27. (a) A 34.5-m length of copper wire at 20.0 °C has a radius of 0.25 mm. If a potential difference of 9.0 V is applied across the length of the wire, determine the current in the wire. (b) If the wire is heated to 30.0 °C while the 9.0-V potential difference is maintained, what is the resulting current in the wire?

Solution

(a) For copper, the resistivity is $\rho = 1.7 \times 10^{-8}\ \Omega \cdot \text{m}$

and the temperature coefficient of resistivity is $\alpha = 3.9 \times 10^{-3}\ (^\circ\text{C})^{-1}$

Therefore, the resistance of this wire at $T = T_0 = 20.0\ ^\circ\text{C}$ is

$$R_0 = \frac{\rho L}{A} = \frac{\rho L}{\pi r^2} = \frac{\left(1.7 \times 10^{-8}\ \Omega \cdot \text{m}\right)(34.5\ \text{m})}{\pi\left(0.25 \times 10^{-3}\ \text{m}\right)^2} = 3.0\ \Omega$$

When a 9.0-V potential difference is applied across the length of this wire, Ohm's law gives the resulting current as

$$I_0 = \frac{\Delta V}{R_0} = \frac{9.0\ \text{V}}{3.0\ \Omega} = 3.0\ \text{A}$$ ◊

(b) At $T = 30.0\ ^\circ\text{C}$, the resistance is given by $R = R_0\left[1 + \alpha\left(T - T_0\right)\right]$ and the current becomes

$$I = \frac{\Delta V}{R} = \frac{9.0\ \text{V}}{(3.0\ \Omega)\left[1 + \left(3.9 \times 10^{-3}\ (^\circ\text{C})^{-1}\right)(30.0\ ^\circ\text{C} - 20.0\ ^\circ\text{C})\right]} = 2.9\ \text{A}$$ ◊