Atomic Energy Central School, Indore

Class XII Chemistry CO-ORDINATION COMPOUNDS Handout 4/6

Bonding in Coordination Compounds

Valence Bond Theory

According to this theory, the metal atom or ion under the influence of ligands can use its (n-1)d, ns, np or ns, np, nd orbitals for hybridization to yield a set of equivalent orbitals of definite geometry such as tetrahedral(sp³), square planar (dsp²), pentagonal bipyramidal(dsp³) or octahedral (d²sp³/sp³d²).

These hybridised orbitals are allowed to overlap with ligand orbitals that can donate electron pairs for bonding. This is illustrated by the following examples.

For Example: 1. $[Co(NH_3)_6]^{3+}$ $_{27}$ Co – outer e confg = $3d^7 4s^2$ $[Co(NH_3)_6]^{3+}$ Orbitals of Co³⁺ion 1. As inner d orbitals are used in d²sp³, it is an **inner orbital complex** NH₃ being a strong ligand, pairing up the electrons takes place. 2. As the e- are paired, it is called a d^2sp^3 hybridised orbitals of Co3+ low spin or spin paired complex d²sp³ hybrid 3. As the e- are paired, it is $[Co(NH_3)_6]^{3+}$ diamagnetic in nature. (inner orbital or low spin complex) Six pairs of electrons from six NH₃ molecules $_{27}$ Co – outer e confg = $3d^7 4s^2$ 2. $[Co(F)_6]^{3-}$ $[Co(F)_6]^{3-}$ Orbitals of Co3+ion 1. As outer d orbitals are used in sp³d², F being a weak ligand, pairing up the electrons doesn't take place. it is an outer orbital complex sp^3d^2 hybridised orbitals of Co3+ 2. As the e- are not paired, it is called a sp^3d^3 hybrid 4dhigh spin or spin free complex $[CoF_6]^{3-}$ (outer orbital or 3. As the e- are not paired, it is high spin complex) 4dSix pairs of electrons paramagnetic in nature. from six F-ions

Limitations of Valence Bond Theory

- (i) It involves a number of assumptions.
- (ii) It does not give quantitative interpretation of magnetic data.
- (iii) It does not explain the colour exhibited by coordination compounds.
- (iv) It does not give a quantitative interpretation of the thermodynamic or kinetic stabilities of coordination compounds.
- (v) It does not make exact predictions regarding the tetrahedral and square planar structures of 4-coordinate complexes.
- (vi) It does not distinguish between weak and strong ligands.