Chemistry Study Materials for Class 12

(NCERT Based Questions - Answers of Chapter - 09)

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Co-ordination Compounds

Question 1: Write the formulas for the following coordination compounds:

(i) Tetraamminediaquacobalt (III) chloride

(ii) Potassium tetracyanonickelate(II)

(iii) Tris(ethane-1,2-diamine) chromium(III) chloride

(iv) Amminebromidochloridonitrito-N-platinate(II)

(v) Dichloridobis(ethane-1,2-diamine)platinum(IV) nitrate

(vi) Iron(III) hexacyanoferrate(II)

Solution 1:

(i) $CO[(H_2O)(NH_3)_4]Cl_3$

(ii) $K_2[Ni(CN)_4]$

(iii) $Cr[(en)_3]Cl_3$

(iv) $Pt[(NH)_3BrCl(NO_2)]$

(v) $Pt[Cl_2(en)_2(NO_3)_2]$

(vi) $Fe_4[Fe(CN)_6]_3$

Question 2: Write the IUPAC names of the following coordination compounds:

(i) $[CO(NH_3)_8]Cl_3$

(ii) $[CO(NH_3)_6Cl]Cl_3$

(iii) $K_3[Fe(CN)_8]$

(iv) $K_3[Fe(C_2N_4)_3]$

(v) $K_2[PdCl_4]$

(vi) $[Pt(NH_3)_2Cl(NH_2CH_3)]Cl$

Solution 2:

(i) Hexaamminecobalt(III) chloride

(ii) Pentaamminechloridocobalt (III) chloride

(iii) Potassium hexacyanoferrate(III)

(iv) Potassium trioxalatoferrate(III)

(v) Potassium tetrachloridopalladate(II)

(vi) Diamminechlorido(methylamine)platinum(II) chloride

Question 3: Indicate the types of isomerism exhibited by the following complexes and draw the structures for these isomers:

(i) $K[Cr(H_2O)_2(C_2O_4)_2]$

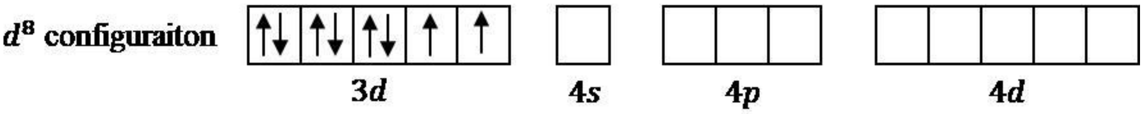
(ii) $[CO(en)_2]Cl_2$

(iii) $[Co(NH_3)_6(NO_2)(NO_3)_2]$

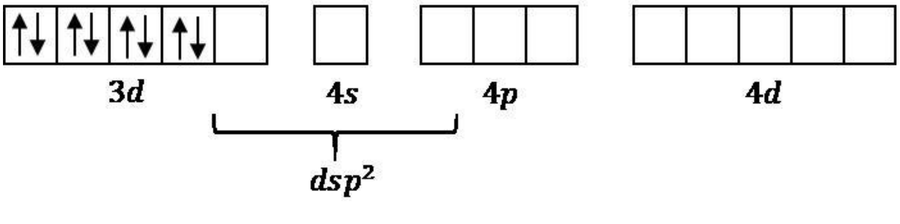
(iv) $[Pt(NH_2)(H_2O)Cl_2]$

Question 4: Explain on the basis of valence bond theory that $Ni(CN)_4^{2-}$ ion with square planer structure is diamagnetic and the $Ni(Cl)_4^{2-}$ ion with tetrahedral geometry is paramagnetic.

Solution 4: Ni is in the +2 oxidation state i.e., in d^8 configuration.

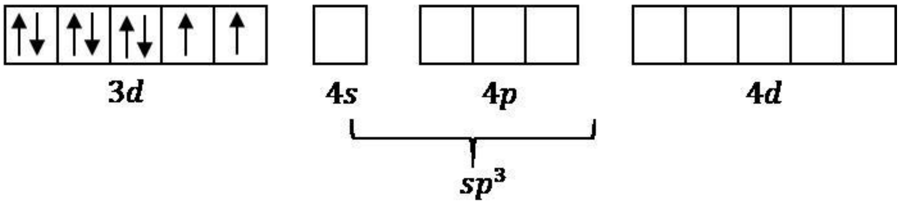


There are 4 CN^- ions. Thus, it can either have a tetrahedral geometry or square planar geometry. Since CN^- ion is a strong field ligand, it causes the pairing of unpaired 3*d* electrons.



It now undergoes dsp^2 hybridization. Since all electrons are paired, it is diamagnetic. In case of $[NiCl4]^{2-}$, Cl^- ion is a weak field ligand. Therefore, it does not lead to the pairing of unpaired 3*d* electrons.

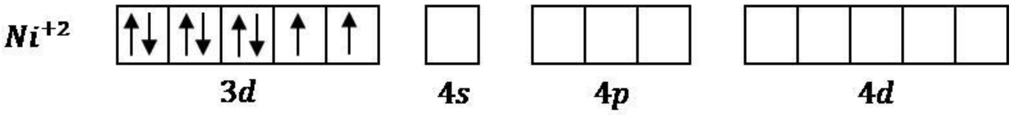
Therefore, it undergoes sp^3 hybridization.



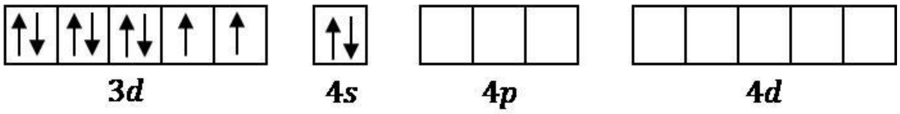
Since there are 2 unpaired electrons in this case, it is paramagnetic in nature.

Question 5: $[NiCl4]^{2-}$ is paramagnetic while $[Ni(CO)4]$ is diamagnetic though both are tetrahedral. Why?

Solution 5: Though both $[NiCl4]^{2-}$ and $[Ni(CO)4]$ are tetrahedral, their magnetic characters are different. This is due to a difference in the nature of ligands. Cl^- is a weak field ligand and it does not cause the pairing of unpaired 3*d* electrons. Hence, $[NiCl4]^{2-}$ is paramagnetic.



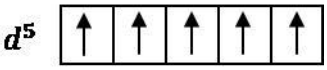
In $[Ni(CO)4]$, Ni is in the zero oxidation state i.e., it has a configuration of $3d^8\ 4s^2$.



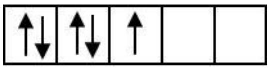
But CO is a strong field ligand. Therefore, it causes the pairing of unpaired 3*d* electrons. Also, it causes the 4s electrons to shift to the 3d orbital, thereby giving rise to sp^3 hybridization. Since no unpaired electrons are present in this case, $[Ni(CO)4]$ is diamagnetic.

Question 6: $[Fe(H2O)6]^{3+}$ is strongly paramagnetic whereas $[Fe(CN)6]^{3+}$ is weakly paramagnetic. Explain.

Solution 6: In both $[Fe(H2O)6]^{3+}$ and $[Fe(CN)6]^{3+}$, Fe exists in the +3 oxidation state i.e., in d^5 configuration



Since CN^- is a strong field ligand, it causes the pairing of unpaired electrons. Therefore, there is only one unpaired electron left in the *d*-orbital.



Therefore magnetic moment is given by,

$$\mu = n(n+2) = 1(1+2) = 3 = 1.732BM$$

On the other hand, $H2O$ is a weak field ligand. Therefore, it cannot cause the pairing of electrons. This means that the number of unpaired electrons is 5.

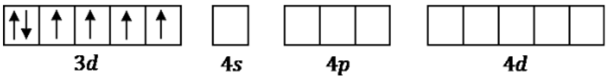
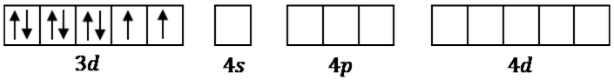
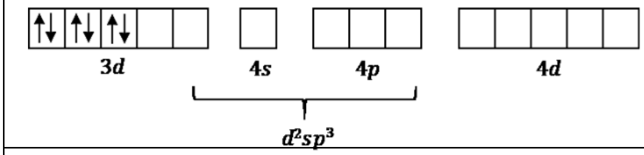
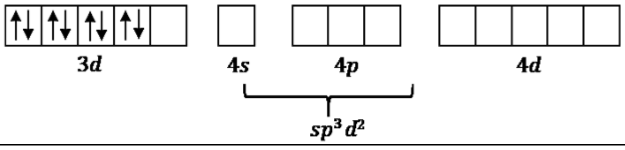
Therefore, magnetic moment is given by,

$$\mu = \sqrt{n(n+2)} = \sqrt{5(5+2)} = \sqrt{35} = 5.91BM$$

Thus, it is evident that $[Fe(H2O)6]^{3+}$ is strongly paramagnetic, while $[Fe(CN)6]^{3+}$ is weakly paramagnetic

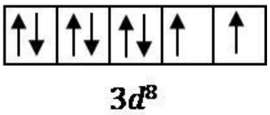
Question 7: Explain $[Co(NH_3)_6]^{3+}$ is an inner orbital complex whereas $[Ni(NH_3)_6]^{2+}$ is an outer orbital complex.

Solution 7:

$[Co(NH3)6]^{3+}$	$[Ni(NH3)6]^{2+}$
Oxidation state of cobalt = +3	Oxidation state of Ni = +2
Electronic configuration of cobalt = d^6	Electronic configuration of nickel = d^8
	
$NH3$ being a strong field ligand causes the pairing. Therefore, Cobalt can undergo d^2sp^3 hybridization.	If $NH3$ causes the pairing, then only one $3d$ orbital is empty. Thus, it cannot undergo d^2sp^3 hybridization. So in this complex NH3 acts as weak field ligand. Therefore, it undergoes $sp3d^2$ hybridization.
	
Hence, it is an inner orbital complex.	Hence, it forms an outer orbital complex.

Question 8: Predict the number of unpaired electrons in the square planar $[Pt(CN4)]^{2-}$ ion.

Solution 8: $[Pt(CN4)]^{2-}$ In this complex, Pt is in the +2 state. It forms a square planar structure. This means that it undergoes dsp^2 hybridization. Now, the electronic configuration Pd (+2) of is $5d^8$.



CN^- being a strong field ligand causes the pairing of unpaired electrons. Hence, there are no unpaired electrons in $[Pt(CN4)]^{2-}$.

Question 9: The hexaquomanganese (II) ion contains five unpaired electrons, while the hexacyanoion contains only one unpaired electron. Explain using Crystal Field Theory**.**

Solution 9:

$[Mn(H_2O)_6]^{2+}$	**$[Mn(CN)_6]^{4-}$**
Mn is in the +2 oxidation state.	Mn is in the +2 oxidation state
The electronic configuration is d^5.	The electronic configuration is d^5.
The crystal field is octahedral. Water is a weak field ligand. Therefore, the arrangement of the electrons in **$[Mn(H_2O)_6]^{2+}$** is $t_2g^3eg^2$.	The crystal field is octahedral. Cyanide is a strong field ligand and hence force pairing occurs. Therefore, the arrangement of the electrons in **$[Mn(CN)_6]^{4-}$** is $t_2g^5eg^0$.
Hence, hexaaquo manganese (II) ion has five unpaired electrons	While hexacyano ion has only one unpaired electron.

Question 10: Calculate the overall complex dissociation equilibrium constant for the $[Cu(NH3)4]^{2+}$ ion, given that $_4$ for this complex is 2.1×10^{13}.

Solution 10: The overall complex dissociation equilibrium constant is the reciprocal of the overall stability constant,

$$\frac{1}{\beta_4} = \frac{1}{2.1 \times 10^{13}} = 4.7 \times 10^{-14}$$

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