

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) $\text{Co}[(\text{H}_2\text{O})(\text{NH}_3)_4]\text{Cl}_3$
- (ii) $\text{K}_2[\text{Ni}(\text{CN})_4]$
- (iii) $\text{Cr}[(\text{en})_3]\text{Cl}_3$
- (iv) $\text{Pt}[(\text{NH}_3)_3\text{BrCl}(\text{NO}_2)]$
- (v) $\text{Pt}[\text{Cl}_2(\text{en})_2(\text{NO}_3)_2]$
- (vi) $\text{Fe}_4[\text{Fe}(\text{CN})_6]_3$

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

- (i) $[\text{Co}(\text{NH}_3)_8]\text{Cl}_3$
- (ii) $[\text{Co}(\text{NH}_3)_6\text{Cl}]\text{Cl}_3$
- (iii) $\text{K}_3[\text{Fe}(\text{CN})_8]$
- (iv) $\text{K}_3[\text{Fe}(\text{C}_2\text{N}_4)_3]$
- (v) $\text{K}_2[\text{PdCl}_4]$
- (vi) $[\text{Pt}(\text{NH}_3)_2\text{Cl}(\text{NH}_2\text{CH}_3)]\text{Cl}$

Solution 2:

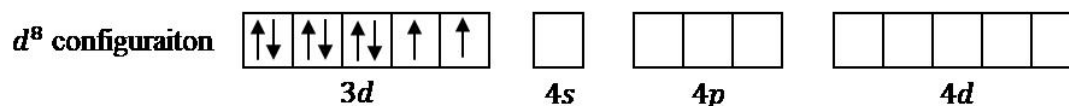
- (i) Hexaamminecobalt(III) chloride
- (ii) Pentaamminechloridocobalt (III) chloride
- (iii) Potassium hexacyanoferrate(III)
- (iv) Potassium trioxalatoferrate(III)
- (v) Potassium tetrachloridopalladate(II)
- (vi) Diamminechlorido(methylamine)platinum(II) chloride

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

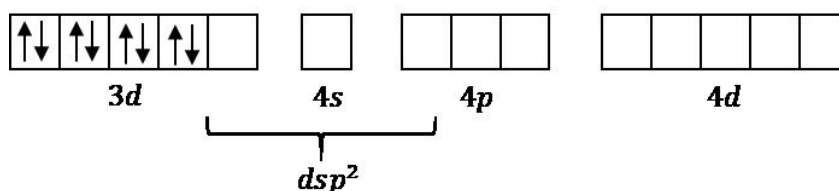
- (i) $K [Cr (H_2O)_2 (C_2O_4)_2]$
- (ii) $[Co(en)_2] Cl_2$
- (iii) $[Co(NH_3)_6 (NO_2) (NO_3)_2]$
- (iv) $[Pt(NH_2)(H_2O)Cl_2]$

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.

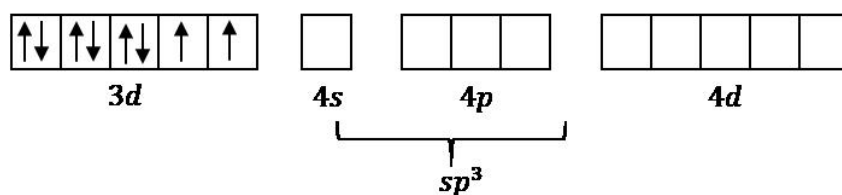


There are 4 CN^- ions. Thus, it can either have a tetrahedral geometry or square planar geometry. Since CN^- ion is a strong field ligand, it causes the pairing of unpaired $3d$ electrons.



It now undergoes dsp^2 hybridization. Since all electrons are paired, it is diamagnetic. In case of $[NiCl_4]^{2-}$, Cl^- ion is a weak field ligand. Therefore, it does not lead to the pairing of unpaired $3d$ electrons.

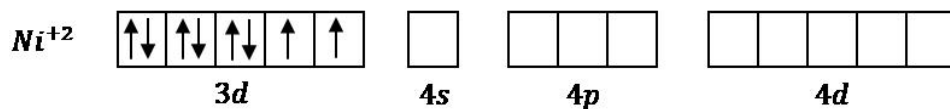
Therefore, it undergoes sp^3 hybridization.



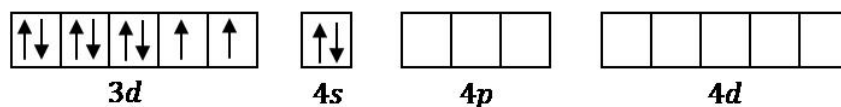
Since there are 2 unpaired electrons in this case, it is paramagnetic in nature.

Question 5: $[NiCl_4]^{2-}$ is paramagnetic while $[Ni(CO)_4]$ is diamagnetic though both are tetrahedral. Why?

Solution 5: Though both $[NiCl_4]^{2-}$ 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 $3d$ electrons. Hence, $[NiCl_4]^{2-}$ is paramagnetic.

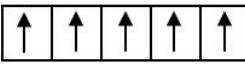


In $[Ni(CO)_4]$, Ni is in the zero oxidation state i.e., it has a configuration of $3d^8 4s^2$.



But CO is a strong field ligand. Therefore, it causes the pairing of unpaired $3d$ 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: $[Fe(H_2O)_6]^{3+}$ is strongly paramagnetic whereas $[Fe(CN)_6]^{3+}$ is weakly paramagnetic. Explain.

Solution 6: In both $[Fe(H_2O)_6]^{3+}$ and $[Fe(CN)_6]^{3+}$, Fe exists in the +3 oxidation state i.e., in d^5 configuration d^5 

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,

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

On the other hand, H_2O is a weak field ligand. Therefore, it cannot cause the pairing of electrons. This means that the number of unpaired electrons is 5.

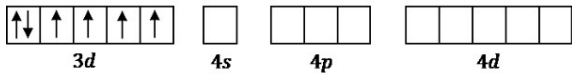
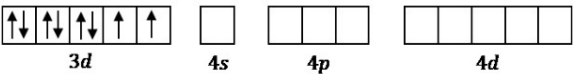
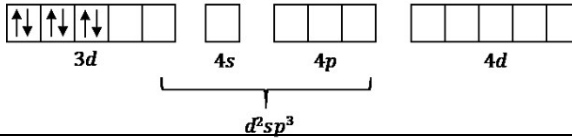
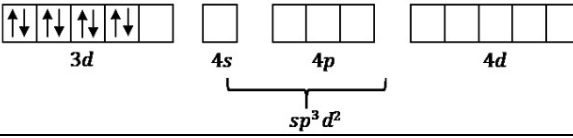
Therefore, magnetic moment is given by,

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

Thus, it is evident that $[Fe(H_2O)_6]^{3+}$ is strongly paramagnetic, while $[Fe(CN)_6]^{3+}$ is weakly paramagnetic

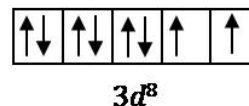
Question 7: Explain $[Co(NH_3)_6]^{3+}$ is an inner orbital complex whereas $[Ni(NH_3)_6]^{2+}$ is an outer orbital complex.

Solution 7:

$[Co(NH_3)_6]^{3+}$	$[Ni(NH_3)_6]^{2+}$
Oxidation state of cobalt = +3	Oxidation state of Ni = +2
Electronic configuration of cobalt = d^6	Electronic configuration of nickel = d^8
	
NH_3 being a strong field ligand causes the pairing. Therefore, Cobalt can undergo d^2sp^3 hybridization.	If NH_3 causes the pairing, then only one $3d$ orbital is empty. Thus, it cannot undergo d^2sp^3 hybridization. So in this complex NH_3 acts as weak field ligand. Therefore, it undergoes sp^3d^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 $[Pt(CN)_4]^{2-}$ ion.

Solution 8: $[Pt(CN)_4]^{2-}$ 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 $[Pt(CN)_4]^{2-}$.

Question 9: The hexaquo manganese (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 $t_{2g}^3e_g^2$.	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 $t_{2g}^5e_g^0$.
Hence, hexaquo 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 $[Cu(NH_3)_4]^{2+}$ ion, given that K_f for this complex is 2.1×10^{13} .

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

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