

CHEM 120
Spring 2006
Pre-Exam Assignment 1

Name: _____

Instructions

Write your answers in blue or black ink. Work done in pencil will be accepted, but you will not be able to appeal any apparent grading mistakes (except simple addition errors). Write neatly. If I can't read it, I can't grade it.

Show all work for full credit! For the word problems write your final answer in a complete sentence. Indicate what you are doing at important steps (you do not need to tell me about every mathematical manipulation you do). If you change your mind on a question, cross out the incorrect answer and clearly indicate your final answer.

There are **8** pages, none blank.

You may use your book to look up any needed physical constants, equations, etc. However, you may not work with anyone else, and you may not ask any other faculty members to help you with the specific questions given here. You may ask any chemistry faculty member for help on the concepts involved, and you may ask me anything you want.

You may use the back of any page as additional workspace. Please indicate that you have done so.

Problem	Possible Points	Points Received
1	10	
2	5	
3	5	
4	10	
5	28	
6	12	
Free	30	30
Total	100	
	Bonus	
	Grand Total	

1. (10 Points) One line in the emission spectrum of Be^{3+} has a wavelength of 253.4 nm. If the transition that gives rise to this line starts from a state with $n = 5$, what is the principal quantum number of the lower-energy state involved in this transition? See the text, or the lecture notes, for the required equations and fundamental constants.

2. (5 Points) Which is higher in energy: the 2s or the 2p orbital in hydrogen? Is this also true for helium? Explain.

3. (5 Points) Use the equation for the $2p_z$ wavefunction given in Table 12.1 of your text to demonstrate that the maximum probability of finding the electron lies along the z axis and that it is zero in the xy-plane. See Figure 12.15 and Table 12.1 in the text for the definition of the coordinate system and parameters used in the equation, respectively.

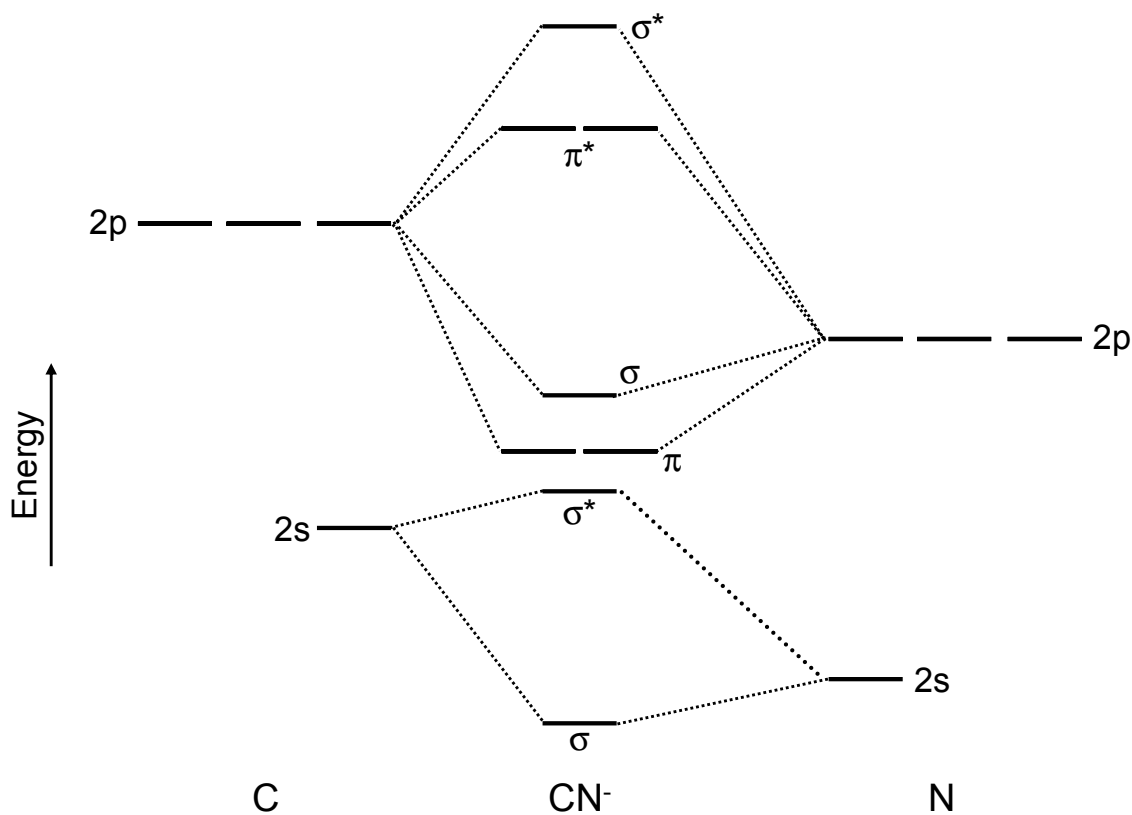
4. (10 Points) The photoelectric effect for Mg metal has a threshold frequency of $8.95 \times 10^{14} \text{ s}^{-1}$ (i. e., ν_0). Can Mg be used in photoelectric devices that sense visible light? Perform a calculation and explain.

5. The CN^- ion binds strongly to many metals and it is the strong bond formed between CN^- and the iron in hemoglobin which is responsible for the ion's extreme toxicity.

a. (8 Points) Draw the Lewis dot structure for CN^- and determine the formal charge on each atom. Based on the formal charge, which end of the CN^- ion would you expect to interact more strongly with a positively charged metal ion?

b. (4 Points) Based solely on electronegativity, which end of the CN^- would you expect to interact more strongly with a positively charged metal ion?

c. (5 Points) The partial MO energy level diagram for CN^- is shown below. Complete the diagram (you can place the extra electron either on C or on N initially).



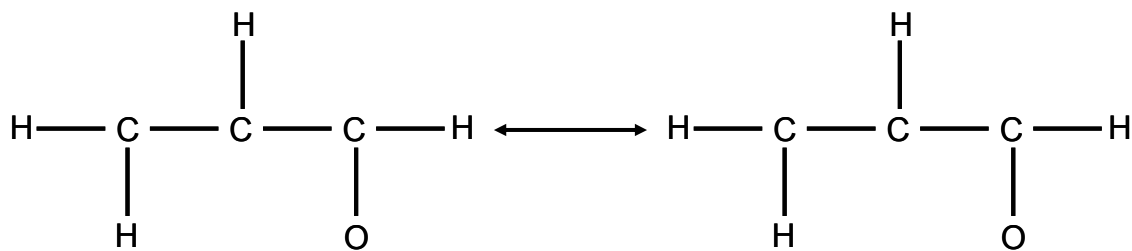
d. (5 Points) Draw qualitative pictures of the HOMO and of the LUMO for CN^- . For π , or π^* , orbitals, draw only one of the pair. Don't forget the effect that the energy difference between the atomic orbitals on C and the atomic orbitals on N has on the wavefunctions.

e. (4 Points) Based only on the MO diagram, predict which end of CN^- will bind to a positive metal ion. Explain your reasoning. Hint: use your answer to parts c and d.

f. (3 Points) In reality CN^- binds to transition metal cations through the carbon, which is not what you would have predicted from MO theory. The problem is that we forgot something in our MO treatment, and that was the metal ion. Assume that we are looking at the interaction between CN^- and Fe^{3+} and that CN^- will donate the two electrons in its HOMO to the Fe^{3+} . When this happens there will be two additional interactions between the Fe^{3+} and the CN^- LUMO. Draw one of them. Hint: think about what the valence orbitals for Fe^{3+} are.

g. (3 Points) How would the interaction between Fe^{3+} and CN^- , described in part f, affect the bond order of the CN^- ? Why?

6. Acrolein, C_3H_4O , is used in the manufacture of plastics. It has the arrangement of atoms shown below and two possible resonance structures.



a. (4 Points) Fill in the missing electrons to complete the Lewis dot structures.

b. (4 Points) Calculate the formal charge on each atom (show your work below). If a formal charge is not zero, write it next to the atom in the appropriate resonance structure above.

c. (4 Points) Which resonance structure contributes the most to the resonance hybrid structure of acrolein? Explain.

d. (4 Points) Acrolein reacts with Lewis bases to give compound like that shown below where B stands for the Lewis base. How might this fact force you to modify your answer to part c?

