# The Equivalence of the Transfer of Energy by Electricity and Heat

## 1 Objective

- The experiment will establish the equivalence between energy transferred by electric means to that by heating.

## 2 Prelab Questions

1. Derive the equation $C = \frac{c_{cal}}{c_w} = \frac{m_h(T_h - T_f) - m_c(T_f - T_c)}{T_f - T_c}$. Where $C$ is the mass equivalent of the calorimeter, $m_c$ and $m_h$ are the masses of the cold and hot water respectively, $T_f$ is the final temperature of the mixture, $c_{cal}$ is the heat capacity of the calorimeter, $c_w$ is the heat capacity of the water and $T_c$ and $T_h$ are the temperatures of the cold and hot water respectively.

2. Knowing that you will be using an electrical heating coil, write an expression by which you can calculate the electrical energy $E_{elec}$ used for heating.

3. Identify the following quantity: $c_w(C + m_w)(T_f - T_c)$.

## 3 Principles

- Water is warmed up by electric means.

- The electric energy provided is found and used to compare with heat needed to warm up the water by the same amount.

# 4 Apparatus

- Calorimeter (thermos).
- Heating coil attached to the calorimeter lid.
- Thermometer.
- Ammeter and voltmeter.
- Stopwatch.
- Wires and power supply.

# 5 Precautions

1. Minimize heat loss as much as possible.
2. The heating coil is fargile and can snap when subject to high temperatures/electric current values. Do not exceed a temperature of 50° and a current of 2 A.

# 6 Experimental Steps

## 6.1 Part 1:

1. Find the mass of the dry and clean calorimeter without the cover $m_{cal}$.
2. Fill the calorimeter with 300 g of tap water and record the temperature $T_{cal}$.
3. Cover the calorimeter and note that the heating coil is in place.
4. Insert a thermometer through the hole in the cover and make sure it reaches the water but does not come into contact with the heating coil.
5. Connect the voltmeter to the outlets of the heating coil.

6. Connect the power supply to the ammeter and the calorimeter. Refer to the figure in the helpful site and your lab TA.
7. Switch on the power supply and the stop watch at the same time.
8. Record the current $I$ and voltage $V$. The operating current should be about 2 A.
9. Record the temperature $T$ every 5 minutes, for 50 minutes.
10. Dispose of the water in the calorimeter and allow it to cool for 15 minutes at least.

### 6.2 Part 2: Calculating C

Some of the heat provided by the coil to the calorimeter-water system will be absorbed by the calorimeter. This heat is given by $Q_{cal}$. There exists an equivalent amount of water $C$ that will compensate for this effect. This quantity of calorimeter-equivalent water $C$ will be added to the mass of the rest of water in the calorimeter, allowing us to drop $Q_{cal}$ in the calorimetery equation.

1. Use about 120 g of cold water at room temperature $T_c$ and mix it with about 120 g of hot water $T_h$ at [50 - 60]° in the calorimeter.
2. From the known values for water calculate the amount of heat $Q$ absorbed by calorimeter.
3. Assume the same heat capacity of water for the calorimeter to get the mass equivalence of calorimeter to water. Let this mass be known as $C$.

## 7 Evaluation

1. Calculate $C$ for the calorimeter.
2. Plot a graph between the time $t$ in minutes and temperature $T$ in $°C$ and find the slope of the line.
3. Refering to the definition of heat $Q$, and using the heat capacity of water $c_w$ and the slope, calulate the thermal power $P_{th}$.
4. Calculate the energy used to warm up the water $Q_{th}$.
5. Compare $Q_{th}$ to the electric energy $E_{elec}$ used up in this experiment.

## 8 Postlab Questions

1. Describe the calorimeter used in this experiment. How does the assembly make the calorimeter useful for use in this experiment?
2. Is there a difference between the energy calculated form the heat capacity of water and calorimeter and that provided by the heating coil (electric energy)? If there is a difference, what could be the reasons behind it?
3. If you ignore the effect of the calorimeter in the calculation $C$, how will this effect your results?
4. Find the units of: $c_w(C + m_w)(T_f - T_c)$.

## 9 Helpful Sites (clickable links)

- Converting electrical energy into heat energy. Measuring with a voltmeter and an ammeter.