Answer on Question #76803, Chemistry / Inorganic Chemistry

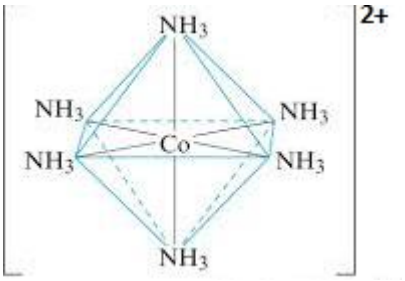
Answer ALL parts a) — c).
a) Draw the structure of the following coordination compounds and determine the oxidation state, dn electronic configuration,t2gm egn or emt2n configuration and the spin only magnetic moment (Us.o.) of the metal ion.

i. [Co(NH3)6]2+

ii. [Cu(en)3]2+, en = 1,2-diaminoethane
iii. [NiCl4]2-

Solution

i. Structure of $[Co(NH_3)_6]^{2+}$



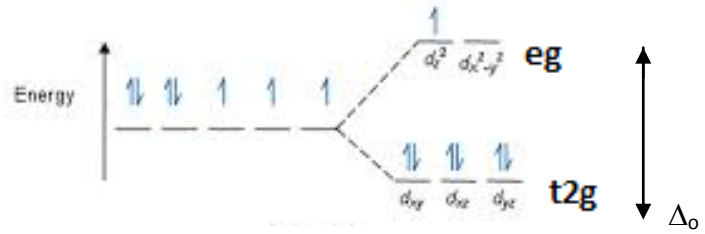
Atom of Cobalt has electron configuration [Ar] $3d^7 4s^2$

Oxidation state of cobalt in $[Co(NH_3)_6]^{2+}$ is Co^{2+}, as NH_3 ligands have no charge.

Atom of Co loses two electrons to become an ion Co^{2+} which has d^7 electronic configuration.

The coordination number of Co is 6. The complex $[Co(NH_3)_6]^{2+}$ has an octahedral shape. Complex $[Co(NH_3)_6]^{2+}$ can be high spin or low spin. As NH_3 is a strong field ligand, complex $[Co(NH_3)_6]^{2+}$ is low spin, splitting energy Δ_o is large.

Splitting d-orbital diagram for $[Co(NH_3)_6]^{2+}$ is: $t_{2g}^6 e_g^1$



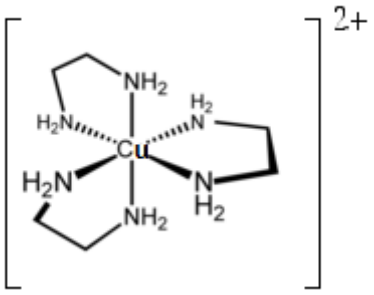
This complex is paramagnetic as it has one lone electron.

To find the spin only magnetic moment we should use the formula, where n is number of unpaired electrons :

$\mu_{so} = \sqrt{n(n+2)}$

For complex $[Co(NH_3)_6]^{2+}$ $\mu_{so} = \sqrt{1(1+2)} = \sqrt{3} = 1.73\ \mu_B$

ii. Structure of $[Cu(en)_3]^{2+}$, en = 1,2-diaminoethane



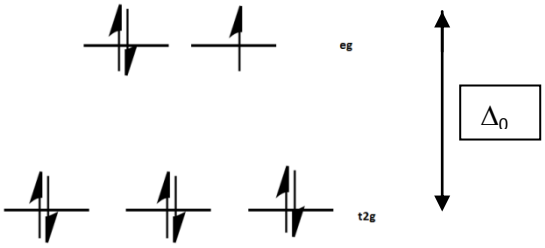
The electron configuration of Copper is : [Ar] $3d^{10}4s^1$

Oxidation state of Copper in $[Cu(en)_3]^{2+}$ is Cu^{2+}, as en ligands have no charge.

d^9 electronic configuration, as atom of Cu looses two electrons to become an ion Cu^{2+}.

The complex $[Cu(en)_3]^{2+}$ has an octahedral shape, en is a strong field ligand, but the appropriate crystal field diagram shows that only one configuration is possible irrespective of the strength of the ligand field.

Splitting d-orbital diagram for $[Cu(en)_3]^{2+}$ is: $t_{2g}^{6}e_g^{3}$

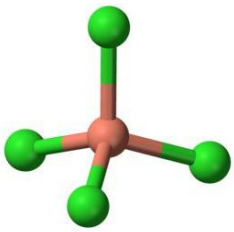


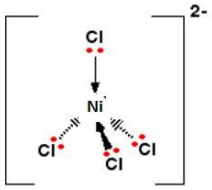
This complex is paramagnetic as it has at least one lone electron.

$\mu_{so} = \sqrt{n(n+2)}$

For complex $[Cu(en)_3]^{2+}$ $\mu_{so} = \sqrt{1(1+2)} = \sqrt{3} = 1.73\ \mu_B$

iii. Structure of $[NiCl_4]^{2-}$





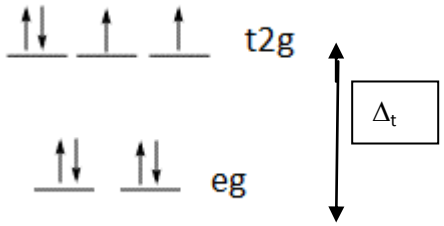
The electron configuration of Nickel is : [Ar] $3d^8 4s^2$

Oxidation state of Nickel in $[NiCl_4]^{2-}$ is Ni^{2+}, as each of Cl^- ligands has one negative charge and charge of the complex is -2 (+2+4·(-1)= -2).

d^8 electronic configuration, as atom of Ni looses two electrons to become an ion Ni^{2+}.

The complex $[NiCl_4]^{2-}$ can have either tetrahedral or square-planar shape. As Cl^- is a weak field ligand complex $[NiCl_4]^{2-}$ has tetrahedral shape.

Splitting d-orbital diagram for $[NiCl_4]^{2-}$ is: $e_g^4\ t_{2g}^4$



This complex is paramagnetic as it has two lone electron.

$$\mu_{so} = \sqrt{n(n+2)}$$

For complex$[NiCl_4]^{2-}$ $\mu_{so} = \sqrt{2(2+2)} = \sqrt{8} = 2.83\ \mu_B$