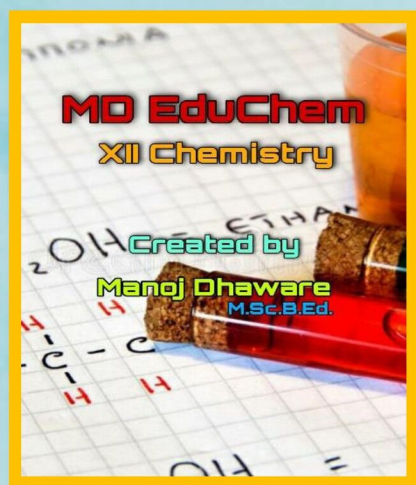
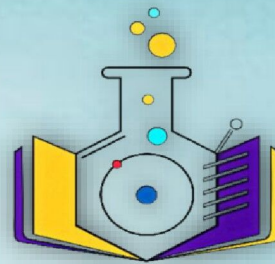


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***M.Sc. B.Ed.***



## ***XII Chemistry***

**Max. Marks: 5**

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# ***9. Coordination Compounds***

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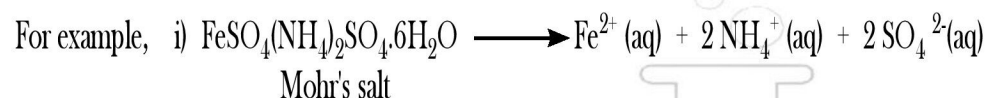
## 9. Coordination Compounds

**9.1 Introduction:** The concept of coordination compounds arises from complex forming tendency of transition elements (d-block elements). Coordination compounds are also known as **complex compounds or complexes**. For example, a Chemotherapy drug, **Cis-Platin** ( $\text{Pt}(\text{NH}_3)_2\text{Cl}_2$ ) which is used in **cancer** treatment is a coordination compound.

**Coordination chemistry:** 'It is a branch of chemistry which deals with the study coordination compounds.'

**9.2 Double salt and Coordination compounds:** Combination of two or more stable compounds in stoichiometric ratio can give two types of substances, namely double salt and coordination compounds.

**I] Double salt:** Double salt dissociates in water completely into **simple ions**.



When Mohr's salt is dissolved in water gives  $\text{Fe}^{2+}$ ,  $\text{NH}_4^+$ ,  $\text{SO}_4^{2-}$  simple ions



When Carnalite is dissolved in water gives  $\text{K}^+$ ,  $\text{Mg}^{2+}$ ,  $\text{Cl}^-$  simple ions

**II] Coordination complex:** Coordination compounds dissociates in water with at least one **complex ion**.



When  $\text{K}_4[\text{Fe}(\text{CN})_6]$  is dissolved in water gives  $[\text{Fe}(\text{CN})_6]^{4-}$  complex ion

### 9.3 Coordination compounds (Complexes) and their classification:

**Definition:** The compounds in which central metal atom or ion surrounded by ligands are known as coordination compounds.

**Classification:** Coordination compounds (complexes) are classified by following ways

#### **I] Classification based on type of ligand:**

**1) Homoleptic complexes:** The complexes in which the central metal atom or ion is bound to **only one type of ligands** are known as homoleptic complexes.

Example:  $[\text{Co}(\text{NH}_3)_6]^{3+}$ ,  $[\text{Cu}(\text{C}_2\text{O}_4)_3]^{3-}$ ,  $[\text{Ni}(\text{CN})_4]^{2-}$ ,  $\text{Na}_3[\text{Co}(\text{NO}_2)_6]$

**2) Heteroleptic complexes:** The complexes in which the central metal atom or ion is bound to **more than one type of ligands** are known heteroleptic complexes.

Example:  $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]^+$ ,  $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{SO}_4$ ,  $[\text{Co}(\text{ONO})(\text{NH}_3)_5]\text{Cl}_2$ ,  $[\text{CoCl}(\text{NH}_3)(\text{en})_2]^{2-}$

vi) For electronic configurations  $d^1$ ,  $d^2$ ,  $d^3$  and  $d^8$ ,  $d^9$ ,  $d^{10}$  the high spin and low spin configurations cannot be distinguished.

vii) Only the electronic configurations  $d^4$  to  $d^7$  render the high and low spin complexes. These are depicted in right side table.

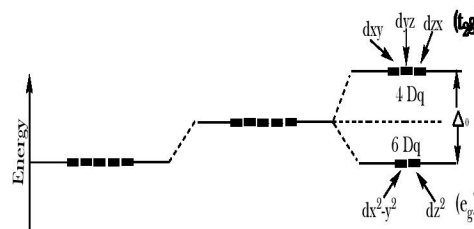


Fig. Splitting of d-orbital in a tetrahedral crystal field

### 9.13 Factors affecting Crystal Field Splitting Parameter ( $\Delta_0$ )

1) **Relative strength of the ligands:** The magnitude of the crystal field splitting depends on strength of the ligands. The strong ligands those appear in spectrochemical series approach closer to the central metal which results in a large crystal field splitting.

2) **Oxidation state of the metal:** A metal with the higher positive charge is able to draw ligands closer to it than that with the lower one. Thus the metal in higher oxidation state results in larger separation of  $t_{2g}$  and  $e_g$  set of orbitals. The trivalent metal ions cause larger crystal field splitting than corresponding divalent ones.

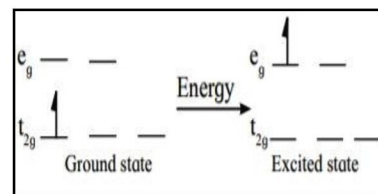
9.14 **Colour of the octahedral complexes:** The colour of coordination compounds can be explained on the basis of crystal field theory.

For example, 1)  $[\text{Ti}(\text{H}_2\text{O})_6]^{3+}$  complex is purple in colour.

i) The electronic configuration of  $\text{Ti}^{3+}$  is  $[\text{Ar}] 3d^1 4s^0$  and it contains one unpaired electron

ii) In ground state the single electron is available in  $t_{2g}$  level and the higher energy level  $e_g$  is empty.

iii) If light absorbed by the complex in visible region, it would excite the electron from  $t_{2g}$  level to  $e_g$  level. i. e. there is **d-d transition** of electron gives purple colour to complex



- The absorption of the wavelength of light corresponding to  $\Delta_0$  parameter promotes an electron from the  $t_{2g}$  level. such **energy gap in case of the  $[\text{Ti}(\text{H}_2\text{O})_6]^{3+}$  complex is  $20,300 \text{ cm}^{-1}$  (520 nm, 243 kJ/mol)**

### 9.15 Tetrahedral complexes and their Splitting of d-orbital crystal field:

i) A pattern of splitting of d orbitals, which is a key in the crystal field theory, is dependent on the ligand field environment. This is illustrated for the tetrahedral ligand field environment.

ii) In tetrahedral complexes, four ligands are placed at the four corners and the metal atom **M** placed at the centre as shown in right side figure.

iii) The  $d_{xy}$ ,  $d_{yz}$  and  $d_{zx}$  orbitals experience more repulsion from the ligands compared to that by  $d_{x^2-y^2}$  and  $d_{z^2}$  orbitals

iv) Due to larger such repulsions the  $d_{xy}$ ,  $d_{yz}$  and  $d_{zx}$  orbitals are of higher energy while the  $d_{x^2-y^2}$  and  $d_{z^2}$  orbitals are of relatively lower energy.

