AP Chemistry: Water Vapor Equilibrium Worksheet

1. What measured properties of the system indicate that the two phases of water are in equilibrium in the flask?

2. What measurements would you make of the system to know that equilibrium has been reached?

3. What changes take place in the flask the moment after you add the liquid water to the flask?

4. What changes take place over time in the flask as the system approaches equilibrium?

5. Write a reaction for the process taking place in the flask.

6. Write rate law expressions for the forward and reverse reactions and name each.

7. Based on your analysis of the data collected in the simulation, are the concentrations of reactants and products equal at any point in the reaction? Are they equal at equilibrium? If not, what is equal at equilibrium?

8. Can you incorporate any numbers into your rate law expressions from the data collected in the simulation? At what point in the simulation do you have numbers to use? Write the rate law expressions with the numbers.

9. How do the rate constants forward (evaporation) and reverse (condensation) compare? What data can you use to make this comparison?

10. Calculate the molarity of the water vapor at equilibrium. Assume the volume of water vapor in the experiment is 1.0L.

11. What changes in molarity of the liquid water did you observe during the simulation? First describe the changes observed at a single temperature and then describe the changes observed from one temperature to another.

12. Given the molarities of liquid water shown in the simulation, what property of liquid water can you now determine?

13. Does the volume of the water in the flask matter? If you remove some liquid water will the concentrations at equilibrium change or remain the same? Why?

14. Record values for Pressure and Temperature from the VP vs. T graph and plot them in graphical analysis as lnP and 1/T (in Kelvin). Based on the Clausius-Claperyon equation ($\ln P = -\Delta H/R(1/T) + C$) what property of water can you now determine? (see graph)

Some Sample Calculations:

8. At equilibrium at 20: Rate evaporation = Rate condensation

$$k_{evap}[H_2O_{(l)}] = k_{cond}[H_2O_{(v)}]$$

$$k_{evap}[55.4082] = k_{cond}[9.58E-4]$$

So concentrations are not equal at equilibrium and $k_{evap} \ll k_{cond}$ in order for the two rates to be equal.

10. moles of vapor = PV/RT, where P = vapor pressure, V = 1.0L, R = 8.314, and T = Kelvin temperature.

12. Molarity of water at 20°C = (55.40916 moles/L) x (18.01528 grams/1 mole) x (10^{-3}L/1mL) = 0.9982115 g/mL