The melting or fusion of ice is an endothermic process. As ice is converted to liquid water, it absorbs heat from its surroundings. In this experiment, you will determine the enthalpy of fusion (or heat of fusion) of ice by bringing a small quantity of ice that is at its melting point into a large quantity of water at room temperature. You will use a thermocouple to measure the temperature of melting ice, the initial temperature of the water, and the final temperature of the new, larger quantity of water. In addition, you will need to know the exact mass of both the original water and the water that was added. Both of these masses will be obtained from differences in weights.

As your calorimeter, you will use a Styrofoam coffee cup. For better stability, the cup should be placed in a 400-mL beaker. For temperature measurements with a thermocouple you will use the calibration stored in the Microlab program. Therefore, your temperature readings may be slightly off. However, the temperature differences that you need for your calculations should be reasonably accurate as long as you use the same thermocouple under the same conditions for all of your temperature measurements.

While measuring temperatures, the cup should be gently swirled to ensure that its contents are well mixed. At the same time, the thermocouple should be kept in the center of the liquid. It is important not to lose any water during the experiment since the mass of the ice is obtained from the difference between the final and initial mass of cup and contents.

As ice is brought into a large quantity of water, the water will cool down. In a first step, the ice will melt and absorb the heat that is needed for this phase change from the water and from the cup that holds the water. In a second step, the liquid water formed from the ice (let’s call it ice water) will absorb an additional amount of heat from the original water and from the cup until the cup and the new, combined quantity of water are at the same, uniform temperature. From the difference between the final and the initial temperature of the water, $\Delta T_w$, you can calculate the amount of heat $q_w$ that was lost by the original water and also the amount of heat $q_{cup}$ that was lost by the cup.

\[
(1) \quad q_w = m_w \times s_w \times \Delta T_w \\
(2) \quad q_{cup} = C_{cup} \times \Delta T_w \\
\]

Specific heat of water:

\[ s_w = 4.18 \text{ J} / (\text{g} \times ^\circ \text{C}) \]

Heat capacity $C_{cup}$ of cup:

\[ C_{cup} = 42 \text{ J} / ^\circ \text{C} \]

The sum $q_{total}$ of these two amounts,

\[
(3) \quad q_{total} = q_w + q_{cup}
\]

is also equal to the total amount of heat $q_{total}$ that was required for melting the ice and for bringing the resulting ice water to the final temperature.

\[
(4) \quad q_{total} = q_{meltg} + q_{ice \ water}
\]

The amount of heat required for bringing the ice water from the melting point of ice to the final temperature, $q_{ice \ water}$, can be calculated from the difference $\Delta T_{ice \ water}$ between the final temperature of the water and the temperature of the melting ice:

\[
(5) \quad q_{ice \ water} = m_{ice} \times s_w \times \Delta T_{ice \ water}
\]

with that, you will be able to calculate the amount of heat $q_{meltg}$ required to melt the ice:

\[
(6) \quad q_{meltg} = q_{total} - q_{ice \ water}
\]
In the next step, you will calculate the amount of heat required to melt one gram of ice and finally, in a last step, the enthalpy of fusion for ice, $\Delta H_{\text{fusion}}$, which is simply the heat required to melt one mole of ice.

Notes:

1. You will need CRUSHED ice rather than ice cubes for this experiment.

2. Report not only the numbers but also the units.

3. Show all calculations that involve more than simple additions/subtractions.

4. Report the average enthalpy of fusion (line 19) to the correct number of significant figures. For intermediate results, keep two more digits than are significant and underline the last digit that is significant.

5. Report the enthalpy of fusion and the average enthalpy of fusion (lines 18 & 19) in kJ. Report all other amounts of heat in J.
Experimental Procedure

1. Pre-Experiment Set-up

Obtain a Styrofoam coffee cup from your lab instructor. Clean and dry it if necessary. Weigh the cup to the nearest 0.001 g and record the mass of the empty cup.

Add about 100 mL of DI water to the cup. Accurately weigh the filled cup and record the mass of cup + water.

For better support, place the cup in a 400-mL beaker.

Put a clean, dry glass stirring rod in the cup and leave it there for the duration of the experiment.

2. Power up Interface Box and Enter Microlab Program

Press CTRL / ALT / DELETE to log on to YSU.
Push the power button on the interface box.
(Is the green light on in the “o” of Microlab?)
Obtain a thermocouple from your instructor and connect it to the interface box.
Enter experiment title (Heat of Fusion) and your name; click ok.

3. Add Time and Temperature Sensors

Click add sensor; choose sensor: time
Click the first of the three red time boxes
Click next; click automatic operation; click seconds; click finish

Click add sensor; choose sensor: temperature thermocouple
Click red thermocouple box
Click next; click read calibration from file; click thermocouple; open; finish

4. Set up Graph and Spreadsheet

Drag and drop:   Time1 to horizontal axis
                Thermocouple to vertical axis

Drag and drop:   Time1 to spreadsheet column A
                Thermocouple to spreadsheet column B

5. Data Acquisition for Heat of Fusion: First Run

Place the thermocouple in your calorimeter. Begin measuring by clicking on the start button. Swirl your calorimeter gently during all temperature determinations to allow the temperature to stabilize more quickly. When the temperature reading has stabilized to two decimal places, record it as the “Initial temperature of the water.” Keep the temperature running.

(If stabilizing the temperature takes too long, stop and restart recording. Compare part 6.)

Place about 3 g of CRUSHED ice in a small beaker. Decant and discard any adhering water. While continuing to swirl the calorimeter and to collect temperature readings, transfer the ice to the calorimeter cup. Swirl the cup as you continue acquiring temperature data until all the ice has melted and until it is evident from the displayed “temperature vs. time” graph that the temperature is no longer falling. Record the constant minimum temperature reached as the “Final temperature” on your report form, and stop the
data acquisition by clicking the “Stop” button. Look at the acquired data in your spreadsheet to verify the initial and final temperature readings.

Remove the thermocouple from the cup. Accurately weigh the cup and its contents and record the “Mass of calorimeter + water + melted ice.”

6. Set-up for Second Run

Remove the water from the cup and prepare it for your second run as described in item 1.

Click: repeat experiment. Save Experiment? Click no; then click ok.

7. Data Acquisition for Heat of Fusion: Second Run

Proceed as described above in item 5.

8. Third Run

Proceed with the third run as described under items 5-7.

9. Determining the Temperature of Melting Ice

Fill your Styrofoam cup halfway with a mixture of crushed ice and DI water. Place the thermocouple in the mixture and begin measuring by clicking on the start button. Swirl your calorimeter gently to allow the temperature to stabilize more quickly. When the temperature reading has stabilized to two decimal places, record it as the “Temperature of melting ice.”

Since we did not calibrate our thermocouple, our temperature readings will be slightly off. However, the temperature differences determined should be reasonably accurate as long as we use the same thermocouple for all of our temperature measurements.

10. Calculations

Do your calculations and verify that results from your three runs are consistent.

11. Exit Microlab Program

Exit Microlab program (don’t save data).
Power off interface box.
Remove thermocouple from interface box and return it to your instructor.
Also return your Styrofoam cup to the supply table.
Log off computer using CTRL / ALT / DELETE.
<table>
<thead>
<tr>
<th>Report Sheet: Heat of Fusion</th>
<th>First Run</th>
<th>Second Run</th>
<th>Third Run</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass of cup + water</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Mass of cup</td>
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<td></td>
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<tr>
<td>Mass of original water, ( m_w )</td>
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<tr>
<td>Initial temperature of water</td>
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<tr>
<td>Final temperature of water</td>
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<tr>
<td>Temperature difference of original water, ( \Delta T_w )</td>
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<tr>
<td>Temperature of melting ice (same for all runs)</td>
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<tr>
<td>Temperature difference of ice water, ( \Delta T_{ice\ water} )</td>
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<tr>
<td>Mass of cup + water + melted ice</td>
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<tr>
<td>Mass of melted ice ( (09 - (01) ) )</td>
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<tr>
<td>Moles of ice melted</td>
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<tr>
<td>Heat lost by original water, ( q_w )</td>
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<tr>
<td>Heat lost by cup, ( q_{cup} )</td>
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<tr>
<td>Heat ( q_{total} ) lost by original water + cup</td>
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<tr>
<td>Heat required to bring ice water to final temperature, ( q_{ice\ water} )</td>
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<tr>
<td>Heat absorbed when ice was converted to liquid water, ( q_{ice} )</td>
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<tr>
<td>Heat absorbed per gram of ice</td>
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<tr>
<td>Enthalpy of fusion, ( \Delta H_{fusion} ) (heat absorbed per mole of ice)</td>
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<td></td>
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<tr>
<td>Average enthalpy of fusion</td>
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</tbody>
</table>