CH 222 Practice Problem Set #4

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

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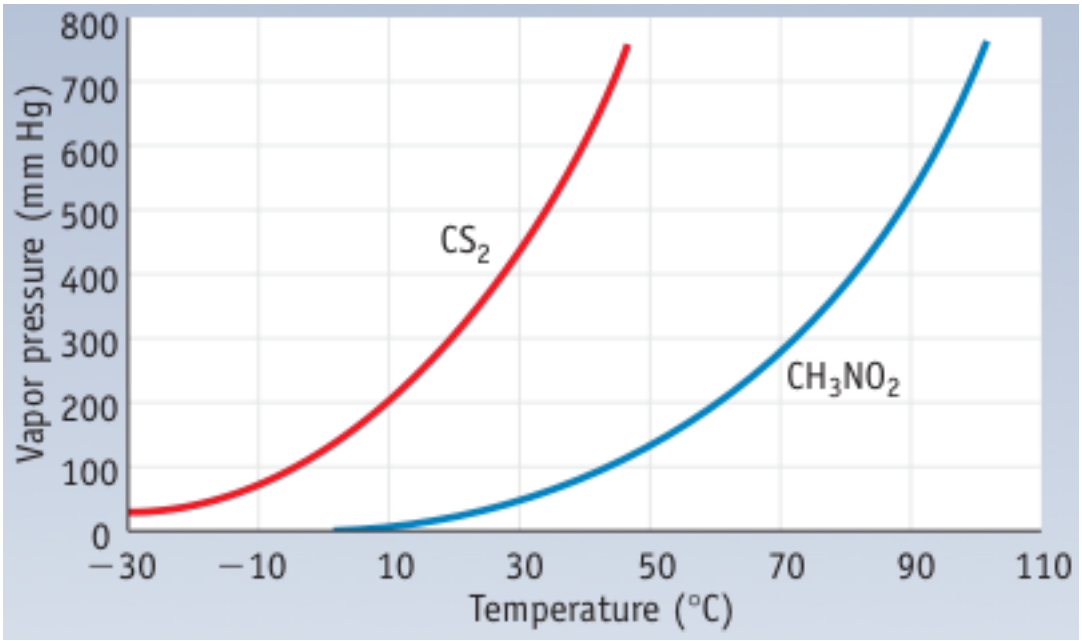
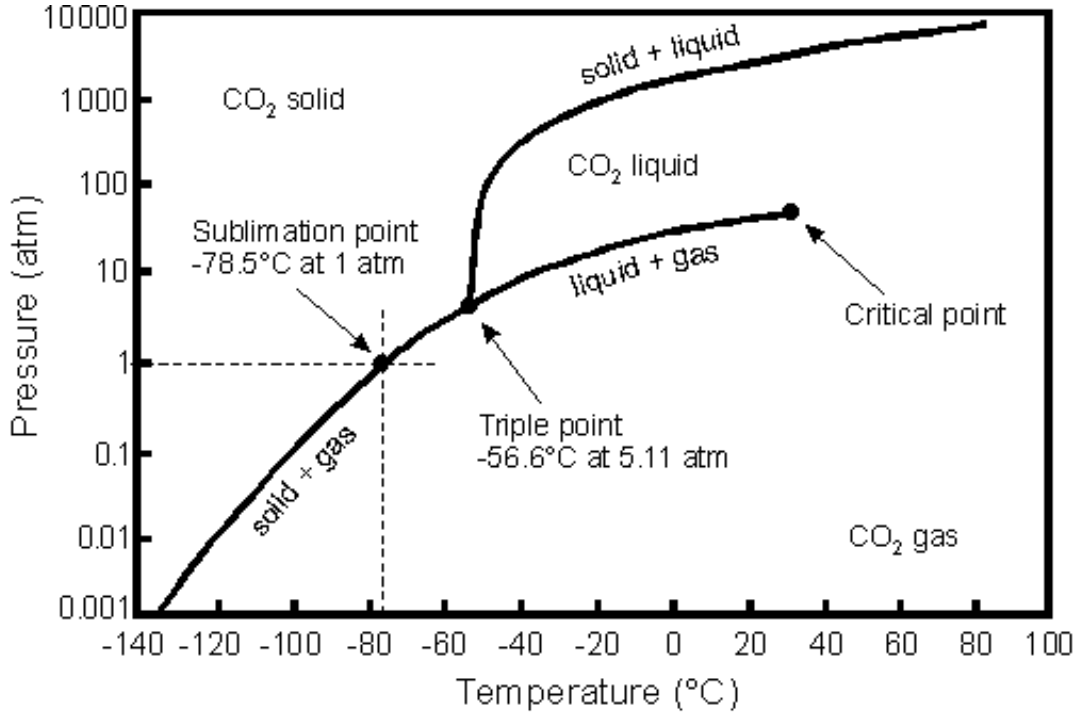
1. What type of intermolecular force must be overcome in converting each of the following from a liquid to a gas?
   a. liquid O_2 b. H_2O c. CH_3I d. CH_3CH_2OH
2. Rank the following atoms or molecules in order of increasing strength of intermolecular forces in the pure substance. Which exist as gases at 25 °C and 1 atm?
   a. Ne b. CH_4 c. CO d. CCl_4
3. In each pair of ionic compounds, which is more likely to have the greater heat of hydration? Briefly explain your reasoning in each case.
   a. LiCl or CsCl
   b. $NaNO_3$ or $Mg(NO_3)_2$
   c. RbCl or $NiCl_2$
4. Ethanol, CH_3CH_2OH, has a vapor pressure of 59 mm Hg at 25 °C. What quantity of heat energy is required to evaporate 125 mL of the alcohol at 25 °C? The enthalpy of vaporization of the alcohol at 25 °C is 42.32 kJ/mol. The density of the liquid is 0.7849 g/mL.
5. 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?



6. 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?
7. 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.

8. 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.
9. 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.

10. 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

11. Liquid methanol, CH_3OH, is placed in a glass tube. Predict whether the meniscus of the liquid is concave or convex.
12. 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.
13. 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?

Answers to the Practice Problem Set:

1. a. induced dipole - induced dipole b. hydrogen bonding c. dipole-dipole d. hydrogen bonding
2. $CH_4 < Ne < CO < CCl_4$ First three are gases
3. a. LiCl b. $Mg(NO_3)_2$ c. $NiCl_2$
4. 90.1 kJ
5. *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
6. -1.97 kJ evolved. +1.97 kJ absorbed for solid -> liquid.
7. $q_{total} = 9.4 \times 10^2$ kJ + 1.6×10^4 kJ + 8.8×10^2 kJ = **1.8×10^4 kJ**
8. a. gas b. solid c. between -40 and -10 d. 0.01 atm e. solid denser than liquid
9. 135.7 pm
10. ΔH_{vap} = 38.6 kJ/mol, and T = 128 ºC
11. The meniscus is concave since there are adhesive forces between the methanol and the silicate of the glass.
12. 1-propanol has stronger intermolecular forces (hydrogen bonding) than methyl ethyl ether (dipole-dipole) zinc
13. -4.80×10^3 J (-4.80 kJ)