chapter 6

Electricity

section 1 Electric Charge

What You'll Learn

- how electric charges exert forces
- about conductors and insulators
- how things become electrically charged

Before You Read

Think about some electric objects that are plugged into an outlet. But cars, cell phones, and even wristwatches also use electricity. List three things you use every day that use electricity but do not plug in.

Read to Learn

Mark the Text

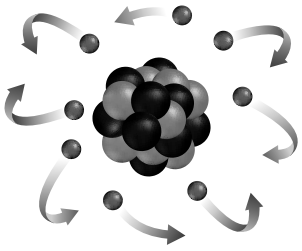
Identify Main Ideas
Highlight the main point under each heading. Then explain the main point in your own words.

Positive and Negative Charges

Sometimes, when you walk across a carpet and then touch an object, you get a shock. Why does this happen? The answer has to do with electric charge. The center of an atom is made up of particles called protons and neutrons. Other particles, electrons, move around the center of the atom. Protons and electrons have electric charge. Neutrons have no electric charge. In the figure below, the light gray particles are the protons, the black particles are the neutrons, and the floating particles are the electrons.

Picture This

1. **Differentiate** Circle the electrons with a colored pen or pencil.



There are two types of electric charge, positive and negative. Protons have positive electric charge. Electrons have negative electric charge. The amount of positive charge on a proton is the same as the amount of negative charge on an electron. Each atom has the same number of protons and electrons. So, the number of positive and negative charges cancel each other out. This makes atoms electrically neutral. They have no overall electric charge. An atom becomes negatively charged if it gains extra electrons. An atom that loses electrons becomes positively charged overall.

Reading Check

2. **Determine** What is the charge of an object with more electrons than protons?

How is electric charge transferred?

Electrons are bound more tightly to some atoms and molecules than to others. Electrons in the soles of your shoes are bound tightly to the atoms. Electrons in atoms in carpet are not bound as tightly. When you walk on carpet, electrons are transferred from the carpet to the soles of your shoes.

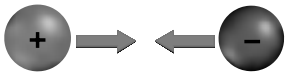
Now, the soles of your shoes have more electrons than protons. They are negatively charged. The carpet has fewer electrons than protons. It is positively charged. The transfer of electrons changed the electric charge of each object. **Static electricity** is the buildup of electric charges on an object. When there is static electricity, electric charges are not balanced.

Is new electrical charge created?

The electrons that moved to your shoe are not new electrons. The **law of conservation of charge** states that charge can be transferred from one object to another, but it cannot be created or destroyed. An object becomes charged when electric charges move from one place to another.

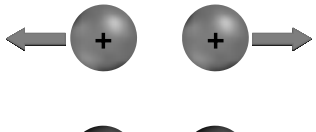
What happens when electrical charges move?

Have you ever taken clothes out of a dryer and had them cling together? Look at the figure below. Opposite electric charges attract each other. They tend to move toward each other. Electric charges that are the same repel each other. They tend to move away from each other.



Opposite charges attract

When clothes tumble in a dryer, the atoms in some clothes lose electrons. Those clothes become positively charged. The atoms in other clothes gain electrons and become negatively charged. The clothes have opposite charges. Objects that have opposite charges attract each other, so the clothes cling together.



Like charges repel

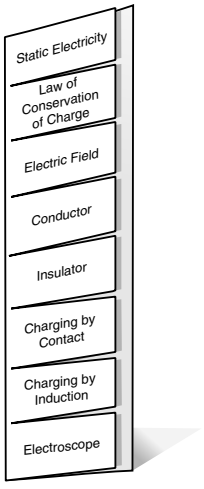
How do charges exert forces?

The electric force between two charged objects depends on how far apart the objects are. The electric force between two charges decreases as the charges move farther apart.

The electric force also depends on the amount of charge on each object. When the amount of charge on one of the objects increases, the electric force increases.

FOLDABLES™

A Build Vocabulary As you read this section, make the following vocabulary Foldable. Write the definition for each vocabulary word under its tab.



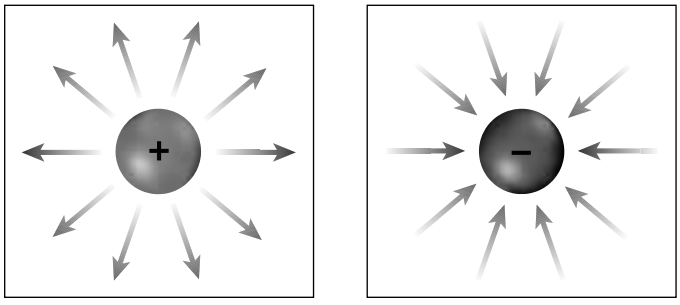
Picture This

3. **Illustrate** Look at the figures of like and unlike charges. Highlight the negative charges in one color and the positive charges in other color. Notice the charges only attract when the colors are different.

What are electric fields?

When a charged balloon comes near your hair, your hair will move toward it. Your hair does not have to touch the balloon for an electric force to act on it. So what makes your hair move? It is positively charged. The balloon is negatively charged. They are attracted to each other because they have opposite electric charges.

Move of a Positive Charge in Electric Fields



There is an electric field around every electric charge. The **electric field** exerts a force that attracts or repels other electric charges. The figure shows two electric fields. The arrows show the direction a positive charge would move in each electric field. Your hair has the positive charge and moves to the balloon.

The force of gravity between you and Earth seems very strong. However, electric forces are much stronger. Electric forces between the protons and the electrons hold the particles in atoms together. For example, the electric force between a proton and an electron in a hydrogen atom is a thousand trillion trillion times larger or, 10^{39} times larger than the attractive gravitational forces between the same proton and electron.

Forces Between Atoms Atoms also are held together by electric forces. Electric forces between atoms cause chemical bonds. These electric forces are also much greater than the gravitational forces between the atoms.

Forces Between Objects Many of the forces that act on objects are due to the electric forces between atoms and molecules. All atoms contain electrically charged protons and electrons. When atoms or molecules get close enough, they can exert forces that attract or repel. For example, when you push on a door, the atoms in your hand get close to the atoms in the door. The atoms are close enough to exert forces on each other. The forces between the atoms in your hand and the atoms in the door cause the door to move.

Picture This

4. **Identify** Look at the figure of electric fields. Why do the arrows point outward from the positive field? Why do they point inward toward the negative field?

Think it Over

5. **Explain** in your own words why usually there is very little electric force between two objects.

Conductors and Insulators

Remember the example of electrons moving from the carpet to your shoe? If you reach for a metal doorknob after walking on carpet, you might see a spark. Electrons moving from your hand to the doorknob cause the spark. How did those electrons move from your shoe to your hand?

What is a conductor?

Electrons can move more easily in some materials than in others. A **conductor** is a material in which electrons can move easily. Your skin is a better conductor than your shoes. Electrons move from your shoes to your skin, spreading to your hands. The best electric conductors are metals. Atoms in metals have electrons that are able to move easily through the metal. Copper is one of the best conductors.

What is an insulator?

An **insulator** is a material in which electrons cannot move easily. In insulators, electrons are held tightly to atoms. The plastic coating around an electric wire keeps you from getting a dangerous electric shock when you touch the wire coating. Wood, rubber, and glass are other good insulators.

Charging Objects

Just like the clothes in the dryer, when two materials are rubbed together, electrons can be transferred between them. One object will have a negative charge. The other will have the same amount of positive charge. **Charging by contact** is the transfer of charges by touching or rubbing.

How can something be charged at a distance?

Remember, electric forces change when objects move closer together. If a charged object is moved near a neutral object, electrons on the neutral object will move around.

Think about the balloon that was charged by rubbing it on your hair. The charged balloon doesn't need to touch the hair to make the hair move toward it. The same is true if you hold the charged balloon close to a wall. The extra electrons on the balloon repel the electrons in the wall. The electrons in the wall move away from the balloon. Now there is a positively charged area on the wall. The negatively charged balloon is attracted to the positive area of the wall. A charged object rearranging the electrons on a nearby neutral object is **charging by induction**. The wall was charged by induction. The balloon will stick to the wall. An electric force holds it there.

Think it Over

6. **Apply** Which is a better conductor, a flagpole or a flag? Why?

Think it Over

7. **Explain** why it is hard for electrons to move through an insulator.

Reading Check

8. **Compare** What is the difference between charging by contact and charging by induction?

What is lightning?

Have you ever seen lightning hit the ground? Lightning is a large static discharge—a transfer of charge between two objects. It happens if there is a buildup of static electricity.

A large amount of static electricity is formed when air moves around in thunderclouds. Areas of positive and negative charge build up. When enough charge builds up, there is a static discharge between the cloud and the ground. As the electric charges move through the air, they run into atoms and molecules, making the atoms and molecules light up.

What is thunder?

Lightning makes a bright light. It also creates powerful sound waves. Thunder is the sound that lightning makes. The electric energy in a lightning bolt rips electrons off atoms in the air. This causes great amounts of heat. The air temperature around the lightning bolt can be as high as 25,000°C. The heat makes the air around the lightning bolt move faster. This rapid movement of air produces the sound waves that you hear as thunder.

Why is grounding important?

Lightning can cause damage and injury because it releases a great amount of energy. One way to avoid the damage is to make the charges flow to Earth's surface. Earth is a large neutral object that is also a conductor. Because Earth is so large, it can absorb a great amount of excess charge. Grounding provides a path for electric charges to move to Earth. For example, a metal lightning rod on top of a building provides a path to move excess charges to Earth's surface.

Think it Over

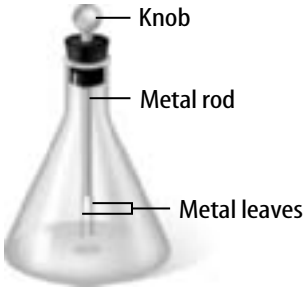
9. Analyze Why do you think a lightning rod is made of metal?

_____

_____

_____

Detecting Electric Charge



An **electroscope** can detect when an object has an electric charge. One type of electroscope is a glass beaker with a metal rod inside it, as shown. The metal rod connects to a knob at the top of the beaker. There are two metal branches, or leaves, at the bottom of the metal rod. The metal leaves hang down when there is no charge to the rod. When an object with a negative charge touches the knob, electrons travel down the rod to the leaves. Both leaves gain negative charges. When an object with a positive charge touches the knob, it attracts electrons that move up the rod. The leaves have a positive charge. When the leaves have a charge, they repel each other and spread apart.

Picture This

10. Draw On the figure, draw what the leaves look like if they have a charge.

After You Read

Mini Glossary

charging by contact: transferring charges by touching or rubbing

charging by induction: when electrons on a neutral object are moved by a charged object

conductor: a material in which electrons can move easily

electric field: a region in which charged particles attract or repel

electroscope: a device that detects electric charge

insulator: a material in which electrons cannot move easily

law of conservation of charge: charge can be transferred from one thing to another, but it cannot be created or destroyed

static electricity: the buildup of electric charges on an object

1. Read the terms and their definitions in the Mini Glossary above. Use the words **insulator** and **conductor** in a sentence that shows that you understand them.

_____

_____

2. Column 1 lists some of the concepts you learned about in this section. Column 2 gives a fact about each concept. Write the letter of the fact on the line next to the concept that matches it.

Column 1	Column 2
_____ **1.** transferring charge	**a.** static electricity is discharged between a cloud and the ground
_____ **2.** conservation of charge	**b.** electrons cannot move easily in some materials
_____ **3.** insulator	**c.** electrons can move from one object to another
_____ **4.** lightning	**d.** charge cannot be created or destroyed

3. Mark the Text You highlighted the main points to help you understand electric charge. How did you decide what the main points were?

_____

_____

End of Section