Section 4.2 Static Electricity

Key Terms

- static electricity
- attract
- repel
- discharges

Figure 4.8 Do your socks go with your shirt—a little too well? Static electricity can make different fabrics stick together.

You pull a shirt out of the clean laundry basket and some other clothing is stuck to it. You drag your feet across the carpet and feel a shock when you reach for the doorknob. You brush your hair on a winter day and it sticks out from your head. You pull out an extra blanket on a winter night and sparks crackle. All of these are examples of **static electricity**. Static electricity is a buildup of positive and negative charges that have become separated from each other. The word "static" means "not moving." Static electricity is an electric charge that stays in one place on the surface of an object.

But what makes these charges build up? And why is static electricity noticeable sometimes, but not always? In this section you will explore the properties of static electricity.

Explaining Static Electricity

In Section 4.1 you saw that atoms can pick up electrons from other atoms. When this happens, both atoms become electrically charged. This picking up and losing—or *transfer*—of electrons takes place between the atoms of different objects or materials. If you rub two pieces of wool cloth together, they won't pick up electrons from each other. But if you rub a balloon and a wool cloth together, one will pick up electrons from the other. When you separate the objects, you leave a static charge on each object.

Rubbing Builds a Charge

In Starting Point Activity 4-A, you charged a balloon with static electricity by rubbing it with a piece of wool. As you can see in Figure 4.9, the surface of the balloon picked up electrons from the wool and became negatively charged. The surface of the wool lost electrons and became positively charged.

If you keep rubbing the balloon and the wool together, electrons will continue to move from the wool to the balloon. The longer or harder you rub, the larger a static charge you build.

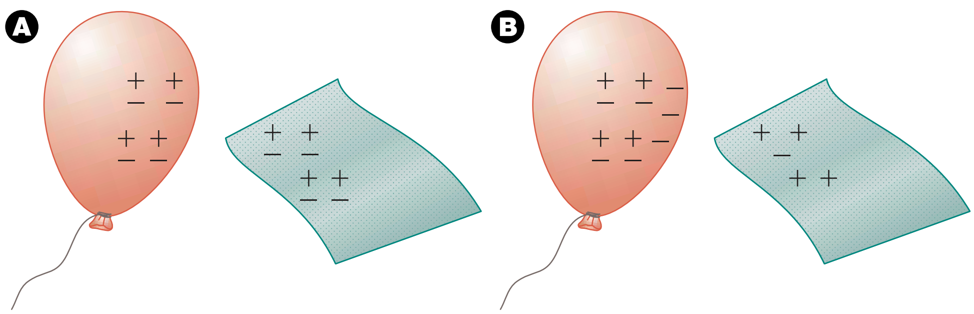


Figure 4.9 (A) Before the balloon is rubbed with the wool cloth, the charges on both objects are balanced. (B) After the balloon is rubbed with the wool cloth and the objects are separated, the wool is left with a positive charge. The balloon is left with a negative charge. Electrons have transferred from the wool to the balloon on the spot that was rubbed.

After the balloon became charged with electricity, it behaved in a specific way. As you moved toward the charged balloon, the balloon moved toward you. The balloon was reacting to the electric charges within your body. When the charged balloon was placed near another charged balloon, the two charged balloons moved away (were repelled) from each other. Electricity can "pull together" or **attract** other objects. Electricity can also "push away" or **repel** other objects. In Investigation 4-C, you will charge different objects to find out more about how electric charges behave.

Pause & Reflect

What would happen if you rubbed the balloon only *once* with the wool? Would you still see the effects of static electricity? Why do you think the effect is different when you rub the balloon *several times* with the wool?

CONDUCT AN

INVESTIGATION 4-C

SKILLCHECK
- Predicting
- Observing
- Interpreting Observations
- Communicating

Get Ready, Get Set, Charge!

In the 1600s, scientists began to study carefully the behaviour of electric charges to find out what was causing static electricity. In this investigation, you will play the role of a scientist trying to discover how static electricity works. You will find out which types of objects can be charged with electricity, and you will observe what happens when charged objects are brought near other objects. You will also change the strength of an electric charge.

Question

Which objects can be charged with static electricity, and how do charged objects behave?

Safety Precautions

- Small static shocks may occur.

Apparatus

2 plastic spoons
2 rods of glass
piece of wool cloth
piece of silk

Materials

paper punches or confetti

Procedure

Part 1

1. Copy Table 1 into your science notebook. Give it a title.
2. **Predict** what kinds of effects you will see when you create a static electric charge.
3. Put a small pile of paper confetti on your desk.
4. Rub the two plastic spoons together. Place them near the confetti. **Record** your observations as "Trial 1" in your table.
5. Rub the two glass rods together. Place them near the confetti. **Record** your observations as "Trial 2" in your table.
6. Rub one of the spoons with a piece of silk. Place the spoon near the confetti. **Record** your observations as "Trial 3" in your table.
7. Rub one of the glass rods with a piece of silk. Place the rod near the confetti. **Record** your observations as "Trial 4" in your table.
8. Rub the bowl of each spoon with the silk. Do not touch the bowl of the spoon after you have rubbed it. Put one spoon down on your desk. Hold the other spoon by the handle and bring it close to the spoon on the desk. **Record** your observations as "Trial 5" in your table.
9. Rub the ends of both glass rods with the silk. Do not touch the ends after you have rubbed the rods. Put one rod down on your desk. Bring the second glass rod close to the first. **Record** your observations as "Trial 6" in your table.
10. Rub one glass rod and the bowl of one spoon with the silk. Put the spoon down on your desk and bring the glass rod close to it. **Record** your observations as "Trial 7" in your table.

Table 1

Trial	Observations
Trial 1: Plastic rubbed with plastic and put near paper	
Trial 2: Glass rubbed with glass and put near paper	
Trial 3: Plastic rubbed with silk and put near paper	
Trial 4: Glass rubbed with silk and put near paper	
Trial 5: Two plastic spoons rubbed with silk and put near each other	
Trial 6: Two glass rods rubbed with silk and put near each other	
Trial 7: Plastic spoon rubbed with silk and put near glass rod rubbed with silk	

Part 2

1. Copy Table 2 into your science notebook. Give it a title.
2. Rub one plastic spoon with a piece of wool. Rub the spoon 10 times and put it near the paper confetti. **Record** your observations under "Trial 1" in your table.
3. Rub the spoon with the wool 60 times and put it near the paper confetti. **Record** your observations under "Trial 2" in your table.

Table 2

Trial	Observations
Trial 1: 10 rubs	
Trial 2: 60 rubs	

4. Clean up your work area and return all your objects to your teacher.

Analyze

1. How many different types of effects did you observe in Part 1? Describe those effects.
2. Which trials in Part 1 did not show the effect of an electric charge? Why was there no electric charge even though the objects were rubbed together?
3. What was the effect of rubbing more times in Part 2?

Conclude and Apply

4. Write a few sentences or draw and label a picture that explains your observations when
   (a) you rubbed silk on glass and held the glass near the paper.
   (b) you rubbed glass on glass and held the glass near the paper.
5. If you wash cotton socks and put them in the dryer, will they cling to one another? What would happen if you put a silk shirt into the dryer with the socks? Give a reason for your answer.
6. When you brush your hair, your hair sometimes stands on end and is attracted to your brush. Will brushing your hair for a longer time help to settle it? Explain.
7. In Part 2, what do you think happens to the wool in each trial? Explain.

Extend Your Skills

8. Try this experiment using other materials around the classroom: Styrofoam™, metal, wood, rubber.

Pause& Reflect

"Nothing could exist without electric charges." Do you agree with this sentence? Think about the structure of the atom. What do you think holds an atom together?

DidYouKnow?

Scientists can place materials in order of how easily they give up electrons. If you rub together two materials from the following list, the one higher on the list will give up electrons. It will become positively charged. The one lower on the list will gain electrons. It will become negatively charged. Does this help to explain your observations in Investigation 4-C?

human skin

glass

hair

wool

silk

paper

cotton

rubber

plastic

Three Rules of Electricity

When scientists began to study static electricity, they did experiments as you did in Investigation 4-C. Through this research, scientists concluded that the behaviour of electric charges follows three basic rules.

1. Opposite Charges Attract

You might have heard this expression: "opposites attract." In the case of static electricity, it is definitely true. Objects with a positive charge will attract objects with a negative charge. If you put a silk shirt and cotton socks together in the dryer, they rub together while the dryer runs. The shirt will give up electrons to the socks. The shirt becomes positively charged and the socks become negatively charged. When the laundry is done, the socks and shirt cling together.

Figure 4.10 A bad hair day? When you pull off your sweater, static electricity may make your hair stand on end.

2. Like Charges Repel

Objects that have the same charge will push away from one another. When you rub two balloons with wool, both balloons become negatively charged. Then when you hang them side by side, they move apart.

Two positively charged objects will also repel each other. You may have experienced this yourself if you have ever pulled off a woollen hat or sweater on a dry winter day. As the wool rubs your hair, it picks up electrons. Each hair becomes positively charged. Each hair will try to move away from every other hair because they have the same charge. The result: a positively hair-raising experience!

3. Charged Objects Attract Uncharged Objects

In Investigation 4-C you found that pieces of paper will move toward a charged object. The paper itself did not have a charge—it was electrically neutral. Why did it move?

Remember that an uncharged object still has both positive and negative charges. These charges can move around within an object. Figure 4.11 shows what happens when a negatively charged balloon is brought close to an uncharged wall. The negative charges in the balloon repel the charges in the wall. The result is that the part of the wall nearest the balloon becomes positively charged, even though no electrons have actually moved from the balloon to the wall or from the wall to the balloon.

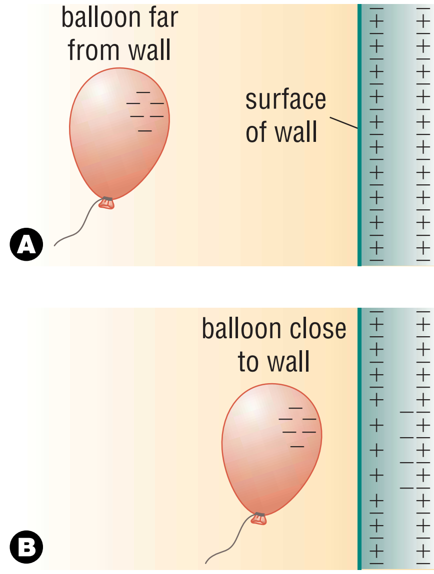


Figure 4.11 (A) When a negatively charged balloon is held far from an uncharged wall, the charges in the wall are evenly distributed. (B) When the charged balloon is held close to the wall, the electrons in the part of the wall next to the balloon move as far away from the balloon as possible. That part of the wall becomes positively charged. The negatively charged balloon and the positively charged part of the wall are attracted to each other. The balloon sticks to the wall.

READING Check

What are the three rules of static electricity?

Using Static Electricity

Making your hair stand on end or sticking balloons to the wall can be fun, but is it useful? Some technologies use the properties of charged objects to do important work.

For example, some pulp mills and factories use static electricity to clean the smoke from their smokestacks. To clean the smoke, charged plates are placed in the smokestack. Oppositely charged particles in the smoke are attracted to the plates and stick to them. The particles can then be collected and removed from the smokestack, allowing the cleaner gas to be released into the air. In the next activity you will build a simple version of another common machine that uses static electricity.

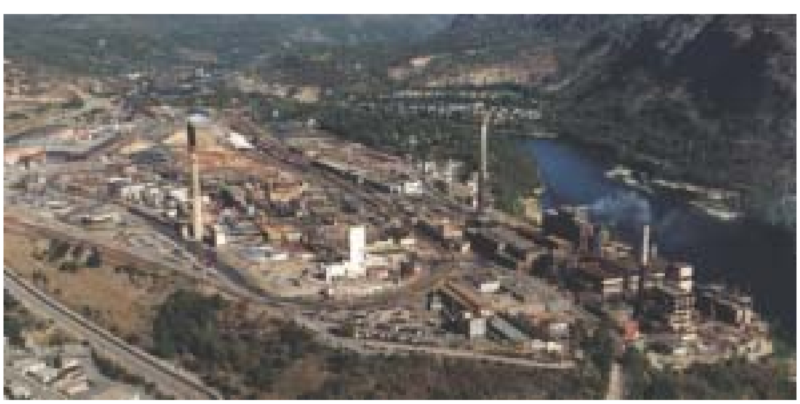


Figure 4.12 The Teck Cominco smelter in Trail, B.C., uses static electricity to reduce pollution from its smokestacks.

Find Out **ACTIVITY 4–D**

Make a Pepper Copier

Your friend has drawn the funniest cartoon you have ever seen, and you will use the library to make a photocopy for yourself. In this activity, you will model what goes on inside the photocopier when you use it to copy the cartoon.

What You Need

a plastic petri dish with a lid
ground pepper
Scotch tape
paper
wool cloth
scissors

What to Do

1. Make a stencil by tracing the outline of the petri dish lid onto a piece of paper. Cut out the circle of paper. Then cut the shape of your first initial out of that circle.
2. Put a small amount of pepper into the petri dish.
3. Shake the dish to spread the pepper evenly so that it covers the entire bottom of the petri dish.
4. Place the lid on the petri dish.
5. Attach the stencil to the outside of the petri dish lid with small pieces of tape at the edges.
6. Trial 1: Turn the petri dish upside down and then right side up again. Remove the lid and **observe** the pepper.
7. Trial 2: Replace the lid on the petri dish. Place the Petri dish on a flat surface, holding the dish at the edges. Using a wool cloth, rub the lid only where it shows through your stencil. Rub hard and quickly with two fingers for 45 to 60 seconds.
8. Remove the stencil from the lid. Be careful to handle the lid only at the edges.
9. With the lid still on, turn the petri dish upside down, and then right side up again. Remove the lid and **observe** the pepper.

What Did You Find Out?

1. What happened to the pepper in your first trial? What happened in the second trial? Explain why the results were different.
2. What happens to electrons in the pepper when they come close to plastic that has a negative charge? Explain.

Extension

3. Why was it important to do the two different trials in this activity? Explain.
4. Use your school library or the Internet to research how a photocopier uses static electricity. Make a diagram or write a short report to communicate what you learned.

Static Shocker: Electricity Can Jump

You have seen that objects charged with static electricity can attract and repel other objects. For example, a negatively charged balloon will attract a positively charged piece of wool. When this happens, the charges stay on the surface of each object. The electrons themselves do not move between the wool and the balloon unless they touch.

Sometimes, however, electrons do jump from one object to another. You may feel the burst of electrons as a shock, and you may see it as a spark. You can even hear it: think about the crackle when you separate clothes that have stuck together in the dryer. The crackle is the burst of electrons transferring from one object to another. This transfer of electrons **discharges** the static electricity. That is, the transfer puts the electric charges back in balance on each object. Figure 4.13 shows what happens when you get a static electric shock from a doorknob.

A
B
C

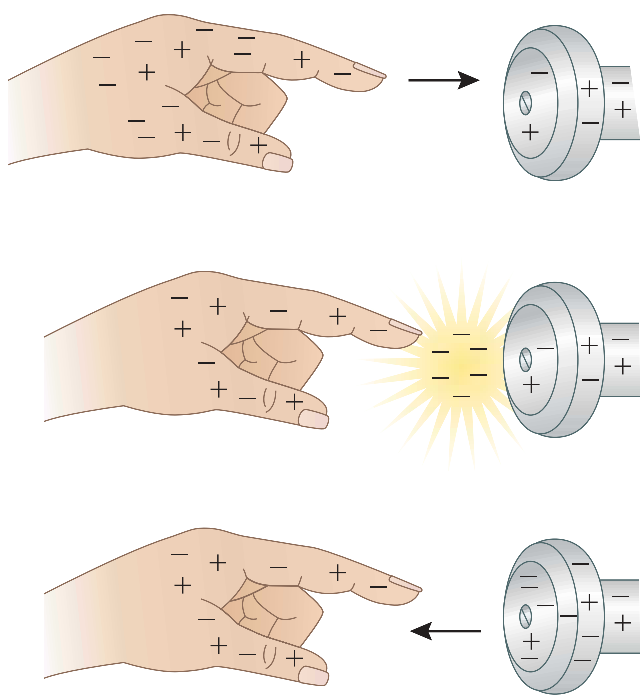


Figure 4.13 (A) If you shuffle your feet across a carpet, you may pick up electrons from the carpet. Your body may build a negative charge. (B) As you reach for the doorknob, the extra electrons are discharged in a sudden burst, which we often call a "shock." The shock happens when your finger and the knob are close together, but not yet touching. Electrons leap between them, making the air light up as they pass. (C) Your body now has a balanced charge again, and the extra electrons have moved into the doorknob.

READING Check

What causes a static electric shock?

Did You Know?

Lightning strikes are millions of times more powerful than the static shocks you get from a doorknob.

Off the Wall

You sometimes get a static shock when you step out of a car and touch the metal around the door. During the drive your body has been rubbing on the seat and building a charge. In most cars, this shock will be several times stronger if you are wearing nylon than if you are wearing cotton.

Figure 4.14 Human cultures have often associated lightning with supernatural beings. In the traditional stories of the Kwakwaka'wakw First Nation on Vancouver Island, lightning is made by a powerful being called Thunderbird.

Lightning Is a Gigantic Static Shock

In the time it takes you to say the word "lightning," lightning strikes about 100 times around the world. A lightning strike is a very powerful natural event. A bolt of lightning can explode a tree, shatter rock, and melt sand into glass. And yet lightning is just a more powerful version of the shock you get from a doorknob.

During a thunderstorm, air currents cause water droplets and ice particles to collide and rub together inside a thundercloud. This action builds an enormous imbalance of charges within the cloud. Figure 4.15 shows how this static electricity is released, or discharged, in the form of lightning.

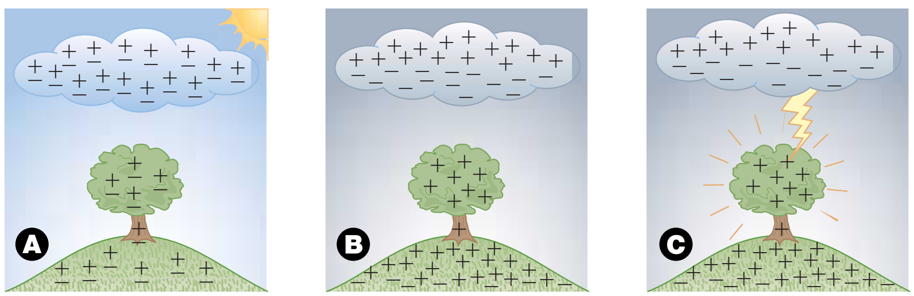


Figure 4.15 Charges that build up during a thunderstorm are released as lightning.
(A) Both the cloud and the ground are neutral to begin with.
(B) Within the cloud, particles of ice and water rub together. Some particles lose electrons and other particles gain electrons. Negative charges build up on the bottom of the cloud. The strong negative charge from the cloud repels negative charges on Earth's surface. The ground under the cloud as well as objects on the ground, such as trees or buildings, become positively charged.
(C) A gigantic spark leaps from the cloud to the ground. What you see as a single flash of lightning is actually many sparks that travel between the cloud and the ground.

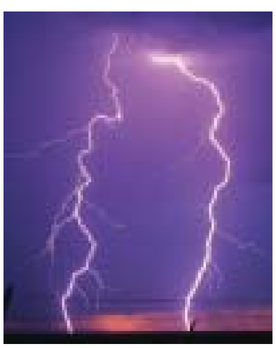
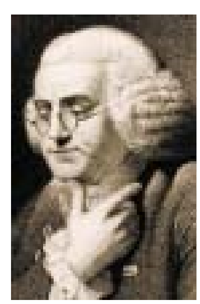


Figure 4.16 An average bolt of lightning is about 10 km long. A lightning stroke can reach a temperature several times hotter than the Sun.

INTERNET CONNECT

www.mcgrawhill.ca/links/BCscience6

Lightning happens suddenly and is over in an instant. The speed of this event makes it hard to study. Benjamin Franklin was an American scientist in the 1700s who studied lightning—and he was lucky to survive his own experiment. He flew a kite in a storm to show that storm clouds carry electricity. To learn more, go to the web site above. Click on **Web Links** to find out where to go next. What did Franklin do?



A lightning strike will usually take the shortest route between the negatively charged cloud and the positively charged ground. This is why lightning tends to strike tall buildings and trees. In the following activity, you will find out more about lightning in your area. You will also learn how to protect yourself from lightning.

READING Check

Why does lightning usually strike tall objects?

Figure 4.17 Some people try to protect themselves during a rain or lightning storm by taking cover under tall trees. Is this a good idea?

Pause & Reflect

If lightning strikes tall buildings, can you think of how lightning rods might work to prevent lightning damage? In Section 4.3, learn how lightning rods work.

At Home **ACTIVITY 4–E**

How Shocking!

You have probably heard the saying "lightning never strikes twice in the same place." Or maybe someone has told you that you can tell whether a thunderstorm is moving toward you or away from you just by listening to it. But are these things really true? In this Activity you will collect information about lightning and then sort fact from fiction.

What to Do

1. Talk with friends and members of your family to find out what they know and believe about lightning. Make a list of all the "facts" you hear from them.
2. Use reference books in your library or the Internet to investigate which of the statements on your list are true, and which are not.
3. As you conduct your research, add more statements to your list. Try to collect statements that are true and statements that are false. For every false statement you collect, write a true statement to correct it.

What Did You Find Out?

1. How much of what you heard in the past about lightning was true?
2. Will any of the things you learned about lightning change how you and your family behave during a thunderstorm? Explain why.
3. Using the information you have collected, prepare a poster or a presentation that will **communicate** accurate information about lightning. Include safety tips that will help people to protect themselves from lightning both indoors and outdoors.
4. Share this information with your family and friends at home.

Section 4.2 Summary

In this section, you learned that you can build a static electric charge by rubbing together objects made of different materials. One object transfers electrons to the other with the following results:

- The object that gives up electrons becomes positively charged.
- The object that picks up electrons becomes negatively charged.

This imbalance of charges is called static electricity. This kind of electric charge stays in one place on the surface of each object. The longer you rub the two different objects together, the stronger the charge becomes. Static electric charges follow three basic rules:

1. Opposite charges attract each other.
2. Like charges repel each other.
3. Charged objects attract uncharged objects.

When two oppositely charged objects are close together, electrons may jump through the air between them to balance the charge. This discharge of static electricity causes a static electric shock. Lightning is an example of a large static electric shock.

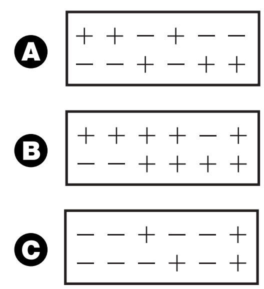
Key Terms

static electricity
attract
repel
discharges

Check Your Understanding

1. How does a positively charged object become uncharged?

2. The following diagram illustrates the charge on three different objects, A, B, and C.
   (a) Is object A positively charged, negatively charged, or uncharged?
   (b) What will happen to object B if object C is brought close?
   (c) What would have to be done to object C to make it neutral?



3. What is it called when electrons enter or leave an object to balance a charge?

4. **Apply** You rub two identical wool cloths together, and then hold them close together (but not touching). What would you expect to observe? Explain.

5. **Thinking Critically** The following diagram shows electric charges (shown as X's) that accumulate on balloons when they are each rubbed with a wool cloth. Each balloon is made of a different material. Which diagram illustrates a static charge on the balloon? Explain.