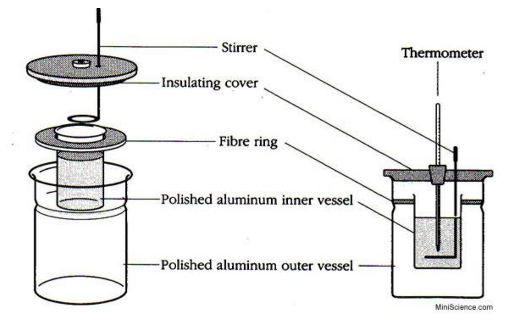
Chemistry Name: ______________________________

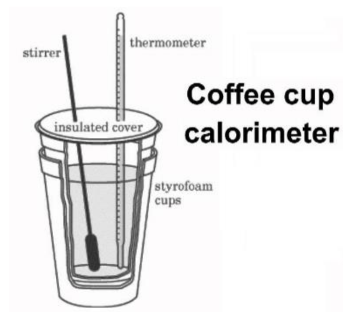
Section _______ HEAT OF FUSION Date: ______________________________

Heat of Fusion of Ice — Lab #4

Pre-Lab Discussion

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





A calorimeter is an insulated container made up of two chambers. The outer chamber contains a known mass of water. The materials that will lose or gain heat while undergoing a physical or chemical change are placed in the inner chamber. When any two bodies at different temperatures are in contact with one another, heat will flow from the warmer body to the colder body. So, the heat lost by one body will be gained by the other. This exchange of heat will continue until the two bodies have the same temperature. In a calorimeter, heat is exchanged between the water and the materials undergoing change. A direct measurement of the temperature change of the water can be made, and the heat gained (or lost) by the water can be calculated. This data is used to determine the heat lost/gained by the materials undergoing change.

Unlike most calorimeters, the Styrofoam-cup calorimeter in this experiment has 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, we can calculate the quantity of heat exchanged between the water and the ice. We then can calculate the heat of fusion of ice.

The following relationships will be used in this experiment:

heat lost by water in the calorimeter = original mass of the water in the calorimeter × Specific Heat Capacity of water × change in temperature of the water

OR

$$q = m \times C \times \Delta T$$

AND

$$q_{(lost)} = q_{(gained)} \quad \text{AND} \quad \frac{q_{(lost)}}{m_{(ice)}} = H_f$$

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 4.18 joules per gram per degree Celsius (4.18 j/g·°C).

Research Question

How can a coffee cup calorimeter be used to determine the heat of fusion of ice?

Materials

Styrofoam calorimeter
thermometer
graduated cylinder, 100-mL
test tube holder
hot tap water
ice cubes

Method

1. Mass the Styrofoam calorimeter and record the mass as M_1.
2. Use the 100 mL graduated cylinder to obtain about 100 mL of hot water and transfer it to the coffee cup calorimeter. Measure and record the mass of the cup and warm water, M_2.
3. Accurately measure the temperature of the warm water in the cup and record it as T_i.
4. **Immediately** add 2 ice cubes. Do not splash water out of the cup.
5. Gently stir the ice-water mixture with the thermometer. The cup *must* contain ice at all times. If it appears that the last of the ice is about to melt, add another cube.
6. Watch the temperature of the ice-water mixture while stirring. Continue stirring and adding ice as necessary until the temperature no longer drops. Record this temperature as T_f.
7. Carefully remove any remaining ice and discard it but try not to remove any liquid water.
8. Measure the mass of the water and cup. Record this value as M_3.

Data Collection and Processing

Data

Data Table				
M_1 (g)	M_2 (g)	T_i (°C)	T_f (°C)	M_3 (g)

Calculations (Show all work – substitutions and units.)

1. Find the mass of warm water, $M_2 - M_1$.

   $\text{mass}_{ww} =$

2. Find the volume of the water due to the melted ice, $M_3 - M_2$.

   $\text{mass}_{ice} =$

3. Find the change in temperature of the hot water ($\Delta T = T_f - T_i$). *Negative indicates lost.*

   $\Delta T =$

4. Find the heat lost by the hot water ($q = m_{ww} \times 4.18$ J/g·K $\times \Delta T$).

   $q =$

5. Find the heat of fusion of ice ($H_f = q \div m_{ice}$).

   $H_f =$

6. Find your percent error. Use your Reference Tables for the equation and the accepted value of H_f.

   $\%_{\text{error}} =$

Conclusion

1. List the possible sources of error in this experiment. How might the use of a "real" calorimeter reduce some of these errors?
2. One source of error is the flow of heat between the water in the cup and the room. Explain how this error is reduced by starting with hot water from the tap.
3. How have you demonstrated the Law of Conservation of Energy?
4. Define these terms: exothermic, endothermic, heat of fusion, 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. Define the term *joule*.
8. Here's another calorimetry problem to solve: 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. g 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?

Applications

1. What did YOU (personally) learn?
2. How can any idea, principle, or activity in this lab be used in the real world?