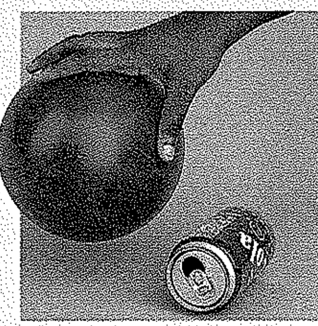
SECTION 1

Electric Charge and Static Electricity

DISCOVER ACTIVITY

Can You Move a Can Without Touching It?

1. Place an empty aluminum can on its side on the floor.
2. Blow up a balloon. Then rub the balloon back and forth on your hair several times.
3. Hold the balloon about 3 to 4 centimeters away from the can.
4. Slowly move the balloon farther away from the can. Observe what happens.
5. Move the balloon to the other side of the can and observe what happens.



Think It Over

Inferring What happens to the can? What can you infer from your observation?

GUIDE FOR READING

- **How do electric charges interact?**
- **How does static electricity differ from electric current?**
- **How are electrons transferred in static discharge?**

Reading Tip **Before you read, preview the headings and record them in outline form. Fill in details as you read.**

You're in a hurry to get dressed for school, but you can't find one of your socks. You quickly head for the pile of clean laundry. You've gone through everything, but where's the sock? The dryer couldn't have really destroyed it, could it? Oh no, there it is. Your sister has found the sock stuck to one of her shirts. What makes clothes stick together? The explanation has to do with tiny electric charges.

Types of Electric Charge

The charged parts of atoms are electrons and protons. As you have learned, protons and electrons are charged particles. When two protons come close, they push one another apart. In other words, they repel each other. But if a proton and an electron come close, they attract one another.

Why do protons repel protons but attract electrons? The reason is that they have different types of charge. Protons and electrons have opposite charges. The charge on the proton is called positive (+), and the charge on the electron is called negative (−). The names positive and negative were given to charges by Benjamin Franklin in the 1700s. They have been used by scientists ever since.

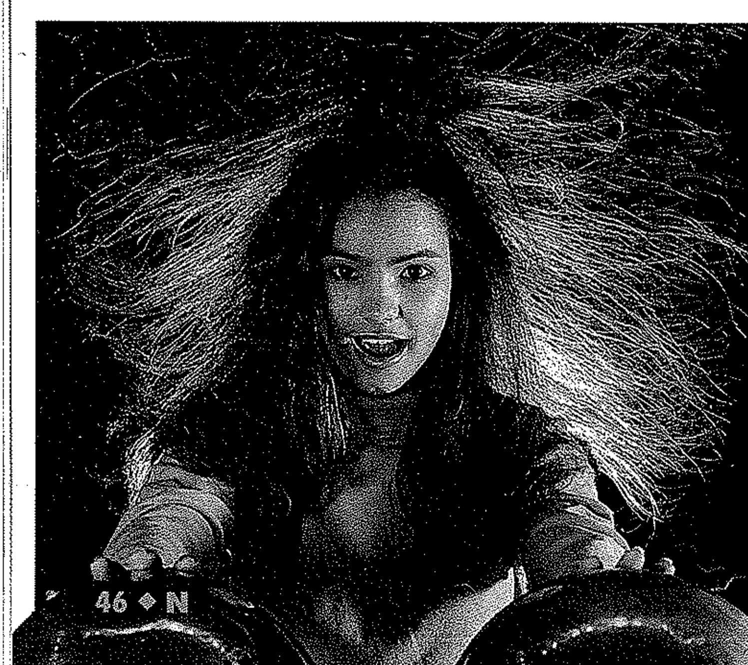


Figure 1 The interaction of electric charges is making this girl's hair stand on end.

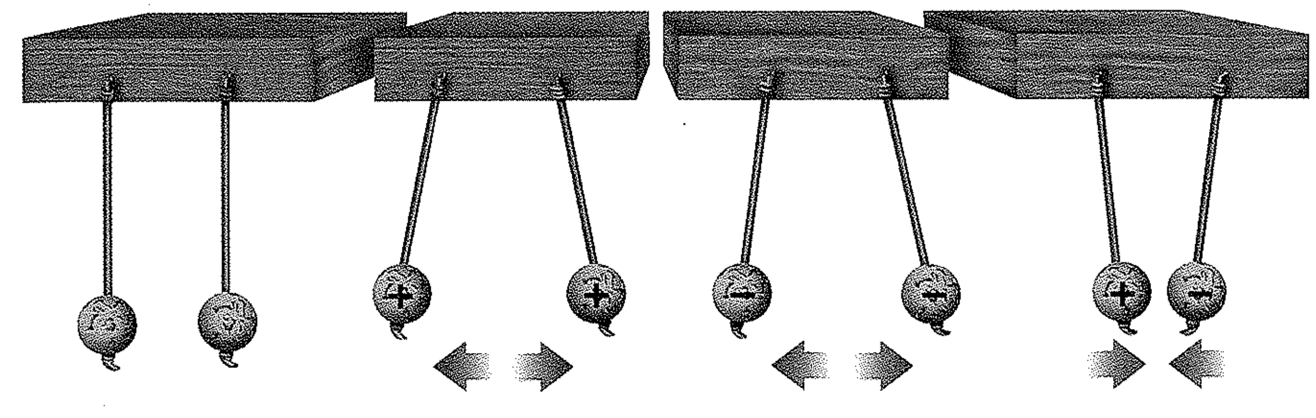


Figure 2 Charged objects exert forces on each other. They can either attract or repel. ***Interpreting Diagrams*** *What is the rule for the interaction of electric charges?*

Interactions Between Charges

The two types of charge interact in specific ways. **Charges that are the same repel each other. Charges that are different attract each other.**

Does this sound familiar to you? This rule is the same as the rule for interactions between magnetic poles. Recall that magnetic poles that are alike repel each other and magnetic poles that are different attract each other.

There is one important thing about electric charges that is different from magnetic poles. Recall that magnetic poles do not exist alone. Whenever there is a south pole, there is always a north pole. Electric charges can exist alone. In other words, a negative charge can exist without a positive charge.

☑ *Checkpoint* *How are the interactions between electric charges similar to the interactions between magnetic poles?*

Electric Fields

Just as magnetic poles exert their forces over a distance, so do electric charges. An electric charge exerts a force through the **electric field** that surrounds the charge. An electric field extends outward from every charged particle.

When a charged particle is placed in the electric field of another charged particle, it is either pushed or pulled. It is pushed away if the two charges are the same. It is pulled toward the other charge if the two charges are different.

Sharpen your Skills

Drawing Conclusions

ACTIVITY

1. Tear tissue paper into small pieces, or cut circles out of it with a hole punch.
2. Run a plastic comb through your hair several times.
3. Place the comb close to, but not touching, the tissue paper pieces. What do you observe?

What can you conclude about the electric charges on the comb and the tissue paper?

Electric Fields Around Single Charges You will recall using magnetic field lines to picture a magnetic field in an earlier chapter. In a similar way, you can use electric field lines to visualize the electric field. Electric field lines are drawn with arrows to show the direction of the force on a positive charge.

The electric fields in Figure 3A are strongest where the lines are closest together. You can see that the strength of the electric field is greatest near the charged particle. The field decreases as you move away from the charge.

Electric Fields Around Multiple Charges When there are two or more charges, the resulting electric field is altered. The electric fields due to the individual charges combine. Figure 3B shows the electric fields from two sets of charges.

☑ *Checkpoint* *Where is an electric field strongest?*

Static Charge

If matter consists of charged particles that produce electric fields, why aren't you attracted to or repelled by every object around you—your book, your desk, or your pen? The reason is that each atom has an equal number of protons and electrons. And the size, or magnitude, of the charge on an electron is the same as the size of the charge on a proton. So each positive charge is balanced by a negative charge. The charges cancel out and the object as a whole is neutral. As a result there is no overall electrical force.

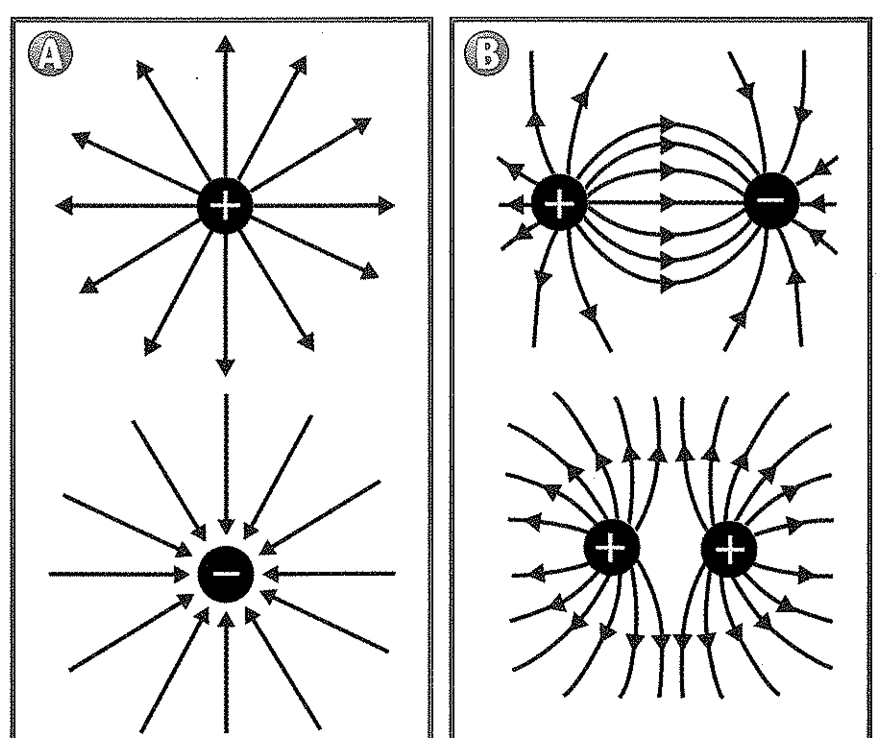
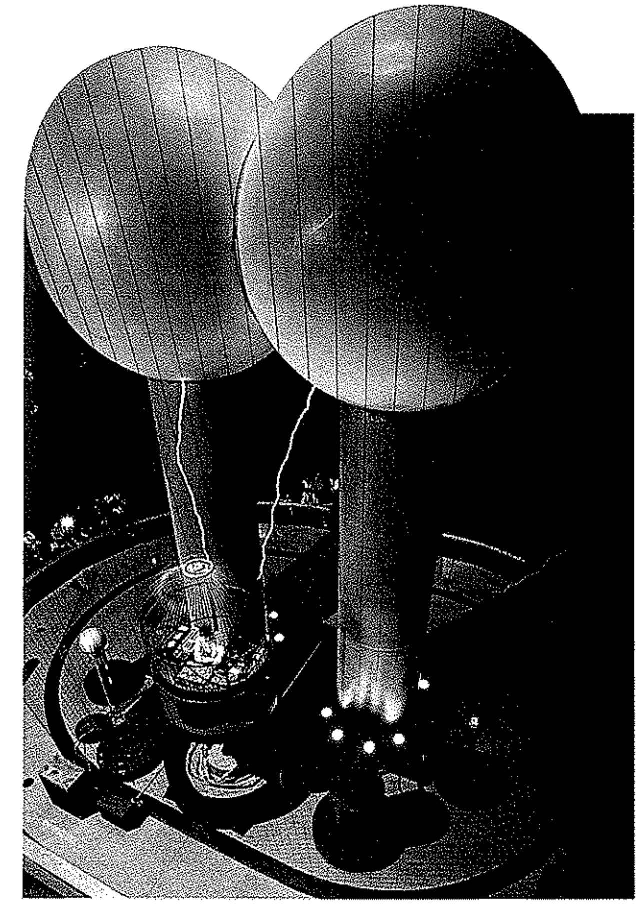


Figure 3 Electric charges can attract or repel one another. **A.** The arrows show that a positive charge repels another positive charge. A negative charge attracts a positive charge. **B.** When two charged particles come near each other, the electric fields of both particles are altered.



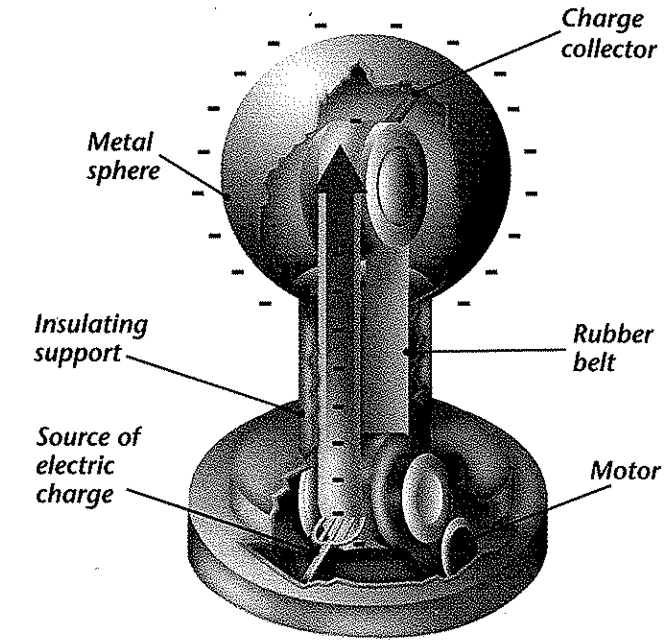


Figure 4 A Van de Graaff generator produces static electricity. Electrons are carried up a rubber belt and are transferred to the metal sphere. The charge built up on the sphere is enough to send a spark several meters through the air.

Charged Objects Protons are bound tightly in the center of an atom, but electrons can sometimes leave their atoms. Whether or not an electron will move depends on the material. Atoms in insulators, such as wood, rubber, plastic, and glass, hold their electrons tightly. Atoms in conductors, such as gold, silver, copper, and aluminum, hold some of their electrons loosely. These electrons move freely from atom to atom within the material.

A neutral object can become charged by gaining or losing electrons. If an object loses electrons, it is left with more protons (positive charge) than electrons (negative charge). Thus the object is positively charged overall. If, instead, an object gains electrons, it has more electrons than protons. Thus it has an overall negative charge.

The buildup of charges on an object is called **static electricity.** Static electricity behaves quite differently from electric currents. In an electric current, charges move continuously. **In static electricity, charges build up, but they do not flow.**

Transferring Charge Exactly how do charges build up? Charges must be transferred from one object to another. There are three methods by which charges are transferred: friction, conduction, and induction. **Friction** is the transfer of electrons from one object to another by rubbing. **Conduction** is the transfer of electrons from a charged object to another object by direct contact.

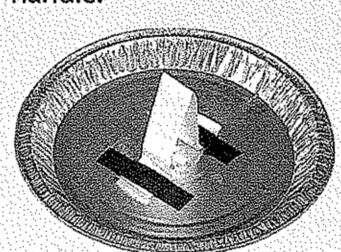
TRY THIS

Sparks Are Flying

ACTIVITY

You can make your own lightning.

1. Cut a strip 3 cm wide from the middle of a foam plate. Fold the strip to form a T. Tape it to the center of an aluminum pie plate as a handle.



2. Rub a second foam plate on your hair. Put it upside down on a table.
3. Use the handle to pick up the pie plate. Hold the pie plate about 30 cm over the foam plate and drop it.
4. Now, very slowly, touch the tip of your finger to the pie plate. Be careful not to touch the foam plate. Then take your finger away.
5. Use the handle to pick up the pie plate again. Slowly touch the pie plate again.

Inferring What did you observe each time you touched the pie plate? How can you explain your observations?

Induction is the movement of electrons to one part of an object by the electric field of another object. The three methods of transferring charge are illustrated in *Exploring Static Electricity.*

Keep in mind that charges are not created or destroyed. If an object gives up electrons, another object gains those electrons. Electrons are only transferred from one location to another. This is known as the law of **conservation of charge.**

Static Cling Static electricity explains why clothes stick together in the clothes dryer. In a dryer, different fabrics rub together. Electrons from one fabric rub off onto another. In this way, the clothes become charged. A positively charged sock might then be attracted to a negatively charged shirt—the clothes stick together.

Your clothes are less likely to stick together if you use a fabric softener sheet. These sheets add a thin coating to your clothes as they bounce around in the dryer. The coating prevents electrons from rubbing off the clothing, so the clothes don't become charged.

Can you think of situations in which you might want to increase static electricity? Think about wrapping leftover food in plastic wrap. Plastic wrap picks up a charge when you unroll it. Since plastic is an insulator, the charge cannot move off it. So the wrap keeps its charge. When you place the plastic wrap on a container, it charges the edges of the container by induction. The force between the opposite charges on the wrap and the container causes the wrap to cling.

Static electricity allows you to make copies quickly. In a photocopier, a drum is given a negative static charge that is the image of the page to be copied. This charged image picks up positively charged particles of a very fine black powder. The drum then rolls against a negatively charged piece of paper, and the powder is transferred to the paper. Finally, the paper is heated to melt the powder, and the powder sticks to the paper.

☑ ***Checkpoint*** *What is the law of conservation of charge?*

Static Discharge

An object that gains a static charge doesn't hold the charge forever. Electrons tend to move, returning the object to its neutral condition. **When a negatively charged object and a positively charged object are brought together, electrons move until both objects have the same charge.** The loss of static electricity as electric charges move off an object is called **static discharge.**

Humidity If you rub a balloon on your clothing and then hold it next to a wall, it should stick. But the balloon may not always stick. Why is that? The answer could have to do with the weather.

EXPLORING Static Electricity

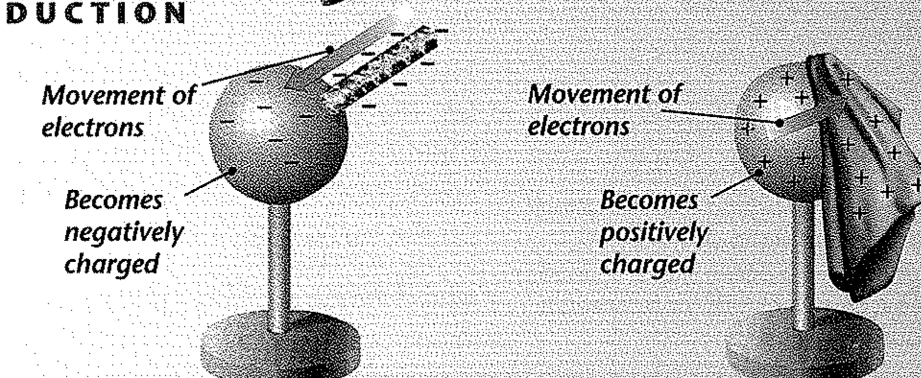
Static electricity involves the transfer of electrons from one object to another. Electrons are transferred by friction, conduction, or induction.

CHARGING BY FRICTION

When you rub two objects together, electrons move from one object to the other. This is known as charging by friction.

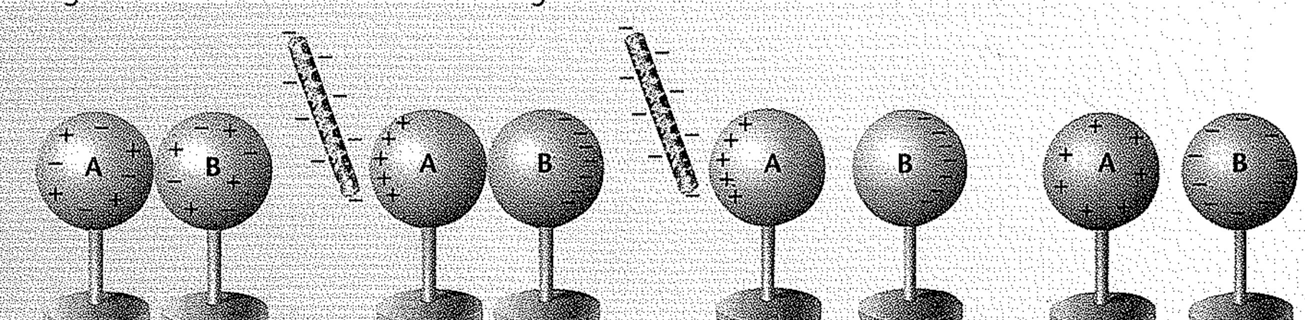
CHARGING BY CONDUCTION

When the charged rod or cloth touches the sphere, electrons are transferred by direct contact. This is known as conduction.



CHARGING BY INDUCTION

During induction, charges within the spheres are rearranged without direct contact with the charged rod.



Neutral charge | *Negative charges in the rod repel negative charges in the spheres.* | *When the spheres are separated, each one is charged.* | *Removing the charged rod leaves two charged spheres.*

On a humid day, the air is filled with water molecules. Extra electrons on an object are carried off by molecules of water in the air. Thus the charges do not have a chance to build up on objects such as the balloon.

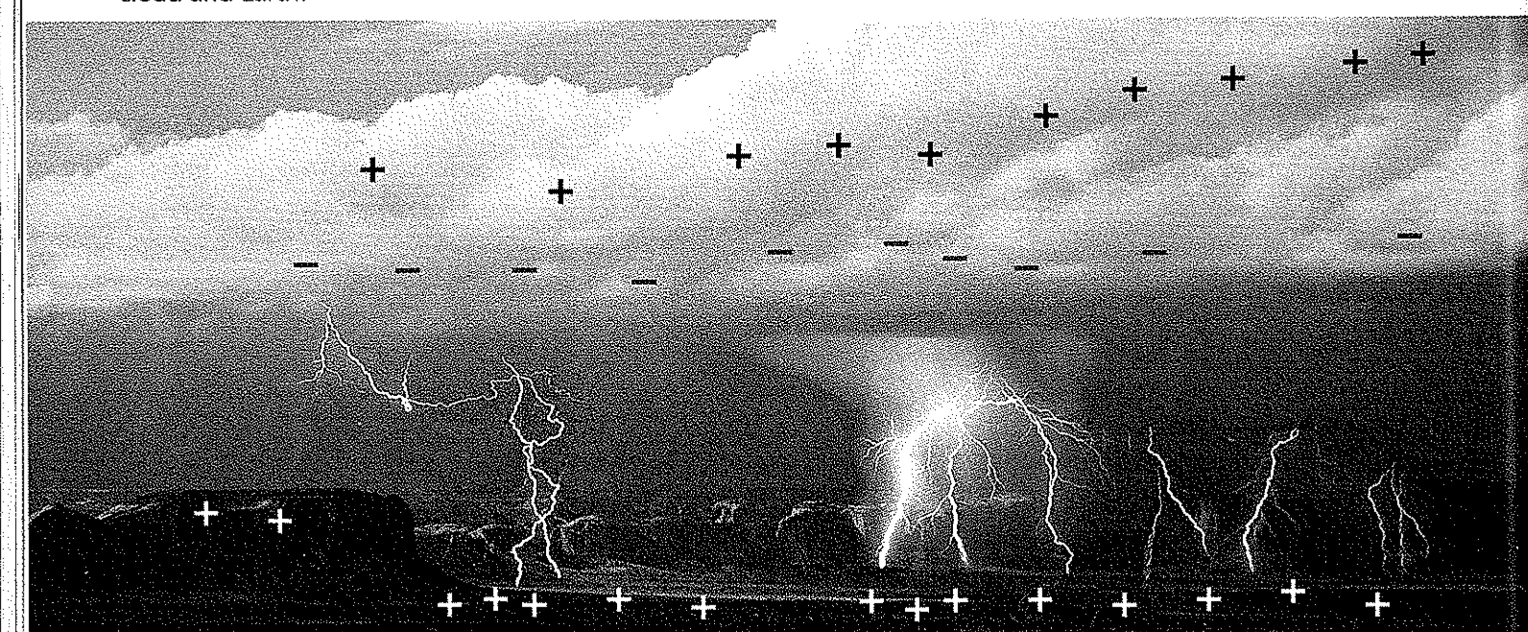
Sparks and Lightning Have you ever felt a shock from touching a doorknob after walking across a carpet? That shock is the result of static discharge. For example, as you walk across the carpet, electrons may rub off the soles of your shoes. This gives you a slight positive charge. When you touch the doorknob, electrons jump from the doorknob to your finger, making you neutral again.

Lightning is a dramatic example of static discharge. Lightning is basically a huge spark. During thunderstorms, air swirls violently. Water droplets within the clouds become electrically charged. Notice in Figure 5 that electrons collect in the lower parts of the cloud. To restore a neutral condition, electrons move from areas of negative charge to areas of positive charge. As electrons jump, they produce an intense spark. You see that spark as lightning.

Much of the lightning in a storm occurs between different regions of a cloud or between different clouds. But some lightning reaches Earth. This is because the cloud causes the surface of Earth to become charged by induction, as shown in Figure 5. Negative charges on the bottom of a cloud repel electrons, leaving the surface of Earth with a positive charge. If the charge buildup is sufficient, a huge spark of lightning is produced. The spark jumps between the cloud and Earth's surface or tall objects on the surface, such as trees or buildings.

✓ *Checkpoint* *How can you get a shock from a doorknob?*

Figure 5 Lightning is a spectacular discharge of static electricity. Lightning can occur within a cloud, between two clouds, or between a cloud and Earth.



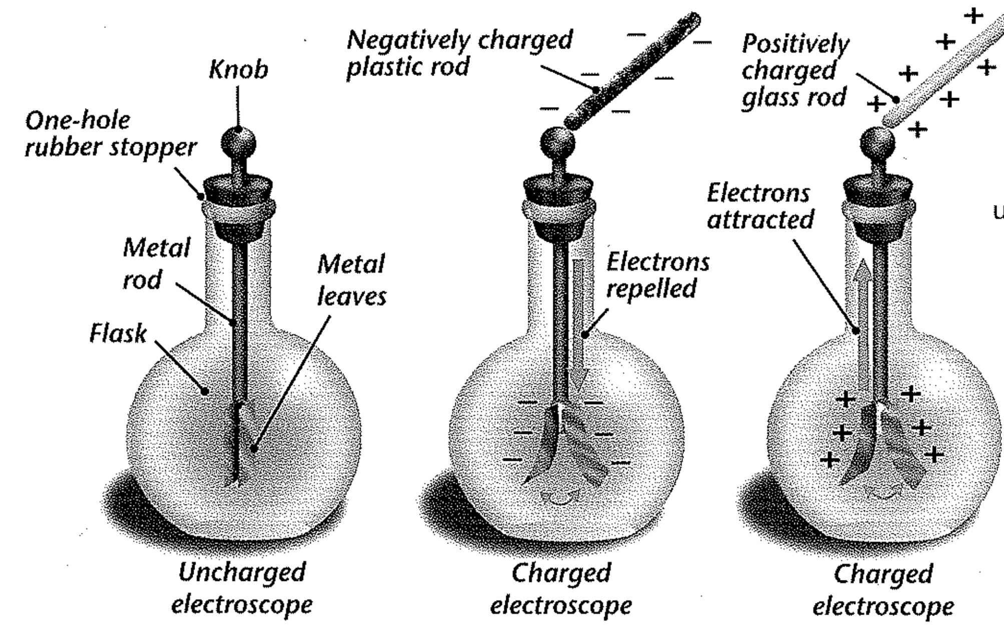


Figure 6 An electroscope is used to detect electric charges. ***Relating Cause and Effect*** *Why do the leaves in an electroscope move apart when either a positively charged object or a negatively charged object touches the knob?*

Detecting Charge

Electric charge is invisible, but it can be detected by a special instrument called an **electroscope.** A typical electroscope consists of a metal rod with a knob at the top. At the bottom of the rod are two sheets, or leaves, of very thin metal (aluminum, silver, or gold). When the electroscope is uncharged, the leaves hang straight down.

When a charged object touches the metal knob, electric charge travels along the rod and into or out of the leaves. The leaves then have a net charge. Since the charge on both leaves is the same, the leaves repel each other and spread apart.

The leaves of an electroscope move apart in response to either negative charge or positive charge, so you cannot use an electroscope to determine the type of charge. You can use an electroscope only to detect the presence of charge.

Section 1 Review

1. How do particles with the same charge interact? How do particles with opposite charges interact?
2. What is static electricity?
3. What are the three ways by which static charge is produced?
4. How is static electricity discharged?
5. How does an electroscope detect charge?
6. **Thinking Critically Comparing and Contrasting** How are electric charges similar to magnetic poles? How are they different?

Science at Home

Rub a balloon against your hair and bring the balloon near one of your arms. Then bring your other arm near the front of a television screen that is turned on. Ask a family member to explain why the hairs on your arms are attracted to the balloon and to the screen. Explain that this is evidence that there is a static charge on both the balloon and the screen.