Temperature Coefficient of Resistance

PURPOSE:

To investigate the change in the resistance of a coil of wire as the temperature of the coil is varied.

THEORY:

Since the electrical resistance of a conductor such as a copper wire is dependent upon collisional processes within the wire, the resistance could be expected to increase with temperature since there will be more collisions. When a potential difference, V, exists across a length of metallic conductor it is observed that negative charges flow in the conductor, from low to high electric potential, due to the electric field associated with the potential difference. A charge flow, called a current, **I**, is taken to be positive in the direction positive charges move in response to an electric field. In real life, many electrical circuits employ currents caused by the motions of electrons, which have negative charge; therefore, the actual direction of motion of the charged particles runs *opposite* to the direction of the current. A linear relationship is observed between the current through and the potential difference across a conductor. This relationship, called Ohm's Law, is often stated as:

$$\mathbf{V = I.R} \quad \text{or} \quad \mathbf{R = V/I}$$

Where R is resistance in ohms

V is voltage in volts and A is current in amperes.

For most materials, the resistance changes with temperature. If the temperature range is not too large, the resistance is a linear function of the temperature, **T**, and can be expressed as:

$$\mathbf{R_T = R_0 . (1+ \alpha.T)} \quad \text{or} \quad \mathbf{\alpha = (R_T - R_0)/ R_0 .T} \qquad \mathbf{(1)}$$

T = temperature of interest (deg Celsius
R_0 = resistance at reference temperature (usually 0˚C)
R_T = resistance at temperature of interest
α = temperature coefficient of resistance (1/deg Celsius)

If the resistance of a conductor is measured at several different temperatures, a graph of the data will be linear with a slope of $\boldsymbol{\alpha.R_0}$ and a vertical intercept at $\mathbf{R_0}$ at $\mathbf{0^{\circ}C}$.

Apparatus: copper wire, beaker, stirrer, thermometer, heating arrangement and digital multi-meter.

PROCEDURE:

In this experiment, you will determine the resistance of a coil of copper wire while its temperature is varied from room temperature to near boiling temperature. The resistance will be measured using a digital multi-meter.

1. Take enamel coated copper wire of 40 gauges and fold it at midpoint. Now wind non-inductively the folded wire on suitable length of wooden /rubber rod. Using sand-paper to remove the coating from both ends of the copper wire. Connect these ends with the multi-meter through connectors.
2. Place approximately 200 ml of tap water in the beaker and place it on the heating arrangement. Holding the resistor and the thermometer fix making sure that the resistor coil and the bulb of the thermometer are near each other and sufficiently submersed in the water. Thus the thermometer measures the temperature of the water. The temperature of the coil will be the same as the temperature of the water assuming that it remains in thermal equilibrium with the water.
3. Turn on the gas supply and adjust the flame.
4. Push the resistance (Ω) knob while you watch the multi-meter's display.
5. Make measurements of resistance and temperature as water warms up from room temperature to near boiling. Record your readings in the table.
6. Record the measurements of resistance and temperature as water cools down afterwards.
7. You are to plot resistance vs. temperature on linear graph paper. Fit a line to the data on this graph. From the slope of this line and its vertical intercept at T_0, determine R_0 and the temperature coefficient of resistance α(from equ.1). In you report you should compare your value for α with that found in literature.
8. Draw separate graphs for the warming-up and cooling-down processes.

Safety Precautions: Don't touch portions of the apparatus which are hot!

Temperature ˚C	Resistance (Ω)	
	Warming	Cooling
40		
45		
50		
55		
60		
65		
70		
75		
80		
85		
90		
95		