EXPERIMENT 3B

Specific Heat of Copper

Background:

We have learned how to determine the density of a substance. There is another important physical property of substances which is called specific heat. The **specific heat** of a substance is defined as the number of calories (cal) of heat needed to raise the temperature of 1 gram (g) of the substance 1 degree Celsius (°C). Knowing the specific heat of water (1 cal/g· °C) among with the total number of g of water and the temperature increase (measured as the difference between the final and initial temperatures of water), enables the experimenter to determine the quantity of heat absorbed or released:

$$\mathbf{Q = m_{water}\ (1\ cal/g\cdot {}^{o}C)\ (\Delta T)}$$

The measurement of heat energy changes is called **calorimetry**. A device used for these measurements is a **calorimeter**, which measures heat changes in calories. A Styrofoam coffee cup is a simple design for a calorimeter, and it produces surprisingly accurate results. It is a good insulator, and when filled with water, it can be used to measure temperature changes taking place. The change in the temperature of the water, caused by the energy flows (from a substance at a higher temperature to a substance at a lower temperature), can be used to calculate the gain or loss of the heat energy.

heat lost by substance = heat gained by water

Purpose:

In this experiment, students will determine the specific heat of copper. The copper cylinder will be heated to a high temperature then placed into a calorimeter containing a known quantity of water at a lower temperature. Having measured the mass of the water in the calorimeter, the temperature change of the water (ΔT), and knowing the specific heat of water (1 cal/g· °C), the heat gained by the water (lost by copper cylinder) can be calculated as follows:

Heat gained by water (cal) =

mass of water (g) × ΔT of water (°C) × the specific heat of water (1 cal/g· °C)

The specific heat of copper can now be calculated:

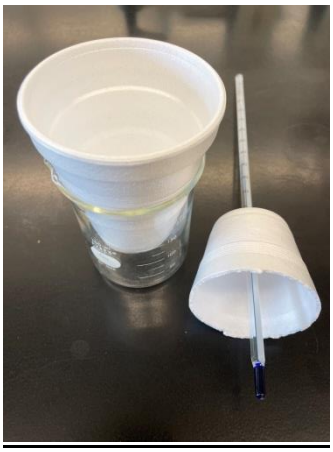
$$\textbf{Specific heat of copper} = \frac{\textbf{Heat gained by water (cal)}}{\textbf{mass of Copper (g)} \times \Delta\textbf{T of Copper (°C)}}$$

Equipment:

Balance, Styrofoam coffee cups, copper cylinder, 600-mL beaker, thermometers, 100-mL graduated cylinders, hot plate.

Procedure:

Calorimeter Apparatus:



The calorimeter used in this experiment is made by two white Styrofoam coffee cups. The bottom of the top-cut-off Styrofoam coffee cup is pierced in order to insert a thermometer. For added stability, students may place the Styrofoam coffee cup into a 250-mL breaker.

1. On the hot plate, a 600 mL beaker are filled with about 400 mL of water which is heating to boiling.

2. Obtain a sample of copper cylinder from your instructor. **Measure and record the mass of the copper cylinder in the data table.**

3. Place exactly 50.0 mL of cold water in the Styrofoam coffee cup and use the thermometer to measure the temperature of the cold water in the Styrofoam coffee cup. **Record the temperature and the volume of the cold water in the Data Table.**

4. With crucible tongs, carefully place the copper cylinder into the boiling water for about 5 minutes. This is to ensure the initial temperature of the copper cylinder same as the temperature of the boiling water. Use the thermometer to measure the highest temperature you can get from the boiling water. Ideally, the initial temperature of copper cylinder is 100 ℃**.**

5. Use crucible tongs to quickly and carefully transfer the copper cylinder from the boiling water into the Styrofoam coffee cup. Then, quickly place the top-cut-off coffee cup containing the thermometer back on the Styrofoam coffee cup.

6. Occasionally swirl the Styrofoam coffee cup. Do this slowly and gently so you do not break the thermometer. **Note and record the highest temperature reached by the contents of the Styrofoam coffee cup.**

Data table:

Volume of water in Styrofoam cup	**50.0 mL**
Density of Water	**1.0 g/mL**
Mass of water in Styrofoam cup	
Final temperature of water in Styrofoam cup	
Initial temperature of water in Styrofoam cup	
ΔT of water	
Specific heat of water	**1.00 cal/g·°C**
Mass of copper cylinder	
Initial temperature of copper cylinder	
Final temperature of copper cylinder	
ΔT of copper cylinder	

Note - The final temperature of water in Styrofoam coffee cup is same as the final temperature of copper cylinder.

Calculation and Results:

1. Calculate the heat gained by the water (lost by the substance) in the Styrofoam coffee cup using the equation in the Introduction. **Remember to write the units!!**

Heat gained by water = mass of water $\times$ ΔT of water $\times$ the specific heat of water

2. Calculate the specific heat of the copper cylinder using the answer from number 1 and the equation in the introduction. **Remember to write the units!!**

$$\text{Specific heat of copper} = \frac{\text{heat gained by water}}{\text{mass of Copper} \times \Delta\text{T of Copper}}$$

Questions:

1. The accepted value of the specific heat of copper is 0.385 J/g·°C. Calculate the percent error.
Note: 1 cal = 4.184 J

2. Why did the temperature of the water in Styrofoam coffee cup increase? How was energy transferred from the copper cylinder to the water?

3. Why is it important to keep the thermometer from touching the bottom of the Styrofoam coffee cup or the breaker while measuring the temperature? Why should the water in the Styrofoam coffee cup be stirred while measuring its temperature?