TABLE 18–1 Resistivity and Temperature Coefficients (at 20°C)

Material	Resistivity, ρ ($\Omega \cdot$ m)	Temperature Coefficient, α $(C°)^{-1}$
Conductors		
Silver	1.59×10^{-8}	0.0061
Copper	1.68×10^{-8}	0.0068
Gold	2.44×10^{-8}	0.0034
Aluminum	2.65×10^{-8}	0.00429
Tungsten	5.6×10^{-8}	0.0045
Iron	9.71×10^{-8}	0.00651
Platinum	10.6×10^{-8}	0.003927
Mercury	98×10^{-8}	0.0009
Nichrome (Ni, Fe, Cr alloy)	100×10^{-8}	0.0004
Semiconductors†		
Carbon (graphite)	$(3–60) \times 10^{-5}$	−0.0005
Germanium	$(1–500) \times 10^{-3}$	−0.05
Silicon	0.1–60	−0.07
Insulators		
Glass	$10^{9} – 10^{12}$	
Hard rubber	$10^{13} – 10^{15}$	

† Values depend strongly on the presence of even slight amounts of impurities.

EXAMPLE 18–5 **Speaker wires.** Suppose you want to connect your stereo to remote speakers (Fig. 18–14). (*a*) If each wire must be 20 m long, what diameter copper wire should you use to keep the resistance less than 0.10 Ω per wire? (*b*) If the current to each speaker is 4.0 A, what is the potential difference, or voltage drop, across each wire?

APPROACH We solve Eq. 18–3 to get the area A, from which we can calculate the wire's radius using $A = \pi r^2$. The diameter is $2r$. In (*b*) we can use Ohm's law, $V = IR$.

SOLUTION (*a*) We solve Eq. 18–3 for the area A and find ρ for copper in Table 18–1:

$$A = \rho \frac{L}{R} = \frac{(1.68 \times 10^{-8}\,\Omega \cdot \text{m})(20\,\text{m})}{(0.10\,\Omega)} = 3.4 \times 10^{-6}\,\text{m}^2.$$

The cross-sectional area A of a circular wire is $A = \pi r^2$. The radius must then be at least

$$r = \sqrt{\frac{A}{\pi}} = 1.04 \times 10^{-3}\,\text{m} = 1.04\,\text{mm}.$$

The diameter is twice the radius and so must be at least $2r = 2.1$ mm.

(*b*) From $V = IR$ we find that the voltage drop across each wire is

$$V = IR = (4.0\,\text{A})(0.10\,\Omega) = 0.40\,\text{V}.$$

NOTE The voltage drop across the wires reduces the voltage that reaches the speakers from the stereo amplifier, thus reducing the sound level a bit.

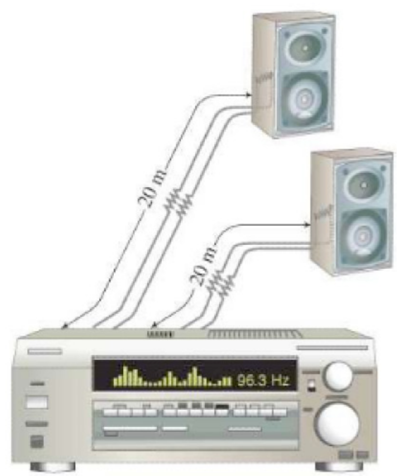

FIGURE 18–14 Example 18–5.

CONCEPTUAL EXAMPLE 18–6 **Stretching changes resistance.** A wire of resistance R is stretched uniformly until it is twice its original length. What happens to its resistance?

RESPONSE If the length L doubles, then the cross-sectional area A is halved, because the volume ($V = AL$) of the wire remains the same. From Eq. 18–3 we see that the resistance would increase by a factor of four $\left(2/\tfrac{1}{2} = 4\right)$.

EXERCISE C Copper wires in houses typically have a diameter of about 1.5 mm. How long a wire would have a 1.0-Ω resistance?