Section 17C – Phase Changes

Heating Substances

The following data is needed to solve the following problems:

H_2O	CH_3CH_2OH
mp = 0.0 °C bp = 100.0 °C ΔH_{fus} = 6.02 kJ/mol ΔH_{vap} = 40.7 kJ/mol c_{gas} = 2.00 J/g·°C c_{liquid} = 4.21 J/g·°C c_{solid} = 2.09 J/g·°C	**mp = -114°C bp = 78.5°C** **ΔH_{fus} = 4.9 kJ/mol** **ΔH_{vap} = 40.5 kJ/mol** **c_{gas} = 1.43 J/g·°C** **c_{liquid} = 2.45 J/g·°C** **c_{solid} = 2.42 J/g·°C**

1) How much energy is needed to convert 150 g of ice from -10.0°C to 50.0°C?

2) What is the energy needed to convert 2.50 mole of water from 25.0°C to steam at 125°C?

3) If 400 kJ is added to 1 kg of water in a closed container at 50.0°C, what is the mass and temperature of liquid water?

4) How much energy is needed to convert 300 g of ethanol from -10.0°C to 50.0°C?

5) How much energy is needed to convert 1.50 mole of solid ethanol at -114°C to ethanol vapor at 100°C?

6) if 150 kJ of energy is added to a 2.0 kg sample of ethanol at 25°C, what is the mass and temperature of all states of matter present?

7) What are the similarities and differences between the thermodynamic data given for water and ethanol?

Vapor Pressure

1) A liquid has a ΔH_{vap} of 35.5 kJ/mol and a boiling point of 122°C at 1 atm. What is the vapor pressure at 113°C

2) Using the information from (1), what is the vapor pressure at 50°C?

3) Does the data between (1) and (2) make sense? Why is this the case?

4) What is the vapor pressure of water at 75°C?

5) What is the vapor pressure of water at 25°C (about room temp)

6) What is the heat of vaporization for methanol if it has a bp = -164°C at 1atm and a vapor pressure of 42.8 atm at -100°C?

Draw a phase diagram for the substances below			
CH_3OH	**CH_3CH_2OH**	**Hg**	**F_2**
CCl_4	**NaCl**	**CCl_2F_2**	

Good Times
1) What mass of liquid water must be injected into a 5.0 L closed container at 50.0°C so that all the water vaporizes?
2) On a humid day in New Orleans, the temperature is 22°C and the partial pressure of water is vapor is 31.0 torr. A 9000lb air conditioning unit on the Superdome maintains a temperaure of 22°C, but the partial pressure of water is 10.0 torr. The of air in the dome is 2.4×10^6 m^3 and the total pressure inside and outside of the dome is 1 atm. **a) What mass of water is taken out of the air everytime the inside is completely replaced by outside air?** **b) If the ΔH_{vap} of water is 40.7 kJ/mol, how much heat is given off everytime the air inside is completely replaced with air from outside?**
3) A 4.7 L evacuated, sealed container is injected with 0.33 g of liquid ethanol, CH_3CH_2OH. It is placed in a refrigerator at –11°C. The vapor pressure of ethanol is 10 torr at –2.3°C and 40 torr at 19°C. **a) What mass of ethanol will be in the vapor phase?** **b) When the container is removed and warmed to room temperature, 20°C, will all the ethanol vaporize?** **c) What mass of liquid ethanol will be present at 0.0°C?**

Demonstration

Procedure
1) Obtain a 10.0 mL graduated cylinder fill between 7-8 mL, be sure to write out the volume of water in the cylinder.
2) Invert the cylinder in a beaker filled with water. It is important that the entire beaker is under water.
3) Heat the system on a hot plate until the water reaches a temperature of about 80°C. Stir the water You will have to monitor the system and heat it slowly, if the water boils then you will have to start over.
4) Remove the beaker and the cylinder from the heat and record the volume of the moist air in the cylinder, be sure to lift the beaker so that the water level in the cylinder and the beaker are the same.
5) Place beaker in a container to catch over flow. Add ice to the beaker one or two pieces at a time, be sure to stir to get uniform temperature throughout the beaker. Continue cooling and check the volume of air every 5°C until you reach 40°C.

6) Cool the beaker until it reaches 5°C or colder. Record your final volume.
7) Record the barometric pressure in the room

Questions
1) Because the graduated cylinder was being read upside down a volume correction is necessary. To all the volumes recorded subtract 0.2mL.
2) Below 5°C the vapor pressure of water is negligible, therefore any gas in the cylinder is just trapped air. Use the Ideal Gas Law to determine the number of moles of air in the cylinder.
3) Use the corrected volume measurements for each of the temperatures and the value of **n** calculated in **2** determine the pressure of air at each temperature.
4) The pressure of water at each temperature is the barometric pressure minus the calculated values from **3**. Record the pressure of water at each temperature.
5) On Excel, plot a graph between temperature and vapor pressure of water. Print the graph and draw a curve of best fit. Do your best, this is not for a grade.
6) Compare your results with accepted values.