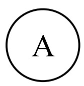
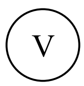
Electrical Equivalent of Heat

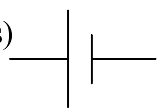
Saddleback College

Purpose:
Determine the Electrical Equivalent of Heat using an Electrical Calorimeter and compare it to the theoretical value.

Equipment:

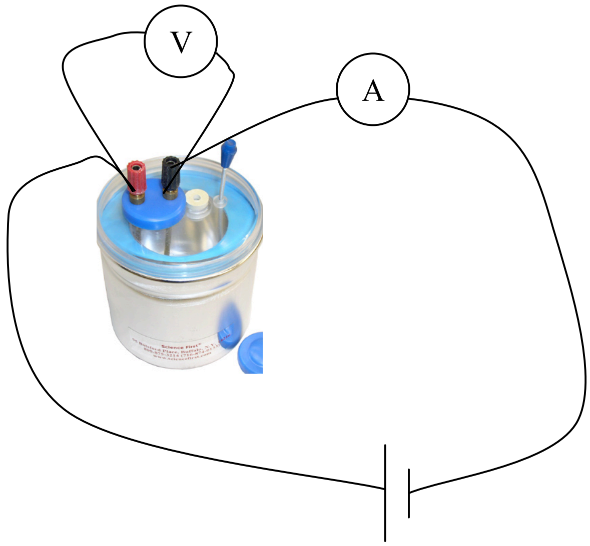
Electrical Calorimeter (including coils, stirrer and calorimeter)
Water
Leads
Ammeter 

Voltmeter 

Battery (5 – 6 Volts) 

Thermometer
Timer

http://www.thesciencefair.com/Merchant2/graphics/00000001/ElecCalormtr741_M.jpg



Theory:

Equating the Electrical Energy to the Heat Energy, allows the specific heat of the water to be calculated as shown below.

Let

I = *Current* read from ammeter
V = Voltage read from voltmeter
t = time
m = mass of water, including water equivalent of stirrer, leads & coil
c = specific heat of water $\left(use\ 1\frac{cal}{g \cdot C^{\circ}} \right)$
ΔT = temperature change of water (final temperature – initial temperature) in Celsius or Kelvins

$$Electrical\ Energy = Power \cdot time = \left(I \cdot V\right) \cdot t \qquad (1)$$

$$Heat\ Energy\ \text{(stored in water)} = mc\Delta T \qquad (2)$$

Notice that eqn (1) will be in units of Joules since:

$$\text{Amps} \cdot \text{Volts} \cdot \text{seconds} = \left(\frac{\text{Coulombs}}{\text{second}}\right) \cdot \left(\frac{\text{Joule}}{\text{Coulomb}}\right) \cdot \text{second} = \text{Joules}$$

Notice that equation (2) will have units of calories.
Calculate equation (1) & then calculate equation (2) then set them equal to each other.

The last step is to divide both sides of the new equation by the heat energy (numerical value only) this should yield something similar to the *accepted electrical equivalent of heat* seen below:

1 calorie = 4.186 Joules

Procedure:

1. The heating coil is to be placed in a double-walled calorimeter with sufficient amount of water to cover entirely the heating coil; this water to have a temperature between 5 and 10 degrees below the temperature of the room. The heating coil, an ammeter and a battery (~ 6 Volt) should be put in series (see Figure 2) with a switch so that the circuit can be closed at a given instant and the exact time observed during which the current is flowing.
2. A voltmeter is also connected to the terminals of the heating coil so that the correct voltage difference across the coil can be observed by the voltmeter. This should be observed several times during the experiment and a mean reading of the instrument obtained. The same is true of the ammeter.
3. The inner vessel of the calorimeter should be weighted accurately by itself and this weight recorded. It should also be weighted with enough water, as stated above, to cover completely the heating coil and the second weight should also be recorded. The temperature of the water should be obtained after the heating coil is in position and the water stirred carefully so that the temperature will be uniform. Care should be observed that the water is not stirred so rigorously as to splatter some outside of the calorimeter or so quickly that it will significantly raise the temperature of the water.
4. Having taken the temperature of the water (as stated, this should be 5 to 10 degrees below room temperature) with a thermometer reading preferably to fifths of a degree, close the switch of the circuit at a given instant, recording the time and temperature.
5. Read both the voltmeter and the ammeter at intervals of one or two minutes keeping the water stirred so that the heat from the coil will not localize at any point.
6. Let the current flow until the temperature is the same number of degrees above the temperature of the room that it started below. This balances all heat losses due to radiation.
7. Observe the time of opening the switch, then stir the water carefully and observe the highest temperature reached by the thermometer. Just previous to cutting the current both ammeter and voltmeter should have been read.
8. Observe the water equivalent of the leads, stirrer and coil as stamped on the fiber top of the calorimeter. This value represents the number of grams of water which has the heating value equivalent to the referenced (above) metal. This water equivalent value should be added to the number of grams of water in the calorimeter.

Analysis:

Follow the instructions in the theory to calculate the experimental Electrical Equivalent of Heat.

The theoretical value for the electrical equivalent of heat is 4.186 J = 1 cal.

See the table below for sample values of the water equivalent of calorimeter, leads, stirrer and coils.

Water equivalent of calorimeter	16.1 g
Water equivalent of leads, stirrer, coils	2.5 g

Be sure to discuss heat losses that were not accounted for, in your conclusion.