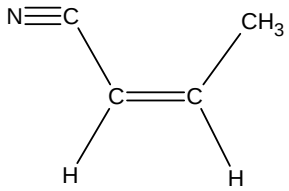
Chem 121 **Name**_____
Exam 2: Ch 11, 12, 13, 26 **March 4, 2009**
100 Points

Please follow the instructions for each section of the exam. Show your work on all mathematical problems. Provide answers with the correct units and significant figures. Be concise in your answers to discussion questions.

Bonus (4 points). One day at the very beginning of class I wrote a value on the board and suggested that it be written down. Write that value here, with its correct units. _____

Complete all of problems 1-7.

1. How many sigma bonds are there in the molecule below? (4 points)



   a. 3
   b. 6
   c. 9 Answer _____
   d. 12

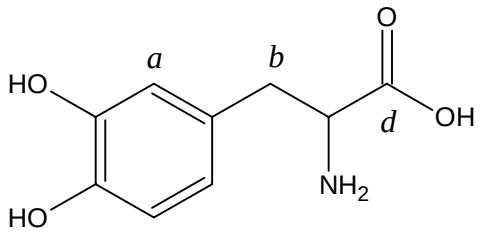
2. A water sample is found to have 9.4 ppb of chloroform ($CHCl_3$). What mass of $CHCl_3$ would be in one glassful (250 mL) of water? (4 points)

   a. 2.35 g
   b. 2.35 mg
   c. 2.35 μg Answer _____
   d. 2.35 ng

3. In order for an ion or molecule to have square planar geometry, valence bond theory would predict that the central atom must be _____ hybridized. (4 points)

   a. sp^2
   b. sp^3
   c. sp^3d Answer _____
   d. sp^3d^2

4. For the following, consider the structure shown below of DL-Dopa, a drug often used to treat Parkinson's disease.



I. Circle and identify three functional groups in the molecule. (6 points)

II. What is the molecular formula for DL-Dopa? (3 points)

III. What is the hybridization and approximate bond angles at: (6 points)

i. carbon *a?*

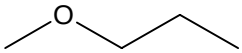
ii. carbon *b*?

iii. carbon *d*?

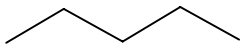
5. In the context of valence bond theory, describe how p-orbitals can form <u>both</u> sigma (σ) and pi (π) bonds, but s-orbitals do not. Feel free to use sketches to illustrate your points. (15 points)

6. More complex theories must be developed to deal with the shortcomings of more basic theories. Shortcomings of valence bond theory are highlighted by the two experimental observations below. For **<u>one</u>** of the observations, clearly describe how molecular orbital theory can account for the observation. (15 points)
    a. Molecular oxygen (O_2) is paramagnetic.
    b. Ozone (O_3) has only one type of O-O bond, not one single and one double bond.

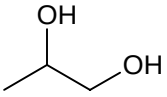
7. Consider the compounds below. Remembering that "*like dissolves like,*" arrange the molecules in order of increasing solubility in water. Clearly justify you reasoning. Ignore any effects of molecular mass. (15 points)



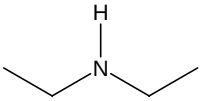
A



B



C

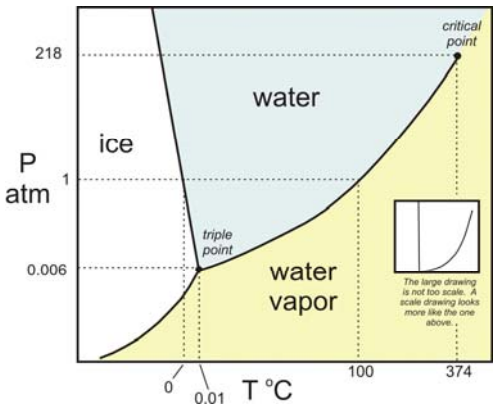


D

Part II Answer two (2) of problems 8-11. Clearly mark the problems you do not want graded. 15 points each.

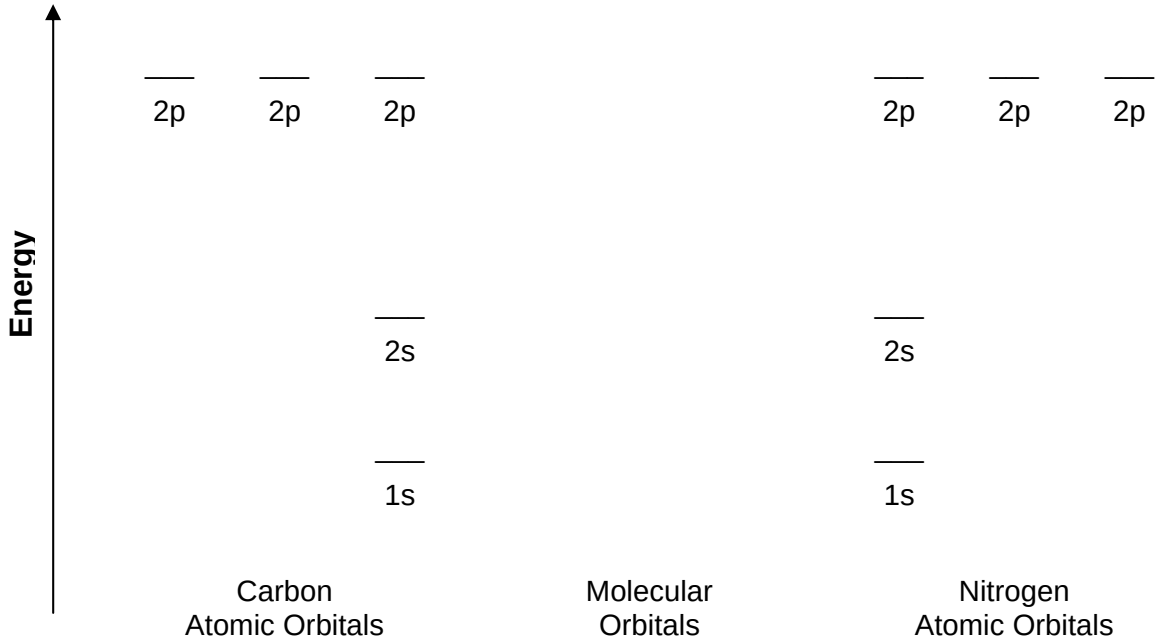
8. A forensic chemist is given a white solid that is expected of being pure cocaine ($C_{17}H_{21}NO_4$, 303.36 g/mol). She dissolves 1.22 g of the solid in 15.60 g of benzene (K_b = 2.53°C kg/mol, K_f = 5.12°C kg/mol). The freezing point is lowered by 1.32°C. Assuming a 1% uncertainty in her measurements, can the chemist state that the substance is likely to be cocaine?

9. You decide to cool a can of soda (or pop depending on where you are from) quickly by placing it in the freezer. When you take the can out, the contents are still liquid, but when you open the can, the soda (or pop) immediately freezes. Explain why this happens. A phase diagram for water is shown below.



10. The atomic radius of tungsten, W, is 202 pm. If the density of W is 19.3 g/cm^3, does tungsten form a face-centered cubic lattice? Justify your answer.

11. Answer the following questions regarding the CN^- ion:
    a. Complete and clearly label the molecular orbital diagram for CN^-, whose molecular orbital energy levels are similar to those in N_2. Fill MO's with electrons as appropriate. For this problem, we will ignore any differences in the energies of the atomic orbitals in nitrogen as compared to carbon. (9 points)



    b. Is CN^- paramagnetic? Justify your response. (3 points)

    c. What is the bond order in CN^-? Show how you arrived at your answer. (3 points)

Possibly Useful Information

$R = 8.31441\ J\ mol^{-1}\ K^{-1}$ $\qquad$ $R = 0.0821\ L\ atm\ mol^{-1}\ K^{-1}$

$a^2 + b^2 = c^2$ $\qquad$ $N_A = 6.02 \times 10^{23}\ mol^{-1}$

$\Delta t_{fp} = k_{fp} m$ $\qquad$ $\Delta t_{bp} = k_{bp} m$

$\Pi = MRT$ $\qquad$ $P_{soln} = X_{solvent} P^o_{solvent}$

Selected Constants

Solvent	Boiling Point (^oC)	K_b (^oC kg/mol)	Freezing Point (^oC)	K_f (^oC kg/mol)
Water	100.0	0.51	0	1.86
Benzene	80.1	2.53	5.5	5.12
Ethyl Ether	34.5	2.02	-116.2	1.79
Chloroform	61.2	3.63	-63.5	4.70