CH 222 Practice Problem Set #5

*This is a **practice problem set** and not the actual graded problem set that you will turn in for credit.*
Answers to each problem can be found at the end of this assignment.

Covering: **Chapter Ten, Chapter Eleven** *and* **Chapter Guide Five**
Important Tables and/or Constants: **R = 8.3145 J mol^{-1} K^{-1}**, "**Cubic Unit Cells Guide**" *(Handout)*, "**Solids**" *(Lab)*

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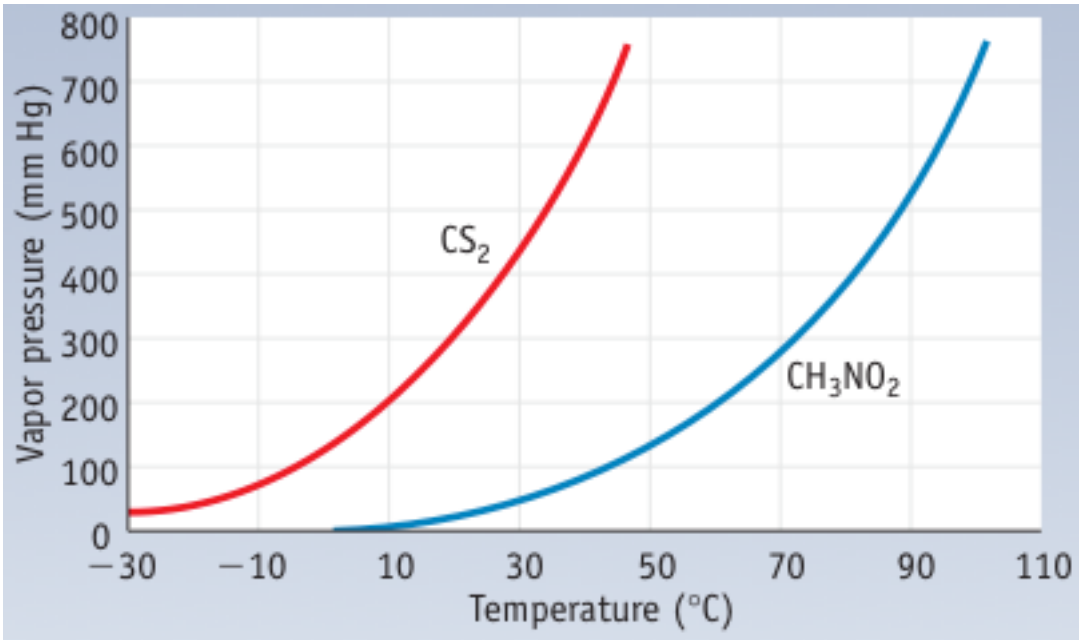
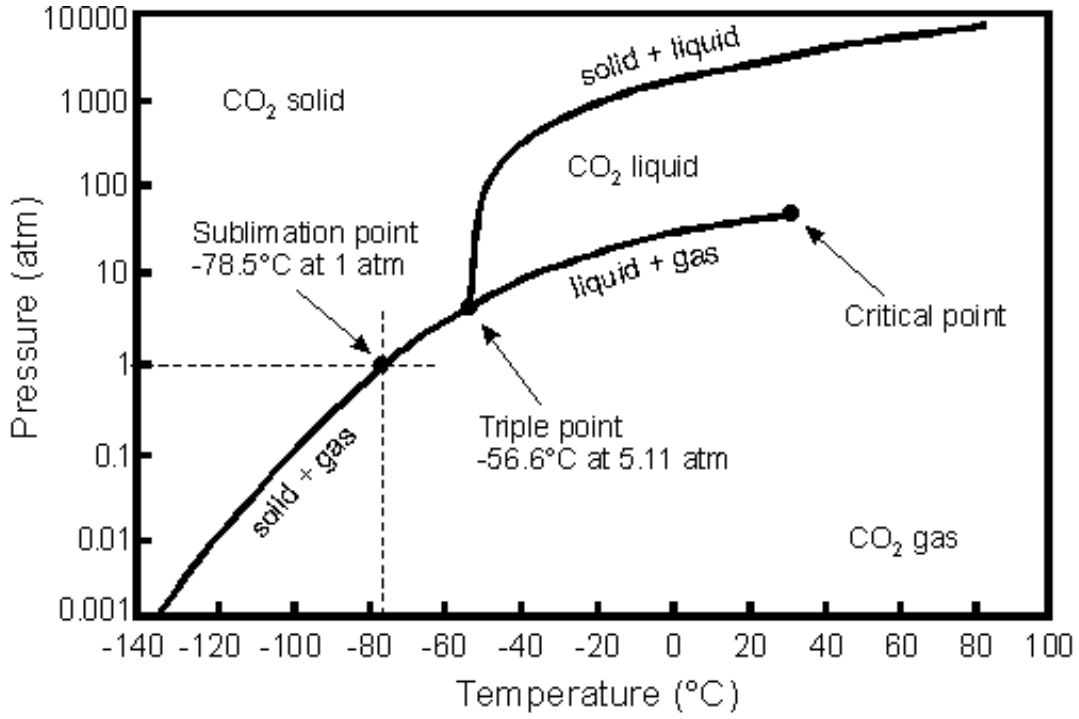
1. Vapor pressure curves for CS_2 (carbon disulfide) and CH_3NO_2 (nitromethane) are drawn here.
   a. What are the approximate vapor pressures of CS_2 and CH_3NO_2 at 40 °C?
   b. What types of intermolecular forces exist in the liquid phase of each compound?
   c. What is the normal boiling point of CS_2? Of CH_3NO_2?
   d. At what temperature does CS_2 have a vapor pressure of 600 mm Hg?
   e. At what temperature does CH_3NO_2 have a vapor pressure of 60 mm Hg?



2. Benzene, C_6H_6, is an organic liquid that freezes at 5.5 °C to form beautiful, feather-like crystals. How much heat is evolved when 15.5 g of benzene freezes at 5.5 °C? (The heat of fusion of benzene is 9.95 kJ/mol.) If the 15.5 g sample is remelted, again at 5.5 °C, what quantity of heat is required to convert it to a liquid?
3. Liquid ammonia, $NH_3(l)$, was once used in home refrigerators as the heat transfer fluid. The specific heat of the liquid is 4.7 J/g • K and that of the vapor is 2.2 J/g • K. The enthalpy of vaporization is 23.33 kJ/mol at the boiling point. If you heat 12 kg of liquid ammonia from -50.0 °C to its boiling point of -33.3 °C, allow it to evaporate, and then continue warming to 0.0 °C, how much heat energy must you supply?



Pressure-Temperature phase diagram for CO_2.

4. Use the phase diagram for carbon dioxide given above to answer the following questions:
   a. In what phase is CO_2 found at room temperature and 1.0 atm pressure?
   b. If the pressure exerted on a sample is 0.75 atm and the temperature is -114 °C, in what phase does the substance exist?
   c. If you measure the vapor pressure of a liquid sample and find it to be about 10 atm, what is the temperature of the liquid phase?
   d. What is the vapor pressure of the solid at -120 °C?
   e. Which is the denser phase, solid or liquid? Explain.
5. The very dense metal iridium has a face-centered cubic unit cell and a density of 22.56 g/cm^3. Use this information to calculate the radius of an atom of the element.
6. Use the vapor pressure data (below) for octane, C_8H_{18}, and the Clausius-Clapeyron equation to calculate the molar enthalpy of vaporization of octane and its normal boiling point.

Temperature (°C)	**Vapor Pressure (mm Hg)**
25	13.6
50	45.3
75	127.2
100	310.8

7. Liquid methanol, CH_3OH, is placed in a glass tube. Predict whether the meniscus of the liquid is concave or convex.

8. Rationalize the observation that $CH_3CH_2CH_2OH$, 1-propanol, has a boiling point of 97.2 °C, whereas a compound with the same empirical formula, methyl ethyl ether ($CH_3CH_2OCH_3$) boils at 7.4 °C.
9. Fill in the blanks in the table. All solutions are aqueous.

Compound	Molality	Weight Percent	Mole Fraction
NaI	0.15	_____	_____
C_2H_5OH	_____	5	_____
$C_{12}H_{22}O_{11}$	_____	_____	0.0027

10. Hydrochloric acid is sold as a concentrated aqueous solution. If the molarity of commercial HCl is 12.0 and its density is 1.18 g/cm^3, calculate the following:
    a. the molality of the solution
    b. the weight percent of HCl in the solution
11. The average lithium ion concentration in sea water is 0.18 ppm. What is the molality of Li^+ in sea water?
12. An unopened soda can has an aqueous CO_2 concentration of 0.0506 M at 25 °C. What is the pressure of CO_2 gas in the can? ($k_H = 4.48 \times 10^{-5}$ M/mm Hg)
13. Pure iodine (105 g) is dissolved in 325 g of CCl_4 at 65 °C. Given that the vapor pressure of CCl_4 at this temperature is 531 mm Hg, what is the vapor pressure of the CCl_4–I_2 solution at 65 °C? (Assume that I_2 does not contribute to the vapor pressure.)
14. What is the boiling point of a solution composed of 15.0 g of $CHCl_3$ (which boils at 61.70 °C) and 0.515 g of the nonvolatile solute acenaphthene, $C_{12}H_{10}$, a component of coal tar? ($K_{bp} = 3.63$ °C/m)
15. Assume a bottle of wine consists of an 11 weight percent solution of ethanol (C_2H_5OH) in water. If the bottle of wine is chilled to -20 °C, will the solution begin to freeze? ($K_{fp} = 1.86$ °C/m)
16. Anthracene, a hydrocarbon obtained from coal, has an empirical formula of C_7H_5. To find its molecular formula you dissolve 0.500 g in 30.0 g of benzene ($K_{bp} = 2.53$ °C/m). The boiling point of the pure benzene is 80.10 °C, whereas the solution has a boiling point of 80.34 °C. What is the molecular formula of anthracene?
17. Phenylcarbinol is used in nasal sprays as a preservative. A solution of 0.52 g of the compound in 25.0 g of water ($K_{fp} = -1.86$ °C/m) has a melting point of -0.36 °C. What is the molar mass of phenylcarbinol?
18. An aqueous solution containing 1.00 g of bovine insulin (a protein, not ionized) per liter has an osmotic pressure of 3.1 mm Hg at 25 °C. Calculate the molar mass of bovine insulin.

Answers to the Practice Problem Set:

1. *Answers*:
   a. CS_2: 620 mm Hg CH_3NO_2: 80 mm Hg
   b. induced dipole/induced dipole; dipole-dipole
   c. 46 ºC; 100 ºC
   d. 39 ºC
   e. 34 ºC
2. -1.97 kJ evolved. +1.97 kJ absorbed for solid -> liquid.
3. $q_{total} = 9.4 \times 10^2$ kJ + 1.6×10^4 kJ + 8.8×10^2 kJ = $\mathbf{1.8 \times 10^4}$ **kJ**
4. a. gas b. solid c. between -40 and -10 d. 0.01 atm e. solid denser than liquid
5. 135.7 pm
6. ΔH_{vap} = 38.6 kJ/mol, and T = 128 ºC
7. The meniscus is concave since there are adhesive forces between the methanol and the silicate of the glass.
8. 1-propanol has stronger intermolecular forces (hydrogen bonding) than methyl ethyl ether (dipole-dipole) zinc
9. *Answers*:

Compound	Molality	Weight percent	Mole fraction
NaI	0.15	2.2	0.0027
C_2H_5OH	1.1	5.0	0.020
$C_{12}H_{22}O_{11}$	0.15	4.9	0.0027

10. a. 16.2 *m* b. 37.1%
11. 2.6 x 10^{-5} *m*
12. 1130 mm Hg
13. 444 mm Hg
14. 62.51 ºC
15. Solution will freeze beginning at -5.0 ºC
16. $C_{14}H_{10}$
17. 110 g/mol
18. 6.0 x 10^3 g/mol