HEAT OF FUSION OF ICE

This lab investigates the concept of conservation of energy as applied to calorimetry: In a closed system, the sum of all materials that gain (absorb) energy must equal the sum of all materials that lose energy. The relationship between temperature and heat is discussed, including the topics of specific heat and latent heat of transformation.

Materials and Equipment

- Calorimeter (ET-8499)
- Temperature Sensor or Thermometer
- Balance
- Ice Cubes

Theory

Heat added to (or removed from) a solid or a liquid can change the material's internal thermal energy and thus change its temperature. The relationship between the heat flow and the resulting change in temperature is given by

$$Q = mc\Delta T$$

where Q is heat, m is mass, c is specific heat, and ΔT is the change in temperature.

In addition, when a material is at a boundary state between phases, heat flow can cause a change in phase. For example, in this experiment heat added to ice at 0°C causes a change in phase from solid to liquid. The relationship between the heat flow and the resulting change in phase is given by

$$Q = mL_{\mathrm{f}}$$

where Q is heat, m is mass, and L_{f} is the latent heat of fusion.

In this experiment, the water and the inner aluminum Calorimeter cup lose energy and cool down, while the ice gains energy first in melting, and then in warming that melted ice-water up to the final equilibrium temperature of the system. The water and cup undergo the same temperature change, but the melted ice-water undergoes a different temperature change. It is assumed that the initial temperature of the ice is 0 °C.

Safety

Follow these important safety precautions in addition to your regular classroom procedures:

- Wear safety goggles at all times.
- Use caution with hot water.

Procedure

Setup

This experiment requires a source of ice that is not crushed, preferably small chunks of about 5 grams. Some care must be taken with the ice. Ice that is taken from the freezer will be much colder than 0°C and cannot be used immediately straight out of the freezer. You must wait until the ice has warmed up to 0°C and is melting. On the other hand, if the ice sits around the lab for a hour in an icy water bath, there will be pockets of water within the ice that have already melted. The ideal is to take a chunk of ice out of the freezer, place it on napkin, and wait until it is melting.

Experiment

1. Measure the ambient temperature of the room.
2. Measure the mass of the inner aluminum cup from the Calorimeter. Only the inner cup changes temperature and is part of the experiment. The outer (bigger) cup acts only as a holder, and due to the air gap in between, helps to insulate the inner cup.

3. Prepare some water that is about 8°C above room temperature. Add about 40 g of this water to the inner cup. Measure the combined mass of the cup and water to determine the exact mass of the water. After the cup and water have come to equilibrium and you are ready to start the experiment, you will want the temperature to be at least 5°C above room temperature.
4. Measure the mass of the cup plus water and calculate the mass of the water.
5. Assemble the Calorimeter using the spacer to suspend the inner cup inside the bigger cup. Put on the lid and use the one-hole stopper in the lid to hold the thermometer.
6. Prepare about 5 grams of ice. It must be a solid chunk, not crushed. If you take the ice cube directly from the freezer, you must wait a few minutes for it to warm up and start to melt. You do not need to know the exact mass now, but it should be about 5 grams.
7. Check the temperature of the water again. If the water is not about 5°C above room temperature, you can place the cup and water in a water bath to change the temperature slightly. Wipe off any moisture on the cup before placing it back into the outer cup. Gently swirl the cup to stir the water and wait for equilibrium before adding the ice.
8. Record the initial temperature of the water and cup to a resolution of at least 0.1°C.
9. Dry off the ice with a paper towel, and then place it in the Calorimeter. Replace the lid and watch the temperature of the water. Gently swirl the Calorimeter every 10 seconds to ensure an even temperature.
10. Continue to gently swirl the Calorimeter every 10 seconds as you watch the temperature decrease, until it reaches its lowest value. Lift the lid and look inside to see that all the ice has melted. If not, replace the lid and continue. Record the lowest temperature.
11. Remove the inner cup and determine the mass of cup and water. Use this to calculate the mass of ice you added.

Data Collection

Ambient Temperature	
Mass of Inner Cup	
Mass of Inner Cup and Water	
Mass of Water	
Initial Temperature of Water	
Final Temperature of Water	
Mass of Ice	

1. Calculate the change in temperature, ΔT, of the cup and water.

2. Calculate the change in temperature of the melted ice water.

3. Calculate the total amount of heat, Q_{lost} , lost from the cup and water. Use the proper specific heat for each.

4. Calculate the total amount of heat, Q_{gained} added to the ice. You should have two terms.

5. What percentage of the energy supplied by the water and cup is delivered to the ice? Calculate the percent difference.

$$\% \text{ difference} = \frac{Q_{\text{lost}} - Q_{\text{gained}}}{Q_{\text{lost}}} \times 100$$

6. Did the system "lose" energy or "gain" energy. Explain your results using the concept of conservation of energy.

Questions and Analysis

1. Why did we go to the trouble to start with water in the cup that was above room temperature? What does that accomplish?

2. Why does Q for the aluminum cup include only the inner cup? Why do you not include the spacer? Why is the spacer not made of aluminum?

3. Why does the gap between the inner and outer cup provide insulation? In theory, what would ideally be in this gap?

4. Why did you wipe the water off the ice to dry it before adding it to the cup.