JEE Mains 2019 Chapter wise Question Bank

Coordination Compounds - Questions

Q1

Two complexes $[Cr(H_2O)_6]Cl_3$ (A) and $[Cr(NH_3)_6]Cl_3$ (B) are violet and yellow coloured, respectively. The incorrect statement regarding them is:

(1) Δ_0 values of (A) and (B) are calculated from the energies of violet and yellow light, respectively.
(2) both are paramagnetic with three unpaired electrons.
(3) both absorb energies corresponding to their complementary colors.
(4) Δ_0 value for (A) is less than that of (B).

9 Jan Morning

Q2

The highest value of the calculated spin only magnetic moment (in BM) among all the transition metal complexes is :

(1) 5.92 (2) 6.93
(3) 3.87 (4) 4.90

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Q3

The complex that has highest crystal field splitting energy (Δ) is:

(1) $[Co(NH_3)_5(H_2O)]Cl_3$ (2) $K_2[CoCl_4]$
(3) $[Co(NH_3)_5Cl]Cl_2$ (4) $K_3[Co(CN)_6]$

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Q4

Homoleptic octahedral complexes of a metal ion 'M^{3+}' with three monodentate ligands L_1, L_2 and L_3 absorb wavelengths in the region of green, blue and red respectively. The increasing order of the ligand strength is:

(1) $L_3 < L_1 < L_2$ (2) $L_3 < L_2 < L_1$
(3) $L_1 < L_2 < L_3$ (4) $L_2 < L_1 < L_3$

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Q5

The total number of isomers for a square planar complex $[M(F)(Cl)(SCN)(NO_2)]$ is:

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

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Q6

The difference in the number of unpaired electrons of a metal ion in its high-spin and low-spin octahedral complexes is two. The metal ion is:

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

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Q7

A reaction of cobalt(III) chloride and ethylenediamine in a 1 : 2 mole ratio generates two isomeric products A (violet coloured) and B (green coloured). A can show optical activity, but, B is optically inactive. What type of isomers does A and B represent?

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

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Q8

Match the metals **(column I)** with the coordination compound(s)/enzyme(s) **(column II)** :

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

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

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Q9

The coordination number of Th in $K_4[Th(C_2O_4)_4(H_2O)_2]$ is:
($C_2O_4^{2-}$ = oxalato)
(1) 14 (2) 6
(3) 8 (4) 10

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Q10

The number of bridging CO ligand(s) and Co-Co bond(s) in $Co_2(CO)_8$, respectively are:
(1) 2 and 1 (2) 2 and 0
(3) 0 and 2 (4) 4 and 0

11 Jan Evening

Q11

The pair of metal ions that can give a spin only magnetic moment of 3.9 BM for the compex $[M(H_2O)_6]Cl_2$, is:
(1) V^{2+} and Co^{2+} (2) V^{2+} and Fe^{2+}
(3) Co^{2+} and Fe^{2+} (4) Cr^{2+} and Mn^{2+}

12 Jan Morning

Q11

The metal *d*-orbitals that are directly facing the ligands in $K_3[Co(CN)_6]$ are :

(1) d_{xy} and $d_{x^2-y^2}$ (2) $d_{x^2-y^2}$ and d_{z^2}

(3) d_{xz}, d_{yz} and d_{z^2} (4) d_{xy}, d_{xz} and d_{yz}

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Q12

The magnetic moment of an octahedral homoleptic Mn(II) complex is 5.9 BM. The suitable ligand for this complex is :
(1) Ethylenediamine (2) CN^-
(3) NCS^- (4) CO

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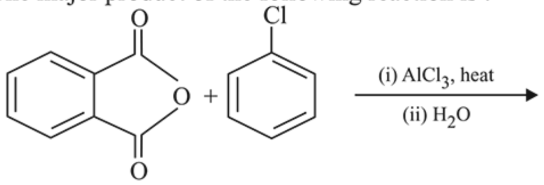
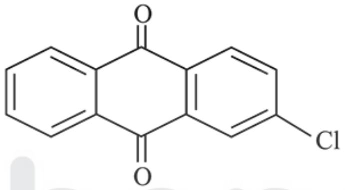
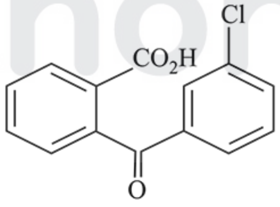
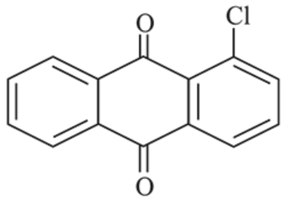
Q13

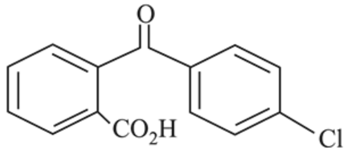
The major product of the following reaction is :



(1) 

(2) 

(3) 

(4) 

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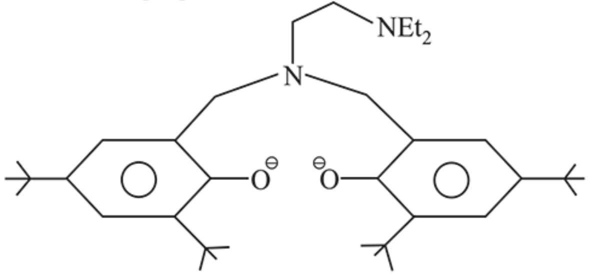
Q14

The following ligand is:



(1) hexadentate (2) tetradentate

(3) bidentate (4) tridentate

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Q14

The compound that inhibits the growth of tumors is :

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

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

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Q15

The calculated spin-only magnetic moments (BM) of the anionic and cationic species of $[Fe(H_2O)_6]_2$ and $[Fe(CN)_6]$, respectively, are:

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

(3) 4.9 and 0 (4) 0 and 5.92

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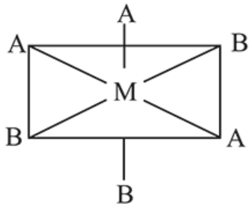
Q16

The one that will show optical activity is:

(en = ethane 1, 2-diamine)

(1)



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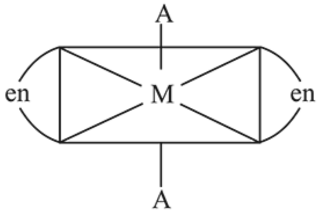

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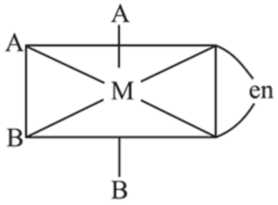

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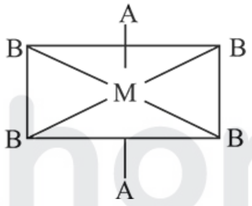

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Q17

The degenerate orbitals of $[Cr(H_2O)_6]^{3+}$ are:

(1) d_{xz} and d_{yz} (2) d_{yz} and dz^2

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

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Q18

The correct statements among I to III are:

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

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

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

(1) (II) and (III) only (2) (I), (II) and (III)

(3) (I) and (III) only (4) (I) and (II) only

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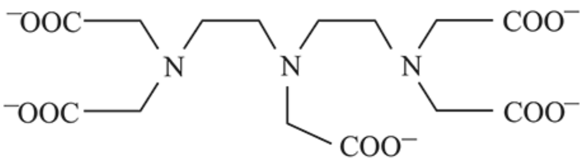
Q19

The maximum possible denticities of a ligand given below towards a common transition and inner-transition metal ion, respectively, are:



(1) 8 and 6 (2) 6 and 8
(3) 6 and 6 (4) 8 and 8

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Q20

Three complexes, $[CoCl(NH_3)_5]^{2+}$(I), $[Co(NH_3)_5H_2O]^{3+}$(II) and $[Co(NH_3)_6]^{3+}$ (III) absorb light in the visible region. The correct order of the wavelength of light absorbed by them is :

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

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Q21

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

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

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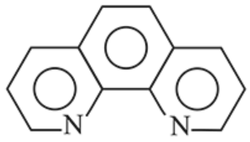
Q22

The complex ion that will lose its crystal field stabilization energy upon oxidation of its metal to +3 state is :

(Phen =



and
ignore pairing energy)

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

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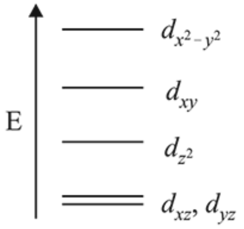
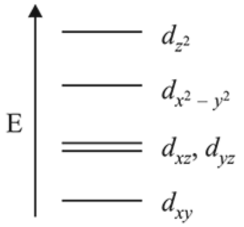
Q23

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

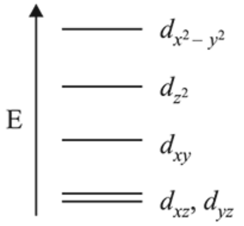
(1)



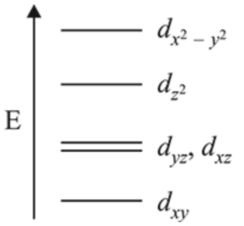
(2)



(3)



(4)



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Q24

The compound used in the treatment of lead poisoning is :

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

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Q25

The coordination numbers of Co and Al in $[Co(Cl)(en)_2]Cl$ and $K_3[Al(C_2O_4)_3]$, respectively, are :

(en = ethane-1, 2-diamine)

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

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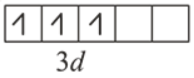
JEE Mains 2019 Chapter wise Question Bank

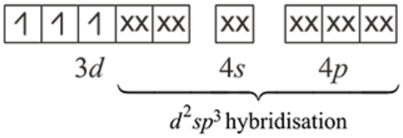
Coordination Compounds - Answers

Q1

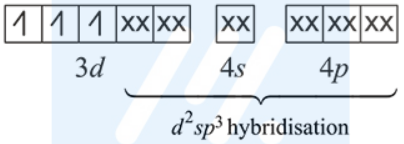
(1) E.C. of Cr^{3+} $(3d^3)$:



For complex A $[Cr(H_2O)_2]^{3+}$:



For complex B $[Cr(NH_3)_6]^{3+}$:



Here, both the complexes (A) and (B) are paramagnetic with 3 unpaired electrons each. Also H_2O is a weak field ligand which causes lesser splitting than NH_3 which is comparatively stronger field ligand. Hence, the (Δ_0) value of (A) and (B) are calculated from the wavelengths of light absorbed and not from the wavelengths of light emitted

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Q2

(1) Magnetic moment, $\mu = \sqrt{n(n+2)}$ BM (where, n = no. of unpaired electrons)

As transition metal atom/ion in a complex may have unpaired electrons ranging from zero to 5. So, maximum number of unpaired electrons that may be present in a complex is 5.

$\therefore$ Maximum value of magnetic moment among all the transition metal complexes is

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Q3

(4) In case of similar metal atom or ion, the value of co-ordination number and the strength of the ligands determine the value of crystal field splitting energy.

Greater the co-ordination number and strength of value of the ligand, greater will be the value of CFSE.

Strength of ligands : $CN^- > NH_3 > H_2O > Cl^-$

$\therefore$ $K_3[Co(CN)_6]$ has the highest crystal field splitting energy.

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Q4

(1) Lesser the wavelength of light absorbed (more energy) greater will be ligand strength.

Energy: Blue > Green > Red

Ligand strength: $L_2 > L_1 > L_3$

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Q5

(4) No. of isomers

$[M(F)(Cl)(SCN)(NO_2)] \rightarrow 3$

$[M(F)(Cl)(SCN)(ONO)] \rightarrow 3$

$[M(F)(Cl)(NCS)(NO_2)] \rightarrow 3$

$[M(F)(Cl)(NCS)(ONO)] \rightarrow 3$

Total = 12

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Q6

(3)

Metal ion	No. of unpaired elec.		Difference in the unpaired electrons
	High spin	Low spin	
Ni^{2+} $(3d^8)$	2	2	0
Mn^{2+} $(3d^5)$	5	1	4
Fe^{2+} $(3d^6)$	4	0	4
Co^{2+} $(3d^7)$	3	1	2

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Q7

(1) Reaction for the given condition can be written as:

$[CoCl_6]^{3-} + 2(en) \longrightarrow [CoCl_2(en)_2]^+$

(1:2 mole ratio) (*cis-trans*-isomer)

A = optically active (*cis*-isomer), violet

B = optically inactive (*trans*-isomer), green

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Q8

(1) Wilkinson catalyst : $[Rh(PPh)_3Cl]$

Chlorophyll : $C_{55}H_{72}O_5N_4Mg$

Vitamin B_{12} contains Co.

Carbonic anhydrase contains a Zn ion.

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Q9

(4) $K_4[Th(C_2O_4)_4(H_2O)_2]$

$C_2O_4^{2-}$ (oxalato) : bidentate ligand

H_2O (aqua): monodentate

$\therefore$ Co-ordination no. of Th = 2 × 4 + 2 = 10

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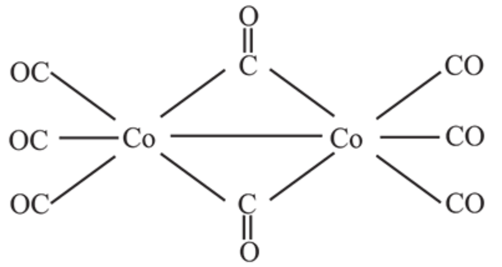
Q10

(1) The structure of $Co_2(CO)_8$ is represented as



It contains two bridging CO ligands and one metal – metal (Co – Co) bond.

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Q11

(1) Given μ = 3.9 BM

$\mu = \sqrt{n(n+2)}$ B.M. ; $3.9 = \sqrt{n(n+2)}$; $n = 3$

So, the central metal ion has 3 unpaired electrons.

$\therefore$ Configuration is either d^3 or d^7

As H_2O is a weak field ligand. V^{2+} and Co^{2+} will have 3 unpaired electrons.

V^{2+} has d^3 configuration; Co^{2+} has d^7 configuration.

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Q11

(2) $K_3[Co(CN)_6]$ is an octahedral complex.

During splitting of *d* orbitals in octahederal complexes, $d_{x^2-y^2}$ and d_{z^2} orbitals point towards the direction of ligands (i.e. they experience more repulsion and will be raised in energy by $\frac{3}{5}\Delta_0$).

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Q12

(3) Electronic configuration of Mn is,

$Mn^{2+} : 3d^5$ $\underset{3d^5}{\boxed{\upharpoonleft}\boxed{\upharpoonleft}\boxed{\upharpoonleft}\boxed{\upharpoonleft}\boxed{\upharpoonleft}}$

Presence of 5 unpaired e^- shows that the complex of Mn^{2+} has only weak field ligand (NCS^-).

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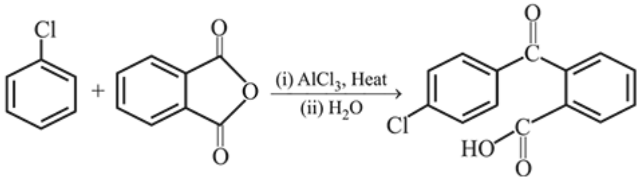
Q13

(4)



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Q14

(2) It has four atoms containing lone pair of e$^-$, therefore, it will be able to donate these lone pairs and acts as a tetradentate ligand.

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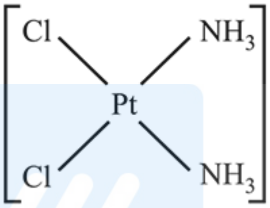
Q14

(3) *cis*-Platin is used as an anti-cancer drug.



cis-$[Pt(Cl)_2(NH_3)_2]$

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Q15

(3) $[Fe(H_2O)_6]^{2+}$: cationic species of $[Fe(H_2O)_6]_2$
$[Fe(CN)_6]^{4-}$: anionic species of $[Fe(CN)_6]$
Magnetic Moment $(\mu) = \sqrt{n(n+2)}$
Where n = no. of unpaired electrons
Now, $[Fe(H_2O)_6]^{2+}$ $[Fe(CN)_6]^{4-}$
n = 4 n = 0

$\therefore\ \mu = \sqrt{4(4+2)}$ $\mu = \sqrt{0(0+2)}$

$\mu = 4.9$ $\mu = 0$

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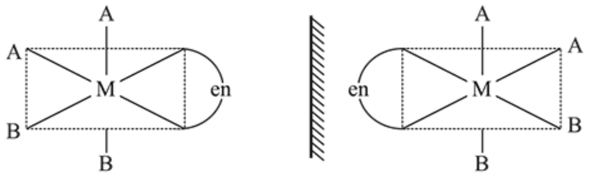
Q16

(3)



No plane of symmetry or centre of symmetry
Hence it is optically active.

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Q17

(1) Cr^{3+} has d^3 configuration and forms an octahedral inner orbitals complex.

The set of degenerate orbitals are

$(d_{xy},\ d_{yz}$ and $d_{xz})$ and $(d_{x^2-y^2}$ and $d_{z^2})$.

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Q18

(3) Valence bond theory cannot distinguish between weak field ligands and strong field ligands. Therefore, it cannot predict quantitatively the magnetic properties of transition metal complexes.

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Q19

(2) The maximum possible denticites of the given ligand towards transition metal ion is 6 and towards inner transition metal ion (due to greater ionic radii and more atomic orbitals) is 8.

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Q20

(4) Wavelength of the energy absorbed by the co-ordination compound is inversely proportional to ligand field strength of the given co-ordination compound. The strong field ligand causes higher splitting of the *d*-orbitals. The decreasing order of ligand field strength is $NH_3 > H_2O > Cl$. Therefore decreasing order of absorbed wavelength is (I) > (II) > (III).

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Q21

(2) $[Fe(H_2O)_6]^{2+}$ $t_{2g}^4\ e_g^2$

CFSE = $(-4 \times 0.4 + 2 \times 0.6)\ \Delta_0 = -0.4\ \Delta_0$

$[NiCl_4]^{2-}$ $e^4\ t_2^4$

CFSE = $(-4 \times 0.6 + 4 \times 0.4)\ \Delta_t = -0.8\ \Delta_t$

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Q22

(4) $\underset{t_{2g}^6 e_g^2}{Ni^{2+}(d^8)} \longrightarrow \underset{t_{2g}^6 e_g^1}{Ni^{3+}(d^7)}$

$\underset{t_{2g}^6 e_g^1}{Co^{2+}(d^7)} \longrightarrow \underset{t_{2g}^6 e_g^0}{Co^{3+}(d^6)}$

$\underset{t_{2g}^6 e_g^4}{Zn^{2+}(d^{10})} \longrightarrow \underset{t_{2g}^6 e_g^3}{Zn^{3+}(d^9)}$

$\underset{t_{2g}^6 e_g^0}{Fe^{2+}(d^6)} \longrightarrow \underset{t_{2g}^5 e_g^0}{Fe^{3+}(d^5)}$

So, only Fe^{2+} will lose crystal field stabilisation energy upon oxidation to +3, others will gain crystal field stabilisation energy.

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Q23

(1) After removal of both axial ligands from octahedral complex the field becomes square planar and the order of energy becomes

$$d_{x^2-y^2} > d_{xy} > d_{z^2} > d_{xz} = d_{yz}$$

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Q24

(4) EDTA is used in the treatment of lead poisoning. Deferrioxime B is used in treatment of iron poisoning and D-penicillamine is used in treatment of heavy metal poisoning, while *cis*-platin is used for treating cancer.

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Q25

(4) $[Co(en)_2\ Cl]\ Cl$

Cl^- - monodentate ligand

en - bidentate ligand

∴ Co-ordination Number of Co = (2 × 2) + 1 = 5

$K_3[Al(C_2O_4)_3]$

$C_2O_4^{2-}$- bidentate ligand

∴ Co-ordination Number of Al = 2 × 3 = 6

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