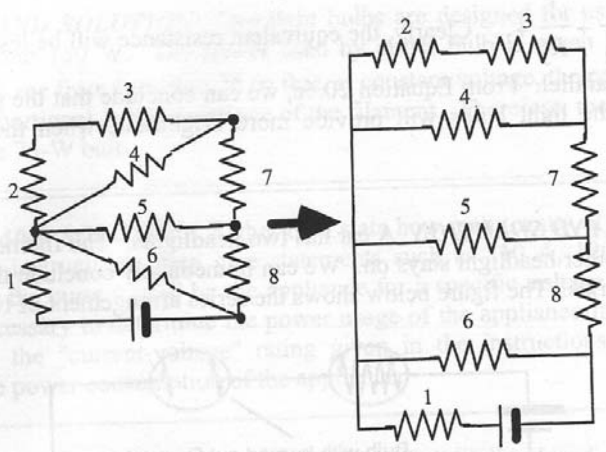
5. ***REASONING AND SOLUTION*** One electrical appliance operates with a voltage of 120 V, while another operates with a voltage of 240 V. The power used by either appliance is given by Equation 20.6c: $P = V^2 / R$. Without knowing the resistance $R$ of each appliance, no conclusion can be reached as to which appliance, if either, uses more power.

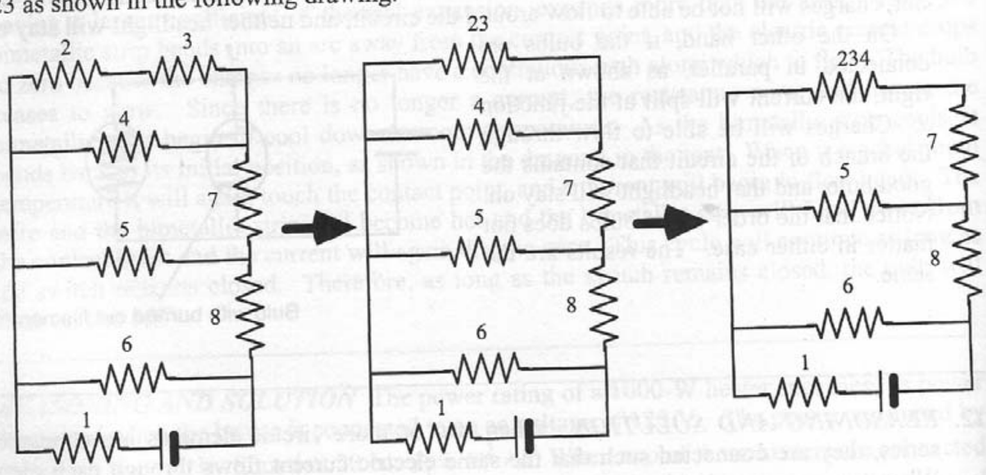
12. ***REASONING AND SOLUTION*** When two or more circuit elements are connected in series, they are connected such that the same electric current flows through each element. When two or more circuit elements are connected in parallel, they are connected such that the same voltage is applied across each element.

The circuit in Figure (*a*) can be shown to be a combination of series and parallel arrangements of resistors. The circuit can be redrawn as shown in the following drawing.

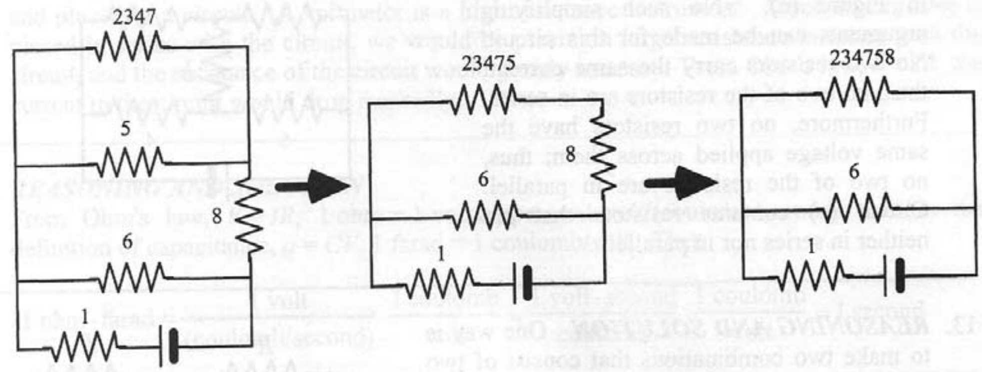




We can see in the redrawn figure that the current through resistors 2 and 3 is the same; therefore, resistors 2 and 3 are in series and can be represented by an equivalent resistance 23 as shown in the following drawing.

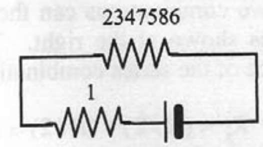


The voltage across resistance 23 and resistor 4 is the same, so these two resistances are in parallel; they can be represented by an equivalent resistance 234. The current through resistance 234 is the same as that through resistor 7, so resistance 234 is in series with resistor 7; they can be represented by an equivalent resistance 2347 as shown in the following figure.

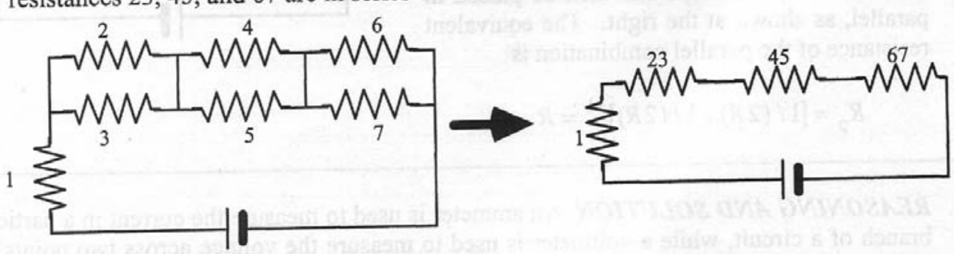



The voltage across 2347 is the same as that across resistor 5; therefore, resistance 2347 is in parallel with resistor 5. They can be represented by an equivalent resistance 23475. Similarly, resistance 23475 is in series with resistor 8, giving an equivalent resistance 234758. Resistance 234758 is in parallel with resistor 6, giving an equivalent resistance 2347586.

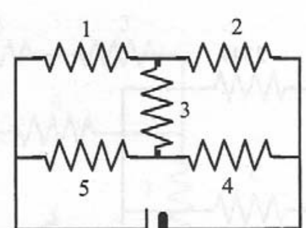
Finally, the current through resistor 1 and resistance 2347586 is the same, so they are in series as shown at the right.




The circuit in Figure (*b*) can also be shown to be a combination of series and parallel arrangements of resistors. Since both ends of resistors 2 and 3 are connected, the voltage across resistors 2 and 3 is the same. The same statement can be made for resistors 4 and 5, and resistors 6 and 7. Therefore, resistor 2 is in parallel with the resistor 3 to give an equivalent resistance labeled 23. Resistor 4 is in parallel with resistor 5 to give an equivalent resistance 45, and resistor 6 is in parallel with resistor 7 to give an equivalent resistance 67. From the right-hand portion of the drawing below, it is clear that the resistances 23, 45, and 67 are in series with resistor 1.




The drawing at the right shows the circuit in Figure (*c*). No such simplifying arguments can be made for this circuit. No two resistors carry the same current; thus, no two of the resistors are in series. Furthermore, no two resistors have the same voltage applied across them; thus, no two of the resistors are in parallel. Circuit (*c*) contains resistors that are neither in series nor in parallel.



6. ***REASONING AND SOLUTION***

a. The total charge that can be delivered is

$$\Delta q = (220\ \text{A·h})[3600\ \text{s}/(1\ \text{h})] = \boxed{7.9 \times 10^5\ \text{C}}$$

b. The maximum current is

$$I = (220\text{A·h})/[(38\ \text{min})(1\ \text{hr})/(60\ \text{min})] = \boxed{350\ \text{A}}$$

26. ***REASONING*** A certain amount of time $t$ is needed for the heater to deliver the heat $Q$ required to raise the temperature of the water, and this time depends on the power produced by the heater. The power $P$ is the energy (heat in this case) per unit time, so the time is the heat divided by the power or $t = Q/P$. The heat required to raise the temperature of a mass $m$ of water by an amount $\Delta T$ is given by Equation 12.4 as $Q = cm\Delta T$, where $c$ is the specific heat capacity of water [4186 J/(kg·C°), see Table 12.2]. The power dissipated in a resistance $R$ is given by Equation 20.6c as $P = V^2/R$, where $V$ is the voltage across the resistor. Using these expressions for $Q$ and $P$ will allow us to determine the time $t$.

***SOLUTION*** Substituting Equations 12.4 and 20.6c into the expression for the time and recognizing that the normal boiling point of water is 100.0 °C, we find that

$$t = \frac{Q}{P} = \frac{cm\Delta T}{V^2/R} = \frac{Rcm\Delta T}{V^2}$$

$$= \frac{(15\ \Omega)\left[4186\ \text{J}/(\text{kg}\cdot\text{C}^\circ)\right](0.50\ \text{kg})(100.0\ ^\circ\text{C} - 13\ ^\circ\text{C})}{(120\ \text{V})^2} = \boxed{190\ \text{s}}$$

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40. ***REASONING*** Since the two resistors are connected in series, they are equivalent to a single equivalent resistance that is the sum of the two resistances, according to Equation 20.16. Ohm's law (Equation 20.2) can be applied with this equivalent resistance to give the battery voltage.

***SOLUTION*** According to Ohm's law, we find

$$V = IR_s = I(R_1 + R_2) = (0.12\ \text{A})(47\ \Omega + 28\ \Omega) = \boxed{9.0\ \text{V}}$$

54. ***REASONING*** The series combination has an equivalent resistance of $R_S = R_1 + R_2$, as given by Equation 20.16. The parallel combination has an equivalent resistance that can be determined from $R_P^{-1} = R_1^{-1} + R_2^{-1}$, according to Equation 20.17. In each case the equivalent resistance can be used in Ohm's law with the given voltage and current. Thus, we can obtain two equations that each contain the unknown resistances. These equations will be solved simultaneously to obtain $R_1$ and $R_2$.

***SOLUTION*** For the series case, Ohm's law is $V = I_S(R_1 + R_2)$. Solving for sum of the resistances, we have

$$R_1 + R_2 = \frac{V}{I_S} = \frac{12.0\ \text{V}}{2.00\ \text{A}} = 6.00\ \Omega \qquad (1)$$

For the parallel case, Ohm's law is $V = I_P R_P$, where $R_P^{-1} = R_1^{-1} + R_2^{-1}$. Thus, we have

$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{I_P}{V} = \frac{9.00\ \text{A}}{12.0\ \text{V}} = 0.750\ \Omega^{-1} \qquad (2)$$

Solving Equation (1) for $R_2$ and substituting the result into Equation (2) gives

$$\frac{1}{R_1} + \frac{1}{6.00 - R_1} = 0.750 \quad \text{or} \quad R_1^2 - 6.00R_1 + 8.00 = 0$$

In this result we have suppressed the units in the interest of clarity. Solving the quadratic equation (see Appendix C.4 for the quadratic formula) gives

$$R_1 = \frac{-(-6.00) \pm \sqrt{(-6.00)^2 - 4(1.00)(8.00)}}{2(1.00)} = \frac{6.00 \pm \sqrt{36.0 - 32.0}}{2.00} = 4.00 \text{ or } 2.00$$

Substituting these values for $R_1$ into Equation (1) reveals that

$$R_2 = 6.00 - R_1 = 2.00 \text{ or } 4.00$$

Thus, the values for the two resistances are $\boxed{2.00\ \Omega \text{ and } 4.00\ \Omega}$.

64. ***REASONING*** The power $P$ dissipated in each resistance $R$ is given by Equation 20.6b as $P = I^2 R$, 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

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

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

88. ***REASONING AND SOLUTION*** The equivalent capacitance of the circuit is

$$1/C = 1/(4.0\ \mu\text{F}) + 1/(6.0\ \mu\text{F}) + 1/(12.0\ \mu\text{F}) \qquad \text{or} \qquad C = 2.0\ \mu\text{F}$$

The total charge provided by the battery is, then,

$$Q = CV = (2.0 \times 10^{-6}\ \text{F})(50.0\ \text{V}) = 1.0 \times 10^{-4}\ \text{C}$$

This charge appears on each capacitor in a series circuit, so the voltage across the 4.0-$\mu$F capacitor is

$$V_1 = Q/C_1 = (1.0 \times 10^{-4}\ \text{C})/(4.0 \times 10^{-6}\ \text{F}) = \boxed{25\ \text{V}}$$