**EXPERIMENT 4**

**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:

\[ Q = m_{\text{water}} (1 \text{ cal/g·°C}) (\Delta T) \]

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 (\( \Delta T \)), 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) =

\[
mass \text{ of water (g)} \times \Delta T \text{ of water (°C)} \times \text{ the specific heat of water (1 cal/g·°C)}
\]

The specific heat of copper can now be calculated:

\[
\text{Specific heat of copper} = \frac{\text{Heat gained by water (cal)}}{mass \text{ of Copper (g)} \times \Delta T \text{ of Copper (°C)}}
\]
**Equipment:**

Balance, Styrofoam coffee cups, copper cylinder, 250-mL beaker, thermometer, 100-mL graduated cylinders, hot plate.

**Procedure:**

**Calorimeter Apparatus:**

The calorimeter used in this experiment is made by two white Styrofoam coffee cups. For added stability, one Styrofoam coffee cup is placed inside a 250-mL beaker. The bottom of the top-cut-off Styrofoam coffee cup is pierced in order to insert a thermometer.

1. Fill a 250 mL beaker with about 150 mL of water. Place it on your hot plate and begin heating the water to boiling. Use a thermometer to measure the highest temperature you can get from the boiling water.

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 water in the calorimeter (Styrofoam coffee cup) and use a thermometer to measure the temperature of the water in the calorimeter. **Record the temperature and volume in the Data Table.**

4. With crucible tongs, carefully place the copper cylinder into the boiling water for about 3 minutes. This is to ensure the initial temperature of the copper cylinder same as the temperature of the boiling water. Ideally, the initial temperature of copper cylinder is 100 °C.

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

6. Occasionally swirl the calorimeter. Do this slowly and gently so you do not break the thermometer. **Note and record the highest temperature reached by the contents of the calorimeter.**
Data table:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume of water in calorimeter</td>
<td>50.0 mL</td>
</tr>
<tr>
<td>Mass of water in calorimeter</td>
<td></td>
</tr>
<tr>
<td>Final temperature of water in</td>
<td></td>
</tr>
<tr>
<td>calorimeter</td>
<td></td>
</tr>
<tr>
<td>Initial temperature of water in</td>
<td></td>
</tr>
<tr>
<td>calorimeter</td>
<td></td>
</tr>
<tr>
<td>ΔT of water (Final - Initial)</td>
<td></td>
</tr>
<tr>
<td>Specific heat of water</td>
<td>1.00 cal/g.°C</td>
</tr>
<tr>
<td>Mass of copper cylinder</td>
<td></td>
</tr>
<tr>
<td>Initial temperature of copper</td>
<td></td>
</tr>
<tr>
<td>cylinder</td>
<td></td>
</tr>
<tr>
<td>Final temperature of copper</td>
<td></td>
</tr>
<tr>
<td>cylinder</td>
<td></td>
</tr>
<tr>
<td>ΔT of copper cylinder (Initial</td>
<td></td>
</tr>
<tr>
<td>- Final)</td>
<td></td>
</tr>
</tbody>
</table>

Note - The Initial temperature of water in calorimeter 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 calorimeter using the equation in the Introduction. **Remember to write the units!!**

\[
\text{Heat gained by water} = \text{mass of water} \times \Delta T \text{ of water} \times \text{the specific heat of water}
\]

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!!**

\[
\text{Specific heat of copper} = \frac{\text{heat gained by water}}{\text{mass of Copper} \times \Delta T \text{ of Copper}}
\]
Questions:

1. Look up the literature value of the specific heat of copper. Is your value of the specific heat of copper higher or lower than the literature value? Explain.

2. Why did the temperature of the water in calorimeter (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 calorimeter (Styrofoam coffee cup) while measuring the temperature? Why should the water in the calorimeter be stirred while measuring its temperature?