Learning Objectives and Worksheet X

Chemistry 1B-AL Fall 2016

~~Lectures~~ (17-18) Coordination Chemistry

WE WILL ONLY COVER LIMITED PARTS OF CHAPTER 19. (940-944; 952-954;963-970).

Supplementary video: Introduction to Ligands and Complexes: http://youtu.be/EufPZFAwWco

Great introduction to coordination complex chemistry: http://www.chem.purdue.edu/gchelp/cchem/whatis2.html

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The next two class sessions will be devoted to an introduction to a fourth type of bonding, the coordinate covalent bond. Transition metal coordination complexes are an important class of molecules that exhibit this type of bonding and are important in a number of areas including material science and biology. In addition we will study “crystal field theory” that describes the electron configuration of d-electrons in transition metal complexes and, in making predictions about the chromatic and magnetic properties of transition metal complexes, will provide for us experimental correlation of the ‘reality’ of d-orbital shapes which we discussed in chapter 12.

I. Introduction

1. A coordination complex is composed of a central atom or ion (often a transition metal) and molecules (or ions) called ________________________ that are bound to the central atom by ________________________ bonds where both ____________________ are contributed by the _____________________.

HW#8: 55, S16

2. In the coordination complex $[Cu(CN)_4]^{3-}$ the central atom/ion is _______________ , the ligands are _________________ , and the coordination number is ________________

II. Common Ligands

1. In order to form a coordinate covalent bond the ligand must generally have one or more

   ________________________________ .

2. Why is ethylene diamine $H_2NCH_2CH_2NH_2$ with two pairxs of non-bonding electrons a bidentate ligand while cyanide $(CN)^-$ with two pairs of non-bonding electrons can only form one coordinate covalent bond?

III. Formulas, oxidation states, d-electrons in coordination compounds

1. To calculate the number of ligands in a coordination complex you must
   i. know the coordination number of the complex from the ______________________ of the complex ion, (or perhaps vice versa)
   ii. and the ____ of each ligand.
2. To calculate the total charge on the complex ion you must know the total charges of the ____________________ forming the neutral ionic 'salt' along with the complex ion.
3. To calculate the oxidation state of the metal ion you must
   i. know the ________________________ of the complex ion
   ii. and the _________________________________ (multiplied by the number of ligands)
4. To calculate the number of d-electrons on the metal ions one applies the oxidation state of the metal and the Aufbau principle for positive ions.

5. A tetrahedral complex of $[CuCl_x]^{2-}$ has a total charge of 2−
   i. The number of chloride ligands, x, is _____________ .
   ii. The oxidation state of the $Cu^{?}$ ion is _______________ .
   iii. The number of d-electrons on the $Cu^{?}$ ion is ___________ .

Further links to the orientation of d-orbitals relative to coordination sites:

Octahedral:

http://switkes.chemistry.ucsc.edu/teaching/CHEM1B/Jmol/CrystalField/CFT_OrbsOctahedral

Several geometries: http://wwwchem.uwimona.edu.jm:1104/courses/CFT_Orbs.html

Hemoglobin:

http://switkes.chemistry.ucsc.edu/teaching/CHEM1B/WWW_other_links/ox_deox_hemo.htm

IV. Magnetic and chromatic properties of transition metal complexes

see: https://www.youtube.com/watch?v=xNXRSE7pxXM

1. Although in the free atom or ion all five components the d-orbital have equal energies the presence of ligands may cause some components to be more or less stable than others. The pattern of the splitting of d-orbital energies depends on the ____________________ of the coordination complex. The magnitude of the splitting may depend on both the nature of the _____________________ and that of the _____________________ .
2. In regular octahedral complexes the d-orbital energies are split into ________ levels with the ________________________ d-orbital components having the lower energy and the ________________________ d-orbital components having the higher energy.

3. In octahedral complexes, why are electrons in orbitals in the e_g group of higher energy than those in the t_{2g} group ?

4. Strong (high field, low-spin) ligands yield _____________ energy splittings while weak (low field, high-spin) ligands result in _____________ energy splittings.
5. In octahedral complexes with d^1, d^2, or d^3 electron configuration, the lowest energy configuration will place all electrons in a __________ orbital with spins _______________ .
6. For a d^4 configuration of an octahedral complex, what determines whether the

t_{2g}^4 ↑↓ ↑ ↑	or	t_{2g}^3 ↑ ↑ ↑ e_g^1 ↑	will be the ground state ?

HW#6: 56, 57, 58, 59, S17, S18

7. For a metal ion like Co^{3+} with six 3d electrons ($3d^6$), a weak field ligand would give an octahedral coordination complex with _______________ unpaired electrons while a strong field ligand would give a complex with _______________ unpaired electrons. The magnetic properties of the weak field complex would be ____________________ and the magnetics properties of the strong field complex would be ____________________.
8. In octahedral complexes, a transition between what two types of electronic energy levels allows the complex to absorb visible light ______________________ ?
9. A metal ion M^{+n} can form bot the complexes $[M(CN)_6]^{n-6}$ and $[MF_6]^{n-6}$ that both absorb visible light. Which complex is more likely to appear red ? ______________