

Homework #4

8. **REASONING AND SOLUTION**

a. The total charge that can be delivered is

$$\Delta q = (220 \text{ A} \cdot \text{h}) \left(\frac{3600 \text{ s}}{1 \text{ h}} \right) = \boxed{7.9 \times 10^5 \text{ C}}$$

b. The maximum current is

$$I = \frac{220 \text{ A} \cdot \text{h}}{(38 \text{ min}) \left(\frac{1 \text{ h}}{60 \text{ min}} \right)} = \boxed{350 \text{ A}}$$

10. **REASONING**

a. The resistance R of a piece of material is related to its length L and cross-sectional area A by Equation 20.3, $R = \rho L / A$, where ρ is the resistivity of the material. In order to rank the resistances, we need to evaluate L and A for each configuration in terms of L_0 , the unit of length.

	Resistance	Rank
a	$R = \rho \frac{4L_0}{L_0 \times 2L_0} = \rho \left(\frac{2}{L_0} \right)$	1
b	$R = \rho \frac{L_0}{2L_0 \times 4L_0} = \rho \left(\frac{1}{8L_0} \right)$	3
c	$R = \rho \frac{2L_0}{L_0 \times 4L_0} = \rho \left(\frac{1}{2L_0} \right)$	2

Therefore, we expect that a has the largest resistance, followed by c , and then by b .

b. Equation 20.2 states that the current I is equal to the voltage V divided by the resistance, $I = V / R$. Since the current is inversely proportional to the resistance, the largest current arises when the resistance is smallest, and vice versa. Thus, we expect that b has the largest current, followed by c , and then by a .

SOLUTION

a. The resistances can be found by using the results from the **REASONING**:

$$a \quad R = \rho \left(\frac{2}{L_0} \right) = (1.50 \times 10^{-2} \Omega \cdot \text{m}) \left(\frac{2}{5.00 \times 10^{-2} \text{ m}} \right) = \boxed{0.600 \Omega}$$

$$b \quad R = \rho \left(\frac{1}{8L_0} \right) = (1.50 \times 10^{-2} \Omega \cdot \text{m}) \left(\frac{1}{8 \times 5.00 \times 10^{-2} \text{ m}} \right) = \boxed{0.0375 \Omega}$$

$$c \quad R = \rho \left(\frac{1}{2L_0} \right) = (1.50 \times 10^{-2} \Omega \cdot \text{m}) \left(\frac{1}{2 \times 5.00 \times 10^{-2} \text{ m}} \right) = \boxed{0.150 \Omega}$$

b. The current in each case is given by Equation 20.2, where the value of the resistance is obtained from part (a):

$$a \quad I = \frac{V}{R} = \frac{3.00 \text{ V}}{0.600 \Omega} = \boxed{5.00 \text{ A}}$$

$$b \quad I = \frac{V}{R} = \frac{3.00 \text{ V}}{0.0375 \Omega} = \boxed{80.0 \text{ A}}$$

$$c \quad I = \frac{V}{R} = \frac{3.00 \text{ V}}{0.150 \Omega} = \boxed{20.0 \text{ A}}$$

20. **REASONING** The length L of the wire is related to its resistance R and cross-sectional area A by $L = AR / \rho$ (see Equation 20.3), where ρ is the resistivity of tungsten. The resistivity is known (see Table 20.1), and the cross-sectional area can be determined since the radius of the wire is given. The resistance can be obtained from Ohm's law as the voltage divided by the current.

SOLUTION The length L of the wire is

$$L = \frac{AR}{\rho} \tag{1}$$

Since the cross-section of the wire is circular, its area is $A = \pi r^2$, where r is the radius of the wire. According to Ohm's law (Equation 20.2), the resistance R is related to the voltage V and current I by $R = V / I$. Substituting the expressions for A and R into Equation (1) gives

$$L = \frac{AR}{\rho} = \frac{(\pi r^2)\left(\frac{V}{I}\right)}{\rho} = \frac{[\pi(0.0030 \times 10^{-3} \text{ m})^2]\left(\frac{120 \text{ V}}{1.24 \text{ A}}\right)}{5.6 \times 10^{-8} \Omega \cdot \text{m}} = \boxed{0.049 \text{ m}}$$

24. **REASONING AND SOLUTION** The power delivered is $P = VI$, so that we have

a. $P_{\text{bd}} = VI_{\text{bd}} = (120 \text{ V})(11 \text{ A}) = \boxed{1300 \text{ W}}$

b. $P_{\text{vc}} = VI_{\text{vc}} = (120 \text{ V})(4.0 \text{ A}) = \boxed{480 \text{ W}}$

c. The energy is $E = Pt$, so that we have

$$\frac{E_{\text{bd}}}{E_{\text{vc}}} = \frac{P_{\text{bd}}t_{\text{bd}}}{P_{\text{vc}}t_{\text{vc}}} = \frac{(1300 \text{ W})(15 \text{ min})}{(480 \text{ W})(30.0 \text{ min})} = \boxed{1.4}$$

33. **REASONING**

a. The average power \bar{P} delivered to the copy machine is equal to the square of the rms-current I_{rms} times the resistance R , or $\bar{P} = I_{\text{rms}}^2 R$ (Equation 20.15b). Both I_{rms} and R are known.

b. According to the discussion in Section 20.5, the peak power P_{peak} is twice the average power, or $P_{\text{peak}} = 2\bar{P}$.

SOLUTION

a. The average power is

$$\bar{P} = I_{\text{rms}}^2 R = (6.50 \text{ A})^2 (18.6 \Omega) = \boxed{786 \text{ W}} \quad (20.15b)$$

b. The peak power is twice the average power, so

$$P_{\text{peak}} = 2\bar{P} = 2(786 \text{ W}) = \boxed{1572 \text{ W}}$$

52. **REASONING**

a. The three resistors are in series, so the same current goes through each resistor: $I_1 = I_2 = I_3$. The voltage across each resistor is given by Equation 20.2 as $V = IR$. Because the current through each resistor is the same, the voltage across each is proportional to the resistance. Since $R_1 > R_2 > R_3$, we expect the ranking of the voltages to be $V_1 > V_2 > V_3$.

b. The three resistors are in parallel, so the same voltage exists across each: $V_1 = V_2 = V_3$. The current through each resistor is given by Equation 20.2 as $I = V/R$. Because the voltage across each resistor is the same, the current through each is inversely proportional to the resistance. Since $R_1 > R_2 > R_3$, we expect the ranking of the currents to be $I_3 > I_2 > I_1$.

SOLUTION

a. The current through the three resistors is given by $I = V/R_s$, where R_s is the equivalent resistance of the series circuit. From Equation 20.16, the equivalent resistance is $R_s = 50.0 \, \Omega + 25.0 \, \Omega + 10.0 \, \Omega = 85.0 \, \Omega$. The current through each resistor is

$$I_1 = I_2 = I_3 = \frac{V}{R_s} = \frac{24.0 \, \text{V}}{85.0 \, \Omega} = \boxed{0.282 \, \text{A}}$$

The voltage across each resistor is

$$V_1 = IR_1 = (0.282 \, \text{A})(50.0 \, \Omega) = \boxed{14.1 \, \text{V}}$$

$$V_2 = IR_2 = (0.282 \, \text{A})(25.0 \, \Omega) = \boxed{7.05 \, \text{V}}$$

$$V_3 = IR_3 = (0.282 \, \text{A})(10.0 \, \Omega) = \boxed{2.82 \, \text{V}}$$

b. The resistors are in parallel, so the voltage across each is the same as the voltage of the battery:

$$V_1 = V_2 = V_3 = \boxed{24.0 \, \text{V}}$$

The current through each resistor is equal to the voltage across each divided by the resistance:

$$I_1 = \frac{V}{R_1} = \frac{24.0 \, \text{V}}{50.0 \, \Omega} = \boxed{0.480 \, \text{A}}$$

$$I_2 = \frac{V}{R_2} = \frac{24.0 \, \text{V}}{25.0 \, \Omega} = \boxed{0.960 \, \text{A}}$$

$$I_3 = \frac{V}{R_3} = \frac{24.0 \, \text{V}}{10.0 \, \Omega} = \boxed{2.40 \, \text{A}}$$

70. **REASONING** The power P dissipated in each resistance R is given by Equation 20.6b as $P = I^2R$, where I is the current. This means that we need to determine the current in each resistor in order

to calculate the power. The current in R_1 is the same as the current in the equivalent resistance for the circuit. Since R_2 and R_3 are in parallel and equal, the current in R_1 splits into two equal parts at the junction A in the circuit.

SOLUTION To determine the equivalent resistance of the circuit, we note that the parallel combination of R_2 and R_3 is in series with R_1 . The equivalent resistance of the parallel combination can be obtained from Equation 20.17 as follows:

$$\frac{1}{R_p} = \frac{1}{576 \Omega} + \frac{1}{576 \Omega} \quad \text{or} \quad R_p = 288 \Omega$$

This 288- Ω resistance is in series with R_1 , so that the equivalent resistance of the circuit is given by Equation 20.16 as

$$R_{\text{eq}} = 576 \Omega + 288 \Omega = 864 \Omega$$

To find the current from the battery we use Ohm's law:

$$I = \frac{V}{R_{\text{eq}}} = \frac{120.0 \text{ V}}{864 \Omega} = 0.139 \text{ A}$$

Since this is the current in R_1 , Equation 20.6b gives the power dissipated in R_1 as

$$P_1 = I_1^2 R_1 = (0.139 \text{ A})^2 (576 \Omega) = \boxed{11.1 \text{ W}}$$

R_2 and R_3 are in parallel and equal, so that the current in R_1 splits into two equal parts at the junction A. As a result, there is a current of $\frac{1}{2}(0.139 \text{ A})$ in R_2 and in R_3 . Again using Equation 20.6b, we find that the power dissipated in each of these two resistors is

$$P_2 = I_2^2 R_2 = \left[\frac{1}{2}(0.139 \text{ A}) \right]^2 (576 \Omega) = \boxed{2.78 \text{ W}}$$

$$P_3 = I_3^2 R_3 = \left[\frac{1}{2}(0.139 \text{ A}) \right]^2 (576 \Omega) = \boxed{2.78 \text{ W}}$$
