NEET REVISION SERIES

COORDINATION COMPOUNDS

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Q-1 - 12979209

Which of following coordination compounds contains the central

metal with the highest oxidation number?

(A)
$$[Ru(NH_3)_5(H_2O)]CI_2$$

(B) $[Cr(NH_3)_6](NO_3)_3$
(C) $[Fe(CO)_5]$
(D) $K_4[Fe(CN)_6]$

CORRECT ANSWER: B

SOLUTION:

Each nitrate ion has a charge of -1, therefore, the

cation must be $\left[Cr(NH_3)_6 \right]^{3+} NH_3$ is netural so the oxidation In (1), both NH_3 and H_2O are netural species. Since each chloride ion carries a 1 - charge, and there are two CI^{-} ions, the oxidation number of Ru must be +2 In (3), the oxidation number of Fe is zero, since the CO species are netural. In (4), each potassium ion has a charge of 1+, therefore, the anion is $\left[Fe(CN)_{6}\right]^{4-}$. Next we know that each cyanide group bears a charge of $1 - \,$, so Fe must have an oxidation number of +2 .

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In the coordination compound $[Co(en)_2Cl_2]Cl$

(en=ethylenediamine), the coordination number and oxidation

number of the central atom are, respectively:

(A) (a) 4, +3

(B) (b) 6, +2

(C) (c) 4, +2

(D) (d) 6, +3

CORRECT ANSWER: D

SOLUTION:

$$\left[Co(en)_2 Cl_2
ight]Cl$$

(en)=ethylenediamine has two donor sites



(en)=4 donor sites

 $Cl_2=2$ donor sites

6 donor sites (so, six coordination number).

 $\left[Co(en)_2 Cl_2\right] CL$

 \downarrow $x+2\,(\,0\,)\,+\,(\,-3\,)$ =0(en) Neutralligand

x = +3 oxidation state.



The oxidation number of iron in sodium nitroprusside is

(A) + 3

(B) + 4

(C) + 2

(D) + 1

CORRECT ANSWER: C

SOLUTION:

Sodium pentacyanidonitrosoferrate (II),

 $Na_2 [Fe(CN)_5 NO]$

 $]2H_2O$

, is usually called sodium nitroprusside. This complex

has NO^+ as a ligand. Each sodium ion has a change

of 1+ , therefore, the anion is $\left\lceil Fe(CN)_5 NO
ight
ceil^{2-}$. Next, we know that each cyanide group bears a change of 1- , so Fe must have an oxidation number of +2 . It is found as Brown-red crystals by reacting a ferrocyanide with either $30 \% HNO_3$ or with a nitrite: $\left[Fe(CN)_{6}\right]^{4-} + NO_{3}$ $(-) + 4H^+$ $\rightarrow \left[Fe(CN)_{5}(NO)\right]^{2-}$ $+ NH_{4}^{+} + CO_{2}$

 $egin{aligned} &Na_4ig|Fe(CN)_6ig|\ &+NO_2^-+H_2O\ & o Na_2ig[Fe(CN)_5(NO)ig]\ &+2NaOH+CN^- \end{aligned}$

Sodium nitroprusside reacts with sulphide ions to give a

purple complex
$$ig[Fe(CN)_5(NOS)ig]^{4-}$$
 . This is used as

a sensitive complex test for sulphides.





Q-4 - 12979212

Which of the following is not a chelating ligand ?

(A) Monodentate

(B) Bidentate

(C) Tridentate

(D) Quadridentate



CORRECT ANSWER: A

SOLUTION:

A monodenate ligand (meaning " one - toothed" ligand) is a ligand that bonds to a metal atom/ion through one atom of the ligand. In some complexes a ligand occupies more than one coordination position. Thus more than one atom in the ligand is bonded to the central metal. For example, ethylinediamine (en) forms a complex with coppeer ions:

$$Cu^{2+} + 2 | \xrightarrow{CH_2NH_2} \left[\begin{array}{c} CH_2 - NH_2 & NH_2 - CH_2 \\ CH_2NH_2 & CH_2 - NH_2 & NH_2 - CH_2 \end{array} \right]^{2+}$$

In this complex the copper is surrounded by four $-NH_2$ group. Thus each ethylenedimine molecule is bonded to the cu^{2+} in two place. For this reason ethylendiamine is

called a bidentate ligand (Bidentate means literally two

teeth !) Thus, a ring structure is formed (in this case a

pair of five-membered rings). Such rings structure are

called chelates and the corresponding ligands are called

chelating ligands. All chelating are polydentate ligands. A polydentate ligand ("having many teeth") is a ligand that can bond with two or more atoms to a metal atom. A complex formed by polydentate ligands is frequently quite stable and is called a chelate. Chelated complexes are more stable than similar complexes with unidentate lengands, as dissociation of the omplex invlves breaking two bonds rather than one. Chelates are even more stable when they contian a system of alternate double and single bonds. This is better represented as a system in which electron density is delocalized and spread over the ring. Examples of this include acetylcetone and porphyrin complexes with metals.



Resonance in acetylacetone chelate

Resonance in acetylacetone chelate



Q-5 - 14625577

Which of the following is not an ambidentate ligand?

(A) *CN* ⁻ (B) *SCN* ⁻ (C) *CO*

(D) NO_2^-

CORRECT ANSWER: 3

SOLUTION:

Ligands which can ligate through two different atoms

present in it are called ambidentate ligands. Examples of

such ligands are the CN^-, NO_2^- and SCN^- ions.

CO is not an ambidentate ligand.

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Q-6 - 12979215

The IUPAC name of $|Ru(NH_3)_5N_2|CI_2$ is

(A) pentaammine (azido) ruthenium (II) dichloride

(B) rutheniumpentammine (II) dichlorodinitrogen

(C) pentamine (nitrogen) ruthenium (II) chloride

(D) pentaammine (dinitrogen) ruthenium (II) chloride

CORRECT ANSWER: D

SOLUTION:

Cations are always namedbefore anions, with a space

between their names. In naming the coordination

sphere, ligands are named in alphabetical order. The

prefixes

 $egin{aligned} di &= 2, tri = 3, trtra \ &= 4, penta = 5, hexa \ &= 6 \end{aligned}$

, and so on specify the number of each kind of simple (monodentate) ligand. Neural ligands are usually given the name of the molecule and have no special endings. Thus the ligand N_2 is called dinitrogen. However, there are several important exceptions.

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The IUPAC name of $Ba[BrF_4]_2$ is

(A) brium bis [tetrafluorobrominate (III)]

(B) brium bromofluoride (III)

(C) barium bis [tetrafluorobromate (IV)]

(D) barium tetrafluoridobromate (III)

CORRECT ANSWER: D

SOLUTION:

In naming a salt, the name of the cation precedes the name of the anino. The ligands are named in alphabetical order before the name of the central atom/ion (However this procedure is reversed form writing formula). The complete ligand name consist of a Greek prefix denoting the number of ligands followed by

the specific name of he ligand.



Q-8 - 12979223

The IUPAC name for $[Co(NH_3)_6][Cr(CN)_6]$ is

(A) hexacynochromate (III) hexaamminecobalt (III)

(B) hexaaamminecobalt (III) hexacyanidochromate (III)

(C) hexaamminechrominum cobalt hexaammine (VI)

(D) hexamminecobalt (III) hexacyanochomium (III)

CORRECT ANSWER: B

SOLUTION:

In the given ionic coordination compound, both positive and negative ions. Ionic species are written as two words with the cation first. The central metal atom is

identified by name, followed by the formal oxidation

number in Roman numerals in parenthese. If the

complex is an anion, the ending-ate adds to the metla

name or replacees any -ium, -en, -or-ese ending . Thus,

we have cobaltate and nickelate, but chromate and tungstate (not chromiumate). For a few metals, the element: ferrate (iron), argentate (silver), cuprate (copper) and aurate (gold).



Q-9 - 12979228

How may structural isomers are possible are possible for a complex consisting of Co^{3+} as the central metal ion, two en molecules, two

 CI^- ions one NO_2^- ion ?

(A) Four



(C) Five

(D) Two

SOLUTION:

Keeping in mind that the coordination number of Co^{3+}

ion is six, we have following possibilities:

```
|CoCI_2(en)_2|NO_2|
[CoCI_2(en)]
+ (2)NO_2 ]CI
```

 $|CoCI_2(en)_2(ONO)|$ |CI|

Therefore only ionization and linkage isomerism are possble. Hydrate isomersm is not possible as there is no

H_2O molecule. Coordination isomerism is also not

possible as both positive and negative ions are complex

ions.



How many total ionization isomers of the complex

 $[CoCl(en)_2 NO_2]SCN$ are possible ?

(A) 2

(B) 3

(C) 4

(D) 1

CORRECT ANSWER: B

SOLUTION:

 $[CoCl(en)_2NO_2]SCN,$ $\left[CoCl(en)_2 SCN \right] NO_2,$

 $\left[Co(en)_2(NO_2)(SCN)
ight]$

]Cl

Q-11 - 11481067

Assertion The total number of isomers shown by $[Co(en)_2 CI_2]^{\oplus}$ complex ion is three $[Co(en)_2 CI_2]^{2+}$ complex ion has an octahedral geometry.

(A) If both (A) and (R) are correct and (R) is the correct explanation of (A) .

(B) If both (A) and (R) are correct and (R) is the correct explanation of (A) .

(C) If (A) is correct, but (R) is incorrect .

(D) Both (A) and (R) are incorrect .

CORRECT ANSWER: B



What kind of isomerism exists between $[Cr(H_2O)_6]Cl_3$ (violet) and $[Cr(H_2O)_5Cl]$. H_2O (greyish-green)?

(A) Linkage isomerism

(B) Solvate isomerism

(C) Ionisation isomerism

(D) Coordination isomerism

CORRECT ANSWER: 2

SOLUTION:

The given compounds have different number of water

o 1

molecules inside and outside the coordinate sphere.



The valency of Cr in the complex $\left[Cr(H_2O)_4Cl_2\right]^+$

(A) 1

(B) 3

(C) 5

(D) 6

CORRECT ANSWER: B

SOLUTION:

 $\left[{{^*Cr(H_2O)}_4Cl_2}
ight]$

$$x + 0 + 2(-1)$$
, x-2=+1x=+3f or Cr` in complex.



Q-14 - 12979237

Which of the following types of square planar complexes can't show

geometric isomerism?

(A) MA_4

(B) MA_3B

(C) MAB_3

(D) All of these

CORRECT ANSWER: D

SOLUTION:

They do not show gemetric isomerism because in any of

these case, the possible spatial arrangements are

equivalent i.e., both 90 and 180 separations for any pair

of ligands (2 A' s or A and B) exist in the same complex.



For $[Ma_2b_2c_2]$ no. of isomer with resultant dipole moment not

equal to zero are

CORRECT ANSWER: 4

SOLUTION:

Total 5 isomer are possible out of which one has $\mu = 0$



Q-16 - 11480829

Consider to following isomers of $[Co(NH_3)_2Br_4]^?$ and answer the questions



If PQRS

are four different ligands then how many geometric isomers will be

found for square planar $[PtPQRS]^{2+}$.

(A) 1

(B) 2

(C) 3

(D) 4

CORRECT ANSWER: C



Q-17 - 12979242

Which of the following is incorrect regarding the octahedral

complex of the type MA_4B_2 ?

(A) It has two distereoisomers

(B) cis- MA_4B_2 is optically active

(C) trans- MA_4B_2 is optically inactive

CORRECT ANSWER: B

SOLUTION:

cis- MA_4B_2 is optically inactive due to the presence of



Q-18 - 11480803

Consider the following spatial arrangements of the octahedral

complex ion $\left[Co(NH_3)_4CI_2\right]^{\oplus}$





Which of the following statements is incorrect regarding these

structures?

(a) I and II are enantiomers

(b) II and III are cis and trans isomers respectively

(c) III and IV are trans and cis isomers respectively

(d) II and IV have identical structures .

CORRECT ANSWER: C

SOLUTION:

Enantiomers are non-super imposable mirror images

Clearly I and II are mirror image but NOT super

imposabel

II: cis isomer III trans isomer

Ivand II are identical structures

IV Can t be cis isomer so incorrect choice is (c).

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Q-19 - 12973620

Which of the following is incorrect regarding the MO theory?

(A) The number of molecular orbitals formed is always equal to the number of atomic orbitals combined. (B) The more stable the bonding molecular orbitals, the less stable the corresponding antibonding molecular orbital.

(C) In a stable molecule, the number of electrons in bonding molecular orbitals is always equal to that in antibonding molecular orbitals.

(D) Like an atomic orbital, each molecular orbital can accommodate up to two electrons with opposite spins in accordance with the Pauli exclusion principle.

CORRECT ANSWER: C

SOLUTION:

In a stable molecule, the number of bonding electrons is

always greater than the number of antibonding

electrons.



Q-20 - 11480814

One the basis of VBT answer the following complex ions

(i) $[Ti(bpy)_3]^?$ (b) $[V(H_2O)_6]^{3+}$ (ii) $[V(H_2O)_6]^{3+}$ (III) $[Mn(CN)_6]^{4-}$ $[Mn(CN)_6)]^{3-}$ (V) $[Ir(NH_3)_6]^{3+}$.

Type of hybridisation involed

(b) Type of inner or outer orbital octahedral complex

(c) Magnetic behaviour and $\mu_{s\pi n}$ value .

SOLUTION:

bpy or dipy is a strong field neutral bidentage ligand



(a) d^2sp^3 hybridisation with OH shape

- (b) Inner orbital complex

(c) Paramagnetic n = 1

 $\mu_{
m spin}=\sqrt{3}BM$

= 1.732BM

(II) $|V(H_2 - (o)]^{3+}$

$$egin{aligned} V(Z=23) &\Rightarrow 3d^34s^2, \ V^{3+} &= 3d^24s^0 \end{aligned}$$

 $CN^{\ ?}$ is a strong field ligand so pairing occurs



 d^2sp^3 hybridisation with OH shape

(b) Inner orbital complex

(c) Paramagnetic , n=2

(d) $\mu({
m spin})=\sqrt{8}BM$ =2.828BM

(III) $\left[Mn(CN)_6
ight]^{4-}$

Mn(Z = 25)

 $egin{array}{lll} \Rightarrow 3d^54s^2,\,Mn^{2\,+}\ = 3d^{54s^0} \end{array}$

 $CN^{\,?}$ is a strong field ligand so pairing occurs



(a) d^2sp^3 hybridisation with OH shape

(b) Inner orbital complex

(c) Paramagnetic n=1

(d)

 $\mu_{s\pi n} = \sqrt{3}BM$ = 1.732BM

$$egin{aligned} &(\mathsf{IV})\left[Mn(CN)_6
ight]^{3-}\ &Mn(Z=25)\ &\Rightarrow 3d^54s^2,\,Mn^{3+}\ &\Rightarrow 3d^54s^2,\,Mn^{3+} \end{aligned}$$



$CN^{\,?}$ is a strong field ligand so only one pairing occurs



(a) d^2sp^3 hybridisation with OH shape

(b) Inner orbital complex

(c) Paramagnetic n=2

(d)

 $\mu_{
m spin} = \sqrt{8}BM
onumber \ = 2.828BM$

(V)
$$\left[Ir(NH_3)_6
ight]^{3+}$$

 $ir(Z=7)implies5d^{7}(7) 6s^{2}, Ir^{3+} = 5d^{6} 6s^{0}$





(a) d^2sp^3 hybridisation

(b) Inner orbital complex



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Q-21 - 12979244

Total number of isomers of $[Co(en)_2 CI_2]^+$ is

(A) 3

(B) 4

(C) 2

(D) 5

CORRECT ANSWER: A

SOLUTION:

Ethylenediamine (or any bidentate ligand) always spans

adjacent corner of an octahedron, but tge $C1^-$ ligands

can be on either adjacent or opposite corners. Therefore

there are two diastereoisomers, cis trans :



Because the trans isomer has several symmetry planeone cuts through the Co and the en ligands -it is achrial and has no enantiomers. However, the cis isomer is chiral and exists as a pair of enantiomers that are non identical mirror images. We can see that the cis enantiomer on the right is not the same as the one the left if we rotate it by 180 about the vertical N-Co-N Axis.



Q-22 - 20866741

Draw all the isomers (geometrical and optical) of:

- (i) $\left[CoCl_2(en)_2\right]^+$
- (ii) $\left[Co(NH_3)Cl(en)_2\right]^{2+}$

(iii) $\left[Co(NH_3)_2Cl_2(en)\right]^+$

SOLUTION:



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Q-23 - 12979245

Total number of all possible optical isomers of an octahedral

complex, composed of Co^{3+} ion (central metal), two en molecules,

two CI^- ions and NO_2 ion, is
(A) 3

(B) 4

(C) 6

(D) 5

CORRECT ANSWER: C

SOLUTION:

CN of Co^{3+} ion is 6. There are three structural isomers

of the given complex: $[CoC1_2(en_2)]NO_2,$ $\begin{bmatrix} CoC1(en)_2(NO_2) \end{bmatrix} C1$

 $\left\lceil CoC1(en)_2(ONO)
ight
angle$

]C1

Ethylenediamine always spans adjacent corner of an

octahedron but the $C1^-$ ligands (or $C1^-$ and NO_2 / ONO) can be on either adjacent or opposite corners. Therefore, there are two diastereomers, cis and trans of each of these. Because the trans isomer of each has several symmetry planes - one cut through the Co and the en ligands - it is achiral and has no enantiomers. However, the cis isomer of each is chiral and exist as a pair of enantiomers that are nonidentical mirror images.



Q-24 - 12979246

Which one of the following postulates of Werner's theory is



(A) Primary valence are nondirectional while secondery

valences are directional

(B) Primary valences can be satisfied by neutral as well

as negative ions only

(C) Primary valence is linked to what we now call the

oxidation number of the central metal

(D) Secondery valence corresponds to whalt we now call

the coordination number of the central metal

CORRECT ANSWER: B

SOLUTION:

Werner postulated that most elements exihibit two types

of valences: primary valence and secondary valence.

The primary (or ionisable) links are satisfied by

negaative ions while the secondry (or noninizable) links

can be satisfied by neural or negative ions.

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- A complete has the composition $Co(NH_3)_4(H_2O)CI_3$. Conductance measurements show that there are three ions per formula unit and precipitation of AgCI with silver nitrate shows that there are CI^- ions not coordinated to cobalt. The structural formula of the compound is
 - (A) $\left[Co(NH_3)_3\right]CI_3\right]H_2O$ (B) $[Co(NH_3)CI_3H_2O]$ (C) $[Co(NH_3)(H_2O)]CI_3$ (D)
 - $\lfloor Co(NH_3)_3 CI_2(H_2O)
 angle$

|CI|

CORRECT ANSWER: D

SOLUTION:

Any $C1^-$ ion which is present outside the coordination sphere will be precipitated as AgCI by excess silver nitrate. On the other hand, $C1^-$ ion directly bonded to Co^{3+} ion i.e., C1-ion present the coordination sphere

will not be precipitated.

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Q-26 - 12979251

Which of the following complexes will lead to lowest cryoscopic

measurement?

(A) $CoCI_3$. $6NH_3$

(B) $CoCI_3$. $5NH_3$

(C) $CoCI_3$. $4NH_3$

(D) $CoCI_3$. $3NH_3$

SOLUTION:

The freezin point of a liquid is lowered when a chemical substance is dissolved in it . Cryoscopic measuring how much the freezing point is lowered. The depression of freezing point obtained depends on the number of particles present i.e., more the particles, the higer the depression . cryoscopic measurements can be used to find if a given substance dissociates into two ion it will give twice the expected depression for a single particle. If three ions are formed this will give three times expected depression. Thus:

$ig[Co(NH_3)_6 ig] C1_3 ightarrow 4$ particles (6 charges)

- $\left[Co(NH_3)_5C1\right]C1_2$
- ightarrow 3

particles (4 charges)

 $\begin{bmatrix} Co(NH_3)_A C1_2 \end{bmatrix} C1$ $\rightarrow 2$ particles (2 charges) $|Co(NH_3)_3C1_3| \rightarrow 1$ particle (0 charges) The number of particles formed form a complex determines the magnitude of the depression of freezing point. Note that the number of particles formed may be different from the number of charges which can obtained form conductivity measurements. the two types of information can be used to establish the structure.

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Q-27 - 14625138

Which of the following coordination complex is/are diamagnetic?

(A) $K_3ig[Cu(CN)_4ig]$

(B) $\left[CoCl_4 ight]^{2\,-}$

(C)
$$\left[Ni(H_2O)_6
ight]^{2+}$$

(D) $\left[Zn(H_2O)_4
ight]^{2+}$

CORRECT ANSWER: A::D

SOLUTION:

 Cu^+ and Zn^{2+} have d^{10} configuration

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Q-28 - 12979259

Which of the following is not an inner orbital complex ?

(A)
$$\left[Mn(CN)_6\right]^{3+}$$

(B) $\left[Fe(CN)_{6}\right]^{3-}$

(C) $\left[Co(H_2O)_6\right]^{2+}$

(D) $\left[Co(C_2O_4)_3 \right]^{3-1}$

SOLUTION:

In the formation of an inner orbital complex, the inner d

orbital (3d) is used in hybridization.

$$\begin{split} & \left[Mn(CN)_6 \right]^{3-} \\ & \left[Fe(CN)_6 \right]^{3-} \\ & \text{and} \left[Co(C_2O_4)_3 \right]^{3-} \text{ are inner orbital complexes} \\ & \text{involving } d^2sp^3 \text{ hybrization. The first two complexes are} \\ & \text{paramagnetic corresponding to one unpaired electron} \\ & \text{while the third one is diamagnetic. Such complexes are} \\ & \text{unsually formed with strong field ligands} \end{split}$$

 $\left[Co(H_2O)_6\right]^{2+}$ is an outer orbital complex involving

sp^3d^2 hybridization. Note that H_2O is a weak field

ligand.



Which of the following is a low spin (spin-paired) complex ?

(A)
$$\left[Co(NH_3)_6\right]^{3+}$$

(B) $\left[Ni(NH_3)_6\right]^{2+}$
(C) $\left[Co(NH_3)_6\right]^{2+}$
(D) $\left[Fe(C_2O_4)_3\right]^{3-}$

CORRECT ANSWER: A

SOLUTION:

$$egin{bmatrix} Co(NH_3)_6 \end{bmatrix}^{3+} \
ightarrow d^2 \sin^3 \end{pmatrix}$$

hybridization \rightarrow zero unpaired electrons

 $ig[Ni(NH_3)_6ig]^{2+}$

 $ightarrow sp^3 d^2$

hybridization \rightarrow Two unpaired electrons

$$egin{split} & \left[Co(NH_3)_6
ight]^{2\,+} \ &
ightarrow \, sp^3 d^2 \end{split}$$

hybridization \rightarrow Three unpaired electrons A low spin (or spin-paired) complex, such as $\left[Co(NH_3)_6\right]^{3+}$ is one in which the electrons are paired up to give a maximum number of doubly occupied d orbitals and a minimum number of unpaired electrons. Usually inner orbital complexes (d^2sp^3) are low-spin (or spin paired) complexes. Fe^{3+} has a d^5 electronic configuration. Thus complexes with weak field ligands (such as halide ions) will have a high spin arrangement with five unpaired electrons. On the other hand, strong

field ligands such as $CN^{-}SCN^{-}$ and oxalate form

complexes with Fe^{3+} which have a spin paired

arrangement.



Which of the following statements are correct?

(i) In octahedral complexes, $d_z 2$, $d_{x^2 - y^2}$ orbitals have higher energy than d_{xy} , d_{yz} and d_{zx} orbitals.

(ii) In tetrahedral complexes, d_{xy} , d_{yz} , d_{zx} orbitals have higher energy than $d_z 2$ and $d_{x^2 - y^2}$ orbitals.

(iii) The colours of complexes are due to electronic transitions from one set of d-orbitals to another set of orbitals.

(iv)
$$\Delta_{tetrahedral} = rac{9}{4}, \Delta_{octahedral}$$

(A) (a) (i), (ii) and (iii)

(B) (b) (i) and (iv)

(C) (c) (iii) and (iv)

(D) (d) (ii), (iii) and (iv)

CORRECT ANSWER: A



$$\Delta_{tetrahedral} = rac{9}{4}$$
, $\Delta_{octahedral}$

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Q-31 - 11480756

In which structure crystal field splitting energy (CFSE) for octahedral complex will be zero when $\Delta < P$.

(A) d^5

(B) d^6

(C) d^8



CORRECT ANSWER: D

SOLUTION:

If $\Delta < P$ weak field no pairing $d^5 = \left(t_{2g}^3 e_g 2\right)$ CFSE = -0.4 imes 3 + 2 imes 1.6 = 0 If $\Delta > P$ strong field pairing $d^5 = t_{2g} 5 e_g^0$ CFSE = $-0.4 imes 5 = -2\Delta$

For

$$egin{aligned} d^{10}, \ \Rightarrow t_{2g} 6 e_g^4 = \ &-0.4 imes 6 + 0.6 imes 4 \ &= 0 \end{aligned}$$

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Q-32 - 12973054

Which of the following *d* orbitals has diagonal nodal planes?

(A) $d_{x^2-y^2}$

(B) d_{xz}

(C) d_{xy}

CORRECT ANSWER: A

SOLUTION:

In case of $d_{x^2-y^2}$, there are two diagonal nodel planes passing through the origin and bisecting the x-and y-

axis.



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Q-33 - 12973625

If E is the total energy of the combining atomic orbitals, and E_b and

E_a are the energies of the bonding and antibonding molecular

orbitals formed, respectively, then

(A)
$$E-E_b < E_a-E$$

(B) $E-E_b = E_a-E$
(C) $E-E_b > E_a-E$

(D) Any of these depending upon the nature of

combining atoms

CORRECT ANSWER: A

SOLUTION:

The energy of the bonding MO is lower than that of the atomic orbitals by an amount $\Delta(=E-E_b)$. This is

known as the stabilization energy. Similarly, the energy

of the antibonding molecular orbital is increased by

$\Delta(=Ea-E)$ and is referred to as the destabilization

energy. In general, the destabilization energy is greater

than the stabilization energy because the antibonding

MO is raised more in energy than the energy by which

the bonding MO is lowered.

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Q-34 - 12979266

In an ocahedral crystal field, the t - (2g) orbitals are

(A) lower in energy by $0.4\Delta_{\,\circ}$

(B) raised in energy by $0.4\Delta_{\,\circ}$

(C) lowered in energy by $0.6\Delta_{\,\circ}$

(D) raised in energy by $0.6\Delta_{\,\circ}$

CORRECT ANSWER: A

SOLUTION:

The $d_{x^2-y^2}$ and d_{z^2} orbitals a directed along a set of mutually perpendicular x, y and z axes. As a group, these orbitals are called e_g orbitals. The d_{xy} , d_{yz} and d_{xz} orbitals, collectively called t_{2g} orbitals, lie between the axes. The ligand donor atoms approach the metal ion along the axes to form octahedral complexes. The approach of the six donor atoms (point charges) alon the axes sets up an electrical field called the crystal field. Electrons on the ligands repel electrons in e_q orbitals on the metal ion more strongly then they repel those tn t_{2g} orbitals.



This removes the degeneracy of the set of d orbitals and

split them into two sets, the e_q set higher energy and the t_{2q} set of lower energy. This splitting of the degenerate levels due to the presence of ligands in a denfinite geometry between the two sets of d orbitals in the energy difference between the two sets of d orbitals in the octahedral field is called the crystal field splitting energy, denoted by $\Delta_{\text{ocatahedral}}$, or Δ_{oct} or Δ_o . The sum of the orbital energies equals the dengenerate energy (sometimes called Bair centure). Thus, the energy of the two (higher energy) e_q orbitals is $3/5\Delta_{oct}$ and the energy of the three (lower energy) t_{2q} orbitals is $-2/5\Delta_{oct}$ below the mean.



Q-35 - 11481120

Give the number of 3d electrons occupied in t_{2g} orbitals of hydrated

$$Cr^{3+}$$
 ion (octahedral).

CORRECT ANSWER: 3

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Q-36 - 19212942

Number of ions which given blue colour in aqueous state:

$$V^{+4}, Ni^{+2}, Ti^{+3}, Co^{+2},
onumber \ Fe^{+3}, Cu^{+2}$$

CORRECT ANSWER: 2

SOLUTION:

$$V^{\,+\,4},\,Cu^{\,+\,2}$$



Q-37 - 12979273

Which of the following complex ions has three unpaired electrons?

(A)
$$\left[Cr(en)_3 \right]^{3+}$$

(B) $\left[Mn(CN)_6 \right]^{3-}$
(C) $\left[Co(H_2O)_6 \right]^{2+}$

(D) Both (1) and (3)

CORRECT ANSWER: D

SOLUTION:

All three complexes are octahedral , so the crystal field orbital energy level diagram will show three lower energy and two higher energy d orbitals. F or d^1-d^3 and

$d^8 - d^{10}$ complexes, the electrons occupy the orbitals

in accord with Hund's rule so as to give the maximun

number of unpaired electrons. But for $d^4 - d^7$ complex,

the orbital occupancy and number of unpaired electrons

depend on the position of the ligand in the

spectrochemical series. $Cr^{3+}\left([Ar]3d^3
ight)$ has three

unpaired electrons. In the complex, they occupy the

lower energy set of d orbitals:



 $Mn^{3+}([Ar]3d^4)$ can have a high spin or low spin configuration. Because CN^- is a strong field ligand, all four 3d electrons go into the lower energy t_{2q} orbitals.

Consequently, the complex ion is low spin with two

unpaired electrons.



 $Co^{2+} \left([Ar] 3d^7
m has a$ high spin configuration $t_{2g}^5 e_g^2$ with three unpaired electrons because H_2O is a weak field ligand.





Q-38 - 12979274

 CuF_2 contains Cu^{2+} ions surrounded by six F^- ions, four F^-

being at a distance of 0.193 nm other two at a distance of 0.227 nm.

Thus, it should have the configuration.

$$\begin{array}{l} \text{(A)} \ (d_{z^2})^1 (d_{x^2 - y^2})^2 \\ \text{(B)} \ (d_{z^2})^2 (d_{x^2 - y^2})^1 \\ \text{(C)} \ (d_{xy})^1 (d_{yz})^1 (d_{xz})^1 \\ \text{(D)} \ (d_{xy})^2 (d_{yz})^2 (d_{yz})^0 \end{array}$$

CORRECT ANSWER: B

SOLUTION:

Planar complexes can be regarded as distorted

octahedral complexes. Application of crytal field theory

shows that an octahedral arrangement of ligands

interacts more strongly with e_g orbitals than with t_{2g}

orbitals. Therefore an asymmetric occupation of the two

 e_q orbitals results in a distorted ocahedral arrangement of ligands in transition metal complex. The two possible distributions of the electrons in the e_q orbitals are shown below for a transition metal ion having nne 3d electrons (thus three electrons in the e_q orbitals).



Consider the arrangement of two electrons in the d_{z^2} orbital and one electron in the $d_{x^2-y^2}$ orbital. The two electrons in the former orbital will interact more strongly with the ligands directed along the z axis than the one elecron in the latter with ligands lying along the x and y

axes. Consequently the ligands in teh xy plane are

drawn closer to the central transition metal ion than the

ligands directed along the z axis, i.e., for short and two

long bonds would be formed. If the occupation of the two

 e_q orbitals is reversed it is result. Many octahedrally coordinated compounds of Cu^{2+} (nine 3d electrons) do indeed have four short bonds and two long ones. Thus, the configuration $(d_{z^2})^1 (d_{x^2 - y^2})^1$ is preferred to the alternative $(d_{z^2})^1 (d_{x^2 - y^2})^2$.

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Q-39 - 12979280

Which of the following d orbitals has highest energy in square

planer complexes ?

(A) d_{xy}



(C) $d_{x^2-y^2}$



SOLUTION:

The crystal field splitting energy Δ is small in tetrahedral complexes but much larger in square planar complexes. Square palner complexes look loke octahedral ones except that the two trans ligands along the z axis are missing. In square planer complexes, the $d_{x^2-y^2}$ is highest in energy because it points directly at all four ligands, which lie along the x and y axes. The splitting pattern is more complicated here than for the octahedral and tetrahedral case, but the main point to remember is that a larger energy gap exists between the $d_{x^2-y^2}$

orbital and the four lower-energy orbitals. Square planar

geomertry is mopst common for metal ions with electron

configuration d^8 because this configuration favours low

spin complexes in which all four lower energy orbitals

are filled and the higher energy $d_{x^2-y^2}$ orbital is vacant. Common examples are $[Ni(CN)_4]^{2-}$, $[PdC1_4]^{2-}$ $[PrC1_4]^{2-}$ and $[Pt(NH_3)_2C1_2]$.

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Q-40 - 12979282

Oxidation state of Fe in ferrocene is

(A) 0

(B) + 3

(C) + 2

(D) + 1

CORRECT ANSWER: C

SOLUTION:

The oxidation number assigned does not necessarily relate to the actual charge on the metal. The convention used is that the organic moiety (C_5H_5) is usually assigned a charge of -1 In ferrocence, $(\eta^5 - C_5H_5)$

Fe, iron has an oxidation state of +2.

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Q-41 - 19294400

$$\begin{bmatrix} Co(en)_2(H_2O)_2 \end{bmatrix}^{3+} + en$$

 \rightarrow
complex (X) is :

(A) it is a low spin complex

(B) it is diamagnetic

(C) it show geometrical isomerism

(D) (A) & (B)

SOLUTION:

(D) , complex is $[Co(en)_3]^{3+}$, as an is a strong field ligand pairing of electrons will take place. $[Co(en)_3]^{3+}, Co^{3+}$

 $: 3d^6$



Diamagnetic. As it has 3 bindntate symmetrical en

ligands so it will not show geometrical isomerism.



Q-42 - 12979288

Which of the following metals from polynuclear complex ?

(A) Ti

(B) V

(C) Cr

(D) Mn

CORRECT ANSWER: D

SOLUTION:

Odd electron complexes may achieve stability by accepting an electron. For example, $V(CO)_6$ is a 17 electron species. It readily completes form a reducing agent.

 $V(CO)_6 + Na$

 $\rightarrow Na^{+} \left[V(CO)_{6} \right]^{-}$

$17\bar{e} \ 18\bar{e}$

Other old electerons species acquire an additional

electron by dimerzing with another molecule. For

example, $Mn(CO)_5$ has 17 electrons. Two molecules

'share' their odd electron in order to form a Mn-Mn bond.

Consequently each Mn becomes an 18 electron species. $2Mn(CO)_5$ $\rightarrow Mn_2(CO)_{10}$

$17\bar{e} \ 18\bar{e}$

Cobalt has an odd number of electrons, so the carbonyl compound $Co(CO)_8$ has 17 electrons and dimerizes to givec $CO_2(CO)_8$.

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The water -soluble complex among the following is

(a) $\left[Ni(HDMG)_{2}\right]$

(b) $[Co(NH_3)_3CI_3]$

(c) $Ni(CO)_4$

 $\left[Ni(HDMG)_2\right]CI_2$.

CORRECT ANSWER: D

SOLUTION:

The complex which shows ionisation isomerism are

soluble in water Hence answer is (d).

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Q-44 - 19294010

The ionizable valency of Ni in $Ni(CO)_4$ is

(A) 2

(B) 4

(C) 0

CORRECT ANSWER: 3

SOLUTION:

No primary valencies which can ionise

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Q-45 - 12661604

What is the co-ordination number of the metal in $[Co(en)_2 Cl_2]^+$?

(A) (a) 4

(B) (b) 5



(D) (d) 3

CORRECT ANSWER: C

SOLUTION:

$${\sf In}\left[{\it Co(en)}_2{\it Cl}_2\right]^+$$

No. of monodentate ligand = 2

No. of bidentate ligand = 2

Co-ordinate no. of the metal = 2 + 2(2) = 6.

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Q-46 - 11882178

In which of the following metal atom has negative oxidation satate?

$$egin{array}{lll} CuH, & \left[Fe(CO)
ight]^2, & Na-Hg \ I & III & III \end{array}$$

(A) I,II and III



(C) I and III

(D) II and III

SOLUTION:

Cu in CuH and Fe in $\left[Fe(CO)
ight]^{2-}$ have -1 and -2

oxidation state respectively.

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Q-47 - 19294083

Which of the following is correct arrangement of ligands in terms of

field strength

(A)

$$Cl^- < F^- < NCS^-$$

$< NH_3 < CN$

(B)

$egin{array}{ll} NH_3 < F^{\,-} < Cl^{-} \ < NCS^{\,-} < CN^{\,-} \end{array}$

(C)
$egin{aligned} Cl^- < F^- < NCS^- \ < CN^- < NH_3 \end{aligned}$ (D) $NH_3 < CN^- \ < NCS^- < Cl^- \ < F^- \end{aligned}$

CORRECT ANSWER: 1

SOLUTION:

Spectrochemical series.

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Q-48 - 12661790

In which of the following octahedral complexes of Co (at. no. 27),

will the magnitude of Δ_o be the highest?

(A) (a) $\left[Co(CN)_6\right]^{3-}$

(B) (b) $\left[Co(C_2O_4)_3 \right]^{3-1}$

(C) (c) $\left[Co(H_2O)_6
ight]^{3\,+}$ (D) (d) $\left[Co(NH_3)_6
ight]^{3\,+}$

CORRECT ANSWER: A

SOLUTION:

 $CN^{\,?}$ is stronger ligand hence Δ_0 is highest.

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Q-49 - 12979382

 $[Co(NH_3)_4(NO_2)_2]CI$ exhibits

(A) linkage isomerism, geometrical isomerism, and



(B) linkage isomerism, ionization isomerism and optical

isomerism

(C) linkage isomerism, ionization isomerism and

geometrical isomerism

(D) ionization isomerism, geometrical isomerism and

optical isomerism.

CORRECT ANSWER: C

SOLUTION:

Complex exhibits: Linkage isomerism as NO_2 is an

ambidantate ligand:

 $egin{aligned} & \left[Co(NH_3)_4(NO_2)_2
ight] C1 \ & \left[Co(NH_3)_4(ONO)_2
ight] C1 \end{aligned}$

Ionization isomerism due to interacharge of NO_2 and

C1:

$ig[Co(NH_3)_4(NO_2)_2ig]C1$ and

$$ig[Co(NH_3)_4(NO_2)C1ig]NO_2$$

Geometrical isomerism as two NO_2 groups may be 90

apart (cis) or 180 apart (trans):



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Q-50 - 19294118

For an octahedral complex, which of the following d electron

configuration will give maximum crystal-field stabilisation energy?

(A) High spin d^6

(B) Low - spin d^4

(C) Low spin d^5

(D) High - spin d^7

CORRECT ANSWER: 3

SOLUTION:

High spin d^6 : $t^4_{2g} e^2_g, CFSE$ $= [-0.4 imes 4 + 0.6 \ imes 2] \Delta_0$

Low spin d^4 : $t^4_{2g} e^0_g, CFSE$ $= [-0.4 imes 4] = -1.6\Delta_0$

Low spin $d^5: t_{2g}^5 e_g^0, CFSE$ $= [\,-0.4 imes 5]\Delta_0$



$$egin{aligned} &d^7 \colon t_{2g}^5 e_g^2, CFSE \ &= [\,-0.4 imes 5 + 0.6 \ & imes 2] \Delta_0 \end{aligned}$$

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Q-51 - 11881097

The volume (in mL) of $0.1MAgNO_3$ required for complete

precipitation of chloride ions present in 30mL of 0.01M solution

of $[Cr(H_2O)_5Cl]Cl_2$, as silver chloride is close to:

CORRECT ANSWER: 6

SOLUTION:

Number of isonisable

$$Cl^{\,-} \operatorname{in} ig[Cr(H_2O)_5 Cl ig]$$

 $|Cl_2|$

is 2

- \therefore Mill-mole of $Cl^-=30 imes 0.01 imes 2$ =0.6
 - \therefore Milli-mole of Ag^+ required = 0.6
 - $\therefore 0.6 = 0.1V$
- V = 6mL

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Q-52 - 19294217

Stabilisation energy of octahedral complex with d^7 configuration

- (A) $-1.8\Delta_0$ with one unpaired electron
- (B) $1.8\Delta_0$ with three unpaired electrons

(C) $-0.8\Delta_0$ with one unpaired electron

(D) $0.8\Delta_0$ with three unpaired electrons

(A) A and D

(B) A and B

(C) C and D

(D) B and C

CORRECT ANSWER: 1

SOLUTION:

For strong field ligands - $CFSE = (-6 imes 0.4 \ -1 imes 0.6) = -1.8$ Δ_0

one unpaired electron

For weak field ligands $CFSF = (5 \times 0)$



three unpaired electrons

(D) (a) and (e)

(C) (a) and (f)

(B) (c) and (d)

(A) (a) and (b)

Q-53 - 19294132

(d) $C_2 O_4^{2+}$ (e) SCN^- (f) $H_2 NCH_2 CH_2 NH_2$

(a) NO_2^- (b) NO_3^- (c) $EDTA^+$

Among the following which are ambidentate ligands?

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SOLUTION:

$-NO_2^-$ and -SCN are ambidentate ligands which

have two donor atoms.

Q-54 - 11480794

The number of donor sites in dimethy1 glyoxime glycinato

diethylene triamine and EDTA are respectively

2, 2, 3 and 4

(b) 2, 2, 3 and 6

(c) 2, 2, 2 and 6

 $2,\,3,\,3$ and 6 .

CORRECT ANSWER: B

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Q-55 - 12661584

One mole of complex compound $Co(NH_3)_5Cl_3$ gives 3 moles of

ions on dissolution in water. One mole of same complex reacts with

SOLUTION:

CORRECT ANSWER: C

(D) (d) $\left[Co(NH_3)_3Cl_3
ight].2NH_3$

- (C) (c) $\left[Co(NH_3)_5Cl\right]Cl_2$
- $. NH_3$
- $\left[Co(NH_3)_4Cl
 ight]Cl_2$
- (B) (b)
- $\left\lfloor Co(NH_3)_4 Cl_2 \right\rfloor Cl$. NH_3
- (A) (a)
- is:

two moles of $AgNO_3$ to yield two moles of AgCl(s). The complex

 $\left[Co(NH_3)_5Cl\right]Cl_2$

 $\stackrel{H_2O}{\longrightarrow} \left [Co(NH_3)_5 Cl
ight]^+$

 $+ 2Cl^{-}$

 $2AgNO_3 + 2Cl^{-1}$ $ightarrow 2AgCl + 2NO_3^{-}$

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Q-56 - 19294125

The primary and secondary valencies of chromium in the complex

ion, dichlotodioxalatochromoium (III), are respectrively

- (A) 3, 4
- (B) 4, 3
- (C) 3, 6
- $(D) \, 6, \, 3$

CORRECT ANSWER: 3

SOLUTION:

Primary valency corresponds to oxidation state and

secondary valency corresponds to coordination number

primary =3, secondary=6



Q-57 - 19294129

The molar ionic conductances of octahedral complexes.

(I) $PtCl_4.5NH_3$ (II) $PtCl_4.4NH_3$

(III) $PtCl_4.3NH_3$ (IV) $PtCl_4.2NH_3$

(A) I < II < III < IV

(B) IV < III < II < I

(C) III < IV < II < I

(D) IV < III < I < II

CORRECT ANSWER: 2

SOLUTION:

IV of four complexes (1) is 3, (2) is 2, (3) is 1, (4) is 0

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Q-58 - 19294337

The complex ion . $[M(en)Br_2I_2]^{-1}$, has two optical isomers.

Their correct configurations are:







SOLUTION:

Optical (C) is mirror image and non-super impossible

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Q-59 - 15090547

Which kind of isomerism is shown by $Co(NH_3)_4 Br_2 Cl$?

(A) Geometrical and ionisation

(B) Optical and ionisation

(C) Geometrical and optical

(D) Geometrical only

CORRECT ANSWER: A



Q-60 - 19294263

The two compounds $[Co(SO_4)(NH_3)_5]Br$ and $[Co(SO_4)(NH_3)_5]Cl$ represent:

(A) Linkage isomerism

(B) Ionisation isomerism

(C) Co-ordination isomerism

(D) no isomerism

CORRECT ANSWER: D

SOLUTION:

Different complexes



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