Answer Question #64547 – Physics – Electric Circuit

When an iron wire and a carbon rod, each having the same 10 ohm resistance at 25 deg.celcius, are cooled from that temperature to -80 deg.celcius, find the ratio of the resistance of the carbon rod to the resistance of the iron wire at the lower temperature?

Solution. With increasing temperature in the metal increased the amplitude of thermal motion of atoms, reduces mean time between collisions of electrons with thermal lattice vibrations, and thus leads to the growth of resistivity with temperature. Since the range of measured temperatures, that $R = \frac{\rho L}{S}$, where L (the length of the conductor) and S (cross-sectional area) are constant, the increase in electrical resistance can be expressed using a simplified formula:

$$R = R_0\big(1 + \alpha(t - t_0)\big)$$

where R is the resistance at temperature t and R_0 is the resistance at temperature t_0, α – the temperature coefficient of electrical resistance.

Using tabular data the temperature coefficient of electrical resistance for iron and carbon:

$$\alpha_i = 0.005K^{-1} \text{ and } \alpha_c = -0.0005K^{-1}.$$

According to the condition of the problem

$R_{0i} = R_{0c} = 10\Omega$ at temperature $t_0 = 25^0C$.

After cooling the iron wire and a carbon rod to a temperature $t = -80^0C$ we get resistance

$R_i = R_{0i}\big(1 + \alpha_i(t - t_0)\big)$ – for iron,

$R_c = R_{0c}\big(1 + \alpha_c(t - t_0)\big)$ – for carbon.

Hence the ratio of the resistance of the carbon rod to the resistance of the iron wire at the lower temperature

$$\frac{R_c}{R_i} = \frac{R_{0c}\big(1 + \alpha_c(t - t_0)\big)}{R_{0i}\big(1 + \alpha_i(t - t_0)\big)} = \frac{1 + \alpha_c(t - t_0)}{1 + \alpha_i(t - t_0)} = \frac{1 - 0.0005(-80 - 25)}{1 + 0.005(-80 - 25)} \approx 2{,}216$$

Answer. 2.216