chapter 6

Electricity

section 2 Electric Current

What You'll Learn

- what makes current flow
- how batteries work
- what Ohm's law says

Before You Read

Have you noticed that one end of a battery is marked with a plus sign and the other end with a minus sign? What happens if you put the batteries in a flashlight in the wrong direction?

Read to Learn

Mark the Text

Identify Details Use one color to highlight each question heading. Then use another color to highlight the answer to the question.

Current and Voltage Difference

You have read about the ways electric charges move. One example is the spark that can jump between your hand and a metal doorknob. **Electric current** is the net movement of electric charges in one direction.

To understand net movement, consider the movement of electrons in all materials. In all materials, electrons move in every direction. Since the electrons are not moving in the same direction, there is no electric current. When electric current flows in a wire, the electrons still move in all directions, but they also drift in the direction that the current flows. The drifting of the electrons is the net movement in one direction.

Electric current is measured in units called amperes. Amperes are also called amps. The symbol for amperes is the letter A. Amperes measure the electrons that flow past one point. One ampere is equal to 6,250 million billion electrons moving past a point every second.

Reading Check

1. **Explain** How many electrons must move past a point every second to equal one ampere of electric current?

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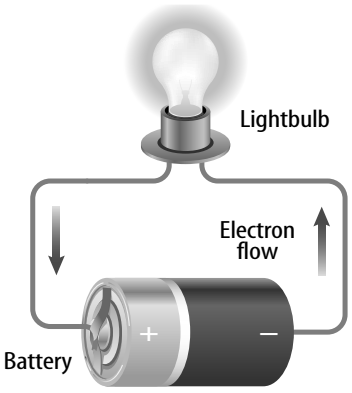
What is voltage difference?

Even though the electrons are moving in all directions, an electric force acts on the charges to make them flow in one direction. Voltage is the electric force that makes charges move.

Voltage is also like the force that acts on water in a pipe. Water flows from higher pressure to lower pressure. In the same way, electric charge flows from higher voltage to lower voltage. A **voltage difference** is related to the force that makes electric charges flow. Voltage difference is measured in units called volts. The symbol for volts is V.

What is an electric circuit?

Look at the figure. It shows an electric current doing work by lighting a lightbulb. Electric current must have a closed "loop-like" path to follow. If there is no closed path to follow, the current stops. An **electric circuit** is a closed path that electric current follows. If the circuit in the figure is broken by taking away one part, such as the battery or the lightbulb, current will not flow. It will also not flow if a wire is broken or cut. The lightbulb will not light.



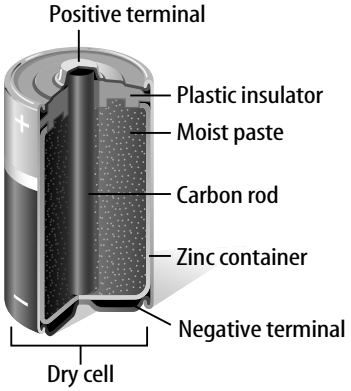
Batteries

A circuit needs a voltage difference to keep electric current flowing in it. A battery can provide the voltage difference that keeps electric current flowing. Look at the figure of the circuit again. The positive end and the negative end of a battery are called the terminals. When a closed path connects the terminals, the current will flow.

How do dry-cell batteries work?

The batteries used in a flashlight are called dry-cell batteries. Look at the figure below of a dry-cell battery. The battery has two electrodes. One electrode is a carbon rod. The other electrode is a zinc container.

Around the electrodes is a moist paste. The paste is called an electrolyte. The electrolyte contains chemicals that are conductors. The electrolyte lets charges move from one electrode to the other electrode. This kind of battery is called a dry cell because the electrolyte is a paste, not a liquid.



Picture This

2. **Describe** Look at the figure of a circuit. Which direction do electrons flow in the circuit, away from the negative terminal or away from the positive terminal?

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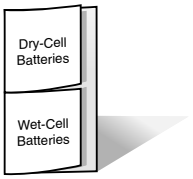
FOLDABLES™

B Build Vocabulary

Make a Foldable as shown. Write the definitions under the tabs and add information as you read this section.



Picture This

3. **Locate** What is used as an electrolyte in a dry-cell battery?

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Think it Over

4. **Describe** when the chemical reaction occurs in a dry-cell battery.

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Picture This

5. **Compare** What two things are shown in both the figure of the dry-cell battery and the figure of the wet-cell battery?

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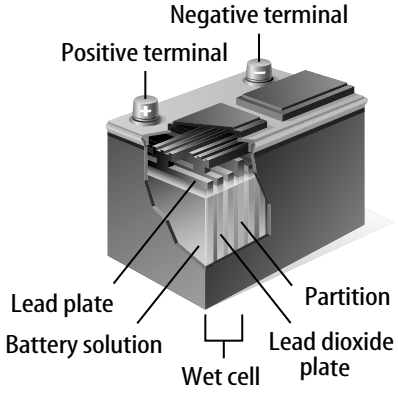
Making Electricity When the two terminals of a dry-cell battery are connected in a circuit, there is a reaction between the zinc and the chemicals in the electrolyte. Electrons move between some of the compounds in this chemical reaction. The carbon rod becomes positive. The positive terminal is marked with a plus sign (+). Electrons build up on the zinc, making it the negative terminal. The negative terminal is marked with a minus sign (–). The voltage difference between the terminals causes current to flow through a closed circuit.

How do wet-cell batteries work?

Another kind of battery is the wet-cell battery shown below. A wet cell has two connected plates made of different metals. The metals are in a conducting solution. Chemical reactions transfer electrons from the lead plates to the lead dioxide plates. This battery is called a wet cell because the conductor is a liquid. A wet-cell battery contains several wet cells that are connected. Together the cells give a larger voltage difference than each of the cells alone.



What is a lead-acid battery?

Lead-acid batteries are wet-cell batteries. They are usually used in cars. A lead-acid battery has six separate wet cells that are connected. The cells are made of lead and lead dioxide plates. The plates are in a sulfuric acid solution. A chemical reaction gives a voltage difference of about 2 V in each cell. There are six cells, so the total voltage difference is 12 V.

How are electric outlets different from batteries?

Electric outlets, such as wall sockets, also give a voltage difference. This voltage difference usually is much higher than the voltage difference a battery gives. Most wall sockets give a voltage difference of 120 V. Some outlets have a voltage of 240 V that is needed for large appliances, such as electric ovens and clothes dryers.

Resistance

Flashlights use dry-cell batteries to make the current that lights up the lightbulb. What makes a lightbulb glow? Part of the circuit is a thin wire in the bulb. The wire is called a filament. The electrons in the current flow through the filament. As they move, they bump into the metal atoms in the filament.

The electrons bump into the metal atoms, turning some of their electrical energy into thermal energy. The metal filament gets hot enough to glow. The radiant energy lights up the room.

How do materials resist current?

Electric current loses energy when it moves through material because of resistance. **Resistance** is the tendency for a material to oppose, or go against, the flow of electrons. Resistance turns electrical energy into thermal energy and light.

Almost all materials have electrical resistance. Materials that are electrical conductors have less resistance than materials that are electrical insulators. Resistance is measured in units called ohms (Ω).

What can affect resistance?

The temperature, length, and thickness of a material can affect the electric resistance of the material. Usually, the hotter something is, the more resistance it has. The resistance of an object also depends on its length and thickness. The longer the circuit is, the more resistance it has. Resistance also increases as the wire gets thinner.

A lightbulb filament is a thin piece of tungsten wire made into a short coil. The uncoiled wire is about 2 m long and very thin. Tungsten is a good conductor, but since the wire is so long and thin, it has resistance. The resistance makes the filament glow. The more resistance a filament has, the brighter it glows.

The Current in a Simple Circuit

A simple electric circuit has three main parts. First, it has a source of voltage difference, such as a battery. Second, it has a device that has resistance, like a lightbulb. Third, it has conductors, such as wires. The conductors connect the resistance device to the battery terminals. When the wires are connected to the battery terminals, the path is closed and current flows.

Two electric circuits are shown in the figures on the next page. Each circuit is a battery connected to a lightbulb by wires and a rod. The circuit on the right is shorter because the wires are closer together on the rod. That circuit has less resistance.

Reading Check

6. List the three types of energy needed to make a lightbulb in a flashlight glow.

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Reading Check

7. Recognize Cause and Effect How does the resistance of a filament affect its glow?

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Picture This

8. Compare In which circuit will the light be brighter, the one on the left or the one on the right?

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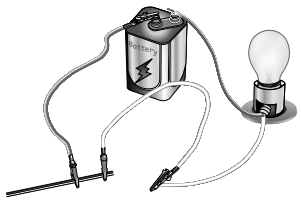
More resistance

Less resistance



The voltage difference, current, and resistance in a circuit are related. If the voltage difference stays the same as the resistance decreases, the current in the circuit increases. If the wire is short, the lightbulb will be brighter. If the resistance doesn't change, increasing the voltage difference increases the current. If you use a larger battery, the lightbulb will be brighter.

What is Ohm's law?

There is a relationship between voltage difference, current, and resistance in a circuit. **Ohm's law** states that the current in a circuit equals the voltage difference divided by the resistance. If *I* stands for electric current, Ohm's law can be written as:

$$\textbf{current (in amperes)} = \frac{\textbf{voltage difference (in volts)}}{\textbf{resistance (in ohms)}}$$

$$I = \frac{V}{R}$$

Ohm's law can also be used to measure resistance. Change the equation so that resistance, *R*, is alone on one side. Do this by multiplying both sides of the equation by *R*. Then divide both sides by *I*. The new equation is:

$$R = \frac{V}{I}$$

Applying Math

9. Solve the equation to show how $I = \frac{V}{R}$ becomes $R = \frac{V}{I}$. Show your work.

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Suppose a current of 0.5 A flows in a 75-W lightbulb. The voltage difference between the ends of the filament is 120 V. Find the resistance of the filament.

$$R = \frac{V}{I}$$

$$= \frac{120}{0.5}$$

$$= 240$$

The resistance is 240 Ω.

After You Read

Mini Glossary

electric circuit: a closed path that electric current follows

electric current: the rate at which electric charges move in one direction past one point

Ohm's law: the current in a circuit equals the voltage difference divided by the resistance

resistance: the tendency for a material to oppose the flow of electrons, changing electric energy into heat and light

voltage difference: something related to the force that makes electric charges flow

1. Read the terms and their definitions in the Mini Glossary above. Rewrite the definition of *resistance* in your own words on the lines below.

2. Complete the table below to describe a simple circuit. The first column lists the parts of a circuit. In the second column, give an example of each part of a circuit. Under the heading *Function*, write a short description of what job each part does in the circuit.

Parts of a Simple Circuit		
Part	**Example**	**Function**
Voltage difference		
Source of resistance		
Conductors		

3. Mark the Text As you read this section, you highlighted the question headings and their answers. Why was using two colors helpful?

End of Section