Chem 130 – Second Exam

Name________________________________

On the following pages you will find questions that cover the structure of molecules, ions, and solids, and the different models we use to explain the nature of chemical bonding. Read each question carefully and consider how you will approach it before you put pen or pencil to paper. If you are unsure how to answer one question, then move on to another question; working on a new question may suggest an approach to the one that is more troublesome. If a question requires a written response, be sure that you answer in complete sentences and that you directly and clearly address the question.

Question 1 _____/24	Question 5 _____/12
Question 2 _____/8	Question 6 _____/12
Question 3 _____/12	Question 7 _____/8
Question 4 _____/12	Question 8 _____/12

Total _____/100

Some potentially useful equations and constants are provided here. A periodic table and other potentially useful data are provided on a separate handout.

$c = \lambda\nu$ $E = h\nu$ $KE = h\nu - W$

$$\frac{1}{\lambda} = 1.09737\times10^{-2}\ \text{nm}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$$V \propto \frac{Q_+Q_-}{d}$$

$$\text{AVEE} = \frac{xIE_s + yIE_p + zIE_d}{x + y + z}$$

(valence shell electrons only)

$$\text{FC}_a = \text{V}_a - \text{N}_a - \frac{\text{B}_a}{2}$$

$$\delta_a = \text{V}_a - \text{N}_a - \text{B}_a\left(\frac{\text{EN}_a}{\text{EN}_a + \text{EN}_b}\right)$$

$c = 2.998\times10^{8}$ m/s $h = 6.626\times10^{-34}$ Js $N_A = 6.022\times10^{23}$ mol^{-1}

Problem 1. For each of the following, draw **one** valid Lewis structure, which need not be the "best" structure. Next, indicate the three-dimensional geometry by both drawing its VSEPR structure and by providing the name for the geometry around the underlined central atom. Then, predict whether the molecule or ion is polar or is non-polar. Finally, give the idealized bond angles for the stated bonds based on your VSEPR structure; if there is more than one possible bond angle, then list each unique bond angle and annotate your Lewis structure to indicate which is which. *Your answers for these last two items must be consistent with the bonding geometry you identify*.

Molecule or Ion	Draw the Lewis Structure	Draw and Name Bonding Geometry	Is it Polar or Non-Polar?	Ideal Bond Angle(s) for …
$\underline{S}O_2$				O–S–O is (are)
$\underline{S}O_3^{2-}$				O–S–O (is) are
$\underline{S}F_5^+$				F–S–F is (are)

Problem 2. The triiodide anion, I_3^-, is linear. The corresponding anion of fluorine, F_3^-, however, does not exist. In 1–3 sentences, explain why it is impossible for an anion of F_3^- to form.

Problem 3. The element *Z*, which is an element in the first three rows of the periodic table, forms the molecule ZFO_2 with a trigonal pyramidal bonding geometry around *Z*. In addition, the length of the Z–O bond suggests it has a bond order greater than 1 but less than 2. Identify *Z* and, in 2–3 sentences, explain how you arrived at your identification.

Problem 4. Consider the ion N_2F^+, which has a skeletal structure of N–N–F. Draw all possible resonance structures for this ion and annotate each of your structures with the formal charge for each atom.

Circle the resonance structure above that provides the best overall picture of the bonding for N_2F^+ and in no more than two sentences, explain your reason for selecting this resonance structure.

Problem 5. The underlined central atom for two of the anions below use identical hybrid orbitals to form bonds with the anion's other atoms; the remaining anion uses a different set of hybrid orbitals. Circle the anion that is different and, in 2–3 sentences explain the reason for your choice. As part of your answer, identify the specific hybrid orbitals used by each anion's central atom.

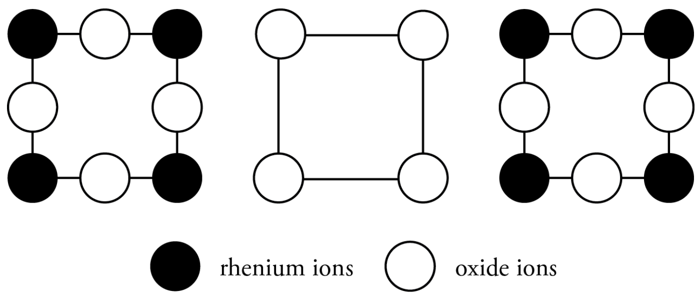
$\underline{N}O_2^-$ $\underline{C}O_3^{2-}$ $\underline{B}F_4^-$

Problem 6. Molecular orbitals form when atomic orbitals interact with each other. Consider the three 2*p*-orbitals on nitrogen. When these orbitals interact with the three 2*p*-orbitals on another atom of nitrogen to form N_2, the resulting molecular orbitals are of four types: sigma bonding, sigma antibonding, pi bonding, and pi antibonding. For each of these four types of molecular orbitals, draw a picture in the table below that shows how the electrons are distributed in space relative to the two nitrogen atoms.

sigma bonding N————————N	sigma antibonding N————————N
pi bonding N————————N	pi antibonding N————————N

Problem 7. Consider the lead halides PbF_2, $PbCl_2$, and $PbBr_2$. Which of these compounds likely has the highest melting point? Explain your reasoning in 1–2 sentences.

Problem 8. The figure below shows three cross-sections through the lattice structure for a solid-state compound that consists of rhenium ions and oxide ions. From left-to-right, these cross-sections are at z = 0, 0.5, and 1.



What is the empirical formula for rhenium oxide. Be sure that how you arrived at your formula is clear by annotating the figure above to show the contribution of each ion. The chemical symbol for rhenium is Re.

Based on your empirical formula, what is the charge on the rhenium ion? In one sentence, explain how you arrived at your answer.

What kind of lattice structure do the rhenium ions exhibit? In one sentence, explain how you arrived at your answer.

In what kind of holes within the oxide lattice are rhenium ions found? In one sentence, explain how you arrived at your answer.

What is coordination number for the oxide ions relative to the rhenium ions? In one sentence, explain how you arrived at your answer.