Chem 130 – First Exam

Name_____

On the following pages you will find questions that cover various topics ranging from nomenclature to periodic properties, and from electromagnetic radiation to the quantum model of the atom. 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. *Of particular importance for this exam: if a question asks you to explain a periodic trend, it is insufficient to write that "the <insert your property> of atoms increases to the right and to the top of the periodic table." Instead, your answer must explain why this trend exists.*

Partial credit is willingly given on all problems so be sure to answer all questions!

Question 1 _____/16	Question 5 _____/24
Question 2 _____/6	Question 6 _____/13
Question 3 _____/16	Question 7 _____/13
Question 4 _____/12	

Total _____/100

Useful equations, constants, Slater's rules, and a periodic table are provided on a separate handout.

Problem 1. For each of the following, provide **one** example of an element that fulfills the stated condition. If no element meets the condition, then write NONE. Limit your elements to those in the first four rows of the periodic table (H through Kr). *Do not use any element more than once!*

(a) is a noble gas

(b) has a core electron configuration of [Ar]

(c) forms a monoatomic ion with a charge of +3

(d) has exactly two electrons in a *p*-orbital

(e) forms a monoatomic ion with a charge of –2

(f) has exactly three unpaired electrons

(g) is in the same period as sulfur

(h) has six peaks in its photoelectron spectroscopy spectrum

(i) has a valence shell that consists of only *s* and *p* electrons

(j) is a alkaline metal with a covalent radius smaller than that for potassium

(k) forms an ion with a charge of +1 that has a noble gas electron configuration

(l) has six core electrons

(m) is an alkaline earth

(n) is in the *p*-block

(o) has a *Z* of 24

Problem 2. Fill in the missing information for these three compounds.

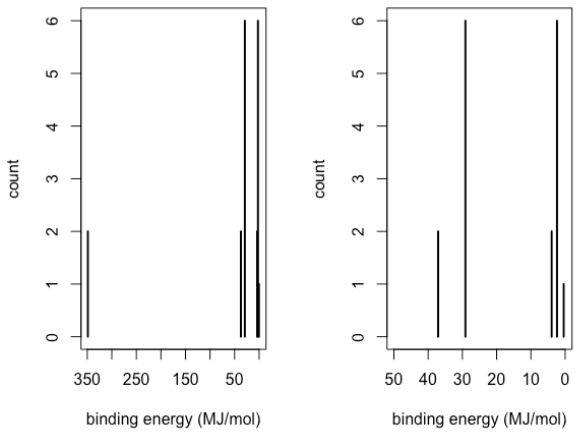
Formula	Name	Covalent or Ionic?
$Al_2(SO_4)_3$		
Cl_2O_7		
	cobalt (II) hydroxide	

Problem 3. Consider two photons, one with a wavelength of 200 nm and one with a frequency of 8.0×10^{14} s^{-1}. Which photon has the smaller energy and what is that energy in Joules? Explain your reasoning with both a calculation and a brief written response of no more than two sentences.

Is either photon capable of ejecting a 4*s* electron from calcium, which has an ionization energy of 590 kJ/mol? Explain your reasoning with both a calculation and a brief written response of no more than two sentences.

Problem 4. The figure on the right shows two views of the photoelectron spectrum for the element *X*. The view on the left shows the full spectrum and the figure on the right shows only those peaks with energies less than 50 MJ/mol.

What is the electron configuration for *X*?



Draw a circle around the peak or peaks in the photoelectron spectrum that corresponds to *X*'s valence electron(s). In one sentence, explain the reason for your choice.

For the peak with a binding energy of approximately 30 MJ/mol, what are the values for the quantum numbers n, l, and m_l.

Suppose you pass a beam of gas-phase atoms of *X* through the poles of a magnet. Will the beam of atoms pass through the magnet without being deflected? Explain your reasoning in 1-2 sentences.

Problem 5. The table below shows several properties for the elements lithium, beryllium, and boron, where IE_1, IE_2, and IE_3 are the first, second, and third ionization energies, AVEE is the average valence electron energy, and EA is the electron affinity.

property	Li	Be	B
IE_1 (kJ/mol)	520	900	800
IE_2 (kJ/mol)	7300	1760	2430
IE_3 (kJ/mol)	11800	14850	3660
AVEE (kJ/mol)	520	900	1170
EA (kJ/mol)	60	0	27

Use the values in this table to answer the following, limiting yourself to 2-4 sentence each.

Explain the trend in the first ionization energies for these elements.

Compared to lithium and beryllium, the third ionization energy for boron is rather small. Why?

Interestingly, the AVEE for Li and for Be are identical to their first ionization energies. This is not the case for boron. Explain why.

Explain why lithium has a more positive electron affinity than does boron and why beryllium has an electron affinity of zero.

Problem 6. Consider the set of ions listed below, each of which has a noble gas configuration, and rearrange them so that they are listed from the smallest radius to the largest radius.

Na^+ Li^+ Mg^{2+} S^{2-} Cl^- Se^{2-}

smallest radius largest radius

Explain the basis of your ranking, limiting your response to 2–4 sentences.

Problem 7. The electron configuration for arsenic often is written as $[Ar]4s^2 3d^{10} 4p^3$ to indicate the order in which the element's orbitals fill. This configuration seems to suggest that the 3*d* electrons are in the valence shell; however, the 3*d* electrons generally are considered to be core electrons, leaving the 4*s* and the 4*p* electrons as valence electrons. Use Slater's rules to estimate the effective nuclear charge for one of arsenic's 3*d* electrons and for one of its 4*s* or 4*p* electrons. Next, using these values, explain why it is reasonable to consider arsenic's 3*d* electrons as core electrons. Limit your explanation to 2–3 sentences.