Quiz # 5
Physics 222, Section 009
Feb. 28, 2008

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1. Suppose that in last week's experiment we used instead of water some liquid that has twice the specific heat capacity of water. Assuming that the mass of the (aluminum) calorimeter cup is much less than that of the liquid it holds, which of the following is going to happen?
    a. The slope of temperature versus time will roughly double.
    b. The slope of temperature versus time will be roughly halved.
    c. The value of J will double.
    d. The value of J will be halved.
    e. Such a change will neither affect the temperature versus time plot, not the value of J because the power delivered VI is kept constant.

2. Again, referring to last time's experiment; if you ran your experiment several times, and consistently obtained a value of J that is a bit larger than what you expect, it is reasonable to attribute this to systematic error. State (without detail) two probable sources of such an error (*you will get bonus points if you come up with more than two*)

    a. _____

    b. _____

    c. _____

    d. _____

3. The main goal of today's experiment is to determine:
    a. Charge of the electron.
    b. Mass of the electron.
    c. Charge of the proton.
    d. Mass of the proton.
    e. All of the above.
    f. None of the above.

Solution

1. **(3 points)** First, let's rule out answers that are clearly wrong, and those are **(c)** and **(d)**, as they imply that the constant of conversion J will change. The whole idea of the experiment is that energy is transformable completely between the electrical form (measured in Joules) and the heat form (measured in calories). If J were to change by changing conditions of the experiment, this would means that the equivalence of these two types of energy is not correct. Let's now write out the conservation of energy equation to see what would change:

$$E_{elect} = Q$$
$$I\,V\,\Delta t = J\,(m_{liq}\,c_{liq} + m_{cal}\,c_{cal})\,\Delta T$$

where '*liq*' refers to the liquid, and '*cal*' refers to calorimeter cup. Rearranging:

$$\frac{\Delta T}{\Delta t} = \frac{I\,V}{J\,(m_{liq}\,c_{liq} + m_{cal}\,c_{cal})}$$

Now, because m_{cal} is much less than m_{liq}, we can neglect it by approximation:

$$\frac{\Delta T}{\Delta t} \approx \frac{I\,V}{J\,(m_{liq}\,c_{liq})}$$

From this, it is easy to see that if c_{liq} is doubled, the slope would be halved, as the stand in inverse proportionality relative to each other. So, the answer is **(b)**.

2. **(2 points per correct reason)** From the conservation of energy equation from the previous question, we see that a value of J that is consistently higher than what we expect means that the input electrical energy is higher than what gets converted, in other words it looks like some of the energy we put in is lost not going where we want it to go. Here are two main reasons why this could happen:

   a. The calorimeter cup is not well insulated, and part of the energy is dissipated to the outside environment.

   b. The liquid was not uniformly heated during the experiment, and that could happen if one doesn't stir constantly to transport the heat away from the coil and into the liquid.

   c. Some (negligible) amount of energy could be lost in the wiring.

   d. A mis-calibrated thermometer could lead to anomalies, but that's not very likely.

3. **(3 points)** Answer is **(f)**, from its name, the *e*/*m* experiment just determines this ratio, but neither *e* nor *m* individually, for that you need an independent measurement of one of them.