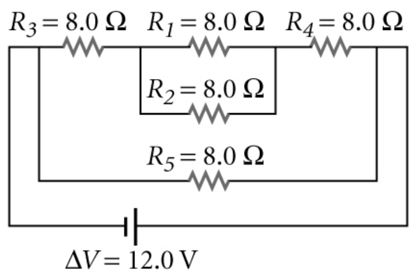
Name:______________________________ Class:__________________ Date:__________________

Circuits and Circuit Elements

Problem D

CURRENT IN AND POTENTIAL DIFFERENCE ACROSS A RESISTOR PROBLEM

For the circuit from the previous section's sample problem, determine the current in and potential difference across the 8.0 Ω resistor (R_4) in the figure below.



REASONING

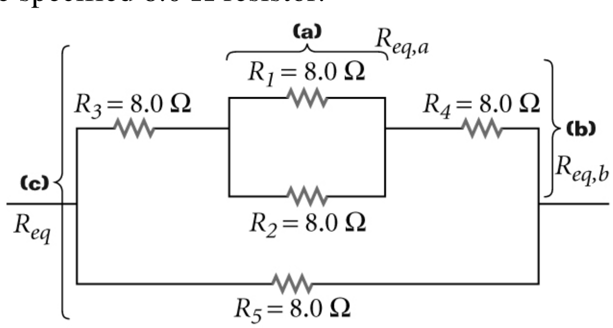
First find the equivalent resistance of the circuit. From this, determine the total circuit current. Then rebuild the circuit in steps, calculating the current and potential difference for the equivalent resistance of each group until the current in and potential difference across the specified 8.0 Ω resistor are known.

SOLUTION

1. **Determine the equivalent resistance of the circuit.**
   The equivalent resistance, which was calculated in the sample problem of the previous section, is 5.7 Ω.
2. **Calculate the total current in the circuit.**
   Substitute the potential difference and equivalent resistance in $\Delta V = IR$, and rearrange the equation to find the current delivered by the battery.

$$I = \frac{\Delta V}{R_{eq}} = \frac{(12.0\ \text{V})}{(5.9\ \Omega)} = 2.0\ \text{A}$$

3. **Determine a path from the equivalent resistance found in step 1 to the specified resistor**.
   Review the path taken to find the equivalent resistance in the diagram below, and work backward through this path. The equivalent resistance for the entire circuit is the same as the equivalent resistance for group (**c**). The top resistors in group (**c**), in turn, form the equivalent resistance for group (**b**), and the rightmost resistor in group (**b**) is the specified 8.0 Ω resistor.



4. **Follow the path determined in step 3, and calculate the current in and potential difference across each equivalent resistance. Repeat this process until the desired values are found**.

Regroup, evaluate, and calculate.

Replace the circuit's equivalent resistance with group (**c**), as shown in the figure. The resistors in group (**c**) are in parallel, so the potential difference across each resistor is equal to the potential difference across the equivalent resistance, which is 12.0 V. The current in the equivalent resistance in group (**b**) can now be calculated using $\Delta V = IR$.

Given: $\Delta V = 12.0 \text{ V}$ $R_{eq,b} = 20.0\ \Omega$

Unknown: $I_b = ?$

$$I_b = \frac{\Delta V}{R_{eq,b}} = \frac{(12.0 \text{ V})}{(20.0\ \Omega)} = 0.600 \text{ A}$$

Regroup, evaluate, and calculate.

Replace the 20.0 Ω resistor with group (**b**). The resistors R_3, $R_{eq,b}$, and R_4 in group (**b**) are in series, so the current in each resistor is the same as the current in the equivalent resistance, which equals 0.600 A.

$$I_b = 0.600 \text{ A}$$

The potential difference across the 8.0 Ω resistor at the right can be calculated using $\Delta V = IR$.

Given: $I_b = 0.600 \text{ A}$ $R_4 = 8.0\ \Omega$

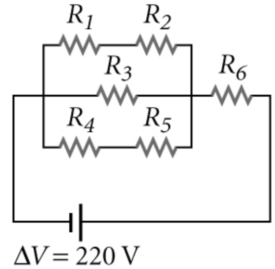
Unknown: $\Delta V = ?$

$$\Delta V = IR = (0.600 \text{ A})\ (8.0\ \Omega) = 4.8 \text{ V}$$

The current through the specified resistor is 0.600 A, and the potential difference across it is 4.8 V.

ADDITIONAL PRACTICE

1. Recall from the previous section the high-powered searchlight with the power rating of 6.0×10^5 W. For a potential difference of 220 V placed across the light bulb of this searchlight, you found a value for the bulb's resistance. You also determined the equivalent resistance for the circuit shown in the figure below.

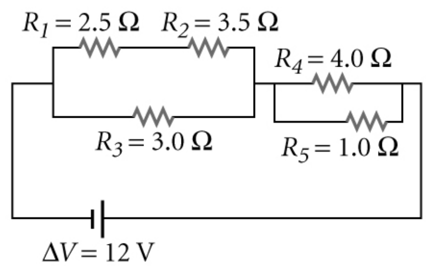


a. Calculate the potential difference across and current in the searchlight bulb labeled R_3

b. Calculate the potential difference across and current in the searchlight bulb labeled R_2.

c. Calculate the potential difference across and current in the searchlight bulb labeled R_4.

2. Recall the portable power pack that can provide 12 V for 40.0 h. The device powers a combination of small appliances with the resistances shown in the circuit diagram below. In the previous section, you calculated the equivalent resistance and net current for this circuit



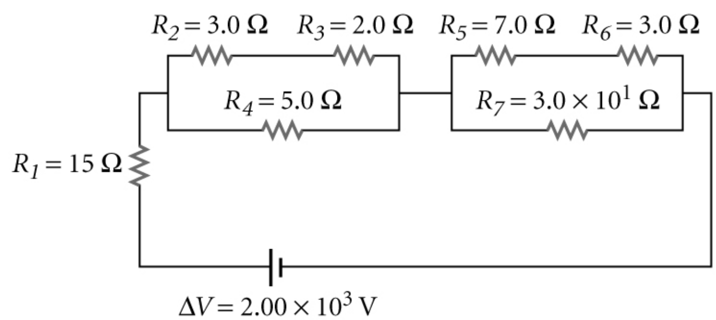
a. Calculate the potential difference across and current in the 1.0 Ω appliance.

b. Calculate the potential difference across and current in the 2.5 Ω appliance.

c. Calculate the potential difference across and current in the 4.0 Ω appliance.

d. Calculate the potential difference across and current in the 3.0 Ω appliance.

3. Recall the longest-lasting battery in the world, which was constructed at Oxford University in 1840. In 1977, the terminal voltage of the battery was 2.00×10^3 V. Suppose the battery is placed in the circuit shown in the diagram below. Determine the equivalent resistance of the circuit, and then find the following:



a. the potential difference and current in the 5.0 Ω resistor (R_4).

b. the potential difference and current in the 2.0 Ω resistor (R_3).

c. the potential difference and current in the 7.0 Ω resistor (R_5).

d. the potential difference and current in the 3.0×10^1 Ω resistor (R_7).