

# Latent Heat of Fusion

**Goal:** To measure the latent heat of fusion for water.

## Lab Preparation

In this lab you will mix some ice and water and allow them to come to thermal equilibrium, thus review of calorimetry problems that include phase changes is essential for this lab.

Recall that the main concept behind calorimetry problems is conservation of energy – the heat lost by one substance must equal the heat gained by another substance. This is written as

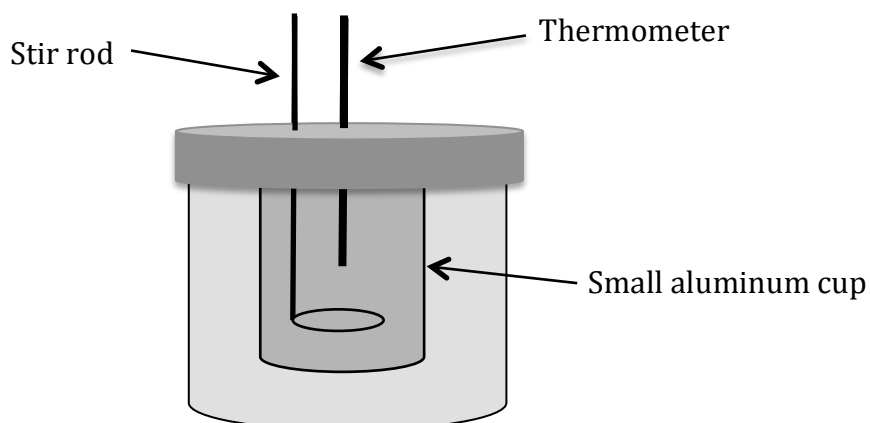
$$Q_{\text{lost}} + Q_{\text{gained}} = 0.$$

When substances warm or cool we can use  $Q = mc\Delta T$  to determine the heat gained or lost by the substance. Here  $m$  is the mass of the substance,  $c$  is the specific heat of the substance and  $\Delta T$  is the temperature change.

When substances go through phase changes the temperature does not change. The relationship  $Q = mL$  can be used to determine the energy needed to change phase. In this lab the ice will be melting and our goal is to find the latent heat of fusion for water ( $L_f$ ). The accepted value for the latent heat of fusion is 335 J/g so your calculations will hopefully be close to this value.

## Equipment

In this lab ice and water will be mixed in a calorimeter. A calorimeter is a thermally insulating container that reduces energy transfer to the surroundings. The calorimeter in this lab is a small aluminum cup that holds the water and ice and sits inside a second larger cup on an insulating plastic ring. A cover is placed on the top and a thermometer and stir rod are inserted.



## Procedure

### I. Determining the latent heat of fusion.

- A. Obtain some ice and put 3-5 cubes in the small plastic insulating container with a small amount of water and allow the mixture to come to equilibrium while you make other preparations. This will ensure that the ice is at  $0^{\circ}\text{C}$  when you combine it with water later.
- B. Open up the "thermometer" file on the computer and record room temperature. Measure the mass of the small aluminum cup and stir rod of the calorimeter ( $m_c$ ). Fill the cup about  $2/3$  full with warm water 6 to  $10^{\circ}\text{C}$  above room temperature and determine the mass of the water added ( $m_w$ ) in grams.
- C. Place the cup and contents into the outer larger cup of the calorimeter, supported by the plastic ring. Cover, insert the thermometer, and stir for at least a minute, until a stable initial temperature is achieved. Record this starting value,  $T_{i,w}$ .
- D. Avoid splashing and carefully place a dried (use a paper towel) ice cube or two into the calorimeter (about 30-40g is appropriate if you want to check it on a balance, but you will determine the exact mass later). Put the cover back on and stir gently until a minimum temperature is reached. Record this as  $T_f$ .
- E. Find the mass of the small cup with contents and determine the mass of the ice added ( $m_i$ ).
- F. Starting with  $Q_{\text{lost}} + Q_{\text{gained}} = 0$  calculate the latent heat of fusion for water,  $L_f$ . Solve for your unknown first, before you put numbers in. The specific heat of water is  $c_w = 4.186 \text{ J/gC}^{\circ}$ , while for the aluminum cup and stirrer the specific heat is  $c_{Al} = 0.900 \text{ J/gC}^{\circ}$ .

### II. Trial 2

Repeat the experiment with a similar amount of ice and warm water. This time, use your prior experience to adjust the starting water temperature so that your expected final temperature is about as far below room temperature as your initial temperature is above room temperature (for example: if in your first trial your warm water was  $6^{\circ}\text{C}$  above room temperature and the final temperature was  $10^{\circ}\text{C}$  below room temperature, you would start with water about  $2^{\circ}\text{C}$  warmer). This reduces the effects of heat exchange with the surroundings during the experiment. Calculate  $L_f$  again.

### III. Analysis

Find the average value of  $L_f$ . Compare either the average value of  $L_f$  or your second trial (whichever is closer to the accepted) to the accepted value of  $L_f$  by finding the % difference.

**\*When finished with your lab clean up your lab station.**

#### **Homework**

- #1. How many significant figures are there in your measurements? How many significant figures should be reported in your result? Explain.
- #2. The stir rod is included in the calculations, but the thermometer is not included. Is this a significant omission? Would your value of  $L_f$  be larger or smaller if it were included? Would your value of  $L_f$  have been closer or further away from the accepted value if it were included?
- #3. Assume that the thermometer you used reads  $+0.5^\circ\text{C}$  when immersed in an ice/water mixture known to be truly  $0^\circ\text{C}$ . If all readings made with this thermometer were  $0.5^\circ\text{C}$  too high, would this systematic error increase or decrease the value found for  $L_f$  relative to the true value? Briefly explain your reasoning.
- #4. Initially, you put the ice in water so that it is at  $0^\circ\text{C}$  when put in with the warmer water. Suppose instead, you took it directly out of a freezer that is at a temperature of  $-10^\circ\text{C}$ . Show and explain how your equation to find  $L_f$  would be different.