SOLVED EXAMPLES

Ex. 1 A solution containing 0.319 gm of complex $CrCl_3 . 6H_2O$ was passed through cation exchanger and the solution given out was neutralised by 28.5 ml of 0.125 M NaOH. The correct formula of the complex will be: [molecular weight of complex = 266.5]

(A) $[CrCl(H_2O)_5]Cl_2 . H_2O$
(B) $[Cr(H_2O)_6]Cl_3$
(C) $[CrCl_2(H_2O)_4]Cl. 2H_2O$
(D) All are correct

Ans. **(B)**

Sol. $Cl^- = HCl = NaOH$

$$nCl^- + nH^+ \longrightarrow nHCl$$

Thus 1 mol of complex will form n mol of HCl

1 mole of complex = n mol of HCl = n mole of NaOH

$$\text{mole of complex} = \frac{0.319}{266.5} = 0.0012; \text{ mole of NaOH used} = \frac{28.5 \times 0.125}{1000} = 0.0036$$

So 0.0012 mole of complex = 0.0036 mole of NaOH = 0.0036 mole of HCl

$$1 \text{ mole of complex} = \frac{0.0036}{0.0012} = 3 \text{ mole of HCl}$$

$\therefore$ n = 3

So complex is $[Cr(H_2O)_6]Cl_3$.

Ex. 2 Calculate the effective atomic number of the metal atoms in the following complexes / complex ions.

(A) $[Cr(CO)_6]$ **(B)** $[Fe(CN)_6]^{3-}$ **(C)** $[Co(CN)_6]^{4-}$ **(D)** $[Ni(NH_3)_6]^{2+}$

[Cr = 24 ; Fe = 26; Co = 27 and Ni = 28 as atomic numbers]

Ans. **(A)** 36 **(B)** 35 **(C)** 37 **(D)** 38

Sol. EAN = Number of electrons in metal atom or ion + Number of electrons donated by ligands to metal.

(A) $[Cr^0(CO)_6]$; EAN = 24 + 12 = 36 ; **(B)** $[Fe^{III}(CN)_6]^{3-}$; EAN = 23 + 12 = 35

(C) $[Co^{II}(CN)_6]^{4-}$; EAN = 25 + 12 = 37 ; **(D)** $[Ni^{II}(NH_3)_6]^{2+}$; EAN = 26 + 12 = 38

Ex. 3 Consider the following complexes :

(i) K_2PtCl_6 **(ii)** $PtCl_4 . 2NH_3$ **(iii)** $PtCl_4 . 3NH_3$ **(iv)** $PtCl_4 . 5NH_3$

their electrical conductance in aqueous solutions are :

(A) 256, 0, 97, 404 **(B)** 404, 0, 97, 256 **(C)** 256, 97, 0, 404 **(D)** 404, 97, 256, 0

Ans. **(A)**

Sol. The electrical conductance of the complexes depend upon the number of ions given by them in the aqueous solutions.

(i) $K_2[PtCl_6] \overset{aq}{\rightleftharpoons} 2K^+(aq) + [PtCl_6]^{2-}(aq)$ **(ii)** $[Pt(NH_3)_2Cl_4] \overset{aq}{\rightleftharpoons} [Pt(NH_3)_2Cl_4](aq)$

(iii) $[Pt(NH_3)_3Cl_3]Cl \overset{aq}{\rightleftharpoons} [Pt(NH_3)_3Cl_3]^+(aq) + Cl^-(aq)$ **(iv)** $[Pt(NH_3)_5Cl]Cl_3 \overset{aq}{\rightleftharpoons} [Pt(NH_3)_5Cl]^{3+} + 3Cl^-$

	Complex	Number of ions	Expected electrical conductance
(i)	$K_2[PtCl_6]$	3	256
(ii)	$[Pt(NH_3)_2Cl_4]$	0	0
(iii)	$[Pt(NH_3)_3Cl_3]Cl$	2	97
(iv)	$[Pt(NH_3)_5Cl]Cl_3$	4	404

So, the correct option is (A).

Ex. 4 Give the order of chelating effect of following ligands.

(i) $C_2O_4^{2-}$ **(ii)** EDTA **(iii)** dien

(A) iii > ii > i **(B)** i > ii > iii **(C)** ii > iii > i **(D)** i > iii > ii

Ans. **(C)**

Sol. As number of donor atoms increases the number of bonds increase. So the chelating effect of ligands increase as oxalato, dien and EDTA has two, three and six donor atoms respectively.

Ex. 5 Write the structural formula corresponding to each of the following IUPAC names :

(A) potassium tetracyanidozincate (II) **(B)** tetracarbonyl nickel (0)

(C) potassium tetracyanonickelate (0) **(D)** potassium tris(oxalato)aluminate (III)

Ans. **(A)** $K_2[Zn^{II}(CN)_4]$ **(B)** $[Ni^0(CO)_4]$ **(C)** $K_4[Ni^0(CN)_4]$ **(D)** $K_3[Al^{III}(C_2O_4)_3]$

Sol. Refer IUPAC rule.

Ex. 6 Write IUPAC names of the following :

(A) $[Cr(acac)_3]$ **(B)** $[V(H_2O)_6]Cl_3$ **(C)** $(NH_4)_3[Co(C_2O_4)_3]$ **(D)** $K_2[CrO_4]$

Ans. **(A)** tris (acetylacetonato) chromium(III)

(B) hexaaqua vanadium (III) chloride

(C) ammonium tris(oxalato)cobaltate(III) or ammonium trioxalatocobaltate(III)

(D) potassium tetraoxidochromate(VI)

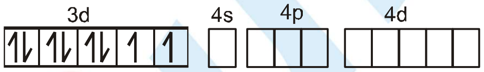
Sol. Refer IUPAC nomenclature rule.

Ex. 7 Explain the following :

(i) All the octahedral complexes of Ni^{2+} must be outer orbital complexes.

(ii) $[CoF_6]^{3-}$ is paramagnetic but $[Co(CN)_6]^{3-}$ is diamagnetic.

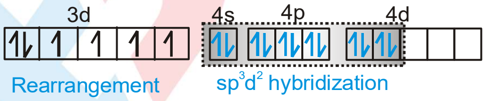
Sol. (i) Ni^{2+} configuration



During rearrangement only one 3d-orbital may be made available for pairing of the electrons. Thus, d^2sp^3 hybridization is not possible. So only sp^3d^2 (outer) hybridization can occur.

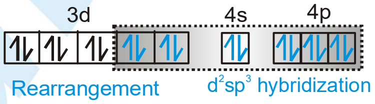
(ii) In $[CoF_6]^{3-}$, Co^{3+} undergoes sp^3d^2 hybridization. Four d-orbitals are singly occupied. Hence, it is paramagnetic.

$[CoF_6]^{3-}$



In $[Co(CN)_6]^{3-}$, Co^{3+} undergoes d^2sp^3 hybridization. All electrons are paired and thus it is diamagnetic.

$[Co(CN)_6]^{3-}$



Ex. 8 You are given the following two complexes X and Y which are isomers of each other ; X is $Hg[Co(SCN)_4]$. It is further given that 'spin only' magnetic moment of X is found to be 3.78 B.M. and that of Y is 1.73 B.M. Then which of the following is correct ?

(A) Anion of X will be tetrahedral and that of Y will be square planar.

(B) Anion of X will be square planar but that of Y will be tetrahedral

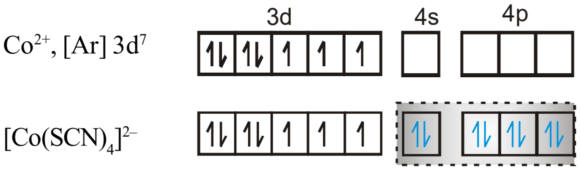
(C) Both the anions will be tetrahedral

(D) Both the anions will be square planar

Ans. **(A)**

Sol. In Hg $[Co(SCN)_4]$ (X) , the cobalt is in +2 oxidation state.

$\mu = \sqrt{n(n+2)}$; So, 3.78 B.M $= \sqrt{n(n+2)}$ or n = 3. So,

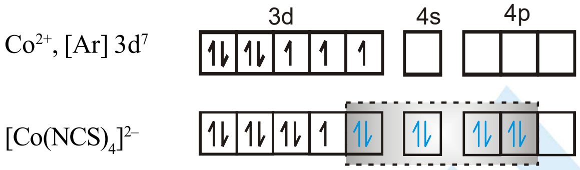


sp^3 hybrid orbitals

Four pairs of electrons from four SCN$^-$ ions.

In Hg $[Co(NCS)_4]$ (Y), the cobalt is in +2 oxidation state. Further 'spin only' magnetic moment of complex, $Hg[Co(NCS)_4]$ is 1.73 B.M. So,

$\mu = \sqrt{n(n+2)}$; So, 1.73 B.M $= \sqrt{n(n+2)}$ or n = 1.



dsp^2 hybrid orbitals

Four pairs of electrons from four NCS$^-$ ions.

So, X is tetrahedral and Y is square planar.

Ex. 9 All the following complexes show a decreases in their weights when placed in a magnetic balance. Then which of the these has square planar geometry ?

(A) $Ni(CO)_4$ **(B)** $K[AgF_4]$ **(C)** $Na_2[Zn(CN)_4]$ **(D)** None of these

Ans. **(B)**

Sol. In K $[AgF_4]$, Ag(III) has 4d^8 configuration. This has higher CFSE which favours pairing of electrons and thus complex is diamagnetic and square planar.

Ex. 10 Which of the following statements is not correct?

(A) $[Ni(H_2O)_6]^{2+}$ and $[Ni(NH_3)_6]^{2+}$ have same value of CFSE

(B) $[Ni(H_2O)_6]^{2+}$ and $[Ni(NH_3)_6]^{2+}$ have same value of magnetic moment

(A) Only a **(B)** Only b **(C)** Both a and b **(D)** None of these

Ans. **(A)**

Sol. **(A)** Ammonia is a stronger field ligand than water. So $[Ni(NH_3)_6]^{2+}$ will have higher CFSE than $[Ni(H_2O)_6]^{2+}$.

(B) Both complexes $[Ni(H_2O)_6]^{2+}$ and $[Ni(NH_3)_6]^{2+}$ have sp^{3}d^2 hybridisation with two unpaired electrons. So, they possess same magnetic moment ('spin only')

Ex. 11 **Statement-1 :** $[Co^{II}(NH_3)_6]^{2+}$ is not readily oxidized to $[Co^{III}(NH_3)_6]^{3+}$ when air is bubbled through it.

Statement-2 : Crystal field stabilization energy of Co(+III) with a d^6 configuration is higher than for Co(+II) with a d^7 arrangement.

(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

Ans. **(D)**

Sol. Statement 1 is false statement. $[Co^{II}(NH_3)_6]^{2+}$ is readily oxidised in $[Co^{III}(NH_3)_6]^{3+}$ in presence of air due to the higher CFSE value $(-2.4\Delta_o)$ of d^6 configuration than d^7 configuration $(-0.8\,\Delta_o)$.

Ex. 12 Which of the following is true about the complex $[PtCl_2(NH_3)(OH_2)]$? [Atomic number of Pt = 78]

(i) It will have two geometrical isomeric forms, cis and trans.

(ii) The hybridisation state of Pt(II) is sp^3.

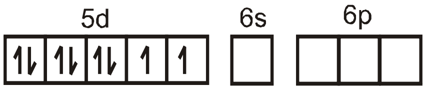
(iii) It is a square planar complex. **(iv)** It is a diamagnetic complex.

(v) It can show hydrate isomerism. **(vi)** It is a tetrahedral complex.

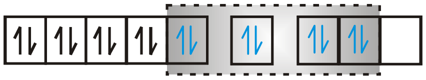
(A) (i), (iii),(iv) **(B)** (ii),(iv),(v) **(C)** (ii),(v),(vi) **(D)** (i),(v),(vi)

Ans. (A)

Sol. Pt^{2+}, $[Xe]4f^{14}5d^8$



$[PtCl_2(NH_3)(OH_2)]$

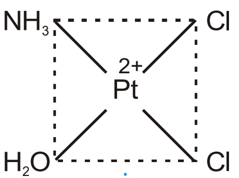


diamagnetic

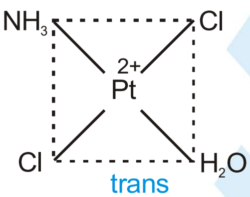
dsp^2 hybrid orbitals

Four pairs of electrons from four Cl^- ions.

Ma_2bc have cis- and trans isomers.



cis



trans

Ex. 13 It is an experimental fact that $Cs_2[CuCl_4]$ is orange coloured but $(NH_4)_2[CuCl_4]$ is yellow. It is further known that total paramagnetic moment of a unpaired electron is due to spin as well as due to nature of orbital ; 'd' orbital contributing more than 's' or 'p'. Thus the total paramagnetic moment of orange compound is found to be more than that of yellow compound. Then which of the following is correct ?

(A) Anion of orange compound is tetrahedral and that of yellow is square planar

(B) Anion of orange compound is square planar and that of yellow is tetrahedral

(C) Both the anions are tetrahedral

(D) Both the anions are square planar

Ans. (A)

Sol. $Cs_2[CuCl_4]$ (orange) is tetrahedral because in Cu(II) the unpaired electron is in 3d. But $(NH_4)_2[CuCl_4]$ (yellow) is square planar because the unpaired electron is not in 3d rather in some promoted state 's' or 'p'.

Ex. 14 It is an experimental fact that :

$$DMG + Ni(II)salt + NH_4OH \longrightarrow \text{Red precipitate}$$

Which of the following is wrong about this red precipitate?

(A) It is a non–ionic complex.

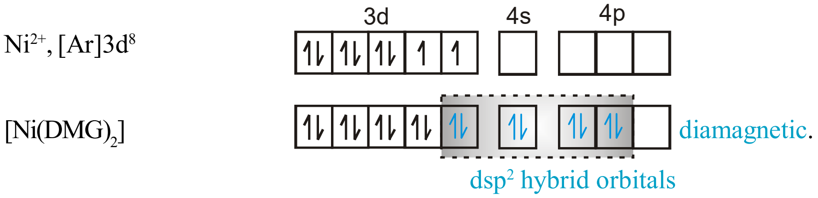
(B) It involves intra molecular H–bonding.

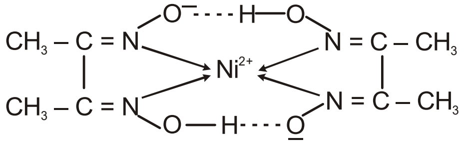
(C) Ni(II) is sp^3 hybridised.

(D) It is a diamagnetic complex.

Ans. (C)

Sol. In complex $[Ni(DMG)_2]$, the nickel is in +2 oxidation state ; the ion has the electronic configuration $3d^8$ and dimethylglyoxime is a chelating ligand. So, the hybridisation scheme is as shown in figure.





square planar

Ex. 15 The correct order for the CFSE (numerical value) for the following complexes is :

Complex	P	Q	R	S
Formula	$[CoF_6]^{3-}$	$[Co(CN)_6]^{3-}$	$[Co(NH_3)_6]^{3+}$	$[Co(H_2O)_6]^{3+}$

(A) P > Q > R > S **(B)** Q > R > S > P **(C)** S > R > P > Q **(D)** R > Q > P > S

Ans. **(B)**

Sol. CFSE depends on the relative magnitude of crystal field splitting, Δ_o and pairing energy, p and in turns Δ_o depends upon the field produced by ligand and charge on the metal ion. So,the order of increasing crystal field strength is $F^- < H_2O < NH_3 < CN^-$. (Co is in +3 oxidation state in all complexes). Thus the (B) option is correct.

Ex. 16 π-bonding is not involved in :

(A) ferrocene **(B)** dibenzenechromium **(C)** Zeise's salt **(D)** Grignard's reagent

Ans. **(D)**

Sol. RMgX i.e. Grignard's reagent is σ bonded complex.

Ex. 17 Wilkinson's catalyst contains :

(A) rhodium **(B)** iron **(C)** aluminium **(D)** cobalt

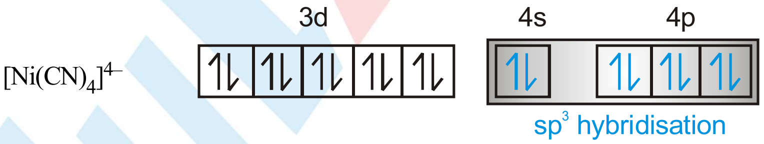
Ans. **(A)**

Sol. Wilkinson's catalyst is $[Rh(I)Cl(PPh_3)_3]$. So it contains rhodium.

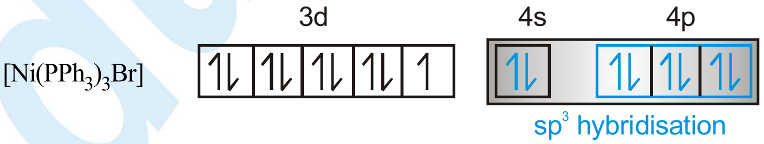
Ex. 18 Among $[Ni(CN)_4]^{4-}$, $[Ni(PPh_3)_3Br]$ and $[Ni(dmg)_2]$ species, the hybridisation states of the Ni-atoms are respectively:

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

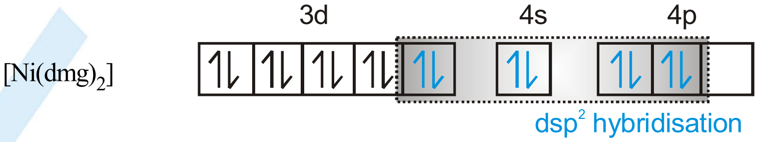
Sol. $[Ni(CN)_4]^{4-}$ - Ni is in zero oxidation state. The CN^- is strong field ligand and, therefore, rearrangement of electrons occur. So,



$[Ni(PPh_3)_3Br]$ - Ni is in +1 oxidation state with $3d^9$ configuration (PPh_3 is a strong field ligand). So,



$[Ni(dmg)_2]$ - Ni is in +2 oxidation state with $3d^8$ configuration. (dmg is a chelating ligand). So,



Ex. 19 For the reaction $Ni^{2+} + 4NH_3 \rightleftharpoons [Ni(NH_3)_4]^{2+}$;

at equilibrium, if the solution contains $1.6 \times 10^{-4}\%$ of nickel in the free state, and the concentration of NH_3 at equilibrium is 0.5 M. Then the instability constant of the complex will be approximately equal to :

(A) 1.0×10^{-5} **(B)** 1.5×10^{-16} **(C)** 1.0×10^{-7} **(D)** 1.5×10^{-17}

Ans. **(C)**

Sol. $Ni^{2+} + 4\,NH_3 \rightleftharpoons [Ni(NH_3)_4]^{2+}$

$$\therefore \quad k = \frac{[Ni(NH_3)_4]^{2+}}{[Ni^{2+}][NH_3]^4}$$

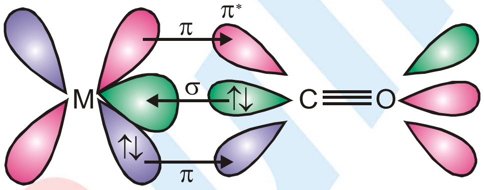
But $\dfrac{[Ni^{2+}]}{[Ni^{2+}]+[Ni(NH_3)_4]^{2+}} = 1.6 \times 10^{-6}$ or $\dfrac{Ni^{2+}}{[Ni(NH_3)_4]^{2+}} \approx 1.6 \times 10^{-6}$

$$\therefore \quad k = \frac{10^6}{1.6 \times (0.5)^4} = 10^7$$

Hence instability constant = 10^{-7}

Ex. 20 In metal carbonyls the metal carbon bond length is found to be less than the expected bond length. Explain why ?

Sol. It is due to synergic interaction between metal and CO which develops partial double bond character between metal and CO.



Synergic bonding

Exercise # 1

[Single Correct Choice Type Questions]

1. Which of the following is not correctly matched ?

(A) $[Fe(en)_3]^{3+}$ - sp^3d^2 and paramagnetic

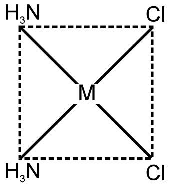
(B) $[FeCl_4]^{2-}$ - sp^3 and paramagnetic

(C) $[Fe(CN)_6]^{3-}$ - d^2sp^3 and paramagnetic

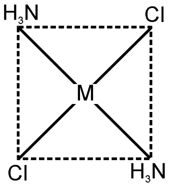
(D) $[Fe(CO)_2(NO^+)_2]$ - sp^3 and diamagnetic

2. Which of the following isomers of $[M(NH_3)_2Cl_2]$ would react with silver oxalate $(Ag_2C_2O_4)$ to give a coordination compound ?

(A)



(B)



(C) Both

(D) None

3. 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

4. The hybridisation of $[CoF_6]^{3-}$ and $[Co(C_2O_4)_3]^{3-}$ are :

(A) both sp^3d^2

(B) both d^2sp^3

(C) sp^3d^2 and d^2sp^3 respectively

(D) d^2sp^3 and sp^3d^2 respectively

5. Consider the following statements ;

S1 : The $[Co(ox)_3]^{3-}$ complex is diamagnetic and gains stability through chelation.

S2 : The $[Co(NO_2)_6]^{4-}$ is inner orbital complex involving d^2sp^3 hybridisation and is paramagnetic.

S3 : The complex $[PtCl_4]^{2-}$ is square planar and diamagnetic.

and arrange in the order of true / false

(A) T T T **(B)** F F T **(C)** T F T **(D)** T T F

6. Select the correct statement ;

(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 $[Co(NH_3)_5 SO_4]Br$ 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) All of these

7. 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

8. 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.

9. Which of the following has dsp^2 hybridisation and is diamagnetic in nature ?

(I) $Na_4[Cr(CO)_4]$ **(II)** $[Ni(DMGH)_2]$ **(III)** $[PtHBr(PEt_3)_2]$

(IV) $[Ag(SCN)_4]^{3-}$ **(V)** $[AuBr_4]^-$

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

10. Of the following complex ions, one exhibits isomerism. That is :

(A) $[Ag(NH_3)_2]^+$ **(B)** $[Co(NH_3)_5NO_2]^{2+}$ **(C)** $[Pt(en)Cl_2]$ **(D)** $[Co(NH_3)_5Cl]^{2+}$

11. Which of the following compounds show optical isomerism ?

1. cis - $[Co(NH_3)_4Cl_2]^+$ 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

12. Which one of the following high-spin complexes has the largest CFSE (Crystal field stabilization energy) ?

(A) $[Mn(H_2O)_6]^{2+}$ **(B)** $[Cr(H_2O_6)]^{2+}$ **(C)** $[Mn(H_2O)_6]^{3+}$ **(D)** $[Cr(H_2O)_6]^{3+}$

13. 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

14. 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

15. 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.

16. Which of the following is/are inner orbital complex(es) as well as diamagnetic in nature ?

(A) $[Zn(NH_3)_6]^{2+}$ **(B)** $[Ni(NH_3)_6]^{2+}$ **(C)** $[Cr(NH_3)_6]^{3+}$ **(D)** $[Co(NH_3)_6]^{3+}$

[Atomic Number : Cr = 24, Mn = 25, Fe = 26, Co = 27].

17. 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)** $[Cr(OX)_3]^{3-}$

18. Which of the following is/are inner orbital complexes as well as paramagnetic with magnetic moment equal to 3.78 (approximate)?

(A) $[Co(ox)_3]^{3-}$ **(B)** $[Cr(NH_3)_6]^{3+}$ **(C)** $[Fe(H_2O)_5NO]^{2+}$ **(D)** $[Zn(NH_3)_6]^{2+}$

19. 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

20. Among the following, metal carbonyls, the C—O bond is strongest :

(A) $[Mn(CO)_6]^+$ **(B)** $[Cr(CO)_6]$ **(C)** $[V(CO)_6]^-$ **(D)** $[Ti(CO)_6]^{2-}$

21. A square planar complex is formed by hybridization of which atomic orbitals ?

(A) s, p_x, p_y, d_{yz} **(B)** s, p_x, p_y, $d_{x^2-y^2}$ **(C)** s, p_x, p_y, d_{z^2} **(D)** s, p_x, p_y, d_{xy}

22. 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

23. Complex ion $[\text{FeN}_3(\text{O}_2)(\text{SCN})_4]^{4-}$ 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)

24. Trioxalatoaluminate(III) and tetrafluoro-borate(III) ions are:

(A) $[\text{Al}(\text{C}_2\text{O}_4)_3]$, $[\text{BF}_4]^{3-}$
(B) $[\text{Al}(\text{C}_2\text{O}_4)_3]^{3+}$, $[\text{BF}_4]^{3+}$
(C) $[\text{Al}(\text{C}_2\text{O}_4)_3]^{3-}$, $[\text{BF}_4]^{-}$
(D) $[\text{Al}(\text{C}_2\text{O}_4)_3]^{2-}$, $[\text{BF}_4]^{2-}$

25. Which of the following are bidentate monoanion ligands ?

(1) Acetylacetonato
(2) Oxalato ion
(3) Dimethylglyoximato

Select the correct answer using the codes given below :

(A) 1 only
(B) 1 and 3 only
(C) 3 only
(D) 2 and 3 only

26. Diethylenetriamine is:

(A) chelating agent
(B) tridentate neutral molecule
(C) tridentatemonoanion
(D) **(A)** and **(B)** both

27. $\text{Na}_2\text{S} + \text{Na}_2[\text{Fe}(\text{CN})_5\text{NO}] \longrightarrow \text{Na}_4[\text{Fe}(\text{CN})_5\text{NOS}]$; oxidation number of Fe in reactant (complex) and product (complex) are :

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

28. 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

29. Which of the following is correct for both the following coordination compounds ?

(I) $\text{CoCl}_3.6\text{NH}_3$ and **(II)** $\text{PtCl}_4.5\text{NH}_3$

(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

30. In which of the following complexes the nickel metal is in highest oxidation state ?

(A) $\text{Ni}(\text{CO})_4$
(B) K_2NiF_6
(C) $[\text{Ni}(\text{NH}_3)_6](\text{BF}_4)_2$
(D) $\text{K}_4[\text{Ni}(\text{CN})_6]$

31. $K_6[(CN)_5\ Co - O - O - Co(CN)_5] \xrightarrow{\text{oxidizes}} K_5[(CN)_5\ Co - O - O - Co(CN)_5]$

(X) **(Y)**

In both the complexes Co have $t_{2g}^{6}e_g^{0}$ configuration.
The bond energy of (O — O) in X and Y is :
(A) bond energy of (O — O) in Y < bond energy of (O — O) in X.
(B) bond energy of (O — O) in X < bond energy of (O — O) in Y.
(C) bond energy of (O — O) in X = bond energy of (O — O) in Y.
(D) bond energy of (O — O) in X and bond energy of (O — O) in Y can't be comparable.

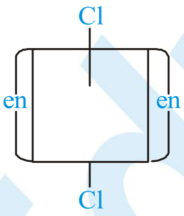
32. Consider the following statements and select the correct option using the codes given.
(i) $[Cr(NH_3)_6][Cr(CN)_6]$ and $[Cr(NH_3)_4(CN)_2]\,[Cr(NH_3)_2(CN)_4]$ are coordination isomers.
(ii) $[Cr(py)_2(H_2O)_2Cl_2]Cl$ and $[Cr(py)_2(H_2O)Cl_3]H_2O$ are ligand isomers.
(iii) $[Pt(NH_3)_4Br_2]Cl_2$ and $[Pt(NH_3)_4Cl_2]Br_2$ are linkage isomers.
(iv) $[NiCl_2(PPh_3)_2]$ (tetrahedral) exhibits geometrical isomerism.
(A) (i) only **(B)** (i) and (ii) only **(C)** (ii) and (iii) only **(D)** (iii) and (iv) only

33. How many moles of AgCl would be obtained, when 100 ml of 0.1 M $Co(NH_3)_5Cl_3$ is treated with excess of $AgNO_3$?
(A) 0.01 **(B)** 0.02 **(C)** 0.03 **(D)** none of these

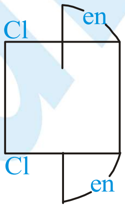
34. Aqueous solution of nickel sulphate on treating with pyridine and then adding a solution of sodium nitrite gives dark blue crystals of :
(A) $[Ni(py)_4]SO_4$ **(B)** $[Ni(py)_2(NO_2)_2]$ **(C)** $[Ni(py)_4](NO_2)_2$ **(D)** $[Ni(py)_3(NO_2)]_2SO_4$

35. Given that the energy of the photons of different colours decreases in the order of **vibgyor** (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

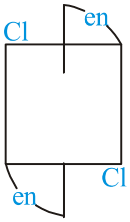
36. Which of the following pairs of structures shows geometrical isomerism ?



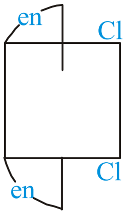
I



II



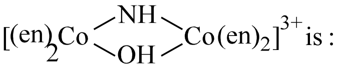
III



IV

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

37. The oxidation number of Co in the complex ion



$[(en)_2Co\begin{smallmatrix}NH\\OH\end{smallmatrix}Co(en)_2]^{3+}$ is :

(A) +2 **(B)** +3 **(C)** +4 **(D)** +6

38. 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

39. 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)** $Co_2(CO)_{10}$

40. Complexes $[Co(NH_3)_5SO_4]Br$ and $[Co(NH_3)_5Br]SO_4$ can be distinguished by :

(A) conductance measurement **(B)** using $BaCl_2$

(C) using $AgNO_3$ **(D)** all of these

41. 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) $Co(NH_3)_4Cl_3$ **(B)** $[Co(NH_3)_4Cl_2]Cl$ **(C)** $[Co(NH_3)_4Cl_3$ **(D)** $[CoCl_3(NH_3)]NH_3$

42. Which of the following is non–conducting ?

(A) $CoCl_3.6NH_3$ **(B)** $CoCl_3.5NH_3$

(C) $CoCl_3.4NH_3$ **(D)** $CoCl_3.3NH_3$

43. Which of the following complexes is not a chelate ?

(A) bis(dimethylglyoximato)nickel(II)

(B) potassium ethylenediaminetetrathiocyanatochromate (III)

(C) tetramminediazidocobalt(III) nitrate

(D) trans-diglycinatoplatinum(II)

44. Select the correct statement from the following .

(A) $[Sc(H_2O)_6]^{3+}$ and $[Ti(H_2O)_6]^{3+}$ both are colourless.

(B) $Co(NH_3)_4Br_2Cl$ show ionization isomers and geometrical isomers.

(C) $[Pd(NO_2)_2(NH_3)_2]$ is square planar and shows geometrical as well as linkage isomers.

(D) Both (B) and (C) are correct.

45. Which of the following statements is correct for complex $[Cr(NH_3)(CN)_4(NO)]^{2-}$ (given that n = 1)?

(A) It is d^2sp^3 hybridised .

(B) The chromium is in + I oxidation state

(C) It is heteroleptic complex and its aqueous solution is coloured

(D) All of these.

46. Which of the following is correct for the complex $[NiBr_2(PPh_3)_2]$?

(A) It is square planar with one unpaired electron

(B) It is tetrahedral with two unpaired electrons

(C) It is square planar and diamagnetic

(D) It is tetrahedral with one unpaired electron.

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

(A) $[Cr(H_2O)_6]^{3+}$ and $[Fe(H_2O)_5NO]^{2+}$

(B) $[Mn(CN)_6]^{4-}$ and $[Fe(CN)_6]^{3-}$

(C) $[Ni(CO)_4]$ and $[Zn(NH_3)_4]^{2+}$

(D) All of these.

48. Consider the following statements

S1 : $[\text{Cr}(\text{NH}_3)_6]^{3+}$ is a inner orbital complex with crystal field stabilization energy equal to $-1.2\,\Delta_o$

S2 : 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.

S3 : $\text{Na}_2\text{S} + \text{Na}_2[\text{Fe}(\text{CN})_5\text{NO}] \longrightarrow \text{Na}_4[\text{Fe}(\text{CN})_5\text{NOS}]$, In reactant and product the oxidation states of iron are same

and arrange in the order of true/false.

(A) F T F **(B)** T T F **(C)** T T T **(D)** F F F

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

(A) 2.83 B.M. **(B)** 3.87 B.M. **(C)** 5.92 B.M. **(D)** 1.73 B.M.

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

	Column - I (Complex)		**Column - II (Hybridisation)**
(I)	$[\text{AuF}_4]^-$	**(p)**	dsp^2 hybridisation
(II)	$[\text{Cu(CN)}_4]^{3-}$	**(q)**	sp^3 hybridisation
(III)	$[\text{Co}(\text{C}_2\text{O}_4)_3]^{3-}$	**(r)**	sp^3d^2 hybridisation
(IV)	$[\text{Fe}(\text{H}_2\text{O})_5\text{NO}]^{2+}$	**(s)**	d^2sp^3 hybridisation

Codes :

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

51. $$\underset{\text{Brown}}{[(\text{NH}_3)_5\text{Co}-\text{O}-\text{O}-\text{Co}(\text{NH}_3)_5]^{4+}} \xrightarrow[\text{oxidise}]{[\text{S}_2\text{O}_8]^{2-}} \underset{\text{Green}}{[(\text{NH}_3)_5\text{Co}-\text{O}-\text{O}-\text{Co}(\text{NH}_3)_5]^{5+}}$$

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 oxidation state 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

52. The complex $[\text{Fe}(\text{H}_2\text{O})_5\text{NO}]^{2+}$ is formed in the 'brown ring test' for nitrates. Choose the incorrect statement for the complex.

(A) Its magnetic moment is approximately 3.9 B.M.
(B) The oxidation state of iron is + 1
(C) The hybridisation of central metal ion is sp^3d^2
(D) The brown colour of the ring is due to d – d transition.

53. Which of the following complexes is correctly matched with their geometries ?

(A) $[\text{Co(py)}_4]^{2+}$ - square planar **(B)** $[\text{Cu(CN)}_4]^{3-}$ - tetrahedral

(C) $[\text{Fe(CO)}_4]^{2-}$ - tetrahedral **(D)** All of these

54. What will be the correct order for the wave length of light observed for the following ?

(I) $[\text{Ni}(\text{NO}_2)_6]^{4-}$, (II) $[\text{Ni}(\text{NH}_3)_6]^{2+}$; (III) $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$

(A) I > II > III **(B)** II > I > III **(C)** III > II > I **(D)** II > III > I

55. Which one of the following statement is false for nickel-dimethylglyoximate complex ?

(A) The stability of complex is only due to the presence of intra-molecular hydrogen bonding.

(B) The complex is stable because tridentate dimethyl glyoxime ligand forms a five membered chelate rings.

(C) The complex is stable as it has five membered chelate rings as well as intra molecular hydrogen bonding.

(D) A and B both.

56. Which of the following statements are correct for the complex $[Co(NH_3)_4(Cl)(NO_2)]Cl$?

1. Cobalt is in +III oxidation state involving d^2sp^3 hybridisation.
2. Cobalt is in +III oxidation state involving sp^3d^2 hybridisation.
3. It shows ionisation as well as linkage isomerism.
4. It also shows geometrical isomerism.

(A) 1, 3 and 4 only **(B)** 2, 3 and 4 only **(C)** 1 and 4 only **(D)** 2 and 4 only.

57. Which of the following complexes are low spin and diamagnetic ?

(1) $K_4[Os(CN)_6]$ (2) $[Mo(CO)_6]$ (3) $[Mn(CN)_6]^{4-}$

Select the correct answer using the codes given below.

(A) 1, 2 and 3 **(B)** 1 and 2 only **(C)** 1 and 3 only **(D)** 2 and 3 only

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

(A) it is a low spin complex. **(B)** it is diamagnetic.

(C) it shows geometrical isomerism. **(D)** **(A)** and **(B)** both.

59. For Co(II), (choose incorrect statement) :

(A) tetrahedral complexes are generally formed with monodentate anionic ligands like N_3^-, OH^- etc.

(B) planar complexes are formed with bidentate monoanions like dmg, o-aminophenoxide etc.

(C) planar complexes are also formed with a neutral bidentate ligands like ethylenediamine

(D) none of these

60. Which of the following are square planar complexes ?

(1) $[AuCl_4]^-$ (2) $[Pt(Cl)_4]^{2-}$ (3) $[Mn(Br)_4]^{2-}$ (4) $[Cu(NH_3)_4]^{2+}$

Select the correct answer using the codes given below.

(A) 1 and 2 only **(B)** 2 and 3 only **(C)** 2 and 4 only **(D)** 1, 2 and 4 only

61. Which of the following statements is incorrect ?

(A) Potassium amminetetracyanidonitrosoniumchromate(I) having $\mu = 1.73$ 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 $[Cr(NH_3)_4ClBr]Cl$

62. Which of the following complex involves d^2sp^3 hybridisation ?

(A) $[Co(H_2O)_6]^{3+}$ **(B)** $[CoF_6]^{3-}$ **(C)** $[Mn(H_2O)_6]^{2+}$ **(D)** $[Fe(H_2O)_6]^{3+}$

63. Which of the following statements is false ?

(A) Complex of Pt (+II) and Au (+III) are square planar - including those with weak field ligands such as halide ions.

(B) In tetrahedral complex , the t_{2g} orbitals are nearer to the direction of the ligands.

(C) For d^o, d^5 and d^{10} arrangements the CFSE is zero in both octahedral and tetrahedral complexes with weak field ligands.

(D) None.

64. Which of the following statements is not correct?

(A) $Ti(NO_3)_4$ 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.

65. The $[Fe(CN)_6]^{3-}$ complex ion :

(A) exhibits planar geometry
(B) is diamagnetic
(C) should be very stable
(D) has 2 unpaired electrons

66. The disodium salt of ethylenediaminetetracetic acid can be used to estimate the following ion(s) in the aqueous solution.

(A) Mg^{2+} ion
(B) Ca^{2+} ion
(C) Na^+ ion
(D) both Mg^{2+} and Ca^{2+}

67. Consider the following statements ;

(I) $[Mn(H_2O)_4]SO_4$ is paramagnetic and square planar.
(II) Crystal field splitting energy (i.e. Δ_O), in $[Cr(H_2O)_6]^{3+}$ is higher than in $[Cr(H_2O)_6]^{2+}$
(III) Wilkinson catalyst, a red–violet complex $[RhCl(Ph_3P)_3]$ is diamagnetic and square planar.
(IV) $Hg[Co(SCN)_4]$, a deep blue complex is paramagnetic and tetrahedral.

and of these select the correct one from the given codes.

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

68. Which of the following complex will show optical activity ?

(A) trans -$[Co(NH_3)_4Cl_2]^+$
(B) $[Cr(H_2O)_6]^{3+}$
(C) cis -$[Co(NH_3)_2(en)_2]^{3+}$
(D) trans -$[Co(NH_3)_2(en)_2]^{3+}$

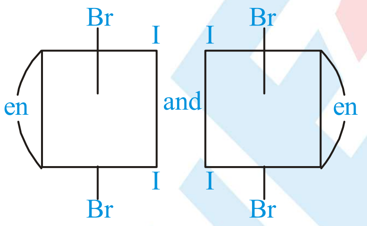
69. The structure of iron pentacarbonyl is : ($\mu = 0$)

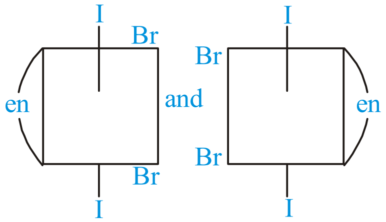
(A) square planar
(B) trigonal bipyramid
(C) triangular
(D) none of these

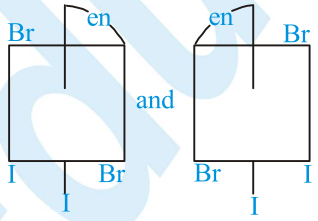
70. A complex of certain metal has the magnetic moment of 4.91 BM whereas another complex of the same metal with same oxidation state has zero magnetic moment. The metal ion could be :

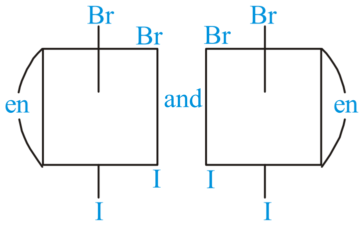
(A) Co^{2+}
(B) Mn^{2+}
(C) Fe^{2+}
(D) Fe^{3+}

71. The complex ion has two optical isomers. Their correct configurations are :

(A)


(B)


(C)


(D)


72. What is the ratio of uncomplexed to complexed Zn^{2+} ion in a solution that is 10 M in NH_3, if the stability constant of $[Zn(NH_3)_4]^{2+}$ is 3×10^9 ?

(A) 3.3×10^{-9}
(B) 3.3×10^{-11}
(C) 3.3×10^{-14}
(D) 3×10^{-13}

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

(A) It is paramagnetic and high spin complex
(B) It is diamagnetic and high spin complex
(C) It is diamagnetic and low spin complex
(D) It is paramagnetic and low spin complex

74. 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.

75. 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

76. 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 :

(A) $I^- < H_2O < NH_3 < CN^-$
(B) $CN^- < I^- < H_2O < NH_3$
(C) $CN^- < NH_3 < H_2O < I^-$
(D) $NH_3 < H_2O < I^- < CN^-$

77. 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 : $[Fe(H_2O)_6]^{3+}$

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

78. Which of the following complex does not show geometrical isomerism ?

(A) $[Co(NH_3)_4Cl_2]^+$
(B) $[Co(NH_3)_3(NO_2)_3]$
(C) $[Cr(en)_3]^{3+}$
(D) $[Pt(gly)_2]$

79. If excess of $AgNO_3$ solution is added to 100 mL of a 0.024 M solution of dichlorobis(ethylenediamine)cobalt (III) chloride. How many moles of AgCl be precipitated ?

(A) 0.0012
(B) 0.0016
(C) 0.0024
(D) 0.0048

80. Which is true for $[Ni(en)_2]^{2+}$? (Atomic number of nickel is 28)

(A) Paramagnetism, dsp^2, square planar, coordination number of Ni = 2
(B) Diamagnetism, dsp^2, square planar, coordination number of Ni = 4
(C) Diamagnetism, sp^3, tetrahedral, coordination number of Ni = 4
(D) Paramagnetism, sp^3, tetrahedral, coordination number of Ni = 4

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

(A) $[Co(NH_3)_6]^{3+}$
(B) $[Co(H_2O)_6]^{3+}$
(C) $[Co(NH_3)_2(H_2O)_4]^{3+}$
(D) $[Co(en)_3]^{3+}$

82. 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

(A) 1, 2, 3 and 4 are correct
(B) 1, 3 and 4 are correct only
(C) 1 and 2 are correct only
(D) 2, 3 and 4 are correct only

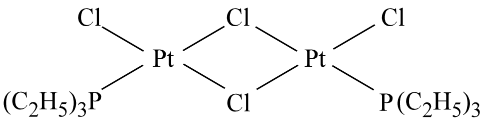
83. Which of the following complexes show geometrical as well as optical isomerism ?

(1) $[Cr(OX)_3]^{3-}$
(2) $[Rh(en)_2Cl_2]^+$
(3) $[Co(NH_3)_2(Cl)_2(en)]^+$

Select the correct answer using the codes given below.

(A) 1 only
(B) 1 and 2 only
(C) 2 and 3 only
(D) All 1, 2, 3

84. The complexes given below show :



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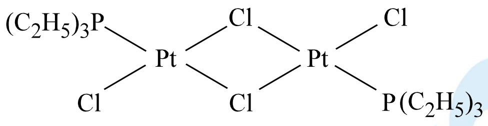
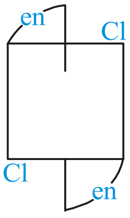


(A) optical isomerism **(B)** co-ordination isomerism
(C) geometrical isomerism **(D)** bridged isomerism

85. Of the following configurations, the optical isomers are :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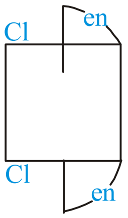
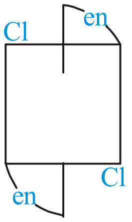

II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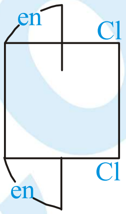
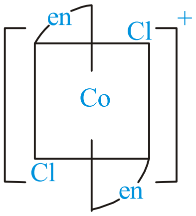
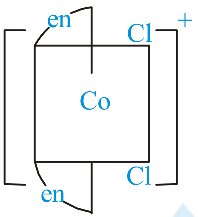
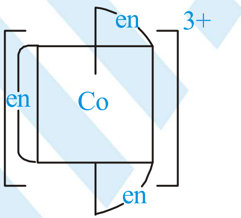

IV

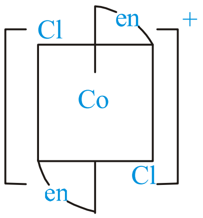
(A) I and II **(B)** I and III **(C)** II and IV **(D)** II and III

86. Which of the following ions are optically active?


I


II


III


IV

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

87. Which of the following polymerisation isomers of the compound having empirical formula $[Cr(NH_3)_3(NO_2)_3]$ has the lowest molecular mass?
(A) $[Cr(NH_3)_4(NO_2)_2]^+[Cr(NH_3)_2(NO_2)_4]^-$ **(B)** $[Cr(NH_3)_6]^{3+}[Cr(NO_2)_6]^{3-}$
(C) $[Cr(NH_3)_5(NO_2)]^{2+}[Cr(NH_3)(NO_2)_5]^{2-}$ **(D)** All

88. The total number of possible isomers of the compound $[Cu^{II}(NH_3)_4][Pt^{II}Cl_4]$ are:
(A) 3 **(B)** 5 **(C)** 4 **(D)** 6

89. Which of the following statements is correct?
(A) Geometrical isomerism is not observed in complexes of coordination number 4 having tetrahedral geometry
(B) Square planar complexes generally do not show geometrical isomerism
(C) The square planar complex of general formulae Ma_3b or Mab_3 exhibits cis–trans isomerism
(D) The platinum glycinato complex, $[Pt(gly)_2]$ does not show geometrical isomerism

90. $[Co(en)_3]^{3+}$ ion is expected to show ;
(A) two optically active isomers: d and *l* forms
(B) d, ● and meso forms
(C) four optically active isomers: cis, d and *l* isomers and trans d and *l* isomers
(D) none of these

91. How many isomers are possible for the complex ion $[Cr(NH_3)Cl_3(OH)_2]^{2-}$?
(A) 2 **(B)** 3 **(C)** 4 **(D)** 5

92. On treatment of $[Pt(NH_3)_4]^{2+}$ with concentrated HCl, two compounds (I) and (II) having the same formula, $[Pt(NH_3)_2Cl_2]$ are obtained, (I) can be converted into (II) by boiling with dilute HCl. A solution of (I) reacts with oxalic acid to form $[Pt(NH_3)_2(C_2O_4)]$ whereas (II) does not react. Point out the correct statement of the following.

(A) (I) cis, (II) trans; both tetrahedral
(B) (I) cis, (II) trans; both square planar
(C) (I) trans, (II) cis; both tetrahedral
(D) (I) trans, (II) cis; both square planar

93. Which of the following complexes shows ionization isomerism ?

(A) $[Cr(NH_3)_6]Cl_3$ **(B)** $[Cr(en)_2]Cl_2$ **(C)** $[Cr(en)_3]Cl_3$ **(D)** $[Co(NH_3)_5Br]SO_4$

94. Which of the following statements is correct ?

(A) A Werner postulated the use of two types of linkage (primary and secondary) by a metal atom / ion in a coordination compound.
(B) Wilkinson catalyst is used for the hydrogenation of alkenes .
(C) Metal carbonyls possess both σ and π bonds.
(D) All of these.

95. Which of the following is correct for the Zeise's salt ?

(A) The complex ion is square planar.
(B) The central metal ion, platinum is in + II oxidation state.
(C) $H_2C = CH_2$ molecules is perpendicular to the $PtCl_3$ plane
(D) All of these.

96. Which amongst the following are organometallic compounds ?

1. $Al_2(CH_3)_6$ **2.** $K[PtCl_3C_2H_2]$ **3.** $N(CH_3)_3$

(A) 1 only **(B)** 3 only **(C)** 1 and 2 only **(D)** 1, 2 and 3

97. In which case racemic mixture is obtained on mixing its mirror images in 1 : 1 molar ratio ?

(A) $[Cr(en)_3]^{3+}$ **(B)** $[Ni(DMG)_2]$ **(C)** cis-$[Cu(Gly)_2]$ **(D)** In all

98. Isomerism exhibited by $[Cr(NH_3)_2(H_2O)_2Cl_2]^+$ are :

(A) ionisation, optical
(B) hydrate, optical
(C) geometrical, optical
(D) coordination, geometrical

99. Which one of the following complexes exhibit chirality ?

(A) $[Cr(ox)_3]^{3-}$ **(B)** cis-$[PtCl_2(en)]$ **(C)** cis-$[RhCl_2(NH_3)_4]^+$ **(D)** mer-$[Co(NO_2)_3(dien)]$

100. The number of sigma bonds in Zeise's salt is:

(A) 4 **(B)** 6 **(C)** 7 **(D)** none of these

101. Which has aromatic ring in complex ?

(A) DMG in dimethylglyoximate
(B) cyclopentadienyl anion in ferrocene
(C) both **(A)** and **(B)**
(D) none of the above

102. 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)	1	3	2	4
(B)	5	2	4	3
(C)	5	3	2	4
(D)	1	2	4	3

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

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

(A) cryoscopic method

(B) measurement of molar conductance

(C) measuring magnetic moments

(D) observing their colours

104. 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.

105. Match List-I (complex ions) with List-II (number of unpaired electrons) and select the correct answer using the codes given below lists :

List-I (Complex ions)	**List-II** (Number of Unpaired Electrons)
A. $[CrF_6]^{4-}$	**1.** One
B. $[MnF_6]^{4-}$	**2.** Two
C. $[Cr(CN)_6]^{4-}$	**3.** Three
D. $Mn(CN)_6]^{4-}$	**4.** Four
	5. Five

Code :

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

106. Match List-I (complex ions) with List-II (CFSE) and select the correct answer using the codes given below the lists

List-I	**List-II**
(P) $[Mn(H_2O)_6]^{2+}$	**1.** $0.6\,\Delta_0$
(Q) $[Cr(H_2O)_6]^{2+}$	**2.** $0.4\,\Delta_0$
(R) $[Fe(H_2O)_6]^{2+}$	**3.** 0
(S) $[Cr(H_2O)_6]^{3+}$	**4.** $1.2\,\Delta_0$

Code :

	P	Q	R	S
(A)	3	1	2	4
(B)	1	2	3	4
(C)	4	3	2	1
(D)	None of these			

Exercise # 2 Part # I [Multiple Correct Choice Type Questions]

1. Which of the following will produce a white precipitate upon reacting with $AgNO_3$?

(A) $[Co(NH_3)_6]Cl_3$ **(B)** $[Co(NH_3)_3Cl_3]$ **(C)** $K_2[Pt(en)_2Cl_2]$ **(D)** $[Fe(en)_3]Cl_3$

2. Which of the following statements is(are) correct ?

(A) $[Ag(NH_3)_2]^+$ is linear with sp hybridised Ag^+ ion.

(B) $NiCl_4^{2-}$, VO_4^{3-} and MnO_4^- have tetrahedral geometry.

(C) $[Cu(NH_3)_4]^{2+}$, $[Pt(NH_3)_4]^{2+}$ and $[Ni(CN)_4]^{2-}$ have dsp^2 hybridisation of the metal ions.

(D) $Fe(CO)_5$ have trigonal bipyramidal structure with dsp^3 hybridised iron.

3. Which of the following exhibit geometrical isomerism (M stands for a metal, and a and b are achiral ligands)?

(A) Ma_2b_2 **(B)** Ma_2b_4 **(C)** Ma_5b **(D)** Ma_6

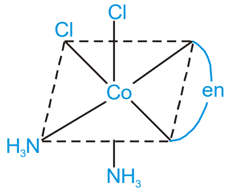
4. Which of the following is/are paramagnetic ?

(A) $[Fe(CN)_6]^{4-}$ **(B)** $[Ni(CO)_4]$ **(C)** $[Ni(CN)_4]^{2-}$ **(D)** $[CoF_6]^{3-}$

5. Co-ordination number of Cr in $CrCl_3.5H_2O$ is six. The maximum volume of 0.1 N $AgNO_3$ needed to precipitate the chlorine in outer sphere in 200 ml of 0.01 M solution of the complex is :

(A) 140 ml **(B)** 40 ml **(C)** 80 ml **(D)** 20 ml

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



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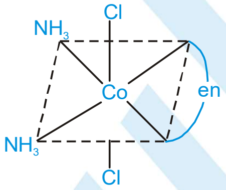

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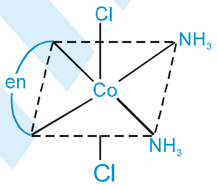


(III)

(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

7. Which of the following are π-bonded organometallic compounds ?

(A) Ferrocene **(B)** Diethyl zinc

(C) Ethylmagnesium iodide **(D)** Bis(benzene) chromium(0)

8. 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

9. Which statement(s) about co-ordination number of a cation is/are true ?

(A) Most metal ions exhibit only a single characteristic co-ordination number

(B) The co-ordination number is equal to the number of ligands bonded to the metal atom

(C) The co-ordination number is determined solely by the tendency to surround the metal atom with the same number of electrons as one of the rare gases.

(D) For most cations, the co-ordination number depends on the size, structure and charge of the ligands.

10. 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.

11. 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.

12. Which of the following statements is/are true for $[Pt(NH_3)(H_2O)(Cl)_2]$?

(A) It has diamagnetic character

(B) It has square planar geometry

(C) It shows geometrical and optical isomerism

(D) It shows only geometrical isomerism

13. Which of the following statement(s) is /are correct ?

(A) In $K_3[Fe(CN)_6]$, the ligands has satisfied only the secondary valencies of ferric ion.

(B) In $K_3[Fe(CN)_6]$, the ligands has satisfied both primary and secondary valencies of ferric ion.

(C) In $K_4[Fe(CN)_6]$, the ligands has satisfied only the secondary valencies of ferrous ion.

(D) In $[Cu(NH_3)_4]SO_4$, the ligands has satisfied only the secondary valencies of copper.

14. 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.

15. 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

16. 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 $[Rh(H_2O)_6]^{3+}$

(iii) $[Co(H_2O)_6]^{3+}$ and $[Co(H_2O)_3]^{3+}$

(iv) $[Co(NH_3)_6]^{3+}$ and $[CoF_6]^{3-}$

Select the correct one

(A) $[Co(CN)_6]^{3-} > [Co(H_2O)_6]^{3+}$

(B) $[Co(H_2O)_6]^{2+} < [Co(H_2O)_6]^{3+}$

(C) $[Co(H_2O)_6]^{3+} > [Rh(H_2O)_6]^{3+}$

(D) $[Co(NH_3)_6]^{3+} < [CoF_6]^{3-}$

17. 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. $(n-1)\ d^{10}ns^0np^0$.

18. Which statements is/are incorrect ?

(A) $[Ni(PPh_3)_2Br_2]$ - tetrahedral and paramagnetic.
(B) $[Ni\,(CO)_4]$ - tetrahedral and diamagnetic.
(C) $[Ni(CN)_4]^{2-}$ - square planar and diamagnetic.
(D) $[Ni(Cl)_4]^{2-}$ square planar and diamagnetic.

19. Which of the following statements is/are true for the complexes, $[Fe(H_2O)_6]^{2+}$, $[Fe(CN)_6]^{4-}$, $[Fe(C_2O_4)_3]^{3-}$ and $[Fe(CO)_5]$?

(A) Only $[Fe(C_2O_4)_3]^{3-}$ show optical isomerism.
(B) $[Fe(C_2O_4)_3]^{3-}$ is less stable than $[Fe(CN)_6]^{2-}$
(C) All complexes have same effective atomic number.
(D) $[Fe(CO)_5]$ shows back bonding.

20. $[CoCl_2(en)_2]Br$ will show :

(A) coordinate position isomerism
(B) ionization isomerism
(C) geometrical isomerism
(D) optical isomerism.

21. In which of the following pairs both the complexes do not show optical isomerism ?

(A) cis- $[Cr(en)_2Cl_2]$ and cis - $[Co(NH_3)_4Cl_2]$
(B) $[Co(gly)_3]$ and cis-$[CoCl_2(en)_2]$
(C) $[Pt\,(en)Cl_2]$ and fac- $[Ni(NH_3)_3Cl_3]$
(D) mer - $[Co(NO_3)_3(NH_3)_3]$ and $[PtCl_2(en)]$

22. 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.

23. 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) $[PtCl_2Br_2]^{2-}$

24. 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.

25. A complex compound of one cobalt (III) ion, two 'en' molecules, two chloride ions and one nitrite ion will show:

(A) linkage isomerism
(B) ionisation isomerism
(C) geometrical isomerism
(D) optical isomerism.

26. A complex containing cobalt (III) ion is associated with two diaminopropane molecules and two chloride ions forming an octahedral geometry. The complex ion will show :

(A) ligand isomerism
(B) geometrical isomerism
(C) optical isomerism
(D) ionization isomerism

27. Which of the following statement(s) is/are correct ?

(A) cis-$[Pt(NH_3)_2Cl_2]$ 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.

Part # II [Assertion & Reason Type Questions]

Each question has 5 choices (A), (B), (C), (D) and (E) out of which only one is correct.

(A) Statement-1 is true, Statement-2 is true and Statement-2 is correct explanation for Statement-1.

(B) Statement-1 is true, Statement-2 is true and Statement-2 is not correct explanation for Statement-1.

(C) Statement-1 is true, Statement-2 is false

(D) Statement-1 is false, Statement-2 is true

(E) Both Statements are false

1. **Statement-1 :** In the complex $[Co(NH_3)_3 Cl_3]$, chloride ions satisfy the primary valencies as well as the secondary valencies of cobalt metal.

Statement-2 : $[Co(NH_3)_3Cl_3]$ shows geometrical as well as optical isomerism.

2. **Statement-1 :** The complex $[Cr(SCN)(NH_3)_5]Cl_2$ is linkage isomeric with $[Cr(NCS)(NH_3)_5]Cl_2$.

Statement-2 : SCN^- is an ambident ligand in which there are two possible coordination sites.

3. **Statement-1 :** $[Ni(CN)_4]^{2-}$ is a paramagnetic complex.

Statement-2 : This complex is heteroleptic complex.

4. **Statement-1 :** In the co-ordination complex $[Pt(NH_3)_4 Cl_2] Br_2$, a yellow precipitate of AgBr is obtained on treating it with $AgNO_3$ (aq).

Statement-2 : Bromide ions are present as counter ions in the ionization sphere.

5. **Statement-1 :** Co-ordination number of cobalt in the complex $[Co(en)_3]^{3+}$ is six.

Statement-2 : Ethylenediamine acts as a bidentate ligand.

6. **Statement-1 :** Charge on the complex of ferric ion with EDTA is minus one.

Statement-2 : EDTA is a hexadentate ligand.

7. **Statement-1 :** The $[Ni(en)_3] Cl_2$ has higher stability than $[Ni(NH_3)_6] Cl_2$

Statement-2 : In $[Ni(en)_3] Cl_2$, the geometry around Ni is octahedral.

8. **Statement-1 :** Potassium ferrocyanide is diamagnetic where as potassium ferricyanide is paramagnetic.

Statement-2 : Crystal field splitting in ferrocyanide ion is greater than that of ferricyanide ion.

9. **Statement-I :** $K_2[PtCl_6]$ gives white ppt when reacts with $AgNO_3$

Statement-II : Chloride ion in the complex is non-ionisable.

10. **Statement-I :** Trans $[CoCl_2(en)_2]^+$ is optically inactive.

Statement-II : It has plane of symmetry.

11. **Statement-I :** Cis - $[Fe(en)_2Cl_2]^+$ can form recemic mixture.

Statement-II : Cis - $[Fe(en)_2Cl_2]^+$ is optically active square planar complex .

12. **Statement-I :** K_2SO_4. $Al_2(SO_4)_3$. $24H_2O$ is a double salt compound.

Statement-II : It ionises to give a complex ion.

13. **Statement-I :** $[Fe(CO)_5]$ is dimagnetic complex.

Statement-II : In the given complex oxidation state of Iron is zero.

14. **Statement-I :** $[Ni(CN)_4]^{-2}$ has zero unpaired electron while that of $[NiCl_4]^{-2}$ has two unpaired e^-
Statement-II : $[Ni(CN)_4]^{-2}$ has strong crystal field while $[NiCl_4]^{-2}$ has weak crystal field

15. **Statement-I :** Potassium ferrocyanide is diamagnetic whereas potassium ferricyanide is paramagnetic.
Statement-II : Crystal field spliting in ferrocyanide ion is greater than that of ferricyanide ion.

16. **Statement-I :** $[Co(NO_2)_3(NH_3)_3]$ does not show optical isomerism.
Statement-II : It has plane of symmetry.

17. **Statement-I :** C–C bond length in zeise's salt is same as ethylen.
Statement-II : Double bond is shorter as compaire to single bond.

18. **Statement-I :** EAN of Fe in ferrocene is 36.
Statement-II : 6π e^- are co-ordinated by each cyclo pentadien ring with central metal ion.

19. **Statement-I :** $[Ti(H_2O)_6]^{4+}$ is coloured while $[Sc(H_2O)_6]^{3+}$ is colourless.
Statement-II : d-d transition is not possible in $[Sc(H_2O)_6]^{3+}$.

20. **Statement-I :** Hydrazine is a neutral ligand.
Statement-II : It has two N as donor atoms and behaves as a chelating ligand.

Exercise # 3 Part # I [Matrix Match Type Questions]

1. Match the complexes given in column-I and the characteristic(s) given in column-II.

Column – I **(Complexes)**	**Column – II** **(characteristics)**
(A) $[Ni(CO)_4]$	**(p)** sp^3 hybridisation
(B) $[AgF_4]^-$	**(q)** Diamagnetic
(C) $[Zn(CN)_4]^{2-}$	**(r)** dsp^2
(D) $[RhCl(PPh_3)_3]$	**(s)** Unidentate ligand.
	(t) + 3 oxidation state of metal ion

2. Match the complexes given in column-I and the magnetic properties given in column-II.

Column I **(Complexes)**	**Column II** **(Magnetic properties)**
(A) $[NiCl_2(PPh_3)_2]$	**(p)** Paramagnetic with 1 unpaired electrons
(B) $V(CO)_6$	**(q)** Paramagnetic with 2 unpaired electrons
(C) $[Cr(CN)_6]^{4-}$	**(r)** Paramagnetic with 3 unpaired electrons
(D) $Ni(CO)_4$	**(s)** Diamagnetic

3. Match the complexes listed in column-I with type of hybridisation listed in column-II.

Column I	**Column II**
(A) $[AuF_4]^-$	**(p)** dsp^2 hybridisation
(B) $[Cu(CN)_4]^{3-}$	**(q)** sp^3 hybridisation
(C) $[Co(NH_3)_6]^{3+}$	**(r)** sp^3d^2 hybridisation
(D) $[Fe(H_2O)_5NO]^{2+}$	**(s)** d^2sp^3 hybridisation

4. Match the pair of complexes given in column-I and the characteristic(s) given in column-II.

Column - I	**Column- II**
(A) $(NH_4)_2[NiCl_4]$ and $(NH_4)_2[Ni(CN)_4]$	**(p)** Both show same electrical conductance.
(B) $CoCl_3.6NH_3$ and $PtCl_4.5NH_3$	**(q)** Both show same effective atomic number.
(C) $[Pt(NH_3)_2Cl_2]$ and $(NH_4)_2[PtCl_4]$	**(r)** Both show same primary valencies.
(D) $K_2[Fe(H_2O)_6]$ and $K_4[FeCl_6]$	**(s)** Both gives white participate with $AgNO_3$ solution.

5. Match the complexes given in column-I and the characteristic(s) given in column-II.

Column – I **(Complexes)**	**Column – II** **(characteristics)**
(A) $[Ni(CO)_4]$	**(p)** Tetrahedral
(B) $[Fe(NO)_2(CO)_2]$	**(q)** π back bonding
(C) $[Ni(PF_3)_4]$	**(r)** diamagnetic
(D) $[PtCl_3(C_2H_4)]^-$	**(s)** One of the ligand is three electron donor.

6. Match the complexes given in column-I and the characteristic(s) given in column-II.

Column – I **(Complexes)**	**Column – II** **(characteristics)**
(A) $[Co(H_2O)_6]^{3+}$	**(p)** d^2sp^3
(B) $[CoF_6]^{3-}$	**(q)** sp^3d^2
(C) $[Co(NO_2)_6]^{3-}$	**(r)** diamagnetic
(D) $[Co(ox)_3]^{3-}$	**(s)** paramagnetic

7. Match the complexes listed in column-I with the characteristic(s)/hybridisation given in column-II.

Column - I	Column - II
(A) $[MnCl_6]^{2-}$	**(p)** One unpaired electron
(B) $[Fe(CN)_6]^{3-}$	**(q)** d^2sp^3
(C) $[CoF_6]^{3-}$	**(r)** sp^3d^2
(D) $[Fe(H_2O)_6]^{2+}$	**(s)** Four unpaired electrons

8. Match the pairs of the complexes listed in column (I) with the details given in column (II).

Column -I	Column -II
(A) $[Ni(CN)_4]^{2-}$ and $[Co(C_2O_4)_3]^{3-}$	**(p)** Central metals have same primary valences.
(B) $[Mn(CN)_6]^{3-}$ and $[Cr(NH_3)_6]^{3+}$	**(q)** Central metal atoms /ions have same 'spin only' magnetic moment.
(C) $[Cu(CN)_4]^{3-}$ and $[Fe(CO)_4]^{2-}$	**(r)** Metal ions in complexes have same effective atomic number.
(D) $[PtCl_4]^{2-}$ and $[FeF_4]^{2-}$	**(s)** Complexes have same type of ligands i.e. neutral, cationic or anionic.

Note : Spin only magnetic moment is calculated, using $\mu = \sqrt{n(n+2)}$ B.M. and it may be zero also.

Part # II [Comprehension Type 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) $[CoBr(en)_2(H_2O)]Cl_2$

(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) will 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

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.

1. 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.

2. Which of the following statements is true for the complex, $[Co(NH_3)_4 Br_2] NO_2$?

(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.

3. Choose the correct option for the complex $[Pt\,Cl_2\,(en)_2]^{2+}$.

(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

Comprehension # 3

$Co^{2+}\,(aq.) + SCN^{-}\,(aq.) \longrightarrow$ Complex (X).

$Ni^{2+}\,(aq.) +$ Dimethylglyoxime $\xrightarrow{NH_4OH}$ Complex (Y).

The coordination number of cobalt and nickel in complexes X and Y are four.

1. 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).

2. 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.

3. Select the correct statement for the complexes (X) and (Y).

(A) (X) is paramagnetic with two unpaired electrons.

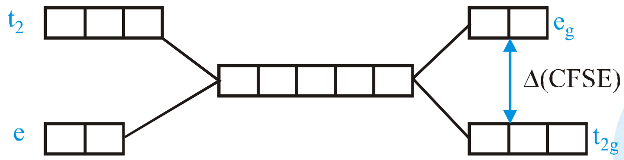
(B) (Y) is diamagnetic and shows intermolecular H-bonding.

(C) (X) is paramagnetic with three unpaired electrons and (Y) is diamagnetic.

(D) (X) and (Y) both are diamagnetic.

Comprehension # 4

When degenerate d-orbitals of an isolated atom/ion come under influence of magnetic field of ligands, the degeneracy is lost. The two set $t_{2g}(d_{xy}, d_{yz}, d_{xz})$ and eg $(d_{z^2}, d_{x^2-y^2})$ are either stabilized or destrabilized depending upon the nature of magnetic field. It can be expressed diagrammatically as:



Tetrahedral field Octahedral field

Value of CFSE depends upon nature of ligand and a spectrochemical series has been made experimentally, for tetrahedral complexes, Δ is about 4/9 times to Δ_0 (CFSE for octahedral complex). This energy lies in visible region and i.e., why electronic transition are responsible for colour. Such transitions are not possible with d^0 and d^{10} configuration.

1. The CFSE for $[CoCl_6]^{4-}$ complex is 18000 cm^{-1}. The Δ for $[CoCl_4]^{2-}$ will be –

(A) 18000 cm^{-1} **(B)** 16000 cm^{-1} **(C)** 8000 cm^{-1} **(D)** 2000 cm^{-1}

2. The d-orbitals, which are stabilised in an octahedral magnetic field, are –

(A) d_{xy} and d_{z^2} **(B)** $d_{x^2-y^2}$ and d_{z^2} **(C)** d_{xy}, d_{xz} and d_{yz} **(D)** d_{z^2} only

3. For an octahedral complex, which of the following d-electron configuration will give maximum CFSE?

(A) High spin d^6 **(B)** Low spin d^4 **(C)** Low spin d^5 **(D)** High spin d^7

4. $Ti^{3+}_{(aq)}$ is purple while $Ti^{4+}_{(aq)}$ is colourless because –

(A) There is no crystal field effect in Ti^{4+}

(B) There energy difference between t_{2g} and e_g of Ti^{4+} is quite high and does not fall in the visible region

(C) Ti^{4+} has d^0 configuration.

(D) Ti^{4+} is very small in comparison to Ti^{3+} and hence does not absorb any radiation.

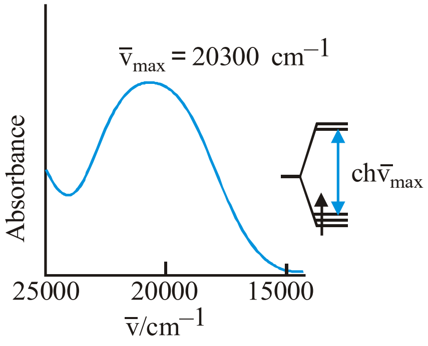
5. Crystal field stabilization energy for $[CoF_6]^{3-}$ in terms of parameter Dq is – (Δ = 10Dq)

(A) 4 **(B)** 6 **(C)** 12 **(D)** 24

Comprehension # 5

With the help of CFT number of unpaired electron in a compound can be calculated and we can calculate its paramagnetic moment (due to spin only), by the formula:

$\mu = \sqrt{n(n+2)}$ Bohr magneton (BM), where 'n' is the number of unpaired electron in the complex. For spectral analysis the separation between t_{2g} and e_g orbitals, called ligand field splitting parameter Δ_0 (for octahedral complexes) should be known to us, which can be easily calculated by observing the absorption spectrum of one e^- complex figure shows the optical absorption spectrum of the d^1 hexaaquatitanium (III) ion $[Ti(H_2O)_6]^{3+}$. The CFT assigns the first absorption maximum at 20,300 cm–1 to the transition $e_g \leftarrow t_{2g}$. For multielectronic (d^2 to d^{10}) system, the calculation of Δ_0 by absorption spectrum is not that easy as the absorption spectrum will also be affected by electron-electron repulsions.



1. The crystal field stabilization energy (CFSE) for complex given in the passage, $[Ti(H_2O)_6]^{3+}$ will be (in kJ/mol) –

(A) 243 kJ/mole **(B)** 97 kJ/mole **(C)** 194 kJ/mole **(D)** 143 kJ/mole

2. The complex for which the calculation of crystal field splitting can be most easily done, by knowing its absorption spectrum, will be –

(A) $[TiCl_6]^{2-}$ **(B)** $[Fe(H_2O)_6]^{2+}$ **(C)** $[Ti(CN)_6]^{3-}$ **(D)** $[CoF_6]^{3-}$

3. The magnetic moments of following, arranged in increasing order will be (atomic number of Co = 27)

(1) Co^{3+} (octahedral complex with a strong field ligand)

(2) Co^{3+} (octahedral complex with a weak field ligand)

(3) Co^{2+} (tetrahedral complex)

(4) Co^{2+} (square planar complex)

(A) 1 > 2 > 3 > 4 **(B)** 2 > 3 > 4 > 1 **(C)** 3 > 2 > 4 > 1 **(D)** 2 > 4 > 3 > 1

Exercise # 4

[Subjective Type Questions]

1. Deduce the value of x in the formulae of following complexes

(i) $Mo(CO)_x$ **(ii)** $H_xCr(CO)_5$ **(iii)** $H_xCo(CO)_4$

2. Predict the hybridisation and geometry of the following complexes.

(a) $[NiBr_4]^{2-}$ **(b)** $[Fe(CN)_6]^{3-}$ **(c)** $[MnBr_4]^{2-}$ **(d)** $[AuCl_4]^-$

(e) $[Fe(H_2O)_6]^{2+}$ **(f)** $[Pt(NH_3)_4]^{2+}$ **(g)** $[Co(SCN)_4]^{2-}$

3. Write the IUPAC nomenclature of the given complex along with its hybridizations and structure.

$[Cr(NH_3)_6](NO_3)_3$. $\mu = 3.83$ B.M

4. Name the following compounds.

(a) $[CoBr(en)_2(ONO)]^+$

(b) $[Co(NH_3)_6][Co(ONO)_6]$

(c) $[Co(NH_3)_5(CO_3)]Cl$

(d) $[Pt(NH_3)_4Cl_2][PtCl_4]$

(e) $[Co(en)_3]_2(SO_4)_3$

(f) $[(NH_3)_5Co\text{-}NH_2\text{-}Co(NH_3)_4(H_2O)]Cl_5$

(g) $[Cr(CO)_5(PPh_3)]$

(h) $[(CO)_5Mn\text{-}Mn(CO)_5]$

(i) $K[PtCl_3(\eta 2\text{–}C_2H_4)]$

(j) $Cr(\eta 6\text{–}C_6H_6)_2$

(k) $[Co(NH_3)_4(OH_2)_2][BF_4]_3$

(l) $K[(NH_3)_5Co—NC—Co(CN)_5]$

(m) $Na_4[Cu_6(S_2O_3)_5]$

(n) $Ba[Zr(OH)_2(ONO)_2(ox)]$

(o) $[Co(NH_3)_6][Co(C_2O_4)_3]$

5. 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)	Dicyanidoaurate(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

6. 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)** $[Cr(NH_3)_6]Cl_3$

7. A complex having empirical formula $PtCl_2.2NH_3$ is an insoluble solid that, when ground with $AgNO_3$, gives a solution containing $[Pt(NH_3)_4](NO_3)_2$ and an insoluble solid, $Ag_2[PtCl_4]$. Give the formula, IUPAC name and structure of the Pt(II) compound.

8. 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)** $[FeF_6]^{3-}$

9. $[Fe(CN_6]^{3-}$ is weakly paramagnetic while $[Fe(CN_6]^{4-}$ is diamagnetic why ?

10. **(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.

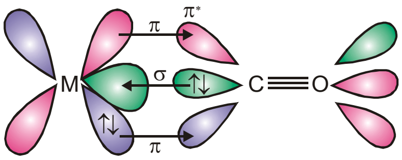
(b) There are six possible isomers for a square planar palladium(II) complex that contains two Cl^- and two SCN^- ligands. Sketch the structures of all six, and label them according to the classification.

11. Tell how many diastereoisomers are possible for each of the following complexes, and draw their structures.

(a) $[Cr(NH_3)_2Cl_4]^-$ **(b)** $[Co(NH_3)_5Br]^{2+}$ **(c)** $[FeCl_2(NCS)_2]^{2-}$

(d) $[PtBr_2Cl_2]^{2-}$ **(e)** $[Co(en)(SCN)_4]^-$ **(f)** $[Cr(NH_3)_2(H_2O)_2Cl_2]^+$

(g) $[Ru(NH_3)_3I_3]$

12. 

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.

13. All the octahedral complexes of Ni^{2+} must be high spin complexes why ?

14. Cobalt (II) is stable in aqueous solution but in the presence of complexing reagents(strong field ligands) it is readily oxidised. Why ?

15. $[Ni(CO)_4]$ is tetrahedral whereas $[Ni(CN)_4]^{2-}$ & $[Pt(NH_3)_4]^{2+}$ are square planar why ?

16. Deduce the structure of $[NiCl_4]^{2-}$ and $[Ni(CN)_4]^{2-}$ considering the hybridisation of the metal ion. Calculate the magnetic moment (spin only) of the species.

17. (A), (B) and (C) are three complexes of chromium(III) with the empirical formula $H_{12}O_6Cl_3Cr$. All the three complexes have water or chloride ion as ligands. Complex (A) does not react with concentrated H_2SO_4, whereas complexes (B) and (C) lose 6.75% and 13.5% of their original weight, respectively, on treatment with concentrated H_2SO_4.

(i) Identify (A), (B) and (C)

(ii) Write their formulae

(iii) Calculate their EAN.

(vi) By the addition of $AgNO_3$ what happens with each complex.

18. A solution containing 0.319 g of complex $CrCl_3.6H_2O$ was passed through cation exchanger and the solution given out was neutralised by 28.5 mL of 0.125 M NaOH.

(i) Deduce the structure of the compound ?

(ii) How many constitutional isomers are possible ?

(iii) What is the magnetic moment (μ) ?

(iv) Is the complex is coloured or colourless ?

(v) What will be the EAN of complex ?

(vi) What is the correct formula of complex ?

(vii) Write the IUPAC name of each isomers.

19. Draw the structures of $[Co(NH_3)_6]^{3+}$, $[Ni(CN)_4]^{2-}$ and $[Ni(CO)_4]$. Write the hybridisation of atomic orbitals of the transition metal in each case.

20. Comment on the fact that, while an aqueous solution of cobalt(III) sulphate is diamagnetic, the solution becomes paramagnetic when a larger excess of fluoride ion is added.

21. Use the crystal field model to write the electron configuration i.e., distribution of d-electrons of each ion.
(A) $[Fe(CN)_6]^{4-}$ **(B)** $[MnF_6]^{4-}$ **(C)** $[Cr(en)_3]^{3+}$

22. The cobalt (III) ion with ammonia $[Co(NH_3)_6]^{3-}$ absorbs light with a wave length of about 475 nm. What is the colour of the solution ?

23. For the $[Cr(H_2O)_6]^{2+}$ ion, the mean pairing energy P, is found to be 23,500 cm^{-1}. The magnitude of Δ_o is 13,900 cm^{-1}. Calculate the CFSE for this complex ion corresponding to high spin and low spin state. Which is more stable.

24. **(a)** Predict the possible coordination isomers for the empirical formula $PtCl_2.2NH_3$ and write their IUPAC name. Also mention the hybridisation and magnetic moment of the complexes.
(b) $[Fe(bipy)_3](ClO_4)_3$ complex has a magnetic moment of 1.7 BM. It is an inner orbital or outer orbital complex. Explain.

25. Lanthanides have a poor tendency to form complexes. Explain.

26. The magnitude of the crystal field splitting Δ_t in tetrahedral complex is considerably less than in octahedral field. Explain?

27. For which of the following tetrahedral complexes are isomers possible? Draw all the isomers. $[CoBr_2Cl_2]^-$, $[CoBrCl_2(OH_2)]$, $[CoBrClI(H_2O)]$.

28. What types of isomerism are possible for the six coordinate complex $Cr(NO_2)_2.6H_2O$. Identify all isomers.

29. **(a)** Which of the complexes (a) $[Cr(edta)]^-$, (b) $[Ru(en)_3]^{2+}$ and (c) $[Pt(dien)Cl]^+$ are chiral ?
(b) Give the IUPAC name of the complex, $[IrH(CO)(PMe_3)_2]$ and also give the hybridisation of the central atom along with the magnetic moment.

30. Give the IUPAC names and illustrate all types of isomers that are possible in an octahedral complex compound of one cobalt (III) ion, two ethylenediamine molecules, two chloride ions and one nitrite ion.

31. The complex first denoted β-$[PtCl_2(NH_3)_2]$ was identified as trans isomer. It reacts slowly with solid Ag_2O to produce $[Pt(NH_3)_2(OH_2)_2]^{2+}$. This complex does not react with ethylenediamine to give a chelated complex. Give the structure and IUPAC name of the diaqua complex.

32. Draw all the possible isomers of $[Co(NH_3)_2(en)Cl_2]^+$.

Exercise # 5 Part # I [Previous Year Questions] [AIEEE/JEE-MAIN]

1. In the coordination compound $K_4[Ni(CN)_4]$, the oxidation state of nickel is : **[AIEEE– 2004]**

(1) – 1 **(2)** 0 **(3)** + 1 **(4)** + 2

2. The co-ordination number of a central metal atom in a complex is determined by : **[AIEEE– 2004]**

(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

3. Which one is an outer orbital complex ? **[AIEEE– 2004]**

(1) $[Ni(NH_3)_6]^{2+}$ **(2)** $[Mn(CN)_6]^{4-}$ **(3)** $[Co(NH_3)_6]^{3+}$ **(4)** $[Fe(CN)_6]^{4-}$

4. Co-ordination compounds have great importance in biological systems. In this context, which statement is incorrect ? **[AIEEE– 2004]**

(1) Carboxypeptidase–A is an enzyme and contains zinc.
(2) Haemoglobin is the red pigment of blood and contains iron.
(3) Cyanocobalamin is B_{12} and contains cobalt.
(4) Chlorophylls are green pigments in plants and contain calcium.

5. Which one has largest number of isomers ? **[AIEEE– 2004]**

(1) $[Co(en)_2Cl_2]^+$ **(2)** $[Co(NH_3)_5Cl]^{2+}$ **(3)** $[Ir(PhR_3)_2H(CO)]^{2+}$ **(4)** $[Ru(NH_3)_4Cl_2]^+$

6. The correct order of magnetic moments (only spin value in BM) among is : **[AIEEE– 2004]**

(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)** $[MnCl_4]^{2-} > [CoCl_4]^{2-} > [Fe(CN)_6]^{4-}$

7. The oxidation state of Cr in $[Cr(NH_3)_4Cl_2]^+$ is : **[AIEEE– 2005]**

(1) 0 **(2)** +1 **(3)** +2 **(4)** +3

8. The IUPAC name of $K_3Fe(CN)_6$ is : **[AIEEE– 2005]**

(1) Potassium hexacyanoferrate(II) **(2)** Potassium hexacyanoferrate(III)
(3) Potassium hexacyanoiron(II) **(4)** Tripotassium hexacyanoiron(II)

9. Which of the following will show optical isomerism ? **[AIEEE– 2005]**

(1) $[Cu(NH_3)_4]^{2+}$ **(2)** $[ZnCl_4]^{2-}$ **(3)** $[Cr(C_2O_4)_3]^{3-}$ **(4)** $[Co(CN)_6]^{3-}$

10. The value of 'spin only' magnetic moment for one of the following configurations is 2.84 BM. The correct one is: **[AIEEE– 2005]**

(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)

11. Which one of the following complexes would exhibit the lowest value of paramagnetic behaviour ? **[AIEEE– 2005]**

(1) $[Co(CN)_6]^{3-}$ **(2)** $[Fe(CN)_6]^{3-}$ **(3)** $[Mn(CN)_6]^{3-}$ **(4)** $[Cr(CN)_6]^{3-}$

12. 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 :
(1) one, tetrahedral **(2)** two, tetrahedral **[AIEEE– 2006]**
(3) one, square planar **(4)** two, square planar

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

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

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

16. The 'spin only' magnetic moment (in units of Bohr magneton, μ_B) of Ni^{2+} in aqueous solution would be (atomic number Ni = 28) **[AIEEE– 2006]**
(1) 2.84 **(2)** 4.80 **(3)** 0 **(4)** 1.73

17. Which one of the following has a square planar geometry? **[AIEEE 2007]**
(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)

18. 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]**
(1) 4 and 2 **(2)** 4 and 3 **(3)** 6 and 3 **(4)** 6 and 2

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

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

21. Which of the following pairs represents linkage isomers ? **[AIEEE 2009]**
(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) $[PtCl_2(NH_3)_4Br_2$ and $[PtBr_2(NH_3)_4]Cl_2$
(4) $[Cu(NH_3)_4][PtCl_4]$ and $[Pt(NH_3)_4[CuCl_4]$

22. 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]**
(1) $[Co(NH_3)_6]Cl_3$ **(2)** $[CoCl_2(NH_3)_4]Cl$ **(3)** $[CoCl_3(NH_3)_3]$ **(4)** $[CoCl(NH_3)_5]Cl_2$

23. Which one of the following has an optical isomer ? **[AIEEE 2010]**
(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)

24. Which of the following facts about the complex $[Cr(NH_3)_6]Cl_3$ is wrong ? **[AIEEE 2011]**

(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.

25. The magnetic moment (spin only) of $[NiCl_4]^{2-}$ is : **[AIEEE 2011]**

(1) 1.82 BM
(2) 5.46 BM
(3) 2.82 BM
(4) 1.41 BM

26. Which among the following will be named as dibromidobis (ethylene diamine) chromium (III) bromide? **[AIEEE 2012]**

(1) $[Cr(en)_3]Br_3$
(2) $[Cr(en)_2Br_2]Br$
(3) $[Cr(en)Br_4]^-$
(4) $[Cr(en)Br_2]Br$

27. Which of the following complex species is not expected to exhibit optical isomerism ? **[JEE(Mains) 2013]**

(1) $[Co(en)_3]^{3+}$
(2) $[Co(en)_2\,Cl_2]^+$
(3) $[Co(NH_3)_3\,Cl_3]$
(4) $[Co(en)(NH_3)_2\,Cl_2]^+$

28. Which one of the following complexes shows optical isomerism? **[JEE(Mains) 2016]**

(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)

29. The pair having the same magnetic moment is: **[JEE(Mains) 2016]**

[At. No.: Cr = 24, Mn = 25, Fe = 26, Co = 27]

(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 $[CoCl_4]^{2-}$

30. On treatment of 100 mL 0.1 M solution of $CoCl_3.6H_2O$with excess $AgNO_3$, 1.2×10^{22} ions are precipitated. The complex is : **[JEE(Mains) 2017]**

(1) $[Co(H_2O)_4Cl_2]Cl.2H_2O$
(2) $[Co(H_2O)_3Cl_3].3H_2O$
(3) $[Co(H_2O)_6]Cl_3$
(4) $[Co(H_2O)_5Cl]Cl_2.H_2O$

31. 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(Mains) 2018]**

(1) +3, +2, and + 4
(2) + 3, 0, and + 6
(3) + 3, 0, and + 4
(4) +3, +4, and + 6

32. Consider the following reaction and statements : **[JEE(Mains) 2018]**

$$[Co(NH_3)_4Br_2]^+ + Br^- \rightarrow [Co(NH_3)_3Br_3] + NH_3$$

(I) Two isomers are produced if the reactant complex ion is a cis-isomer.

(II) Two isomers are produced if the reactant complex ion is a trans-isomer.

(III) Only one isomer is produced if the reactant complex ion is a trans-isomer.

(IV) Only one isomer is produced if the reactant complex ion is a cis-isomer.

The correct statements are :

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

Part # II [Previous Year Questions][IIT-JEE ADVANCED]

1. The species having tetrahedral shape is : **[JEE–2004]**

(A) $[PdCl_4]^{2-}$ **(B)** $[Ni(CN)_4]^{2-}$ **(C)** $[Pd(CN)_4]^{2-}$ **(D)** $[NiCl_4]^{2-}$

2. The spin magnetic moment of cobalt in the compound, Hg $[Co(SCN)_4]$ is : **[JEE–2004]**

(A) $\sqrt{3}$ **(B)** $\sqrt{8}$ **(C)** $\sqrt{15}$ **(D)** $\sqrt{24}$

3. 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.

(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. **[JEE–2004]**

4. Which kind of isomerism is exhibited by octahedral $[Co(NH_3)_4Br_2]Cl$? **[JEE–2005]**

(A) Geometrical and ionization **(B)** Geometrical and optical

(C) Optical and ionization **(D)** Geometrical only

5. In the given reaction sequence, Identify **(A)** and **(B)**.

$$Fe^{3+} + \xrightarrow[\text{(Excess)}]{SCN^-} \underset{\text{Blood red}}{A} \xrightarrow{F^-\text{ (excess)}} \text{colourless}(B)$$

(A) Write the IUPAC name of **(A)** and **(B)**.

(B) Find out the spin only magnetic moment of B. **[JEE–2005]**

6. The bond length in CO is 1.128 Å. What will be the bond length of CO in $Fe(CO)_5$? **[JEE–2006]**

(A) 1.158 Å **(B)** 1.128 Å **(C)** 1.178 Å **(D)** 1.118 Å

Comprehension # (Q.7 to Q.9)

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

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

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

7. The IUPAC name of complexes 'A' & 'B' are respectively : **[JEE–2006]**

(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]**

(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]**

(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]**

(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]**

	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]**

(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]**

(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]**

(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
Statement - 2 : The Fe in $[Fe(H_2O)_5NO]SO_4$ has three unpaired electrons. **[JEE–2008]**

(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]**

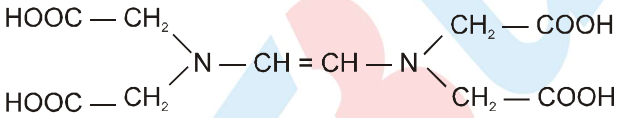
(A) $[Pt(en)Cl_2]$ **(B)** $[Pt(en)_2]Cl_2$
(C) $[Pt(en)_2Cl_2]Cl_2$ **(D)** $[Pt(NH_3)_2Cl_2]$

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

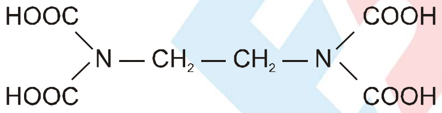
(A) 0 **(B)** 2.84 **(C)** 4.90 **(D)** 5.92

18. The correct structure of ethylenediaminetetraacetic acid (EDTA) is : **[JEE–2010]**

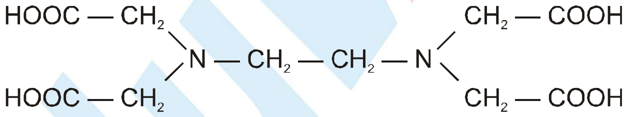
(A)



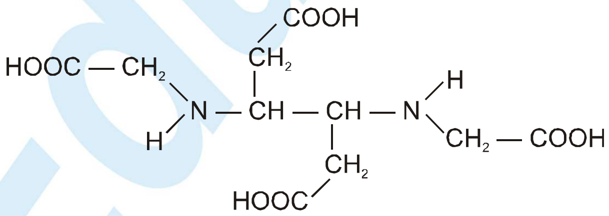
(B)



(C)



(D)



19. The ionization isomer of $[Cr(H_2O)_4Cl\ (NO_2)]Cl$ is : **[JEE–2010]**

(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]**

(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]**

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

(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]**

(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]**

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

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

(C) Diaminetetraaquacoblat (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]**

(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]**
$P = [FeF_6]^{3-}$, $Q = [V(H_2O)_6]^{2+}$ 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]**

(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]**

30. The reagent(s) that can selectively precipitate S^{2-} from a mixture of S^{2-} and SO_4^{2-} in aqueous solution is (are) **[JEE(Advanced) 2016]**

(A) $CuCl_2$ **(B)** $BaCl_2$ **(C)** $Pb(OOCCH_3)_2$ **(D)** $Na_2[Fe(CN)_5NO]$

31. The number of geometric isomers possible for the complex $[CoL_2Cl_2]^-$ ($L = H_2NCH_2CH_2O^-$) is **[JEE(Advanced) 2016]**

32. Addition of excess aqueous ammonia to a pink coloured aqueous solution of $MCl_2.6H_2O$ (X) and NH_4Cl gives an octahedral complex Y in the presence of air. In aqueous solution, complex Y behaves as 1 : 3 electrolyte. The reaction of X with excess HCl at room temperature results in the formation of a blue coloured complex Z. the calculated spin only magnetic of X and Z is 3.87 B.M., whereas it is zero for complex Y. **[JEE(Advanced) 2017]**

Among the following options, which statement(s) is(are) correct?

(A) The hybridization of the central metal ion in Y is d^2sp^3

(B) Addition of silver nitrate to Y gives only two equivalents of silver chloride

(C) when X and Z are in equilibrium at 0°C, the colour of the solution is pink

(D) Z is a tetrahedral complex

33. The correct statement (s) regarding the binary transition metal carbonyl compounds is (are)

(Given Atomic No. Fe - 26, Ni - 28) **[JEE(ADVANCED) 2018]**

(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) Netal - 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

34. The correct option regarding the complex $[Co(en)(NH_3)_3(H_2O)]^{3+}$ **[JEE(ADVANCED) 2018]**
(en = $H_2NCH_2CH_2NH_2$) is (are)
(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 $[Co(en)NH_3)_4]^{3+}$

35. Match each set of hybrid orbitals from LIST-I with complex(es) given in LIST-II. **[JEE(ADVANCED) 2018]**

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) $P \rightarrow 5 ; Q \rightarrow 4, 6 ; R \rightarrow 2, 3 ; S \rightarrow 1$
(B) $P \rightarrow 5, 6 ; Q \rightarrow 4 ; R \rightarrow 3 ; S \rightarrow 1, 2$
(C) $P \rightarrow 6 ; Q \rightarrow 4, 5 ; R \rightarrow 1 ; S \rightarrow 2, 3$
(D) $P \rightarrow 4, 6 ; Q \rightarrow 5, 6 ; R \rightarrow 1, 2 ; S \rightarrow 3$

MOCK TEST

SECTION - I : STRAIGHT OBJECTIVE TYPE

1. All the following complex ions are found to be paramagnetic

P : $[FeF_6]^{3-}$; Q : $[CoF_6]^{3-}$; R : $[V(H_2O)_6]^{3+}$; S : $[Ti(H_2O)_6]^{3+}$

The correct order of their paramagnetic moment (spin only) is

(A) P > Q > R > S **(B)** P < Q < R < S **(C)** P = Q = R = S **(D)** P > R > Q > S

2. Which of the following statement(s) most likely to be incorrect?

(A) $Ti(NO_3)_4$ is a colourless compound **(B)** $[Cu(NCCH_3)_4]^+ BF_4^-$ is a colourless compound

(C) $[Cr(NH_3)_6]^{3+} 3Cl^-$ is a colourless compound **(D)** $K_3[VF_6]$ is colourless compound

3. Amongst the following, the species with tetrahedral geometry is :

(A) $[Pd(CN)_4]^{2-}$ **(B)** $[Ni(CN)_4]^{2-}$ **(C)** $[PdCl_4]^{2-}$ **(D)** $[NiCl_4]^{2-}$

4. Which of the following statements is correct?

(A) Potassium ferrocyanide is diamagnetic where as potassium ferricyanide is paramagnetic.

(B) Crystal field splitting in ferrocyanide ion is greater than that of ferricyanide ion.

(C) The geometry of $Ni(CO)_4$ and $[NiCl_2(PPh_3)_2]$ are tetrahedral.

(D) **(A)** & **(C)** both

5. Amongst $[Co(ox)_3]^{3-}$, $[CoF_6]^{3-}$ and $[Co(NH_3)_6]^{3+}$:

(A) $[Co(ox)_3]^{3-}$ and $[CoF_6]^{3-}$ are paramagnetic and $[Co(NH_3)_6]^{3-}$ is diamagnetic.

(B) $[Co(ox)_3]^{3-}$ and $[Co(NH_3)_6]^{3+}$ are paramagnetic and $[CoF_6]^{3-}$ is diamagnetic.

(C) $[Co(ox)_3]^{3-}$ and $[Co(NH_3)_6]^{3+}$ are diamagnetic and $[CoF_6]^{3-}$ is paramagnetic.

(D) $[Co(NH_3)_6]^{3+}$ and $[CoF_6]^{3-}$ are paramagnetic and $[Co(ox)_3]^{3-}$ is diamagnetic.

6. All the following complex show decreases 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. $[Fe(en)_2(H_2O)_2]^{2+} + en \rightarrow$ complex(X). The correct statement about the complex (X) is :

(A) It is a low spin complex **(B)** It is diamagnetic

(C) It shows geometrical isomerism **(D)** **(A)** and **(B)** both

8. On treatment of $[Ni(NH_3)_4]^{2+}$ with concentrated HCl, two compounds I and II having the same formula, $[Ni(NH_3)_2Cl2_{]}$ are obtained, I can be converted into II by boiling with dilute HCl. A solution of I reacts with oxalix acid to form $[Ni(NH_3)_2(C_2O_4)]$ where as II does not react. Point out the correct statement from the following.

(A) I cis, II trans; both tetrahedral **(B)** I cis, II trans; both square planar

(C) I trans, II cis; both tetrahedral **(D)** I trans, II cis; both square planar

9. The total number of isomers shown by $[Co(NH_3)_4(NO_2)_2]$ (NO_3) complex is :

(A) 10 **(B)** 6 **(C)** 4 **(D)** 12

10. In which of the following complex ion, the metal ion will never have t^6_{2g}, $e_g^{\,0}$ configuration according to CFT?

(A) $[FF_6]^{3-}$ **(B)** $[Fe(CN)_6]^{3-}$ **(C)** $[Fe(CN)_6]^{4-}$ **(D)** None of these

SECTION - II : MULTIPLE CORRECT ANSWER TYPE

11. Which complex of the following pairs has the larger value of Δ_s?

(i) $[Co(CN)_6]^{3-}$ and $[Co(NH_3)_6]^{3+}$
(ii) $[Co(H_2O)_6]^{3+}$ and $[Rh(H_2O)_6]^{3+}$
(iii) $[Co(H_2O)_6]^{3+}$ and $[Co(H_2O)_3]^{3+}$
(iv) $[Co(NH_3)_6]^{2+}$ and $[CoF_6]^{3-}$

Select the correct one

(A) $[Co(CN)_6]^{3-} > [Co(H_2O)_6]^{2+}$
(B) $[Co(H_2O)_6]^{2+} < [Co(H_2O)_6]^{3+}$
(C) $[Co(H_2O)_6]^{3+} > [Rh(H_2O)_6]^{3+}$
(D) $[Co(NH_3)6]^{3+} < [CoF_6]^{3-}$

12. Wilkinson's catalyst react with H_2 to form an octahedral complex in which Rh(Z = 45) has the following electronic configuration in the ligand field $t_{2g}^{2,2,2}$, $e_g^{0,0}$. Then which of the following is (are) correct about this new complex?

(A) It is diamagnetic
(B) Its IUPAC name is chlorodihydridotris (triphenylphosphine) rhodium (III)
(C) Hybridisation of Rh(I) is d2sp3
(D) It is a paramagnetic complex

13. In the crystal field of the complex $[Fe(Cl)(CN)_4(O_2)]^{4-}$, the electronic configuration of metal is found to be t_{2g}^{6}, e_g^{0} then which of the following is/are true about this complex ion :

(A) It is a paramagnetic complex
(B) O – O bond length will be more than found in O_2 molecule
(C) Its IUPAC name will be chloridotetracyanidosuperoxidoferrate (II) ion.
(D) It will show geometrical as well as optical isomerism

14. Select the correct statement(s) for the coordination compound $K_2[Cr(NO^+)(NH_3)(CN)_4]$.

(A) It IUPAC name is potassium amminetetracyanidonitrosoniumchromate(I).
(B) Its 'spin only' magnetic moment is $\sqrt{8}$ B.M.
(C) Its hybridisation is d^2sp^3.
(D) Its show geometrical isomerism.

15. S_1 : $[Mn\ Cl_6]^{3-}$, $[FeF_6]^{3-}$ and $[CoF_6]^{3-}$ are paramagnetic having four, five and four unpaired electrons respectively.

S_2 : Valence bond theory gives a quantitative interpretation of the thermodynamic stabilities of coordination compounds.

S_3 : The crystal field splitting Δ_o, depends upon the field produced by the ligand and charge on the metal ion.

(A) T T T **(B)** T F T **(C)** F T F **(D)** T F F

16. S_1 : Generally square planar complexes show geometrical isomerism but do not exhibit optical isomerism because they do not possess planer of symmetry.

S_2 : $\Delta_t = \frac{4}{9}\Delta_0$

S_3 : In octahedral complexes each electron entering the t_{2g} orbitals stabilizes the complex ion by $0.4\ \Delta 0$ and each electron entering the e.g. orbital destabilizes the complex by an amount of $0.6\ \Delta_0$.

(A) F T T **(B)** F F T **(C)** T F T **(D)** T T F

17. S_1 : Both $[Co(ox)_3]^{3-}$ and $[CoF_6]^{3-}$ are paramagnetic.
S_2 : $CoCl_3$ $3NH_3$ complex is non-conducting.
S_3 : The number of possible geometrical isomers for the complex $[Pt(NO)_2 (Py)(OH)(NH)_3]$ is six.
S_4: The oxidation state of iron in brown ring complex $[Fe(H_2O)_5NO^+]\ SO_4$ is + II where NO is NO^+

(A) F T T F **(B)** T T T T **(C)** F T T F **(D)** T T T F

SECTION - III : ASSERTION AND REASON TYPE

18. **Statement -1** : A solution of $[Ni(H_2O)_6]^{2+}$ is green is green but a solution of $[Ni(CN)_4]^{2-}$ is colourless.

Statement - 2 : Energy difference between d levels (i.e. Δ) for H_2O complex (paramagnetic) is in the visible region and that for the cyano complex (diamagnetic) is in the UV region.

(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 -1 is False.

(D) Statement-1 is False, Statement-2 is True.

19. **Statement-1** : All the complexes of Pt(+II) and Au(+III) with strong field as well as with weak field ligands are square planar.

Statement-2 : The crystal field splitting energy is larger for second and third row transition elements, and for ore highly charged species. This larger value of crystal field splitting energy energetically favorus the pairing of electron for square planar geometry.

(A) Statement-1 is True, Statement-2 is True; Statement-2 is True 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.

20. **Statement - 1** : In complex $[Cr(NH_3)_4BrCl]Cl$, the 'spin only' magnetic moment is close to 1.73 B.M.

Statement - 2 : All known mononuclear complexes of chromium(III), irrespective of the strength of the ligand field, must have 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 False.

(D) Statement-1 is False, Statement - 2 True.

SECTION - IV : COMPREHENSION TYPE

Read the following comprehensions carefully and answer the questions.

Comprehension # 1

Double salts are addition compounds which lose their identity in aqueous solution whereas complexes which are also addition compounds do not loss 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.

21. Which of the following statement(s) 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 (triphenyl phosphine) rhodium(I) is effective heterogeneous catalyst for hydrogenation of alkenes.

22. Which of the following statement is true for the complex, $[Co(NH_3)_4 Br_2] NO_2$?

(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 nitrates solution.

(D) **(A)** and **(B)** both

23. Choose the correct option for the complex $[Pt\,Cl_2\,(en)_2]^{2+}$.

(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.

Comprehension # 2

Co^{2+} (aq.) + SCN^- (aq.) $\longrightarrow$ Complex (X).

Ni^{2+} (aq.) + Dimetyhlglyoxime $\xrightarrow{NH_4OH}$ Complex (Y).

The coordination number of cobalt and nickel in complex X and Y are four.

24. The IUPAC names of the complex (X) and (Y) are respectively P

(A) tetratiocyanato-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).

25. 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

26. Select the correct statement for the complexes (X) an (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

Square planar complexes are formed by d^8 ions with strong field ligands. The crystal field splitting is larger for second and third row transition elements and for more highly charged species. All the complexes having $4d^8$ and $5d^8$ configurations are mostly square planar including those with weak field ligands such as halide ions. Square planar complexes can show geometrical isomerism but they do not show optical isomerism due to the presence of plane of symmetry.

27. Amongst the following ions which do not form the square planar complexes?

(A) Ni (+II) and Rh (+I) with strong field ligands.

(B) Rh(+I) and Ag(+II) with strong field ligand.

(C) Pd (+II), Pt (+II) and Au(+III) with strong and weak field ligands.

(D) None

28. Amongst the following complexes which has square planar geometry?

(A) $[RhCl(CO)(PPh_3)_2]$ **(B)** $K_3[Cu(CN)_4]$ **(C)** $K_2[Zn(CN)_4]$ **(D)** $[Ni(CO)_4]$

29. Which one of the following square planar complexes will show geometrical isomerism?

(A) $[Pt(en)_2]^{2+}$ **(B)** $[Pt(gly)_2]$

(C) $[Pt(NH_3)_2Cl(NH_2CH_3)]Cl$ **(D)** **(B)** and **(C)** Both

Comprehension # 4

In metal carbonyls, there is synergic bonding interaction between metal and carbon monoxide. The leads to increases in strength of metal ligand bond and decrease in bond order of CO in carbonyl complex as compared to bond order in carbon monoxide.

Simple carbonyls are invariably spin-paired complex except for vanadium metal.

30. The increases in bond length in CO as compared to carbon monoxide is due to :

(A) the donation of lone pair of electrons on the carbon into a vacant orbital of the metal atom

(B) the donation of a pair of electrons from a filled d-orbital of metal into the vacant antibonding π^+ orbital of carbon monoxide.

(C) (A) and (C) both

(D) None

31. Which amongst the following metal carbonyls are inner orbital complexes with diamagnetic property.

(I) $Ni(CO)_4$; (II) $Fe(CO)_5$; (III) $V(CO)_6$ (IV) $Cr(CO)_6$

Select the correct answer from the codes gives below :

(A) I and II only **(B)** II, III and IV only

(C) II and IV only **(D)** I, II and IV only

32. Which one of the following metal carbonyls involves the d^2sp^3 hybridisation for the formation of metal-carbon σ bonds and is paramagnetic.

(A) $[Cr(CO)_6]$ **(B)** $[V(CO)_6]$ **(C)** $[Mo(CO)_6]$ **(D)** $[W(CO)_6]$

SECTION - V : MATRIX - MATCH TYPE

33. Match the complex listed in column-I with characteristic(s) listed column-II.

Column - I	**Column - II**
(A) $[Ni(CO)_4]$	(p) Tetrahedral
(B) $[Fe(CO)_2(NO)_2]$	**(q)** π-back bonding
(C) $[Ni(PF_3)_4]$	**(r)** Diamagnetic
(D) $[Ni(PPh_3)_2Br_2]$	**(s)** One of the ligand is three electron donor.

34. Match the complex 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 hybridisation
(B) $[Co\,(OX)_3]^{3-}$	**(q)** Diamagnetic
(C) $[Co\,(H_2O)_6]^{2+}$	**(r)** Paramagnetic
(D) $[Co\,(NO_2)_6]^{4-}$	**(s)** Chelating reagent

35. 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)** Optical isomer
(B) $[Co(NH_3)_4\,(NO_2)_2]\,(NO)_3$	**(q)** Geometrical isomers
(C) $[Co(en)(pn)(NO_3)_2]Cl$	**(r)** Ionization isomer
(D) $[Co(gly)_3]$	**(s)** Linkage isomer

SECTION - VI : SUBJECTIVE TYPE

36. Calculate the difference in net stabilisation energies (in kJ mol^{-1}) of Fe^{2+} complexes with CN^- ligands ($\Delta_0 = 25000\ cm^{-1}$) and with H_2O ligands ($\Delta_0 = 10000\ cm^{-1}$). Given that the pairing energy, P = 15000 cm^{-1} for Fe^{2+} ion for both the complexes.

(Given that $h = 6 \times 10^{-34}$ J sec., Avogadro Number = 6×10^{23}, Speed of light in Vacuum = 3×10^8 m sec^{-1}).

37. A symmetrical bridged complex cation made of Co(III), NH_3 molecules and oxygen (in the proper ligand form) is found to contain the following composition [Atomic mass of Co = 59]

Co = 36.875% ; NH_3 = 53.125% ; O = 10%

Co = 36.875% ; NH3 = 53.125% ; O = 10%

The complex cation exists in three ionic forms with cationic charges A : (n^+) ; B : $(n-1)^+$ and C : $(n-2)^+$ such that O – O in all of them is found to be more than that in $O_2[PtF_6]$. Calculate the value of n, (n–1) and (n–2).

38. A metal complex having composition $Cr(NH_3)_4\,Cl_2Br$ has been isolated in two forms (A) and (B). The form A reacts with $AgNO_3$ to give a while precipitate readily soluble in dilute aqueous ammonia, whereas (B) gives a pale yellow precipitate partial soluble in concentrated ammonia. Calculate their magnetic moments (spin-only value).

ANSWER KEY

EXERCISE - 1

1. A **2.** A **3.** D **4.** C **5.** A **6.** D **7.** D **8.** D **9.** C **10.** B **11.** C **12.** D **13.** C
14. B **15.** B **16.** D **17.** A **18.** B **19.** D **20.** A **21.** B **22.** B **23.** A **24.** C **25.** B **26.** D
27. B **28.** B **29.** C **30.** B **31.** B **32.** A **33.** B **34.** C **35.** A **36.** C **37.** B **38.** C **39.** C
40. D **41.** B **42.** D **43.** C **44.** D **45.** D **46.** B **47.** D **48.** C **49.** C **50.** B **51.** A **52.** D
53. D **54.** A **55.** A **56.** A **57.** B **58.** D **59.** D **60.** D **61.** C **62.** A **63.** D **64.** C **65.** C
66. D **67.** D **68.** C **69.** B **70.** C **71.** D **72.** C **73.** C **74.** C **75.** C **76.** A **77.** A **78.** C
79. C **80.** B **81.** D **82.** C **83.** C **84.** C **85.** C **86.** C **87.** D **88.** C **89.** A **90.** A **91.** B
92. B **93.** D **94.** D **95.** D **96.** C **97.** A **98.** C **99.** A **100.** D **101.** B **102.** D **103.** B **104.** D
105. C **106.** A

EXERCISE - 2 : PART # I

1. A, D **2.** A, B, C, D **3.** A, B **4.** D **5.** B, D **6.** B, C, D **7.** A, D
8. A, C, D **9.** B, D **10.** A, C, D **11.** A, B, C, D **12.** A, B, D **13.** B, D **14.** C, D
15. B, C **16.** A, B **17.** A, C **18.** D **19.** A, D **20.** B, C, D
21. A, C **22.** A, B, C, D **23.** A, D **24.** A, B, C **25.** A, B, C, D **26.** A, B, C
27. A, B, C, D

PART # II

1. C **2.** A **3.** E **4.** A **5.** A **6.** B **7.** B **8.** C **9.** D **10.** A **11.** C **12.** C **13.** B
14. A **15.** C **16.** A **17.** D **18.** A **19.** D **20.** C

EXERCISE - 3 : PART # I

1. $A \rightarrow p, q, s, B \rightarrow q, r, s, t, C \rightarrow p, q, s, t, D \rightarrow q, r, s$ **2.** $A \rightarrow q, B \rightarrow p, C \rightarrow q, D \rightarrow s$
3. $A \rightarrow p, B \rightarrow q, C \rightarrow s, D \rightarrow r$ **4.** $A \rightarrow p, q, r, B \rightarrow p, s, C \rightarrow q, r, D \rightarrow q, r$
5. $A \rightarrow p, q, r, B \rightarrow p, q, r, s, C \rightarrow p, q, r, D \rightarrow q, r$ **6.** $A \rightarrow p, r, B \rightarrow q, s, C \rightarrow p, r, D \rightarrow q, r$
7. $A \rightarrow q, B \rightarrow p, C \rightarrow q, D \rightarrow s$ **8.** $A \rightarrow q, s, B \rightarrow p, C \rightarrow q, r, D \rightarrow p, s$

PART # II

Comprehension # 1 : **1.** D **2.** C **3.** B **4.** A **5.** A
Comprehension # 2 : **1.** D **2.** D **3.** C
Comprehension # 3 : **1.** B **2.** A **3.** C
Comprehension # 4 : **1.** C **2.** C **3.** C **4.** A
Comprehension # 5 : **1.** B **2.** C **3.** B

EXERCISE - 5 : PART # I

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

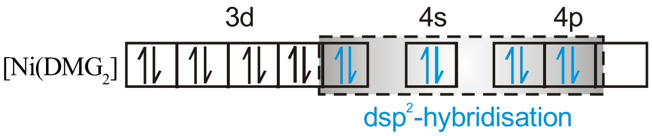
PART # II

1. D **2.** C

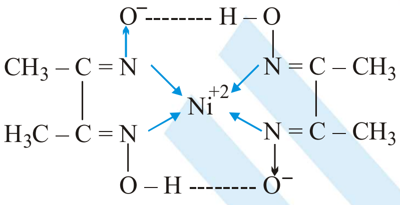
3. $Ni^{2+} + 2dmg \xrightarrow{NH_4OH} [Ni(dmg_2] \downarrow$ (bright red).

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



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



rosy red ppt

4. A

5. **(a)** $Fe^{3+} \xrightarrow[\text{(Excess)}]{SCN^-}$ blood red$[Fe((H_2O_5(SCN]^{2+}$ (A) $\xrightarrow{F^-\text{ (excess)}}$ colourless(B $[Fe(F_6]^{3-} + SCN^- + 5H_2O)$.

(A) Pentaaquathiocyanato-S-iron(III) ; (B) Hexafluoridoferrate(III)

(b) Fe^{3+} CFSE electron configuration, $t_{2g}^{1,1,1}e_g^{1,1}$; as F^- being weak field ligand does not compel for pairing of electrons. So it contains five unpaired electrons.

So, $\mu = \sqrt{5(5+2)} = 5.93$ B.M.

The magnetic moment value of B is 5.93 B.M.

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.** C, D **17.** A **18.** C **19.** B **20.** B **21.** 3 **22.** B **23.** C **24.** 6 **25.** D **26.** C
30. A or A,C **31.** 5 **32.** A, C, D **33.** B, C **34.** A, B, D **35.** C

MOCK - TEST

1. A **2.** D **3.** D **4.** D **5.** C **6.** D **7.** D **8.** B **9.** A **10.** C **11** A, B **12.** A, B
13. A, B, C **14.** A, C, D **15.** B **16.** A **17.** C **18.** A **19.** A **20.** D **21.** D **22.** D **23.** C **24.** B
25. A **26.** C **27.** D **28.** A **29.** D **30.** B **31.** C **32.** B
33. A → p, q, r ; B → p, q, r, s; C → p, q, r ; D → p **34.** A → q, r, t ; B → q, r, t ; C → p, s ; D → r, s
35. A → p,q,r ; B → q,r,s ; C → p,q,r,s ; D → p,q