CHEMISTRY 112, Section 1 NAME: _____
Exam #1 February 15, 2013, Version 24

Q1. Consider two gas samples: **Flask A**: 1 mole of Ar in a 2-L flask at 25 °C

(10.2) **Flask B**: 1.5 moles of H_2 in a 1-L flask at 25 °C

a) which flask has more molecules? **B** *because it has more moles of gas*

b) in which flask do the molecules move faster on average? **B** *because they are at the same temperature and H_2 has a lower mass than Ar*

c) which flask has the greater pressure? **B** *because it has more moles of gas and smaller volume*

d) in which flask do the molecules have greater average kinetic energy? **the same** *because they are at the same temperature*

Q2. Consider a gas sample with P = 2 atm, V = 3 L, and T = 400 K. Assuming any property not mentioned remains constant, calculate the value of the asked for property when the noted change is made. (10.2 -10.3)

a) if volume is halved, pressure will be = **4 atm**

b) if temperature is doubled, volume will be = **6 L**

c) if temperature is doubled and volume doubled, pressure will be = **2 atm**

Q3. Which of the following forces are responsible for holding HBr in the liquid state? Circle all that apply. (11.4)
Dipole-dipole and Induced dipole-Induced dipole: *IMFs hold molecules in the liquid state. All molecules have Induced dipole-induced dipole forces; HBr is polar so it also has dipole-dipole forces. It does not form hydrogen bonds because it does not have a bond of type: N-H, O-H, or F-H. Covalent bonds hold the H and Br together in a single molecule, but are not responsible for holding different molecules near one another.*

Q4. Consider these molecules: **A:** $CH_3CH_2NH_2$ **B:** CH_3CH_2F **C:** $CH_3CH_2CH_3$ **D:** CH_3CH_3 (11.5)
a. Which has the strongest IMFs: ***enter letter*** **A**

b. Which will have the highest vapor pressure: **D**

c. Which will have the highest boiling point: **A**

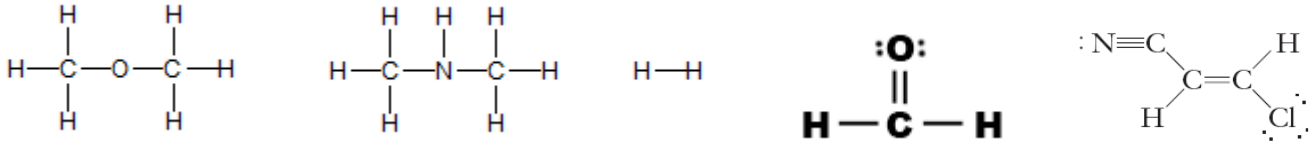
d. Which will have the highest enthalpy of vaporization: **A**

Q5. Rank the following ionic compounds in order of increasing melting point: LiF, NaCl , MgO (12.4)

NaCl < LiF < MgO

MgO is a 2+/2- salt so has the strongest forces; LiF has smaller ions than NaCl, so it has stronger forces than NaCl.

Q6. For which of the following compounds would hydrogen bonding be expected to play an important role in holding the molecules in the liquid state. Circle all that apply. (11.4)



The second structure can form hydrogen bonds because it has an N-H bond. None of the others have a bond of type: N-H, O-H, or F-H and so do not form hydrogen bonds.

Q7. Use the vapor pressure curves to answer the following questions. (11.2)

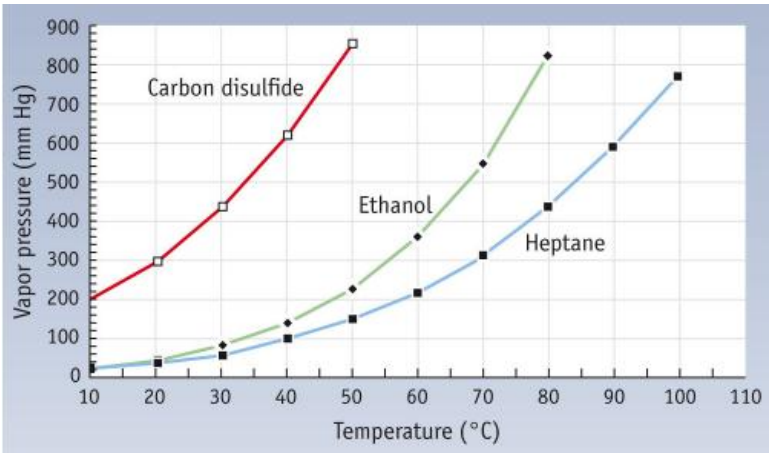
a. What is the vapor pressure of ethanol when the temperature is 70 °C.

about 550 mm Hg

b. What is the normal boiling point of carbon disulfide.

About 46 °C

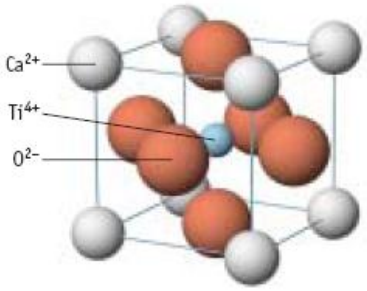
c. Which of the three has the weakest intermolecular forces?



Carbon *disulfide* *because it has the highest vapor pressure at a given temperature*

d. Draw a new curve on the graph for a compound with weaker intermolecular forces than the compounds depicted. ***Draw a curve to the left of CS_2.***

Q8. Using the unit cell structure shown here, determine the formula of the unit cell of this compound. The Ti ion is in the very center of the unit cell. (12.3)



Ca^{2+}: 8 corners x 1/8 = 1 Ca^{2+} ion
Ti^{4+}: 1 inside = 1 Ti^{4+} ion
O^{2-}: 6 faces x ½ = 3 O^{2-} ions

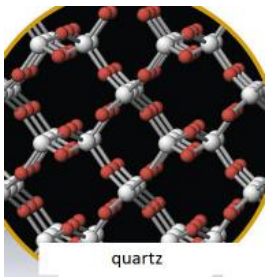
$CaTiO_3$ or $TiCaO_3$

Q9. What type of solid is each of the following: (choices: molecular, ionic, extended/covalent, metallic) (12.1)

quartz **network/extended covalent**

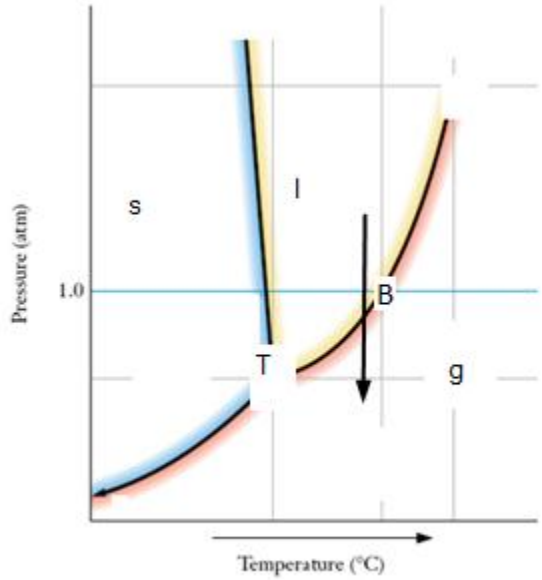
ice **molecular**

potassium nitrate **ionic**



Which of the above will have the weakest IMFs? **Ice/molecular**

Q10. Consider the phase diagram below. (12.5)



a. Label the regions for gas, liquid and solid.

b. Draw an arrow for the transition that occurs when the liquid evaporates at constant temperature.

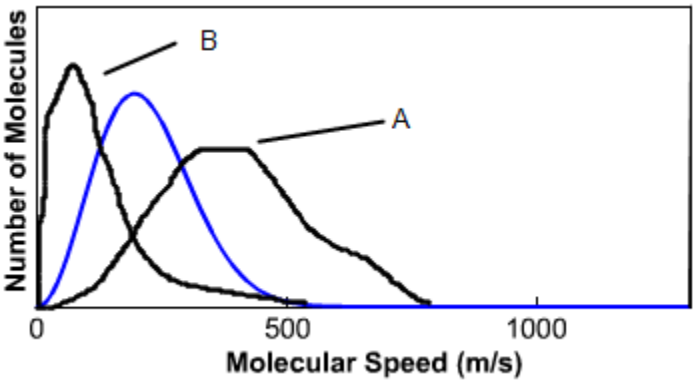
c. Write a "T" on top of the triple point.

d. Write a "B" showing the normal boiling point.

e. Which is more dense:
the liquid

Q11. The box on the left has a depiction of HCl in the liquid phase. Draw in the right box a depiction of the same atoms/molecule after they vaporize. **Draw the molecules apart from each other but not broken into separate H and Cl atoms or ions.**

Q12. A Boltzmann distribution plot for Xe gas at a temperature of 300 K is shown here. (10.5)



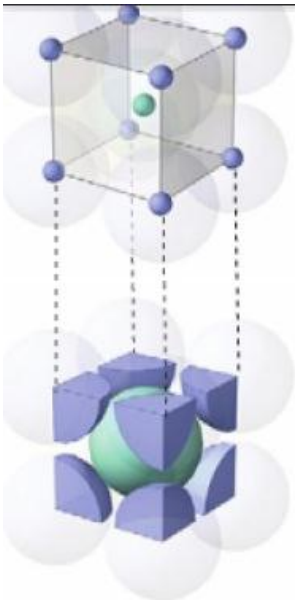
a. Draw another curve showing the distribution of speeds for CO_2 at the same temperature. Label it **A**.

b. Draw another curve for Xe at a temperature of 270 K. Label it **B**.

c. On average, do the gas particles for Xe at 300 K move faster than a car going 60 mph?

yes

Q13. An element takes the solid state form of a body-centered cubic unit cell. You must show all your work. (12.2)



a) How many atoms are contained within the boundaries of the unit cell?

8 corners + 1 inside = 2 atoms

b) Assume the atom has a radius of 1 cm (it's much smaller than that, of course). What volume do the atoms take up?

2 atoms x 4/3 pi (1 cm)^3 = 8.38 cm^3

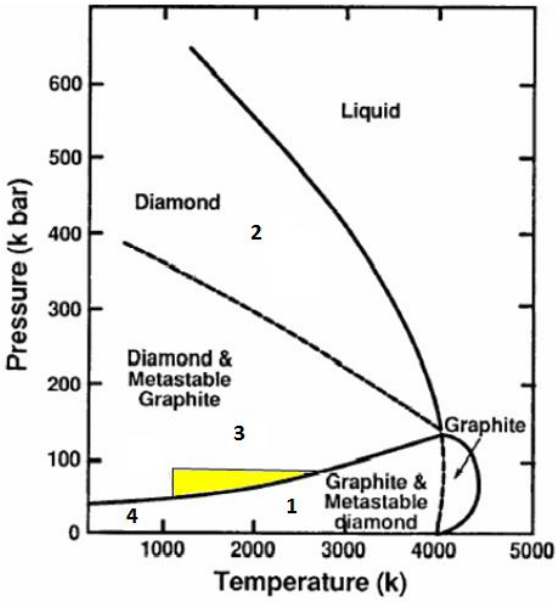
c) What percentage of space in the unit cell is taken up by the atoms?

Edge $= \frac{4r}{\sqrt{3}} = 2.309\ cm$

Volume of unit cell = edge^3 = (2.309 cm)^3 = 12.32 cm^3

% filled = $\frac{8.38\ cm^3}{12.32\ cm^3} x100\% = 68\%$

Q14. The phase diagram for carbon is shown to the right. You start with graphite at position **1** and then move to positions **2**, **3**, and finally **4**, in order. In what form is the carbon when you are at the final position 4? Choose one.



Moving from 1 to 2 converts the graphit to diamond. Moving to position 3 does not change anything because diamond is more stable than graphite in that region. Moving to position 4 does not change anything because, although graphite is more stable, diamond is metastable in that regions. So:

diamond

Q15. You perform an experiment like you did in lab. A flask of 134 mL volume weighs 106.00 g. You add 4.50 g of a volatile liquid. You then cover the flask with foil containing a small hole and heat the flask to 98.0 °C. Atmospheric pressure is 748 mm Hg. When all the liquid has just evaporated, the flask is removed and cooled, allowing the remaining vapor to condense. The flask is reweighed and found to have a mass of 106.86 g. What is the molar mass of the gas? (10.3)

You must show all your work.

mass vapor = 106.86 g – 106.00 g = 0.86 g

T = 371.15 K
P = 0.984 atm

mol gas = $\frac{PV}{RT} = \frac{0.984\ atm \times 0.134 L}{0.0082057 \frac{L \cdot atm}{K \cdot mol} \times 371.15\ K} = 0.00429\ mol$

Molar mass = 0.86 g/0.00429 mol = 200 g/mol

Q16. The vapor pressure of acetic acid at 10 °C is 43.5 mm Hg, and at 50 °C is 156.5 mm Hg. Use this to determine the enthalpy of vaporization of acetic acid. (11.2)

You must show all your work.

P_1 = 43.5 mm Hg; P_2 = 156.5 mm Hg
T_1 = 10 °C = 283.15 K; T_2 = 50°C = 323.15 K

$$ln\frac{156.5\ mm\ Hg}{43.5\ mm\ Hg} = \frac{\Delta H_{vap}}{R}\left[\frac{1}{283.15\ K} - \frac{1}{323.15\ K}\right]$$

ΔH_{vap} = 24.4 kJ/mol

Points per question:

Q1=8, 2=6, 3=6, 4=8, 5 = 4, 6 = 5, 7 = 5, 8 = 6, 9 = 4, 10 = 5, 11 = 5, 12 = 6, 13 = 8, 14 = 5, 15 = 10, 16 = 10