CHM 1046 - JOENS WORKSHEET #1 Due date: Wednesday, August 30th

KEY

1) Which of the following is a condensed state of matter?

a) a solid
b) a liquid
c) a gas
d) both a and b
e) both b and c _____D_____

(In condensed phases the particles making up the phase are in close contact, and so both solids and liquids are condensed phase.)

2) The phase diagram for a pure chemical substance is given below, and may be used to answer the following questions.

a) What are the values for p and T at the triple point of the substance?

p = ____0.10 atm_____ T = _____44 °C_____

b) What are the values for p and T at the critical point of the substance?

p = ____100. atm_____ T = _____120 °C_____

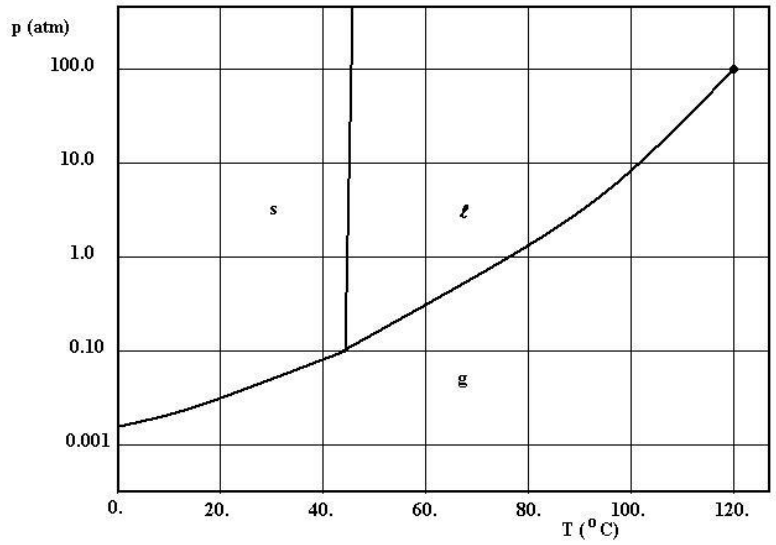
c) Give the temperature and pressure corresponding to the normal freezing point, the normal boiling point, and the normal sublimation point for the substance. If a normal point for any of these phase transitions does not exist, write n/a (not applicable) for the pressure and temperature.

normal freezing point p = ____1.00 atm_____ T = _____44 °C_____

normal boiling point p = ____1.00 atm_____ T = _____76 °C_____

normal sublimation point p = _____n/a_____ T = _____n/a_____

(Normal means equilibrium and 1.00 atm. There is no normal sublimation point for this substance because the line representing 1.00 atm never crosses the solid-gas boundary).



3) For the substances H_2, H_2O, and CH_4

a) H_2 has the highest normal boiling point, and H_2O has the lowest normal boiling point
b) H_2 has the highest normal boiling point, and CH_4 has the lowest normal boiling point
c) H_2O has the highest normal boiling point, and H_2 has the lowest normal boiling point
d) H_2O has the highest normal boiling point, and CH_4 has the lowest normal boiling point
e) CH_4 has the highest normal boiling point, and H_2O has the lowest normal boiling point

____C_____

(H_2O will hydrogen bond and so should have the highest normal boiling point. H_2 and CH_4 are both nonpolar. Since CH_4 is larger (higher mass) than H_2 it should have a higher normal boiling point than H_2.)

4) The vapor pressure of a particular pure organic liquid is 48.5 torr at T = 20. °C, and 245. torr at T = 60. °C.

a) What is the numerical value for $\Delta H°_{vap}$, the enthalpy of vaporization for the liquid?

$$\ln(p_2/p_1) = - \frac{\Delta H°_{vap}}{R} [(1/T_2) - (1/T_1)] \text{ and so}$$

$$\Delta H°_{vap} = - \frac{R \ln(p_2/p_1)}{[(1/T_2) - (1/T_1)]} = - \frac{(8.314 \text{ J/mol·K}) \ln(245./48.5)}{[(1/333.\text{ K}) - (1/293.\text{ K})]} = 32850.\text{ J/mol} = 32.85\text{ kJ/mol}$$

b) What is the value for $T°_{vap}$, the normal boiling point for the liquid. Give your final answer in °C?

We now know the value for $\Delta H°_{vap}$ from part a. You can pick either of the points in part a for p_1 and T_1. Since we are talking about the normal boiling point, p_2 = 760. torr. So our only unknown is T_2.

$$\ln(p_2/p_1) = - \frac{\Delta H°_{vap}}{R} [(1/T_2) - (1/T_1)] \text{ and so}$$

$$(1/T_2) = (1/T_1) - \frac{R \ln(p_2/p_1)}{\Delta H°_{vap}} = (1/333.\text{ K}) - \frac{(8.314 \text{ J/mol·K}) \ln(760/245.)}{32850.\text{ J/mol}} = 0.002716\text{ K}^{-1}$$

And so $T_2 = \frac{1}{(0.002716\text{ K}^{-1})} = 368.\text{ K} = 95.\text{ °C}$

Notice we used R = 8.314 J/mol·K in our calculations because $\Delta H°_{vap}$ has energy units (J/mol). If we did the calculation in part b using the other data point (T = 20. °C, p = 48.5 torr) we should get the same answer for the temperature at the normal boiling point.