<u>SPECIFIC HEAT OF COPPER</u>

Reminder – Goggles must be worn at all times in the lab

PRE-LAB DISCUSSION:

The amount of heat required to raise the temperature of a solid body depends on its change in temperature (ΔT), its mass (m), and an intrinsic characteristic of the material forming the body called specific heat (c_p). The heat is calculated from the equation

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

The unit for c_p is thus heat per unit mass per unit temperature. The value of c_p does depend on the temperature. However, for the small temperature range we are interested in, it is a good approximation to regard c_p as temperature independent. Historically, heat (Q) was measured in terms of calories. The calorie was defined as the amount of heat required to raise the temperature of 1 gram of water by 1 °C from 14.5 °C to 15.5 °C at 1 atmosphere pressure. With this definition, the specific heat of water is 1.00 cal/(g·°C). The use of the calorie began before it was established that heat is a form of energy and 1 calorie is equivalent to 4.18 J. The joule (J) has become the more favored unit in recent years. Thus, the units for c_p that we will use are J/(g·°C). The specific heat of water is then 4.18 J/(g·°C).

When two bodies in an isolated system, initially at different temperatures, are placed in intimate contact with each other, in time they will come to equilibrium at some common intermediate temperature. Because of energy conservation, the quantity of heat lost by the hot object is equal to that gained by the cold object provided that no heat is lost to the surroundings. This is the basis for the method of calorimetry through mixture: A metal sample whose specific heat is to be determined is heated in boiling water to 100 °C. It is then quickly transferred to a Styrofoam calorimeter cup which contains a known volume of water of known temperature. When the metal specimen and the calorimeter (including the water) come to equilibrium, the final temperature is measured with a thermometer. It is assumed that the heat loss to the Styrofoam cup and thermometer is negligible and if the heat exchange with the environment is kept small, then the heat lost by the metal sample is equal to the total heat gained by the water.

PURPOSE:

To apply the experimental methods of calorimetry in the determination of the specific heat of a metal.

MATERIALS

Copper plumbing fixtures	LabPro with temperature probe
Styrofoam cup	Milligram balance
100 mL graduated cylinder	Crucible tongs
Hotplate	

PROCEDURE:

1. Get a hotplate and begin heating approximately 200 mL of water in a 400 mL glass beaker. Heat the water to boiling.
2. Get a copper object from the counter. Determine its mass to three decimal places, and record the results in the data section.
3. Lower the copper object into the water with your crucible tongs. Be careful not to <u>drop</u> the piece of copper into the beaker (you might crack the beaker).
4. Obtain a Styrofoam cup “calorimeter” and add to it 75.0 mL of water. Remembering that the density of water is 1 gram per mL, record the mass of the water in your data table.
5. Set up a LabPro CBL with a stainless steel temperature probe connected to Channel 1. Start the DataMate program (APPS button). It will auto-recognize the type of probe. Data collection mode must be set to “Time Graph,” to collect 1 data point every second for 180 seconds.
6. When the copper object has been in the <u>boiling</u> water for 3 minutes, begin the graphing of the water temperature in the calorimeter, and then quickly move the piece of copper to the calorimeter using the tongs. DO NOT try to handle the copper object with your hands. Do not allow the temperature probe to come in direct contact with the piece of copper.
7. After three minutes are up, the calculator will display the final graph of the temperature change over the three minutes. Scroll along the graph to determine the lowest temperature (initial, T_1) and the highest temperature (final, T_2). Record these values in your data table.
8. Repeat the entire procedure two more times (three total) recording new values for change in temperature.

9. When done, return the copper and the Styrofoam cup to the counter. Turn off the hotplate. Do not touch the hot water beaker or the hotplate until they have cooled enough for handling. This will usually be at least 30 minutes!

OBSERVATIONS AND DATA:

	Trial #1	Trial #2	Trial #3
1. Mass of the copper object	g	g	g
2. Volume of water in the calorimeter	mL	mL	mL
3. Initial temperature of water in calorimeter(T_1)	°C	°C	°C
4. Final (highest) temperature of calorimeter(T_2)	°C	°C	°C

CALCULATIONS: <u>Show your work</u>!

	Trial #1	Trial #2	Trial #3	Average
ΔT_{water} (T_2 - T_1)				
Δ_{copper} (T_2 - 100 °C)				

1. Copy the table above, and calculate the temperature change of the water, ΔT_{water}, T_2 - T_1 for each trial. Then calculate the average of these values for water.
2. In the same table, calculate the temperature change of the copper, ΔT_{copper}, T_2 - 100 °C (Yes your answer, will be negative). Then calculate the average of these values for copper.
3. Calculate the amount of energy absorbed by the water. In order to do this, we use the specific heat (c_p) of pure water, 4.18 J/(g·°C), and we assume the density of the water was 1.00 gram/mL. Express your final answer in joules.

$$Q_{water} = c_{p\ water} \times m_{water} \times \Delta T_{water}$$

4. Next, we assume that the energy ***absorbed*** by the water is equal to the energy ***lost*** by the copper.

$$-Q_{water} = Q_{copper}$$

On this assumption, we can calculate the specific heat of copper using the mass of the copper (m), the value of Q calculated above, and ΔT_{copper}.

$$c_{p\ copper} = \frac{Q_{copper}}{m_{copper} \cdot \Delta T_{copper}}$$

5. Using the known value of the specific heat of copper, 0.385 J/(g·°C), calculate the absolute error in your averaged experimental result.
6. Calculate your relative error (<u>PERCENT ERROR</u>). Remember that:

$$\%\,Error = \frac{Absolute\ Error}{Accepted\ Value} x100$$