Lab 05: Latent Heat of Fusion

It's the real thing.

Introduction

Mmmmm…a nice cold coke. When you pour that coke over ice, what happens? Well, it gets cold. Of course it does, but how? Does the warm soda absorb cold from the ice cold ice? Not exactly. You know what happens: the ice melts as the coke gets cold. Eventually, if you leave the glass on the table at room temperature long enough, all the ice melts. Then the watered-down drink gets warmer, until it reaches room temperature. Then you pour it down the sink, because at this point it's warm, all the fizz is gone, and who wants to drink that?

Because two separate things are happening simultaneously, we need to distinguish between phase change and temperature change. The ice undergoes a phase change: from solid to liquid. So it must be absorbing heat (energy). The coke gets cold, so it must be losing heat (energy). What energy the coke loses, the ice absorbs.

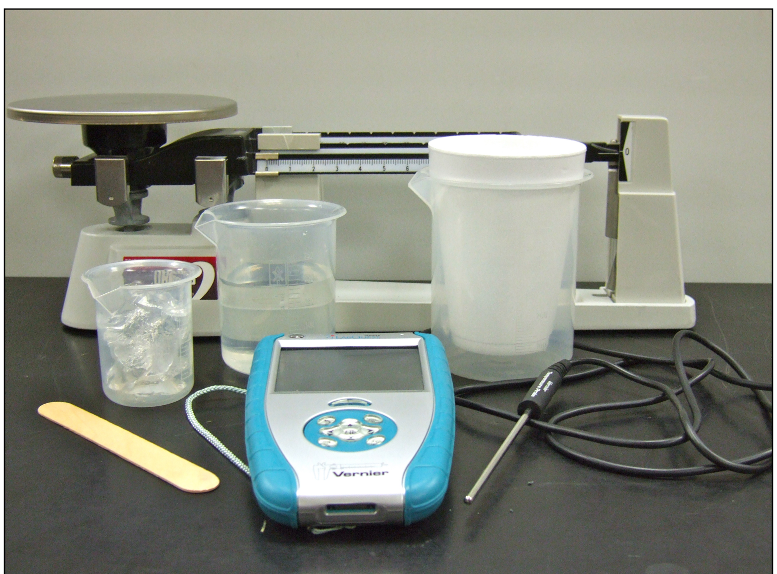
It seems like this should be a straightforward accounting process: subtract energy from the coke, add it to the ice. But we also need to consider what happens when all the ice melts: its temperature changes. Once the ice melts, the liquid (coke + meltwater) will reach a temperature equilibrium. The warmer coke will continue to transfer energy to the colder meltwater until the water is at the same temperature as the coke. The final temperature will be cold, but not freezing (0°C). We won't waste perfectly delicious cokes on our experiment—the principle is the same if we add ice to any other liquid. Like Dr. Pepper. Ok, we're not going to use Dr. Pepper either—we are just going to add ice to warm water and monitor the temperature change as the ice is melting.

Objectives

- Observe the transfer of heat energy from warm water to ice
- Measure the temperature change as ice is melted
- Calculate the latent heat of fusion for water
- Compare the experimental value to the accepted value
- Examine experimental configuration for possible flaws and suggest improvements

Equipment

- Vernier LabQuest
- Temperature probe
- Styrofoam cups
- Set of beakers
- Triple-beam balance



Use the tongue depressor to get the ice into the styrofoam calorimeter cup without splashing.

Procedure

- Place the styrofoam cup in the large beaker to make an insulated calorimeter. Measure its mass using the balance (m_c).
- Add **200ml** of very hot tap water to the styrofoam cup. Measure the total mass of calorimeter + water (m_1).
- While someone is preparing the calorimeter, someone else should be connecting the temperature probe to the LabQuest. Under the **Meter** tab, select the **Sensor** menu adjust the **Data Collection** parameters. Change the time interval to **4 minutes**, and collect data every six seconds (**10 readings per minute**).
- While someone is preparing the LabQuest, someone else should be filling a second styrofoam cup with ice.
- After the warm water has been weighed, place the temperature probe in the cup. When the temperature stops rising, tap the **GO** button to begin collecting data.
- Immediately add some ice to the warm water. Do not try to measure or weigh it now, but you want only about a few large spoonfuls (the smallest beaker is about the right size). Be more concerned with only adding solid ice to the calorimeter, and not any water that melts in the ice cup as you are waiting.
- The ice should begin to melt immediately, and it should only take a minute or two to completely melt. Watch the LabQuest display, and when the temperature stops dropping (you have two or three consecutive readings at the same temperature), tap the **STOP** button to end data collection. Tap the **File Cabinet** icon to save the trial!
- Make sure to record the initial temperature of the warm water (T_1), and the final temperature of the system (T_2).

- Place the calorimeter back on the balance and weigh one more time (m_2), to record how much additional mass you added when you added the ice.
- Repeat the experiment twice more, emptying out the calorimeter and adding fresh hot water each time. Do not forget to re-weigh both calorimeter with only the warm water, and again at the end with the melted ice as well.

Data & Analysis

If you have not already, make sure to record your data in a neat table.

Trial	Calorimeter Mass m_c (g)	Calorimeter + Water m_1 (g)	Calorimeter + Water + Ice m_2 (g)	Mass of Water m_w (g)	Mass of Ice m_i (g)	Initial Temp T_1 (°C)	Final Temp T_2 (°C)	Latent Heat L (cal/g)
1								
2								
3								

1. Calculate and record the mass m_w of the warm water:

$$m_w = m_1 - m_c$$

2. Calculate and record the mass m_i of the ice:

$$m_i = m_2 - m_1$$

3. Calculate the latent heat of fusion L for each of the three trials you performed. Assume that the energy lost by the warm water is gained by the ice, but notice that the energy is used first to melt the ice, then to raise the temperature of the melted ice to match the water (the final temperature of water + melt ice is the same). Pay careful attention to the values you substitute into the expression for L, making sure to use the proper masses and temperatures.

$$\textit{energy lost by water} = \textit{energy gained by ice}$$

$$m_w c\Delta T_w = m_i L + m_i c\Delta T_i$$

$$L = \frac{m_w c\Delta T_w - m_i c\Delta T_i}{m_i}$$

$$L = \frac{m_w(1)(T_1 - T_2) - m_i(1)(T_2 - 0)}{m_i}$$

$$L = \frac{m_w(T_1 - T_2) - m_i T_2}{m_i}$$

(Note that the specific heat of water $c = 1$ cal/g·°C, and the initial temperature of the ice is 0°C)

4. Calculate the average value for L, then compare it to the accepted value (80 cal/g) by calculating the percent error:

$$\%\ error = \left(\frac{accepted - average}{accepted}\right) \times 100$$

5. Look at the equation for the energy transfer, and think about "heat leaks." That is, think about energy transfer not just between the water and the ice. In what other ways could energy be added to or dissipated from the system?
6. How would a "heat leak" show up in your data? If your value for L is lower than expected, what does this mean in terms of energy transferred in or out of the system? What if the value for L is higher than the accepted value?
7. Suggest some ways to decrease the amount of energy exchanged with the surroundings.