Exercise-1

✍ **Marked questions are recommended for Revision.**

PART - I : SUBJECTIVE QUESTIONS

Section (A) : General introduction of complex salts and definitions to be used

A-1. K_2SO_4 solution mixed with $Cr_2(SO_4)_3$ solution in 1 : 1 molar ratio gives the test of Cr^{3+} ion but $CuSO_4$ solution mixed with aqueous ammonia in 1 : 4 molar ratio does not give the test of Cu^{2+} ion. Explain why?

A-2. What is the coordination number and the oxidation state of the metal in each of the following complexes?

(a) $[AgCl_2]^-$; (b) $[Cr(H_2O)_5Cl]^{2+}$; (c) $[Co(NCS)_4]^{2-}$
(d)✍ $[Co(NH_3)_3(NO_2)_3]$; (e)✍ $[Fe(EDTA)]^-$ (f)✍ $[Cu(en)_2]SO_4$;
(g) $K[Pt(NH_3)Cl_5]$

A-3.✍ Write the name of the following ligands and classify their denticity

(A) CH_3NC (B) $acac^{-1}$ (C) N_3^- (D) dien (E) $edta^{4-}$
(F) $edta^{3-}$ (G) ox^{2-} (H) dmg^{-1} (I) NC^- (J) NO_2^-
(K) O^{2-} (L) O_2^-

A-4. Predict the different ligating sites by drawing structures in the following ligands.

(A) $(NO_2)^-$ (B) $(SCN)^-$ (C) $(C_2O_2S_2)^{2-}$ (D) $(OCN)^-$
(E) $(NOS)^-$

A-5. **(a)** Determine the denticity of the ligands in complexes $[Fe(C_2O_4)_3]^{3-}$ and $[Pt(en)_2]^{2+}$. What are the coordination number and the oxidation number of the central metal ion?

(b) Designate the coordination entities and counter ions in the coordination compounds.
$K_2[Ni(CN)_4]$; $[Cr(en)_3]\ Cl_3$; $Fe_4[Fe(CN)_6]_3$; $[PtCl_2(en)_2]\ (NO_3)_2$.

(c) Identify the Lewis acid and Lewis base components of the following complexes.
(i) $[HgBr_4]^{2-}$ (ii) $[Ni(H_2O)_6]^{2+}$ (iii) $[PdCl_2(NH_3)_2]$
(iv) $[Al(OH)_4]^-$ (v) $[Ag(CN)_2]^-$ (vi) $[Cr(CO)_6]$

Section (B) : Nomenclature of coordination compounds

B-1. Name the following compounds

(a)✍	**$[Co(NH_3)_6]Cl_3$**	Prepared in 1798 by B.M. Tassaert and considered to be first complex salt prepared.
(b)	**$[Rh(NH_3)_5I]I_2$**	A yellow colored complex obtained by heating $[Rh(NH_3)_5(H_2O)]I_3$ above 100^0C.
(c)	**$[Fe(CO)_5]$**	A highly toxic volatile liquid.
(d)	**$[Fe(C_2O_4)_3]^{3-}$**	The ion formed when Fe_2O_3 rust is dissolved in oxalic acid, $H_2C_2O_4$.
(e)✍	**$[Cu(NH_3)_4]SO_4$**	A deep blue compound obtained when $CuSO_4$ is treated with excess of NH_3.
(f)	**$Na[Cr(OH)_4]$**	The compound formed when $Cr(OH)_3$ precipitate is dissolved in excess of NaOH.
(g)✍	**$[Co(gly)_3]$**	A complex that contains the anion of amino acid, glycine.
(h)✍	**$[Fe(H_2O)_5(SCN)]^{2+}$**	The red complex ion formed in the qualitative analysis test of Fe^{3+} ion.
(i)✍	**$K_2[HgI_4]$**	Alkaline solution of this complex is called **Nessler's Reagent.**
(j)	**$Co[Hg(SCN)_4]$**	Deep blue crystalline precipitate obtained in qualitative detection of Hg^{2+}.
(k)	**$Fe_4[Fe(CN)_6]_3$**	**Prussian blue**, deep blue colored complex obtained in detection of Fe^{2+}.
(l)	**$K_3[Co(NO_2)_6]$**	**Potassium cobaltinitrite** or **Fischer salt** yellow precipitate obtained in detection of Co^{2+}.
(m)	**$[Ni(dmg)_2]$**	Rosy red precipitate obtained in detection of Ni^{2+} ions.
(n)	**$K_2[PtCl_6]$**	Yellow precipitate obtained in detection of potassium ions.

(o)	**$Na_2[Fe(CN)_5NO^+]$**	**Sodium nitroprusside** used for detection of sulphide ions/sulphur.
(p)	**$[Fe(H_2O)_5(NO^+)]SO_4$**	Brown ring complex, obtained in detection of Fe^{+1} ions.
(q)	**$[Cu(CN)_4]^{3-}$**	Colourless stable soluble complex obtained in detection of Cu^{2+} on adding excess of KCN solution.
(r)	**$(NH_4)_2[PtCl_6]$**	Only few compounds of ammonium ions are precipitate this is one of these, a yellow precipitate.

B-2.^ Name the following compounds.

(a) $[CoBr(en)_2(ONO)]^+$
(b) $[Co(NH_3)_5(CO_3)]Cl$
(c) $[Co(en)_3]_2(SO_4)_3$
(d) $[Cr(CO)_5(PPh_3)]$
(e) $Ba[Zr(OH)_2(ONO)_2(ox)]$
(f) $[(CO)_5Mn\text{-}Mn(CO)_5]$
(g) $[Co(NH_3)_6][Co(ONO)_6]$
(h) $[Pt(NH_3)_4Cl_2][PtCl_4]$
(i) $[(NH_3)_5Co\text{-}NH_2\text{-}Co(NH_3)_4(H_2O)]Cl_5$
(j) $[Cr(\eta^6\text{–}C_6H_6)_2]$
(k) $[Co(NH_3)_4(OH_2)_2][BF_4]_3$
(l) $[Co(NH_3)_6][Co(C_2O_4)_3]$

B-3. Write down the formulae of the following compounds

(a)	Tetraamminezinc(II) Nitrate	The compound formed when zinc nitrate is treated with an excess of ammonia
(b)	Tetracarbonylnickel(0)	The first metal carbonyl(prepared in 1888) and an important compound in the industrial refining of nickel metal
(c)	Potassium amminetrichloridoplatinate(II)	A compound that contains a square planar anion
(d)	Dicyanidoaurrate(I) ion	An ion important in the extraction of gold from its ores
(e)	Sodium hexafluoridoaluminate(III)	Called cryolite, used in the electrolytic refining of aluminium
(f)	Diamminesilver(I) ion	Ion formed when AgCl is dissolved in excess of ammonia

B-4. Write down the formulae of the following compounds

(a)	diamminetriaquahydroxidochromium (III) nitrate
(b)	barium dihydroxidodinitrito-O-oxalatozirconate(IV)
(c)	dibromidotetracarbonyliron (II)
(d)	ammonium diamminetetrakis(isothiocyanato)chromate(III).
(e)	pentaamminedinitrogenruthenium(II) chloride
(f)	tetrakis(pyridine)platinum(II) tetraphenylborate(III)
(g)	tetrapyridineplatinum(II) tetrachloridonickelate(II)

Section (C) : Werner's Theory

(Initial bonding theories and EAN rule)

C-1. Werner conducted many experiments to establish the formula of complexes, one of these were conductivity measurements. On the basis of the experiments performed he obtained the following values of conductivity for different type of complexes.

Type of complex	**Electrical Conductivity**
Nonelectrolyte	0 – 10 (due to impurities)
1:1 Electrolyte	90 – 130
1:2 or 2:1 Electrolyte	230 – 290
1:3 or 3:1 Electrolyte	390 – 450
1:4 Electrolyte	500 – 550

On the basis of above table Match the following two columns.

	COLUMN A		**COLUMN B**
	Formula of compound	**Conductivity**	**Correct Werner's Representation**
(a)	$PtCl_4.2NH_3$	6.99	(i) $[Cr(NH_3)_5Cl]Cl_2$
(b)	$PtCl_4.NH_3.KCl$	106.8	(ii) $[Co(NH_3)_5Br]Br_2$
(c)	$CrCl_3.5NH_3$	260.2	(iii) $[Cr(NH_3)_6]Cl_3$
(d)	$PtCl_4.2KCl$	256.8	(iv) $[Pt(NH_3)_2Cl_4]$
(e)	$CrCl_3.6NH_3$	441.7	(v) $[Pt(NH_3)_6]Cl_4$
(f)	$PtCl_4.6NH_3$	522.9	(vi) $[Pt(NH_3)_3Cl_3]Cl$
(g)	$CoBr_3.5NH_3$	257.6	(vii) $K_2[PtCl_6]$
(h)	$PtCl_4.3NH_3$	96.8	(viii) $K[Pt(NH_3)Cl_5]$

C-2. 1 g of complex $[Cr(H_2O)_5Cl]Cl_2.H_2O$ was passed through a cation exchanger to produce HCl. The acid liberated was diluted to 1 litre. What will be the molarity of acid solution
[Molecular weight of complex = 266.5] ?

C-3.✍ Calculate the EAN of central atom in the following complexes
(a) $[Cr(CO)_6]$ (b) $[Fe(CN)_6]^{4-}$ (c) $[Fe(CO)_5]$ (d) $[Co(NH_3)_6]^{3+}$
(e) $[Ni(CO)_4]$ (f) $[Cu(CN)_4]^{3-}$ (g) $[Pd(NH_3)_6]^{4+}$ (h) $[PtCl_6]^{2-}$

C-4.✍ Arrange the following compounds in order of increasing molar conductivity.
(i) $K[Co(NH_3)_2(NO_2)_4]$ (ii) $[Cr(NH_3)_3(NO_2)_3]$ (iii) $[Cr(NH_3)_5(NO_2)]_3[Co(NO_2)_6]_2$ (iv) $[Cr(NH_3)_6]Cl_3$

Section (D) : Valence Bond Theory + Crystal Field Theory (Part-I)

D-1.✍ A metal complex having composition $Cr(NH_3)_4Cl_2Br$ has been isolated in two forms A and B. The form A reacts with $AgNO_3$ to give a white precipitate readily soluble in dilute aqueous ammonia, whereas B gives a yellow precipitate soluble in concentrated ammonia.
(i) Write the formulae of A and B.
(ii) State hybridisation of chromium in each.
(iii) Calculate their magnetic moments for each (spin-only value).
(iv) Calculate the EAN for both.
(v) Will they conduct electricity or not.
(vi) Write the formula of the complexes formed when the precipitates dissolve in aqueous ammonia & the concentrated ammonia respectively.

D-2. Predict the hybridisation and geometry of the following complexes.
(a) $[NiBr_4]^{2-}$ (b) $[AuCl_4]^{-}$ (c) $[Pt(NH_3)_4]^{2+}$

Section (E) : Valence Bond Theory + Crystal Field Theory (Part-II)

E-1. For the complex $K_2[Cr(NO)(NH_3)(CN)_4]$; $\mu = 1.73$ BM.
(i) Write IUPAC name.
(ii) What will be structure?
(iii) How many unpaired electrons are present in the central metal ion?
(iv) Is it paramagnetic or diamagnetic?
(v) Calculate the EAN of the complex.
(vi)What will be the hybridisation of the complex?

E-2.✍ Predict the hybridisation and geometry of the following complexes.
(a) $[Fe(CN)_6]^{3-}$ (b) $[MnBr_4]^{2-}$ (c) $[Fe(H_2O)_6]^{2+}$ (d) $[Co(SCN)_4]^{2-}$

E-3. $[Co(NH_3)_6]^{3+}$ & $[CoF_6]^{3-}$ both are complexes of Co(III), but $[Co(NH_3)_6]^{3+}$ is diamagnetic while $[CoF_6]^{3-}$ is paramagnetic with $\mu = 4.90$ B.M. Explain.

E-4.✍ Arrange the following in increasing order as directed.
(a) (i) $[CoCl_3(NH_3)_3]$, (ii) $[CoCl(NH_3)_5]Cl_2$, (iii) $[Co(NH_3)_6]Cl_3$, (iv) $[CoCl_2(NH_3)_4]Cl$ - Molar conductance
(b) C, N, O, F (halogen) - tendency of σ donation.
(c) Br^-, S^{2-}, NO_2^-, CO, H_2O, CN^-, NH_3, NO_3^- - strength of ligands.

E-5. For each of the following complexes, draw a crystal field energy-level diagram, assign the electrons to orbitals, and predict the number of unpaired electrons:

(a) $[CrF_6]^{3-}$ (b) $[V(H_2O)_6]^{3+}$ (c) $[Fe(CN)_6]^{3-}$
(d) $[Cu(en)_3]^{2+}$ (e) $[FeF_6]^{3-}$

Section (F) : Applications of crystal field theory
(Magnetic moment of complex, Colour of complex, Limitation, Stability of complex)

F-1. Cobalt (II) is stable in aqueous solution but in the presence of complexing reagents(strong field ligands) it is readily oxidised. why ?

F-2. The value of Δ_0 for $[Ti(H_2O)_6]^{3+}$ is found to be 240 kJ mol^{-1} then predict the colour of the complex using the following table. Give the number corresponding to the colour.
($h = 6 \times 10^{-34}$ J-sec, $N_A = 6 \times 10^{23}$, $c = 3 \times 10^8$ m/sec)

Absorbed light	**λ (nm) (absorbed)**	**Colour exhibited**
Blue	435 – 480	1. Yellow
green-blue	480 – 490	2. Orange
blue-green	490 – 500	3. Red
Green	500 – 560	4. purple
yellow-green	560 – 580	5. violet
Yellow	580 – 595	6. blue
Red	605 – 700	7. blue green

F-3. (a) $[Ti(H_2O)_6]^{3+}$ absorbs light of wavelength 5000 Å. Name one ligand which would form a titanium(III) complex absorbing light of lower wavelength than 5000 Å and one ligand which would form a complex absorbing light of wavelength higher than 5000 Å.
(b) Calculate the magnetic moments (spin only) of the following complexes
(i) $[PtCl_6]^{2-}$ (ii) $[Cr(CO)_6]$ (iii) $[Ir(NH_3)_6]^{3+}$ (iv) $[Pd(en)_2]^{2+}$

Section (G) : Isomerism in Coordination compounds
(Structural Isomerism, Stereoisomerism, Geometrical Isomerism, Optical Isomerism)

G-1. What type of isomers are the following :

(i) $[Mn(CO)_5SCN]$ and $[Mn(CO)_5NCS]$
(ii) $[Co(en)_3]\ [Cr(CN)_6]$ and $[Cr(en)_3]\ [Co(CN)_6]$
(iii) $[Co(NH_3)_5\ NO_3]SO_4$ and $[Co(NH_3)_5SO_4]NO_3$
(iv) $[Co(H_2O)_2Cl_2\ (py)_2]Cl$ and $[Co(H_2O)Cl_3\ (py)_2]H_2O$

G-2.✍ (a) Draw all possible constitutional isomers of the compound $Ru(NH_3)_5(NO_2)Cl$. Label the isomers as linkage isomers or ionization isomers.
(b) There are six possible isomers for a square planar palladium(II) complex that contains two NH_3 and two SCN^- ligands. Sketch the structures of all six, and label them according to the classification.

G-3. How many geometrical isomers are possible for each of the following complexes?

(a) $[Pt(NH_3)_2(SCN)_2]$ (b) $[CoCl_2Br_2]^{2-}$ (tetrahedral)
(c) $[Co(NH_3)_3\ (NO_2)_3]$ (d) $[Pt(en)Cl_2]$
(e) $[Cr\ Br_2\ (en)_2]^+$ (f) $[Rh(en)_3]^{3+}$

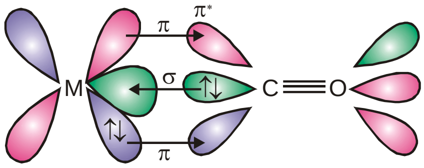
G-4.✍ Which of the following complexes can exist as enantiomers? Draw their structures

(a) cis-$[Co(NH_3)_4Br_2]^+$ (b) cis-$[Cr(H_2O)_2(en)_2]^{3+}$ (c) $[Cr(gly)_3]$
(d) $[Cr(en)_3]^{3+}$ (e) cis-$[Co(NH_3)Cl(en)_2]^{2+}$ (f) trans-$[Co(NH_3)_2(en)_2]^{2+}$

Section (H) : Organometallic Compounds

H-1. Draw the structures of the following metal carbonyls

(a) $[V(CO)_6]$ (b) $[Cr(CO)_6]$ (c) $[Mn_2(CO)_{10}]$
(d) $[Fe(CO)_5]$ (e) $[Ni(CO)_4]$

H-2. 

The figure represents the synergic bonding interaction in metal carbonyl complex. On the basis of this explain the following :
(i) Strength of Metal-ligand bond
(ii) Bond order of CO in carbonyl complex as compared to bond order in carbon monoxide.

PART - II : ONLY ONE OPTION CORRECT TYPE

Section (A) : General introduction of complex salts and definitions to be used

A-1. Ethylene diamine is an example of a .... ligand :
(A) monodentate (B) bidentate (C) tridentate (D) hexadentate

A-2. The donor sites of $(EDTA)^{4-}$ are ?
(A) O atoms only (B) N atoms only
(C) Two N atoms and four O atoms (D) Three N atoms and three O atoms

A-3. Some salts although containing two different metallic elements give test for one of them in solution. Such salts are :
(A) complex salt (B) double salt (C) normal salt (D) none

A-4. Ligands are :
(A) Lewis acids (B) Lewis bases (C) neutral (D) none

A-5. The oxidation state of Mo in its oxido-complex species $[Mo_2O_4(C_2H_4)_2(H_2O)_2]^{2-}$ is
(A) +2 (B) +3 (C) +4 (D) +5

A-6. Co-ordination number of platinum in $[Pt(NH_3)_4Cl_2]^{2+}$ ion is:
(A) 4 (B) 2 (C) 8 (D) 6

A-7. Which of the following is copper(I) compound ?
(A) $[Cu(H_2O)_4]^{2+}$ (B) $[Cu(CN)_4]^{3-}$ (C) $[Cu(NH_3)_4]^{2+}$ (D) All of these

A-8. In the complex $[CoCl_2(en)_2]Br$, the co-ordination number and oxidation state of cobalt are :
(A) 6 and +3 (B) 3 and +3 (C) 4 and +2 (D) 6 and +1

A-9. What is the charge on the complex $[Cr(C_2O_4)_2(H_2O)_2]$ formed by Cr(III) ?
(A) +3 (B) +1 (C) +2 (D) –1

Section (B) : Nomenclature of coordination compounds

B-1. A complex cation is formed by Pt (in some oxidation state) with ligands (in proper number so that coordination number of Pt becomes six). Which of the following can be its correct IUPAC name ?
(A) Diammineethylenediaminedithiocyanato-S-platinum (II) ion
(B) Diammineethylenediaminedithiocyanato-S-platinate (IV) ion
(C) Diammineethylenediaminedithiocyanato-S-platinum (IV) ion
(D) Diamminebis (ethylenediamine) dithiocyanate-S- platinum (IV) ion

B-2. Which of the following names is impossible ?
(A) Potassium tetrafluoridooxidochromate (VI) (B) Barium tetrafluoridobromate (III)
(C) Dichlorobis(urea)copper (II) (D) All are impossible.

B-3. The formula of the complex tris(ethylenediamine)cobalt(III) sulphate is :
(A) $[Co(en)_2SO_4]$ (B) $[Co(en)_3SO_4]$ (C) $[Co(en)_3]_2SO_4$ (D) $[Co(en)_3]_2(SO_4)_3$

B-4. The correct IUPAC name for the compound $[Co(NH_3)_4Cl(ONO)]Cl$ is :
(A) Tetraamminechloridonitrito–N–cobalt(III) chloride
(B) Chloridonitrito–O–tetraamminecobalt(II) chloride
(C) Dichloridonitrito–O–tetraamminecobalt(III)
(D) Tetraamminechloridonitrito–O–cobalt(III) chloride

B-5. The hypothetical complex triamminediaquachloridocobalt(III) chloride can be represented as :
(A) $[CoCl(NH_3)_3(H_2O)_2]$ (B) $[Co(NH_3)_3(H_2O)Cl_3]$
(C) $[Co(NH_3)_3(H_2O)_2Cl]Cl_2$ (D) $[Co(NH_3)_3(H_2O)_3]Cl_3$]

Section (C) : Werner's Theory
(Initial bonding theories and EAN rule)

C-1. EAN of a metal carbonyl $M(CO)_x$ is 36. If atomic number of metal M is 26, what is the value of x?
(A) 4 (B) 8 (C) 5 (D) 6

C-2. The EAN of platinum in potassium hexachloridoplatinate(IV) is (Atomic number of Pt = 78) :
(A) 90 (B) 86 (C) 76 (D) 88

C-3. A compound is made by mixing cobalt (III) nitrite and potassium nitrite solutions in the ratio of 1 : 3. The aqueous solution of the compound showed 4 particles per molecule whereas molar conductivityreveals the presence of six electrical charges. The formula of the compound is :
(A) $Co(NO_2)_3.2KNO_2$ (B) $Co(NO_2)_3.3KNO_2$ (C) $K_3[Co(NO_2)_6]$ (D) $K[Co(NO_2)_4]$

C-4. Which of the following will exhibit maximum ionic conductivity?
(A) K_4 $[Fe(CN_6]$ (B) $[Co(NH_3)_6]$ Cl_3 (C) $[Cu(NH_3)_4]$ Cl_2 (D) $[Ni (CO)_4]$

C-5. Which of the following shows maximum molar conductance?
(A) $[Co(NH_3)_6]Cl_3$ (B) $[Co(NH_3)_3Cl_3]$ (C) $[Co(NH_3)_4\,Cl_2]$ Cl (D) $[Co(NH_3)_5Cl]Cl_2$

C-6. The complex $[Cr(H_2O)_4Br_2]Cl$ gives the test for :
(A) Br^- (B) Cl^- (C) Cr^{3+} (D) Br^- and Cl^- both

C-7. Which of the following complexes will be dehydrated to relatively minimum extent by conc. H_2SO_4 under identical condition.
(A) $[Cr(H_2O)_5Cl]Cl_2.H_2O$ (B) $[Cr(H_2O)_4Cl_2]Cl.2H_2O$
(C) $[Cr(H_2O)_6]Cl_3$ (D) all of these

C-8. On adding $AgNO_3$ solution to a solution of $[Pt(NH_3)_3Cl_3]Cl$, the percentage of total chloride ion precipitated is:
(A) 100 (B) 75 (C) 50 (D) 25

C-9. A complex of platinum, ammonia and chloride produces four ions per molecule in the solution. The structure consistent with the observation is:
(A) $[Pt(NH_3)_4]Cl_4$ (B) $[Pt(NH_3)_2Cl_4]$ (C) $[Pt(NH_3)_5Cl]Cl_3$ (D) $[Pt(NH_3)_4Cl_2]Cl_2$

Section (D) : Valence Bond Theory + Crystal Field Theory (Part-I)

D-1. The complex ion which has no. 'd' electrons in the central metal atom is :
(A) $[MnO_4]^-$ (B) $[Co(NH_3)_6]^{3+}$ (C) $[Fe(CN)_6]^{3-}$ (D) $[Cr(H_2O)_6]^{3+}$

D-2. For the correct assignment of electronic configuration of a complex, the valence bond theory often requires the measurement of
(A) molar conductance (B) optical activity
(C) magnetic moment (D) dipole moment

D-3. The magnitude of crystal field stabilisation energy (CFSE of Δ_1) in tetrahedral complexes is considerably less than that in the octahedral field. Because
(A) There are only four ligands instead of six so the ligand fild is only 2/3 in tetradedral complex
(B) 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
(C) Both points (A) and (B) are correct
(D) Both points (A) and (B) are wrong

D-4. The crystal field splitting energy for octahedral complex (Δ_o) and that for tetrahedral complex (Δ_t) are related as:
(A) $\Delta_t = \frac{4}{9}\Delta_0$ (B) $\Delta_t = 0.5\,\Delta_o$ (C) $\Delta_t = 0.33\,\Delta_o$ (D) $\Delta_t = \frac{9}{4}\Delta_0$

D-5. All the metal ions contains $t_{2g}^6\, e_g^0$ configurations. Which of the following complex will be paramagnetic?
(A) $[FeCl(CN)_4(O_2)]^{4-}$ (B) $K_4[Fe(CN)_6]$ (C) $[Co(NH_3)_6]Cl_3$ (D) $[Fe(CN)_5(O_2)]^{-5}$

Section (E) : Valence Bond Theory + Crystal Field Theory (Part-II)

E-1. Chromium hexacarbonyl is an octahedral compound involving :
(A) sp^3d^2 (B) dsp^2 (C) d^2sp^3 (D) dsp^3

E-2. Which of the following molecules is not tetrahedral?
(A) $[Pt(en)_2]^{2+}$ (B) $[Ni(CO)_4]$ (C) $[Zn(NH_3)_4]^{2+}$ (D) $[NiCl_4]^{2-}$

E-3.✍ The complex $[Pt(NH_3)_4]^{2+}$ has ..... structure :
(A) square planar (B) tetrahedral (C) pyramidal (D) pentagonal

E-4.✍ Match Column-I with Column-II and select the correct answer with respect to hybridisation using the codes given below :

	Column - I		**Column - II**
	(Complex)		**(Hybridisation)**
(I)	$[Au\,F_4]^-$	(p)	dsp^2 hybridisation
(II)	$[Cu(CN)_4]^{3-}$	(q)	sp^3 hybridisation
(III)	$[Co(C_2O_4)_3]^{3-}$	(r)	sp^3d^2 hybridisation
(IV)	$[Fe(H_2O)_5NO]^{2+}$	(s)	d^2sp^3 hybridisation

Codes :

	(I)	(II)	(III)	(IV)		(I)	(II)	(III)	(IV)
(A)	q	p	r	s	(B)	p	q	s	r
(C)	p	q	r	s	(D)	q	p	s	r

E-5. The hybridisation and unpaired electrons in $[Fe(H_2O)_6]^{2+}]$ ion are :
(A) sp^3d^2 ; 4 (B) d^2sp^3 ; 3 (C) d^2sp^3 ; 4 (D) $sp^3\,d^2$; 2

E-6. The number of unpaired electrons in d^6, low spin, octahedral complex is :
(A) 4 (B) 2 (C) 1 (D) 0

E-7. Which of the following is a high spin complex ?
(A) $[Co(NH_3)_6]^{3+}$ (B) $[Fe(CN)_6]^{4-}$ (C) $[Ni(CN)_4]^{2-}$ (D) $[FeF_6]^{3-}$

E-8.✍ Which has maximum paramagnetic nature ?
(A) $[Cu(H_2O)_4]^{2+}$ (B) $[Cu(NH_3)_4]^{2+}$ (C) $[Mn(H_2O)_6]^{2+}$ (D) $[Fe(CN)_6]^{4-}$

E-9. The number of unpaired electrons present in complex ion $[FeF_6]^{3-}$ is :
(A) 5 (B) 4 (C) 6 (D) 0

E-10. Which of the following complexes has a geometry different from others ?
(A) $[Ni\,Cl_4]^{2-}$ (B) $Ni\,(CO)_4$ (C) $[Ni(CN)_4]^{2-}$ (D) $[Zn(NH_3)_4]^{2+}$

E-11. Select the correct statement.
(A) Complex ion $[MoCl_6]^{3-}$ is paramagnetic. (B) Complex ion $[Co(en)_3]^{3+}$ is diamagnetic.
(C) Both (A) and (B) are correct. (D) None of correct.

E-12.✍ Amongst $Ni(CO)_4$, $[Ni(CN)_4]^{2-}$ and $NiCl_4^{2-}$:
(A) $Ni(CO)_4$ and $NiCl_4^{2-}$ are diamagnetic and $[Ni(CN)_4]^{2-}$ is paramagnetic.
(B) $NiCl_4^{2-}$ and $[Ni(CN)_4]^{2-}$ are diamagnetic and $Ni(CO)_4$ is paramagnetic.
(C) $Ni(CO)_4$ and $[Ni(CN)_4]^{2-}$ are diamagnetic and $NiCl_4^{2-}$ is paramagnetic.
(D) $Ni(CO)_4$ is diamagnetic and $NiCl_4^{2-}$ and $[Ni(CN)_4]^{2-}$ are paramagnetic.

Section (F) : Applications of crystal field theory
(Magnetic moment of complex, Colour of complex, Limitation, Stability of complex)

F-1. The compound which does not show paramagnetism ?
(A) $[Cu(NH_3)_4Cl_2]$ (B) $[Ag(NH_3)_2]Cl$ (C) NO (D) NO_2

F-2. Among the following ions, which one has the highest paramagnetism ?
(A) $[Cr(H_2O)_6]^{3+}$ (B) $[Fe(H_2O)_6]^{2+}$ (C) $[Cu(H_2O)_6]^{2+}$ (D) $[Zn(H_2O)_6]^{2+}$

F-3. Which of the following factors tends to increase the stability of metal ion complexes ?
(A) Higher ionic radius of the metal ion (B) Higher charge/size ratio of the metal ion
(C) Lower ionisation potential of the metal ion (D) Lower basicity of the ligand

Section (G) : Isomerism in Coordination compounds

(Structural Isomerism, Stereoisomerism, Geometrical Isomerism, Optical Isomerism)

G-1. The complexes $[Pt(NH_3)_4]\ [PtCl_6]$ and $[Pt(NH_3)_4Cl_2]\ [PtCl_4]$ are :
(A) linkage isomers (B) optical isomers
(C) co-ordination isomers (D) ionisation isomers

G-2.✍ $[Co(NH_3)_5NO_2]Cl_2$ and $[Co(NH_3)_5ONO]Cl_2$ are related to each other as :
(A) geometrical isomers (B) linkage isomers
(C) coordination isomers (D) ionisation isomers

G-3. The number of geometrical isomer of $[Co(NH_3)_3(NO_3)_3]$ are :
(A) 0 (B) 2 (C) 3 (D) 4

G-4. Geometrical isomerism is found in coordination compounds having coordination number :
(A) 2 (B) 3 (C) 4 (tetrahedral) (D) 6

G-5.✍ Cis-trans isomerism is found in square planar complexes of molecular formula ('a' and 'b' are monodentate ligands) :
(A) Ma_4 (B) Ma_3b (C) Ma_2b_2 (D) Mab_3

G-6. Geometrical isomerism can be shown by :
(A) $[Ag(NH_3)(CN)]$ (B) $Na_2[Cd(NO_2)_4]$ (C) $[PtCl_4I_2]$ (D) $[Pt(NH_3)_3Cl][Au(CN)_4]$

Section (H) : Organometallic Compounds

H-1. Which one is not an organometallic compound ?
(A) RMgX (B) $(C_2H_5)_4Pb$ (C) $(CH_3)_4Sn$ (D) C_2H_5ONa

H-2. Formula of ferrocene is:
(A) $[Fe(CN)_6]^{4-}$ (B) $[Fe(CN)_6]^{3+}$ (C) $[Fe(CO)_5]$ (D) $[Fe(C_5H_5)_2]$

PART - III : MATCH THE COLUMN

1.✍

	Column-I		**Column-II**
(A)	$[Fe(en)_3]^{3+}$	(p)	d^2sp^3 hybridisation of central metal
(B)	$[Co(ox)_3]^{3-}$	(q)	sp^3d^2 hybridisation of central metal
(C)	$[Cr(CN)_6]^{3-}$	(r)	paramagnetic
(D)	$[NiCl_6]^{4-}$	(s)	diamagnetic
		(t)	metal ion has +3 oxidation state

2. There are some coordination compounds given in column-I which may exist in different isomeric forms as given in column-II. Select the correct option(s) for the coordination compounds and their respective isomeric forms.

	Column-I		**Column-II**
(A)	$[Co(en)_2NH_3Cl]SO_4$	(p)	Enantiomer
(B)	$[Co(NH_3)_4(NO_2)_2](NO_3)_2$	(q)	Geometrical isomer
(C)	$[Co(en)(pn)(NO_2)_2]Cl$	(r)	Ionization isomer
(D)	$[Co(gly)_3]$	(s)	Linkage isomer

Exercise-2

✍ **Marked questions are recommended for Revision.**

PART - I : ONLY ONE OPTION CORRECT TYPE

1. A complex anion is formed by Osmium (in some oxidation state) with ligands (in proper number so that coordination number of osmium becomes six). Which of the following can be its correct IUPAC name?
(A) pentachloridonitridoosmium(VI) (B) pentachloridonitridoosmate(VI)
(C) azidopentachloridoosmate(VI) (D) None of these

2. The EAN of metal atoms in $[Fe(CO)_2(NO^+)_2]$ and $Co_2(CO)_8$ respectively are :
(A) 34, 35 (B) 34, 36 (C) 36, 36 (D) 36, 35

3. Which of the following is inner orbital complex as well as diamagnetic in nature ?
(A) $[Ir(H_2O)_6]^{3+}$ (B) $[Ni(NH_3)_6]^{2+}$ (C) $[Cr(NH_3)_6]^{3+}$ (D) $[Co(NH_3)_6]^{2+}$

4. Which of the following statement is correct ?
(A) The oxidation state of iron in sodium nitro prusside $Na_2[Fe(CN)_5(NO))]$ is +3
(B) $[Ag(NH_3)_2]^+$ is linear in shape
(C) In $[Fe(H_2O)_6]^{3+}$, Fe is d^2sp^3 hybridized
(D) In Ni $(CO)_4$, the oxidation state of Ni is 1

5.✍ The complex $K_4[Zn(CN)_4(O_2)_2]$ is oxidised into $K_2[Zn(CN)_4(O_2)_2]$, then which of the following is correct ?
(A) Zn(II) is oxidised into Zn(IV) (B) Paramagnetic moment decreases
(C) O–O bond length increases (D) Paramagnetic moment increases

6. All the following complexes show decrease in their weights when placed in a magnetic balance then the group of complexes having tetrahedral geometry is :
I $Ni(CO)_4$ II $K[AgF_4]$ III $Na_2[Zn(CN)_4]$
IV $K_2[PtCl_4]$ V $[RhCl(PPh_3)_3]$
(A) II, III, V (B) I, II, III (C) I, III, IV (D) none of these

7.✍ The complex $[Fe(H_2O)_5NO]^{2+}$ is formed in the brown ring test for nitrates when freshly prepared $FeSO_4$ solution is added to aqueous solution of NO_3^- ions followed by addition of conc. H_2SO_4. Select correct statement about this complex.
(A) Hybridisation of iron is sp^3d^2.
(B) Iron has +1 oxidation state.
(C) It has magnetic moment of 3.87 B.M. confirming three unpaired electrons in Fe.
(D) All the above are correct statements.

8. Which of the following statements is not correct?
(A) $TiCl_4$ is a colourless compound. (B) $[Cr(NH_3)_6)]Cl_3$ is a coloured compound.
(C) $K_3[VF_6]$ is a colourless compound. (D) $[Cu(NCCH_3)_4][BF_4]$ is a colourless compound.

9. Among TiF_6^{2-} , CoF_6^{3-} , Cu_2Cl_2 and $NiCl_4^{2-}$ the colourless species are:
(A) CoF_6^{3-} and $NiCl_4^{2-}$ (B) TiF_6^{2-} and CoF_6^{3-} (C) $NiCl_4^{2-}$ and Cu_2Cl_2 (D) TiF_6^{2-} and Cu_2Cl_2

10. The number of geometrical isomers for octahedral $[Co(NH_3)_2Cl_4]^-$, square planar $AuCl_2Br_2^-$ are :
(A) 4, 2 (B) 2, 2 (C) 3, 2 (D) 2, 3

11.✍ Which of the following statements is not true about the complex ion $[Pt(en)_2Cl_2]^{2+}$?
(A) It has two geometrical isomers – cis and trans.
(B) Both the cis and trans isomers display optical activity.
(C) Only the cis isomer displays optical activity.
(D) Only the cis isomer has non–superimposable mirror image.

12. Both geometrical and optical isomerism are shown by :
(A) $[Co(en)_2Cl_2]^+$ (B) $[Co(NH_3)_5Cl]^{2+}$ (C) $[Co(NH_3)_4Cl_2]^+$ (D) $[Cr(OX)_3]^{3-}$

13. Among the following, metal carbonyls, the C–O bond is strongest :
(A) $[Mn(CO)_6]^+$ (B) $[Cr(CO)_6]$ (C) $[V(CO)_6]^-$ (D) $[Ti(CO)_6]^{2-}$

PART - II : SINGLE AND DOUBLE VALUE INTEGER TYPE

1. Sum of denticity of following ligands are
Glycinate ion, Oxalate ion, o-phenathroline, 2,2-bipyridyl, diethylenetriamine, ethylenediamine

2. How many total sodium ions are present in one formula unit of sodium ethane-1,2-diaminetetraacetatochromate(II) and sodium hexanitrito cobaltate(III) ?

3.✍ A blue colour complex is obtained in the analysis of Fe^{+3} having formula $Fe_4[Fe(CN)_6]_3$
Let a = oxidation number of Iron in the coordination sphere
b = no. of secondary valencies of central iron ion.
c = Effective atomic number of Iron in the coordination sphere.
Then find the value of (c + a – 2b)

4.✍ Coordination number of Cr in $CrCl_3.5H_2O$ as six. The possible volumes of 1 M Ag NO_3 needed to precipitate the chlorine inoutersphere in 200 ml of 0.1 M solution of the complex is/are.
Write your answer as $V_1 + V_2 + V_3 + ...$

5. Ni^{+2} form a complex ion in water having the formula $[Ni(H_2O)_6]^{+2}$. How many of the following statements are true for the complex ion ?
(i) The complex is octahedral in shape.
(ii) The complex is diamagnetic in nature.
(iii) Ni^{+2} has incompletely filled 3d subshell.
(iv) Secondary valency of Ni^{+2} is 6.
(v) All the bonds (metal-ligand) are perpendicular to each other.
(vi) All the 3d orbitals of Ni^{+2} are degenerate
(vii) Total spin of the complex is 1.
(viii) The hybridisation of Ni^{+2} is d^2sp^3
(ix) The complex is more stable than $[Ni(en)_3]^{+2}$
(x) Effective atomic number of Ni^{+2} is 36.

6. How many of the following is correctly matched complex ?

	Complex	Oxidation no. on central metal	Electronic configuration
(a)	$K_3[Co(C_2O_4)_3]$	+3	t_{2g}^6
(b)	$(NH_4)_2\ [CoF_4]$	+2	$t_{2g}^5\ e_g^2$
(c)	Cis - $[Cr(en)_2Cl_2]Cl$	+3	$t_{2g}^3\ e_g^0$
(d)	$[Mn(H_2O)_6]SO_4$	+2	$t_{2g}^3\ e_g^2$

7.^✍ Total number of paramagnetic complexes which are inner orbital complexes :
(i) $[Cr(NH_3)_6]Cl_3$
(ii) $[Co(NH_3)_6](NO_3)_2$
(iii) $[Ni(NH_3)_6]SO_4$
(iv) $K_2[PtCl_6]$,
(v) $[V(H_2O)_6]SO_4$
(vi) $[Fe(H_2O)_5\ (NO)]SO_4$
(vii) $K_3[CuCl_4]$
(viii) $Na_4[Fe(CN)_5(NOS)]$

8. The number of coordination isomers possible for $[Fe(NH_3)_6]^{3+}\ [Cr(C_2O_4)_3]^{3-}$ is _______

9. Find the sum of number of geometrical isomers for following complexes.
(a) $[CoCl_2Br_2]^{2-}$
(b) $[Rh(en)_3]^{3+}$
(c) $[Cr(en)_2\ Br_2]^+$
(d) [Pt en Cl_2]
(e) $[Co(NH_3)_3(NO_2)_3]$

10.✍ What is the sum of bond order of Fe–C bond and C–O bond in $Fe(CO)_5$?

11. How many isomeric forms are possible for the octahedral complex, $[Rh(en)_2(NO_2)(SCN)]^+$?

PART - III : ONE OR MORE THAN ONE OPTIONS CORRECT TYPE

1. Which of the following statement(s) are incorrect ?
(A) Those additional compounds which lose their identity in solution are called double salts.
(B) In $K_3[Fe(CN)_6]$ Fe^{2+} and CN^- ion can give quantitative identification test.
(C) $[KAl(SO_4)_2.12H_2O]$ is a coordination compound.
(D) All acids are lewis acids and σ donors.

2. The effective atomic number of $Co(CO)_4$ is 35 and hence is less stable. It attains stability by
(A) oxidation of Co
(B) reduction of Co
(C) dimerization
(D) none

3. Select the correct statements ;
(A) Potassium ferrocyanide and potassium ferricyanide can be differentiated by measuring the solid state magnetic moment.
(B) The complex $[Co(NH_3)_5Br]SO_4$ and $[Co(NH_3)_5SO_4]Br$ can be differentiated by adding aqueous solution of barium chloride
(C) The complex $[Co(NH_3)_5Cl]Br$ and $[Co(NH_3)_5Br]Cl$ can be differentiated by adding aqueous solution of silver nitrate.
(D) the complex $[Co(NH_3)_6]Cl_3$ and $[Co(NH_3)_5Cl]Cl_2$ can be differentiated by measuring molar conductance

4. Consider the following statements :
S_1 : $[MnCl_6]^{3-}$, $[FeF_6]^{3-}$ and $[CoF_6]^{3-}$ are paramagnetic having four, five and four unpaired electrons respectively.
S_2 : Low value of formation constant of a complex indicates its high thermodynamic stability.
S_3 : The crystal field splitting Δ_o, depends upon the field produced by the ligand and charge on the metal ion.
and arrange in the order of true/ false.

5. Which of the following is/are correctly matched ?
(A) $[Ni(CO)_4]$ - dsp^2 and diamagnetic.
(B) $[Ni(en)_3](NO_2)_2$ - sp^3d^2 and two unpaired electrons.
(C) $[V(NH_3)_6]Cl_3$- sp^3d^2 and two unpaired electrons.
(D) $[Mn(NO^+)_3(CO)]$ - sp^3 and diamagnetic.

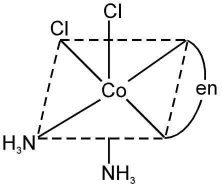
6. Which of the following statement(s) is/are correct with respect to the crystal field theory ?
(A) It considers only the metal ion d–orbitals and gives no consideration at all to other metal orbitals.
(B) It cannot account for the π bonding in complexes.
(C) The ligands are point charges which are either ions or neutral molecules
(D) The magnetic properties can be explained in terms of splitting of d- orbitals in different crystal field.

7. 'Spin only' magnetic moment of Ni in $[Ni(dmg)_2]$ is same as that found in :
(A) Ni in $[NiCl_2(PPh_3)_2]$
(B) Mn in $[MnO_4]^-$
(C) Co in $[CoBr_4]^{2-}$
(D) Pt in $[Pt(H_2O)_2Br_2]$

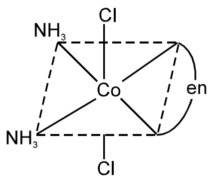
8.^ Which complex of the following pairs has the larger value of Δ_0 ?
(i) $[Co(CN)_6]^{3-}$ and $[Co(NH_3)_6]^{3+}$
(ii) $[Co(H_2O)_6]^{3+}$ and $[Co(H_2O)_6]^{2+}$
(iii) $[Co(H_2O)_6]^{3+}$ and $[Rh(H_2O)_6]^{3+}$
(iv) $[Co(NH_3)_6]^{3+}$ and $[CoF_6]^{3-}$
Select the correct one
(A) $[Co(CN)_6]^{3-} > [Co(NH_3)_6]^{3+}$
(B) $[Co(H_2O)_6]^{2+} < [Co(H_2O)_6]^{3+}$
(C) $[Co(H_2O)_6]^{3+} > [Rh(H_2O)_6]^{3+}$
(D) $[Co(NH_3)_6]^{3+} < [CoF_6]^{3-}$

9. Which of the following isomerisms is/are shown by the complex $[CoCl_2(OH_2)_2(NH_3)_2]Br$?
(A) Ionization (B) Linkage (C) Geometrical (D) optical

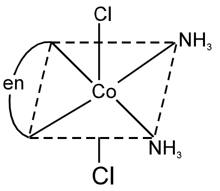
10. Three arrangements are shown for the complex $[Co(en)(NH_3)_2Cl_2]^+$. Pick up the wrong statement.



(I)



(II)



(III)

(A) I and II are geometrical isomers
(B) II and III are optical isomers
(C) I and III are optical isomers
(D) II and III are geometrical isomers

11. Consider the following complexies $[V(CO)_6]^-$, $[Cr(CO)_6]$ and $[Mn(CO)_6]^+$. Then incorrect statement (s) about metal carbonyls is /are.
(A) 'C–O' bond is strongest in the cation and weakest in the anion
(B) 'C–O' bond order is less in the cation than in anion.
(C) 'C–O' bond longer in the cation than in anion or neutral carbonyl.
(D) 'M–C' bond order is higher in the cation than in anionic or neutral carbonyl.

12. Following Sidwick's rule of EAN, $Co(CO)_x$ will be :
(A) $Co_2(CO)_4$ (B) $Co_2(CO)_3$ (C) $Co_2(CO)_8$ (D) $Co_2(CO)_{10}$

PART - IV : COMPREHENSION

Read the following passage carefully and answer the questions.

Comprehension # 1

In coordination chemistry there are a variety of methods applied to find out the structure of complexes. One method involves treating the complex with known reagents and from the nature of reaction, the formula of the complex can be predicted. An isomer of the complex $Co(en)_2(H_2O)Cl_2Br$, on reaction with concentrated H_2SO_4 (dehydrating agent) it suffers loss in weight and on reaction with $AgNO_3$ solution it gives a white precipitate which is soluble in NH_3 (aq).

1. The **correct** formula of the complex is :
(A) $[CoClBr(en)_2]H_2O$ (B) $[CoCl(en)_2(H_2O)]BrCl$
(C) $[Co\,Br(en)_2(H_2O)]Cl_2$ (D) $[CoBrCl(en)_2]Cl.H_2O$

2. If all the ligands in the coordination sphere of the above complex be replaced by F^-, then the magnetic moment of the complex ion (due to spin only) wll be :
(A) 2.8 BM (B) 5.9 BM (C) 4.9 BM (D) 1.73 BM

3.✍ Similarly if all the ligands in the coordination sphere be replaced by NO_2^-, then the magnetic moment of the complex ion (due to spin only) will be :
(A) 1.73 BM (B) 0.0 BM (C) 4.9 BM (D) 5.9 BM

4. If one mole of original complex is treated with excess $Pb(NO_3)_2$ solution, then the number of moles of white precipitate (of $PbCl_2$) formed will be :
(A) 0.5 (B) 1.0 (C) 0.0 (D) 3.0

5. The number of geometrical isomers of the formula of the above original complex are (including the complex):
(A) 2 (B) 3 (C) 4 (D) 1

Comprehension # 2

Co^{2+} (aq.) + SCN^- (aq.) $\longrightarrow$ Complex (X).
Ni^{2+} (aq.) + Dimethylglyoxime $\xrightarrow{NH_4OH}$ Complex (Y).
The corrdination number of cobalt and nickel in complexes X and Y are four.

6.✍ The IUPAC names of the complexes (X) and (Y) are respectively :
(A) tetrathiocyanato-S-cobalt(II) and bis(dimethylglyoximate) nickel(II).
(B) tetrathiocyanato-S-cobaltate (II) and bis(dimethylglyoximato)nickel (II).
(C) tetrathiocyanato-S-cobaltate (II) and bis(dimethylglyoximato)nickelate(II).
(D) tetrathiocyanato-S-cobaltate(III) and bis(dimethylglyoximato)nickel(II).

7.✍ The geometry of complexes (X) and (Y) are respectively :
(A) tetrahedral and square planar. (B) both tetrahedral.
(C) square planar and tetrahedral (D) both square planar.

8.✍ Select the correct statement for the complexes (X) and (Y).
(A) (X) is paramagnetic with two unpaired electrons.
(B) (Y) is diamagnetic and shows intermolecular H-bonding.
(C) (X) is paramagnetic with three unpaired electrons and (Y) is diamagnetic.
(D) (X) and (Y) both are diamagnetic.

Comprehension # 3

Q.9, Q.10 and Q.11 by appropriately matching the information given in the three columns of the following table.

Let us consider following columns		
Column 1	**Column 2**	**Column 3**
μ (in B.M.)	Hybridisation state	No. of geometrical isomers
(I) μ = 2.83 B.M.	(i) sp^3	(P) 2
(II) μ = 5.93 B.M.	(ii) sp^3d^2	(Q) 3
(III) μ = 3.88 B.M.	(iii) d^2sp^3	(R) 4
(IV) μ = 0 B.M.	(iv) dsp^2	(S) 5

[**Note :** Atomic Number of Cr = 24, V = 23, Pt = 78)]

9. About ($CrCl_3(NH_3)_3$) which of following combination is correct ?
(A) (III), (iii), P (B) (II), (iv), Q (C) (IV), (i), R (D) (I), (ii), S

10. Correct combination for $[VCl_2(NO_2)_2(NH_3)_2]^-$.
(A) (II), (i), P (B) (I), (iii), S (C) (III), (ii), R (D) (IV), (iv), Q

11. Correct combination for $[PtCl_2(NH_3)_2]$ is :
(A) (II), (iii), Q (B) (I), (iv), S (C) (IV), (iv), P (D) (III), (ii), R

Exercise-3

*** Marked Questions may have more than one correct option.**

PART - I : JEE (ADVANCED) / IIT-JEE PROBLEMS (PREVIOUS YEARS)

1. A green complex, $K_2[Cr(NO)(NH_3)(CN)_4]$ is paramagnetic and has μ_{eff} = 1.73 BM. Write the IUPAC name of the complex and draw the structure of anion and find out the hybridisation of metal ion. **[JEE 2003, 4/60]**

2. The species having tetrahedral shape is : **[JEE 2004, 3/84]**
(A) $[PdCl_4]^{2-}$ (B) $[Ni(CN)_4]^{2-}$ (C) $[Pd(CN)_4]^{2-}$ (D) $[NiCl_4]^{2-}$

3. The spin magnetic moment of cobalt in the compound, Hg $[Co(SCN)_4]$ is : **[JEE 2004, 3/84]**
(A) $\sqrt{3}$ (B) $\sqrt{8}$ (C) $\sqrt{15}$ (D) $\sqrt{24}$

4. When dimethyl glyoxime is added to the aqueous solution of nickel(II) chloride in presence of dilute ammonia solution, a bright red coloured precipitate is obtained. **[JEE 2004, 4/60]**
(a) Draw the structure of bright red substance.
(b) Write the oxidation state of nickel in the substance and hybridisation.
(c) State whether the substance is paramagnetic or diamagnetic.

5. Which kind of isomerism is exhibited by octahedral $[Co(NH_3)_4Br_2]Cl$? **[JEE 2005, 3/84]**
(A) Geometrical and ionization (B) Geometrical and optical
(C) Optical and ionization (D) Geometrical only

6. The bond length in CO is 1.128 Å. What will be the bond length of CO in $Fe(CO)_5$? **[JEE 2006, 5/184]**
(A) 1.158 Å (B) 1.128 Å (C) 1.178 Å (D) 1.118 Å

Comprehension # (Q.7 to Q.9)

$NiCl_2 \xrightarrow[HCN]{KCN}$ complex A

$NiCl_2 \xrightarrow[excess]{KCl}$ complex B

A & B complexes have the co-ordination number 4.

7. The IUPAC name of complexes 'A' & 'B' are respectively : **[JEE 2006, 5/184]**

(A) Potassium tetracyanonickelate(II) and Potassium tetrachloronickelate(II)
(B) Potassium tetracyanonickel(II) and Potassium tetrachloronickel(II)
(C) Potassium cyanonickelate(II) and Potassium chloronickelate(II)
(D) Potassium cyanonickel(II) and Potassium chloronickel(II)

8. The hybridisation of both complexes are : **[JEE 2006, 5/184]**

(A) dsp^2 (B) sp^2 & dsp^2 (C) dsp^2 & sp^3 (D) both sp^3

9. What are the magnetic nature of 'A' & 'B' ? **[JEE 2006, 5/184]**

(A) Both diamagnetic.
(B) 'A' is diamagnetic & 'B' is paramagnetic with one unpaired electrons.
(C) 'A' is diamagnetic & 'B' is paramagnetic with two unpaired electrons.
(D) Both are paramagnetic.

10. Among the following metal carbonyls, the C–O bond order is lowest in : **[JEE 2007, 3/162]**

(A) $[Mn(CO)_6]^+$ (B) $[V(CO)_6]^-$ (C) $[Cr(CO)_6)]$ (D) $[Fe(CO)_5]$

11. Match the complexes in Column-I with their properties listed in Column-II. **[JEE 2007, 6/162]**

	Column-I		**Column-II**
(A)	$[Co(NH_3)_4(H_2O)_2]Cl_2$	(p)	Geometrical isomers
(B)	$[Pt(NH_3)_2Cl_2]$	(q)	Paramagnetic
(C)	$[Co(H_2O)_5Cl]Cl$	(r)	Diamagnetic
(D)	$[Ni(H_2O)_6]Cl_2$	(s)	Metal ion with +2 oxidation state

12. The IUPAC name of $[Ni(NH_3)_4]$ $[NiCl_4]$ is : **[JEE 2008, 3/163]**

(A) Tetrachloronickel(II) tetraamminenickel (II)
(B) Tetraamminenickel(II) tetrachloronickel (II)
(C) Tetraamminenickel(II) tetrachloronickelate (II)
(D) Tetraamminenickel(II) tetrachloronickelate (0)

13. Both $[Ni(CO)_4]$ and $[Ni(CN)_4]^{2-}$ are diamagnetic. The hybridisation of nickel in these complexes, respectively, are : **[JEE 2008, 3/163]**

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

14. **Statement-1 :** The geometrical isomers of the complex $[M(NH_3)_4Cl_2]$ are optically inactive, **and**
Statement-2 : Both geometrical isomers of the complex $[M(NH_3)_4Cl_2]$ possess axis of symmetry.
[JEE 2008, 3/163]

(A) Statement-1 is true, statement-2 is true; statement-2 is a correct explanation for statement-1.
(B) Statement-1 is true, statement-2 is true; statement-2 is NOT a correct explanation for statement-1.
(C) Statement-1 is true, Statement-2 is false.
(D) Statement-1 is false, Statement-2 is true.

15. **Statement - 1 :** $[Fe(H_2O)_5NO]SO_4$ is paramagnetic, **and** **[JEE 2008, 3/163]**
Statement - 2 : The Fe in $[Fe(H_2O)_5NO]SO_4$ has three unpaired electrons.

(A) Statement-1 is true, statement-2 is true; statement-2 is a correct explanation for statement-1.
(B) Statement-1 is true, statement-2 is true; statement-2 is NOT a correct explanation for statement-1.
(C) Statement-1 is true, Statement-2 is false.
(D) Statement-1 is false, Statement-2 is true.

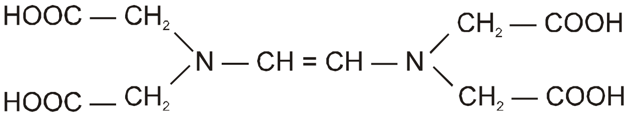
16.* The compound(s) that exhibit(s) geometrical isomerism is(are) : **[JEE 2009, 4/160]**

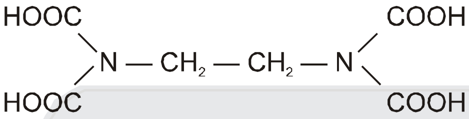
(A) $[Pt(en)Cl_2]$ (B) $[Pt(en)_2]Cl_2$ (C) $[Pt(en)_2Cl_2]Cl_2$ (D) $[Pt(NH_3)_2Cl_2]$

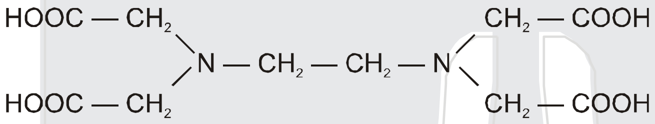
17. The spin only magnetic moment value (in Bohr magneton units) of $Cr(CO)_6$ is : **[JEE 2009, 3/160]**

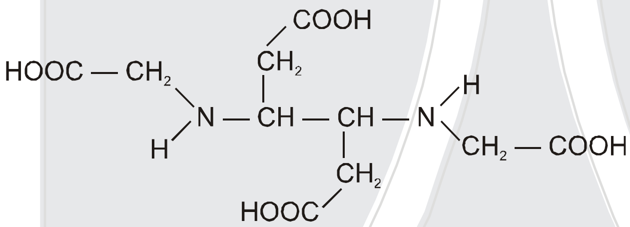
(A) 0 (B) 2.84 (C) 4.90 (D) 5.92

18. The correct structure of ethylenediaminetetraacetic acid (EDTA) is : **[JEE 2010, 3/163]**

(A) 

(B) 

(C) 

(D) 

19. The ionization isomer of $[Cr(H_2O)_4Cl(NO_2)]Cl$ is : **[JEE 2010, 3/163]**

(A) $[Cr(H_2O)_4(O_2N)]Cl_2$ (B) $[Cr(H_2O)_4Cl_2](NO_2)$

(C) $[Cr(H_2O)_4Cl(ONO)]Cl$ (D) $[Cr(H_2O)_4Cl_2(NO_2)].H_2O$

20. The complex showing a spin-only magnetic moment of 2.82 B.M. is : **[JEE 2010, 5/163]**

(A) $Ni(CO)_4$ (B) $[NiCl_4]^{2-}$ (C) $Ni(PPh_3)_4$ (D) $[Ni(CN)_4]^{2-}$

21. Total number of geometrical isomers for the complex $[RhCl(CO)(PPh_3)(NH_3)]$ is : **[JEE 2010, 3/163]**

22. Geometrical shapes of the complexes formed by the reaction of Ni^{2+} with Cl^-, CN^- and H_2O, respectively, are **[JEE 2011, 3/160]**

(A) octahedral, tetrahedral and square planar (B) tetrahedral, square planar and octahedral

(C) square planar, tetrahedral and octahedral (D) octahedral, square planar and octahedral

23. Among the following complexes (K–P),

$K_3[Fe(CN)_6]$ (K), $[Co(NH_3)_6]Cl_3$ (L), $Na_3[Co(oxalate)_3]$ (M), $[Ni(H_2O)_6]Cl_2$ (N), $K_2[Pt(CN)_4]$ (O) and $[Zn(H_2O)_6](NO_3)_2$ (P)

the diamagnetic complexes are : **[JEE 2011, 3/160]**

(A) K, L, M, N (B) K, M, O, P (C) L, M, O, P (D) L, M, N, O

24. The volume (in mL) of 0.1 M $AgNO_3$ required for complete precipitation of chloride ions present in 30 mL of 0.01 M solution of $[Cr(H_2O)_5Cl]Cl_2$, as silver chloride is close to. **[JEE 2011, 4/160]**

25. As per IUPAC nomenclature, the name of the complex $[Co(H_2O)_4(NH_3)_2]Cl_3$ is : **[JEE 2012, 3/143]**

(A) Tetraaquadiaminecobalt (III) chloride (B) Tetraaquadiamminecobalt (III) chloride

(C) Diaminetetraaquacobalt (III) chloride (D) Diamminetetraaquacobalt (III) chloride

26. $NiCl_2\{P(C_2H_5)_2(C_6H_5)\}_2$ exhibits temperature dependent magnetic behaviour (paramagnetic/ diamagnetic). The coordination geometries of Ni^{2+} in the paramagnetic and diamagnetic states are respectively **[JEE 2012, 3/143]**

(A) tetrahedral and tetrahedral (B) square planar and square planar
(C) tetrahedral and square planar (D) square planar and tetrahedral

27. Consider the following complex ions, P, Q and R. **[JEE(Advanced) 2013, 2/120]**
$P = [FeF_6]^{3-}$, $Q = [V(H_2O)_6]^{2+}$ and $R = [Fe(H_2O)_6]^{2+}$.
The correct order of the complex ions, according to their spin-only magnetic moment values (in B.M.) is
(A) $R < Q < P$ (B) $Q < R < P$ (C) $R < P < Q$ (D) $Q < P < R$

28.* The pair(s) of coordination complexes/ions exhibiting the same kind of isomerism is(are) :
[JEE(Advanced) 2013, 4/120]
(A) $[Cr(NH_3)_5Cl]Cl_2$ and $[Cr(NH_3)_4Cl_2]Cl$ (B) $[Co(NH_3)_4Cl_2]^+$ and $[Pt(NH_3)_2(H_2O)Cl]^+$
(C) $[CoBr_2Cl_2]^{2-}$ and $[PtBr_2Cl_2]^{2-}$ (D) $[Pt(NH_3)_3(NO_3)]Cl$ and $[Pt(NH_3)_3Cl]Br$

29. *$EDTA^{4-}$* is ethylenediaminetetraacetate ion. The total number of *N–Co–O* bond angles in *$[Co(EDTA)]^{1-}$* complex ion is : **[JEE(Advanced) 2013, 4/120]**

30.^ A list of species having the formula XZ_4 is given below. **[JEE(Advanced) 2014, 3/120]**
XeF_4, SF_4, SiF_4. BF_4^-, BrF_4^-, $[Cu(NH_3)_4]^{2+}$, $[FeCl_4]^{2-}$, $[CoCl_4]^{2-}$ and $[PtCl_4]^{2-}$.
Defining shape on the basis of the location of X and Z atoms, the total number of species having a square planar shape is

31. Match each coordination compound in List-I with an appropriate pair of characteristics from List-II and select the correct answer using the code given below the lists. **[JEE(Advanced) 2014, 3/120]**
{en = $H_2NCH_2CH_2NH_2$; atomic numbers : Ti = 22; Cr = 24; Cp = 27; Pt = 78}

	List-I		**List-II**
P.	$[Cr(NH_3)_4Cl_2)Cl]$	1.	Paramagnetic and exhibits ionisation isomerism
Q.	$[Ti(H_2O)_5Cl](NO_3)_2$	2.	Diamagentic and exhibits *cis-trans* isomerism
R.	$[Pt(en)(NH_3)Cl]NO_3$	3.	Paramagentic and exhibits *cis-trans* isomerism
S.	$[Co(NH_3)_4(NO_3)_2]NO_3$	4.	Diamagentic and exhibits ionisation isomerism

Code :

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

32. For the octahedral complexes of Fe^{3+} in SCN^- (thiocyanato-S) and in CN^- ligand environments, the difference between the spin-only magnetic moments in Bohr magnetons (when approximated to the nearest integer) is : [Atomic number of Fe = 26] **[JEE(Advanced) 2015, 4/168]**

33. In the complex acetylbromidodicarbonylbis(triethylphosphine)iron(II), the number of Fe–C bond(s) is
[JEE(Advanced) 2015, 4/168]

34. Among the complex ions, $[Co(NH_2–CH_2–CH_2–NH_2)_2Cl_2]^+$, $[CrCl_2(C_2O_4)_2]^{3-}$, $[Fe(H_2O)_4(OH)_2]^+$, $[Fe(NH_3)_2(CN)_4]^-$, $[Co(NH_2–CH_2–CH_2–NH_2)_2(NH_3)Cl]^{2+}$ and $[Co(NH_3)_4(H_2O)Cl]^{2+}$, the number of complex ion(s) that show(s) *cis-trans* isomerism is : **[JEE(Advanced) 2015, 4/168]**

35. Among $[Ni(CO)_4]$, $[NiCl_4]^{2-}$, $[Co(NH_3)_4Cl_2]Cl$, $Na_3[CoF_6]$, Na_2O_2 and CsO_2, the total number of paramagnetic compounds is : **[JEE(Advanced) 2016, 3/124]**
(A) 2 (B) 3 (C) 4 (D) 5

36. The number of geometric isomers possible for the complex $[CoL_2Cl_2]^-$ (L = $H_2NCH_2CH_2O^-$) is
[JEE(Advanced) 2016, 3/124]

37. The geometries of the ammonia complexes of Ni^{2+}, Pt^{2+} and Zn^{2+}, respectively, are
[JEE(Advanced) 2016, 3/124]
(A) octahedral, square planar and tetrahedral (B) square planar, octahedral and tetrahedral
(C) tetrahedral, square planar and octahedral (D) octahedral, tetrahedral and square planar

38.* The correct statement(s) regarding the binary transition metal carbonyl compounds is (are)
(Atomic numbers: Fe = 26, Ni = 28) **[JEE(Advanced) 2018, 4/128]**
(A) Total number of valence shell electrons at metal centre in $Fe(CO)_5$ or $Ni(CO)_4$ is 16
(B) These are predominantly low spin in nature
(C) Metal–carbon bond strengthens when the oxidation state of the metal is lowered
(D) The carbonyl C−O bond weakens when the oxidation state of the metal is increased

39. Among the species given below, the total number of diamagnetic species is ___.
H atom, NO_2 monomer, O_2^- (superoxide), dimeric sulphur in vapour phase,
Mn_3O_4, $(NH_4)_2[FeCl_4]$, $(NH_4)_2[NiCl_4]$, K_2MnO_4, K_2CrO_4 **[JEE(Advanced) 2018, 3/120]**

40. The ammonia prepared by treating ammonium sulphate with calcium hydroxide is completely used by $NiCl_2.6H_2O$ to form a stable coordination compound. Assume that both the reactions are 100% complete. If 1584 g of ammonium sulphate and 952 g of $NiCl_2.6H_2O$ are used in the preparation, the combined weight (in grams) of gypsum and the nickel-ammonia coordination compound thus produced is ____. (Atomic weights in g mol^{-1}: H = 1, N = 14, O = 16, S = 32, Cl = 35.5, Ca = 40, Ni = 59)
[JEE(Advanced) 2018, 3/120]

41.* The correct option(s) regarding the complex $[Co(en)(NH_3)_3(H_2O)]^{3+}$
(en = $H_2NCH_2CH_2NH_2$) is (are) **[JEE(Advanced) 2018, 4/120]**
(A) It has two geometrical isomers
(B) It will have three geometrical isomers if bidentate 'en' is replaced by two cyanide ligands
(C) It is paramagnetic
(D) It absorbs light at longer wavelength as compared to $[Co(en)NH_3)_4]^{3+}$

42. Match each set of hybrid orbitals from LIST-I with complex(es) given in LIST-II.
[JEE(Advanced) 2018, 3/120]

LIST-I			**LIST-II**
(P)	dsp^2	(1)	$[FeF_6]^{4-}$
(Q)	sp^3	(2)	$[Ti(H_2O)_3Cl_3]$
(R)	sp^3d^2	(3)	$[Cr(NH_3)_6]^{3+}$
(S)	d^2sp^3	(4)	$[FeCl_4]^{2-}$
		(5)	$Ni(CO)_4$
		(6)	$[Ni(CN)_4]^{2-}$

The correct option is
(A) P → 5 ; Q → 4, 6 ; R → 2, 3 ; S → 1 (B) P → 5, 6 ; Q → 4 ; R → 3 ; S → 1, 2
(C) P → 6 ; Q → 4, 5 ; R → 1 ; S → 2, 3 (D) P → 4, 6 ; Q → 5, 6 ; R → 1, 2 ; S → 3

43. Total number of cis N–Mn–Cl bond angles (that is, Mn–N and Mn–Cl bonds in cis position) present in a molecule of cis-$[Mn(en)_2Cl_2]$ complex is______ (en = $NH_2CH_2CH_2NH_2$) **[JEE(Advanced) 2019, 3/124]**

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

1. An octahedral complex of Co^{3+} is diamagnetic. The hybridisation involved in the formation of the comlex is: **[JEE(Main) 2014 Online (09-04-14), 4/120]**

(1) sp^3d^2 (2) dsp^2 (3) d^2sp^3 (4) sp^3d

2. The correct statement about of the magnetic prperties of $[Fe(CN)_6]^{3-}$ and $[FeF_6]^{3-}$ is : (Z = 26)
[JEE(Main) 2014 Online (09-04-14), 4/120]

(1) both are paramagnetic (2) both are diamagnetic

(3) $[Fe(CN)_6]^{3-}$ is diamagnetic, $[FeF_6]^{3-}$ is paramagnetic.

(4) $[Fe(CN)_6]^{3-}$ is paramagnetic, $[FeF_6]^{3-}$ is diamagnetic.

3. Which of the following name formula combinations is not correct ?
[JEE(Main) 2014 Online (11-04-14), 4/120]

	Formula	**Name**
(1)	$K_2[Pt(CN)_4]$	Potasium tetracyanoplatinate (II)
(2)	$[Mn(CN)_5]^{2-}$	Pentacyanomagnate (II) ion
(3)	$K[Cr(NH_3)_2Cl_4]$	Potassium diammine tetrachlorochromate (III)
(4)	$[Co(NH_3)_4(H_2O)I]SO_4$	Tetraammine aquaiodo cobalt (III) sulphate

4. Consider the coordination compound, $[Co(NH_3)_6]Cl_3$. In the formation of the complex, the species which acts as the Lewis acid is : **[JEE(Main) 2014 Online (11-04-14), 4/120]**

(1) $[Co(NH_3)_6]^{3+}$ (2) Cl^- (3) Co^{3+} (4) NH_3

5. Among the following species the one which causes the highest CFSE, Δ_0 as a ligand is :
[JEE(Main) 2014 Online (12-04-14), 4/120]

(1) CN^- (2) NH_3 (3) F^- (4) CO

6. Which one of the following complexes will most likely absorb visible light ?
(At nos. Sc = 21, Ti = 22, V = 23, Zn = 30) **[JEE(Main) 2014 Online (12-04-14), 4/120]**

(1) $[Sc(H_2O)_6]^{3+}$ (2) $[Ti(NH_3)_6]^{4+}$ (3) $[V(NH_3)_6]^{3+}$ (4) $[Zn(NH_3)_6]^{2+}$

7. An octahedral complex with molecular composition $M.5NH_3.Cl.SO_4$ has two isomers, A and B. The solution of A gives a white precipitate with $AgNO_3$ solution and the solution of B gives white precipitate with $BaCl_2$ solution. The type of isomerism exhibited by the complex is:
[JEE(Main) 2014 Online (19-04-14), 4/120]

(1) Linkage isomerism (2) Ionisation isomerism

(3) Coordinate isomerism (4) Geometrical isomerism

8. Nickel (Z = 28) combines with a uninegative monodenate ligand to form a diamagnetic complex $[NiL_4]^{2-}$. The hybridisation involved and the number of unpaired electrons present in the complex are respectively: **[JEE(Main) 2014 Online (19-04-14), 4/120]**

(1) sp^3, two (2) dsp^2, zero (3) dsp^2, one (4) sp^3, zero

9. The correct statement on the isomerism associated with the following complex ions,
(a) $[Ni(H_2O)_5NH_3]^{2+}$, (b) $[Ni(H_2O)_4(NH_3)_2]^{2+}$ and (c) $[Ni(H_2O)_3(NH_3)_3]^{2+}$ is :
[JEE(Main) 2015 Online (10-04-15), 4/120]

(1) (a) and (b) show only geometrical isomerism.

(2) (b) and (c) show geometrical and optical isomerism

(3) (b) and (c) show only geometrical isomerism

(4) (a) and (b) show geometrical and optical isomerism

10. Which molecule/ion among the following cannot act as a ligand in complex compounds?

[JEE(Main) 2015 Online (10-04-15), 4/120]

(1) CH_4 (2) CN^- (3) Br^- (4) CO

11. Which of the following complex ions has electrons that are symmetrically filled in both t_{2g} and e_g orbitals? **[JEE(Main) 2015 Online (11-04-15), 4/120]**

(1) $[FeF_6]^{3-}$ (2) $[Mn(CN)_6]^{4-}$ (3) $[CoF_6]^{3-}$ (4) $[Co(NH_3)_6]^{2+}$

12. Identify the correct trend given below: (Atomic No.: Ti = 22, Cr = 24 and Mo = 42)

[JEE(Main) 2016 Online (09-04-16), 4/120]

(1) Δ_o of $[Cr(H_2O)_6]^{2+} < [Mo(H_2O)_6]^{2+}$ and Δ_o of $[Ti(H_2O)_6]^{3+} < [Ti(H_2O)_6]^{2+}$

(2) Δ_o of $[Cr(H_2O)_6]^{2+} > [Mo(H_2O)_6]^{2+}$ and Δ_o of $[Ti(H_2O)_6]^{3+} > [Ti(H_2O)_6]^{2+}$

(3) Δ_o of $[Cr(H_2O)_6]^{2+} > [Mo(H_2O)_6]^{2+}$ and Δ_o of $[Ti(H_2O)_6]^{3+} < [Ti(H_2O)_6]^{2+}$

(4) Δ_o of $[Cr(H_2O)_6]^{2+} < [Mo(H_2O)_6]^{2+}$ and Δ_o of $[Ti(H_2O)_6]^{3+} > [Ti(H_2O)_6]^{2+}$

13. Which one of the following complexes will consume more equivalents of aqueous solution of $Ag(NO_3)$?

[JEE(Main) 2016 Online (09-04-16), 4/120]

(1) $Na_3[CrCl_6]$ (2) $[Cr(H_2O)_5Cl]Cl_2$ (3) $[Cr(H_2O)_6]Cl_3$ (4) $Na_2[CrCl_5(H_2O)]$

14. Which of the following is an example of homoleptic complex ?

[JEE(Main) 2016 Online (09-04-16), 4/120]

(1) $[Co(NH_3)_4Cl_2]$ (2) $[Co(NH_3)_6]Cl_3$ (3) $[Co(NH_3)_5Cl]Cl_2$ (4) $[Pt(NH_3)_2Cl_2]$

15. sp^3d^2 hybridization is **not** displayed by : **[JEE(Main) 2017 Online (08-04-17), 4/120]**

(1) PF_5 (2) SF_6 (3) $[CrF_6]^{3-}$ (4) BrF_5

16. $[Co_2(CO)_8]$ displays : **[JEE(Main) 2017 Online (09-04-17), 4/120]**

(1) one Co–Co bond, four terminal CO and four bridging CO

(2) one Co–Co bond, six terminal CO and two bridging CO

(3) no Co–Co bond, four terminal CO and four bridging CO

(4) no Co–Co bond, six terminal CO and two bridging CO

17. The correct combination is : **[JEE(Main) 2018 Online (15-04-18), 4/120]**

(1) $[NiCl_4]^{2-}$ – square-planar; $[Ni(CN)_4]^{2-}$ – paramagnetic

(2) $[Ni(CN)_4]^{2-}$ – tetrahedral; $[Ni(CO)_4]$ – paramagnetic

(3) $[NiCl_4]^{2-}$ – paramagnetic; $[Ni(CO)_4]$ – tetrahedral

(4) $[NiCl_4]^{2-}$ – diamagnetic; $[Ni(CO)_4]$ – square-planar

18. The correct order of spin-only magnetic moments among the following is :

(Atomic number : Mn = 25, Co = 27, Ni = 28, Zn = 30) **[JEE(Main) 2018 Online (15-04-18), 4/120]**

(1) $[ZnCl_4]^{2-} > [NiCl_4]^{2-} > [CoCl_4]^{2-} > [MnCl_4]^{2-}$ (2) $[CoCl_4]^{2-} > [MnCl_4]^{2-} > [NiCl_4]^{2-} > [ZnCl_4]^{2-}$

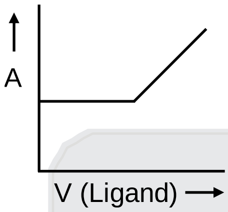
(3) $[NiCl_4]^{2-} > [CoCl_4]^{2-} > [MnCl_4]^{2-} > [ZnCl_4]^{2-}$ (4) $[MnCl_4]^{2-} > [CoCl_4]^{2-} > [NiCl_4]^{2-} > [ZnCl_4]^{2-}$

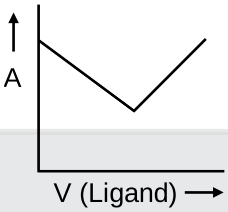
19. The total number of possible isomers for square-planar $[Pt(Cl)(NO_2)(NO_3)(SCN)]^{2-}$ is :

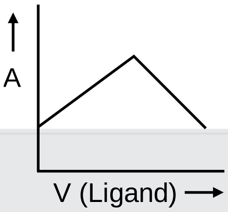
[JEE(Main) 2018 Online (15-04-18), 4/120]

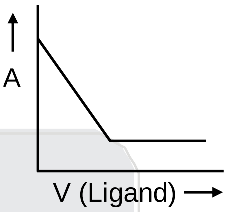
(1) 8 (2) 12 (3) 16 (4) 24

20. In a complexometric titration of metal ion with ligand **[JEE(Main) 2018 Online (16-04-18), 4/120]**
M (Metal ion) + L (Ligand) → C (Complex) end point is estimated spectrophotometrically (through light absorption). If 'M' and 'C' do not absorb light and only 'L' absorbs, then the titration plot between absorbed light (A) versus volume of ligand 'L' (V) would look like :

(1) 

(2) 

(3) 

(4) 

21. In Wilkinson's catalyst, the hybridization of central metal ion and its shape are respectively :
[JEE(Main) 2018 Online (16-04-18), 4/120]
(1) sp^3d, trigonal bipyramidal (2) d^2sp^3, octahedral
(3) dsp^2, square planar (4) sp^3, tetrahedral

22. Which of the following complexes will show geometrical isomerism ?
[JEE(Main) 2018 Online (16-04-18), 4/120]
(1) Potassium tris(oxalato)chromate(III)
(2) Pentaaquachlorochromium(III)chloride
(3) Aquachlorobis(ethylenediamine)cobalt(II) chloride
(4) Potassium amminetrichloroplatinate(II)

23. Two complexes $[Cr(H_2O)_6]Cl_3$ (A) and $[Cr(NH_3)_6]Cl_3$ (B) are violet and yellow coloured respectively. The incorrect statement regarding them is : **[JEE(Main) 2019 Online (09-01-19), 4/120]**
(1) Δ_0 value for (A) is less than that of (B).
(2) both absorb energies corresponding to their complementary colors.
(3) Δ_0 values of (A) and (B) are calculated from the energies of violet and yellow light, respectively.
(4) both are paramagnetic with three unpaired electrons.

24. Homoleptic octahedral complexes of a metal ion 'M^{3+}' with three monodentate ligands L_1, L_2 and L_3 absorb wavelengths in the region of green, blue and red respectively. The increasing order of the ligand strength is : **[JEE(Main) 2019 Online (09-01-19), 4/120]**
(1) $L_1 < L_2 < L_3$ (2) $L_3 < L_2 < L_1$ (3) $L_2 < L_1 < L_3$ (4) $L_3 < L_1 < L_2$

25. The complex that has highest crystal field splitting energy (Δ), is :
[JEE(Main) 2019 Online (09-01-19), 4/120]
(1) $K_2[CoCl_4]$ (2) $[Co(NH_3)_5(H_2O)]Cl_3$
(3) $[Co(NH_3)_5Cl]Cl_2$ (4) $K_3[Co(CN)_6]$

26. Wilkinson catalyst is : **[JEE(Main) 2019 Online (10-01-19), 4/120]**
(1) $[(Et_3P)_3IrCl]$ (Et = C_2H_5) (2) $[(Et_3P)_3RhCl]$
(3) $[(Ph_3P)_3RhCl]$ (4) $[(Ph_3P)_3IrCl]$

27. The total number of isomers for a square planar complex $[M(F)(Cl)(SCN)(NO_2)]$ is :
[JEE(Main) 2019 Online (10-01-19), 4/120]
(1) 16 (2) 4 (3) 12 (4) 8

28. The difference in the number of unpaired electrons of a metal ion in its high-spin and low-spin octahedral complexes is two. The metal ion is: **[JEE(Main) 2019 Online (10-01-19), 4/120]**
(1) Co^{2+} (2) Fe^{2+} (3) Mn^{2+} (4) Ni^{2+}

29. A reaction of cobalt(III) chloride and ethylenediamine in a 1 : 2 mole ratio generates two isomeric products A (violet coloured) and B(green coloured). A can show optical activity, but, B is optically inactive. What type of isomers does A and B represent? **[JEE(Main) 2019 Online (10-01-19), 4/120]**

(1) Ionisation isomers
(2) Linkage isomer
(3) Coordination isomers
(4) Geometrical isomers

30. Match the metals (column I) with the coordination compound(s)/ emzyme (s) (column II): **[JEE(Main) 2019 Online (11-01-19), 4/120]**

(column I) **Metal**		**(column II)** **Coordination compound(s)/enzyme(s)**	
(A)	Co	(i)	Wilkinson catalyst
(B)	Zn	(ii)	Chlorophyll
(C)	Rh	(iii)	Vitamin B_{12}
(D)	Mg	(iv)	Carbonic anhydrase

(1) (A)-(i);(B)-(ii);(C)-(iii);(D)-(iv)
(2) (A)-(iv);(B)-(iii);(C)-(i);(D)-(ii)
(3) (A)-(iii);(B)-(iv);(C)-(i);(D)-(ii)
(4) (A)-(ii);(B)-(i);(C)-(iv);(D)-(iii)

31. The coordination number of Th in $K_4[Th(C_2O_4)_4(OH_2)_2]$ is: **[JEE(Main) 2019 Online (11-01-19), 4/120]**

$\left(C_2O_4^{2-} = \text{Oxalato}\right)$

(1) 14 (2) 10 (3) 6 (4) 8

32. The number of bridging CO ligand(s) and Co-Co bond (s) in $Co_2(CO)_8$, respetively are : **[JEE(Main) 2019 Online (11-01-19), 4/120]**

(1) 4 and 0 (2) 0 and 2 (3) 2 and 1 (4) 2 and 0

33. The metal d-orbitals that are directly facing the ligands in $K_3[Co(CN)_6]$ are : **[JEE(Main) 2019 Online (12-01-19), 4/120]**

(1) d_{xz}, d_{yz} and d_{z^2} (2) d_{xy} and $d_{x^2-y^2}$ (3) d_{xy}, d_{xz} and d_{yz} (4) $d_{x^2-y^2}$ and d_{z^2}

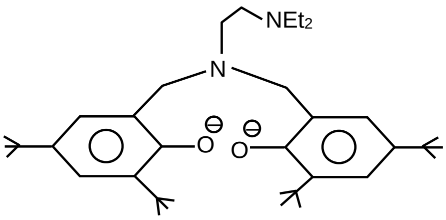
34. $Mn_2(CO)_{10}$ is an organometallic compound due to the presence of : **[JEE(Main) 2019 Online (12-01-19), 4/120]**

(1) Mn – C bond (2) C – O bond (3) Mn – O bond (4) Mn – Mn bond

35. The magnetic moment of an octahedral homoleptic Mn(II) complex is 5.9 BM. The suitable ligand for this complex is: **[JEE(Main) 2019 Online (12-01-19), 4/120]**

(1) Ethylenediamine (2) CN^- (3) NCS^- (4) CO

36. The following ligand is : **[JEE(Main) 2019 Online (08-04-19)S1, 4/120]**



(1) bidentate (2) hexadentate (3) tridentate (4) tetradentate

37. The correct order of the spin-only magnetic moment of metal ions in the following low-spin complexes,$[V(CN)_6]^{4-}$, $[Fe(CN)_6]^{4-}$, $[Ru(NH_3)_6]^{3+}$, and $[Cr(NH_3)_6]^{2+}$ is :

[JEE(Main) 2019 Online (08-04-19)S1, 4/120]

(1) $V^2 > Cr^{2+} > Ru^3 > Fe^{2+}$ (2) $Cr^{2+} > Ru^{3+} > Cr^{2+} > Fe^{2+}$

(3) $V^2 > Ru^{3+} > cr^{2+} > Fe^{2+}$ (4) $Cr^{2+} > V^{2+} > Ru^{3+} > Fe^{2+}$

38. The compound that inhibits the growth of tumors is : **[JEE(Main) 2019 Online (08-04-19), 4/120]**

(1) cis-$[Pd(Cl)_2(NH_3)_2]$ (2) cis-$[Pt(Cl)_2(NH_3)_2]$ (3) trans-$[Pt(Cl)_2(NH_3)_2]$ (4) trans-$[Pd(Cl)_2(NH_3)_2]$

39. The calculated spin-only magnetic moments (BM) of the anionic and cationic species of $[Fe(H_2O)_6]_2$ and $[Fe(CN)_6]$, **[JEE(Main) 2019 Online (08-04-19)S2, 4/120]**

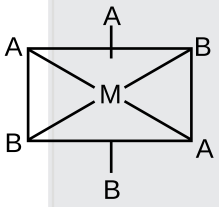
(1) 0 and 5.92 (2) 4.9 and 0 (3) 0 and 4.9 (4) 2.84 and 5.92

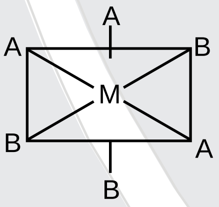
40. The degenerate orbitals of $[Cr(H_2O)_6]^{3+}$ are : **[JEE(Main) 2019 Online (09-04-19)S1, 4/120]**

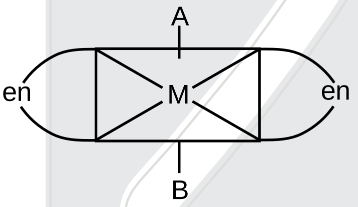
(1) d_{z^2} and d_{xz} (2) d_{yz} and d_{z^2} (3) d_{xz} and d_{yz} (4) $d_{x^2-y^2}$ and d_{xy}

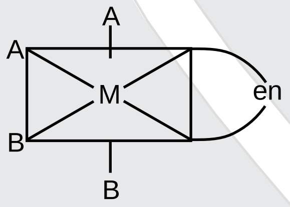
41. The one that will show optical activity is : **[JEE(Main) 2019 Online (09-04-19)S1, 4/120]**

(en = ethane-1,2-diamine)

(1)


(2)


(3)


(4)


42. The correct statements among I to III are **[JEE(Main) 2019 Online (09-04-19)S2, 4/120]**

(I) Valence bond theory cannot explain the color exhibited by transition metal complexes.

(II) Valence bond theory can predict quantitatively the magnetic properties of transition metal complexes.

(III) Valence bond theory cannot distinguish ligands as weak and strong field ones.

(1) (I) and (III) Only (2) (I) and (II) Only (3) (I), (II) and (III) (4) (II) and (III) Only

43. Three complexes, $[CoCl(NH_3)_5]^{2+}$ (I), $[Co(NH_3)_5\ H_2O]^{3+}$(II) and $[Co(NH_3)_6]^{3+}$ (III) absorb light in the visible region. The correct order of the wavelength of light absorbed by them is :

[JEE(Main) 2019 Online (10-04-19)S1, 4/120]

(1) (III) > (I) > (II) (2) (II) > (I) > (III) (3) (I) > (II) > (III) (4) (III) > (II) > (I)

44. The species that can have a trans-isomer is : **[JEE(Main) 2019 Online (10-04-19)S1, 4/120]**

(en = ethane-1,2-diamine, ox=oxalate)

(1) $[Pt(en)Cl_2]$ (2) $[Pt(en)_2Cl_2]^{2+}$ (3) $[Zn(en)Cl_2]$ (4) $[Cr(en)_2(ox)]^+$

45. The INCORRECT statement is : **[JEE(Main) 2019 Online (10-04-19)S2, 4/120]**

(1) the gemstone, ruby, has Cr^{3+} ions occupying the octahedral sites of beryl.

(2) the spin-only magnetic moments of $[Fe(H_2O)_6]^{2+}$ and $[Cr(H_2O)_6]^{2+}$ are nearly similar

(3) the color of $[CoCl(NH_3)_5]^{2+}$ is violet as it absorbs the yellow light

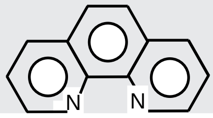
(4) the spin-only magnetic moment of $[Ni(NH_3)_4(H_2O)_2]^{2+}$ is 2.83 BM

46. The crystal field stabilization energy (CFSE) of $[Fe(H_2O)_6]Cl_2$ and $K_2[NiCl_4]$ respectively are :

[JEE(Main) 2019 Online (10-04-19)S2, 4/120]

(1) $-0.4\Delta_0$ and $-1.2\ \Delta_t$ (2) $-2.4\Delta_0$ and $-1.2\ \Delta_t$ (3) $-0.4\Delta_0$ and $-0.8\ \Delta_t$ (4) $-0.6\Delta_0$ and $-0.8\ \Delta_t$

47. The complex ion that will lose its crystal field stabilization energy upon oxidation of its metal to +3 state is **[JEE(Main) 2019 Online (12-04-19)S1, 4/120]**

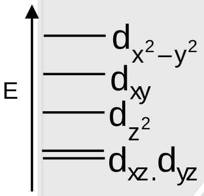
(Phen = 

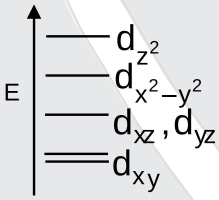
and
ignore pairing energy)

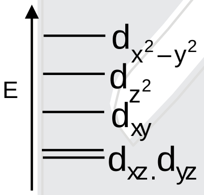
(1) $[Ni(phen)_3]^{2+}$ (2) $[Zn(phen)_3]^{2+}$ (3) $[Co(phen)_3]^{2+}$ (4) $[Fe(phen)_3]^{2+}$

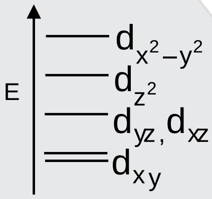
48. Complete removal of both the axial ligands (along , the z-axis) from an octahedral complex leads to which of the following splitting patterns ? (relative orbital energies not on scale)

[JEE(Main) 2019 Online (12-04-19)S1, 4/120]

(1) 

(2) 

(3) 

(4) 

49. The coordination numbers of Co and Al in $[Co(Cl)(en)_2]Cl$ and $K_3[Al(C_2O_4)_3]$, respectively, are :
(en = ethane-1, 2-diamine) **[JEE(Main) 2019 Online (12-04-19)S2, 4/120]**

(1) 3 and 3 (2) 5 and 6 (3) 6 and 6 (4) 5 and 3

50. The compound used in the treatment of lead poisoning is :

[JEE(Main) 2019 Online (12-04-19)S2, 4/120]

(1) D-penicillamine (2) EDTA (3) desferrioxime B (4) Cis-platin

Answers

EXERCISE - 1

PART – I

A-1. $K_2SO_4.Cr_2(SO_4)_3 \xrightleftharpoons{aq.} 2K^+(aq) + 2Cr^{3+}(aq) + 4SO_4^{2-}$

So chrome alum is a double salt. It when dissolved in water gives its constituent ions. Hence it gives the test of K^+, Cr^{3+} and SO_4^{2-} ions.

$CuSO_4.4NH_3\ [Cu(NH_3)_4]\ SO_4 \xrightleftharpoons{aq.} [Cu(NH_3)_4]^{2+}(aq) + SO_4^{2-}(aq)$

As copper (II) is present in coordination sphere it will not give the test of Cu^{2+} ion.

A-2. 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.

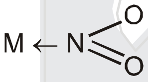
The oxidation number of the central atom is defined as the charge it would carry if all the ligands are removed along with the electron pairs that are shared with the central atom.

	Complex	**Coordination Number**	**Oxidation State**
(a)	$[AgCl_2]^-$	2	1
(b)	$[Cr(H_2O)_5Cl]^{2+}$	6	3
(c)	$[Co(NCS)_4]^{2-}$	4	2
(d)	$[Co(NH_3)_3(NO_2)_3]$	6	3
(e)	$[Fe(EDTA)]^-$	6	3
(f)	$[Cu(en)_2]SO_4$	4	2
(g)	$K[Pt(NH_3)Cl_5]$	6	4

A-3.

(A) methyl isocyanide, monodentate.	(B) acetylacetonato, bidentate
(C) azido, monodentate	(D) diethylenetriamine, tridentate
(E) ethylenediamine tetraacetato, hexadentate	(F) ethylenediamine triacentato, pentadentate
(G) oxalato, bidentate	(H) dimethylglyoximato
(I) isocyanido, monodentate	(J) nitrito, monodentate
(K) oxido, monodentate	(L) superoxido, monodentate

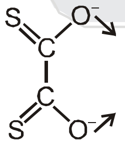
A-4. (A)



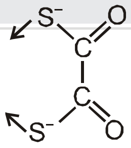
$M \leftarrow N\genfrac{}{}{0pt}{}{O}{O}$ nitrito-N $M \leftarrow O—N{=}O$ nitrito-O

(B) $M \leftarrow SCN$ thiocyanato or thiocyanato-S, $M \leftarrow NCS$ isothiocyanato or thiocyanato-N

(C)



or

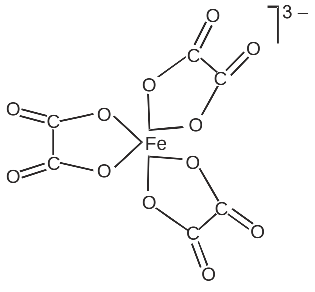


dithioxalate

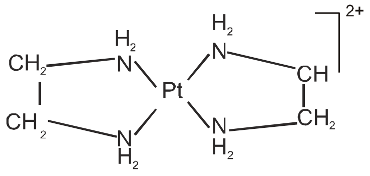
(D) $M \leftarrow OCN$ cyanato-O or cyanato-N, $M \leftarrow NCO$ isothiocyanato or thiocyanato-N

(E) $M \leftarrow NOS$ thionitrito-N or , $M \leftarrow SON$ thionitrito-S

A-5. **(a)**



$[Fe(C_2O_4)_3]^{3-}$



$[Pt(en)_2]^{2+}$

The ligands, oxalate and ethylenediamine are bidentate as each ligand has two donor atoms. So in 1st case the number of chelate rings (five membered) are three where as in 2nd case the number of chelate rings (five membered) are two.

The coordination number and oxidation state of iron are six and +3 respectively and the coordination number and oxidation state of platinum are four and +2 respectively.

(b) $K_2[Ni(CN)_4] \overset{aq.}{\rightleftharpoons} 2K^+(aq) + [Ni(CN)_4]^{2-}(aq)$

$[Cr(en)_3]Cl_3 \overset{aq.}{\rightleftharpoons} [Cr(en)_3]^{3+}(aq) + 3Cl^-(aq)$

$Fe_4[Fe(CN)_6]_3 \overset{aq.}{\rightleftharpoons} 4Fe^{3+}(aq) + 3[Fe(CN)_6]^{4-}(aq)$

$[PtCl_2(en)_2](NO_3)_2 \overset{aq.}{\rightleftharpoons} [PtCl_2(en)_2]^{2+}(aq) + 2(NO_3)^-(aq)$

So, $[Ni(CN)_4]^{2-}$, $[Cr(en)_3]^{3+}$, $3[Fe(CN)_6]^{4-}$ and $[PtCl_2(en)_2]^{2+}$ are coordination entities and K^+, Cl^-, Fe^{3+} and NO_3^- are counter ions.

(c) Coordination compounds are acid-base adduct. Cations are electron deficient, therefore, are called Lewis acids where as ligands are electrons donors, therefore, are called as Lewis base.

		LEWIS ACID	LEWIS BASE
(i)	$[HgBr_4]^{2-}$	Hg^{2+}	$4Br^-$
(ii)	$[Ni(H_2O)_6]^{2+}$	Ni^{2+}	$6H_2O$
(iii)	$[PdCl_2(NH_3)_2]$	Pd^{2+}	$2Cl^-$ & $2NH_3$
(iv)	$[Al(OH)_4]^-$	Al^{3+}	$4OH^-$
(v)	$[Ag(CN)_2]^-$	Ag^+	$2CN^-$
(vi)	$[Cr(CO)_6]$	Cr^0	$6CO$

B-1.

(a)	**$[Co(NH_3)_6]Cl_3$**	Hexaamminecobalt(III) chloride
(b)	**$[Rh(NH_3)_5I]I_2$**	Pentaammineiodidorhodium(III) iodide
(c)	**$[Fe(CO)_5]$**	Pentacarbonyliron(0)
(d)	**$[Fe(C_2O_4)_3]^{3-}$**	Trioxalatoferrate(III) ion OR Tris(oxalato)ferrate(III) ion
(e)	**$[Cu(NH_3)_4]SO_4$**	Tetraamminecopper(II) sulphate
(f)	**$Na[Cr(OH)_4]$**	Sodium tetrahydroxidochromate(III)
(g)	**$[Co(gly)_3]$**	Triglycinatocobalt(III) OR Tris(glycinato)cobalt(III)
(h)	**$[Fe(H_2O)_5(SCN)]^{2+}$**	Pentaaquathiocyanato–S–iron(III) ion
(i)	**$K_2[HgI_4]$**	Potassium tetraiodidomercurate(II)
(j)	**$Co[Hg(SCN)_4]$**	Cobalt(II) tetrathiocyanato–S–mercurate(II)
(k)	**$Fe_4[Fe(CN)_6]_3$**	Iron(III) hexacyanidoferrate(II)
(l)	**$K_3[Co(NO_2)_6]$**	Potassium hexanitrito–N–cobaltate(III)
(m)	**$[Ni(dmg)_2]$**	Bis(dimethylglyoximato)nickel(II)
(n)	**$K_2[PtCl_6]$**	Potassium hexachloridoplatinate(IV)
(o)	**$Na_2[Fe(CN)_5NO^+]$**	Sodium pentacyanidonitrosoniumferrate(II)
(p)	**$[Fe(H_2O)_5(NO^+)]SO_4$**	Pentaaquanitrosoniumiron(I) sulphate
(q)	**$[Cu(CN)_4]^{3-}$**	Tetracyanidocuperate(I) ion
(r)	**$(NH_4)_2[PtCl_6]$**	Ammonium hexachloridoplatinate(IV)

B-2.

(a)	$[CoBr(en)_2(ONO)]^{+1}$	Bromidobis(ethylenediamine)nitrito-O-cobalt(III)
(b)	$[Co(NH_3)_5(CO_3)]Cl$	Pentaamminecarbonatocobalt(III) chloride
(c)	$[Co(en)_3]_2(SO_4)_3$	Tris(ethylenediamine)cobalt(III) sulphate or Tris(ethane-1, 2-diamine)cobalt(III) sulphate.
(d)	$[Cr(CO)_5(PPh_3)]$	Pentacarbonyltriphenylphosphinechromium(0)
(e)	$Ba[Zr(OH)_2(ONO)_2(ox)]$	Barium dihydroxidodinitrito-O-oxalatozirconate(IV)
(f)	$[(CO)_5Mn\text{-}Mn(CO)_5]$	Decacarbonyldimanganese(0)
(g)	$[Co(NH_3)_6][Co(ONO)_6]$	Hexaamminecobalt(III) hexanitrito-O-cobaltate(III)
(h)	$[Pt(NH_3)_4Cl_2][PtCl_4]$	Tetraamminedichloridoplatinum(IV) tetrachloridoplatinate(II)
(i)	$[(NH_3)_5Co\text{-}NH_2\text{-}Co(NH_3)_4(H_2O)]Cl_5$	Pentaamminecobalt(III) -μ-amidotetraammineaquacobalt(III) chloride
(j)	$Cr(\pi\text{-}C_6H_6)_2$	Bis(η^6-benzene)chromium(0)
(k)	$[Co(NH_3)_4(OH_2)_2][BF_4]_3$	Tetraamminediaquacobalt(III) tetrafluoridoborate(III)
(l)	$[Co(NH_3)_6][Co(C_2O_4)_3]$	Hexaamminecobalt(III) trioxalatocobaltate(III)

B-3.

(a)	Tetraamminezinc(II) Nitrate	$[Zn(NH_3)_4](NO_3)_2$
(b)	Tetracarbonylnickel(0)	$[Ni(CO)_4]$
(c)	Potassium amminetrichloridoplatinate(II)	$K[Pt(NH_3)Cl_3]$
(d)	Dicyanidoaurrate(I) ion	$[Au(CN)_2]^-$
(e)	Sodium hexafluoridoaluminate(III)	$Na_3[AlF_6]$
(f)	Diamminesilver(I) ion	$[Ag(NH_3)_2]^+$

B-4.

(a)	Diamminetriaquahydroxidochromium(III) nitrate	$[Cr(NH_3)_2(H_2O)_3(OH)](NO_3)_2$
(b)	Barium dihydroxidodinitrito-O-oxalatozirconate(IV)	$Ba[Zr(OH)_2(ONO)_2(ox)]$
(c)	Dibromidotetracarbonyliron(II)	$[Fe(Br)_2(CO)_4]$
(d)	Ammonium diamminetetrakis(isothiocyanato)chromate(III)	$(NH_4)[Cr(NH_3)_2(NCS)_4]$
(e)	Pentaamminedinitrogenruthenium(II) chloride	$[Ru(NH_3)_5N_2]Cl_2$
(f)	Tetrakis(pyridine)platinum(II) tetraphenylborate(III)	$[Pt(Py)_4][B(ph)_4]_2$
(g)	Tetrapyridineplatinum(II) tetrachloridoplatinate(II)	$[Pt(py)_4][PtCl_4]$

C-1. (a) – iv, (b) – viii, (c) – i, (d) – vii,
(e) – iii, (f) – v, (g) – ii, (h) – vi

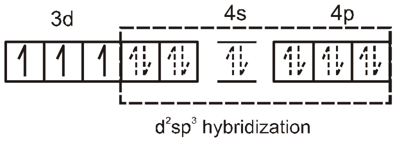
C-2. 0.0075.

C-3. (a) 36 (b) 36 (c) 36 (d) 36
(e) 36 (f) 36 (g) 54 (h) 86

C-4. ii < i < iv < iii.

D-1. (i) $[Cr(NH_3)_4Cl\ Br]Cl \xrightleftharpoons{aq.} [Cr(NH_3)_4Cl\ Br]^+ + Cl^-$; $Ag^+ + Cl^- \longrightarrow AgCl \downarrow$ (white) ; soluble in dilute NH_3.
$[Cr(NH_3)_4Cl_2]Br \xrightleftharpoons{aq.} [Cr(NH_3)_4Cl_2]^+ + Br^-$; $Ag^+ + Br^- \longrightarrow AgBr \downarrow$ (yellow) ; soluble in conc. NH_3.
So, A = $[Cr(NH_3)_4Cl\ Br]Cl$ and B = $[Cr(NH_3)_4Cl_2]Br$.

(ii) In both complexes chromium is in +3 oxidation state. Chromium with $3d^3$ configuration has 3 unpaired electrons with weak field as well as strong field ligand. So, the hybridisation scheme is as follow :



(iii) $\mu = \sqrt{n\ \ (n+2)} = \sqrt{15}$

(iv) EAN = 24 – 3 + 12 = 33

(v) Yes, both have two ions per formula unit.

(vi) $AgCl + 2NH_3 \rightleftharpoons [Ag(NH_3)_2]Cl$; $AgBr + 2NH_3 \rightleftharpoons [Ag(NH_3)_2]Br$

D-2.

	Complex	**Hybridization**	**Geometry**
(a)	$[NiBr_4]^{2-}$	sp^3	Tetrahedral
(b)	$[AuCl_4]^-$	dsp^2	square planar
(c)	$[Pt(NH_3)_4]^{2+}$	dsp^2	square planar

E-1. (i) potasium amminetetracyanidonitrosoniumchromate(I)

(ii) Octahedral

(iii) One unpaired electron

(iv) It is paramagnetic with one unpaired electron

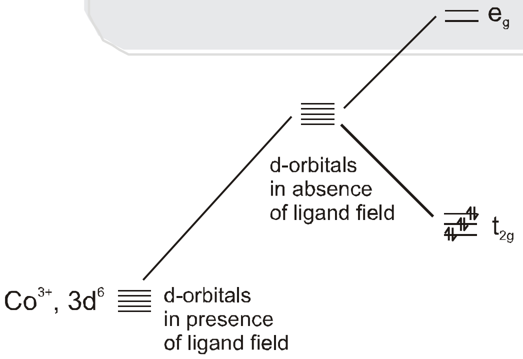
(v) EAN = 24 – 1 + 2 × 6 = 35

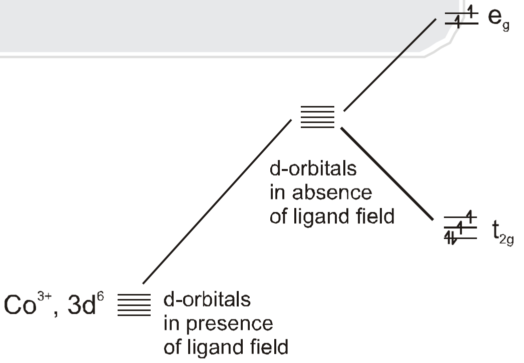
(vi) d^2sp^3

E-2.

	Complex	**Hybridization**	**Geometry**
(a)	$[Fe(CN)_6]^{3-}$	d^2sp^3	octahedral
(b)	$[MnBr_4]^{2-}$	sp^3	Tetrahedral
(c)	$[Fe(H_2O)_6]^{2+}$	sp^3d^2	Octahedral
(d)	$[Co(SCN)_4]^{2-}$	sp^3	Tetrahedral

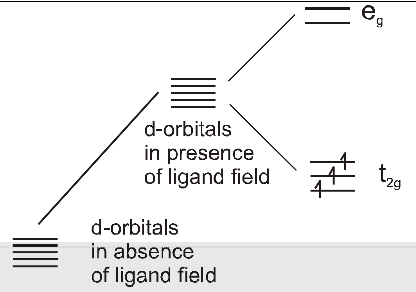
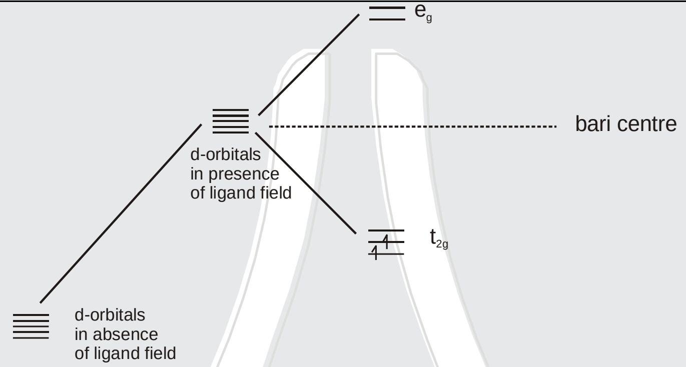
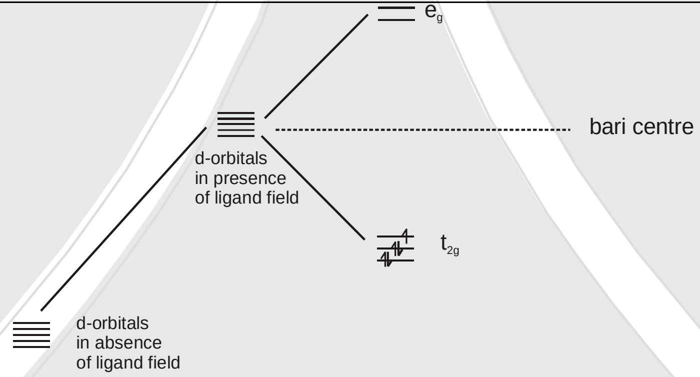
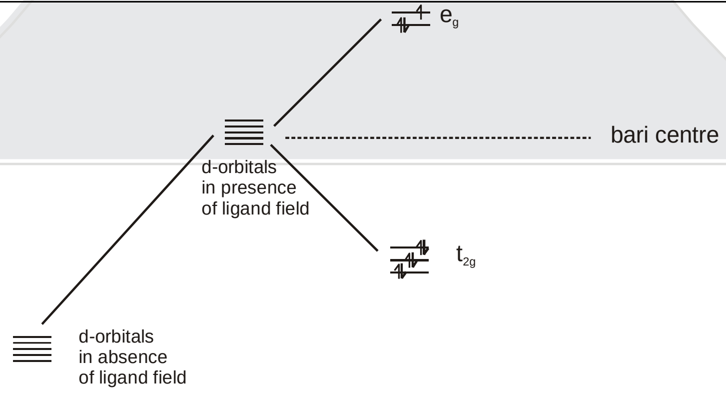
E-3. Since ammonia is a strong field ligand so can pair up the electrons of Co(III), so will form an inner d-orbital complex having zero magnetic moment while fluoride being a weak field ligand can not pair up electrons and forms outer d-complex with higher magnetic moment equal to four unpaired electrons.

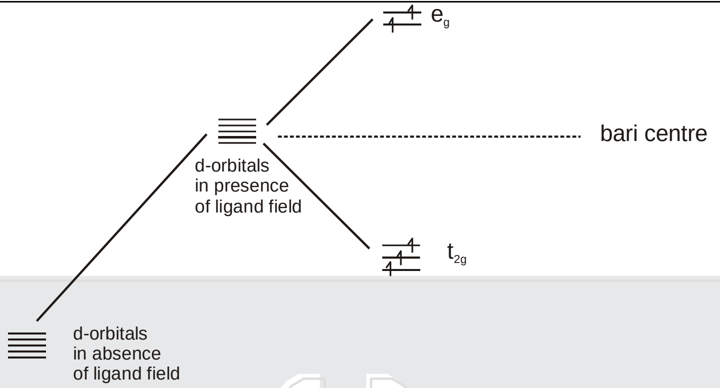




E-4. (a) i < iv < ii < iii (b) X < O < N < C (c) $Br^- < S^{2-} < NO_3^- < H_2O < NH_3 < NO_2^- < CN^- < CO$

E-5.

(a)	F$^-$ is weak field ligand. Cr^{3+}, 3d^3		So number of unpaired electrons = 3
(b)	H$_2$O is weak field ligand. V^{3+}, 3d^2		So number of unpaired electrons = 2
(c)	CN$^-$ is strong field ligand. Fe^{3+}, 3d^5		So number of unpaired electron = 1.
(d)	en is strong field ligand. Cu^{2+}, 3d^9		So number of unpaired electron = 1.

(e)	F⁻ is weak field ligand. Fe^{3+}, $3d^5$		So number of unpaired electrons = 5.

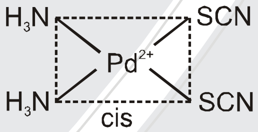
F-1. As $3d^6$ configuration has higher CFSE as compared to $3d^7$ so it gets oxidised in presence of complexing reagent to easily have d^2sp^3 hybridisation.

F-2. yellow colour

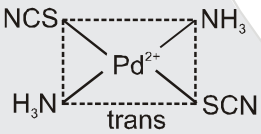
F-3. (a) CN^-, F^-
(b) (i) 0 (ii) 0 (iii) 0 (iv) 0

G-1. (i) Linkage (ii) Coordination (iii) Ionisation (iv) Hydrate

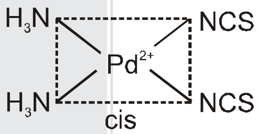
G-2. (a) There are three constitutional isomers
(i) $[Ru(NH_3)_5(NO_2)]Cl$
(ii) $[Ru(NH_3)_5Cl](NO_2)$ or $[Ru(NH_3)_5Cl]ONO$
(iii) $[Ru(NH_3)_5\ ONO]Cl$
(i) & (ii) are ionisation isomers
(i) & (iii) are linkage isomers

(b) (i)


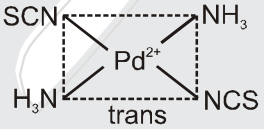
cis

(ii)


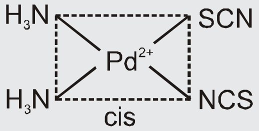
trans

(iii)


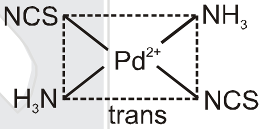
cis

(iv)


trans

(v)


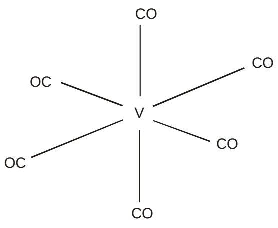
cis

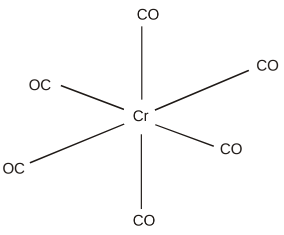
(vi)


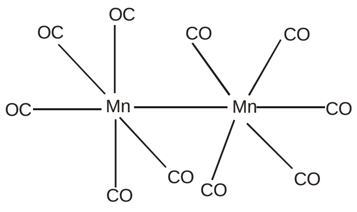
trans

G-3. (a) Two (b) None (c) Two (d) None (e) Two (f) None

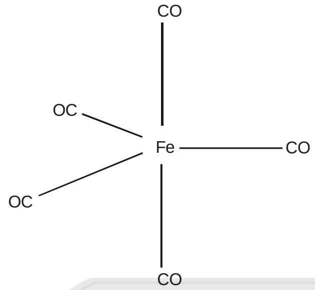
G-4. (a) No ; (b) Yes ; (c) Yes ; (d) Yes ; (e) Yes ; (f) No.

H-1. (a)


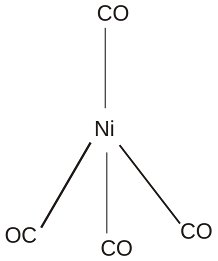
(b)


(c)


(d)



(e)



H-2. (i) Increases (ii) Decreases

PART - II

A-1.	(B)	**A-2.**	(C)	**A-3.**	(A)	**A-4.**	(B)	**A-5.**	(B)
A-6.	(D)	**A-7.**	(B)	**A-8.**	(A)	**A-9.**	(D)	**B-1.**	(C)
B-2.	(A)	**B-3.**	(D)	**B-4.**	(D)	**B-5.**	(C)	**C-1.**	(C)
C-2.	(B)	**C-3.**	(C)	**C-4.**	(A)	**C-5.**	(A)	**C-6.**	(B)
C-7.	(C)	**C-8.**	(D)	**C-9.**	(C)	**D-1.**	(A)	**D-2.**	(C)
D-3.	(C)	**D-4.**	(A)	**D-5.**	(A)	**E-1.**	(C)	**E-2.**	(A)
E-3.	(A)	**E-4.**	(B)	**E-5.**	(A)	**E-6.**	(D)	**E-7.**	(D)
E-8.	(C)	**E-9.**	(A)	**E-10.**	(C)	**E-11.**	(C)	**E-12.**	(C)
F-1.	(B)	**F-2.**	(B)	**F-3.**	(B)	**G-1.**	(C)	**G-2.**	(B)
G-3.	(B)	**G-4.**	(D)	**G-5.**	(C)	**G-6.**	(C)	**H-1.**	(D)
H-2.	(D)								

PART - III

1. (A - p,r,t); (B - p,s,t); (C - p,r,t); (D - q,r)

2. (A - p,q,r); (B - q,r,s) ; (C - p,q,r,s) ; (D - p,q)

EXERCISE - 2

PART - I

1.	(B)	**2.**	(C)	**3.**	(A)	**4.**	(B)	**5.**	(D)
6.	(D)	**7.**	(D)	**8.**	(C)	**9.**	(D)	**10.**	(B)
11.	(B)	**12.**	(A)	**13.**	(A)				

PART - II

1.	13	**2.**	05	**3.**	26	**4.**	(40 + 20) ml = 60 ml
5.	4 (i, iii, iv, vii)	**6.**	3 (a, c, d)	**7.**	2 (i & v)	**8.**	4
9.	4 (0 + 0 + 2 + 0 + 2 = 4)			**10.**	4	**11.**	**12**

PART - III

1.	(BCD)	**2.**	(BC)	**3.**	(ABCD)	**4.**	(B)	**5.**	(BD)
6.	(ABCD)	**7.**	(BD)	**8.**	(AB)	**9.**	(ACD)	**10.**	(BCD)
11.	(BCD)	**12.**	(C)						

PART - IV

1.	(D)	**2.**	(C)	**3.**	(B)	**4.**	(A)	**5.**	(A)
6.	(B)	**7.**	(A)	**8.**	(C)	**9.**	(A)	**10.**	(B)
11.	(C)								

EXERCISE – 3

PART - I

1. IUPAC name is :

Potassium amminetatracyanidonitrosoniumchromate(I)

or Potassium amminetatracyanidonitrocyliumchromate(I).

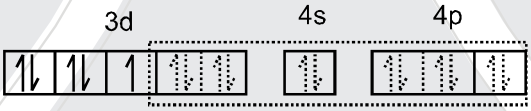
Let n is the number of unpaired electron in the chromium ion.

Since $\mu = \sqrt{n(n+2)}$ or $1.73 = \sqrt{n(n+2)}$ B.M. or $1.73 \times 1.73 = n^2 + 2n$.

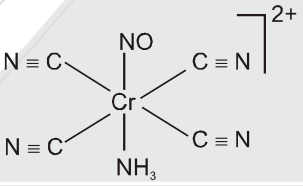
Hence n = 1.

As the CN^- and NH_3 are strong fields ligands, they compel for pairing of electrons. So,

$[Cr(NO)(CN)_4(NH_3)]^{2-}$ =



Hence, the oxidation state of chromium is +1 (having $3d^5$ configuration). So according to charge on the complex NO should be NO^+ and the structure of this complex is octahedral with d^2sp^3 hybridisation as given below



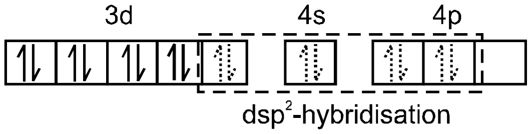
2.	(D)	**3.**	(C)

4. $Ni^{2+} + 2dmg \xrightarrow{NH_4OH} [Ni(dmg)_2] \downarrow$ (bright red).

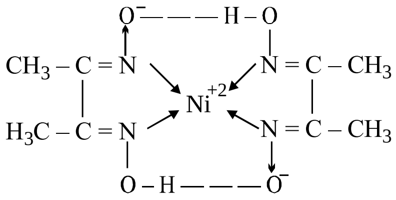
It acquires stability through chelation and intra molecular H-bonding.

In $[Ni(dmg)_2]$ the nickel is in +2 oxidaiton state and to have square planar geometry because of chelation the pairing of electrons takes place. So

$[Ni(dmg)_2]$



As all electrons are paired, so complex is diamagnetic. Nickel with coordination number four will have the structure as given below.



rosy red ppt

5.	(A)	**6.**	(A)	**7.**	(A)	**8.**	(C)	**9.**	(C)
10.	(B)	**11.**	(A - p,q,s); (B - p,r,s); (C - q,s); (D - q,s)					**12.**	(C)
13.	(B)								
14.	(B)	**15.**	(A)	**16.**	(CD)	**17.**	(A)	**18.**	(C)
19.	(B)	**20.**	(B)	**21.**	**3**	**22.**	(B)	**23.**	(C)
24.	6	**25.**	(D)	**26.**	(C)	**27.**	(B)	**28.**	(BD)
29.	**8**	**30.**	4	**31.**	(B)	**32.**	4	**33.**	3
34.	**(6)**	**35.**	(B)	**36.**	**(5)**	**37.**	(A)	**38.**	(BC)
39.	**1**	**40.**	2992	**41.**	(ABD)	**42.**	(C)	**43.**	**(6.00)**

PART - II

1.	(3)	**2.**	(1)	**3.**	(2)	**4.**	(3)	**5.**	(4)
6.	(3)	**7.**	(2)	**8.**	(2)	**9.**	(3)	**10.**	(1)
11.	(1)	**12.**	(4)	**13.**	(3)	**14.**	(2)	**15.**	(1)
16.	(2)	**17.**	(3)	**18.**	(4)	**19.**	(2)	**20.**	(1)
21.	(3)	**22.**	(3)	**23.**	(3)	**24.**	(4)	**25.**	(4)
26.	(3)	**27.**	(3)	**28.**	(1)	**29.**	(4)	**30.**	(3)
31.	(2)	**32.**	(3)	**33.**	(4)	**34.**	(1)	**35.**	(3)
36.	(4)	**37.**	(1)	**38.**	(2)	**39.**	**(Bonus)**	**40.**	(3)
41.	(4)	**42.**	(1)	**43.**	(3)	**44.**	(2)	**45.**	(1)
46.	(3)	**47.**	(4)	**48.**	(1)	**49.**	(2)	**50.**	(2)