(A) An atom (B) Neutral complex (C) Cationic complex (D) Anionic complex

20. Complex ion $[FeN_3(O_2)(SCN)_4]^{4-}$ is named as : (coordination number of central metal ion in complex is six)
(A) azidosuperoxidotetrathiocyanato-S-ferrate(II)
(B) azidodioxygentetrathiocyanatoferrate(III)
(C) azidoperoxidotetrathiocyanato-S-ferrate(II)
(D) azidodioxidotetrathiocyanato-S-ferrate(III)

21. The IUPAC name of $K_2[Cr(CN)_2O_2(O)_2(NH_3)]$ is :
(A) potassium amminecyanoperoxodioxochromatic(VI).
(B) potassium amminedicyanoperoxodioxochromium(VI).
(C) potassium amminecyanoperoxodioxochromium(VI).
(D) potassium amminedicyanodioxoperoxochromate(VI).

22. Consider the following statements:
According the Werner's theory.
(1) Ligands are connected to the metal ions by ionic bonds.
(2) Secondary valencies have directional properties
(3) Secondary valencies are non-ionisable
Of these statements:
(A) 1, 2 and 3 are correct (B) 2 and 3 are correct
(C) 1 and 3 are correct (D) 1 and 2 are correct

23. Which of the following is correct for both the following coordination compounds ?
(I) $CoCl_3.6NH_3$ and (II) $PtCl_4.5NH_3$
(A) They give white precipitate with $AgNO_3$ solution.
(B) They have different primary valencies for the central metal ions.
(C) Both (A) and (B)
(D) None of these

24. In the complex $[SbF_5]^{2-}$, sp^3d hybridisation is present. Geometry of the complex is :
(A) Square pyramidal (B) Square bipyramidal (C) Tetrahedral (D) Square planar

25. Crystal field stabilization energy for high spin d^4 octahedral complex is :
(A) $-0.6\ \Delta_0$ (B) $-1.8\ \Delta_0$ (C) $-1.6\ \Delta_0 + P$ (D) $-1.2\ \Delta_0$

26. $$\underset{\text{Brown}}{[(NH_3)_5Co\text{–}O\text{–}O\text{–}Co(NH_3)_5\ ]^{+4}} \xrightarrow[\text{oxidise}]{[S_2O_8]^{2-}} \underset{\text{Green}}{[(NH_3)_5Co\text{–}O\text{–}O\text{–}Co(NH_3)_5\ ]^{+5}}$$

The magnetic moment of green complex is 1.7 BM & for brown complexes magnetic moment is zero. (O–O) is same in all respect in both the complexes.
The O.S. of Co in brown complex & green complex respectively are-

(A) III III brown & IV III green (B) III II brown & III III green
(C) III III brown & III II green (D) III IV brown & III III green

27. Which one of the following will be able to show cis-trans isomerism ?
(A) Ma_3b (B) $M(AA)_2$ (C) M(AB)(CD) (D) Ma_4

28. Which of the following compounds show optical isomerism ?
1. cis - $[Co(NH_3)_4\ Cl_2]^+$
2. trans - $[Co(en)_2Cl_2]^+$
3. cis - $[Co(en)_2Cl_2]^+$
4. $[Co(en)_3]^{3+}$
Select the correct answer using the codes given below :
(A) 1 and 2 (B) 2 and 3 (C) 3 and 4 (D) 1, 3 and 4

MATCH THE COLUMN

29. Match the complexes listed in column-I with characteristic(s) / type of hybridisation listed in column-II.

	Column – I		**Column – II**
(A)	$[Co\ (en)_3]^{3+}$	(p)	sp^3d^2 hybridisaion
(B)	$[Co\ (ox)_3]^{3-}$	(q)	Diamagnetic
(C)	$[Co\ (H_2O)_6]^{2+}$	(r)	d^2sp^3 hybridisation
(D)	$[Co\ (NO_2)_6]^{3-}$	(s)	Paramagnetic
		(t)	Chelate ligand

SINGLE AND DOUBLE VALUE INTEGER TYPE

30. What is the coordination number of metal in $[M(trien)\ (dipy)]^{\pm n}$?

31. Out of the following. How many have correct IUPAC naming :
(1) $[Ni(CN)_4]^{2-}$ - Tetracyanonickel (II) ion
(2) $[Pt(Py)_4]\ [PtCl_4]$ - Tetrapyridine platinum (II) tetrachloride platinate (II)
(3) $[Ni(dmg)_2]$ - Bis(dimethylglyoximato) nickel (II)
(4) $K_3[Fe(CN)_5NO]$ - Potassium pentacyanonitrosylferrate (II)
(5) $[Fe(CO)_5]$ - Pentacyanocarbonyl Ferrate (O)
(6) $K_2[HgI_4]$ - Potassium tetraiodidomercurate (II)
(7) $[Pt(NH_3)_4]\ [CuCl_4]$ - Tetraammineplatinum (IV) tetrachlorido cuprate (II)
(8) $[Cu(gly)_2]$ - Diglycinate copper (II)
(9) $K_4[Fe(CN)_6]$ - Potassium hexacyanidoferrate (II)
(10) $[Pt(NH_3)_6]\ Cl_4$ - Hexaammine platinum (IV) chloride.

32. How many of the given complexes follow E.A.N. rule ?
(a) $[Fe(CO)_5]$ (b) $[Co_2(CO)_8]$ (c) $[Fe(C_5H_5)_2]$ (d) $K_3[Fe(CN)_6]$
(e) $[Fe(NO)_2(CO)_2]$ (f) $[CoF_6]^{4-}$

33. A name of neutral complex is :
Bis(acetyl acetanato) methylcyanidoethiocyanato-s-iron (Y)
The 'Y' is O.N. of metal then calculate sum of primary and secondary valency ?

34. $Na_2[Cr(NO)\ (NH_3)\ (C_2O_4)_2]$, u = $\sqrt{3}$ B.M., Then total no. of electrons in $d_{x^2-y^2}$ and d_{z^2} orbitals of metal :

35. If CFSE increases by 30% and 40% respectively for Co^{3+} to Rh^{3+} to Ir^{3+} , then the total increase in CFSE for Ir^{3+} with respect to Co^{3+} is ....

36. For the $[Cr(H_2O)_6]^{2+}$ ion, the mean pairing energy P is found to be 23500 cm^{-1}. The magnitude of Δ_0 is 13900 cm^{-1}. Calculate the C.F.S.E (cm^{-1}) for this complex ion corresponding to high spin state (x) and low spin state (y). Write your answer as $\left(\frac{y-x}{100}\right)$

37. The possible number of stereoisomers for the formula $[Ma_2b_2cd]^{\pm n}$.

38. A complex is prepared by mixing $CoCl_3$ & NH_3 0.1 M solution of the complex was found to freeze at –0.372ºC. Total geometrical isomers of complex are x. (Molar depression constant of water = 1.86ºC/m) Report your answer by multiplying x with 6.

39. Calculate total number of geometrical, optical and structural isomers in the compound.
$[Rh(en)_2\ (NO_2)_2]NO_3$

40. What is the EAN value of $[W(CO)_6]$.

ONE OR MORE THAN ONE OPTIONS CORRECT TYPE

41. Which of the following pairs of name and formula of complexes, is correct ?
(A) Tetramminecopper(II) sulphate............. $[Cu(NH_3)_4]SO_4$
(B) Diamminesilver(I) chloride .... $[Ag(NH_3)_2]Cl$
(C) Potassium hexacyanidoferrate (III) .... $K_4[Fe(CN)_6]$
(D) Potassium amminepentachloridoplatinate (IV) .... $K[Pt(NH_3)Cl_5]$

42. In which of the following pairs of complexes the central metals/ions do have same effective atomic number ?
(A) $[Cr(CO)_6]$ and $[Fe(CO)_5]$
(B) $[Co(NH_3)_6]^{2+}$ and $[Ni(NH_3)_6]^{2+}$
(C) $[Cu(CN)_4]^{3-}$ and $[Ni(CO)_4]$
(D) $[V(CO)_6]^-$ and $[Co(NO_2)_6]^{3-}$

43. Which of the following statements is/are correct ?
(A) $Ni(CO)_4$ —— Tetrahedral, paramagnetic
(B) $Ni(CN)_4]^{2-}$ —— Square planar, diamagnetic
(C) $Ni(dmg)_2$ —— Square planar, diamagnetic
(D) $[NiCl_4]^{2-}$ —— Tetrahedral, paramagnetic

44. Which of the following statement(s) is /are correct ?
(A) $[Co(NH_3)_6]^{3+}$, $[Co(CN)_6]^{3-}$ and $[Co(NO_2)_6]^{3-}$ are diamagnetic involving d^2sp^3 hybridisation.
(B) $[Zn(NH_3)_4]^{2+}$, $[FeCl_4]^-$ and $[Ni(CO)_4]$ are diamagnetic involving sp^3 hybridisation.
(C) The magnetic moment of $[Fe(H_2O)_6]^{3+}$ is 5.92 B.M and that of $[Fe(CN)_6]^{3-}$ is 1.73.
(D) The magnetic moment of $K_4[MnF_6]$ and $K_3[FeF_6]$ are same.

45. Consider the following statements :
S_1 : Generally square planar complexes show geometrical isomerism but do not exhibit optical isomerism because they do not possess plane of symmetry.
S_2 : $\Delta_t = \frac{4}{9}\Delta_o$
S_3 : In octahedral complexes each electron entering the t_{2g} orbitals stabilizes the complex ion by 0.4 Δ_o and each electron entering the e_g orbital destabilizes the complex by an amount of 0.6 Δ_o.
Select the correct statement from the codes given below.
(A) S_1 and S_3 are correct
(B) S_2 and S_3 are correct
(C) S_1 is incorrect
(D) S_2 and S_3 are incorrect

46. Select the correct statement(s).
(A) $[Co(EDTA)]^-$ has two optical isomers.
(B) $[Co(NH_3)_5(NO_2)]^{2+}$ show linkage isomerism.
(C) For $[Pt(NH_3)BrClI(NO_2)py]$, theoretically fifteen different geometrical isomers are possible.
(D) $[Cr(H_2O)_4Cl_2]Cl_2.2H_2O$ is an example of hydrate as well as ionisation isomerism.

47. Which of the following are π-bonded organometallic compounds ?
(A) Ferrocene
(B) Diethyl zinc
(C) Ethylmagnesium iodide
(D) Bis(benzene) chromium(0)

COMPREHENSION

Comprehension #

Double salts are addition compounds which lose their identity in aqueous solution whereas complexes which are also addition compounds do not lose their identity in aqueous solution. The coordination compounds show isomerism and find applications in photography, qualitative analysis, metallurgy, water purification and in the treatment of various diseases.

48. Which of the following statements is incorrect ?
(A) Alum is a double salt.
(B) EDTA salt of calcium is used in the treatment of lead poisoning.
(C) Effective atomic number of the metals in complexes $[Ni(CO)_4]$ and $[Fe(CN)_6]^{4-}$ is same.
(D) Chloridotris (triphenylphosphine) rhodium(I) is effective heterogeneous catalyst for hydrogenation of alkenes.

49. Which of the following statements is true for the complex, $[Co(NH_3)_4Br_2]NO_2$?
(A) It shows ionisation, linkage and geometrical isomerism.
(B) It does not show optical isomerism because its cis and trans forms each have at least one plane of symmetry.
(C) Its ionisation isomers cannot be differentiated by silver nitrate solution.
(D) (A) and (B) both.

50. Choose the correct option for the complex $[PtCl_2(en)_2]^{2+}$.
(A) Platinum is in +2 oxidation state
(B) Racemic mixture is obtained on mixing mirror images of its trans form in 1 : 1 molar ratio.
(C) It has two five membered chelating rings
(D) (B) and (C) both

PART - V : PRACTICE TEST-2 (IIT-JEE (ADVANCED Pattern))

Max. Time : 1 Hr. **Max. Marks : 66**

Important Instructions

A. General :

1. The test is of 1 hour duration.
2. The Test Booklet consists of 22 questions. The maximum marks are 66.

B. Question Paper Format

3. Each part consists of five sections.
4. Section 1 contains 7 multiple choice questions. Each question has four choices (A), (B), (C) and (D) out of which ONE is correct.
5. Section 2 contains 5 multiple choice questions. Each question has four choices (A), (B), (C) and (D) out of which ONE OR MORE THAN ONE are correct.
6. Section 3 contains 5 questions. The answer to each of the questions is a single-digit integer, ranging from 0 to 9 (both inclusive).
7. Section 4 contains 1 paragraphs each describing theory, experiment and data etc. 3 questions relate to paragraph. Each question pertaining to a partcular passage should have only one correct answer among the four given choices (A), (B), (C) and (D).
8. Section 5 contains 1 multiple choice questions. Question has two lists (list-1 : P, Q, R and S; List-2 : 1, 2, 3 and 4). The options for the correct match are provided as (A), (B), (C) and (D) out of which ONLY ONE is correct.

C. Marking Scheme

9. For each question in Section 1, 4 and 5 you will be awarded 3 marks if you darken the bubble corresponding to the correct answer and zero mark if no bubble is darkened. In all other cases, minus one (– 1) mark will be awarded.
10. For each question in Section 2, you will be awarded 3 marks. If you darken all the bubble(s) corresponding to the correct answer(s) and zero mark. If no bubbles are darkened. No negative marks will be answered for incorrect answer in this section.

11. For each question in Section 3, you will be awarded 3 marks if you darken only the bubble corresponding to the correct answer and zero mark if no bubble is darkened. No negative marks will be awarded for incorrect answer in this section.

SECTION-1 : (Only One option correct Type)

This section contains 7 multiple choice questions. Each questions has four choices (A), (B), (C) and (D) out of which Only ONE option is correct.

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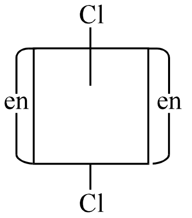
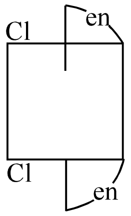
1. Given that the energy of the photons of different colours decreases in the order of **V I B G Y O R** (Violet > Indigo > Blue > Green > Yellow > Orange > Red) and that if complex absorbs a photon of low energy then it shows colour of high energy photon. If an ion, M^{2+}, forms the complexes $[M(H_2O)_6]^{2+}$, $[MBr_6]^{4-}$, and $[M(en)_3]^{2+}$. The colours of the complexes, though not necessarily in order, are green, red, and blue. Match the complexes with the appropriate colour. **(Do not use the table of complementary colours for this question)**

(A) $[MBr_6]^{4-}$ blue, $[M(H_2O)_6]^{2+}$ green , $[M(en)_3]^{2+}$ red
(B) $[MBr_6]^{4-}$ green, $[M(H_2O)_6]^{2+}$ blue , $[M(en)_3]^{2+}$ red
(C) $[MBr_6]^{4-}$ green, $[M(H_2O)_6]^{2+}$ red , $[M(en)_3]^{2+}$ blue
(D) $[MBr_6]^{4-}$ red, $[M(H_2O)_6]^{2+}$ green , $[M(en)_3]^{2+}$ blue

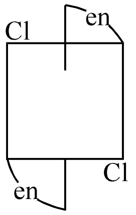
2. Which of the following pairs of structures shows geometrical isomerism ?



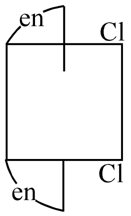
I



II



III



IV

(A) I with III (B) II with IV (C) I with II (D) none of these

3. 50 ml of 0.2 M solution of a compound with empirical formula $CoCl_3.4NH_3$ on treatment with excess of $AgNO_3(aq)$ yields 1.435 g of AgCl. Ammonia is not removed by treatment with concentrated H_2SO_4. The formula of the compound is:

(A) $[Co(NH_3)_4Cl]Cl_2$ (B) $[Co(NH_3)_4Cl_2]Cl$ (C) $[Co(NH_3)_4]Cl_3$ (D) $[CoCl_3(NH_3)_3]NH_3$

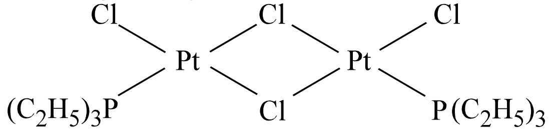
4. Which of the following statements is incorrect ?

(A) Potassium amminetetracyanidonitrosoniumchromate(I) having μ = 1.73 B.M has d^2sp^3 hybridisation.
(B) $K_3[AlF_6] + BF_3 \longrightarrow AlF_3 + 3K[BF_4]$
(C) $[Cr(NH_3)_6]Cl_3$ and $[Cu(NCCH_3)_4]$ $[BF_4]$ both are coloured .
(D) $[Cr(NH_3)_4Cl_2]Br$ can show ionisation isomerism with $[Cr(NH_3)_4ClBr]Cl$

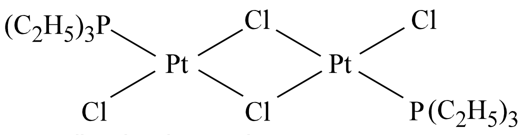
5. Which of the following statements is not true?

(A) $MnCl_4^-$ ion has tetrahedral geometry and is paramagnetic.
(B) $[Mn(CN)_6]^{2-}$ ion has octahedral geometry and is paramagnetic.
(C) $[Cu(CN)_4]^{3-}$ has square planar geometry and is diamagnetic.
(D) $[Ni(Ph_3P)_2Br_3]$ has trigonal bipyramidal geometry and is paramagnetic.

6. The complexes given below show :



and



(A) optical isomerism (B) co-ordination isomerism
(C) geometrical isomerism (D) bridged isomerism

7. Which of the following statements is correct with respect to the metal carbonyls of Ist transition series?

(A) As M–Cπ bonding increases, the C–O bond length increases.
(B) As positive charge on the central metal atom increases, the C–O bond length increases.
(C) As electron density on the central metal atom increases, the C–O bond length increases.
(D) (A) and (C) both.

Section-2 : (One or More than one options correct Type)

This section contains 5 multipole choice questions. Each questions has four choices (A), (B), (C) and (D) out of which ONE or MORE THAN ONE are correct.

8.✍ Which of the following statement(s) is/are correct ?
(A) cis-[Pt(NH_3)$_2$$Cl_2$] is used as an anticancer species.
(B) Carboxypeptidase- A is an enzyme and contains zinc.
(C) In the silver electroplating of copper, K[Ag(CN)$_2$] is used in place of $AgNO_3$.
(D) CN^- ions show the reducing as well as complexing properties towards metal species.

9. Which of the following is true for the complex Co(NO_2)(Cl)$_2$.5NH_3 (Co is in +III oxidation state) ?
(A) It shows linkage isomerism.
(B) It show ionisation isomerism.
(C) It is inner orbital complex.
(D) It is diamagnetic.

10.✍ Which of the following complexes can exist as diastereoisomers ?
(A) $[Cr(NH_3)_2Cl_4]^-$
(B) $[Co(NH_3)_5Br]^{2+}$
(C) $[FeCl_2(NCS)_2]^{2-}$
(D) $[PtCl_2Br_2]^{2-}$

11. Tetrahedral complexes are generally favoured :
(A) where the ligands are bulky
(B) when the ligands are stronger
(C) where the electronic configuration of the central metal is d^0 d^5 or d^{10} (with weak field ligands) as there is no CFSE.
(D) when the central metal ion has pseudo noble gas electron configuration, i.e. (n-1) $d^{10}ns^0np^0$.

12.✍ Which of the following statements is/are incorrect for the complex $[Cr(H_2O)_6]Cl_3$?
(A) It has a magnetic moment of 3.83 BM.
(B) The distribution of 3d electrons is $3dxy^1$, $3dyz^1$, $3dzx^1$
(C) The ligand has satisfied both primary and secondary valencies of chromium.
(D) It shows ionization as well as hydrate isomerism.

Section-3 : (One Integer Value Correct Type.)

This section contains 5 questions. Each question, when worked out will result in one integer from 0 to 9 (both inclusive)

13. In the complex $Fe(CO)_x$, the value of x is :

14.✍ Count the no. of ions which can form both low spin & high spin complexes when co-ordination no. 6
Co^{+3}, Ni^{+2}, Cr^{+3}, Fe^{+2}, Fe^{+3}, Cu^{+2}, Ti^{+3}, Co^{+2}

15. The number of unpaired electrons present in $[NiF_6]^{2-}$ is ....

16.✍ The sum of stereoisomers of complex-A, complex-B and complex-C in following reaction is ....

$$[PtCl_4]^{2-} \xrightarrow[-2Cl^-]{+2\text{ (pyridine)}} [\text{Complex-A}] \xrightarrow[-Cl^-]{+NH_3} [\text{Complex-B}] \xrightarrow[-(\text{Pyridine})]{+Br^-} [\text{Complex-C}]$$

17. The number of d-electrons in $[Cr(H_2O)_6]^{3+}$ [atomic number of Cr = 24] is :

SECTION-4 : Comprehension Type (Only One options correct)

This section contains 1 paragraphs, each describing theory, experiments, data etc. 3 questions relate to the paragraph. Each question has only one correct answer among the four given options (A), (B), (C) and (D)

Paragraph For Questions 18 to 20

The magnetic moment for two complexes of empirical formula $Ni(NH_3)_4(NO_3)_2.2H_2O$ is zero and 2.84 BM respectively. The second complex is not a neutral complex.

18. The number of water molecules of crystallization are respectively
(A) zero, two
(B) zero, zero
(C) two, zero
(D) two, two

19.✍ The correct formula and geometry of the first complex is :
(A) $[Ni(H_2O)_2(NO_3)_2].4NH_3$; tetrahedral.
(B) $[Ni(NH_3)_4](NO_3)_2.2H_2O$; tetrahedral.
(C) $[Ni(NH_3)_4](NO_3)_2.2H_2O$; square planar
(D) $[Ni(NH_3)_4](H_2O)_2](NO_3)_2$; octahedral

20.✍ Which of the following statements are true for the second complex?

(A) It has the EAN value of 36.
(B) It can show optical isomerism.
(C) It cannot show geometrical isomerism
(D) It produces three-fold freezing point depression.

SECTION-5 : Matching List Type (Only One options correct)

This section contains 1 questions, each having two matching lists. Choices for the correct combination of elements from List-I and List-II are given as options (A), (B), (C) and (D) out of which one is correct

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21. **Column-I** and **Column-II** contains four entries each. Entries of **Column-I** are to be matched with some entries of **Column-II**. One or more than one entries of **Column-I** may have the matching with the same entries of **Column-II**.

	Column-I		**Column-II**
	(Coordination compounds)		**(Type of isomerism)**
P.	$[Co(NH_3)_4Cl_2]$	1.	Optical isomerism
Q.	cis-$[Co(en)_3]Cl_2$	2.	Ionization isomerism
R.	$[Co(en)_2(NO_2)Cl]SCN$	3.	Coordination isomerism
S.	$[Co(NH_3)_6]$ $[Cr(CN)_6]$	4.	Geometrical isomerism

Code :

	P	Q	R	S		P	Q	R	S
(A)	1	3	2	4	(B)	3	2	4	1
(C)	4	3	1	2	(D)	4	1	2	3

Practice Test-2 (IIT-JEE (ADVANCED Pattern))

OBJECTIVE RESPONSE SHEET (ORS)

Que.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Ans.										
Que.	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Ans.										
Que.	**21**									
Ans.										

APSP Answers

PART – I

1.	(1)	**2.**	(4)	**3.**	(3)	**4.**	(3)	**5.**	(4)
6.	(3)	**7.**	(3)	**8.**	(3)	**9.**	(3)	**10.**	(3)
11.	(2)	**12.**	(4)	**13.**	(4)	**14.**	(3)	**15.**	(1)
16.	(2)	**17.**	(4)	**18.**	(4)	**19.**	(1)	**20.**	(4)
21.	86.00	**22.**	00.24	**23.**	02.00	**24.**	05.92	**25.**	06.00

PART - II

1.	(3)	**2.**	(4)	**3.**	(2)	**4.**	(4)	**5.**	(1)
6.	(4)	**7.**	(1)	**8.**	(4)	**9.**	(4)	**10.**	(2)
11.	(3)	**12.**	(1)	**13.**	(1)	**14.**	(2)	**15.**	(4)
16.	(2)	**17.**	(3)	**18.**	(2)	**19.**	(3)	**20.**	(4)
21.	(3)	**22.**	(1)	**23.**	(1)	**24.**	(2)	**25.**	(3)
26.	(3)	**27.**	(2)	**28.**	(3)	**29.**	(2)	**30.**	(2)
31.	(1)	**32.**	(1)	**33.**	(4)	**34.**	(4)	**35.**	(1)

PART - III

1.	(A)	**2.**	(A)	**3.**	(A)	**4.**	(D)	**5.**	(A)
6.	(D)	**7.**	(B)	**8.**	(A)	**9.**	(A)	**10.**	(A)
11.	(B)	**12.**	(B)	**13.**	(A)	**14.**	(D)	**15.**	(C)
16.	(A)	**17.**	(C)	**18.**	(B)	**19.**	(C)	**20.**	(A)
21.	(B)	**22.**	(C)	**23.**	(C)	**24.**	(C)	**25.**	(D)
26.	(A)	**27.**	(D)	**28.**	(A)	**29.**	(C)	**30.**	(A)
31.	(C)	**32.**	(B)	**33.**	(D)	**34.**	(B)	**35.**	(A)
36.	(C)	**37.**	(C)	**38.**	(A)	**39.**	(D)	**40.**	(B)
41.	(D)	**42.**	(C)	**43.**	(B)	**44.**	(A)	**45.**	(C)
46.	**(Bonus)**	**47.**	(B)	**48.**	(A)	**49.**	(B)	**50.**	(C)
51.	(D)	**52.**	(C)	**53.**	(B)	**54.**	(D)	**55.**	(A)
56.	(A)	**57.**	(B)	**58.**	(B)	**59.**	(C)	**60.**	(C)
61.	(A)	**62.**	(B)	**63.**	(C)	**64.**	(A)	**65.**	(D)
66.	(D)	**67.**	(C)	**68.**	(C)	**69.**	(C)	**70.**	(A)
71.	(B)	**72.**	(C)	**73.**	(A)	**74.**	(C)		

PART - IV

1. The coordination number of the central atom/ion is determined by the number of sigma bonds between the ligands and the central atom/ions i.e. the number of ligand donor atoms to which the metal is directly attached.

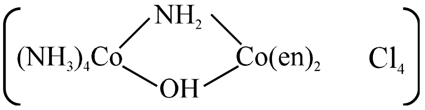
The oxidation number of the central atom is defined as the charge it would carry if all the ligands are removed along with the electron pairs that are shared with the central atom.

	Complex	**Coordination Number**	**Oxidation State**
(a)	$[ZrF_8]^{4-}$	8	4
(b)	$K_3[Cr(C_2O_4)_2Cl_2]$	6	3

2. (a) 1, 10-diaminophenanthrene, bidentate (b) thionitrito, monodentate

3. $K[PtCl_3(C_2H_4)]$ Potassium trichlorido(η^2–ethylene)platinate(II)

4. (a) Tetraamminecobalt(III)-μ-amido-μ-hydroxidobis(ethylenediamine or ethane-1,2-diamine)cobalt(III) chloride



(b) Bis(η^5-cyclopentadienyl)iron(II) $[Fe(\eta^5–C_5H_5)_2]$

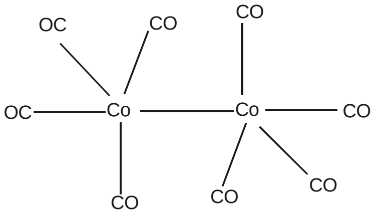
(c) Tetraammineaquacobalt(III)-μ-cyanidotetraamminebromidocobalt(III) $[(NH_3)_4(H_2O)Co–CN–Co(NH_3)_4Br]^{4+}$

5. (a) 36 (b) 36

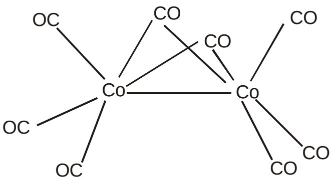
6. Complete the following table (using concepts of VBT).

	Complex	**Geometry**	**Hybridisation**	**Number of unpaired electrons(n)**	**Mag. moment**
	CN =2				
(a)	$[Ag(NH_3)_2]^+$			0	
(b)	$[Cu(CN)_2]^-$	Linear			
(c)	$[AuCl_2]^-$				0
	CN = 4				
(d)	$[PtCl_2(NH_3)_2]$			0	
(e)	$[Zn(CN)_4]^{2-}$			0	
(f)	$[Cu(CN)_4]^{3-}$			0	
(g)	$[MnBr_4]^{2-}$			5	
(h)	$[Cu(NH_3)_4]^{2+}$	Square Planar			
(i)	$[CoI_4]^{2-}$			3	
	CN = 6				
(j)	$[Mn(CN)_6]^{3-}$			2	
(k)	$[Cr(NH_3)_6]^{3+}$			3	
(l)	$[Fe(CN)_6]^{3-}$			1	
(m)	$[Ir(NH_3)_6]^{3+}$			0	
(n)	$[V(CO)_6]$			1	
(o)	$[Fe(H_2O)_6]^{2+}$			4	
(p)	$[MnCl_6]^{3-}$			4	

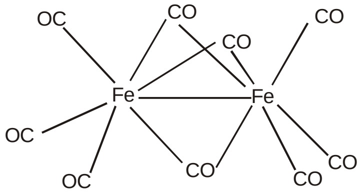
7. (a)



OR



(b)



8. (A) **9.** (B) **10.** (D) **11.** (D) **12.** (C)

13. (B) **14.** (A) **15.** (D) **16.** (C) **17.** (A)

18. (D) **19.** (D) **20.** (A) **21.** (D) **22.** (B)

23. (C) **24.** (A) **25.** (A) **26.** (A) **27.** (C)

28. (C) **29.** (A - q, r, t) ; (B - q, r, t) ; (C - p, s) ; (D - q, r). **30.** 6

31. 5 (3,4,6,9,10) **32.** 4 (a,b,c,e) **33.** 09 **34.** Zero **35.** 82

36. $\frac{1260-(-8340)}{100} = 96$ **37.** 8 **38.** 12 **39.** 15

40. 86 **41.** (ABD) **42.** (ACD) **43.** (BCD) **44.** (ACD)

45. (BC) **46.** (ABC) **47.** (AD) **48.** (D) **49.** (B)

50. (C)

PART - V

1. (A) **2.** (C) **3.** (B) **4.** (C) **5.** (C)

6. (C) **7.** (D) **8.** (ABCD) **9.** (ABCD) **10.** (AD)

11. (ACD) **12.** (CD) **13.** 5 **14.** 4 **15.** 0

16. 7 **17.** 3 **18.** (C) **19.** (C) **20.** (D)

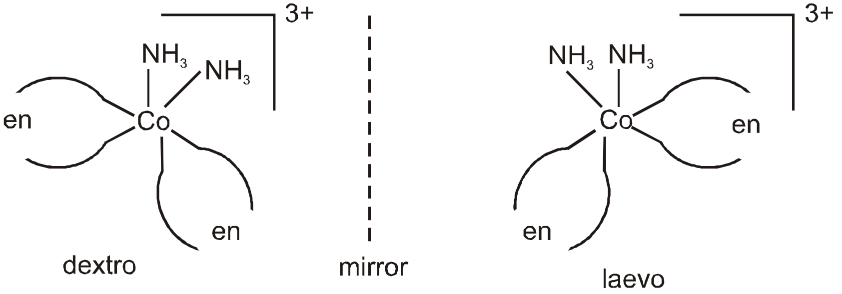
21. (D)

APSP Solutions

PART – I

2. $[Mn(H_2O)_6]^{2+} = 3 \times (-0.4) + 2 \times (0.6) = 0$
$[Cr(H_2O)_6]^{2+} = 3 \times (-0.4) + 1 \times (0.6) = 0.6\ \Delta_0$
$[Mn(H_2O)_6]^{3+} = 3 \times (-0.4) + 1 \times (0.6) = 0.6\ \Delta_0$
$[Cr(H_2O)_6]^{3+} = 3 \times (-0.4) + 0 \times (0.6) = 1.2\ \Delta_0$

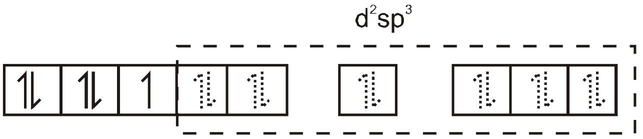
3. (1) trans-$[Co(NH_3)_4Cl_2]^+$ has plane of symmetry as well as centre of symmetry. Hence it does not show optical isomerism.
(2) $[Cr(H_2O)_6]^{3+}$ has plane of symmetry as well as centre of symmetry. Hence it does not show optical isomerism.
(3) cis-$[Co(NH_3)_2(en)_2]^{3+}$ lacks one of the symmetry elements.



(4) trans-$[Co(NH_3)_2(en)_2]^{3+}$ has plane of symmetry as well as centre of symmetry. Hence it does not show optical isomerism.

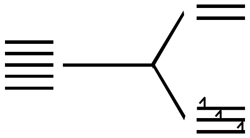
4. NO_2^- is an ambidentate ligand and can link to central metal ion either through N or O. Hence it show linkage isomerism.
There is exchange of NO_2^- and SO_4^{2-} occurs between coordination sphere and ionization sphere. Hence it shows ionisation isomerism.
Ma_5b has only one form, therefore, it does not show geometrical isomerism.
Ma_5b has mirror plane, therefore, it does not show optical isomerism.

5. $[\overset{I}{Cr}(\overset{0}{NH_3})(\overset{-4}{CN})_4(\overset{+1}{NO})]^{2-}$



Central metal ion has one unpaired electron and thus d-d transition of electron is possible. This attributes to the colour of the solution. As different types of ligands are attached to central metal ion, the complex is called heteroleptic complex.

6. **S₁ :** Cr^{3+}



CFSE = $3 \times -0.4 = -1.2\ \Delta_0$, hybridisation is d^2sp^3 (NH_3 is strong field ligand)
S₂ : Fe^{3+}, $3d^5$ - one unpaired electron after pairing (CN^- is stronger field ligand)
∴ $\mu = \sqrt{1\ \ (1+2)} \approx 1.73$ BM
S₃ : $[\overset{II}{Fe}(\overset{-5}{CN})_5\overset{+}{NO}]^{2-}$ and $[\overset{II}{Fe}(\overset{-5}{CN})_5NOS^{-1}]^{4-}$.
In reactant and product, the iron is in same oxidation state i.e. +2.

7. $[\overset{II}{Fe}(H_2O)_6]^{2+}$ n = 4 and $\mu = 4.91$
$[\overset{II}{Fe}(CN)_6]^{4-}$ n = 0 and) $\mu = 0$

8. $[Ni(H_2O)_4]SO_4$ + Pyridine + $NaNO_2 \longrightarrow [Ni(Py)_4](NO_2)_2$
Stronger ligand, pyridine displaces weaker ligand, H_2O in aqueous solution.
$[Ni(py)_4](NO_2)_2$ is formed as dark blue crystals on crystallisation.

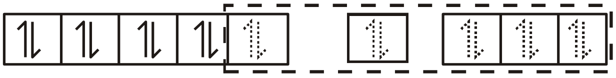
11. (1) $[Cr(NH_3)_6]^{3+}$ $[Cr(NO_2)_6]^{3-}$ and $[Cr(NH_3)_4(NO_2)_2]^{+}$ $[Cr(NH_3)_2(NO_2)_4]^{-}$ have same number of ions, so cryoscopic method can not be used.
(2) Molar conductance depends on the number of ions as well as on the charge on the complexes. $[Cr(NH_3)_6]^{3+}$ $[Cr(NO_2)_6]^{3-}$ and $[Cr(NH_3)_4(NO_2)_2]^{+}$ $[Cr(NH_3)_2(NO_2)_4]^{-}$ have same number of ions but different electrical charges.
(3) Both complexes have same number of unpaired electrons, so measuring magnetic moments methods can not be used.
(4) They have similar colour because of the similar conditions.

12. $[Fe(en)_2(H_2O)_2]^{2+} + en \longrightarrow [Fe(en)_3]^{2+} + 2H_2O$
Complex is $[Fe(en)_3]^{2+}$. 'en' is a strong field ligand and thus it is inner orbital complex (d^2sp^3) and diamagnetic.
It is $M(AA)_3$ type which has only one form.

13. (1) Cr^{3+}, $3d^3$; sp^3d^2 hybridisation with three unpaired electrons (weak field as well as strong field ligand).
Fe^{+} , $3d^7$; sp^3d^2 hybridisation with three unpaired electron (one 4s electron jumps to 3d orbital for the pairing)
(2) Mn^{2+}, $3d^5$; d^2sp^3 hybridisation with one unpaired electron after pairing (CN^- is strong field ligand).
Fe^{3+}, $3d^5$; d^2sp^3 hybridisation with one unpaired electron after pairing (CN^- is strong field ligand).
(3) Ni, $3d^84s^2$; sp^3 hybridisation and all electrons are paired because CO is strong field ligand (4s-electrons jumps to 3d-orbitals for the pairing)
Zn^{2+}, $3d^{10}$; sp^3 hybridisation and all electrons are paired.

14. In $Fe(CO)_5$, Fe in zero oxidation state and CO is stronger field ligand. So,

$Fe(CO)_5$



five dsp^3 hybrid orbitals

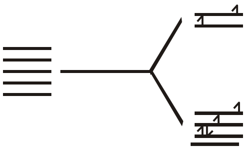
Hence it is diamagnetic and low spin complex.

15. (1) The crystal field-splitting for Cr^{3+} ion in octahedral field increases with increasing strength of ligands. This order given in (1) is according to spectrochemical series.

17. (4) Chelate complex has higher stability than the similar complexes having monodentate ligands and an higher stability means higher overall formation constant.

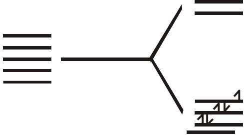
18. In $Fe(CO)_5$, Fe is dsp^3 hybridised. Hence, its structure is trigonal bipyramidal.

19. (I) $[Fe(H_2O)_6]^{2+}$, $3d^6$



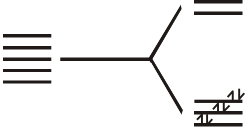
n = 4 (weak field ligand)

(II) $[Fe(CN)_6]^{3-}$, $3d^5$



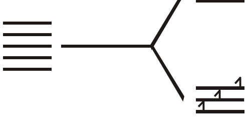
n = 1 (strong field ligand)

(III) $[Fe(CN)_6]^{4-}$, $3d^6$



n = 0 (strong field ligand)

(IV) $[Fe(H_2O)_6]^{3-}$, $3d^5$



n = 5 (weak field ligand)

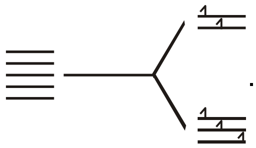
20. $[Ni(CO)_4] = sp^3$; $[Ni(CN)_4]^{2-} = dsp^2$; $[Fe(CN)_6]^{4-} = d^2sp^3$; $[MnF_6]^{4-} = sp^3d^2$.

22. $[CoCl_2(en)_2]Cl$, One mole complex contains, one mole of ionisable Cl^-.

One mole of complex = one mole of Cl^-.

$\therefore$ One mole of AgCl = One mole of complex = $\frac{100 \times 2.4}{1000}$ = 00.24.

23. Let the oxidation state of Fe is x
$4 + x - 5 - 1 = 0$
so $x = 2$

24. $[Fe(SCN)(H_2O)_5]^{2+} \xrightarrow{F^-} \underset{\text{colourless}}{[FeF_6]^{3-}}$, F^- being weak ligand Fe^{3+}—  .

Therefore, five unpaired electrons and so, $\mu = \sqrt{5\ \ (5+2)}$ B.M. ≈ 5.92.

25. Coordination number of nickel in $[Ni(C_2O_4)_3]^{4-}$ is 6 because $C_2O^{2-}{}_4$ is a bidentate ligand.

PART - II

1. Only primary valencies out side the coordination sphere are ionised and these react with $AgNO_3$ to give white precipitate of AgCl.

$[Co(NH_3)_5Cl]Cl_2 \longrightarrow [Co(NH_3)_5Cl] + 2Cl^- \xrightarrow{2AgNO_3} 2AgCl + 2NO_3^-$

2. It is a reason for given fact.

$NH_3 + H^+ \longrightarrow NH_4^+$; NH_4^+ does not act as ligand because it does not have a lone pair of electron to donate to Cu^{2+} ions to form $[Cu(NH_3)_4]^{2+}$.

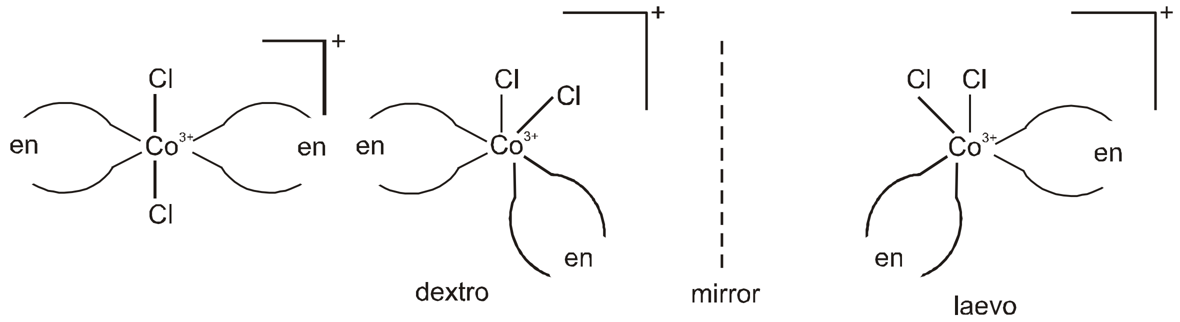
3. $4K^+[Ni(CN)_4]^{4-}$; let the oxidation state of nickel is x, then $x + 4(-1) = -4$ So, $x = 0$

4. Coordination number of a central metal atom in a complex is the number of σ-bonds between metal M and ligand L.

5. $[Ni(NH_3)_6]^{2+}$ has sp^3d^2 hybridisation having octahedral geometry as with d^8 configuration no two empty d-orbitals are available for d^2sp^3 hybridisation. As sp^3d^2 hybridisation involves nd orbital (i.e. outer orbitals), so the complex is called as outer orbital complex.

6. Chlorophyll a green pigment in plants contains Mg.

7. (1) $[Co(en)_2Cl_2]^+$ shows geometrical as well as optical isomerism. (Only cis-form but not trans form as it has one of the symmetry elements).

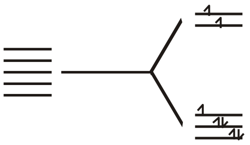


(2) It exists only in one.

(3) Exist in cis and trans forms only (no optical isomerism because of the presence of the plane of symmetry).

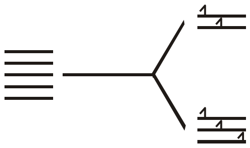
(4) Exist in cis and trans forms only (no optical isomerism because of the presence of the plane of symmetry).

8. (i) Co^{2+}, $3d^7$



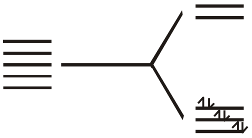
Cl^- is weak field ligand.

(ii) Mn^{2+}, $3d^5$



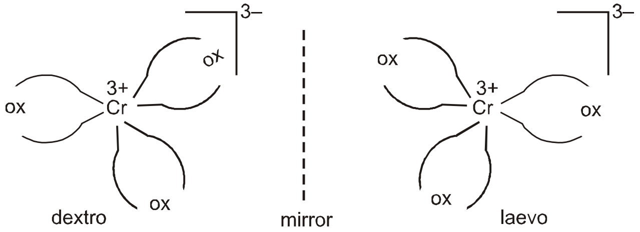
Cl^- is weak field ligand.

(iii) Fe^{2+}, $3d^6$



CN^- is strong field ligand so compels for pairing of electrons.

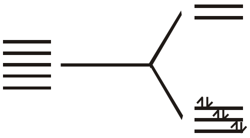
9. $[Cr(NH_3)_4Cl_2]^+$; let the oxidation state of Cr is x, then x + 4 (–0) + 2 (–1) = +1. So, x = 3



10. $3K^+ + [Fe(III)(CN)_6]^{3-}$ now follow IUPAC nomenclature.

11. (3) Due to the absence of symmetry elements it shows optical isomerism.

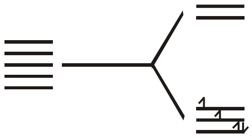
12. $[Co(CN)_6]^{3-}$; $3d^6$



n = 0

CN^- is strong field ligand; so it compels for pairing of electrons.

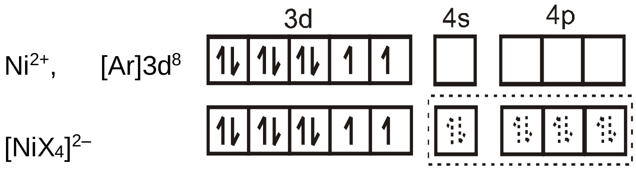
13. $3d^4$



CN^- is strong field ligand; so it compels for pairing of electrons to have two d-orbital empty.

$$\mu = \sqrt{n(n+2)} = \sqrt{2(2+2)} = 2.84 \text{ B.M}$$

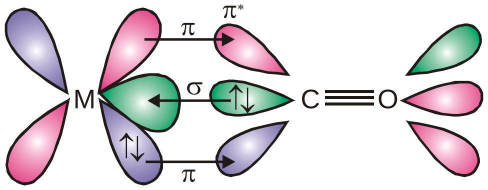
14. If X^- is weak filed then (say Cl^-) $[Ni(Cl)_4]^{2-}$ is tetrahedral (sp^3) with two unpaired electrons. If X^- is strong field ligand then (say CN^-), $[Ni(CN)_4]^{2-}$ is square planar (dsp^2) with no unpaired electrons. Also given $[NiX_4]^{2-}$ is paramagnetic. So,



sp^3 hybrid orbitals

15. $[Co(II)(NO_2)(NH_3)_5]^{2+} + 2Cl^-$ and now follow IUPAC rules.

16. Metal-carbon bond in metal carbonyls has σ as well as π characters.



17. EDTA has four carboxylate oxygens and two ammine nitrogens as donor atoms. So it is a hexadentate ligand.

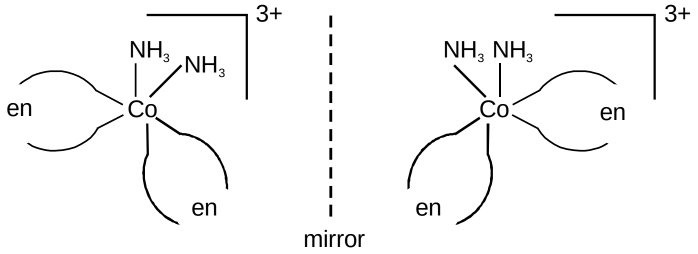
18. In 4-coordinate complex of platinum (Pt^{II}), the four ligands are arranged about the central platinum ion(II) in a square planar geometry (dsp^2) because of higher CFSE of $5d^8$ configuration.

19. Let oxidation state of E is x so $x + (-2) + 0 = +1$ or $x = +3$

Coordination number is number of σ-bonds between metal ion and ligands. 'en' and 'ox' are bidentate ligands Thus ; coordination number of E = 4 + 2 = 6.

20. CFSE depends on the relative magnitude of crystal field splitting, Δ_o and pairing energy and in turns Δ_o depends upon the field produced by ligand and charge on the metal ion. The order of increasing crystal field strength is $C_2O_4^{3-} < H_2O < NH_3 < CN^-$. Thus the (4) option is correct.

21. cis-form of $[Co(en)_2(NH_3)_2]^{3+}$ has optical isomers.



22. SCN^- ion can coordinate through the sulphur or nitrogen atom. Such possibilities give rise to linkage isomerism in coordination compounds.

M ← SCN thiocyanato or thiocyanato-S
M ← NCS isothiocyanato or thiocyanato-N

23. Mole of $CoCl_3 . 6NH_3 = \dfrac{2.675}{267.5} = 0.01$

$AgNO_3 (aq) + Cl^- (aq) \;\; AgCl \downarrow$ (white)

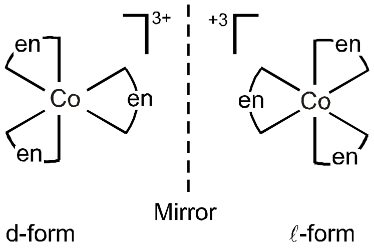
Mole of AgCl = $\dfrac{4.78}{143.5} = 0.03$

0.01 mole of $CoCl_3 . 6NH_3$ gives 0.03 mole of AgCl

∴ 1 mole of $CoCl_3 . 6NH_3$ ionises to give 3 moles of Cl^-.

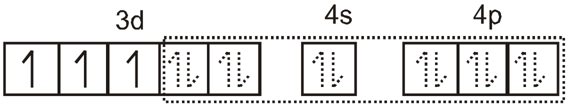
Hence the formula of compound is $[Co(NH_3)_6] Cl_3$.

24. Complex $[Co(en)_3]^{3+}$ lacks plane of symmetry and thus is optically active having following to enantiomeric forms.



25. In case of d^3 configuration, the number of unpaired electrons remains 3 whether the ligand is strong field or weak field. The hybridisation scheme can be shown as follow :

$[Cr(NH_3)_3]^{3+}$ =

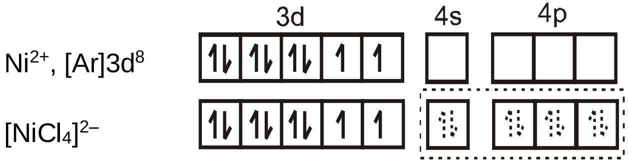


d^2sp^3 hybridisation

Hence the complex is inner orbital complex as it involves (n – 1) d orbitals for hybridisation,

$3.93 = \sqrt{n(n+2)}$; so n = 3 (here n is number of unpaired electron(s)).

26. 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.



sp^3 hybrid orbitals

$\mu_{B.M.} = \sqrt{n\ \ (n+2)} = \sqrt{2\ \ (2+2)} = \sqrt{8} = 2.82$ BM

27. $[Cr(en)_2Br_2]Br$; dibromidobis(ethylenediamine)chromium(III) Bromide.

28. $[Co(NH_3)_3Cl_3]$ show facial as well as meridional isomerism. But both contain plane of symmetry.
So, the answer is (3)

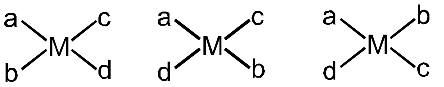
29.

	L_1	L_2	L_3	L_4
λ absorbed	red	green	yellow	blue

∴ Increasing order of energy of wavelengths absorbed reflect greater extent of crystal-field splitting, hence higher field strength of the ligand. Energy : Blue (L_4) > green (L_2) > yellow (L_3) > red (L_1)

∴ $L_4 > L_2 > L_3 > L_1$ in field strength of ligands.

30. The complex is of the type [Mabcd]
M = metal ; a, b, c, d = Monodentate ligands.



3 geometrical isomers

31. Each $[Cr(H_2O)_6]^{2+}$ and $[Fe(H_2O)_6]^{2+}$ contain 4 unpaired electron.

32. With coordination number six, if two bidentate ligands in *cis*-position are present, then it is optically active.

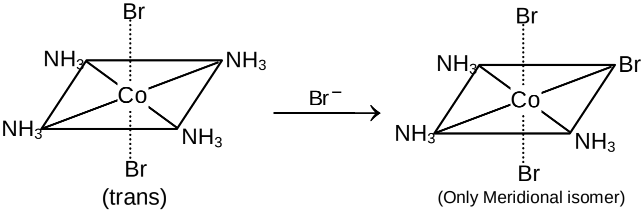
33. 10 millimoles of Complex or 0.01 mol

1.2×10^{22} ions $= \dfrac{1.2 \times 10^{22}}{6 \times 10^{23}}$ mol or 0.02 mol

$[Co(H_2O)_4Cl_2]Cl.2H_2O \xrightarrow{+AgNO_3(\text{excess})} AgCl\downarrow$
0.01 mol 0.01 mol

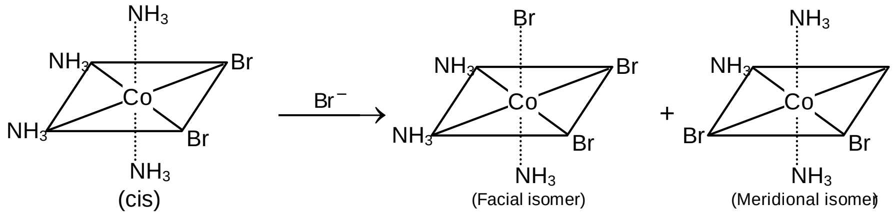
$AgCl\downarrow$ gives $0.01 \times 2 \times N_A$ ions.

34. (I & III)
$[Co(NH_3)_4Br_2]^+ + Br^- \rightarrow [Co(NH_3)_3Br_3] + NH_3$



(trans)

(Only Meridional isomer)



35. **(+3, 0, +6)**

$[Cr(H_2O)_6]Cl_3$

$x + 0 \times 6 + 3 \times (-1) = 0$ $\quad x = +3$

$[Cr(C_6H_6)_2]$

$y + 2 \times 0 = 0$ $\quad y = 0$

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

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

$z = +6$

PART - IV

5. (a) Fe(Z = 26) ; EAN = 26 + 2 + 8 = 36. (b) Fe(Z = 26) ; EAN = 26 + 10 = 36.

8. Correct name is dichloridodimethylglyoximatecobalt (II)

9. $PtCl_4.2KCl \equiv K_2[PtCl_6] \xrightleftharpoons{aq.} 2K^+ + [PtCl_6]^{2-}$.
So, it has three ions per formula unit. The Cl^- is present in coordination sphere so it will not give white precipitate with silver nitrate solution. So in the compound the coordination number of platinum is 6.

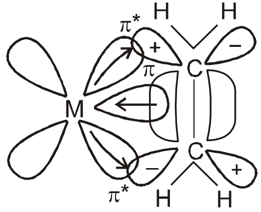
10. (D) $[Cr(H_2O)_6]Cl_3 \xrightleftharpoons{aq.} [Cr(H_2O)_6]^{3+}(aq) + 3Cl^-(aq)$.
Cl^- present in ionisation sphere will give precipitate with $AgNO_3$.
$3Cl^- + 3Ag^+ \longrightarrow 3AgCl$
So, one mole of complex will give three moles of AgCl precipitate.

11. $PtCl_4.4NH_3 \equiv [Pt(NH_3)_4Cl_2]Cl_2 \xrightleftharpoons{aq.} [Pt(NH_3)_4Cl_2]^{2+}(aq) + 2Cl^-(aq)$.
$2Ag^+ + 2Cl^- \longrightarrow 2AgCl \downarrow$ (white)
Concentrated H_2SO_4 will not dehydrate the following complex.

12. (C) $[Co(NH_3)_5(NO_2)]Cl_2 \xrightleftharpoons{aq.} [Co(NH_3)_5(NO_2)]^{2+}(aq) + 2Cl^-(aq)$ (no. of ions = 3)
$2Ag^+ + 2Cl^- \longrightarrow 2AgCl \downarrow$ (white).

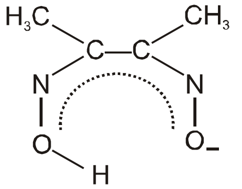
13. $K \propto$ stability.

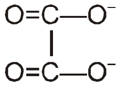
14. Relative to free ethylene the C—C bond is lengthened (from 133.77 pm to 137.5 pm). The bonding scheme is analogous to that in carbon monoxide complexes in which there is a ligand metal σ donation and a reciprocal metal to ligand π bonding.



15. $(C_2H_5)_4Pb$ is a σ-bonded complex.

16. $X + 3(-1) = 1 \therefore X = +2$.

17. (1)


(2)


(3) $NH_2CH_2CH_2NH_2$

18. Diethylenetriamine is a tridentate neutral molecules with three donor nitrogen atoms. Polydentate ligand which uses its two or more donor atoms to bind a single metal ion producing a ring is called as chelating ligand.

20. $[Fe(II)\overset{-1}{N_3}(\overset{-1}{O_2})\ (SC\overset{-4}{N})_4]^{4-}$; so correct name is azidosuperoxidotetrathiocyanato-S-ferrate(II) according to IUPAC rules.

21. $2K^+[Cr(\overset{-2}{C}N)_2\overset{-2}{O}_2(\overset{-4}{O})_2(\overset{0}{N}H_3)]^{2-}$

Oxidation state of chromium = x + 2(– 1) + (– 2) + 2(– 2) + (0) = – 2.

$\therefore$ x = + 6.

As per IUPAC name.

Complex is anionic, so metal ion will be named as chromate with +6 oxidation state. So, potassium amminedicyanodioxoperoxochromate(VI).

22. According to Werner's theory statements (2) and (3) are correct.

(1) Ligands are connected to the metal ion by coordinate covalent bond (dative bond).

(2) Secondary valencies i.e. coordination number give rise to stereochemistry of the complexes because of their directional properties.

(3) Secondary valencies correspond to coordination number i.e. number of σ-bonds between metal ion and lignds.

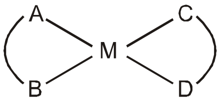
23. (I) $[Co(NH_3)_6]Cl_3 + 3Ag^+ \longrightarrow 3AgCl\downarrow + [Co(NH_3)_6]^{3+}$

$Co^{3+} \longrightarrow$ Primary valencies i.e. ionisable valency = 3.

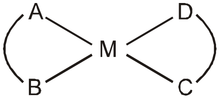
(II) $[Pt(NH_3)_5Cl]Cl_3 + 3Ag^+ \longrightarrow 3AgCl\downarrow + [Pt(NH_3)_5Cl]^{3+}$

$Pt^{4+} \longrightarrow$ Primary valencies = 4.

27. Ma_3b, Ma_4 and $M(AA)_2$ (symmetrical bidentate ligand) have only one form; they does not show geometrical isomerism. But M(AB)(CD) shows two geometrical isomerism.



ATD



ATC

28. (1) cis-$[Co(NH_3)_4Cl_2]^+$ has plane of symmetry as well as centre of symmetry; so optically inactive.

(2) trans-$[Co(en)_2Cl_2]^+$ has plane of symmetry as well as centre of symmetry; so optically inactive.

(3) cis-$[Co(en)_2Cl_2]^+$ lacks plane of symmetry as well as centre of symmetry; so optically active.

(4) $[Co(en)_3]^{3+}$ lacks axis of internal rotation; so optically active.

29. (A) $[Co(en)_3]^{3+}$; Co^{3+} has d^6 configuration which has higher CFSE; so hybridisation is d^2sp^3 and complex is diamagnetic. 'en' is a bidentate chelate ligand.

(B) $[Co(ox)_3]^{3-}$; Co^{3+} has d^6 configuration which has higher CFSE; so hybridisation is d^2sp^3 and complex is diamagnetic. 'ox' is a bidentate chelate ligand.

(C) $[Co(H_2O)_6]^{2+}$; Co^{2+} has d^7 configuration ; H_2O is a weak field monodentated ligand, so it is paramagnetic with three unpaired electrons having sp^3d^2 hybridisation.

(D) $[Co(NO_2)_6]^{3-}$; Co^{3+} has d^6 configuration which has higher CFSE; so hybridisation is d^2sp^3 and complex is diamagnetic. 'NO_2^-' is a monodentate ligand.

30. Trien (triethylene teramine) is a tetradentate Ligand while dipy (2, 2'-dipyridyl) is a Bidentate Ligand.

31. Naming of (1), (2), (5), (7) and (8) are wrong.

32. (d) $K_3[Fe(CN)_6] = 26 - 3 + 2 \times 6 = 35$ does not follow E.A.N. rule.

(f) $[CoF_6]^{4-} = 27 - 2 + 2 \times 6 = 37$ does not follow E.A.N. rule.

33. Complex $[Fe(acac)_2(NCCH_3)(SCN)]$

Y – 2 + 0 – 1 = 0

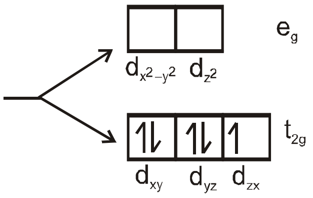
Y = +3

sec. valency = 6

sum = 3 + 6 = 9

34. In given complex, Cr is in +1 oxidation state.

$Cr^+ \Rightarrow 4s^o\, 3d^5$



($u = \sqrt{3}$ B.M.)

36. For a d^4 ion in a high spin state.
CFSE = $-0.6\,\Delta_o = -0.6 \times (13{,}900\ cm^{-1}) = -8340\ cm^{-1}$
For a d^4 ion in a low spin state, the net CFSE is,
$= -1.6\,\Delta_o + P = -1.6 \times (13{,}900\ cm^{-1}) + 23500\ cm^{-1} = +1{,}260\ cm^{-1}$
Since Δ_o (= 13,900 cm^{-1}) < P (= 23,500 cm^{-1}), the high spin configuration would be more stable.

38. $\Delta T_f = imK_f$
$0.372 = 1.86 \times 0.1 \times i$
$i = 2$
Complex is $[Co(NH_3)_4Cl_2]Cl$ octahedral with two geometrical isomers.

39.

$[Rh(en)_2(NO_2)_2]NO_3$	Linkage	Geo.	Optical
	NO_2 NO_2	Cis + trans	Cis
	NO_2 ONO	Cis + trans	Cis
	ONO ONO	Cis + trans	Cis
$[Rh(en)_2(NO_2)NO_3]NO_2$	NO_2 NO_3	Cis + trans	Cis
	ONO NO_3	Cis + trans	Cis

5 × 3 = 15 isomers.

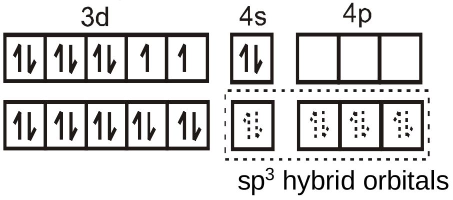
41. (C) It is not correct formula because the Fe is in +3 oxidation state and as such formula should be $[Fe^{3+}(CN)_6]^{3-}$ or $K_3[Fe(CN)_6]$.

42. (A) EAN of Cr = 24 + 12 = 36 and EAN of Fe = 26 + 10 = 36.
(B) EAN of Co^{3+} = 25 + 12 = 37 and EAN of Ni^{2+} = 26 + 12 = 38.
(C) EAN of Cu^+ = 28 + 12 = 36 and EAN of Ni = 28 + 8 = 36.
(D) EAN of V^- = 24 + 12 = 36 and EAN of Co^{3+} = 24 + 12 = 36.

43. In complex nickel is in zero oxidation state. The CO is strong field ligand and therefore compels for the pairing of electrons. The hybridisation scheme is as shown in figure.

$Ni^0([Ar]\ 3d^8\ 4s^2)$

$[Ni(CO)_4]$



Four pairs of electrons from four CO.

It is tetrahedral and as all electrons are paired so diamagnetic.

44. (A) All are diamagnetic and inner orbital complexes because all ligands are strong field ligands.
(B) Fe^{3+} n = 5 ; $\mu = \sqrt{5(5+2)} \approx 5.92$ with H_2O, so $[FeCl_4]^-$ is diamagnetic.
(C) Fe^{3+} n = 5 ; $\mu = \sqrt{5(5+2)} \approx 5.92$ with H_2O.
Fe^{3+} n = 1 ; $\mu = \sqrt{3} = 1.73$ with CN^-.
(D) Mn^{2+} ($3d^5$) and Fe^{3+} ($3d^5$) have same number of unpaired electrons i.e. 5 with weak field ligands, F^-.

45. S_1 : Square planar complexes with symmetrical ligands like (en) do not show geometrical isomerism and they have plane of symmetry, so optically inactive.
S_2 and S_3 are correct statements.

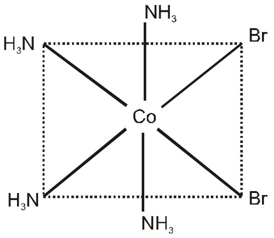
46. (A) $[Co(EDTA)]^- \longleftrightarrow$ shows optical isomerism.
(B) NO_2^- being bidentate ligands can attach to central metal ion through N or O.
(C) It is Mabcdef type and thus have fifteen different geometrical isomers.

(D) Ionisation isomerism involves exchange of different ions between coordination sphere and ionisation sphere. In complex, $[Cr(H_2O)_4Cl_2]Cl_2.2H_2O$, same anionic ligands, i.e., Cl^- are present in coordination sphere and ionisation sphere; so no exchange of ions takes place.

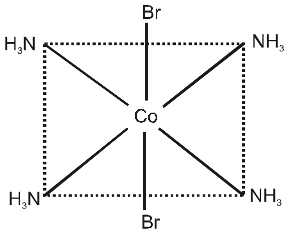
47. (A) and (D) are π-bonded organometallic compounds as they involve the formation of π-bonds between metal and carbon.
(B) and (C) are σ-bonded organometallic compounds as they only form σ bond by sharing of electrons between metal and carbon.

48. It is homogeneous catalyst for hydrogenation of alkenes.

49.



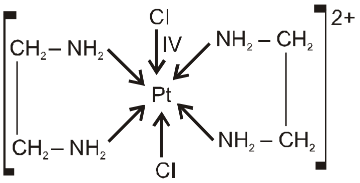
cis -



trans -

It shows geometrical isomerism but not optical isomerism due to the presence of at least one plane of symmetry.
$[Co(NH_3)_4Br_2]NO_2$ and $[Co(NH_3)_4BrNO_2]Br$ are ionisation isomers and later complex reacts with $AgNO_3$ solution to give pale yellow precipitate. $[Co(NH_3)_4BrNO_2]Br$ and $[Co(NH_3)_4BrONO]$ Br are linkage isomers.

50.



trans-form is optically inactive because it is achiral.

PART - V

1. Order of crystal field splitting en > H_2O > Br^- so, more stronger ligand will absorb lower wavelength light and reflect back higher wavelength light.

2. (A) I and III both are identical structures (i.e. trans-isomers).
(B) II and IV are identical structures (i.e. cis - isomers).
(C) I and II are cis- and trans-isomers (i.e. they are geometrical isomers).

3. Mole of complex = $50 \times 0.2 = 0.01$ and mole of AgCl = $\frac{1.435}{143.5} = 0.01$

$nAg^+ = nCl^-$ $\therefore$ 1 mole complex = 1 mole AgCl

4. (C) $[Cr(NH_3)_6]Cl_3$ is coloured as it has three unpaired electrons while $[Cu(NCCH_3)_4]$ $[BF_4]$ is colourless as Cu(I) i.e. $3d^{10}$ electron configuration has all electrons paired, so there is no d-d transition of electron.

5. (C) $[Cu(CN)_4]^{3-}$, $[Ar]^{18}3d^{10}$; As there is no empty d-orbital for dsp^2 hybridization. So it has sp^3 hybridization and is tetrahedral, and diamagnetic.

6. Geometrical isomerism arises in heteroleptic complexes due to different possible geometric arrangements of the ligands.
When two $(C_2H_5)_3P$ groups are on same side it is cis - and when those are on opposite side it is trans-

7. Order of C–O bond strength :

$$[Mn(CO)_6]^+ > [Cr(CO)_6] > [V(CO)_6]^- > [Ti(CO)_6]^{2-} \text{ and } [Ni(CO)_4] > [Co(CO)_4]^- > [Fe(CO)_4]^{2-} .$$

(A) True statement.
(B) As + ve charge on the central metal atom increases, the less readily the metal can donate electron density into the π^* orbitals of CO ligand to weaken the C–O bond.
(C) In the carbonylate anions, the metal has a greater electron density to be dispersed, with the result that M–Cπ bonding is enhanced and the C–O bond is diminished in strength.

8. All statements are correct.

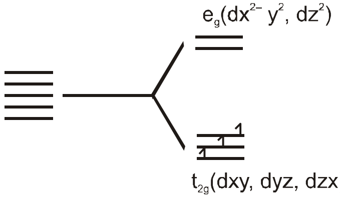
9. $[Co(NH_3)_5 (NO_2)]Cl_2$ and $[Co(NH_3)_5Cl]Cl (NO_2)$ are ionisation isomers.
$[Co(NH_3)_5 (NO_2)]Cl_2$ and $[Co(NH_3)_5 (ONO)]Cl_2$ are linkage isomers.
Cobalt in +3 oxidation state has $3d^6$ configuration which has higher CFSE. So the complex is inner orbital (i.e. d^2sp^3 hybridisation) and diamagnetic.

10. (A) Exists as cis and trans form but neither of the forms can have enantiomeric forms on account of presence of the plane of symmetry as well as centre of symmetry.
(B) Only one form possible.
(C) Tetrahedral in which all positions are adjacent to each other.
(D) Exists as cis and trans form but neither of the forms can have enantiomeric forms on account of presence of the plane of symmetry.

11. Tetrahedral complexes are favoured by steric requirements, either simple electrostatic repulsion of charge ligands or vander wall's repulsions of large one.
Tetrahedral complexes are thus generally favoured by large ligands like Cl^-, Br^-, I^- and PPh_3 and metal ions of three types ;
(1) those with a noble gas configuration such as Be^{2+} (ns^o) ;
(2) those with pseudo noble gas configuration $(n-1)d^{10}\ ns^0np^0$, such as Zn^{2+}, Cu^+ and Ga^{3+}, and
(3) those transition metal ions which do not strongly favour other structure by virtue of the CFSE, such as Co^{2+}, d^7.

12. (A) The $3d^3$ electron configuration always have three unpaired electrons with weak field as well as strong field ligands.

(B) $3d^3$



(C) H_2O being neutral molecule satisfies only secondary valencies.
(D) It shows hydrate isomerism and not ionisation isomerism because anionic ligand is not present in coordination sphere.

13. According to EAN rule
$$26 - 0 + 2x = 36$$
$$x = 5$$

14. Ni^{+2}, Cu^{+2} only high spin complex.

15. $[NiF_6]^{2-}$ oxidation number = +4
$t_{2g}^{2,2,2}\ eg^{0,0}$ (pairing occur due to high oxidation number of Ni).

16.

A	$[Pt(Py)_2Cl_2] \equiv Ma_2b_2$	(2 G.I.)
B	$[Pt(Py)_2(NH_3)Cl] \equiv Ma_2bc$	(2 G.I.)
C	$[Pt(Py)_2(NH_3)(Br)Cl] \equiv Mabcd$	(3 G.I.)

17. $3d^3 = t_{2g}^{1,1,1}\ eg^{0,0}$