Chem 400
Inorganic Chemistry

Exam 1

1 ___ of 10
2 ___ of 10
3 ___ of 30
4 ___ of 10
5 ___ of 10
6 ___ of 20
7 ___ of 10

Σ _______ of 100

% 

Name _________________________________________________________

(please print)
1. Sketch out the molecular orbital energy level diagram for BH$_3$ applying the LGO approach. Define the spatial orientation of BH$_3$ using x,y,z directions and identify all atomic and ligand group orbitals involved in bonding. (10 points)
2. Draw schematic representations for all of the bonding and anti-bonding molecular orbitals (MO’s) of BH$_3$ (use the information derived in Problem 1). (10 points)
3. Draw Lewis structures for each of the following molecules. (2 points each)
   Based on your Lewis structure, develop three-dimensional structures for each
   compound using VSEPR theory. (2 points each) Finally, determine the
   appropriate point group for each of your three dimensional drawings. (2 points
   each)
   a. BrF$_4$

b. IF$_7$

c. SiFClBrI

d. SF$_5$

e. H$_2$O$_2$
4. How many normal modes of vibration does each of the following molecules possess, and how many of those are IR active for (2 points each):

a. CCl$_4$

b. BCl$_3$

c. CS$_2$

d. H$_2$S

e. NF$_3$
5. Give the expected possible covalent MXₙ compounds (where X⁻ = Cl⁻ or Br⁻) of Sn, At, and Ra. Assume only σ-bonding, and predict the geometry of each molecule. **Hint:** To predict possible covalent states, start with the ground state electron configurations of the atom and obtain the simplest possible covalent state by utilizing only the initially unpaired electrons in covalent bond formation. The partial table below indicates would type of answer I expect. (10 points)

<table>
<thead>
<tr>
<th>Valence State Configuration</th>
<th>Hybridization</th>
<th>Formula</th>
<th>Geometry</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
6. a. Draw an MO energy-level diagram for the MOs that would arise in a diatomic molecule from the combination of unhybridized d orbitals. Label the AOs being combined and the resulting MOs. Let the z axis lie along the σ-bond. (10 points)

b. Sketch the shape of the resulting MOs. (10 points)
7. Assign (1) formal charges, (2) oxidation numbers, and (3) evaluate the relative importance of the three Lewis structures of OCN\(^{-}\), the cyanate ion. Compare these (i.e., do the same) to the Lewis structures of the fulminate ion, CNO\(^{-}\). (10 points)

**Extra Credit:** Explain the observation that the cyanate ion is stable, the fulminate ion is explosive, and CON\(^{-}\) does not exist. (2 points)