

# CHEMISTRY STUDY MATERIALS FOR CLASS 12

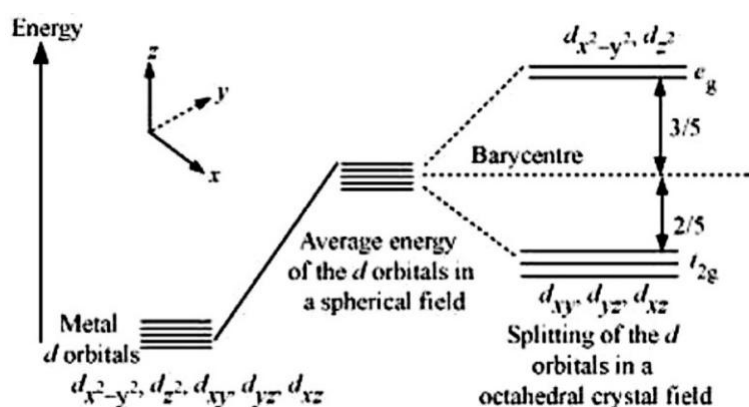
## (NCERT BASED QUESTIONS - ANSWERS OF CHAPTER - 09)

### GANESH KUMAR                      DATE:- 06/09/2020

### Co-ordination Compounds

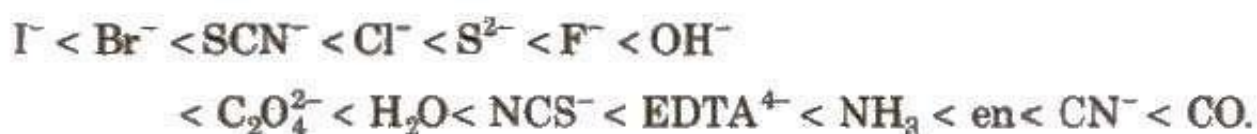
**Q.16:** Draw figure to show the splitting of  $d$  orbitals in an octahedral crystal field.

**Solution 16:** The splitting of the  $d$  orbitals in an octahedral field takes place in such a way that  $d_{x^2-y^2}$ ,  $d_{z^2}$  Experience a rise in energy and form the  $e_g$  level, while  $d_{yz}$ ,  $d_{xz}$  and  $d_{xy}$  experience a fall in energy and form the  $t_{2g}$  level.



**Question 17:** What is spectrochemical series? Explain the difference between a weak field ligand and a strong field ligand.

**Solution 17:** A spectrochemical series is the arrangement of common ligands in the increasing order of their crystal-field splitting energy (CFSE) values. The ligands present on the R.H.S of the series are strong field ligands while that on the L.H.S are weak field ligands. Strong field ligands cause higher splitting in the  $d$  - orbitals than weak field ligands.



**Question 18:** What is crystal field splitting energy? How does the magnitude of  $O$  decide the actual configuration of  $d$  orbitals in a coordination entity?

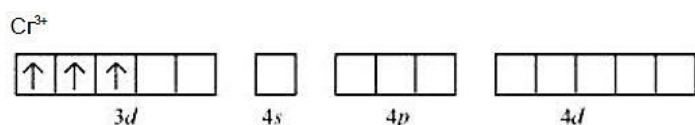
**Solution 18:** The degenerate  $d$ -orbitals (in a spherical field environment) split into two levels i.e.,  $e_g$  and  $t_{2g}$  in the presence of ligands. The splitting of the degenerate levels due to the presence of ligands is called the crystal-field splitting while the energy difference between the two levels ( $e_g$  and  $t_{2g}$ ) is called the crystal-field splitting energy. It is denoted by  $O$ .

After the orbitals have split, the filling of the electrons takes place. After 1 electron (each) has been filled in the three  $t_{2g}$  orbitals, the filling of the fourth electron takes place in two ways. It can enter the  $e_g$  orbital (giving rise to  $t^3_{2g} e^1_g$  like electronic configuration) or the pairing of the electrons can take place in the  $t_{2g}$  orbitals (giving rise to  $t^4_{2g} e^0_g$  like electronic configuration). If the  $\Delta_o$  value of a ligand is less than the pairing energy (P), then the electrons enter the  $e_g$  orbital. **On the other hand**, if the  $\Delta_o$  value of a ligand is more than the pairing energy (P), then the electrons enter the  $t_{2g}$  orbital.

**Question 19:**  $[\text{Cr}(\text{NH}_3)_6]^{3+}$  is paramagnetic while  $[\text{Ni}(\text{CN})_4]^{2+}$  is diamagnetic.

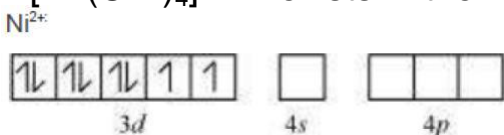
Explain why?

**Solution 19:** In  $[\text{Cr}(\text{NH}_3)_6]^{3+}$  Cr is in the +3 oxidation state i.e.,  $d^3$  configuration. Also, it is a weak field ligand that does not cause the pairing of the electrons in the 3d orbital.

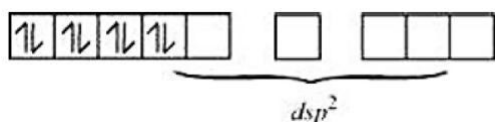


Therefore, it undergoes  $d^2sp^3$  hybridization and the electrons in the 3d orbitals remain unpaired. Hence, it is paramagnetic in nature.

In  $[\text{Ni}(\text{CN})_4]^{2+}$  Ni exists in the +2 oxidation state i.e.,  $d^8$  configuration.



$\text{CN}^-$  is a strong field ligand. It causes the pairing of the 3d orbital electrons. Then,  $\text{Ni}^{2+}$  undergoes  $dsp^2$  hybridization.



As there are no unpaired electrons, it is diamagnetic.

**Question 20:** A solution of  $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$  is green but a solution of  $[\text{Ni}(\text{CN})_4]^{2+}$  is colourless. Explain.

**Solution 20:** In  $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$ ,  $\text{H}_2\text{O}$  is a weak field ligand. Therefore, there are unpaired electrons in  $\text{Ni}^{2+}$ . In this complex, the  $d$  electrons from the lower energy level can be excited to the higher energy level i.e., the possibility of  $d-d$  transition is present. Hence,  $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$  is coloured.

In  $[\text{Ni}(\text{CN})_4]^{2+}$  the electrons are present as  $\text{CN}^-$  is a strong ligand.

Therefore,  $d-d$  transition is not possible in  $[\text{Ni}(\text{CN})_4]^{2+}$ . Hence it is colourless.

**Question 21:**  $[\text{Fe}(\text{CN})_6]^{4+}$  and  $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$  are of different colours in dilute solutions. Why?

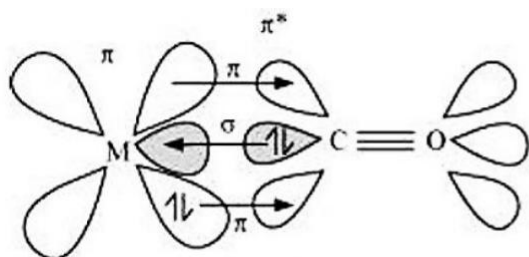
**Solution 21:** The colour of a particular coordination compound depends on the magnitude of the crystal-field splitting energy,

This CFSE in turn depends on the nature of the ligand. In case of  $[\text{Fe}(\text{CN})_6]^{4+}$  and  $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$ , the colour differs because there is a difference in the CFSE.

Now,  $\text{CN}^-$  is a strong field ligand having a higher CFSE value as compared to the CFSE value of water. This means that the absorption of energy for the intra  $d-d$  transition also differs. Hence, the transmitted colour also differs.

**Question 22:** Discuss the nature of bonding in metal carbonyls.

**Solution 22:** The metal-carbon bonds in metal carbonyls have both  $s$  and  $p$  characters.  $\text{M}-\text{C}$  bond is formed by the donation of lone pair of electrons on the carbonyl carbon into a vacant orbital of the metal.  $\text{M}-\text{C}$  bond is formed by the donation of a pair of electrons from the filled metal  $d$  orbital into the vacant anti-bonding  $\pi^*$  orbital of carbon monoxide. This is also known as back bonding of the carbonyl group. The metal to ligand bonding creates a synergic effect which strengthens the bond between  $\text{CO}$  and the metal. This synergic effect strengthens the bond between  $\text{CO}$  and the metal.



Synergic bonding in metal carbonyls

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