Name ___________________________ Partner ________________________ Date _______

Thermal Coefficient of Resistivity: E&M Lab #3

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Objective: to investigate the effect of temperature on the electrical properties of several different substances.

Equipment: electrically heated water bath, metal coil assembly, thermistor assembly, rubber stopper, thermometer or GLX explorer with temperature probe, multimeter, computer with Excel.

Background: Each real material provides resistance to the flow of electric current through it. In most cases this resistance is affected by the temperature of the material. The actual mechanism causing the effect is not the same for different classes of materials.
What is the conversion from degrees Celsius to degrees Kelvin?

Procedure:
1. Put the metal coil into the water bath and place the thermometer or temperature probe in the rubber stopper so that the bulb is centered in the water and not touching the coil. Add cold tap water to the bath to just cover the metal coil. Connect the probes from your multimeter to the binding post terminals on the top of the coil apparatus. Make sure that the stirring ring is free to move up and down.

2. Record the resistance of the coil and the temperature of the water bath.
Turn on the heater and record the resistance and the temperature roughly every 5 degrees Celsius. Keep stirring every few seconds. You may need to turn off the heater sometimes while you stir to get a reliable temperature reading. Stop at 80 degrees C.

3. Carefully remove the metal coil apparatus and pour out the hot water. Be careful not to burn yourself or your lab partner!

4. Fill the water bath with fresh cold tap water and put in the thermistor apparatus. Turn on the heater and take measurements of the resistance and the temperature up to 80 degrees.

5. Repeat the measurements for either the metal coil or for the thermistor to investigate reproducibility.

Analysis:
I. For most metals the expected behavior of resistance R with temperature T in degrees C is

$$R(T) = R_0 + a * R_0 * T$$

where R_0 is the resistance at T = 0 degrees C.

Plot R vs. T.
Fit a linear trendline.
Determine R_0, the slope, and a.

For copper, a = 0.0043/C.
Is this coil made of copper? __________

Repeat the analysis for your second set of coil data and discuss any differences.
Try combining the data on the same graph.

II. For your thermistor data plot R vs. T.
Is the relationship the same as for the metal? ________
Is the relationship linear? ________

For most thermistors the resistance is given by

$R(T) = R_a * \exp(b * (1/T - 1/T_a))$

where T_a is the lowest temperature you used, in degrees Kelvin. R_a is the resistance at that temperature.

We can simplify the equation by dividing both sides by R_a, then by taking a natural logarithm of both sides.

Then $\ln(R(T)/R_a) =$

What should you plot vs. what to get a straight line?

Do the plot.
Fit a linear trendline, and find b.
The value from the manufacturer for our type of thermistor is 3530 $\pm$ 80 degrees K.
Calculate your error and discuss.

Discussion Questions:
1. What are thermistors made of and how are they manufactured?
(What does NTC mean?)
2. Look up explanations of the actual mechanism of the temperature effect on resistance in metals and thermistors. Tabulate some values of a and b for various materials.
3. List some uses of this effect in practical devices.