Homework week 7

64. ***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

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

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

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

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

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

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

65. $\boxed{\text{SSM}}$ $\boxed{\text{WWW}}$ ***REASONING*** Since we know that the current in the 8.00-Ω resistor is 0.500 A, we can use Ohm's law ($V = IR$) to find the voltage across the 8.00-Ω resistor. The 8.00-Ω resistor and the 16.0-Ω resistor are in parallel; therefore, the voltages across them are equal. Thus, we can also use Ohm's law to find the current through the 16.0-Ω resistor. The currents that flow through the 8.00-Ω and the 16.0-Ω resistors combine to give the total current that flows through the 20.0-Ω resistor. Similar reasoning can be used to find the current through the 9.00-Ω resistor.

SOLUTION

a. The voltage across the 8.00-Ω resistor is $V_8 = (0.500\text{ A})(8.00\ \Omega) = 4.00\text{ V}$. Since this is also the voltage that is across the 16.0-Ω resistor, we find that the current through the 16.0-Ω resistor is $I_{16} = (4.00\text{ V})/(16.0\ \Omega) = 0.250\text{ A}$. Therefore, the total current that flows through the 20.0-Ω resistor is

$$I_{20} = 0.500\text{ A} + 0.250\text{ A} = \boxed{0.750\text{ A}}$$

96. ***REASONING AND SOLUTION*** According to Equation 20.21, we find that

$$R = \frac{\tau}{C} = \frac{3.0\text{ s}}{150 \times 10^{-6}\text{F}} = \boxed{2.0 \times 10^{4}\,\Omega}$$

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97. ***REASONING*** The time constant of an *RC* circuit is given by Equation 20.21 as $\tau = RC$, where *R* is the resistance and *C* is the capacitance in the circuit. The two resistors are wired in parallel, so we can obtain the equivalent resistance by using Equation 20.17. The two capacitors are also wired in parallel, and their equivalent capacitance is given by Equation 20.18. The time constant is the product of the equivalent resistance and equivalent capacitance.

SOLUTION The equivalent resistance of the two resistors in parallel is

$$\frac{1}{R_\text{p}} = \frac{1}{2.0\text{ k}\Omega} + \frac{1}{4.0\text{ k}\Omega} = \frac{3}{4.0\text{ k}\Omega} \quad \text{or} \quad \text{R}_\text{p} = 1.3\text{ k}\Omega \qquad (20.17)$$

The equivalent capacitance is

$$C_\text{p} = 3.0\ \mu\text{F} + 6.0\ \mu\text{F} = 9.0\ \mu\text{F} \qquad (20.18)$$

The time constant for the charge to build up is

$$\tau = R_\text{p}\, C_\text{p} = \left(1.3 \times 10^{3}\ \Omega\right)\left(9.0 \times 10^{-6}\ \text{F}\right) = \boxed{1.2 \times 10^{-2}\ \text{s}}$$

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98. ***REASONING*** The charging of a capacitor is described by Equation 20.20, which provides a direct solution to this problem.

SOLUTION According to Equation 20.20, in a series RC circuit the charge q on the capacitor at a time t is given by

$$q = q_0\left(1 - e^{-t/\tau}\right)$$

where q_0 is the equilibrium charge that has accumulated on the capacitor after a very long time and τ is the time constant. For $q = 0.800q_0$ this equation becomes

$$q = 0.800q_0 = q_0\left(1 - e^{-t/\tau}\right) \quad \text{or} \quad 0.200 = e^{-t/\tau}$$

Taking the natural logarithm of both sides of this result gives

$$\ln(0.200) = \ln\left(e^{-t/\tau}\right) \quad \text{or} \quad \ln(0.200) = -\frac{t}{\tau}$$

Therefore, the number of time constants needed for the capacitor to be charged to 80.0% of its equilibrium charge is

$$\frac{t}{\tau} = -\ln(0.200) = -(-1.61) = \boxed{1.61}$$