Determination of Molar Mass by Freezing Point Depression

In this experiment you will determine the molar mass of an unknown by determining the freezing point depression of the solvent, lauric acid, by adding the solute, the unknown.

STOCKROOM

You will need your unknown. Bring a large test tube to Matt to put your unknown in. ***MAKE SURE TO RECORD YOUR UNKNOWN NUMBER IN YOUR DATA TABLE AND CONCLUSION.***

You will also need a digital thermometer and a hot plate.

CHEMICALS

You will need about 4 g of lauric acid.

OTHER EQUIPMENT

You will need a ring stand with two test tube clamps, two large test tubes, a 600-mL beaker, something to keep track of the time elapsed, and your goggles.

WASTE DISPOSAL

DO NOT PUT ANY SOLIDS IN THE SINKS!

All solutions may go down the drain, and all solid waste may go in the trash.

SAFETY

Wear your goggles the entire time. Do not ingest any lauric acid, benzoic acid, or the unknown.

PROCEDURE

DETERMINING THE FREEZING POINT OF PURE LAURIC ACID

Weigh a large test tube that is clean and dry. Enter this mass in your data table. Weigh approximately 4 grams of lauric acid in a weigh boat. Transfer the lauric acid to your test tube and reweigh the test tube with the lauric acid in it.

Fill your 600 mL beaker with tap water and place it on top of the hot plate. Clamp the test tube with a test tube clamp on a ring stand so that the level of the lauric acid in the test tube is below the top of the water in your 600 mL beaker on the hot plate. Use the second test tube clamp to hold the digital thermometer as deep in the lauric acid as you can without it touching the test tube.

Turn on the hot plate and heat the water gently until the lauric acid is completely melted. Do not boil the water, you should not have to go much past 50 °C. You may use your glass thermometer to get an idea of the temperature of the water.

Once the lauric acid has completely melted, turn off the hot plate and remove the test tube from the hot water bath and clamp it using the test tube clamp.

Using the digital thermometer record the temperature every 10 seconds. **MAKE SURE TO CONTINUOUSLY STIR THE LAURIC ACID WITH YOUR THERMOMETER DURING THIS ENTIRE PROCESS!**

The temperature will go down until the lauric acid has frozen, then the temperature might come back up a little, and then remain constant for a while. Then the temperature should start going down again. Once you've reached that point you can stop measuring the temperature. You should not go past 15 minutes total.

You will need space in your data table for these times and temperatures.

DETERMINING THE FREEZING POINT OF LAURIC ACID WITH A SOLUTE

Weigh about 0.8 grams of your unknown into a weigh boat and record the mass to three places past the decimal in your data table.

Add the weighed unknown to the test tube with the lauric acid in it and repeat the above procedure.

<u>**CALCULATIONS**</u>

Using Excel you will make three graphs for each set of data. In the first graph you will plot temperature (y-axis) vs. time (x-axis) for all of the data.

Then you will graph just the first part of the data, all of the points until the temperature either starts to come back up, or if it doesn't until the temperature remains constant.

Next you will graph just the section of the data that appears to remain somewhat constant for a period of time.

For the second and third graphs have Excel give you the equation of the best fit straight line.

I plotted some made up data below to give you a rough idea of what your graphs should look like.

Temperature v. Time - 3
J. Caddell

y = -2E-15x + 22.3
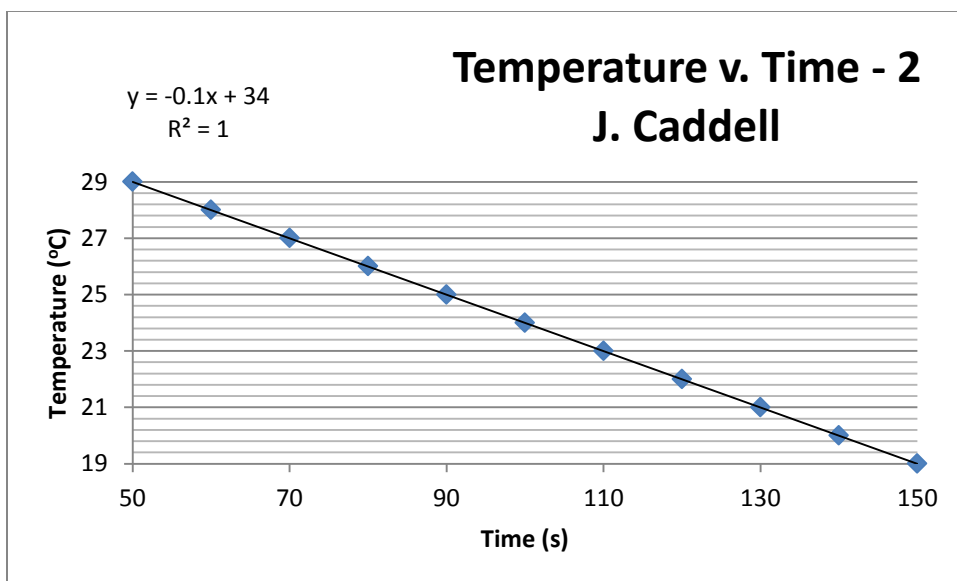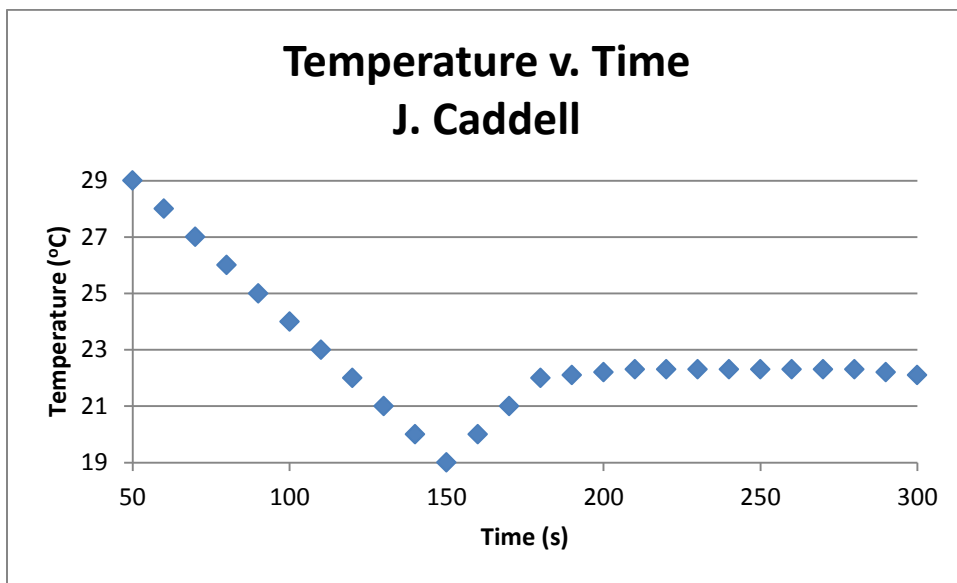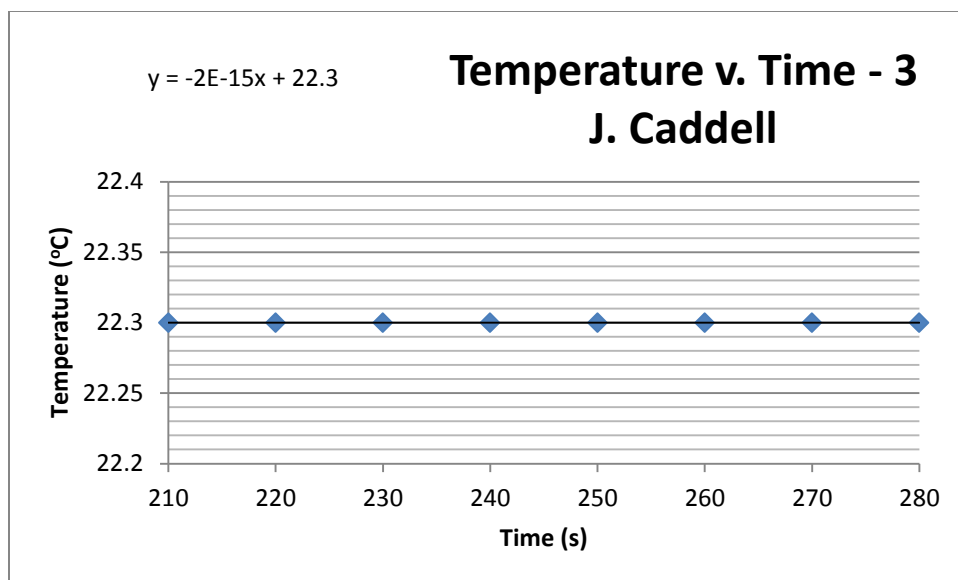
  To find the freezing point of pure lauric, use the two
equations for the best fit straight line from the second and
third graphs and solve that set of two equations to find where
they intersect. The value of y at that point is the freezing
point of pure lauric acid, T_{Pure}.

$$y = m_1 x + b_1$$

$$y = m_2 x + b_2$$

$$y = \frac{m_1 b_2 - m_2 b_1}{m_1 - m_2}$$

Here m_1 is the slope of the second graph, b_1 is the y-intercept
of the second graph, m_2 is the slope of the third graph, and b_2
is the y-intercept of the third graph.

Do the same for the set of data you recorded after adding the
unknown to the lauric acid. This gives you $T_{Solution}$.

The ΔT_F of the lauric acid is T_{Pure} – $T_{Solution}$. Now you have:

$$\Delta T_F = K_F \cdot m$$

The K_F for lauric acid is 4.40 $°C/m$. This should go in your
table of constants. Solve for the molality of the solution, m.
Use the molality to find the moles of the solute (your unknown)
in the solution. Divide the mass of your unknown by the moles
to give you the molar mass of your unknown.

CONCLUSION

REPORT YOUR UNKNOWN NUMBER!!!

Report your freezing point of pure lauric acid and the freezing point of your solution.

Report the molar mass of your unknown.

Discuss (thoroughly) at least two possible sources of error for this experiment. Make sure to explain what effect, and why that error would have that effect, for each source of error.