Week 8 Worksheet

Chem 11300-2: Section 33

May 17, 2022

***Problem* 1:** Nickel and platinum belong to the same family, yet $[NiCl_4]^{2-}$ and $[PtCl_4]^{2-}$ differ greatly in physical properties. Give crystal field diagrams for each complex predicting the geometry, color, and magnetic properties.

***Problem* 2:** Identify which complexes from the following list meet the criteria given below

a) $[IrCl_4]^{2-}$

b) $[Mo(NO_2)_6]^{3-}$

c) $[CuI_4]^{3-}$

d) $[Re(NH_3)_6]^{2+}$

e) $[CrCl_6]^{4-}$

f) $[Cd(H_2O)_6]^{2+}$

g) $[Rh(CN)_6]^{3-}$

h) $[Fe(en)_3]^{3+}$

Complex(es) with *more than* 4 unpaired electrons.

Complex(es) that are likely octahedral.

Complex(es) that are likely square planar.

Complex(es) that are colorless.

Complex(es) that is/are chiral.

***Problem* 3:** What +3 ion is used as a MRI contrast agent since it has the greatest number of unpaired electrons of any naturally occuring element on the periodic table? Which +2 ion has the greatest number of unpaired electrons?

***Problem* 4:** Meishan Zhao is preparing solution 14 and solution 15 in the qualitative analysis lab which contain $[Co(NH_3)_6]^{2+}$ and $[CoCl_4]^{2-}$. Unfortunately, he confused himself and couldn't remember which was the blue-colored solution and which was the yellow-colored solution. As the excellent Chem 113 student you are, you quickly come to his rescue and know how to tell them apart! Please explain which is which so that you can save the lab!

***Problem* 5:** The complexes VCl_3, $FeCl_3$, $TaCl_3$, and $OsCl_3$ have been found to crystallize in the same lattice structure in which each of the metal cations is coordinated to six anions and each anion is coordinated to two metal cations. Experiments have shown that the lattice energy of VCl_3 is much greater than that of $FeCl_3$. Further experiments have shown that the lattice energy of $OsCl_3$ is much greater than $TaCl_3$. How can we explain these trends? **Use crystal field theory to explain and consider the CF stabilization energy.**

The following problems are written by Professor Mcleod or Head TA Miah Turke. They may mimic homework problems closely, but will be highly beneficial for the midterms and final.

***Problem* 6:** Name the compound and draw all possible isomers for each of the following complexes. Note that the name of the molecular geometry is provided.

a) $[Cu(NH_3)_4(H_2O)_2]^{2+}$, octahedral

b) $[Pt(NH_3)_2Cl_2]$, square planar

c) $[Co(NH_3)_3Cl_3]$, octahedral

d) $[Cr(en)_3]^{3+}$, octahedral

***Problem* 7:** In this problem, we will construct the energy-level structure of the 3d orbitals in a trigonal planar crystal field.

a) Draw a generic trigonal planar structure. Use M for the metal ion and L for the ligands.

b) Draw and label the five 3d-orbitals with the locations of the ligands shown.

c) Using your drawings from (b), what orbitals do you think are isoenergetic? Rationalize using repulsion/overlap concepts.

d) Draw the energy-level structure of the d orbitals in a trigonal planar crystal field, labelling each orbitals as xy, xz, yz, $x^2 - y^2$, and z^2. Give rationalizations for the relative energies of the orbitals in your diagram.

***Problem* 8:** Name the complex in each set of octahedral complexes that will have the largest d-splitting value (Δ). Give a one-sentence explanation for your answer in each case. Remember to utilize the spectrochemical series for ligands and metal ions introduced in Section 8.5.

a) $Na_3[CoCl_6]$ versus $Na_4[CoCl_6]$

b) $[RhCl_6]^{3-}$ versus $[RhI_6]^{3-}$

c) $[Fe(CO)_6]^{3+}$ versus $[Ru(CO)_6]^{3+}$

d) $Co(OH_2)_6$ versus $[Co(CN)_6]^{3-}$