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 _____/18	Question 5 _____/14
Question 2 _____/12	Question 6 _____/10
Question 3 _____/12	Question 7 _____/10
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)

$$FC_a = V_a - N_a - \frac{B_a}{2}$$

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

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

Problem 1. For each of the following molecules or ions, draw **one** valid Lewis structure, which need not be the "best" structure. Give the name for the bonding geometry around the underlined central atom, predict whether the molecule or ion is polar or is non-polar, and give the idealized bond angles for the stated bonds; 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	Lewis Structure	Bonding Geometry	Polar or Non-Polar?	Ideal Bond Angles for …
$\underline{S}F_4$				F–S–F are….
$\underline{O}Cl_2$				Cl–O–Cl are….
$\underline{Xe}F_5^+$				F–Xe–F are….

Problem 2. The cation $[HCNXeF]^+$ is interesting both because it is an example of a species that includes an element, Xe, normally thought of as inert, and because it is perfectly linear; that is, the HCN, CNXe, and NXeF bonds all have bond angles of 180°. Draw a Lewis structure for this cation that explains this linear structure and identify the element that carries the positive charge.

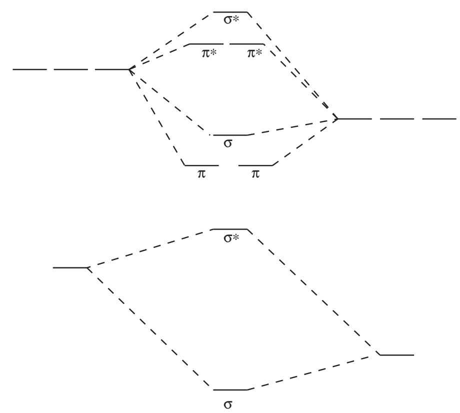
Problem 3. The bicarbonate ion is HCO_3^-, where each oxygen is attached to the carbon. As written, the formula also seems to suggest that the hydrogen is attached to the carbon when actually it is attached to one of the three oxygens. Using one or more of the bonding models developed in this unit, present a convincing argument that the hydrogen is attached to the oxygen and not to the carbon. Your written response should require no more than a single paragraph of 3–5 sentences, accompanied with suitable sketches.

Problem 4. Fulminate, CNO^-, is a particularly unstable anion whose mercury salt is used as the explosive compound in blasting caps. Draw all possible resonance structures for the fulminate anion and report the formal charge on each atom in each structure. The bonding framework for fulminate is C–N–O.

Which of your resonance structures provides the best picture of the bonding in fulminate? Circle your choice above and then explain your reasoning below in 1–2 sentences.

The most important resonance structure for cyanate, OCN^-, has a single bond between the oxygen and the carbon, and a triple bond between the carbon and the nitrogen. Using your resonance structures for fulminate and the information here about cyanate, provide a 1–2 sentence explanation for why fulminate is so explosive while cyanate is very stable.

Problem 5. Sulfur monoxide, SO, is a simple inorganic molecule that is stable at very small concentrations only. It is rarely found on earth, but is found in a variety of interstellar environments, including the atmospheres of Io, one of Jupiter's moons, Venus, and the Hale-Bopp comet. The valence-shell molecular orbital diagram for SO is shown on the right. Complete the molecular orbital diagram by (a) identifying which atom is on the left side and which is on the right side, (b) labeling the valence-shell atomic orbitals with their appropriate *ns* and *np* designations, (c) adding the appropriate number of electrons to the atomic orbitals, and (d) adding the appropriate number of electrons to the molecular orbitals.



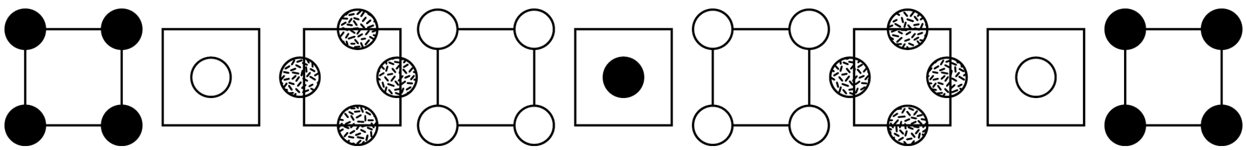
With respect to (a), in 1–2 sentences, explain how you determined which set of atomic orbitals belongs to sulfur.

With respect to (d), based on your molecular orbital diagram, what is the bond order between sulfur and oxygen? Does this agree with the bond order predicted by a Lewis structure? Be sure to support your answers with suitable structures, calculations, and/or a 1–3 sentence explanation.

With respect to (d), what, if anything, can you conclude about the ability of SO to interact with an applied magnetic field. Explain your reasoning in 1–2 sentences.

Problem 6. Consider the following three ionic compounds: MgF_2, SrF_2, and BeF_2. Which of these compounds has the largest melting point? Briefly justify your choice in 2–4 sentences.

Problem 7. The figure below shows nine cross-sections through the unit cell of a compound that consists of cerium (Ce: solid black spheres), gold (Au: speckled spheres), and silicon (Si: solid white spheres), where the left side is the bottom of the unit cell and the right side is the top of the unit cell (the values for *z* are, left-to-right, 0, 0.125, 0.250, 0.375, 0.500, 0.625, 0.750, 0.875, and 1.00). The compound is of interest because of its magnetic and superconducting properties. Using this unit cell, what is the simplest formula for this compound. Be sure that it is clear how you arrived at your formula.



Problem 8. Shown below is a list of hypothetical elements along with their electronegativities and possible charges (note that each element also has a possible charge of zero).

element	Ax	Ay	Cy	Cg	Ny	Kt	Wt	Lt	Bt	Z	Tx
electronegativity	0.92	0.94	1.51	2.89	2.03	0.82	3.82	1.03	1.63	2.31	2.55
charges (0, …)	+1	+2	+2, +3	+2	–2	+1	–1	+2	+1, +3	+1	+1

Using the information in this table, give the formula of (a) the most ionic-like compound, (b) the most metallic-like compound, and (c) the most covalent-like compound. Each of your three compounds must contain **two different elements**. In no more than three sentences, explain the reasoning behind your choices.