Chem 130 – Second Exam

Name_____

On the following pages are eight questions that consider 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 _____/18	Question 5 _____/12
Question 2 _____/12	Question 6 _____/12
Question 3 _____/12	Question 7 _____/12
Question 4 _____/12	Question 8 _____/10

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.

Potentially Useful Equations

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

$$\frac{1}{\lambda} = 1.09737\times10^{-2}\ \text{nm}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) \qquad V \propto \frac{Q_+Q_-}{d} \qquad \text{AVEE} = \frac{xIE_s + yIE_p + zIE_d}{x+y+z}$$

(valence shell electrons only)

$$FC_a = V_a - N_a - \frac{B_a}{2} \qquad \delta_a = V_a - N_a - B_a\left(\frac{EN_a}{EN_a + EN_b}\right)$$

Potentially Useful Constants

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

Please write neatly!

Problem 1. For each of the following molecules or ions, draw any one valid Lewis structure of your choosing (it need not be the "best" structure). Provide the name for the bonding geometry around the underlined central atom, predict whether the molecule or ion is polar (P) or non-polar (NP), and provide the idealized bond angle for the stated bond. Use the space at the bottom of the page to work out your structures and then place the result in the table.

Molecule or Ion	Lewis Structure	Bonding Geometry	Polar or Non-Polar?	Ideal Bond Angle for …
$\underline{S}O_3$				…an O–S–O bond is….
$\underline{I}O_2F_2^-$				…an O–I–O bond is….
$\underline{Sb}O_4^{3-}$				…an O–Sb–O bond is….

Space for work (will examine if included, but not evaluated for credit).

Problem 2. The compound ZFO_2, in which ***Z*** is the central atom, is known to have a trigonal pyramidal geometry. In addition, the length of the ***Z***O bond suggests its bond order is greater than one but less than two. Identify an element that might serve as ***Z*** and in no more than 2-3 sentences, explain how you arrived at your choice of element.

Problem 3. Consider the ion N_2I^+, which has a skeletal structure of N–N–I. Draw all possible resonance structures for this ion and annotate your structures with the formal charges for each atom. Circle the resonance structure that provides the best overall picture of the ion's bonding and, in no more than 2-3 sentences, explain your reason for picking this structure.

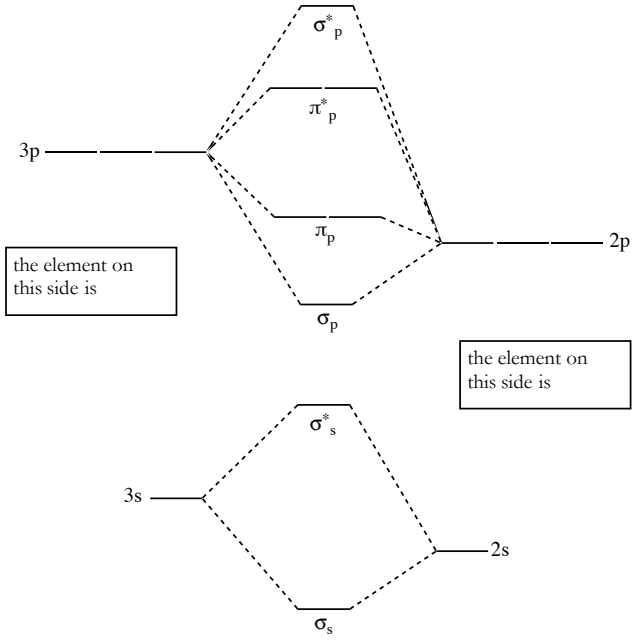
Problem 4. A bond's dissociation energy is the energy needed to break the bond, with stronger bonds having a more positive bond dissociation energy. Consider the following three ions, each of which consists of just bonds between nitrogen and oxygen. Draw Lewis structures below each ion and then rank the ions from the weakest NO bond to the strongest NO bond. In no more than 2-3 sentences, explain the reason for your ranking.

NO^+ NO^- NO_3^-

the weakest NO bond is in:

the strongest NO bond is in:

Problem 5. Shown to the right is a molecular orbital diagram for the ion OCl^+. Complete the diagram by (a) identifying which element is on each side of the diagram, writing your answers in the available boxes; (b) placing the valence electrons for each atom in the appropriate atomic orbitals, giving thought to which element carries the positive charge; and (c) filling in the electrons for the ion's molecular orbitals. Based on your molecular orbital diagram, what is the bond order for OCl^+? Is OCl^+ a paramagnetic or a diamagnetic ion (circle your answer below)? In no more than 4-5 sentences, clearly explain the reasons for your answers, including how you identified the correct location for each element and the element to which you assigned a positive charge.



The bond order for OCl^+ is _____.

OCl^+ is: paramagnetic diamagnetic

Problem 6. The three compounds listed below generally are considered covalent; each, however, has some ionic character. Rank the compounds from the one with the least ionic character to the one with the most ionic character and, in 2-3 sentences, explain how you arrived at your ranking.

HCl ICl SCl_2

the compound with the least ionic character is:

the compound with the most most ionic character is:

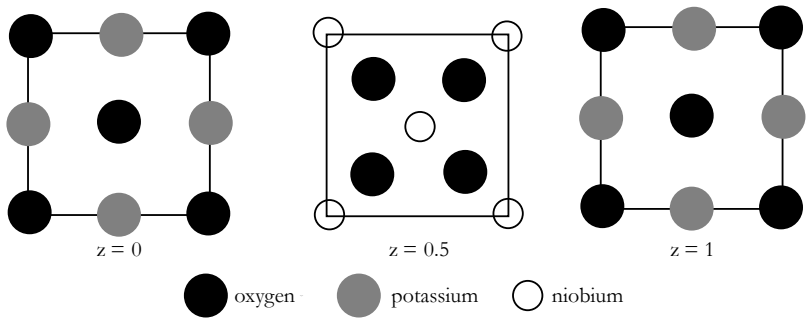
Problem 7. Consider the series of lead halides given below. Rank them from lowest melting point to highest melting point and in 2-3 sentences explain the reason for your ranking.

PbF_2 $PbCl_2$ $PbBr_2$

the compound with the lowest melting point is:

the compound with highest melting point is:

Problem 8. Shown below are three cross-sections through the mineral potassium niobate, whose optical properties make it useful in the production of lasers.



Accounting only for each atom's contribution to the unit cell shown above, how many complete oxygen (O), potassium (K), and niobium (Nb) atoms make up a unit cell? Place your answers in the spaces below and explain in 2-4 sentences how you arrived at your formula; you may find it helpful to annotate the figure above to identify atoms by their possible locations in the unit cell: corner, edge, face, and interior.

the unit cell has _____ atoms of oxygen

the unit cell has _____ atoms of potassium

the unit cell has _____ atoms of niobium