**J. Qureshi** **Current and Resistance Problems(Soln)**
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(1) A wire of Nichrome (a nickel–chromium–iron alloy commonly used in heating elements) is 1.0 m long and 1.0 mm$^2$ in cross-sectional area. It carries a current of 4.0 A when a 2.0 V potential difference is applied between its ends. Calculate the conductivity s of Nichrome. •

We find the conductivity of Nichrome (the reciprocal of its resistivity) as follows:

$$\sigma = \frac{1}{\rho} = \frac{L}{RA} = \frac{L}{(V/i)A} = \frac{Li}{VA} = \frac{(1.0\ \text{m})(4.0\ \text{A})}{(2.0\ \text{V})(1.0\times10^{-6}\ \text{m}^2)} = 2.0\times10^{6}\ /\ \Omega\cdot\text{m}.$$

(2) A wire 4.00 m long and 6.00 mm in diameter has a resistance of 15.0 mΩ . A potential difference of 23.0 V is applied between the ends.

(a) What is the current in the wire? (b) What is the magnitude of the current density? (c) Calculate the resistivity of the wire material. (d) Using Table 26.1 identify the material. •

) $i = V/R = 23.0\ \text{V}/15.0\times10^{-3}\ \Omega = 1.53\times10^{3}\ \text{A}.$

he cross-sectional area is $A = \pi r^2 = \frac{1}{4}\pi D^2$ . Thus, the magnitude of the current :y vector is

$$J = \frac{i}{A} = \frac{4i}{\pi D^2} = \frac{4(1.53\times10^{-3}\ \text{A})}{\pi(6.00\times10^{-3}\ \text{m})^2} = 5.41\times10^{7}\ \text{A/m}^2.$$

(c) The resistivity is

$$\rho = \frac{RA}{L} = \frac{(15.0\times10^{-3}\Omega)\pi(6.00\times10^{-3}\ \text{m})^2}{4(4.00\ \text{m})} = 10.6\times10^{-8}\ \Omega\cdot\text{m}.$$

(d) The material is platinum

(3) What is the resistivity of a wire of 1.0 mm diameter, 2.0 m length, and 50Ω resistance?

$$A = \pi r^2 = \pi\left(0.50 \times 10^{-3}\ \text{m}\right)^2 = 7.85 \times 10^{-7}\ \text{m}^2.$$

**ANALYZE** Thus, the resistivity of the wire is

$$\rho = \frac{RA}{L} = \frac{\left(50\times10^{-3}\Omega\right)\left(7.85\times10^{-7}\,\text{m}^2\right)}{2.0\,\text{m}} = 2.0\times10^{-8}\Omega\cdot\text{m}.$$

(4) A common flashlight bulb is rated at 0.30 A and 2.9 V (the values of
the current and voltage under operating conditions). If the resistance
of the tungsten bulb filament at room temperature (20/C) is 1.1 Ω ,
what is the temperature of the filament when the bulb is on?

The resistance at operating temperature $T$ is $R = V/i = 2.9$ V/0.30 A = 9.67 Ω. Thus,
m $R - R_0 = R_0\alpha(T - T_0)$, we find

$$T = T_0 + \frac{1}{\alpha}\left(\frac{R}{R_0} - 1\right) = 20°\text{C} + \left(\frac{1}{4.5\times10^{-3}/\text{K}}\right)\left(\frac{9.67\Omega}{1.1\Omega} - 1\right) = 1.8\times10^3\ °\text{C}.$$

ıce a change in Celsius is equivalent to a change on the Kelvin temperature scale, the
ue of $\alpha$ used in this calculation is not inconsistent with the other units involved. Table
·1 has been used.

(5) When 115 V is applied across a wire that is 10 m long and has a 0.30 mm radius, the magnitude of the current density is 1.4 x $10^8$ A/$m^2$ .
Find the resistivity of the wire.

3. We use $J = E/\rho$, where $E$ is the magnitude of the (uniform) electric field in the wire, $J$ the magnitude of the current density, and $\rho$ is the resistivity of the material. The ectric field is given by $E = V/L$, where $V$ is the potential difference along the wire and $L$ the length of the wire. Thus $J = V/L\rho$ and

$$\rho = \frac{V}{LJ} = \frac{115\ \text{V}}{(10\ \text{m})\left(1.4\times10^8\ \text{A/m}^2\right)} = 8.2\times10^{-8}\Omega\cdot\text{m}.$$