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Temperature Effect on Conductivity of Copper

[1]Sawsan Ahmed Elhouri Ahmed, [2]Amel Abdalla Ahmed & [3]Alaa Ahmed Mohammed

*[1]University of Bahri- College of Applied & Industrial Sciences-
Department of Physics- Khartoum - Sudan*
*[2,3]Sudan University of Science & Technology-College of Science-
Department of Physics-Khartoum-Sudan*

Abstract: In this work the value of thermal conductivity coefficient was found for three wires, pure copper wire, 15 and 50 cm long copper wire coated with soldering block tin. The comparison of thermal conductivity values for these three wires shows clearly the effect of temperature on copper .
As the thermal conductivity coefficient of the three wires were found and calculated; resistivity was found as well. The obtained results coincide with the theoretical consideration.

Introduction

Electrical resistivity (also known as **resistivity**, **specific electrical resistance**, or **volume resistivity**) is an intrinsic property that quantifies how strongly a given material opposes the flow of electric current. A low resistivity indicates a material that readily allows the flow of electric current. Resistivity is commonly represented by the Greek letter ρ (rho). The SI unit of electrical resistivity is the ohm·metre (Ω·m) [1, 2, and 3] although other units like ohm·centimetre (Ω·cm) are also in use. As an example, if a 1 m × 1 m × 1 m solid cube of material has sheet contacts on two opposite faces, and the resistance between these contacts is 1 Ω, then the resistivity of the material is 1 Ω·m. **Electrical conductivity** or **specific conductance** is the reciprocal of electrical resistivity, and measures a material's ability to conduct an electric current. It is commonly represented by the Greek letter σ (sigma), but (kappa) (especially in electrical engineering) or γ (gamma) are also occasionally used. Its SI unit is siemens per meter (S/m) and CGSE unit is reciprocal second (s^{-1}).

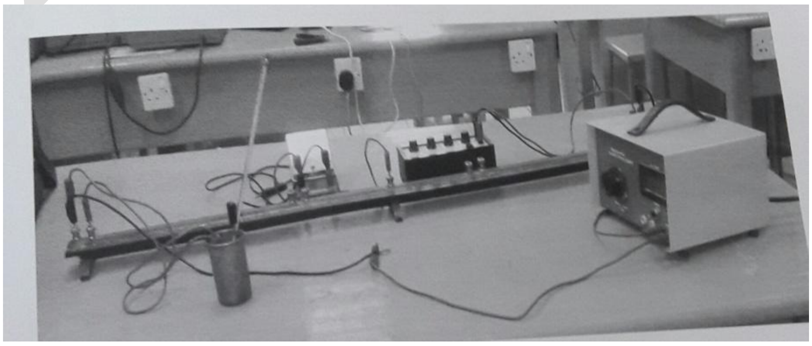
Experimental Setup

Materials

Standard resistance (S = 1 Ω), Galvanometer, DC power supply, two holders, thermometer, calorimeter, heater, Wheatstone bridge, micrometer, and the three copper wires pure copper wire, 15 and 50 cm long copper wire coated with soldering block tin.

Procedure

The circuit was connected as shown below in series; the wires were placed inside the calorimeter respectively (pure copper wire, 15 cm long copper wire coated with soldering block tin and finally 50 cm long copper wire coated with soldering block tin). Temperature was set at 100 ˚C. Using the Wheatstone bridge the current was set at balance state (zero volt), then as the temperature increases the Galvanometer starts to read. L_1 represents the length between the wire at the Wheatstone bridge and the known resistance (1Ω) and L_2 represents the length of the wire at the Wheatstone bridge to the unknown resistance of the three copper wires of the experiment. Results were tabulated as follow:



Results

Table (1) the relationship between the net resistance and temperature for the pure copper wire

Temperature (◦C)	Length (L_1) cm	Length (L_2) cm	$R = S\frac{L_1}{L_2}/\Omega$
90	10.3	89.7	0.115
80	9.9	90.1	0.109
70	9.5	90.5	0.105
60	9.1	90.9	0.100
50	8.9	91.1	0.098
40	8.6	91.4	0.094
30	8.0	92.0	0.087

Table (2) the relationship between the net resistance and temperature for 15 cm long copper wire coated with soldering block tin

Temperature (◦C)	Length (L_1) cm	Length (L_2) cm	$R = S\frac{L_1}{L_2}/\Omega$
90	10.1	89.7	0.112
80	9.2	90.8	0.101
70	9.0	91.0	0.099
60	9.3	90.7	0.103
50	9.0	91.0	0.099
40	8.5	91.5	0.093
30	8.7	91.3	0.095

Table (3) the relationship between the net resistance and temperature for 50 cm long copper wire coated with soldering block tin

Temperature (◦C)	Length (L_1) cm	Length (L_2) cm	$R = S\frac{L_1}{L_2}/\Omega$
90	8.8	91.2	0.096
80	7.6	92.4	0.082
70	7.5	92.5	0.081
60	7.4	92.6	0.080
50	7.1	92.9	0.076
40	7.1	92.9	0.076
30	7.3	92.7	0.079

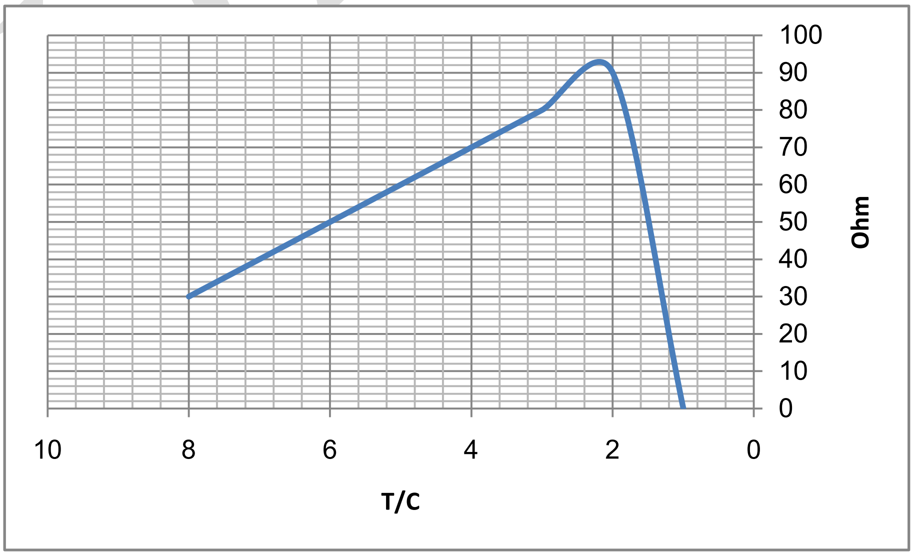


Fig (1) The Relationship between resistance and pure copper wire

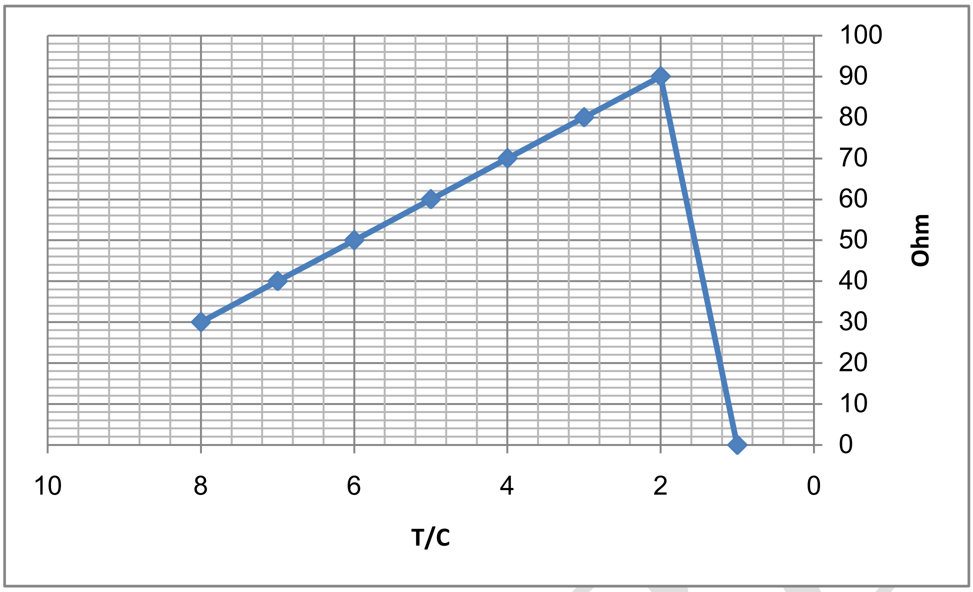


Fig (2) The Relationship between resistance and 15 cm long copper wire coated with soldering block tin

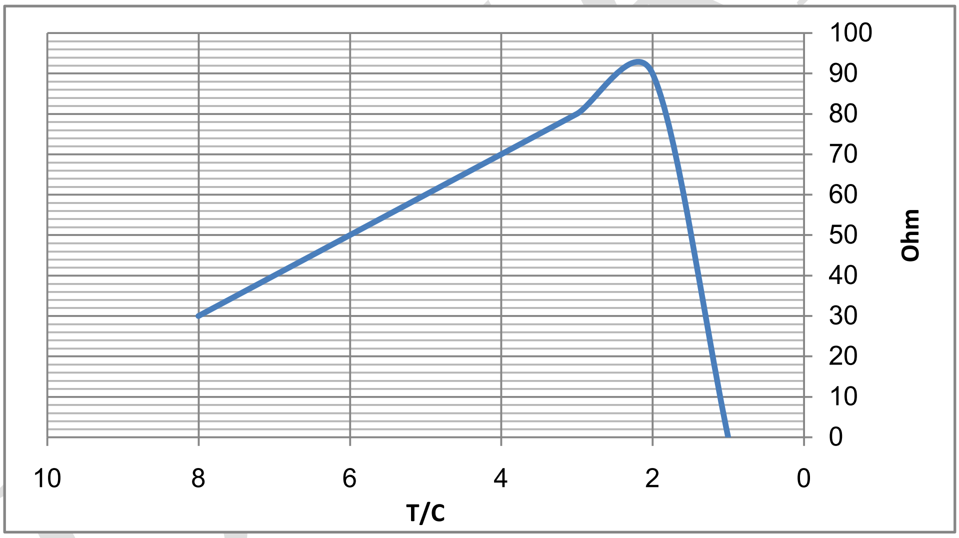


Fig (3) The Relationship between resistance and 50 cm long copper wire coated with soldering block tin

Calculation

a) Pure copper wire

From graph (1) and the equation below:

$$\rho = \frac{\pi r^2}{L} R \quad (1)$$

Where

ρ = resistivity

r = radius of the wire

L = Length of the wire

R = Resistance

$$\alpha = \frac{0.038}{0.072 X 88} = 5.99\ X\ 10^{-3}/°C^{-1}$$

From equation (1)

$$\rho = \frac{\pi (0.039)^2}{50}\ X\ 0.101 = 9.65\ X\ 10^{-6} \Omega\ cm$$

$\rho = 9.65\ X\ 10^{-8} \Omega m$

b) 15 cm long copper wire coated with soldering block tin

$$\alpha = \frac{0.02}{0.084 X 76} = 3.13\ X\ 10^{-3} /°C^{-1}$$

From equation (1)

$$\rho = \frac{\pi (0.0405)^2}{50}\ X\ 0.100 = 1.03\ X\ 10^{-5} \Omega\, cm$$

$\rho = 1.03\ X\ 10^{-7} \Omega m$

c) 50 cm long copper wire coated with soldering block tin

$$\alpha = \frac{0.013}{0.069 X 75} = 2.51\ X\ 10^{-3} /°C^{-1}$$

From equation (1)

$$\rho = \frac{\pi (0.0443)^2}{50}\ X\ 0.081 = 1.003\ X\ 10^{-5} \Omega\, cm$$

$\rho = 1.003\ X\ 10^{-7} \Omega m$

Discussion

Tables (1, 2 & 3) as well as graphs representing these tables shows that as the temperature rises the value of resistance increases.
The intercept of the curves with the y-axis gives the value of the resistance at room temperature of the three copper wires.
The results are shown for the three copper wires respectively (pure copper wire, 15 cm long copper wire coated with soldering block tin and finally 50 cm long copper wire coated with soldering block tin)

R_0/□	Figures
0.072	1
0.084	2
0.069	3

From the table we found that:

- The least resistance value is for the 50 cm long copper wire coated with soldering block tin while the largest one is for the 15 cm long copper wire coated with soldering block tin.
- The thermal coefficient for the three wires is slightly differs due to the soldering tin coating and did not affect the thermal conductivity.
- The resistivity for each wire varies due to the diameter of the wire itself. As conductivity decreases whenever resistivity increases

Conclusion

From the results it is noted that the thermal conductivity is very sensitive for temperature and the resistivity of the three copper wires increased with the increasing of temperature.

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