CH 222 Winter 2025:
Problem Set #5
Instructions

Step One (all sections):

- **Learn the material** for Problem Set #5 by **reading Chapter 10 and Chapter 11** of the textbook and/or by watching the videos found on our website (https://mhchem.org/222)
- **Try the problems** for Problem Set #5 found on the next pages on your own first. **Write out the answers (and show your work) by hand (on a tablet or paper)**; do not type your answers (and work) to avoid a point penalty. If you write the answers on the problem set itself, you will receive fewer points. Include your name on your problem set!

Step Two:

<u>Section 01 and H1:</u> We will go over Problem Set #5 during recitation. ***Self correct all problems*** of your problem set before turning it in at the end of recitation.
- *Section 01:* due **Monday, February 17 at 1:10 PM**
- *Section H1:* due **Wednesday, February 19 at 1:10 PM**

<u>Section W1</u>: **Watch the recitation video** for Problem Set #5 here:
http://mhchem.org/y/x.htm

- **Self correct *all* of the problems** while viewing the video. Mark correct problems with a star (or other similar mark), and correct all incorrect problems (show the correct answer and the steps required to achieve it.)
- **Submit Problem Set #5 via email (mike.russell@mhcc.edu) as a single PDF file** (use CamScanner (https://camscanner.com), CombinePDF (https://combinepdf.com), etc.) **by 11:59 PM Wednesday, February 19.**

If you have any questions regarding this assignment, please email (mike.russell@mhcc.edu) the instructor! Good luck on this assignment!

CH 222 Problem Set #5

* Complete problem set on separate pieces of paper showing all work, circling final answers, etc.
* Self correct your work before turning it in to the instructor.

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)*
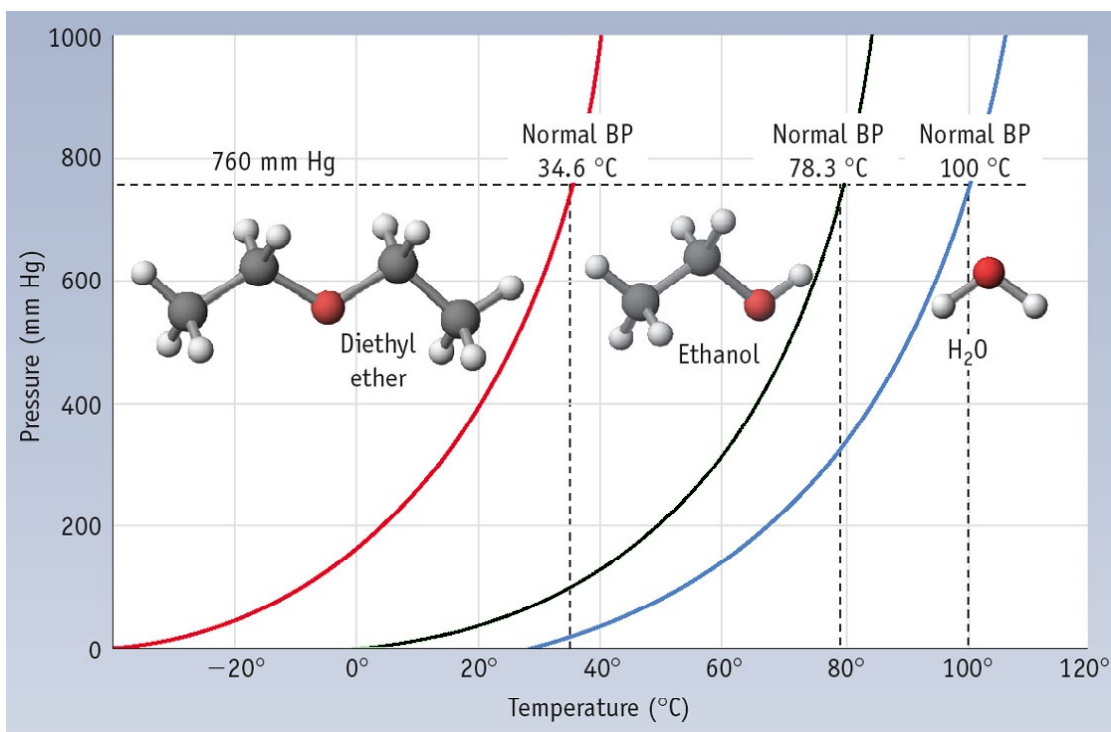

Figure for Problem One

1. Use the figure above to answer the following questions:
    a. What is the equilibrium vapor pressure of diethyl ether at room temperature (approximately 20 °C)?
    b. Place diethyl ether, ethanol and water in order of increasing intermolecular forces.
    c. If the pressure in a flask is 400 mm Hg and the temperature is 40 °C, which of the three compounds are liquids and which are gases?
2. Answer each of the following questions with *increases, decreases* or *does not change*.
    a. If the intermolecular forces in a liquid increase, 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 surface area of a liquid decreases, the vapor pressure _____.
   d. If the temperature of a liquid increases, the equilibrium vapor pressure _____.

Problem Set #5 continues on the next page
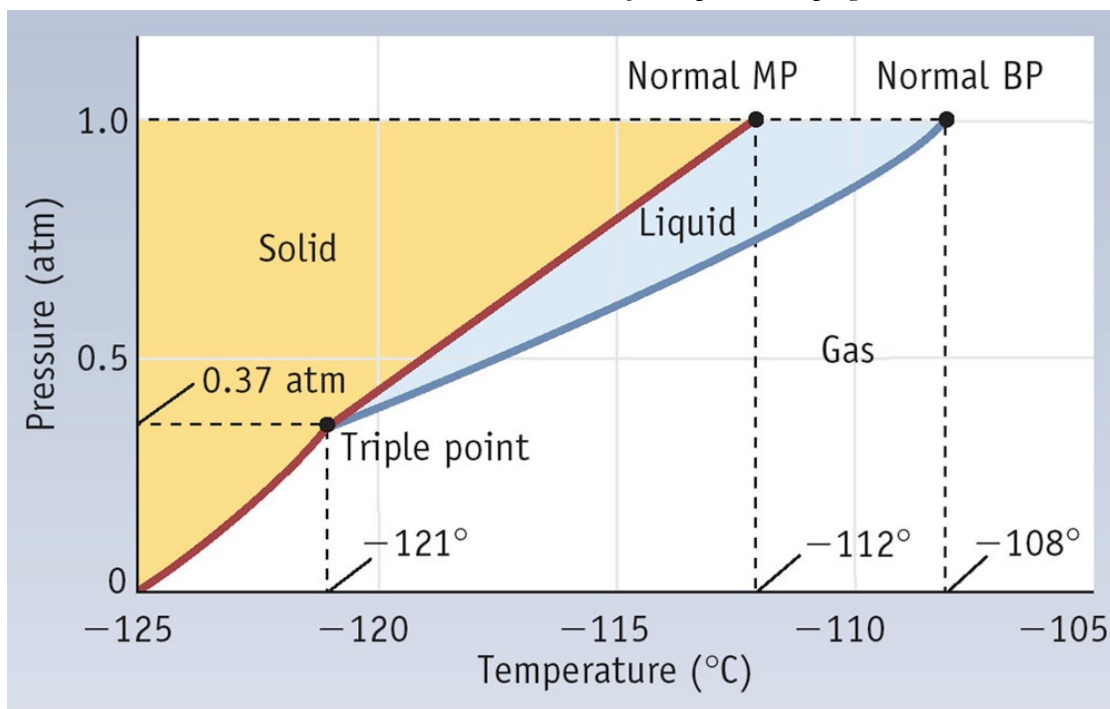
Phase Diagram for Xenon

3. Use the phase diagram for xenon given above to answer the following questions:
    a. In what phase is the xenon 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 380 mm Hg, what is the temperature of the liquid phase?
    d. What is the vapor pressure of the solid at -122 °C?
    e. Which is the denser phase, solid or liquid? Explain.
4. The specific heat capacity of silver is 0.235 J g⁻¹ K⁻¹. Its melting point is 962 °C and its heat of fusion is 11.3 kJ/mol. What quantity of heat, in Joules, is required to change 5.00 g of silver from a solid at 25 °C to a liquid at 962 °C?
5. If your air conditioner is more than several years old, it may use the chlorofluorocarbon CCl_2F_2 as the heat transfer fluid. The normal boiling point of CCl_2F_2 is -29.8 °C, and the enthalpy of vaporization is 20.11 kJ/mol. The gas and the liquid have specific heats of 117.2 J mol⁻¹ K⁻¹ and 72.3 J mol⁻¹ K⁻¹, respectively. How much heat is evolved when 20.0 g of CCl_2F_2 is cooled from +40.0 °C to -40.0 °C?
6. Tungsten crystallizes in the unit cell shown to the right.
    a. What type of unit cell is this?
    b. How many tungsten atoms occur per unit cell?
    c. If the edge of the unit cell is 316.5 pm, what is the radius of a tungsten atom?

316.5 pm
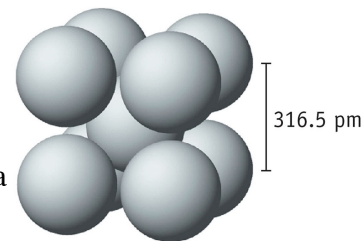
Tungsten unit cell

Problem Set #5 continues on the next page

7. Calcium metal crystallizes in a face-centered cubic unit cell. The density of the solid is 1.54 g/cm³. What is the radius of a calcium atom?
8. Equilibrium vapor pressures of dichlorodimethylsilane, $SiCl_2(CH_3)_2$, are given below.

Temperature (°C)	Vapor Pressure (mm Hg)
-0.4	40.
+17.5	100.
+51.9	400.
+70.3	760.

   a. What is the normal boiling point of dichlorodimethylsilane?
   b. Plot these data as ln P versus 1 / T. Perform a linear regression on the data. At what temperature does the liquid have an equilibrium vapor pressure of 250 mm Hg?
   c. Calculate the molar enthalpy of vaporization for dichlorodimethylsilane using the Clausius-Clapeyron equation.
9. Fill in the blanks in the table. All solutions are aqueous.

Compound	Molality	Weight Percent	Mole Fraction
KNO_3	_____	10.0	_____
CH_3CO_2H	0.0183	_____	_____
$HOCH_2CH_2OH$	_____	_____	0.0599

10. Concentrated aqueous sulfuric acid has a density of 1.84 g/cm³ and is 95.0% by weight H_2SO_4. What is the molarity of this acid? What is the molality?
11. Silver ion has an average concentration of 28 ppb (parts per billion) in U.S. water supplies.
    a. What is the molality of the silver ion?
    b. If you wanted 1.0 x 10² g of silver and could recover it chemically from water supplies, what volume of water, in liters, would you have to treat? Assume the density of water is 1.0 g/cm³.
12. Hydrogen gas has a Henry's law constant of 1.07 x 10⁻⁶ M/ mm Hg at 25 °C when dissolving in water. If the total pressure of the gas (H_2 plus water vapor) over water is 1.00 atm, what is the concentration of H_2 in the water in grams per milliliter? The vapor pressure of water at 25 °C is 23.8 mm Hg.
13. Nonvolatile urea, $(NH_2)_2CO$, which is widely used in fertilizers and plastics, is quite soluble in water. If you dissolve 9.00 g of urea in 10.0 mL of water, what is the vapor pressure of the solution at 24 °C? Assume the density of water is 1.00 g/ mL, and the vapor pressure of water at 24 °C is 22.4 mm Hg.
14. What is the boiling point of a solution composed of 0.755 g of caffeine, $C_8H_{10}O_2N_4$, in 95.6 g of benzene, C_6H_6? The normal boiling point for benzene is 80.10 °C and K_{bp} for benzene = 2.53 °C/ *m*.

Problem Set #5 continues on the next page

15. Some ethylene glycol, $HOCH_2CH_2OH$, is added to your car's cooling system along with 5.0 kg of water. If the freezing point of the water-glycol solution is -15.0 °C, what mass of $HOCH_2CH_2OH$ must have been added? The normal freezing point for water is 0.0 °C and K_{fp} for water = 1.86 °C/ m.

16. Butylated hydroxyanisole (BHA) is used as an antioxidant in margarine and other fats and oils; it prevents oxidation and prolongs the shelf life of the food. What is the molar mass of BHA if 0.640 g of the compound, dissolved in 25.0 g of chloroform ($CHCl_3$), produces a solution whose boiling point is 62.22 °C? The normal boiling point for chloroform is 61.70 °C and K_{bp} for chloroform = 3.63 °C/ m.

17. The organic compound aluminon is used as a reagent to test for the presence of the aluminum ion in aqueous solution. A solution of 2.50 g of aluminon in 50.0 g of water freezes at -0.197 °C. What is the molar mass of aluminon? The normal freezing point for water is 0.000 °C and K_{fp} for water = 1.86 °C/ m.

18. Estimate the osmotic pressure of human blood at 37 °C. Assume blood is isotonic with a 0.154 M NaCl solution, and use a theoretical van't Hoff i factor for NaCl.

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