

Lab Connections

YOUR CONNECTION FOR QUALITY SCIENTIFIC EDUCATIONAL LABORATORY EQUIPMENT

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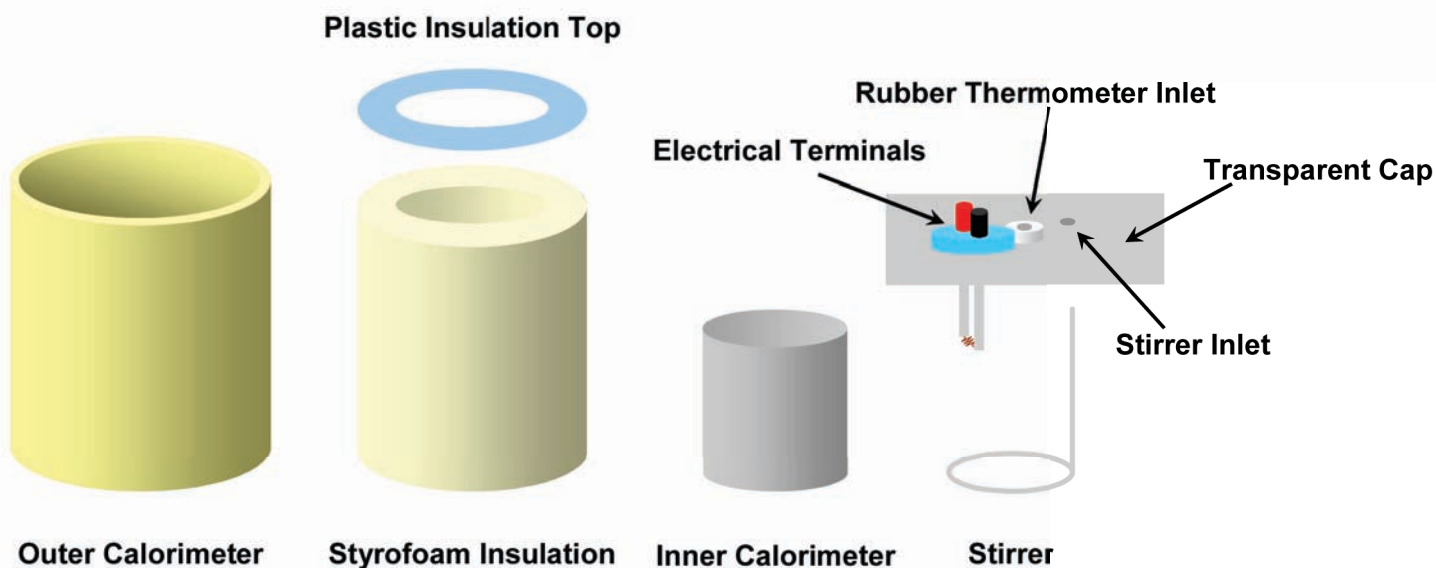
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WARNING: ADULT SUPERVISION REQUIRED. PRODUCT IS NOT A TOY. THEY ARE FOR EDUCATIONAL / LABORATORY USE ONLY. THEY ARE NOT FOR USE BY CHILDREN 12 & UNDER.

741-10 Calorimeter Electric



Parts of the Calorimeter Electric



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Required Materials Not Included



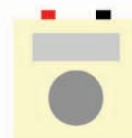
6V Battery



Ammeter and Voltmeter



or



Multimeter



Rheostat



Alligator Clips



Circuit Switch



Stopwatch

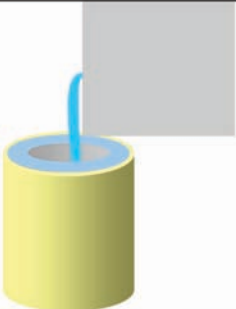
Graduated Beaker, Wire Gauge and
Burner with Tripod

2 Thermometers

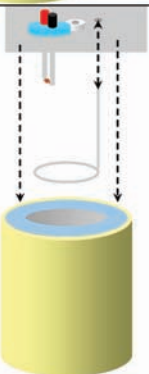
Assembling the Calorimeter Electric



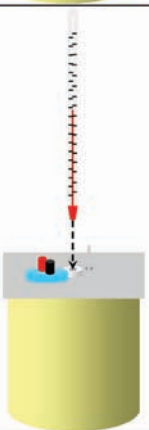
1. Place the Burner, graduated beaker and wire tripod on the table as shown in figure.



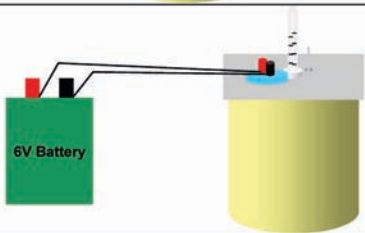
1. Place the bottom lead into the inner electrode.



2. Place the wire in the outer hole and the temperature cap over the outer electrode.



3. Insert a thermometer into the outer thermometer hole.



4. Finally, connect the red and black leads into the terminals and attach an electrode cap with a probe inside. The rest of wire attached to the terminals will keep the liquid inside the electrode.

What is Calorimetry?

Whenever a chemical reaction or physical change of substances in a system takes place, energy is either released or absorbed. When energy is absorbed by a system, the process that takes place is called **endothermic**. A simple example of an endothermic process could be the melting of ice cubes. When energy is released by a system, the process is said to be **exothermic**. An example of an exothermic process could be the burning of a candle. The transfer of energy whether from a endothermic or exothermic process, comes in the form of heat. **Calorimetry** is the measurement of heat in chemical reactions or physical changes. A **calorimeter** is a tool used to measure the heat transferred in a chemical reaction.

Different substances do not absorb or release heat at the same rates. For example, if 100 grams of water was placed in a pot for 10 minutes on a burner that was 100°C, the rise in temperature should be different than the rise in temperature of 100 grams of copper that was placed in a pot for 10 minutes on a burner that was 100°C. This is because water and copper have different values for a quantity called **specific heat**. **Specific heat** describes the amount of heat required to raise a certain amount of a substance 1°C. Therefore, the rate amount of energy transferred, or heat, in a substance depends on the temperature change, mass of the substance and its specific heat.

$$Q = mc\Delta T$$

$$\text{Amount of Energy Transferred (Heat)} = Q$$

$$\text{Mass} = m$$

$$\text{Specific Heat} = c$$

$$\text{Temperature Change} = \Delta T$$

Specific heat is measured in units of calories per gram per °C or joules per gram per °C.

$$\text{Units for Specific Heat} = \frac{\text{J}}{\text{g}^\circ\text{C}} = \frac{\text{cal}}{\text{g}^\circ\text{C}}$$

1 calorie is the amount of heat required to raise 1 gram of water 1°C. It is equivalent to about 4.2 joules. Therefore the specific heat of water is 1 cal/g °C or 4.2 joules/g °C.

Calorimeters can also measure the specific heat of a substance. However, when operating a calorimeter in an experiment with a liquid, both the liquid and the calorimeter will absorb heat. Therefore, in order to accurately calculate the specific heat of the liquid, it is helpful to prepare the calorimeter in water and the system consists of a mixture of the original liquid and water. The water equivalent of the calorimeter will then have to be calculated. The **water equivalent** of a calorimeter is the amount of water that will absorb the same amount of heat as the substance for a given temperature increase. For substance of mass m , has a specific heat of c in units of $\text{J/g}^\circ\text{C}$, and undergoes a temperature increase of ΔT , then the heat absorbed will be:

$$Q = mc\Delta T$$

If the water equivalent of the calorimeter is w , then w grams of water can absorb the same amount of heat:

$$w = 4.2 \text{ J/g}^\circ\text{C} \times \Delta T = Q = mc\Delta T$$

$$w = \frac{mc\Delta T}{4.2 \text{ J/g}^\circ\text{C}}$$

If the specific heat of the substance is described in units of cal/g $^{\circ}$ C, then the water equivalent of the substance is,

$$w = (C \text{ cal/g } ^{\circ}\text{C}) \times \Delta T = w \times \Delta T = q$$

$$w = \frac{q}{\Delta T}$$

$$w = m \times 1$$

When dividing by the specific heat of water, 1, the specific heat of the substance becomes evident. The units for water equivalent is g/1 cal = g/cal.

A method for measuring the water equivalent for the substance is given in lab 41.

Lab #1: Measuring the Water Equivalent of the Calorimeter Electric

Objective: Determine the water equivalent of the Calorimeter Electric

Materials:

1. 40 mL beaker with 40 mL of room temperature water. Heat a thermometer and record the water temperature, T_1 , in table 1. Do not remove the thermometer from the calorimeter.
2. 2.00 g of ice cubes. Heat the water to about 90°C using the burner with input and wire gauze and the second thermometer. Note the final temperature, T_2 , and m in table 1.
3. Immediately pour the water into the Calorimeter Electric with the room temperature water. Cover the calorimeter with a lid and stir the water with the stirrer.
4. The final temperature of the mixture, T_3 , will be the temperature that is constant for a minute or two. Note this temperature and m in table 1.

Procedure:

1. Fill the Calorimeter Electric with 40 mL of room temperature water. Heat a thermometer and record the water temperature, T_1 , in table 1. Do not remove the thermometer from the calorimeter.
2. Fill a beaker with 40 mL of water. Heat the water to about 90°C using the burner with input and wire gauze and the second thermometer. Note the final temperature, T_2 , and m in table 1.
3. Immediately pour the water into the Calorimeter Electric with the room temperature water. Cover the calorimeter with a lid and stir the water with the stirrer.
4. The final temperature of the mixture, T_3 , will be the temperature that is constant for a minute or two. Note this temperature and m in table 1.

Table 1

Temperature of room temperature water T_1	Temperature of hot water T_2	Final temperature of water mixture T_3

5. Calculate the water equivalent of water using the method below. (Heat of water = 1 g of water)

Heat gained by room temperature water and calorimeter = Heat lost by hot water

$$m_1 c_1 (T_3 - T_1) + W (T_3 - T_1) = m_2 c_2 (T_2 - T_3)$$

$$m_1 c_1 T_3 - T_1 = m_2 c_2 T_2 - T_3$$

$$m_1 c_1 T_3 - T_1 = m_2 c_2 T_2 - T_3$$

$$W = \frac{m_1 c_1 (T_3 - T_1)}{T_2 - T_3}$$

W = Water Equivalent of calorimeter (g)

Water Equivalent of Calorimeter = _____

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Lab #2: Measuring the Specific Heat of a Liquid

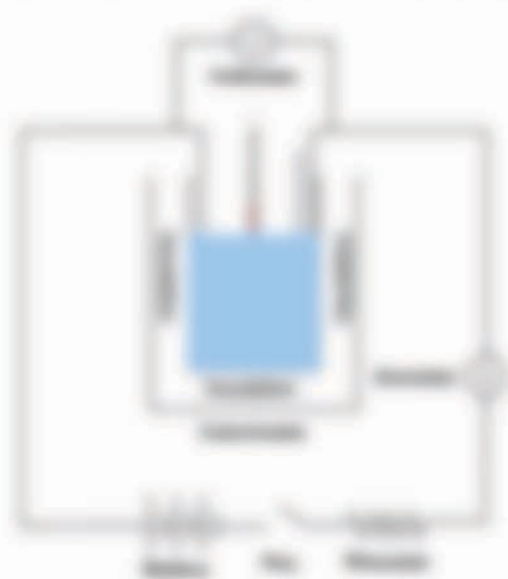
Objective: Determine the specific heat of a liquid.

Materials:

- 1. An insulated cup of the Calorimeter System
- 2. Thermometer
- 3. Liquid
- 4. Thermometer and thermometer holder
- 5. Battery
- 6. Switch
- 7. Voltmeter
- 8. Ammeter

Procedure:

1. Write the water equivalent of the Calorimeter System found from lab #1 in table 1.
2. Weigh the amount of liquid in grams that is to be placed in the calorimeter. Record in table 1.
3. Pour the liquid in the Calorimeter System. Place a thermometer in the thermometer rack. Record the temperature of the liquid in table 1.
4. Assemble a circuit with the Calorimeter System as shown below. Attach the circuit to the terminals on the top of the cup. Make sure that the ammeter is connected in series with the battery and the thermistor. The voltmeter should be connected in parallel with the battery. If using a multimeter instead of a voltmeter and ammeter, connect the circuit in series. Do not turn on the circuit.



5. Gradually turn on the circuit with the circuit key and start the stopwatch. Note the voltage and current. Record in table 1.
6. Turn off the circuit and stop the stopwatch when the temperature of the liquid rises about 10°C. Record the temperature and the amount of time taken to reach this temperature in table 1.

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Table 2

Mass of Copper + Calorimeter (g)	Mass of Liquid (g)	Initial Temperature (°C)	Final Temperature (°C)	Temperature Difference (°C)	Current (A)	Time (sec)

8. Calculate the specific heat of the liquid using the data from table 42 and the method below.

$$Q = Wt$$

Q = Heat produced by cell (J)
 W = Potential difference in the cell (V)
 t = Current flowing through the cell (A)
 τ = Time the current is turned on (sec)

$$m(L_f - T_f) = w(20.0) \text{ Jg}^{-1} \text{ } ^\circ\text{C}^{-1} (T_f - T_i) = Wt$$

$$m = w(20.0) \text{ Jg}^{-1} \text{ } ^\circ\text{C}^{-1} \frac{W}{(T_f - T_i)}$$

$$w = \frac{m(T_f - T_i)}{20.0} = \frac{Wt}{20.0}$$

m = Mass of liquid (g)
 w = Specific heat of liquid (Jg⁻¹ °C⁻¹)
 W = Voltage measured at Calorimeter Reading (V)
 T_i = Initial temperature of the liquid (°C)
 T_f = Final temperature of liquid (°C)

Specific Heat = _____

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