INORGANIC CHEMISTRY

COORDINATION CHEMISTRY

1. Match the electronic configurations in List-I with appropriate metal complex ions in List-II and choose the correct option. [Atomic Number: Fe = 26, Mn = 25, Co = 27] **[JEE(Advanced) 2023]**

List-I		**List-II**	
(P)	$t_{2g}^6 e_g^0$	(1)	$[Fe(H_2O)_6]^{2+}$
(Q)	$t_{2g}^3 e_g^2$	(2)	$[Mn(H_2O)_6]^{2+}$
(R)	$e^2 t_2^3$	(3)	$[Co(NH_3)_6]^{3+}$
(S)	$t_{2g}^4 e_g^2$	(4)	$[FeCl_4]^-$
		(5)	$[CoCl_4]^{2-}$

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

2. The complex(es), which can exhibit the type of isomerism shown by $[Pt(NH_3)_2Br_2]$, is(are)

[en = $H_2NCH_2CH_2NH_2$] **[JEE(Advanced) 2023]**

(A) $[Pt(en)(SCN)_2]$
(B) $[Zn(NH_3)_2Cl_2]$
(B) $[Pt(NH_3)_2Cl_4]$
(D) $[Cr(en)_2(H_2O)(SO_4)]^+$

3. LIST-I contains metal species and LIST-II contains their properties.

LIST-I	**LIST-II**
(I) $[Cr(CN)_6]^{4-}$	(P) t_{2g} orbitals contain 4 electrons
(II) $[RuCl_6]^{2-}$	(Q) μ(spin-only) = 4.9 BM
(III) $[Cr(H_2O)_6]^{2+}$	(R) low spin complex ion
(IV) $[Fe(H_2O)_6]^{2+}$	(S) metal ion in 4+ oxidation state
	(T) d^4 species

[Given : Atomic number of Cr = 24, Ru = 44, Fe = 26]

Metal each metal species in LIST-I with their properties in LIST-II, and choose the correct option

[JEE(Advanced) 2022]

(A) I $\rightarrow$ R, T; II $\rightarrow$ P, S; III $\rightarrow$ Q, T; IV $\rightarrow$ P, Q
(B) I $\rightarrow$ R, S; II $\rightarrow$ P, T; III $\rightarrow$ P, Q; IV $\rightarrow$ Q, T
(C) I $\rightarrow$ P, R; II $\rightarrow$ R, S; III $\rightarrow$ R, T; IV $\rightarrow$ P, T
(D) I $\rightarrow$ Q, T; II $\rightarrow$ S, T; III $\rightarrow$ P, T; IV $\rightarrow$ Q, R

4. The calculated spin only magnetic moments of $[Cr(NH_3)_6]^{3+}$ and $[CuF_6]^{3-}$ in BM, respectively, are

(Atomic numbers of Cr and Cu are 24 and 29, respectively) **[JEE(Advanced) 2021]**

(A) 3.87 and 2.84
(B) 4.90 and 1.73
(C) 3.87 and 1.73
(D) 4.90 and 2.84

5. The total number of possible isomers for $[Pt(NH_3)_4Cl_2]Br_2$ is ______ . **[JEE(Advanced) 2021]**

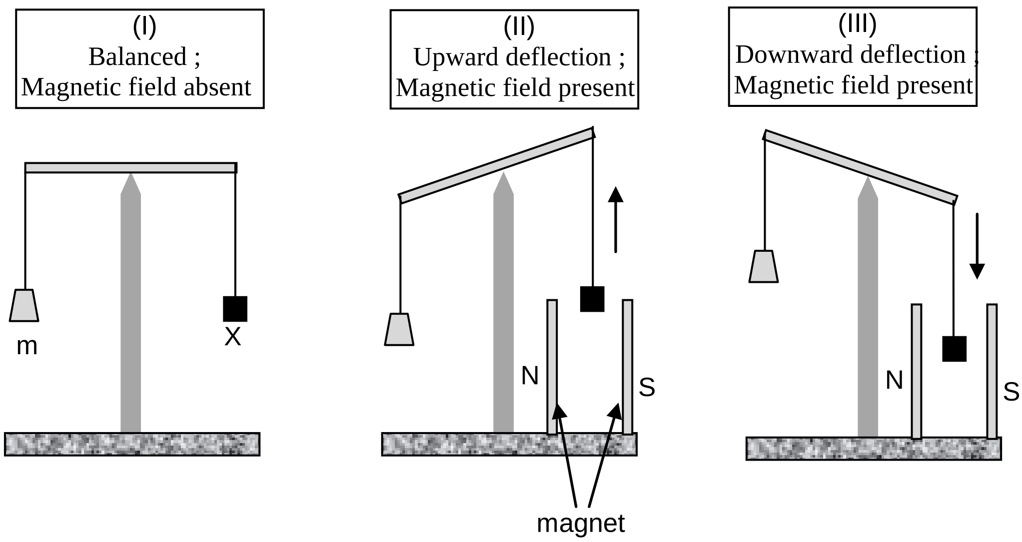
6. The pair(s) of complexes wherein both exhibit tetrahedral geometry is(are)
(Note: py = pyridine
Given: Atomic numbers of Fe, Co, Ni and Cu are 26, 27, 28 and 29, respectively) **[JEE(Advanced) 2021]**

(A) $[FeCl_4]^-$ and $[Fe(CO)_4]^{2-}$
(B) $[Co(CO)_4]^-$ and $[CoCl_4]^{2-}$
(C) $[Ni(CO)_4]$ and $[Ni(CN)_4]^{2-}$
(D) $[Cu(py)_4]^+$ and $[Cu(CN)_4]^{3-}$

7. Choose the correct statement(s) among the following : **[JEE(Advanced) 2020]**

(A) $[FeCl_4]^-$ has tetrahedral geometry.
(B) $[Co(en)(NH_3)_2Cl_2]^+$ has 2 geometrical isomers.
(C) $[FeCl_4]^-$ has higher spin-only magnetic moment than $[Co(en)(NH_3)_2Cl_2]^+$.
(D) The cobalt ion in $[Co(en)(NH_3)_2Cl_2]^+$ has sp^3d^2 hybridization.

8. In an experiment, m grams of a compound **X** (gas/liquid/solid) taken in a container is loaded in a balance as shown in figure **I** below. In the presence of a magnetic field, the pan with **X** is either deflected upwards (figure **II**), or deflected downwards (figure **III**), depending on the compound **X**. Identify the correct statement(s) **[JEE(Advanced) 2020]**



(A) If **X** is $H_2O(l)$, deflection of the pan is upwards.
(B) If **X** is $K_4[Fe(CN)_6](s)$, deflection of the pan is upwards.
(C) If **X** is $O_2(g)$, deflection of the pan is downwards.
(D) If **X** is $C_6H_6(l)$, deflection of the pan is downwards.

9. Total number of *cis* N–Mn–Cl bond angles (that is, Mn–N and Mn–Cl bonds in *cis* positions) present in a molecule of *cis*-$[Mn(en)_2Cl_2]$ complex is ____ ($en = NH_2CH_2CH_2NH_2$) **[JEE(Advanced) 2019]**

10. The correct statement(s) regarding the binary transition metal carbonyl compounds is (are)
(Atomic numbers : 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) Metal - carbon bond strengthens when the oxidation state of the metal is lowered
(D) The carbonyl C–O bond weakens when the oxidation state of the metal is increased

11. Among the species given below, the total number of diamagnetic species is____.

H atom, NO_2 monomer, O_2^- (superoxide), dimeric sulphur in vapour phase,

Mn_3O_4, $(NH_4)_2[FeCl_4]$, $(NH_4)_2[NiCl_4]$, K_2MnO_4, K_2CrO_4 **[JEE(Advanced) 2018]**

12. The correct option(s) regarding the complex $[Co(en)(NH_3)_3(H_2O)]^{3+}$:-

(en = $H_2NCH_2CH_2NH_2$) is (are) **[JEE(Advanced) 2018]**

(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 $[Co(en)(NH_3)_4]^{3+}$

13. Match each set of hybrid orbitals from LIST-I with complex (es) given in LIST-II.

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 **[JEE(Advanced) 2018]**

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

14. 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 moment of X and Z is 3.87 B.M., whereas it is zero for complex Y.

Among the following options, which statements is(are) correct ? **[JEE(Advanced) 2017]**

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

(B) Z is tetrahedral complex

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

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

15. The number of geometric isomers possible for the complex $[CoL_2Cl_2]^-$ (L = $H_2NCH_2CH_2O^-$) is

[JEE(Advanced) 2016]

16. The geometries of the ammonia complexes of Ni^{2+}, Pt^{2+} and Zn^{2+}, respectively, are :

[JEE(Advanced) 2016]

(A) octahedral, square planar and tetrahederal

(B) square planar, octahederal and tetrahederal

(C) tetrahederal, square planar and octahederal

(D) octahederal , tetrahederal and square planar

17. For the octahedral complexes of Fe^{3+} in SCN^- (thiocyanato-S) and in CN^- ligand environments, the difference between the spin only magnetic moments in Bohr magnetons (when approximated to the nearest integer) is

[Atomic number of Fe = 26] **[JEE(Advanced) 2015]**

18. The correct statement(s) about Cr^{2+} and Mn^{3+} is (are)

[Atomic numbers of Cr = 24 and Mn = 25] **[JEE(Advanced) 2015]**

(A) Cr^{2+} is a reducing agent

(B) Mn^{3+} is an oxidizing agent

(C) Both Cr^{2+} and Mn^{3+} exhibit d^4 electronic configuration

(D) When Cr^{2+} is used as a reducing agent, the chromium ion attains d^5 electronic configuration

19. In the complex acetylbromidodicarbonylbis(triethylphosphine)iron(II), the number of Fe–C bond(s) is-

[JEE(Advanced) 2015]

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

21. A list of species having the formula XZ_4 is given below :

XeF_4, SF_4, SiF_4, BF_4^-, BrF_4^-, $[Cu(NH_3)_4]^{2+}$, $[FeCl_4]^{2-}$, $[CoCl_4]^{2-}$ and $[PtCl_4]^{2-}$.

Defining shape on the basis of the location of X and Z atoms, the total number of species having a square planar shape is **[JEE(Advanced) 2014]**

22. Match each coordination compound in List-I with an appropriate pair of characteristics from List-II and select the correct answer using the code given below the lists.

{en = $H_2NCH_2CH_2NH_2$ ' atomic numbers ; Ti = 22 ; Cr = 24 ; Co = 27 ; Pt = 78}

[JEE(Advanced) 2014]

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

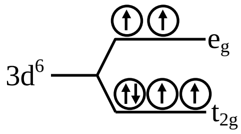
Code :

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

SOLUTIONS

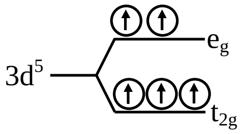
1. Ans. (D)

Sol. 1. $\overset{\text{II}}{[Fe(H_2O)_6]^{+2}}$
WFL

configuration 

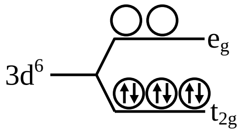
$t_{2g}^4\ e_g^2$(S)

2. $\overset{\text{II}}{[Mn(H_2O)_6]^{+2}}$
WFL

configuration 

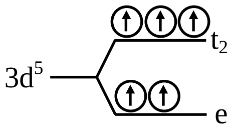
$t_{2g}^3\ e_g^2$(Q)

3. $\overset{\text{III}}{[Co(NH_3)_6]^{+3}}$
SFL

configuration 

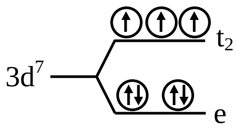
$t_{2g}^6\ e_g^0$(P)

4. $\overset{\text{III}}{[FeCl_4]^{\ominus}}$
WFL

configuration 

$e^2\ t_2^3$(R)

5. $\overset{\text{II}}{[CoCl_4]^{-2}}$
WFL

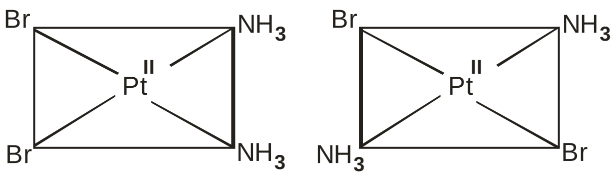
configuration 

$e^4\ t_2^3$(None)

2. Ans. (C, D)

Sol. $\overset{+2}{[Pt(NH_3)_2Br_2]}$

Hybridisation : dsp^2, geometry : square planar

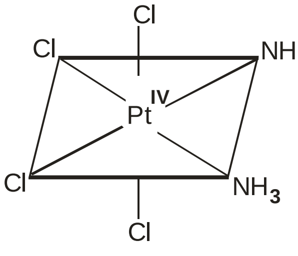


cis trans

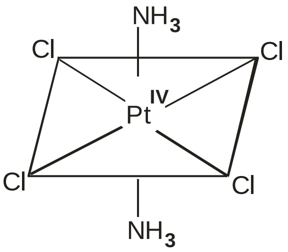
(A) $[Pt(en)(SCN)_2]$: square planar, cis–trans not possible

(B) $[Zn(NH_3)_2Cl_2]$: tetrahedral, cis–trans not possible

(C) $[Pt(NH_3)_2Cl_4]$: octahedral, cis–trans possible

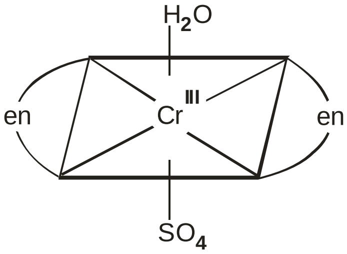


cis

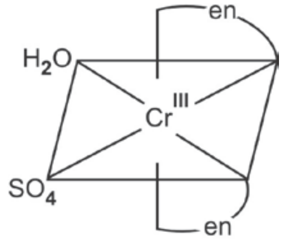


trans

(D) $[Cr(en)_2(H_2O)SO_4]^+$: Octahedral



trans

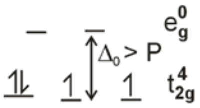


cis

3. Ans. (A)

Sol. (1) $[Cr(CN)_6]^{4-}$

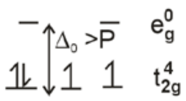
$Cr^{+2} = [Ar]_{18}\, 3d^4 4s^0$; low spin complex



P,R,T

(2) $[RuCl_6]^{2-}$

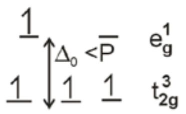
$Ru^{+4} = [Kr]_{36} 4d^4 5s^0$; low spin complex



P,R,S,T

(3) $[Cr(H_2O)_6]^{2+}$

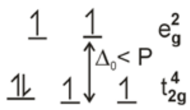
$Cr^{+2} = [Ar]_{18} 3d^4 4s^0$; high spin complex



Q,T

(4) $[Fe(H_2O)_6]^{2+}$

$Fe^{+2} = [Ar]_{18} 3d^6$; High spin complex



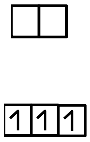
P,Q

4. Ans. (A)

Sol. $[Cr(NH_3)_6]^{3+}$

$Cr^{3+} \Rightarrow [Ar]3d^3$

In presence of NH_3 ligand



e_g

t_{2g}

Number of unpaired electrons = 3

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

$\mu = \sqrt{3(3+2)}$ B.M.

$\mu = \sqrt{15}$ B.M.

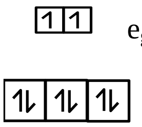
$\Rightarrow$ 3.87 B.M.

$[CuF_6]^{3-}$

$Cu^{3+} \Rightarrow [Ar]3d^8$

In presence of F^- Ligand

$Cu^{3+} \Rightarrow$



e_g

t_{2g}

Number of unpaired electrons = 2

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

$\mu = \sqrt{2(2+2)} \Rightarrow \sqrt{8}$ B.M. $\Rightarrow$ 2.84 B.M

5. Ans. (6)

Sol. Isomers

(I) $[Pt(NH_3)_4Cl_2]Br_2 \Rightarrow$ G.I. = 2

(II) $[Pt(NH_3)_4Br_2]Cl_2 \Rightarrow$ G.I. = 2

(III) $[Pt(NH_3)_4BrCl]Br.Cl \Rightarrow$ G.I. = 2

I, II, III are ionisation isomers of each other, each having 2 geometrical isomers.

Total possible isomers will be 6

6. **Ans. (A, B, D)**

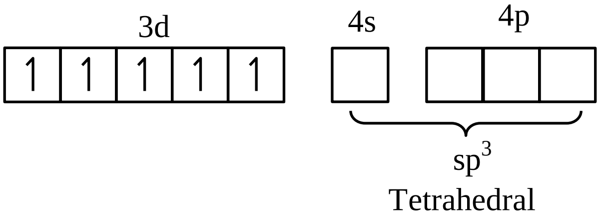
Sol. (A)

$[FeCl_4]^-$

Fe $\longrightarrow$ [Ar] $3d^6 4s^2$

Fe^{+3} $\longrightarrow$ [Ar] $3d^5 4s^0$

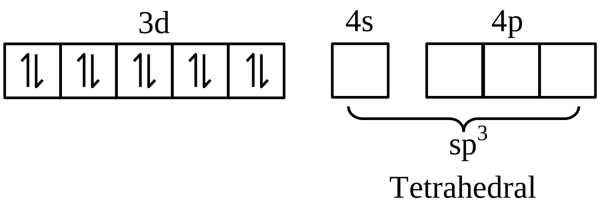
Cl^- is W.F.L. and does not pair up the unpaired electron of central metal atom.

$\therefore$ Fe^{3+} (d^5) in$[FeCl_4]^-$ 

$[Fe(CO)_4]^{2-}$

Fe $\longrightarrow$ [Ar] $3d^6 4s^2$

Fe^{2-} $\longrightarrow$ [Ar] $3d^8 4s^2$

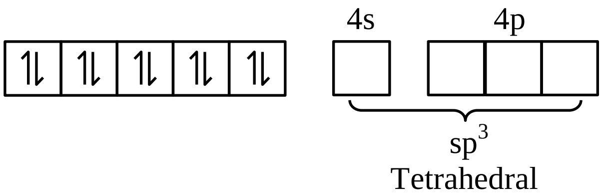
$\therefore$ Fe^{2-} (d^{10}) in $[Fe(CO)_4]^{2-}$ 

(B)

$[Co(CO)_4]^-$

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

Co^{-1} $\longrightarrow$ [Ar] $3d^8 4s^2$

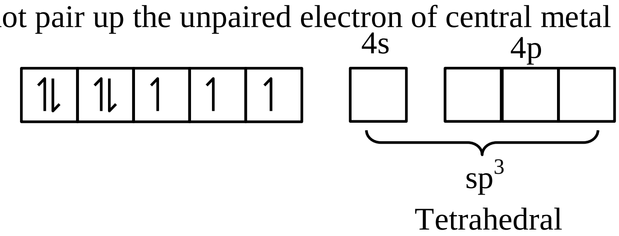
$\therefore$ Co^- (d^{10}) in $[Co(CO)_4]^-$ 

$[CoCl_4]^{2-}$

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

Co^{+2} $\longrightarrow$ [Ar] $3d^7 4s^0$

Cl^- is W.F.L. and does not pair up the unpaired electron of central metal atom.

$\therefore$ Co^{2+} (d^7) in $[CoCl_4]^{2-}$ 

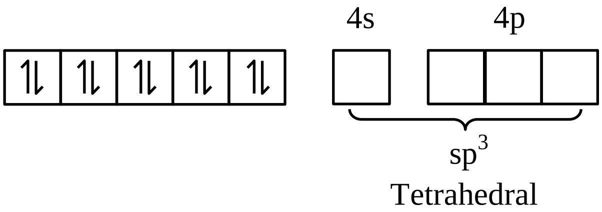
(C)

$[Ni(CO)_4]$

Ni $\longrightarrow$ [Ar] $3d^8 4s^2$

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

$\therefore$ Ni (d^{10}) in $[Ni(CO)_4]$



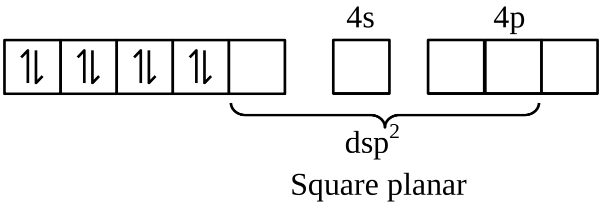
$[Ni(CN)_4]^{2-}$

Ni $\longrightarrow$ [Ar] $3d^8 4s^2$

$Ni^{+2} \longrightarrow$ [Ar] $3d^8 4s^0$

CN^- is S.F.L. and pair up the unpaired electron of central metal atom.

$\therefore$ Ni (d^8) in $[Ni(CN)_4]^{2-}$

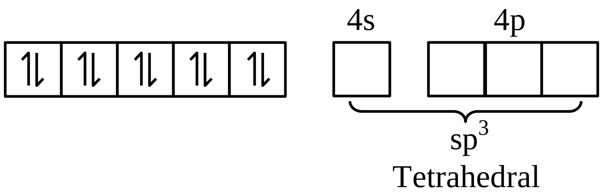


(D) **$[Cu(py)_4]$**

Cu $\longrightarrow$ [Ar] $3d^{10} 4s^1$

$Cu^{+1} \longrightarrow$ [Ar] $3d^{10} 4s^0$

$\therefore Cu^{+1}(d^{10})$ in $[Cu(py)_4]^+$



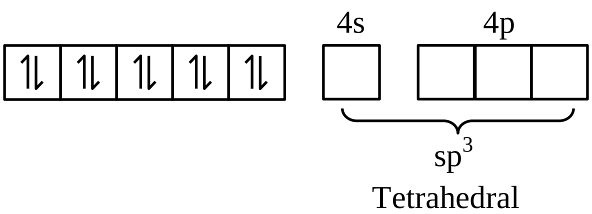
$[Cu(CN)_4]^3$

Cu $\longrightarrow$ [Ar] $3d^{10} 4s^1$

$Cu^{+1} \longrightarrow$ [Ar] $3d^{10} 4s^0$

CN^- is S.F.L. and pair up the unpaired electron of central metal atom.

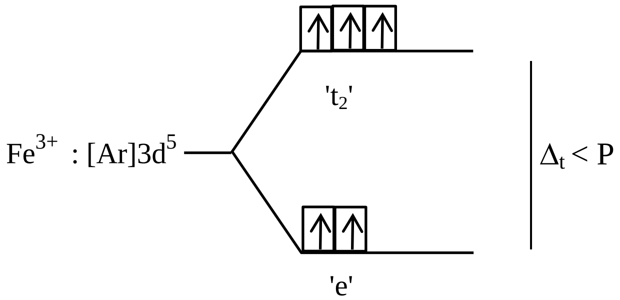
$\therefore$ Cu^{+1} (d^{10}) in $[Cu(CN)_4]^{3-}$



7. Ans. (A, C)

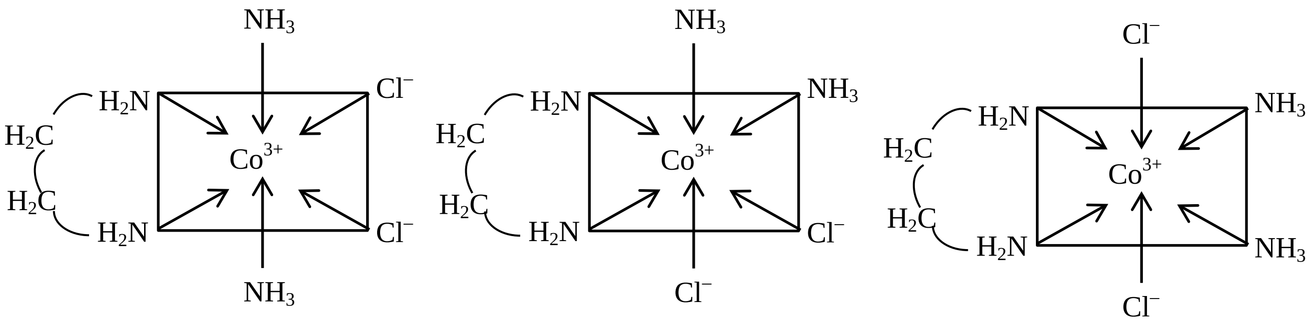
Sol.

(A) $[FeCl_4]^-$

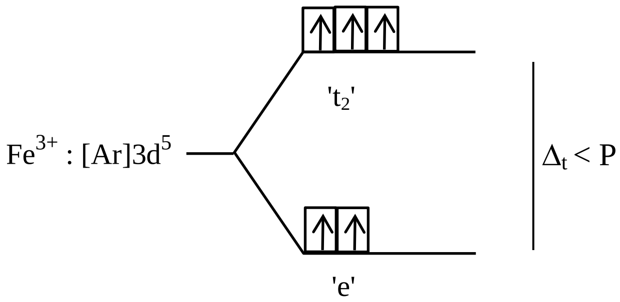


$[FeCl_4]^-$ is sp^3 hybridised and has tetrahedral geometry with 5 unpaired electrons.

(B) $[Co(en)(NH_3)_2Cl_2]^+$ has three geometrical isomers.



(C) $[FeCl_4]^-$

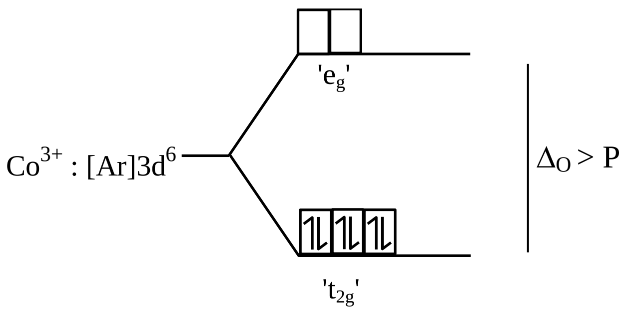


Number of unpaired electrons (n) = 5

Spin only magnetic moment = $\sqrt{n(n+2)}$ B.M.

= 5.92 B.M.

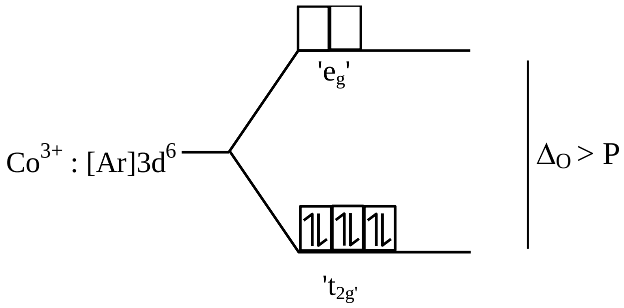
$[Co(en)(NH_3)_2Cl_2]^+$



Number of unpaired electrons (n) = 0

Spin only magnetic moment = $\sqrt{n(n+2)}$ B.M. = 0

(D) $[Co(en)(NH_3)_2Cl_2]^+$



$[Co(en)(NH_3)_2Cl_2]^+$ is d^2sp^3 hybridised and has octahedral geometry with 0 unpaired electron.

8. Ans. (A, B, C)

Sol. **Paramagnetic compound (X)** are attracted towards magnetic field and the pan is deflected downwards. While the **Diamagnetic compound (X)** are repelled by magnetic field and pan is deflected upward.

(A) X $\Rightarrow$ H_2O $\rightarrow$ **Diamagnetic** (correct)

(B) X $\Rightarrow$ $K_4[Fe(CN)_6](s)$ $\rightarrow$ **Diamagnetic** (correct)

Here Fe^{2+} + Strong field ligand $\rightarrow 3d^6 \Rightarrow [t_2g^6, eg^0]$

(C) X $\Rightarrow$ O_2 $\rightarrow$ **Paramagnetic** (correct)

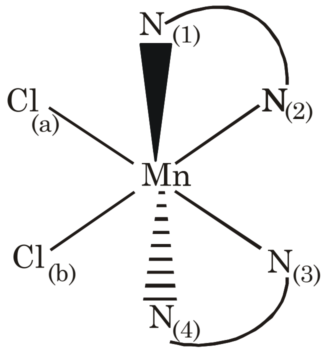
Here $O_2(g)$ is paramagnetic due to two-unpaired electrons present in π^* (antibonding orbitals).

(D) X $\Rightarrow$ $C_6H_6(\ell)$ $\rightarrow$ **Diamagnetic** (Incorrect)

It is due to presence of 0 unpaired electrons.

9. Ans. (6.00)

Sol. cis[M(en)$_2$Cl$_2$



$Cl_{(a)}$— Mn — $N_{(1)}$
$Cl_{(a)}$— Mn — $N_{(2)}$
$Cl_{(a)}$— Mn — $N_{(4)}$
$Cl_{(b)}$— Mn — $N_{(1)}$
$Cl_{(b)}$— Mn — $N_{(3)}$
$Cl_{(b)}$— Mn — $N_{(4)}$

Number of cis (Cl—Mn—N) = 6

10. Ans. (B, C)

Sol. (A) $[Fe(CO_5)]$ & $[Ni(CO)_4]$ complexes have 18-electrons in their valence shell.

(B) Carbonyl complexes are predominantly low spin complexes due to strong ligand field.

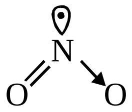
(C) As electron density increases on metals (with lowering oxidation state on metals), the extent of synergic bonding increases. Hence M–C bond strength increases

(D) While positive charge on metals increases and the extent of synergic bond decreases and hence C–O bond becomes stronger.

11. Ans. (1)

Sol.

* H-atom = [↑] $1s^1$ — Paramagnetic

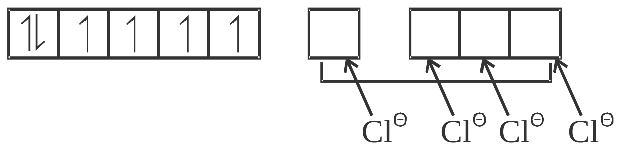
* NO_2 =  odd electron species — Paramagnetic

* O_2^- (superoxide) = One unpaired electrons in π^* M.O. — Paramagnetic

* S_2 (in vapour phase) = same as O_2, two unpaired e^- s are present in π^* M.O. — Paramagnetic

* $Mn_3O_4 = 2\overset{+2}{Mn}O \cdot \overset{+4}{Mn}O_2$ — Paramagnetic

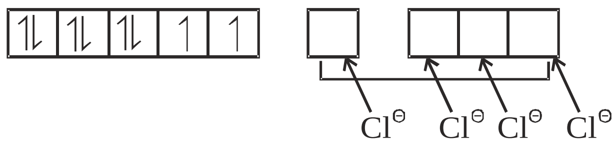
* $(NH_4)_2[FeCl_4]$ = $Fe^{+2} = 3d^6\ 4s^0$



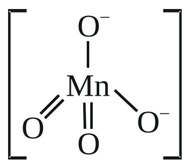
sp^3- hybridisation — Paramagnetic

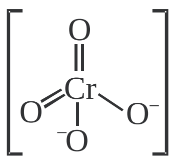
* $(NH_4)_2[NiCl_4]$ = Ni = $3d^8\ 4s^2$

$Ni^{+2} = 3d^8\ 4s^0$



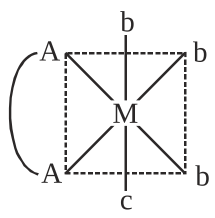
sp^3 - hybridisation — Paramagnetic

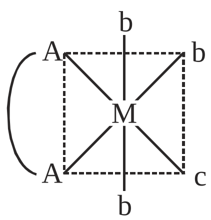
* $K_2MnO_4 = 2K^+$  , Mn^{+6} = [Ar] $3d^1$ — Paramagnetic

* $K_2CrO_4 = 2K^+$  , Cr^{+6} = [Ar] $3d^0$ — Diamagnetic

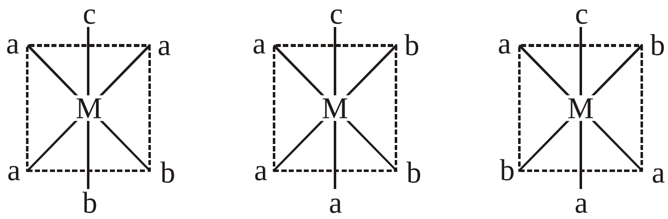
12. Ans. (A, B, D)

Sol. (A) $[Co(en)(NH_3)_3(H_2O)]^{+3}$ complex is type of $[M(AA)b_3c]$ have two G.I.





(B) If (en) is replaced by two cynide ligand, complex will be type of $[Ma_3b_2c]$ and have 3 G.I.



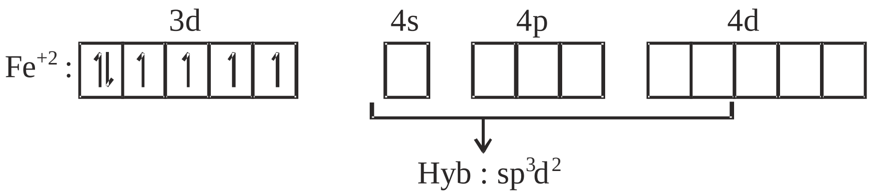
(C) $[Co(en)(NH_3)_3(H_2O)]^{3+}$ have d^6 configuration (t^6_{2g}) on central metal with SFL therefore it is dimagnetic in nature.

(D) Complex $[Co(en)(NH_3)_3(H_2O)]^{3+}$ have lesser CFSE (Δ_O) value than $[Co(en)(NH_3)_4]^{3+}$ therefore complex $[Co(en)(NH_3)_3(H_2O)]^{+}$ absorbs longer wavelength for d–d transition.

13. Ans. (C)

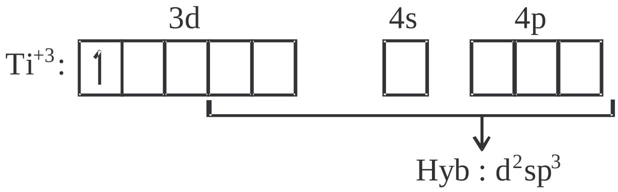
Sol. [1] $[FeF_6]^{4-}$

$Fe^{2+} = [Ar]3d^6$,



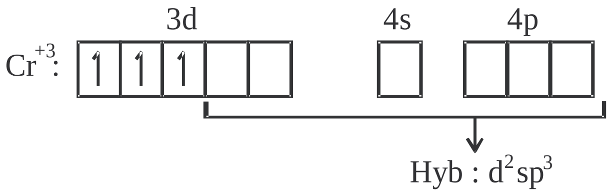
[2] $[Ti(H_2O)_3Cl_3]$

$Ti^{+3} = [Ar]3d^1$,



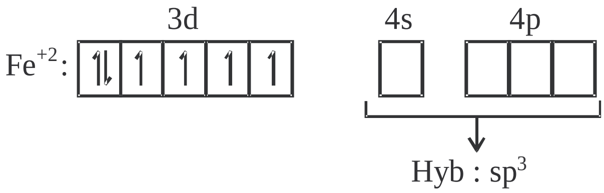
[3] $[Cr(NH_3)_6]^{3+}$

$Cr^{+3} = [Ar]3d^3$,



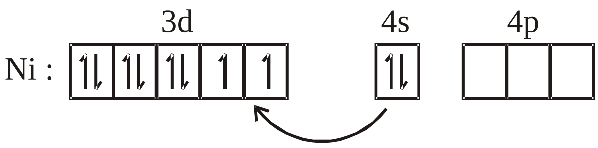
[4] $[FeCl_4]^{2-}$

$Fe^{2+} = [Ar]3d^6$,

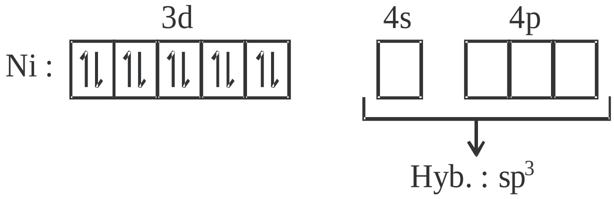


[5] $[Ni(CO)_4]$

Ni : $3d^8\ 4s^2$

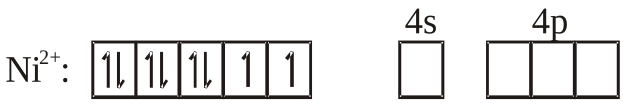


Back pairing of electrons due to presence of strong field ligand

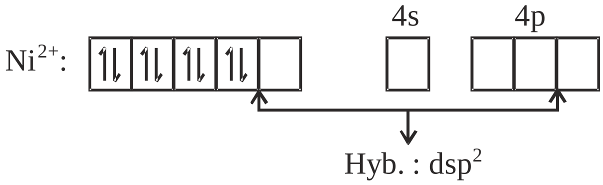


[6] $[Ni(CN)_4]^{2-}$

Ni^{2+} : $3d^8$



Electron pairing take place due to presence of S.F.L.



14. Ans. (A, B, D)

Sol. $\overset{II}{[Co(H_2O)_6]Cl_2} \xrightarrow[\text{Air}/O_2]{\text{Excess } NH_4OH/NH_4Cl} \overset{III}{[Co(NH_3)_6]Cl_3}$

Pink **(X)** **(Y)**

$[Co(H_2O)_6]^{2+} + 4Cl^- \longrightarrow [CoCl_4]^{2-}$

(X) (excess) **(Z)** blue

(A) Hybridisation of (Y) is d^2sp^3 as NH_3 is strong field ligand

(B) $[CoCl_4]^{2-}$ have sp^3 hybridisation as Cl^- is weak field ligand

(C) $\overset{III}{[Co(NH_3)_6]Cl_3} + 3AgNO_3(aq.) \rightarrow 3AgCl$

(Y)

(D) $\underset{(Blue)}{[CoCl_4]^{2-}} + 6H_2O \rightleftharpoons \underset{(Pink)}{[Co(H_2O)_6]^{2+}} + 4Cl^-$ $\Delta H = (-)$ve (exothermic)

When ice is added to the solution the equilibrium shifts right hence pink colour will remain predominant

So, correct answer is (A ,B & D)

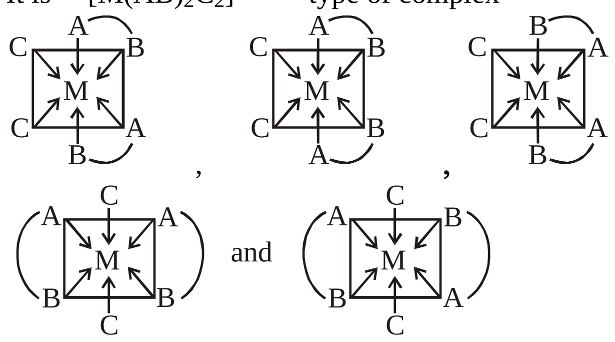
15. Ans. (5)

Sol. $[CoL_2Cl_2]^-$ ($L = H_2NCH_2CH_2O^-$)

$[Co(H_2NCH_2CH_2O)_2Cl_2]^{\ominus}$

↓

It is $[M(AB)_2C_2]$ type of complex



Total geometrical isomers = 5

16. Ans. (A)

Sol.

Metal ion	**Complex with NH_3**	**Geometry**
Ni^{2+}	$[Ni(NH_3)_6]^{2+}$	Octahedral
Pt^{2+}	$[Pt(NH_3)_4]^{2+}$	Square planar
Zn^{2+}	$[Zn(NH_3)_4]^{2+}$	Tetrahedral

So, option (A) is correct.

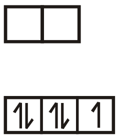
17. Ans. (4)

Sol. $[Fe(CN)_6]^{3-}$

$Fe^{+3} = 3d^5$

$\overset{\ominus}{C}N$ is S.F.L

$\Delta_0 > P$



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

n = number of unpaired electron = 1

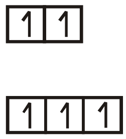
μ = 1.73 B.M.

$[Fe(SCN)_6]^{3-}$

$Fe^{+3} = 3d^5$

$\overset{\ominus}{S}CN$ is W.F.L

$\Delta_0 < P$



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

n = number of unpaired electron = 5

μ = 5.92 B.M.

difference = 5.92 – 1.73 = 4.19

Ans. $\approx$ **4**

18. Ans. (A, B, C)

Sol. (A) Cr^{+2} is a reducing agent **: CORRECT STATEMENT**

Cr^{+2} is a reducing agent as its configuration changes from d^4 to d^3 and Cr^{+3} having a half filled t_{2g} level in presence of H_2O

$Cr^{+2} \rightarrow Cr^{+3} + e^-$

$3d^4 4s^o$ $\quad$ $3d^3 4s^o$

(B) Mn^{+3} is a oxidizing agent **: CORRECT STATEMENT**

The change from Mn^{+3} to Mn^{+2} results in the half filled (d^5) configuration which has extra stability

$Mn^{+3} \xrightarrow{+e^-} Mn^{+2}$

$3d^4 4s^o$ $\quad$ $3d^5 4s^o$

[extra stable half filled (d^5) configuration]

(C) Both Cr^{+2} and Mn^{+3} exhibit d^4 electronic configuration **: CORRECT STATEMENT**

$Cr^{+2} \rightarrow 3d^4 4s^o$

$Mn^{+3} \rightarrow 3d^4 4s^o$

(D) When Cr^{+2} is used as reducing agent chromium ion attain d^5 electronic configuration : **INCORECT**

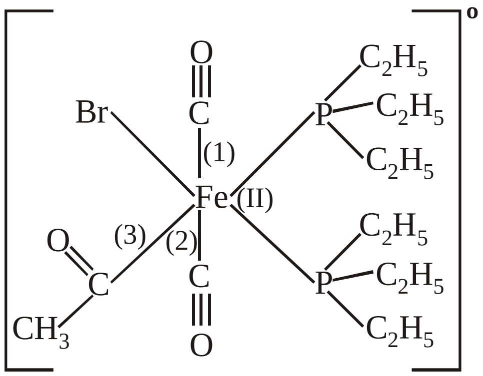
$Cr^{+2} \rightarrow Cr^{+3} + e^-$

$3d^4 4s^o$ $\quad$ $3d^3 4s^o$

Reducing agent $\quad$ It attain d^3 electronic configuration

19. **Ans. (3)**

Sol. Structure of complex



Total number of Fe–C bonds are 3

20. **Ans. (6)**

Sol. Total number of complex ions which show cis-trans isomerism

Complex ion	Complex type	Isomers
$[Co(NH_2–CH_2–CH_2–NH_2)_2Cl_2]^+$	$[M(AA)_2b_2]$	1 cis + 1 trans
$[CrCl_2(C_2O_4)_2]^{3–}$	$[M(AA)_2b_2]$	1 cis + 1 trans
$[Fe(H_2O)_4(OH)_2]^+$	$[Ma_4b_2]$	1 cis + 1 trans
$[Fe(NH_3)_2(CN)_4]^–$	$[Ma_4b_2]$	1 cis + 1 trans
$[Co(NH_2–CH_2–CH_2–NH_2)_2(NH_3)Cl]^{+2}$	$[M(AA)_2bc]$	1 cis + 1 trans
$[Co(NH_3)_4(H_2O)Cl]^{+2}$	$[Ma_4bc]$	1 cis + 1 trans

All six complex ions show cis-trans isomerism

21. **Ans. (4)**

Sol. XeF_4, BrF_4^- , $[Cu(NH_3)_4]^{2+}$, $[PtCl_4]^{2–}$ are square planar

SF_4 – Sea saw

SiF_4 , $BF_4^–$, $[FeCl_4]^{2–}$, $[CoCl_4]^{2–}$ are tetrahedral

22. **Ans. (B)**

Sol.
(P) $[Cr^{III}(NH_3)_4Cl_2]Cl$: (3 unpaired electrons) — (1) Complex given in (P) is Paramagnetic & show two geometrical isomerism (cis and trans) (does not show ionization isomer)

(Q) $[Ti^{III}(H_2O)_5Cl](NO_3)_2$ (1 unpaired electrons) — (2) Complex given in (Q) is paramagnetic show ionization isomerism

(R) $[Pt^{II}(en)(NH_3)Cl]NO_3$ (1 unpaired electrons) — (3) Complex given in (R) is diamagnetic and show ionization isomerism

(S) $[Co^{III}(NH_3)_4(NO_3)_2]NO_3$ (0 unpaired electrons) — (4) Complex given in (S) is diamagnetic does not show ionization isomerism show geometrical isomerism