PHYS 1401
General Physics I

EXPERIMENT 13
LATENT HEAT OF FUSION

I. INTRODUCTION

The objective of this experiment is to determine the latent heat of fusion of ice using the method of mixtures. This will be done by measuring the initial temperatures of a certain amount of ice and warm water, mixing them in a calorimeter cup and then measuring their final temperature as they come to thermal equilibrium.

BASIC CONCEPTS

1. When a solid is being melted, heat is added to it to melt it, yet its temperature remains constant. In fact its temperature will remain the same (= the melting point of the solid) until all the solid has melted.

2. The amount of heat needed to melt a solid depends on the type of solid and its mass.

$$\begin{aligned} \text{Heat to melt a solid} &= \text{mass of the solid} \times \text{its latent heat of fusion} \\ Q &= mL_{\text{f}} \end{aligned} \tag{1}$$

3. When two substances are mixed in an insulated container such as a calorimeter cup, heat will flow from the hot substance to the cold substance. Assuming the heat absorbed by the container and the heat lost to the environment are both negligible, then

$$\text{Heat lost by the hot substance} = \text{Heat gained by the cold substance.} \tag{2}$$

4. In this experiment, the heat lost by the warm water, Q, will divide into three portions:

   (a) One portion of the heat will raise the temperature of the ice from its initial temperature to $0.0^{\circ}C$ which is its melting point. This portion of the heat will be called Q_1.

   (b) The second portion of the heat will melt the ice. This portion of the heat will be called Q_2.

   (c) The third portion of the heat will raise the temperature of the water formed by the melting ice from $0.0^{\circ}C$ to the final temperature of the mixture. This portion of the heat will be called Q_3.

5. We will write this in an equation form like this

$$Q = Q_1 + Q_2 + Q_3 \tag{3}$$

III. APPARATUS

Calorimeter, thermometer, balance, ice and water.

IV. EXPERIMENTAL PROCEDURE

1. Measure the mass of the empty calorimeter cup, m_{c} and record it in the data table.
2. Fill the calorimeter cup about half full of warm water having a temperature about $27^{\circ}C$.
3. Measure the mass of the calorimeter cup and water, $m_{\mathrm{c+w}}$.
4. Measure the initial temperature of the water, T_{iw}.
5. Measure the initial temperature of the ice, T_{ice}. This should be a negative number.
6. Dry small pieces of ice with paper towels to remove the adhering water. Add these pieces of ice to the calorimeter containing the water and watch the temperature drop. Gently stir the water.
7. When the ice is completely melted and the temperature of the water stops decreasing, measure the final temperature of the mixture, T_{f}.
8. Measure the mass of the calorimeter cup and the water. Some of the water is melted ice, $m_{\mathrm{c+w+ice}}$.

V. ANALYSIS

1. Calculate the mass of the water, m_{w} and show your calculation below.

2. Calculate the mass of the ice, m_{ice} and show your calculation below.

3. Calculate the amount of heat lost by the water. Show your calculation below. $c_{\mathrm{w}} = 1.00\,\mathrm{cal/g^{\circ}C}$

$$Q = m_{\mathrm{w}} c_{\mathrm{w}} (T_{\mathrm{w}} - T_{\mathrm{final}}) \tag{4}$$

4. Calculate Q_1 which is the amount of heat which raised the temperature of the ice from its initial temperature T_{ice} to 0.0. Take $c_{\text{ice}} = 0.530\,\text{cal/g°C}$. Show your calculation below.

$$Q_1 = m_{\text{ice}} c_{\text{ice}} (0.0 - T_{\text{ice}}) \tag{5}$$

5. Calculate Q_3 which is the amount of heat which raised the temperature of the melted ice from 0.0 to T_{final}. Take $c_{\text{w}} = 1.00\,\text{cal/g°C}$. Show your calculation below and enter your result in the data table.

$$Q_3 = m_{\text{ice}} c_{\text{w}} (T_{\text{final}} - 0.0) \tag{6}$$

6. Calculate Q_2. This is the amount of heat which melted the ice.

$$Q_2 = Q - Q_1 - Q_3 \tag{7}$$

7. Usint the equation $H_2 = m_{\text{ice}} L_{\text{f}}$, calculate the latent heat of fusion of ice, L_{f}. Show your calculation below and enter your result in the data table.

$$L_{\text{f}} = \frac{Q_2}{m_{\text{ice}}} \tag{8}$$

8. The accepted value of the latent heat of fusion of ice is 80.0 cal/g. Calculate the percent difference between your measured value and the accepted value. Show your calculation below and enter your result in the data table.

9. Write a conclusion summarizing your results. Comment on the success of this experiment. Explain any percent differences which are larger than 10%. What do you think are the two most important sources of error in this experiment?

Experiment (13) Data Table				
Mass of empty cup m_c (g)	Mass of cup+water m_{c+w} (g)	Mass of water m_w (g)	Mass of cup+water+ice $m_{c+w+ice}$ (g)	Mass of ice m_{ice} (g)

Experiment (13) Data Table				
Initial temp of warm water $T_{i,w}$ (°C)	Initial temp of ice T_{ice} (°C)	Final temp of water+ice T_f (°C)	Heat of fusion of ice L_f (cal/g°)	% difference