DIFFUSION THROUGH A STAGNANT FILM LAB WORKSHEET

Ch En 385 – Knotts

Overview

This lab involves measuring the evaporation and diffusion of water, ethanol, and acetone into air. The rate of evaporation is measured by determining the change in volume of the liquid as a function of time. Because evaporation and diffusion occur on a relatively long time scale, you will take measurements multiple time throughout the week. Any one measurement will not take very long, but you will need to set a schedule to obtain the data each day. These data will allow you to calculate the binary diffusion constant (diffusivity) of the vapor phase of each compound in air.

Experimental Procedure

General Procedures

The experiment will be set up and running when you arrive. On the first day of the lab you will read the liquid level on each of the burettes and cylinders. You will also record the ambient conditions in the lab (relative humidity, temperature, and pressure) *and the time of day and date*. On subsequent days, you will take additional measurements. The more data you take, the better your data analysis will be. You should take at least one data point for three days, but you could do more. You could consider having someone in your group take a data point in the morning and in the evening for better averaging.

Experiments

Day 1:

- Identify the location of each set of graduated cylinders.
  - The cylinders for water are on a table next to the north fume hood.
  - The cylinders for acetone and ethanol are in the north fume hood.
- Record the data as outlined in Table 1.
  - You may lift the fume hood to take the readings. Make sure to close the sash when done.
- Use the calipers provided, and the spare burette and set of graduated cylinders, to determine the following:
  - Inner Diameter (ID) of each cylinder
  - Outer Diameter (OD) of the burette

  Record the data in Table 2.
- Do #1 of the Analysis.
- Do #2 of the Analysis.
- You may leave for the day after you do this.

Subsequent Days:

- Visit the lab at least once a day for several days.
- Record the data as outlined in Table 1 for each visit.
- Table 1 has slots for 8 measurements. You can choose to do more or less than this, but I recommend at least three datapoints spread out over three days.

Analysis

Do #1 and #2 on Day 1 of the lab. Do #3-#7 after you finish taking data for the week. Make sure you refer to the prelab for key information.

1. Figure 1 shows the temperature dependence of the vapor pressure of water, ethanol, and acetone.
    a. Explain the behavior from a molecular level perspective.
    b. Based on these data, hypothesize which compound will have the highest rate of evaporation (mass transfer rate) for the experiments conducted this week. Explain your reasoning.

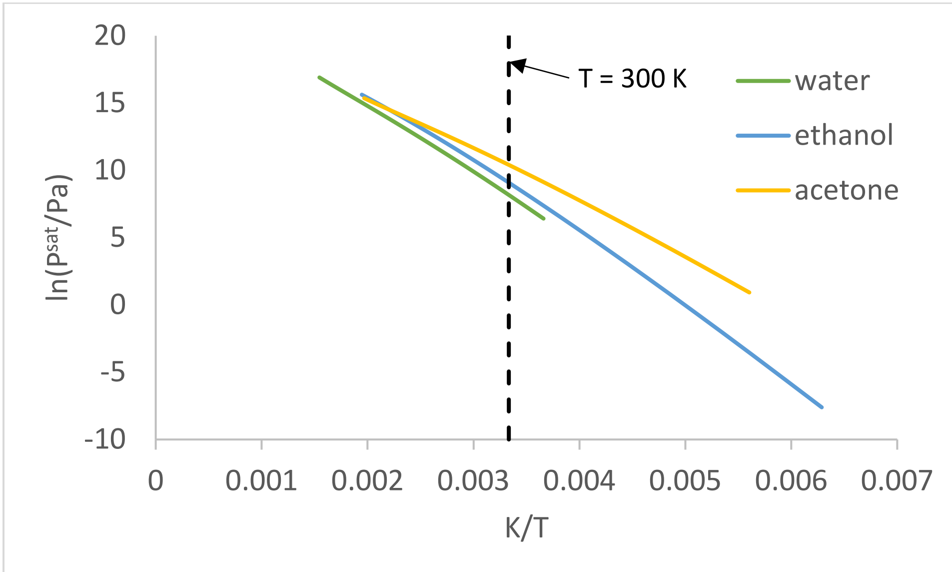

Figure 1 Temperature dependence of the vapor pressure of water, ethanol, and acetone.

2. Equation 3 of the prelab is the key equation needed for this lab. This equation was obtained by integrating Equation 2 and *includes* the effects of advection. Determine the expression for the flux when *neglecting* advection.
    a. start with Equation 2 of the prelab
    b. throw out the advection term
    c. integrate
    d. apply boundary conditions to obtain the constants of integration

    You will use the equation you derive at the end of the lab in #5 below.
3. Calculate the average mass transfer rate for each compound (water, ethanol, acetone) and the associated error. Explain the trend in the values from a molecular level perspective.
4. Calculate the average D_{AB} for each compound (water, ethanol, acetone) in air. Also report the associated error. Explain the trend in the values from a molecular level perspective.
5. Calculate the average D_{AB} for each compound in air *neglecting advection*. (Use the equation you derived in #2 above.) Comment on the importance of advection in this experiment.
6. Compare the D_{AB} values obtained from this experiment to those reported in the literature. *Briefly* discuss the agreement or disagreement.
7. Comment on whether the hypothesis from #1 was proved or disproved by the experiment. Do you trust the data from the experiment? Explain. Do you trust your intuition? Explain

TABLE 1: EXPERIMENTAL DATA

		Measurements							
		1		2		3		4	
Date and Time									
Ambient Conditions (ϕ, T, P)									
Sample	Cylinder Size (mL)	Cylinder Level (cm)	Burette Level (mL)	Cylinder Level (cm)	Burette Level (mL)	Cylinder Level (cm)	Burette Level (mL)	Cylinder Level (cm)	Burette Level (mL)
water	500								
water	1000								
water	2000								
ethanol	500								
ethanol	1000								
ethanol	2000								
acetone	500								
acetone	1000								
acetone	2000								

TABLE 1: EXPERIMENTAL DATA (CONTINUED)

		Measurements							
		5		6		7		8	
Date and Time									
Ambient Conditions (ϕ, T, P)									
Sample	Cylinder Size (mL)	Cylinder Level (cm)	Burette Level (mL)	Cylinder Level (cm)	Burette Level (mL)	Cylinder Level (cm)	Burette Level (mL)	Cylinder Level (cm)	Burette Level (mL)
water	500								
water	1000								
water	2000								
ethanol	500								
ethanol	1000								
ethanol	2000								
acetone	500								
acetone	1000								
acetone	2000								

Table 2: Apparatus Diameters

ID 500 mL Cylinder (mm)	
ID 1000 mL Cylinder (mm)	
ID 2000 mL Cylinder (mm)	
OD Burette (mm)	