(DC1-6) Temperature Dependent Resistance, PTR, NTR

Aim of experiment

Determination of the temperature coefficient of resistance

Apparatus

Glass Beaker with Sand Bath – Test Tube –Metal Resistance; Sample1, and Semiconductor Resistance; Sample2 – Thermometer – Ohmmeter – Heater.

Theory of experiment

The temperature coefficient of resistance is defined as the fractional change in resistance per degree Celsius rise in temperature.

There are two types of the temperature coefficient of resistance:

1- Negative temperature coefficient of resistance NTCR: in which the resistance decreases with rise in temperature as happened in semiconductors. In this case the relation between resistance and temperature is given by, *figure 1.*

$$R = R(T) = R_{ref}\, e^{-\varepsilon / 2kT}$$

$$R = R_{ref}\, e^{\alpha T}$$

$$\alpha = \frac{(R - R_{ref}) / R_{ref}}{T - T_{ref}} = \frac{1}{R_{ref}} \frac{dR}{dT}$$

$$\alpha = -\frac{\varepsilon}{2kT^2}$$

Where, ε is the activation energy, K Boltzmann's constant and T absolute temperature. R_{ref} is the resistance at a reference temperature, chosen on the curve, *figure 1.*

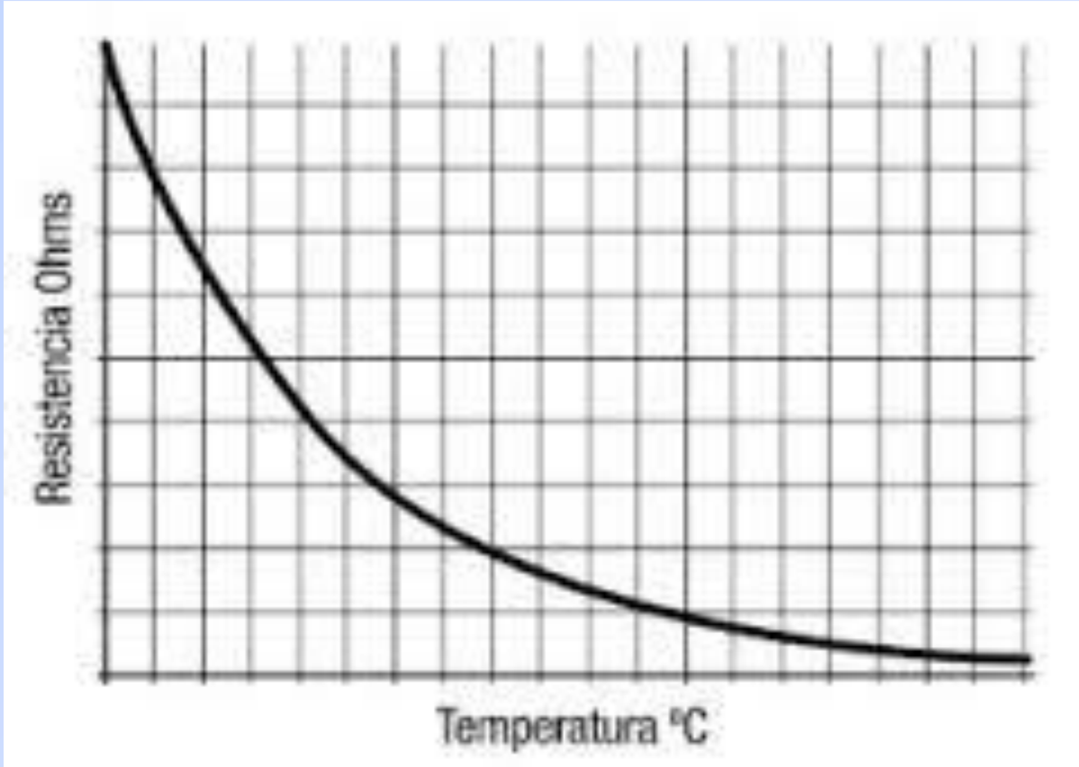

Figure 1 Resistance as a function of temperature for a NTCR sample

The constant α is called the temperature coefficient of resistance. Thus

$$\alpha = (R_T - R_{ref}) / R_{ref}\, \Delta T$$

$$\alpha = \Delta R / R_{ref}\, \Delta T$$

2- Positive temperature coefficient of resistance, PTCR, in which the resistance increases with rise in temperature as happened in metals. In this case the relation between resistance and temperature is given by

$$R(T) = R_{ref}\,(1 + \alpha\, \Delta T + \beta\, \Delta T^2)$$

Where α and β are constants, RT and R_{ref} are the resistances of the metal at temperatures T^oC and $T_{ref}{}^oC$ respectively. The constant β is very small compared to α, and for moderate temperature ranges the law of variation may be taken as

$$R_T = R_{ref}\,(1 + \alpha\, \Delta T)$$

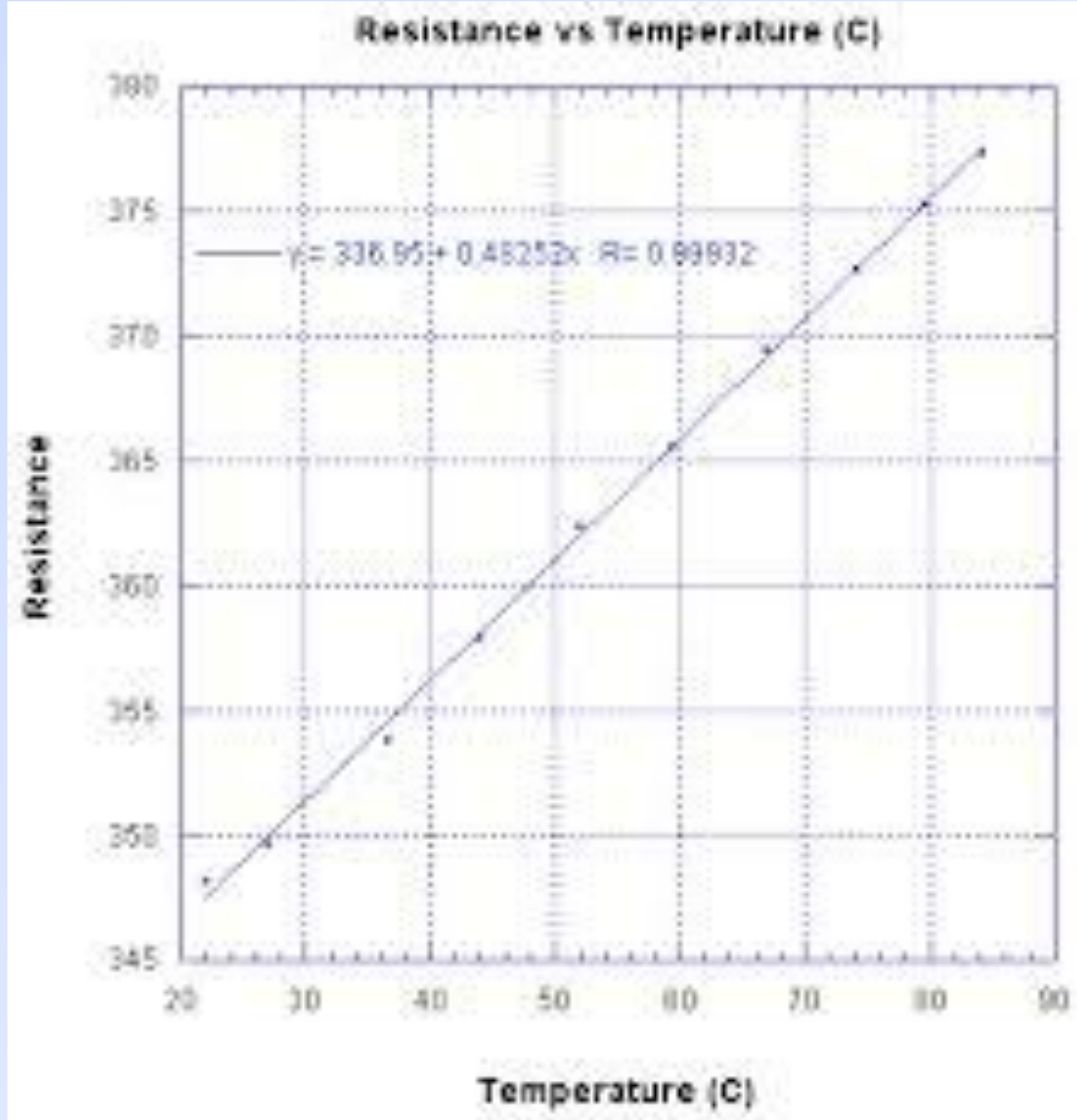

Figure 2 Resistance as a function of temperature for a PTCR sample

Procedures

1. Put the samples and thermometer in a test tube and insert the tube in the sand bath in a glass beaker.
2. Connect the two terminals of the two samples, respectively to the ohmmeter, and record the resistance R_{ref}, *figure 3*.
3. Put the beaker and its contents on the heater, and rise the temperature.
4. Read the temperature from 30°C to 90°C in steps 5°C and record the corresponding resistance for each reading, for both samples respectively.
5. Draw a graph between the change in temperature ΔT on x-axis and change in resistance ΔR on y-axis for both samples.
6. Determine the temperature coefficient of resistance α, from the relation, α = slope / R_{ref} for sample1 (PTCR).

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7. Determine the temperature coefficient of resistance α, for sample 2 **(**NTCR**),** from the relation,

$$\alpha = \frac{(R - R_{ref})/R_{ref}}{T - T_{ref}} \left(= \frac{1}{R_{ref}} \frac{dR}{dT} \right)$$

8. Calculate the activation energy from the relation

$$\alpha = -\frac{\varepsilon}{2kT^2} \; .$$

9. Compare your results with the data in tables.

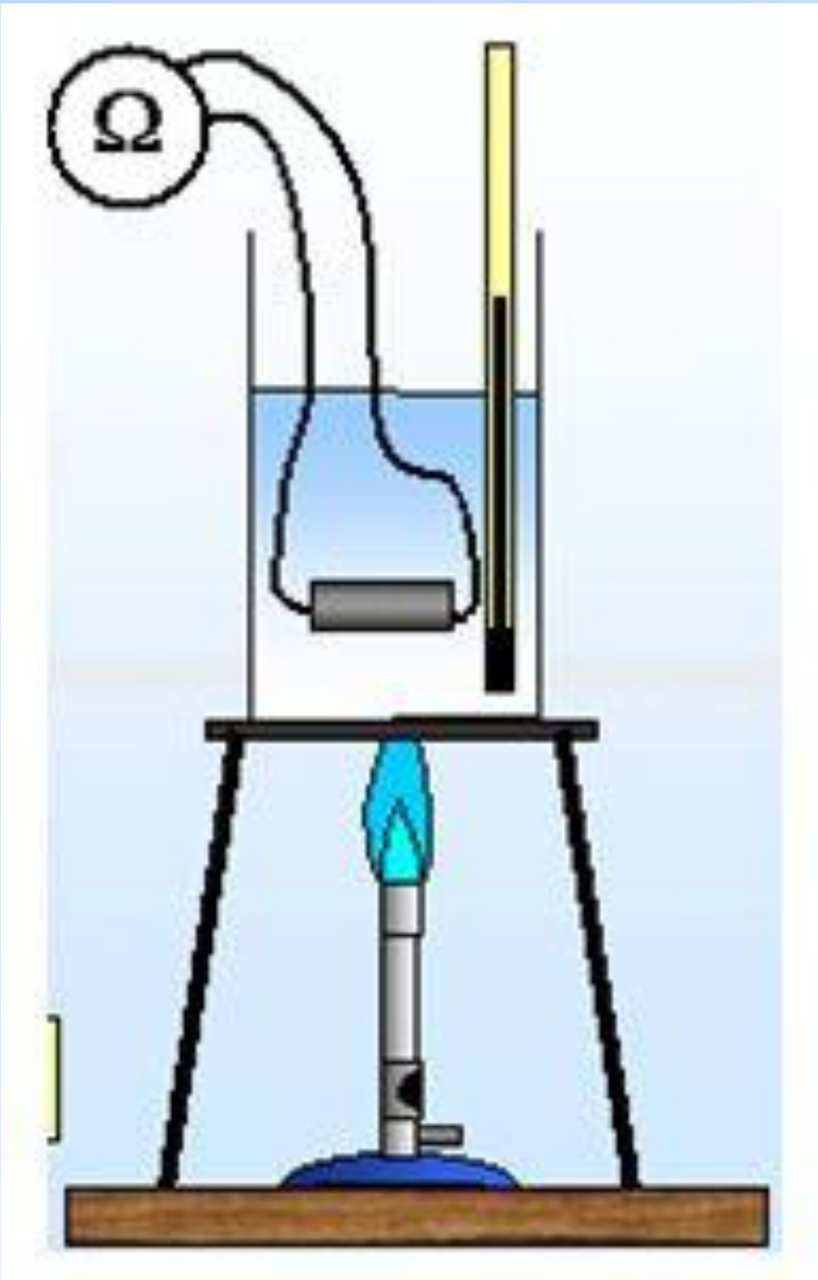

Figure 3 Experiment set up

Results

Sample 1 For the metal material, PTCR

T (°C)	R (Ω)	ΔT (°C)	ΔR (Ω)	T (°C)	R (Ω)	ΔT (°C)	ΔR (Ω)

R_{ref} = Ω T_{ref}= °C

α = $°C^{-1}$

Sample 2 For the semiconductor material, NTCR

T (°C)	R (Ω)	ΔT (°C)	ΔR (Ω)	T (°C)	R (Ω)	ΔT (°C)	ΔR (Ω)

α = $(°C)^{-1}$

ε = (eV)