Name: Key

Practice - 20.3 Resistance and Resistivity

1. What is the resistance of a 20.0-m-long piece of 12-gauge copper wire having a 2.053-mm diameter? (ρ_{Cu} = 1.72 x 10^{-8} Ω·m)

$$R = \rho\frac{L}{A} = \frac{(1.72\times10^{-8}\,\Omega\cdot m)(20.0\,m)}{\pi\left(\frac{2.053\times10^{-3}\,m}{2}\right)^2} = \boxed{0.104\,\Omega}$$

2. The diameter of 0-gauge copper wire is 8.252 mm. Find the resistance of a 1.00-km length of such wire used for power transmission. (ρ_{Cu} = 1.72 x 10^{-8} Ω·m)

$$R = \rho\frac{L}{A} = \frac{(1.72\times10^{-8}\,\Omega\cdot m)(1.00\times10^{3}\,m)}{\pi\left(\frac{8.252\times10^{-3}\,m}{2}\right)^2} = \boxed{0.322\,\Omega}$$

3. If the 0.100-mm diameter tungsten filament in a light bulb is to have a resistance of 0.200 Ω a~~t 20.0 °C~~, how long should it be? (ρ_W = 5.6 x 10^{-8} Ω·m)

$$R = \rho\frac{L}{A} \Rightarrow L = \frac{RA}{\rho} = \frac{(0.200\,\Omega)\,\pi\left(\frac{0.100\times10^{-3}\,m}{2}\right)^2}{5.6\times10^{-8}\,\Omega m} = \boxed{0.028\,m}$$

4. Find the ratio of the diameter of aluminum to copper wire, if they have the same resistance per unit length (as they might in household wiring). (ρ_{Cu} = 1.72 x 10^{-8} Ω·m and ρ_{Al} = 2.65 x 10^{-8} Ω·m)

$$\frac{R_{Al}}{L_{Al}} = \frac{R_{Cu}}{L_{Cu}} \Rightarrow \frac{\rho_{Al}}{A_{Al}} = \frac{\rho_{Cu}}{A_{Cu}} \Rightarrow \frac{A_{Al}}{A_{Cu}} = \frac{\rho_{Al}}{\rho_{Cu}} \Rightarrow \frac{\pi\left(\frac{d_{Al}}{2}\right)^2}{\pi\left(\frac{d_{Cu}}{2}\right)^2} = \frac{\rho_{Al}}{\rho_{Cu}}$$

$$\Rightarrow \frac{d_{Al}}{d_{Cu}} = \sqrt{\frac{\rho_{Al}}{\rho_{Cu}}} = \sqrt{\frac{(2.65\times10^{-8}\,\Omega\cdot m)}{(1.72\times10^{-8}\,\Omega\cdot m)}} = \boxed{1.24}$$

5. What current flows through a 2.54-cm-diameter rod of pure silicon that is 20.0 cm long, when 1.00×10^3 V is applied to it? (Such a rod may be used to make nuclear-particle detectors, for example.) (ρ_{Si} = 2300 Ω·m)

$$I = \frac{V}{R} = \frac{V}{\frac{\rho L}{A}} = \frac{AV}{\rho L} = \frac{\pi \left(\frac{2.54 \times 10^{-3} m}{2}\right)^2 (1.00 \times 10^3 V)}{(2300\ \Omega \cdot m)(20.0 \times 10^{-3} m)} = \boxed{1.10 \times 10^{-3} A}$$

6. A wire is drawn through a die, stretching it to four times its original length. By what factor does its resistance increase?

As $L\uparrow$, $A\downarrow$ Volume = constant = AL

$\Rightarrow L \uparrow 4X \Rightarrow A \downarrow 4X$

$L_{NEW} = 4 L_{OLD}$ & $A_{NEW} = \frac{A_{old}}{4}$

$$\frac{R_{NEW}}{R_{OLD}} = \frac{\frac{\rho L_{new}}{A_{NEW}}}{\frac{\rho L_{old}}{A_{old}}} = \frac{\rho \frac{4 L_{old}}{\frac{1}{4} A_{old}}}{\rho \frac{L_{old}}{A_{old}}} = \boxed{16}$$