Topic 4.3

How can objects become charged and discharged?

Key Concepts

- Objects can become charged by contact and by induction.
- Charged objects can be discharged by sparking and by grounding.

Key Skills

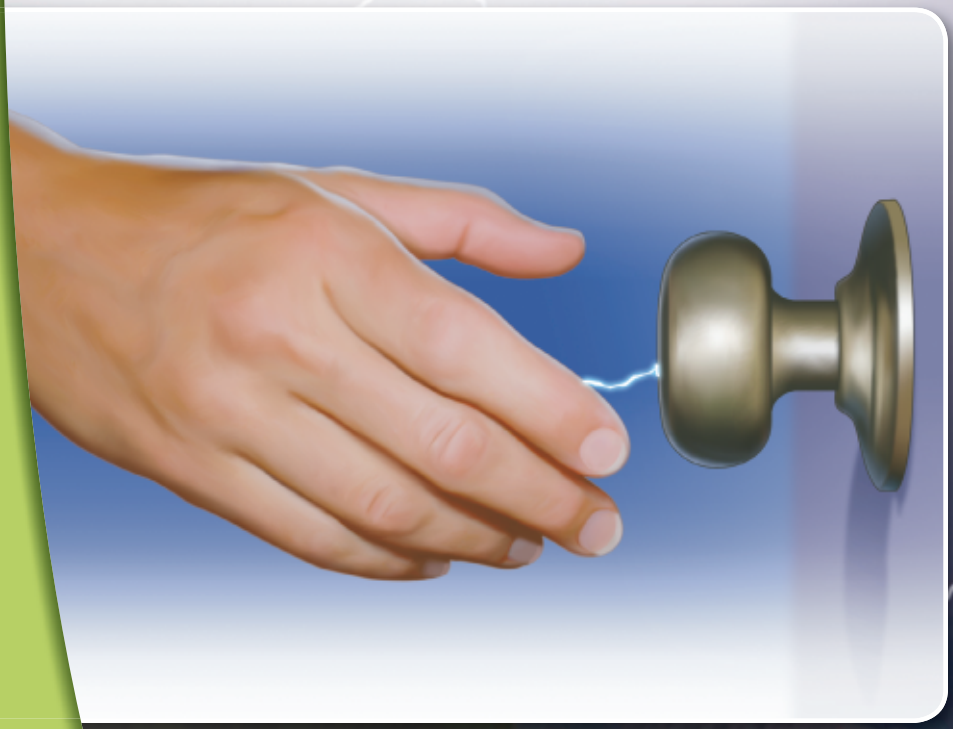
Inquiry

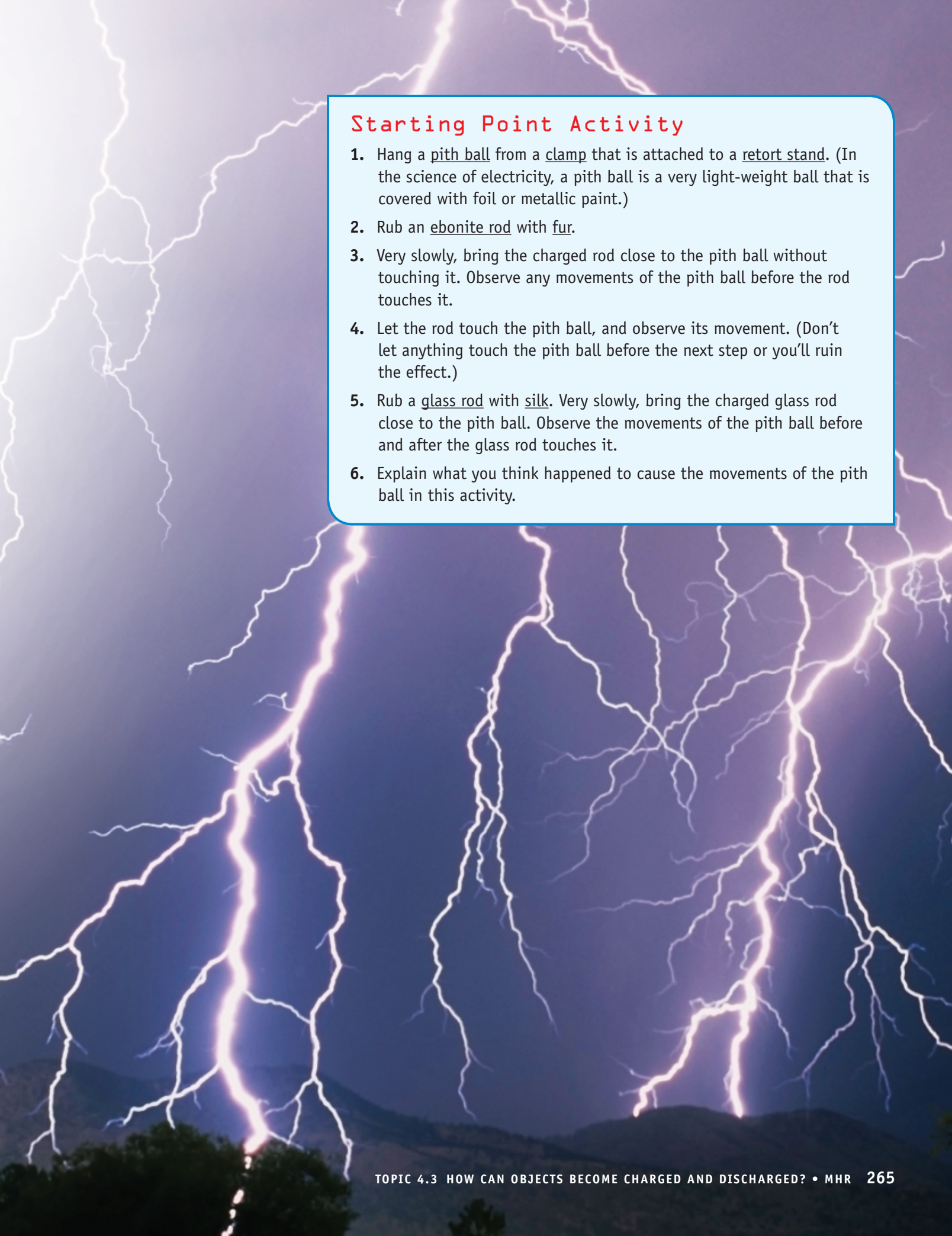
Key Terms

charging by contact
electroscope
charging by induction
discharged
grounding

It's winter. You walk across a carpet while wearing wool socks or rubber-soled shoes. With each step you take, charges are building up on your body. You reach for a metal doorknob. Snap! You get a shock. If the room is dark, you might even see a spark jump between your finger and the doorknob. The object you reach for doesn't even have to be metal. If the amount of charge that your body has built up is great enough, you can cause a spark to jump between your finger and another person's skin.

Lightning looks like a giant spark. In fact, that's exactly what it is! Lightning just has millions of times more energy than the spark you experience when you touch a doorknob. Scientists still aren't sure how charges in clouds become separated. However, scientists do know that the bottoms of the clouds in a thunderstorm are negatively charged, and the tops of the clouds are positively charged. This separation of charges in the clouds leads to the stupendous spark or clusters of sparks that we call lightning.





Starting Point Activity

1. Hang a pith ball from a clamp that is attached to a retort stand. (In the science of electricity, a pith ball is a very light-weight ball that is covered with foil or metallic paint.)
2. Rub an ebonite rod with fur.
3. Very slowly, bring the charged rod close to the pith ball without touching it. Observe any movements of the pith ball before the rod touches it.
4. Let the rod touch the pith ball, and observe its movement. (Don't let anything touch the pith ball before the next step or you'll ruin the effect.)
5. Rub a glass rod with silk. Very slowly, bring the charged glass rod close to the pith ball. Observe the movements of the pith ball before and after the glass rod touches it.
6. Explain what you think happened to cause the movements of the pith ball in this activity.

Objects can become charged by contact and by induction.

There are three ways that you can charge objects. One way that you learned about in Topic 4.2 is by rubbing different materials together (charging by friction). The second way involves objects touching. The third way involves objects being close to each other but not touching.

Charging by Contact: Objects Touch

charging by contact: causing a neutral object to become charged by touching it with a charged object

If you touch an uncharged object with a charged object, some of the charge will move onto the uncharged object. This process is called **charging by contact**. You cannot tell whether an object is charged just by looking at it. Therefore, it is convenient to use a device that changes in shape when it is charged. This device is called an electroscope.

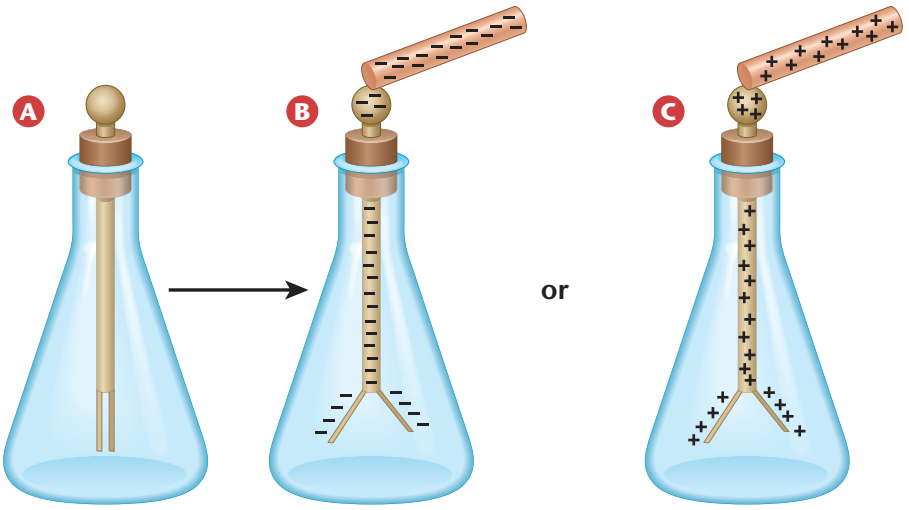
electroscope: a device that enables you to test an object and find out if it is charged

The **electroscope** shown in Figure 4.9 has a metal ball connected to one end of a metal rod. The other end of the metal rod has two lightweight, flexible, metal strips called metal leaves. When you touch a charged object to the metal ball, the ball is charged by contact. The parts of the electroscope are conductors. So the charges spread out over the metal ball, down the metal rod, and onto the metal leaves. When the leaves are charged, they repel each other and move apart. Therefore, when you see the leaves move apart, you know that they are charged. You can also use an electroscope to test an object to find out if the object is charged. If you touch the ball of the electroscope with an uncharged object, the leaves will not move.

A When an electroscope is not charged, the leaves hang down.

B When you touch the electroscope with a negatively charged rod, the charge spreads out over all the metal parts. This gives the metal leaves like charges, so they repel each other.

C If the rod is positively charged, negative charges in the metal parts will be attracted to the rod and will move into it. As a result, the electroscope will be positively charged.



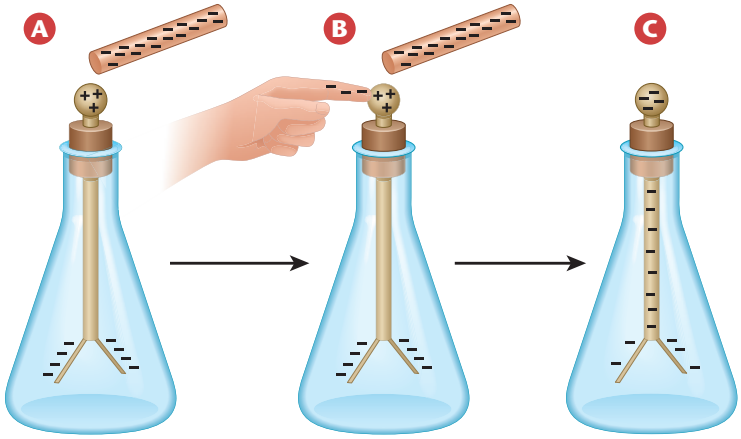
▲ **Figure 4.9** Charging an electroscope by contact. Only excess charges are shown. (There are many more positive and negative charges present.)

Charging by Induction: Objects Don't Touch

Figure 4.10 shows another way to charge an electroscope. This way involves bringing a charged rod near the metal ball but not touching it.

If, for example, the rod is negatively charged, the negative charges on the rod repel negative charges in the metal ball. The negative charges in the metal ball then move away from the rod and down to the leaves. Since the leaves become negatively charged, they repel each other. Positive charges are left behind on the metal ball. Now, without moving the rod, if you touch the ball of the electroscope with your finger, the positive charges on the ball will attract the negative charges on your finger. Because your body is a conductor, the negative charges will move onto the ball. When you remove your hand and move the rod away, the negative charges from your hand will remain on the electroscope, so it will now be charged. Charging an object in this way is called **charging by induction**.

charging by induction: causing a neutral object to become charged by bringing a charged object near to, but not touching, the object



◀ **Figure 4.10** To charge an electroscope by induction, bring a charged rod near the ball. As shown in (A), if the rod is negatively charged, the electrons from the ball will be repelled and go down to the leaves. Now touch the ball with your finger, as shown in (B). Negative charges from your finger will be attracted by the positive charges on the ball of the electroscope. Some negative charges will move onto the ball. Remove your hand first and then the rod. As shown in (C), the electroscope now has an excess of negative charges even though the charged rod never touched it. (Only the excess charges are shown.) If the rod had been positively charged, all the motion of the negative charges would have occurred in the opposite direction.

Inquiry Focus

Activity 4.7

PREDICT THE RESULT

Predict what will happen if you follow the steps below. Sketch the electroscope leaves in each case. Will the leaves look different? If so, how?

1. You touch an uncharged electroscope with a negatively charged rod.
2. You touch an uncharged electroscope with a rod that carries a larger negative charge than the rod in step 1.

LEARNING CHECK

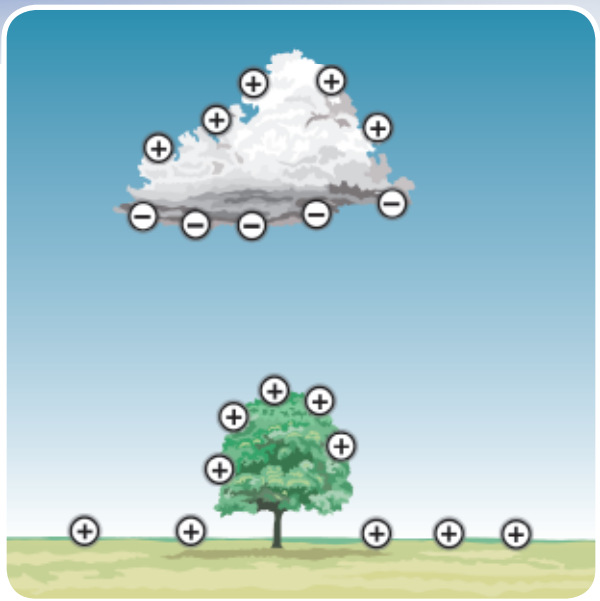
1. Describe how to charge an object by a) contact and b) induction.
2. Draw and label sketches to explain how to use an electroscope to predict if an object is charged.

Charged objects can be discharged by sparking and by grounding.

discharged: an object loses its excess charge

What is happening to the charged objects when a spark between them occurs? Sometimes, the attraction between the negative charges and positive charges becomes so great that charges actually jump across the gap between the objects. If all of the excess charge moved off the objects, the objects are said to be **discharged**. However, in a spark, usually only some of the charges leave the object. Figure 4.11 shows how charges that build up on a body and in a cloud can be discharged with a spark.

▶ **Figure 4.11A** When your shoes rub on a carpet, they rub negative charges off the carpet. Your body is a conductor, so the charges spread over the surface of your body. When your hand is near the doorknob, it induces a charge on the doorknob. If the attraction between the charges on your hand and the doorknob are great enough, the negative charges from your hand jump across the gap to the doorknob and you experience a shock.



▶ **Figure 4.11B** The turbulence in thunderclouds causes many collisions between water droplets and ice crystals. This somehow causes charges to separate so that the bottoms of the clouds become negatively charged and the tops of the clouds become positively charged. The negative bottom of the clouds induces a charge on the ground and objects on the ground. When the attractions between the negative charges in the clouds and positive charges on the ground are great enough, charges jump between the clouds and the ground.

How Grounding Discharges an Object

Lightning can be deadly, and a spark near flammable materials such as gasoline can start a fire. There must be a better way to discharge a charged object. Fortunately, there is. It is called grounding. You can use a conductor to carry charges away from an object safely, and guide them to a place where they will do no harm. That place is Earth. Earth is a giant conductor. Adding charges to Earth is like pouring a cup of water into the ocean. The change is not noticeable. Connecting a conductor to Earth with another conductor is called **grounding**. Figure 4.12 shows two ways that grounding protects people by providing a safe path for charges to follow.

grounding: connecting a conductor to Earth's surface so that charges can flow safely to the ground

◀ **Figure 4.12A** When gasoline flows from the hose of a tank truck, it rubs against the nozzle. This causes the metal of the truck to become charged. The rubber tires are insulators, so the charges cannot flow across them. A spark could ignite the gasoline. Therefore, the driver grounds the truck by leaning a metal rod against the truck so it can carry the charges away safely. Some trucks have dangling chains that are always touching the ground. This is another way to ground the truck.

Go to **scienceontario** to find out more

▲ **Figure 4.12B** Lightning usually strikes the highest point in the area near a thunderstorm. Therefore, people attach metal lightning rods to the roofs of buildings. Metal conductors run from the lightning rod down to the ground and often go deep into the ground. When lightning strikes, it will most likely hit the lightning rod. The rod and conductors will carry the charges down to the ground, preventing the building from catching on fire.

ACTIVITY LINK
Activity 4.9 on page 271

LEARNING CHECK

1. Use a labelled sketch to show what happens when a spark occurs.
2. Describe two ways in which an object can become discharged.
3. How does grounding a metal object prevent sparks from occurring?

INVESTIGATION LINK
Investigation 4C on page 272

Inquiry Focus

Activity 4.8

CHARGING AN ELECTROSCOPE

In this activity, you will charge an electroscope by contact.

What You Need

electroscope

ebonite rod

fur

What To Do

1. Rub the ebonite rod with the fur.
2. Bring the rod near the ball of the electroscope. Observe any movement of the leaves. Record your observations.
3. Move the rod away from the ball of the electroscope, and observe any movement of the leaves. Record your observations.
4. Repeat steps 1 and 2, but touch the ball of the electroscope with the charged ebonite rod. Observe any motion of the leaves. Record your observations.
5. Move the rod away from the ball of the electroscope, and observe any motion of the leaves. Record your observations.

What Did You Find Out?

1. Explain why the leaves of the electroscope move as they do in each of the last four steps.
2. Make sketches for the electroscope for steps 2 through 5. Assume that the ebonite rod was negatively charged. Add charges to your sketches that show why the leaves of the electroscope moved as they did.

Inquiry Focus

Activity 4.9

GROUNDING AN ELECTROSCOPE

Because your body is a conductor, you can ground an object by touching it. Charges will flow along your body to your feet and into the ground. If the amount of charges flowing over your body is small, you will not notice anything. Find out what happens when you ground an electroscope under different conditions.

What You Need

electroscope

ebonite rod

fur

What To Do

1. Rub the ebonite rod with the fur.
2. Touch the ball of the electroscope with the charged rod. Observe the position of the electroscope leaves. Record your observations.
3. Touch the ball of the electroscope with your hand. Observe the final position of the leaves. Record your observations.
4. Rub the ebonite rod with the fur again. Hold the rod near the ball of the electroscope, but do not let it touch the ball. Observe the position of the leaves. Record your observations.
5. While the rod is near the ball of the electroscope, touch the ball with your hand. Remove your hand and then the rod. Observe the position of the leaves. Record your observations.

What Did You Find Out?

1. Make sketches of the positions of the leaves of the electroscope after the completion of each of the last four steps. Add charges to your sketches to show why the leaves were in the positions that you showed in your sketches.
2. Describe what happened when you touched the charged electroscope in step 2. Provide a possible explanation for your observations.
3. Describe the position of the leaves after you completed step 4. Provide a possible explanation for your observations.

Skill Check

- Initiating and Planning
- ✓ **Performing and Recording**
- ✓ **Analyzing and Interpreting**
- Communicating

Materials for Lightning Rods

In this activity, you will build an electroscope out of different materials to determine which of the materials would be best for making a lightning rod.

What You Need

- Styrofoam® cup
- two 5 cm aluminum foil strips
- invisible tape
- 2 cm × 10 cm test materials, including metal, plastic, carbon, cardboard, wood
- ebonite rod
- fur

What To Do

1. Make a table like the one below to record your results.

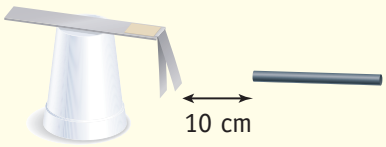
Response of Foil Strips

Test Material	Observation
Metal	
Plastic	
Carbon	
Cardboard	
Wood	
Air (no material)	

2. Turn the cup upside down on your desk.
3. Tape two 5 cm strips of aluminum foil together at the same end so they hang like the leaves of an electroscope. Then tape the foil strips to one end of the 10 cm metal test material.
4. Lay the 10 cm metal test material on top of the cup, as shown in the picture to the left. Tape it to the cup if necessary.
5. Rub the ebonite rod with fur.
6. Touch the charged rod to the free end of the metal test material, as shown in the picture to the left.
7. Observe what happens to the aluminum foil strips. Record your observations in your table.
8. Touch the metal test material with your finger to discharge it.
9. Repeat steps 4 to 8 with each of the test materials listed in the table.
10. To test the effect of air, place the charged ebonite rod 10 cm away from the metal test material, without touching it, as shown in the diagram.

step 4

step 6



step 10

What Did You Find Out?

1. Rank the materials from the best conductors (the ones that charged the foil strips the most) to the best insulators (the ones that did not charge the foil strips at all).
2. What material would make the best lightning rod? Explain.

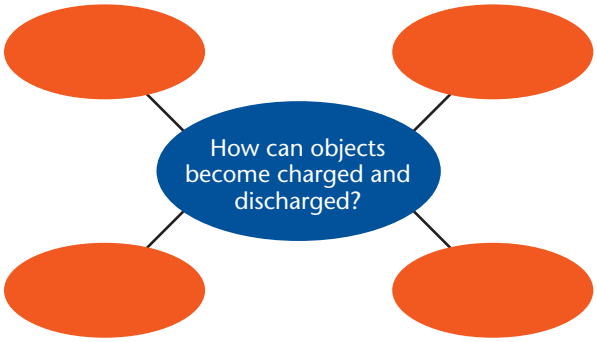
Topic 4.3 Review

Key Concept Summary

- Objects can become charged by contact and by induction.
- Charged objects can be discharged by sparking and by grounding.

Review the Key Concepts

1. K/U Answer the question that is the title of this topic. Copy and complete the graphic organizer below in your notebook. Fill in four examples from the topic using key terms as well as your own words.



2. K/U Use a Venn diagram to compare the similarities and differences between charging an object by contact and charging an object by induction.

3. K/U Use a Venn diagram to compare the similarities and differences between discharging an object by sparking and discharging an object by grounding.

4. C Use a series of labelled diagrams to explain how you can charge an insulator such as a pith ball by contact. Make sure you write a clear caption for the diagrams as part of your explanation.

5. A Have you ever battled "static cling" when removing clothing from a clothes dryer on a dry day? Static cling in clothing is the result of different materials rubbing against each other in the clothes dryer. As a result, some of your clothing sticks together and you may feel, and maybe even see, small sparks. Use words, diagrams, or a graphic organizer to explain what is happening in this situation.

6. A Refer to **Figure 4.12A**. There have been serious accidents associated with fires spontaneously igniting when people were filling portable gas cans in the backs of pickup trucks equipped with plastic liners. In your own words, explain why one of the precautions you should follow is: "Remove the portable gas can from the pickup truck and place it on the ground a safe distance from the vehicle."

7. C Refer to **Figure 4.12B**. Use words, diagrams, or a cause-and-effect map to explain how a lightning rod protects a building from a lightning strike.

8. A The diagram below shows a neutrally charged comb and neutrally charged hair.

a) Explain why both the hair and the comb shown in the diagram are neutrally charged.

b) Imagine that the comb has been used to comb the hair. The comb is now negatively charged. Make a sketch to show the charges on the comb.

c) Make another sketch to show the charges on the hair.