CALORIMETRY: Heat of Fusion of Ice

Pre-Lab Discussion

When a chemical or physical change takes place, heat is either given off or absorbed. That is, the change is either exothermic or endothermic. It is important for chemists to be able to measure this heat. Measurements of this sort are made in a device called a calorimeter. The technique used in making these measurements is called calorimetry.

INSERT FIGURE 7-1 HERE!!

In simplest terms, a calorimeter is an insulated container made up of two chambers (see Figure 7-1). The outer chamber contains a known mass of water. In the inner chamber, the experimenter places the materials that are to lose or gain heat while undergoing a physical or chemical change. The basic principle on which the calorimeter works is that when two bodies at different temperatures are in contact with one another, heat will flow from the warmer body to the colder body. Thus, the heat lost by one body will be gained by the other. This exchange of heat will continue until the two bodies are at the same temperature. In a calorimeter, heat is exchanged between the water and the materials undergoing change. The experimenter makes a direct measurement of the temperature change of the water. From this information, the heat gained (or lost) by the water can be calculated. The experimenter then uses these data to determine the heat lost (or gained) by the materials undergoing change.

Unlike most calorimeters, the simple Styrofoam-cup calorimeter used in this experiment will have only one chamber. The ice will be placed directly into a measured amount of water. The heat required to melt the ice will be supplied by the water. By measuring the temperature change (ΔT) of the water, you can calculate the quantity of heat exchanged between the water and the ice. Using these experimental data, you will calculate the heat of fusion of ice.

The following relationships will be used in this experiment.

a. (heat lost (or gained) by the water in the calorimeter) = (original mass of water in the calorimeter) × (change in temperature of the water) × (specific heat capacity of water)

In symbols, this word formula becomes:

$$\Delta Q = m \times \Delta T \times c$$

b. heat given off by the water = heat absorbed by the ice

c. $$\frac{\text{heat needed to melt the ice}}{\text{mass of the melted ice}} = \text{heat of fusion of ice}$$

The *specific heat capacity* of a substance is the quantity of heat energy needed to raise the temperature of 1 gram of the substance by 1°Celsius. The specific heat capacity of water is 4.2 joules per gram per degree Celsius (4.2 J/g°C).

Purpose

Using a simple calorimeter, find the heat of fusion of ice.

Equipment

beaker, 250-mL
graduated cylinder, 100-mL
lab burner
cup, Styrofoam
thermometer
ring stand
iron ring
wire gauze
tongs or perforated spoon
safety goggles
lab apron or coat

Materials

water
ice cubes

Safety

Handle the thermometer with care. It is fragile and easily broken.
Tie back long hair and secure loose clothing before working with an open flame.
Always wear safety goggles and a lab apron or coat when working in the lab.

Procedure

- In a 250-mL beaker, heat about 125mL of water to a temperature of 50°C.
- Measure exactly 100mL of this heated water in a graduated cylinder and pour it into a Styrofoam cup. Record this volume of Water, V_1.
- Measure accurately and record the temperature of the water, T_1. Immediately add 2-3 ice cubes. See Figure 7-2.

ADD FIGURE 7-2 HERE!!!

- Stir the ice-water mixture carefully with the thermometer. **CAUTION:** *Thermometers break easily*. The cup should contain ice at all times. Therefore, if the last of the ice appears about to melt, add another ice cube. Monitor the temperature of the ice-water mixture as you stir. Continue stirring (and adding ice, if necessary) until the temperature evens off (no longer drops). Record this final temperature, T_2.
- Carefully remove the unmelted ice. Allow any water removed to drain back into the cup. Measure and record the volume of water in the cup, V_2.

Observations and Data

V_2 =_____ T_1 =_____

V_2 =_____ T_2 =_____

Calculations

1. Using the known density of water, find the mass (m_1) of the original volume of water (V_1).

2. Find the volume of water resulting from the melted ice. ($V = V_2 - V_1$)

3. Find the mass (m_2) of this volume of water.

4. Find the change in temperature of the water. ($\Delta T = T_1 - T_2$)

5. Find the heat lost by the original mass of water. ($Q = m_1 \times \Delta T \times c$)

6. Find the heat of fusion of ice. $\left(\frac{Q}{m_2} = \text{heat of fusion of ice}\right)$

7. Find your percent error.

(The true value for the heat of fusion of ice is 336 J/g.)

$$\text{percent error} = \frac{(\text{true value} - \text{experimental value})}{\text{true value}} \times 100$$

Conclusions and Questions

1. List possible sources of error in this experiment. How might the use of a calorimeter such as the one shown in Figure 7-1 reduce some of these errors?

2. One source of error is the flow of heat between the water in the cup and the surroundings. Explain how this error is reduced by starting with water at about 50°C.

3. In what way does calorimetry make use of the law of conservation of energy?

4. Define the following terms: **a.** exothermic; **b.** endothermic; **c.** heat of fusion; **d.** specific heat capacity.

5. Is the process of melting exothermic or endothermic? Give evidence to support your answer.

6. What is the difference between heat and temperature?

7. Try this problem in calorimetry: a solid substance with a mass of 200 g is at its melting point temperature in a calorimeter. While the substance changes from a solid to a liquid at the same temperature, the 400-gram mass of water in the calorimeter goes from an initial temperature of 80°C to a final temperature of 30°C.

a. How much heat did the water lose while the substance melted?

b. What is the heat of fusion of the substance that melted?