Chapter 17
Current and Resistance

Quick Quizzes

1. (d). Negative charges moving in one direction are equivalent to positive charges moving in the opposite direction. Thus, I_a, I_b, I_c, and I_d are equivalent to the movement of 5, 3, 4, and 2 charges respectively, giving $I_d < I_b < I_c < I_a$.

2. (b). Under steady-state conditions, the current is the same in all parts of the wire. Thus, the drift velocity, given by $v_d = I/nqA$, is inversely proportional to the cross-sectional area.

3. (c), (d). Neither circuit (a) nor circuit (b) applies a difference in potential across the bulb. Circuit (a) has both lead wires connected to the same battery terminal. Circuit (b) has a low resistance path (a "short") between the two battery terminals as well as between the bulb terminals.

4. (b). The slope of the line tangent to the curve at a point is the reciprocal of the resistance at that point. Note that as ΔV increases, the slope (and hence $1/R$) increases. Thus, the resistance decreases.

5. (b). Consider the expression for resistance: $R = \rho\frac{\ell}{A} = \rho\frac{\ell}{\pi r^2}$. Doubling all linear dimensions increases the numerator of this expression by a factor of 2, but increases the denominator by a factor of 4. Thus, the net result is that the resistance will be reduced to one-half of its original value.

6. (a). The resistance of the shorter wire is half that of the longer wire. The power dissipated, $\mathcal{P} = (\Delta V)^2/R$, (and hence the rate of heating) will be greater for the shorter wire. Consideration of the expression $\mathcal{P} = I^2R$ might initially lead one to think that the reverse would be true. However, one must realize that the currents will not be the same in the two wires.

7. (b). $I_a = I_b > I_c = I_d > I_e = I_f$. Charges constituting the current I_a leave the positive terminal of the battery and then split to flow through the two bulbs; thus, $I_a = I_c + I_e$. Because the potential difference ΔV is the same across the two bulbs and because the power delivered to a device is $\mathcal{P} = I(\Delta V)$, the 60–W bulb with the higher power rating must carry the greater current, meaning that $I_c > I_e$. Because charge does not accumulate in the bulbs, all the charge flowing into a bulb from the left has to flow out on the right; consequently $I_c = I_d$ and $I_e = I_f$. The two currents leaving the bulbs recombine to form the current back into the battery, $I_f + I_d = I_b$.

8. **(a)** B, **(b)** B. Because the voltage across each resistor is the same, and the rate of energy delivered to a resistor is $\mathcal{P} = (\Delta V)^2/R$, the resistor with the lower resistance (that is, B) dissipates more power. From Ohm's law, $I = \Delta V/R$. Since the potential difference is the same for the two resistors, B (having the smaller resistance) will carry the greater current.

Answers to Even Numbered Conceptual Questions

2. In the electrostatic case in which charges are stationary, the internal electric field must be zero. A nonzero field would produce a current (by interacting with the free electrons in the conductor), which would violate the condition of static equilibrium. In this chapter we deal with conductors that carry current, a nonelectrostatic situation. The current arises because of a potential difference applied between the ends of the conductor, which produces an internal electric field.

4. The number of cars would correspond to charge Q. The rate of flow of cars past a point would correspond to current.

6. The 25 W bulb has the higher resistance. Because $R = (\Delta V)^2 / \mathcal{P}$, and both operate from 120 V, the bulb dissipating the least power has the higher resistance. The 100 W bulb carries more current, because the current is proportional to the power rating of the bulb.

8. An electrical shock occurs when your body serves as a conductor between two points having a difference in potential. The concept behind the admonition is to avoid simultaneously touching points that are at different potentials.

10. The knob is connected to a variable resistor. As you increase the magnitude of the resistance in the circuit, the current is reduced, and the bulb dims.

12. Superconducting devices are expensive to operate primarily because they must be kept at very low temperatures. As the onset temperature for superconductivity is increased toward room temperature, it becomes easier to accomplish this reduction in temperature. In fact, if room temperature superconductors could be achieved, this requirement would disappear altogether.

14. The amplitude of atomic vibrations increases with temperature, thereby scattering electrons more efficiently.