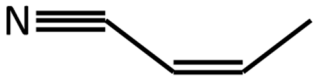
Chem 131 **Name**_____
Exam 2, Ch 10.7-12 **October 9, 2019**
100 Points

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.

Part 0: Warmup.

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



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

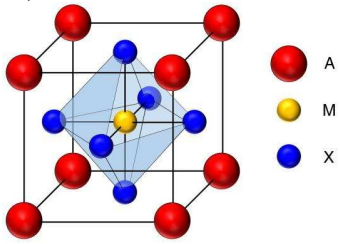
Answer _____

2. 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
d. sp^3d^2

Answer _____

3. The mineral perovskite, consists of calcium, titanium and oxygen. Its unit cell is shown below, with Ti at the corners (A in the diagram), Ca in the center (M in the diagram) and O at each of the faces (X in the diagram). Since the stoichiometry of the unit cell must match that for the compound, what is the formula for perovskite? (4 points)



a. $CaTi_8O_4$
b. $Ca_2Ti_4O_2$
c. $CaTiO_3$
d. CaTiO

Answer _____

4. Complete the following with *increases*, *decreases*, or *does not change*. (6 points)
   a. If the intermolecular forces in a liquid decrease, the normal boiling point of the liquid

      _____.

   b. If the intermolecular forces in a liquid decrease, the vapor pressure of the liquid

      _____.

   c. If the temperature of a liquid increases, the equilibrium vapor pressure

      _____.

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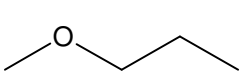
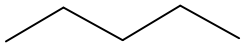
Part I: Complete all of problems 6-8

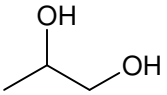
5. Consider the compounds below. Arrange the molecules in order of increasing boiling point. Clearly justify you reasoning. Ignore any effects of molecular mass. (12 points)



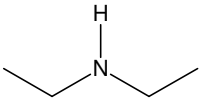
A



B



C



D

6. The compound oxygen difluoride is quite unstable, reacting with water to produce oxygen and hydrogen fluoride in an exothermic reaction with ΔH^{o}_{rxn} = -318 kJ. Use the table of bond energies to calculate the bond dissociation energy of the oxygen-fluorine bond in oxygen difluoride. (12 points)

Bond	H-F	F-F	F=F	H-H	O-H	O-O	O=O
Bond Energy (kJ/mol)	565	159	414	436	464	142	498

Answer_____

7. In the context of valence bond theory, explain how p-orbitals can form both sigma (σ) and pi (π) bonds, but s-orbitals do not. Feel free to use sketches to illustrate your points. (12 points)

8. Choose **two (2)** of the compounds below and draw Lewis structure, indicate the hybridization of the underlined atom and estimate all bond angles. Identify the strongest intermolecular interaction the molecule can participate in with another molecule of the same compound. (12 points)

a. $\underline{C}H_2O$

b. $\underline{N}H_3$

c. $\underline{C}O_2$

Part II. Answer three (3) of problems 9-13. Clearly mark the problems you do not want graded. 12 points each.

9. A certain liquid has a vapor pressure of 92.0 Torr at 23.0°C and 353.0 Torr at 45.0°C.

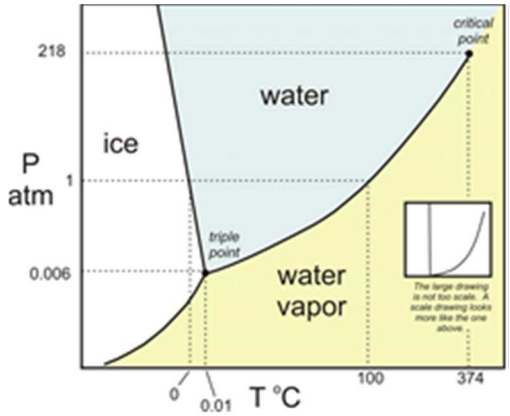
a. Calculate the enthalpy of vaporization (ΔH^{o}_{vap}) for this liquid.

Answer_____

b. Calculate the normal boiling point of this liquid.

Answer_____

10. You decide to cool a can of carbonated 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. You may assume that the soda behaves essentially like water. Use the phase diagram for water, shown below, to support your explanation.

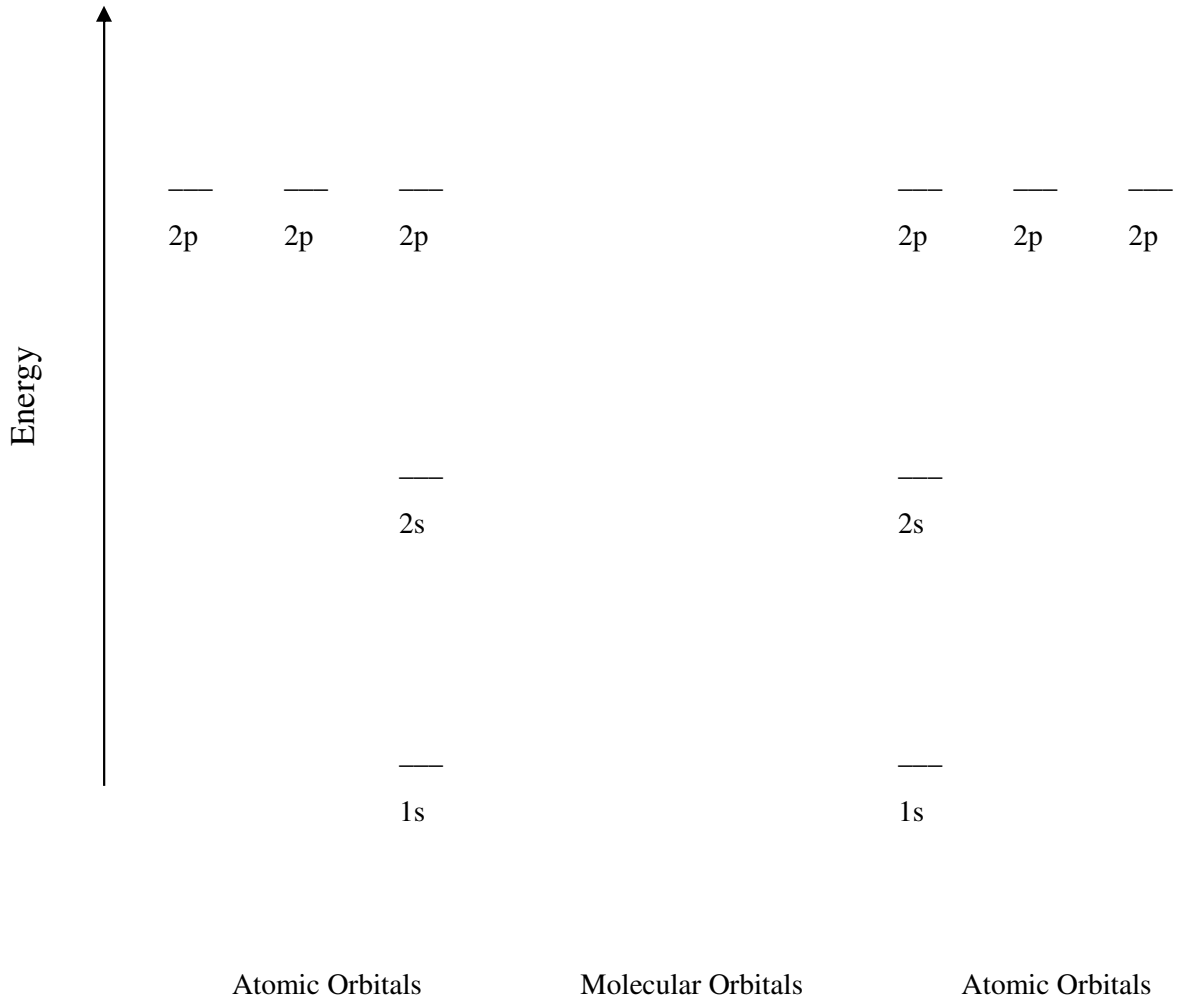


11. The atomic radius of tungsten, W, is 202 pm. If the W has a molar mass of 183.84 g/mol and has a density of 19.3 g/cm^3, does tungsten form a face-centered cubic lattice? Justify your answer with a calculation.

12. Use valence bond theory to describe the bonding around the carbon atom in HCN. Identify the hybridization on the carbon atom and show how hybridization allows the formation of the necessary sigma and pi bonds in the compound. Drawings may be useful!

13. Answer the following questions about peroxide ion (O_2^{2-}).

a. Complete the MO diagram for peroxide below. Account for valence and core electrons. (6 points)



b. What is the bond order for peroxide? (2 points)

c. Is peroxide diamagnetic? Why or why not? (2 points)

d. Would you expect the peroxide ion to be more or less stable than molecular oxygen (O_2)? Why? (2 points)

Possibly Useful Information

$R = 8.31441\ J\ mol^{-1}\ K^{-1}$	$R = 0.0821\ L\ atm\ mol^{-1}\ K^{-1}$	1 atm = 760 Torr
$a^2 + b^2 = c^2$	$N_A = 6.02 \times 10^{23}\ mol^{-1}$	$\ln\left(\frac{P_2}{P_1}\right) = \frac{\Delta H_{vap}}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$
$\Delta H^o = \Sigma$(Bond Energy for bonds broken) – Σ(Bond energy for bonds formed)