Freezing Point Depression

In this lab you will determine the molar mass of an unknown molecular compound by determining the freezing point depression of a sample of a solid organic solvent.

Equipment

You will need a large test tube from your locker, a 250 mL beaker, a ring stand and clamp, a 600 mL beaker, beaker tongs, a hot plate, a plastic weigh boat, a pair of gloves, and soap to clean your test tube. You will also need a LabQuest with temperature probe, and a Surface Pro.

Chemicals

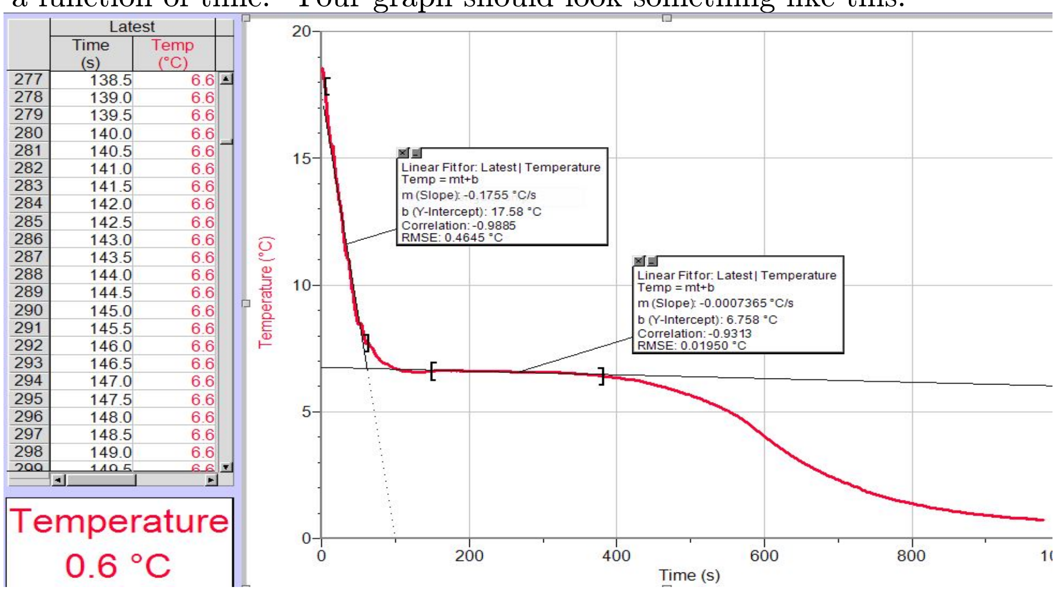
You will need about 20 grams of your solid organic solvent, and a little more than 2 grams of your unknown.

Safety

Wear gloves the entire experiment. The solid organic solvent and the unknown may cause skin irritation. Do not get either one on your skin. If you do get either one on your skin wash off the affected area immediately with soap and water. Do not breath in the powder from either your solid organic solvent or your unknown.

Introduction

In this experiment you will first determine the freezing point of your solid organic solvent. To do this you will use the LabQuest and Surface Pro to record the temperature of the solid solvent as a function of time. Your graph should look something like this:



You will make a graph like this for pure solid organic solvent and one for the solvent with your unknown dissolved in it. The difference in the freezing points on the two graphs will be ΔT in **Equation 1** below.

You use the "Linear Fit" function under the "Analyze" menu to draw the best fit straight line for the first part of the graph that is sloping down. You will do the same for the flat portion of the graph after that. You will see the lines, hover the pointer over the intersection and you will be able to read the temperature underneath the pointer. This is your freezing point for that trial.

You will repeat this process after dissolving your unknown in the solid solvent. Here your unknown is the solute.

The equation that describes how much the freezing point is lowered is given by:

$$\Delta T = -i \cdot m \cdot K_F \quad \textbf{(Equation 1)}$$

Here ΔT is the change in freezing point ($T_F - T_i$) on °C. K_F is called the freezing point depression constant. $K_F = 4.53$ °C/m for your solid organic solvent. m is the molality of the solution and $\boldsymbol{i}$ is the van't Hoff factor. Because your unknowns are all molecular, $\boldsymbol{i} = 1$.

$$m = \frac{\text{moles of solute}}{\text{kilograms of solvent}} \quad \textbf{(Equation 2)}$$

You will measure or be given everything in **Equations 1** and **2** except for the moles of the solute (your unknown).

You will solve **Equation 1** for the molality, m, of your solution. You will then solve **Equation 2** for the moles of your unknown in the solution. The molar mass of your unknown is just the mass of your unknown divided by the moles of your unknown.

Procedure

1.) Place a ring stand with clamp by your hot plate, this is to hold your test tube in the hot water.

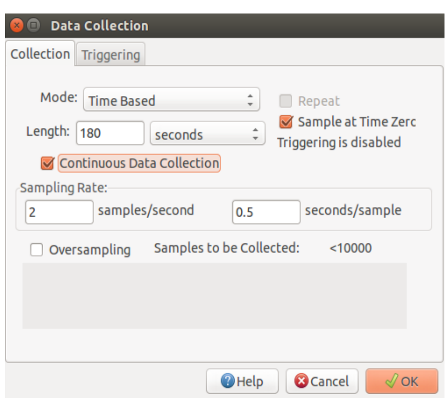
2.) Fill your tall form beaker with about 800 or 900 mL of tap water, and place it on your hot plate. Turn on the hot plate all the way.

3.) **PUT ON GLOVES! WEAR GLOVES THE ENTIRE EXPERIMENT!**

4.) Obtain a 1 hole stopper that fits your large test tube. Place the test tube without the stopper into a beaker and place it on a balance. Tare the balance. Remove the test tube and add the solid organic solvent until you have about 10 grams of the solid organic solvent. Place the test tube with solid organic solvent into the beaker. Put the beaker and test tube back on the balance and record the mass of the solid organic solvent in your data table.

5.) Connect the temperature probe to the LabQuest, and the LabQuest to the computer. Open up LoggerPro on the computer.

6.)In LoggerPro go to "Data Collection" under the "Experiment" menu. Check "Continuous Sampling". Like this:



7.) Place the temperature probe through the hole in the stopper in your test tube so that it is as far down into the solid organic solvent as it will go.

8.) Use the clamp on your ring stand to hold the test tube in the hot water on your hot plate.

9.) When all of the solid organic solvent is melted remove the test tube from the hot water using the clamp to hold it.

10.) Start LoggerPro collecting data.

MAKE SURE TO CONTINUOUSLY AGITATE (GENTLY SHAKE) THE TEST TUBE !

11.)The temperature will decrease, and then stay constant for a time. Continue recording **UNTIL THE TEMPERATURE FLATLINES AND THEN STARTS TO DECREASE, LIKE MY PICTURE ABOVE, IN THE INTRODUCTION**. (The solution with your unknown dissolved in it will look slightly different).

12.) Place the test tube with the solid organic solvent back into the hot water bath, replenishing the tap water if necessary.

13.) Using the "Linear Fit" function under the "Analyze" menu in LoggerPro draw the best fit straight line for the first part of the graph that is decreasing. Do the same for the flat section. Hover the pointer over the point where the two lines intersect. You will see the time and temperature at that point appear on the screen. Record the temperature in your data table. This is the melting point (freezing point) of your solid organic solvent.

14.) In LoggerPro go to Experiment → Delete latest Run.

15.) Obtain your unknown from your instructor. Report your unknown number in both your data table and your conclusion.

16.) Weigh out slightly more that 2 grams of your unknown into a tared weigh boat. Record the mass of your unknown in your data table.

17.) Add all of your weighed out unknown into the test tube that has your solid organic solvent in it.

18.) Repeat steps 8 – 14 with your unknown dissolved in the solid organic solvent.

Calculations:

1.) Find ΔT_F for your experiment using the two freezing points you found in the experiment.

2.) Find the molality of your solution with your unknown dissolved in your solid organic solvent.

3.) Find the moles of your unknown in your solution.

4.) Find the molar mass of your unknown.

Conclusion:

Report your unknown number (the number on the piece of paper taped to your unknown when you got it from your instructor).

Report the molar mass of your unknown to the correct number of significant figures.

Give one potential source of **experimental** error, what effect that error would have on your result, and **why** that error would have that effect on your result.