Answer on Question #76763, Chemistry / Inorganic Chemistry

6. 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.
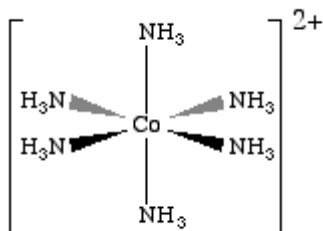
i. [Co(NH3)6]2+

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

iii. [NiCl4]2-

B)Use the Bohr model of the hydrogen atom to explain atomic emission spectra. Your answer should include appropriate diagrams.

Solution

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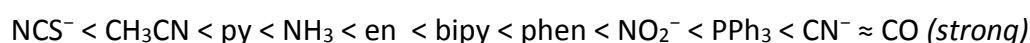

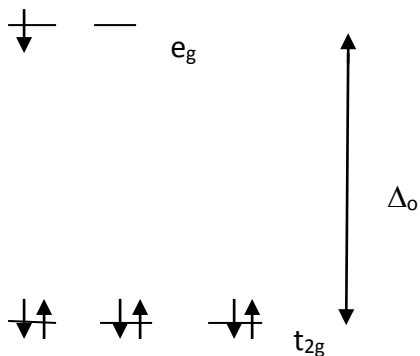
The electron configuration of Cobalt is : [Ar] $3d^7 4s^2$

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

d^7 electronic configuration, as atom of Co loses two electrons to become an ion Co^{2+}.

The complex $[Co(NH_3)_6]^{2+}$ has an octahedral shape. NH_3 is a strong field ligand, consequently, complex $[Co(NH_3)_6]^{2+}$ is low spin, splitting energy Δ_o is large.

$$(weak) \; I^- < Br^- < S^{2-} < SCN^- < Cl^- < NO_3^- < N_3^- < F^- < OH^- < C_2O_4^{2-} \approx H_2O <$$

$$NCS^- < CH_3CN < py < NH_3 < en \; < bipy < phen < NO_2^- < PPh_3 < CN^- \approx CO \; (strong)$$

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

$\begin{array}{cc}\uparrow\!\downarrow & \text{—} \end{array}$ e_g

$\uparrow\!\downarrow \quad \uparrow\!\downarrow \quad \uparrow\!\downarrow$ t_{2g}
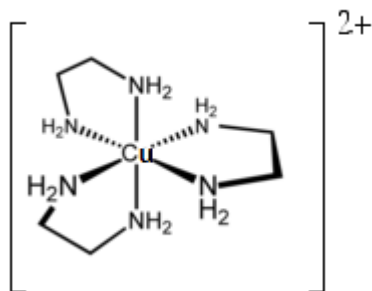
Δ_o

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

The formula used to calculate the spin-only magnetic moment, based on the number of unpaired electrons n, is:

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

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

$2+$

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 loses 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: $t_{2g}^6 e_g^3$

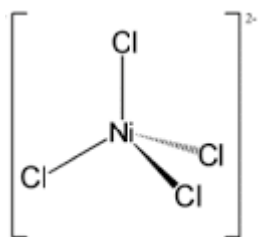$\uparrow\!\downarrow \quad \uparrow$ e_g

Δ_o

$\uparrow\!\downarrow \quad \uparrow\!\downarrow \quad \uparrow\!\downarrow$ t_{2g}
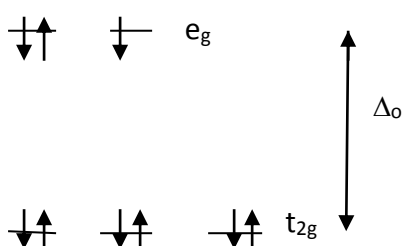
This complex is paramagnetic as it has at least one lone electron.

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

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 negative charge and charge of the complex is -2 (+2+4·(-1)= -2).

d^8 electronic configuration, as atom of Ni loses 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: $e_g{}^4\ t_{2g}{}^4$
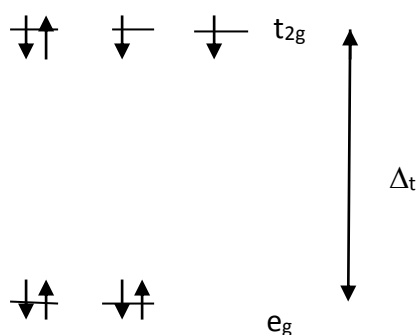
This complex is paramagnetic as it has two lone electron.

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

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

b) Use the Bohr model of the hydrogen atom to explain atomic emission spectra. Your answer should include appropriate diagrams.

Borh's model of hydrogen is based on the nonclassical assumption that electrons travel in specific shells or orbits around the nucleus. Electrons can occupy only discrete orbits (at certain distances from nucleus). When electron moves from one allowed orbit to another it emits or absorbs photons of energy, which is quantized. We see these photons as lines in emission spectra (Balmer series in visible part of spectrum, Lyman series in ultraviolet, Paschen, Bracket, Pfund series in Infrared part of spectrum).

Niels Bohr showed that the energy of an electron in a particular orbit in hydrogen atom is:

$$E_n = -\frac{Rhc}{n^2}$$

Where R is the Rydberg constant, n – number of the orbit.

The difference in energy ΔE between any two orbits is:

$$\Delta E = E_{final} - E_{initial} = -Rhc\left(\frac{1}{n^2_{initial}} - \frac{1}{n^2_{final}}\right)$$

$$\Delta E = \frac{hc}{\lambda} = -Rhc\left(\frac{1}{n^2_{initial}} - \frac{1}{n^2_{final}}\right)$$

Atomic emission spectrum of hydrogen atom