Short Answer Questions-I

Short Answer Questions-I (PYQ)

Q.1. Give the formula of each of the following coordination entities:

i. **Co^{3+} ion is bound to one Cl^{-}, one NH_3 molecule and two bidentate ethylene diamine (en) molecules.**
ii. **Ni^{2+} ion is bound to two water molecules and two oxalate ions.**

Write the name and magnetic behaviour of each of the above coordination entities.

(At. nos. Co = 27, Ni = 28)

[*CBSE Delhi 2012*]

Ans. (i). $[Co(NH_3)Cl(en)_2]^{2+}$: Amminechloridobis (ethane-1, 2-diamine)-cobalt(III) ion
Magnetic behaviour : Diamagnetic

(ii). $[Ni(H_2O)_2(ox)_2]^{2-}$: Diaquadioxalatonickelate (II) ion
Magnetic behaviour : Paramagnetic

Q.2. Answer the following questions:

Q. Write the IUPAC name of the isomer of the following complex:

$Pt(NH_3)_2Cl_2]$

Ans. *cis*-Diamminedichloridoplatinum (II) and *trans*-Diamminedichloridoplatinum (II)

Q. Write the formula for the following:

Tetraammineaquachloridocobalt (III) nitrate

[*CBSE (F) 2017*]

Ans. $[Co(NH_3)_4(H_2O)Cl](NO_3)_2$

Q.3. Using IUPAC norms write the formulae for the following:

i. **Tris(ethane-1, 2-diamine) chromium (III) chloride**
ii. **Potassium tetrahydroxozincate(II)**

[*CBSE (AI) 2017*]

Ans.

i. $[Cr(en)_3]Cl_3$
ii. $K_2[Zn(OH)_4]$

Q.4. When a coordination compound $CrCl_3.6H_2O$ is mixed with $AgNO_3$, 2 moles of AgCl are precipitated per mole of the compound. Write

i. structural formula of the complex.
ii. IUPAC name of the complex.

[*CBSE Delhi 2016*] [*HOTS*]

Ans. (i). $[Cr(H_2O)_5Cl]Cl_2.H_2O$

(ii). Pentaaquachloridochromium (III) Chloride monohydrate.

Q.5. When a coordination compound $PtCl_4.6NH_3$ is mixed with $AgNO_3$, 4 moles of AgCl are precipitated per mole of the compound. Write

Q. structural formula of the complex.

Ans. $[Pt(NH_3)_6]Cl_4$

Q. IUPAC name of the complex.

[*CBSE East 2016*] [*HOTS*]

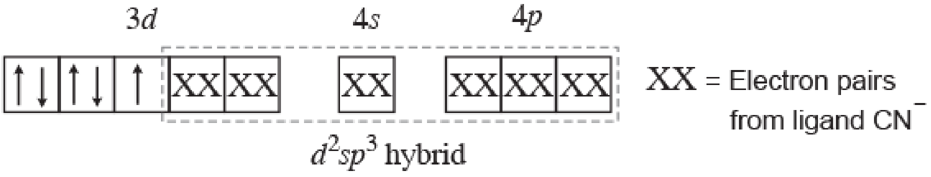
Ans. Hexaammineplatinum (IV) chloride

Q.6. For the complex $[Fe(CN)_6]^{3-}$, write the hybridisation type, magnetic character and spin nature of the complex. (At. Number : Fe = 26).

[*CBSE Delhi 2016*]

Ans.

$[Fe(CN)_6]^{3-}$, $Fe^{3+}(3d^5)$



- d^2sp^3 hybridisation
- Paramagnetic in nature and low spin complex.

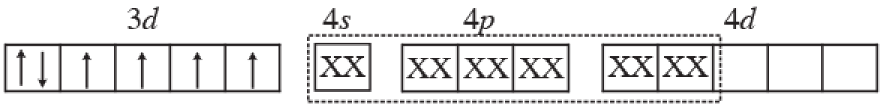
Q.7. Write the state of hybridisation, shape and IUPAC name of the complex $[CoF_6]^{3-}$.

(Atomic no. of Co = 27)

[*CBSE (F) 2014*]

Ans.

$[CoF_6]^{3-}$: Hexafluoridocobaltate (III) ion; $Co^{3+} = [Ar]3d^6$



XX = Electron pair from ligand F^-

Hybridisation = sp^3d^2, Shape = Octahedral

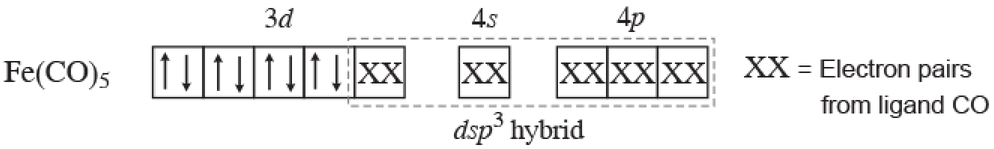
Q.8. For the complex $[Fe(CO)_5]$, write the hybridization, magnetic character and spin of the complex.

(At. number: Fe = 26)

[*CBSE (F) 2016*]

Ans.

Fe([Ar] $3d^6 4s^2$)



Hybridisation	dsp^3
Magnetic character	Diamagnetic
Spin of the complex	Low spin complex or inner orbital complex

Q.9. What is meant by crystal field splitting energy? On the basis of crystal field theory, write the electronic configuration of d^4 in terms of t_{2g} and e_g in an octahedral field when

i. **$\Delta_0 > P$**

ii. **$\Delta_0 < P$**

[*CBSE (AI) 2013*]

Ans. The difference of energy between two sets of degenerate orbitals after crystal field splitting is known as crystal field splitting energy.

i. $t_{2g}^4 e_g^0$

ii. $t_{2g}^3 e_g^1$

Short Answer Questions-I (OIQ)

Q.1. What is the relationship between observed colour of the complex and the wavelength of light absorbed by the complex?

[*NCERT Exemplar*]

Ans. When white light falls on the complex, some part of it is absorbed. Higher the crystal field splitting, lower will be the wavelength absorbed by the complex. The observed colour of complex is the colour generated from the wavelength left over.

Q.2. Why do compounds having similar geometry have different magnetic moment?

[*NCERT Exemplar*]

Ans. It is due to the presence of weak and strong ligands in complexes, if CFSE is high, the complex will show low value of magnetic moment and vice versa, *e.g.*, $[CoF_6]^{3-}$ and $[Co(NH_3)_6]^{3+}$, the former is paramagnetic and the latter is diamagnetic.

Q.3. $CuSO_4.5H_2O$ is blue in colour while $CuSO_4$ is colourless. Why?

[*NCERT Exemplar*]

Ans. In $CuSO_4.5H_2O$, water acts as ligand as a result it causes crystal field splitting. Hence, *d–d* transition is possible in $CuSO_4.5H_2O$ and shows colour. In the anhydrous $CuSO_4$ due to the absence of water (ligand), crystal field splitting is not possible and hence it is colourless.

Q.4. Explain why $[Fe(H_2O)_6]^{3+}$ has magnetic moment value of 5.92 BM whereas $[Fe(CN)_6]^{3-}$ has a value of only 1.74 BM.

[*NCERT Exemplar*]

Ans. $[Fe(CN)_6]^{3-}$ involves d^2sp^3 hybridisation with one unpaired electron and $[Fe(H_2O)_6]^{3+}$ involves sp^3d^2hybridisation with five unpaired electrons. This difference is due to the presence of strong CN^- and weak ligand H_2O in these complexes.

Q.5. Write the formulae of the following coordination compounds:

i. **Tetraamminediaquacobalt(III) chloride**
ii. **Tris (ethane-1, 2-diamine) chromium(III) chloride**

Ans.

i. $[Co(NH_3)_4(H_2O)_2]Cl_3$
ii. $[Cr(en)_3]Cl_3$

Q.6. The π-complexes are known for transition metals only. Why?

Ans. Transition metals have vacant *d*-orbitals in their atoms or ions into which the electron pairs can be donated by ligands containing π-electrons, *e.g.*, C_6H_6, $CH_2=CH_2$, etc. Thus, $d\pi - p\pi$ bonding is possible.

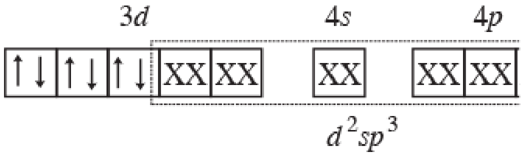
Q.7. Using valence bond theory explain the $[Co(NH_3)_6]^{3+}$ in relation to the terms given below:

i. **Type of hybridisation**
ii. **Inner or outer orbital complex**
iii. **Magnetic behaviour**
iv. **Spin only magnetic moment value.**

[*NCERT Exemplar*]

Ans. $[Co(NH_3)_6]^{3+}$

$Co^{3+} = 3d^6$

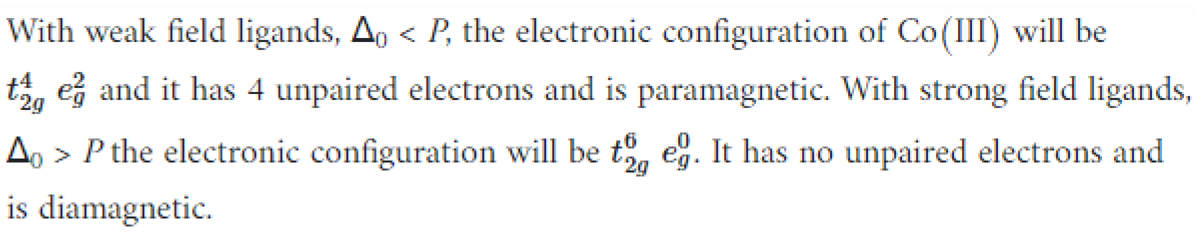


i. d^2sp^3
ii. Inner orbital complex
iii. Diamagnetic
iv. Zero.

Q.8. On the basis of crystal field theory explain why Co(III) forms paramagnetic octahedral complex with weak field ligands whereas it forms diamagnetic octahedral complex with strong field ligands.

[*NCERT Exemplar*]

Ans.

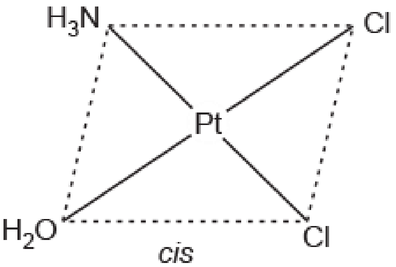


With weak field ligands, $\Delta_0 < P$, the electronic configuration of Co(III) will be $t_{2g}^4\ e_g^2$ and it has 4 unpaired electrons and is paramagnetic. With strong field ligands, $\Delta_0 > P$ the electronic configuration will be $t_{2g}^6\ e_g^0$. It has no unpaired electrons and is diamagnetic.

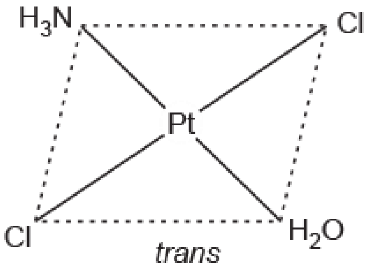
Q.9. Indicate the types of isomerism exhibited by the following complexes and draw the structures for these isomers:

- **i.** **[Pt(NH$_3$)(H$_2$O)Cl$_2$]**
- **ii.** **K[Cr(H$_2$O)$_2$(C$_2$O$_4$)$_2$]**

Ans. (i). Geometrical isomers can exist.



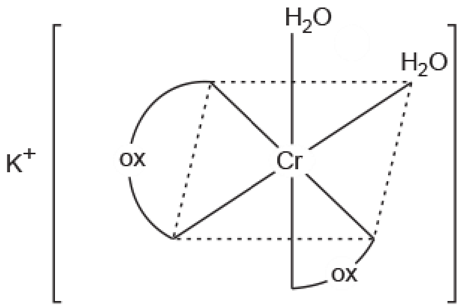
cis



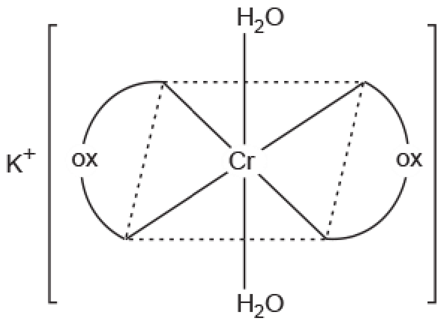
trans

(ii). Both geometrical (*cis–trans*) and optical isomers for *cis* can exist.

a. Geometrical isomers of K[Cr(H$_2$O)$_2$(C$_2$O$_4$)$_2$]:

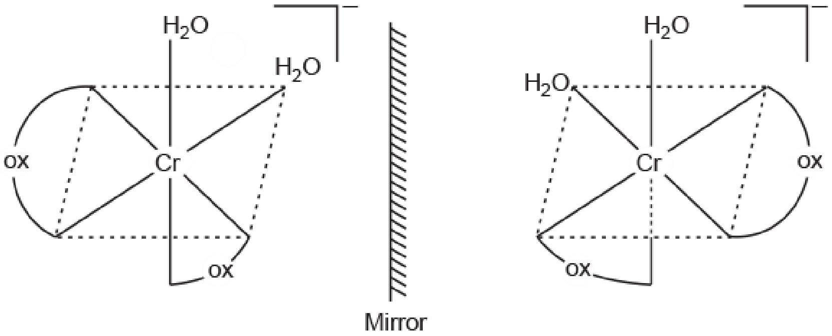


cis



trans

b. Optical isomers (*d*- and *l*-) of *cis*-$K[Cr(H_2O)_2(C_2O_4)_2]$:



Q.10. Answer the following questions:

Q. Write the IUPAC name of $Fe_4 [Fe(CN)_6]_3$.

Ans. Iron (III) hexacyanoferrate (II).

Q. Write all the possible isomers of $[Co(NH_3)_5(SCN)]Cl$.

Ans. $[Co(NH_3)_5(SCN)]Cl$, $[Co(NH_3)_5(NCS)]Cl$, $[Co(NH_3)_5Cl]SCN$, $[Co(NH_3)_5Cl]NCS$.

MA_5B type complexes do not show geometrical or optical isomerism.

Q.11. An octahedral complex is prepared by mixing $CoCl_3$ and NH_3 in the molar ratio 1 : 4, 0.1 m solution of this complex was found to freeze at 0.372°C. What is the formula of the complex? Given that molal depression constant (K_f) for water = 1.86°C/m.

[*HOTS*]

Ans. Theoretical value of

$$\Delta T_f = K_f \times m = 1.86°\text{C/m} \times 0.1 \text{ m} = 0.186°\text{C}$$

Observed value of ΔT_f = 0.372°C.

As observed ΔT_f is twice the theoretical value, this shows that each molecule of the complex dissociate to form two ions. This can be possible only if the formula of the complex is $[Co(NH_3)_4Cl_2]Cl$.

Q.12. Write the IUPAC name of the ionisation isomer of the coordination compound $[Co(NH_3)_5Br]SO_4$. Give one chemical test to distinguish between the two compounds.

[*CBSE Sample Paper 2016*] [*HOTS*]

Ans. Ionisation isomer is $[Co(NH_3)_5SO_4]Br$.

The IUPAC name is Pentaamminesulphatocobalt(III)bromide.

The isomer $[Co(NH_3)_5Br]SO_4$ will give SO2−4 ions in the solution which gives white precipitate with $BaCl_2$solution. The isomer $[Co(NH_3)_5SO_4]Br$ will give Br^- ions in the solution which gives yellow precipitate with $AgNO_3$ solution.

Q.13. A chloride of fourth group cation in qualitative analysis gives a green coloured complex [*A*] in aqueous solution which when treated with ethane-1, 2-diamine (en) gives pale-yellow solution [*B*] which on subsequent addition of ethane-1, 2-diamine turns to blue/purple [*C*] and finally to violet [*D*]. Write the structures of complexes [*A*], [*B*], [*C*] and [*D*].

[*CBSE Sample Paper 2017*]

Ans. $A = [Ni(H_2O)_6]^{2+}$

$B = [Ni(H_2O)_4 (en)]^{2+}$

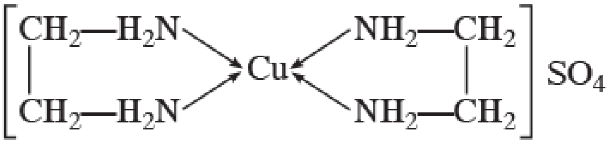
$C = [Ni(H_2O)_2(en)_2]^{2+}$

$D = [Ni(en)_3]^{2+}$

Q.14. Answer the following questions:

Q. Write formula of a chelate complex and give its IUPAC name.

Ans.



Bis-(ethane-1,2-diamine) copper(II) sulphate
(Chelate complex)

Q. Name two complexes which are used in medicines.

Ans.

- **a.** The platinum complex, *cis*-$[Pt(NH_3)_2Cl_2]$ known as cisplatin is used in the treatment of cancer.
- **b.** Ca–EDTA complex is used in the treatment of lead poisoning.

Q.15. Answer the following questions:

Q. What is meant by chelate effect?

Ans. When a bidentate or polydentate ligand is bonded through two or more donor sites to a metal ion and forms a ring structure then it is said to be chelating ligand. Chelating ligands form more stable complexes than monodentate analogs. This is called chelating effect.

Q. Square complexes of MX_2A_2 type with coordination number of 4 exhibit geometrical isomerism whereas tetrahedral complexes with similar composition do not. Why?

Ans. Square planar complexes of MA_2X_2 type with coordination number 4 exhibit geometrical isomerism because any of the two ligand may be arranged adjacent to each other in a *cis*- form or opposite to each other in a *trans*- form. Tetrahedral complexes of this type do not show geometrical isomerism because the relative positions of the monodentate ligands attached to the central metal atom are same with respect to each other.

Q.16. Write IUPAC names of the following coordination compounds:

- **i.** $K_3[Fe(C_2O_4)_3]$
- **ii.** $K_2[PdCl_4]$

Ans.

- **i.** Potassium trioxalatoferrate(III)
- **ii.** Potassium tetrachloridopalladate(II)