Determination of the Specific Heat of Water

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1 Purpose

The purpose of this lab is to calculate the specific heat of water from the power dissipated by resistor.

2 Materials

The materials required for this lab are an ammeter, voltmeter, variable voltage DC power supply, resistor, water, insulating styrofoam cup, and a thermometer. The circuit is set up as in the following diagram:

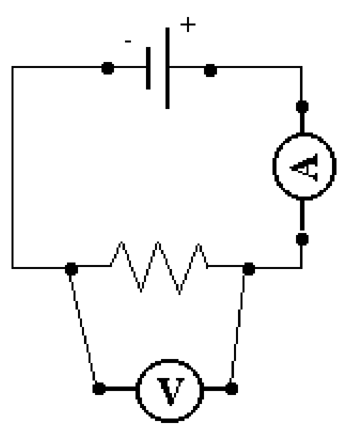

Figure 1: **Schematic of resistive circuit**

3 Procedure

A resistor in the specified circuit is submerged in a known quantity of water with a temperature a few degrees below room temperature. An electromotive force of about 3V is applied to the resistor until the water reaches a temperature exceeding room temperature by an amount equal to the original temperature depression relative to the room temperature. The time for this process to occur is recorded along with the actual supplied voltage and drawn current. Then, the specific heat of water is determined from the data.

4 Data

The following data were collected:

Mass of water (g)	I (A)	V (V)	Time (s)	T_i (°C)	T_f (°C)
23	2.78	2.97	60	18.0	22.0

5 Calculations

Since we know $P = I \cdot V$ and that $P = \frac{W}{t}$, we can calculate the total energy change in the system (W):

$$\begin{aligned} P &= \frac{W}{t} \\ W &= P \cdot t \\ W &= I \cdot V \cdot t \end{aligned}$$

Also, since we know that $W = m \cdot C \cdot \Delta T$ where W is the energy change in the system, m is the mass of the water, C is the specific heat of the water, and ΔT is the change in the water temperature, we can calculate C:

$$\begin{aligned} W &= m \cdot C \cdot \Delta T \\ C &= \frac{W}{m \cdot \Delta T} \\ C &= \frac{I \cdot V \cdot t}{m \cdot \Delta T} \end{aligned}$$

Substituting in the values from the data table, we have:

$$C = \frac{2.77\,\mathrm{A} \cdot 2.97\,\mathrm{V} \cdot 60\,\mathrm{s}}{23\,\mathrm{g} \cdot (22.0°\mathrm{C} - 18.0°\mathrm{C})} = 5.4\,\frac{\mathrm{J}}{\mathrm{g°C}}$$

Therefore, the specific heat according to the lab is $5.4\,\frac{\mathrm{J}}{\mathrm{g}^\circ\mathrm{C}}$.

Since the actual specific heat of water is $4.2\,\frac{\mathrm{J}}{\mathrm{g}^\circ\mathrm{C}}$, the experimental error is $\frac{5.4-4.2}{4.2} = 29\%$

6 Observations

During the course of the experiment, there was a slightly audible sizzling sound and bubbles were emanating from the resistor. It was most likely steam from the heat of the resistor.

There was a problem with following the accepted procedure for the lab due to mob mentality despite knowing better. This is an interesting psychological observation.

7 Conclusions

With this lab, we found that the specific heat of water is about halfway between 0 and $10\,\frac{\mathrm{J}}{\mathrm{g}^\circ\mathrm{C}}$, and that power is indeed dissipated from a resistor. The lab illustrated that energy is conserved during heat transfers even when the source of the energy is electrical energy. The result was off by a somewhat significant amount of 29%, but at least it was within the same order of magnitude.

The main error in this lab is a lack of following procedure exactly, limiting the precision of the time required for heating to about 1 significant digit (the temperature was taken every 30 seconds for some strange reason). Also, the water was not stirred after the power was turned off so the actual final temperature is flawed. I think these are fine examples of human error. Assuming the procedure was accurately followed, some error could be accrued from the loss of energy to the environment, lack of precision in the testing instruments, and the resistivity of the water the resistor was submerged in. The resistivity can be controlled by using distilled water, and the energy loss can be fixed by either conducting the experiment in a vacuum or using a calorimeter that is better insulated.