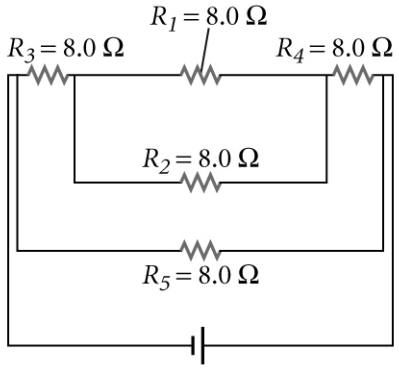
Name:_____ Class:_____ Date:_____

Circuits and Circuit Elements

Problem C

EQUIVALENT RESISTANCE PROBLEM

A certain amplifier can drive five channels with a load of 8.0 Ω each. Consider five 8.0 Ω resistors connected as shown. What is the equivalent resistance?



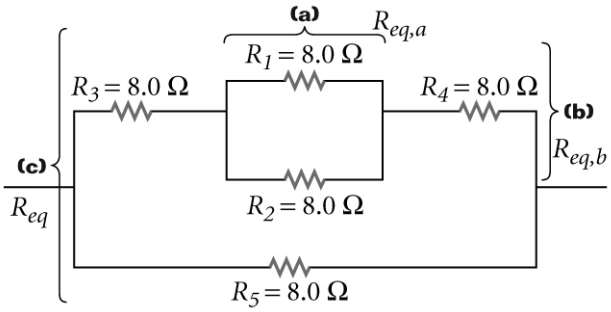
REASONING

Divide the circuit into groups of series and parallel resistors. This way, the methods presented in determining equivalent resistance for resistors in series and parallel can be used to calculate the equivalent resistance for each group.

SOLUTION

1. **Redraw the circuit as a group of resistors along one side of the circuit.**

   Bends in a wire do not affect the circuit and do not need to be represented in a schematic diagram. Redraw the circuit without corners, keeping the arrangement of the circuit elements the same and disregarding the emf source.



2. **Identify components in series, and calculate their equivalent resistance.**

   At this stage, there are no resistors in series.

3. **Identify components in parallel, and calculate their equivalent resistance.**

   Resistors in group (**a**) are in parallel. For group (**a**):

$$\frac{1}{R_{eq,a}} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{2}{(8.0\ \Omega)} = \frac{0.25}{1\ \Omega}$$

$$R_{eq,a} = 4.0\ \Omega$$

4. **Repeat steps 2 and 3 until the resistors in the circuit are reduced to a single equivalent resistance.**

   Resistors in group (**b**) are in series.

$$R_{eq,b} = R_{eq,a} + R_3 + R_4 = 4.0\ \Omega + 8.0\ \Omega + 8.0\ \Omega = 20.0\ \Omega$$

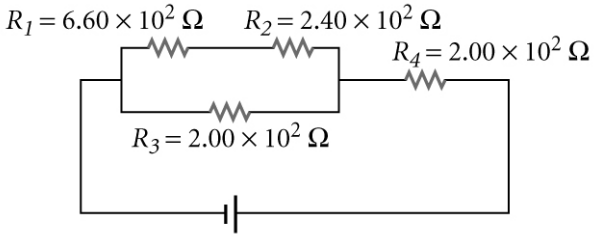
   Resistors in group (**c**) are in parallel.

$$\frac{1}{R_{eq}} = \frac{1}{R_{eq,b}} + \frac{1}{R_5} = \frac{1}{(20.0\ \Omega)} + \frac{1}{(8.0\ \Omega)} = \frac{0.0500}{1\ \Omega} + \frac{0.12}{1\ \Omega}$$

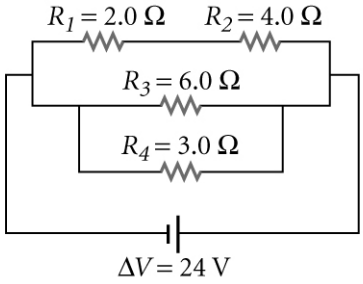
$$R_{eq} = \left(\frac{0.17}{1\ \Omega}\right)^{-1} = 5.9\ \Omega$$

ADDITIONAL PRACTICE

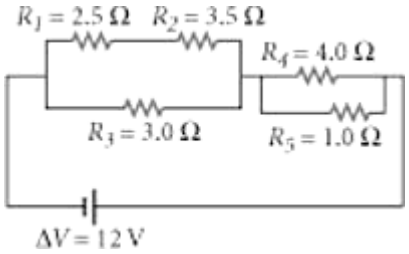
1. In 1993, the gold reserves in the United States were about 8.490×10^6 kg. If all that gold were made into a thick wire with a cross-sectional area of 1cm^2, its total resistance would be about $6.60 \times 10^2\ \Omega$. If the same operation were applied to the gold reserves of Germany, France, and Switzerland, the resistances would be $2.40 \times 10^2\ \Omega$, $2.00 \times 10^2\ \Omega$, and $2.00 \times 10^2\ \Omega$, respectively. Now consider all four resistors connected as shown in the circuit diagram below. Find the equivalent resistance.



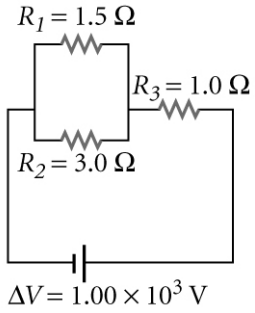
2. 1920, there was an electric car that could travel at about 40 km/h and that had about a 45 km range. The car was powered by a 24 V battery. Suppose this battery is connected to a combination of resistors, as shown in the circuit diagram below. What is the battery current?



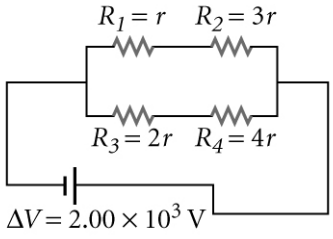
3. By adding water to the Enviro-Gen portable power pack, the device can generate 12 V for up to 40.0 h. If this device powers a combination of small appliances with the resistances shown in the circuit diagram below, what will be the net current for the circuit?



4. In 1995, the most powerful wind generator in the United States was the Z-40, which has a rotor diameter of 40 m. The machine is capable of producing 5.00×10^2 A at 1.00×10^3 V, assuming 100 percent efficiency. Suppose a direct current of 5.00×10^2 A is produced when a potential difference of 1.00×10^3 V is placed across a circuit of resistors, as shown in the diagram below. What is the equivalent resistance of the circuit? What is the power dissipated in the circuit?



5. The longest-lasting battery in the world is at Oxford University, in England. It was built in 1840 and was still working in 1977, producing a 1.0×10^{-8} A current. The battery provided a potential difference of 2.00×10^3 V. If the battery is connected to a group of resistors, as shown in the circuit diagram below, find the value of the equivalent resistance and the value of *r*.



Name:_____ Class:_____ Date:_____

6. During World War II, a high-powered searchlight was produced that had a power rating of 6.0×10^5 W. Assuming a potential difference of 220 V across the searchlight, find the resistance of the light bulb in that searchlight. Find the equivalent resistance for several of these light bulbs connected as shown in the circuit diagram below. What is the total power dissipated in the circuit?

he circuit?