Prepared by: Dr. Vijay Shankar

Sidgwick's Effective Atomic Number (EAN) Rule

Sidgwick suggested that the "when the ligands donate the pair of electrons to the central metal atom or ion, the total no of electrons on the central metal atom or ion including those gained from ligands in the bonding is called effective atomic number (EAN) of the central metal ion.

This rule can also be stated are as follows:

⇒ If the total no of electrons ie EAN of the central metal atom is equal to the atomic no of the inert gas, such compounds are stable and diamagnetic.

⇒ If the total no of electrons ie EAN of the central metal atom is not equal to the atomic number of the inert gas, such compounds are unstable and Paramagnetic.

Formula to calculate EAN of Central metal atom in complex ion:

$$EAN = (Z - X) + n \times Y$$

Z = Atomic no of the central metal atom.
X = Oxidation no of the central metal ion.
n = no of ligands
Y = no of electrons donated by one ligand

Example - Calculate the EAN of the cobalt III in the $[Co(NH_3)_6]^{3+}$

Solution = EAN of Co^{3+} = (Z-X)+nxy

(27-3)+6x2 = 24+12 = 36

The EAN of the Co^{3+} ion is equal to the atomic number of Kr (Z=36)

no of unpaired electrons = Atomic no of Kr - EAN

36-36 = 0

So it contains no unpaired electrons. Hence it is stable and diamagnetic.

Example - Calculate the E·AN of Cu^{2+} in the $[Cu(NH_3)_4]^{2+}$ ion

Solution = EAN of Cu^{2+} = (29-2)+4x2 = 27+8 = 35

no of unpaired electron = 36-35 = 1

Paramagnetic

Example - Calculate the EAN of Cr^{3+} in the $[Cr(NH_3)_6]^{3+}$ ion

Solution = EAN of Cr^{3+} = (24-3)+6x2 = 21+12 = 33

no of unpaired electrons = Atomic no of Kr - EAN

36-33 = 3

Paramagnetic.

Example - calculate the EAN of Pd^{4+} in the $[Pd(NH_3)_6]^{4+}$ ion

Solution = EAN of Pd^{4+} = (46-4)+6x2 = 42+12 = 54

no of unpaired electrons = Atomic no of Xe - EAN

54-54 = 0

diamagnetic

Example - Calculate the EAN of Pt^{4+} in the $[Pt(NH_3)_6]^{4+}$

Solution = EAN of Pt^{4+} = (78-4)+6x2 = 74+12 = 86

no of unpaired electrons = Atomic no. of Rn - EAN

86-86 = 0

Diamagnetic

Problem- Calculate of EAN of the central metal atom of complexes.

(I) $[Fe(CN)_6]^{4-}$ (II) $[Ag(NH_3)_4]^{+}$ (III) $[Fe(CN)_6]^{3-}$

(IV) $[Ni(CN)_4]^{2-}$ (V) $[Pt(NH_3)_2Cl_2]^{\circ}$ (VI) $[Ag(NH_3)_2]^{+}$

(VII) $[CuCl_2]^{-}$ (VIII) $[Co(CN)_6]^{4-}$ (IX) $[Mn(H_2O)_6]^{2+}$

(X) $[Ni(en)_3]^{2+}$

Answer- (I) 36 (II) 54 (III) 35 (IV) 34 (V) 84

(VI) 50 (VII) 32 (VIII) 37 (IX) 35 (X) 38

References: (1) Pradeep's Inorganic Chemistry, K.K. Bhasin

(2) Concise Inorganic Chemistry, J.D. Lee.

(3) Chemistry for degree students, R.L. Madan