Vapor Pressure of Liquids

Caution: All of the liquids used in this experiment are flammable. Do not use any flames in the lab today.

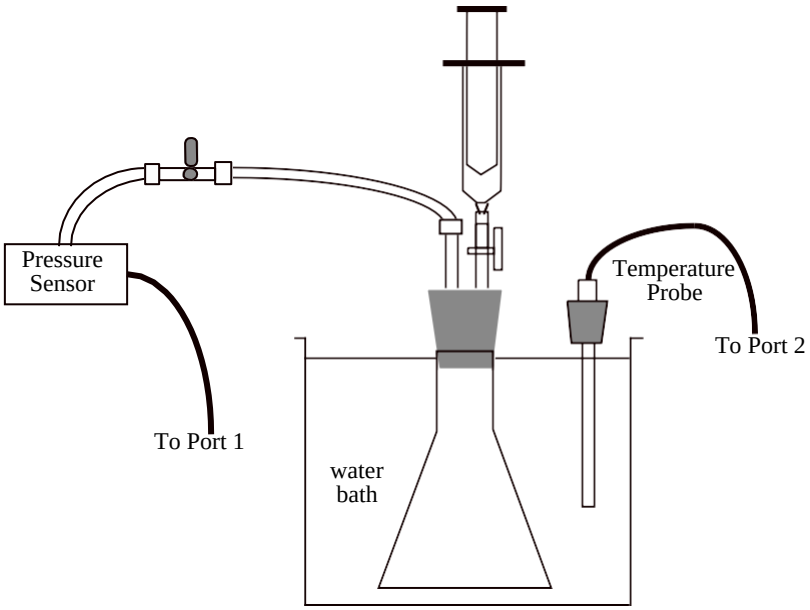
In this experiment, you will investigate the relationship between the vapor pressure of a liquid and its temperature. You will also compare the vapor pressures of several liquids and interpret these in light of the intermolecular forces present in the different liquids.

I. Experimental Set Up

A. Water Baths: Use 1-liter beakers to prepare four water baths, one in each of the following temperature ranges: 0-4°C, 8-10°C, 14-16°C, and 20-22°C(use room temperature water). For each water bath, mix varying amounts of warm water, cold water, and ice to obtain a volume of about 800 mL in the 1-L beaker. If you use a 0°C bath, you must make sure that there is enough ice in the flask to completely surround a submerged 125 mL Erlenmeyer flask.

B. Equipment Set Up: Refer to the figure below but note that the valves between the syringe and the flask and the sensor and the flask will not be present in the set up you are using. Be sure that the pressure sensor is plugged into port 1 of the serial box interface and that the temperature probe is plugged into port 2. Insert a rubber stopper assembly into a clean, dry 125-mL Erlenmeyer flask. **Important**: Twist the stopper into the neck of the flask to ensure a tight fit. Be sure that all of the tubing connectors are secured with a clockwise turn. Place the flask in the room temperature water bath making sure that water does not get inside the flask. Do not connect the syringe yet.

C. Computer Set Up: Open the LoggerPro program located on the desktop. The program *should* automatically detect the sensors that are connected to the LabPro interface, this will likely take a few seconds. When the program is ready, you should see both pressure and temperature readings at the bottom of the window. If the sensors are not automatically detected, consult the instructor.



D. Measuring Atmospheric Pressure:
   1. Be sure that the syringe is not attached to the stopper in the Erlenmeyer flask.
   2. Be sure that the temperature probe is in the water bath.
   3. The live pressure reading at the bottom of the window should be the atmospheric pressure. Record the atmospheric pressure and the temperature values in your laboratory notebook.

II. Ethanol

A. The 125 mL Erlenmeyer flask should still be in the approximately room temperature water bath. Obtain a syringe and several milliliters of ethanol. Draw 2 mL of ethanol up into the syringe. Tip the flask sideways and press the syringe firmly onto the open connector on the stopper.

B. Inject the ethanol into the flask and then pump the syringe barrel in and out four or five times to get all of the liquid out of the syringe tip and stopper and into the flask itself. **Leave the syringe connected to the stopper until step D3 below.**

C. Click on the Collect button. Shake the flask gently several times per minute. When the pressure and temperature readings displayed on the monitor stabilize, record the values in your laboratory notebook. This is the first vapor pressure-temperature data pair.

D. Ethanol at other temperatures:
   1. Move the Erlenmeyer flask with the ethanol liquid and vapor and the temperature probe to the next lower temperature bath. Do not change anything about the flask, stopper, or syringe; just move the flask and the temperature probe. Make sure the flask is submerged up to the neck in the new bath. Again, shake the flask periodically and wait several minutes before the pressure reading stabilizes. When the pressure and temperature have stabilized record the values in your laboratory notebook and move the flask to the next lower temperature bath.
   2. When you have collected and recorded data pairs for the four different temperature baths, click the Stop button to end data collection. To determine the actual vapor pressures of ethanol the measured pressures need to be corrected for the air present in the flask, therefore, do not make a graph from this raw gas pressure and temperature data.
   3. Remove the syringe from the stopper and the stopper from the flask. Shake out the stopper to remove any residual ethanol. Be careful that you do not splash any ethanol in your face. Pull the syringe apart and shake it out also. Pour the ethanol in the Erlenmeyer flask into the appropriately labeled waste container in the hood and then dry out the flask with a paper towel.

III. n-Propanol, iso-Propanol, and Hexane

Repeat part II for n-Propanol, iso-Propanol, and Hexane. Alternate between several Erlenmeyer flasks so that you are always starting with one that is completely dry. Also be sure that the previous liquid has completely evaporated from the syringe and stopper before you use them for a new liquid. It is alright if the temperature of the water baths varies slightly from one liquid to another but try to keep them within a degree or so of the temperatures you used for ethanol. If you take a few minutes and get the water bath temperatures adjusted before you start each new liquid it will save time during the actual data collection steps.

IV. Calculating Vapor Pressures

Adding liquid to the flask reduces the volume available to the air in the flask and therefore increases the air pressure in the flask, however you can assume that this effect is negligible. The following questions are designed to get you thinking about the experiment and working on the calculations. The answers do not necessarily have to be written in your laboratory notebook but you should get them figured out while you’re in the lab and have the assistance of your instructor and lab assistant.

A. How does the pressure in the room temperature flask with liquid in it compare with the pressure when there was no liquid added? What is the reason for this difference?

B. Calculate the pressure exerted by the vapor of the liquids at each temperature. As noted above the measured pressure needs to be corrected for the air present in the flask. In addition, since the flask is closed for all of the readings, the pressure of the air in the flask changes as the temperature changes. Therefore, each of the non-room temperature readings must be corrected for this effect.

The equation: $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

can be used to calculate the corrected air pressures. A table like the one shown here may help you organize the various measured and calculated values. In your hand-in you will need to explain and show examples of your calculations so be sure you know what you're doing before you leave lab.

Ethanol				
Measured Temp. (˚C)	**Measured Temp. (K)**	**Measured Pressure (kPa)**	**Calculated Air Pressure (kPa)**	**Vapor Pressure (kPa)**

C. Prepare a single graph of vapor pressure vs. temperature for the four liquids.

V. **A discussion addressing the following items will be called for in the hand-in. You do not need to answer these questions in your laboratory notebook but you should understand them and get assistance with them before you leave.**

A. On the basis of your data, what is the relationship between vapor pressure and temperature? Explain this relationship.

B. Determine the chemical formulas, structures, and molar masses of the four liquids studied in this experiment.

C. What intermolecular forces are expected for each of these substances?

D. Explain the relative vapor pressures of the four substances based on their intermolecular forces.

E. What would you expect for the vapor pressure of water in comparison to the four liquids you tested?