UNIT 3 OPENER, pp. 222–223

The unit opening photograph features a picture of high power transmission lines set against the natural beauty near Churchill Falls, about 200 km from Labrador City. Our understanding of electricity has allowed us to control its production, transmission, and distribution. Even though this technology seems to contrast nature, as portrayed by the mountains and snow, electricity itself is as natural as the landscape in the backdrop.

USING THE UNIT OPENER

A good starting point of discussion for this unit may be to ask students to brainstorm examples of the many uses of electricity that exist in the classroom. Choose several of these examples, and direct the discussion to the fact that electricity has been "used" to create other forms of energy. For example, electricity is used to obtain light energy from a light bulb. The discussion can then be directed to the question "How is electricity transmitted to the classroom?" The opening photograph shows high-power transmission lines. Students will be familiar with the fact that these lines transmit electricity, but they may be curious about where the lines come from, where they end up, and why they are so high above the ground.

High power transmission lines originate at the source of electrical energy generation. In Newfoundland and Labrador, this source is most likely a dam site where electrical energy is produced by falling water turning a generator. Electrical energy generated this way is referred to as hydroelectric energy. As well, fossil fuels could be burned to heat water so that steam can turn the electric generators. These sites are referred to as thermal-electric sites. Regardless of the method, most of these sites are located far from cities and towns that require the electricity. High power transmission lines transfer the electrical energy generated over these great distances. To transfer this energy efficiently and not lose too much energy to the heating of the lines, the electrical energy is sent at very high voltage. For very long transmissions, this voltage can be as high as 500 000 V. The generators at the sites produce only low voltages, in comparison with the voltages used in transmission, so transformers are used to increase the voltage. The high-power transmission lines arrive at a substation. The substation uses step-down transformers to significantly decrease the voltage and send the electricity to distribution centres, which connect to the wires that travel above and below our streets. Before this electricity enters our schools or residences, it is stepped down further to 240 V.

The reason why the towers for transmission lines are so high is that the electrical energy is being transmitted at a voltage of up to 500 000 V. Charge with a potential difference that is this high would readily travel to the ground if a pathway existed. The great height of the wires above the ground keeps the charge from travelling to the ground. If the wires were too close to the ground, the charge would jump from the wires to the ground, much like a lightning bolt. For safety reasons, high-power transmission lines are a great distance from the ground.

Students might also make the observation that the towers supporting the wires are made of metal and therefore should conduct electricity to the ground. If students closely examine the photograph, they will see that the wires do not directly touch the towers but instead are attached to insulators. This might be a good time to discuss the purpose of an insulating material. The ceramic insulators on these towers do not allow electricity to pass through them; therefore, there is no direct connection between the charge in the wires and the metal towers.

A common question about high-power transmission lines is, "How can a bird land on the wires and not get electrocuted?" Even though the wires are at an extremely high voltage, this voltage is compared to the ground, which is considered to be at zero voltage. If the bird were able to touch the wires and the ground at the same time, it would definitely be electrocuted since the potential difference would be the 500 000 V in the lines minus the ground's potential of zero, producing a 500 000 V shock. But for a bird landing on the wires, the potential at each of the bird's feet would be very similar to the 500 000 V, so the potential difference between the bird's feet would be almost zero. This small potential difference would not be enough to affect the bird.

You may want to hand out BLM 3-1, Unit 3 Summary, and BLM 3-2, Unit 3 Key Terms, to help students record their understanding of the unit and important terms.

GETTING STARTED, pp. 224–225

USING THE TEXT

After students have read the Getting Started section, discuss the advantages and disadvantages of current hybrid vehicles. Some advantages are that they are quiet, consume less fuel, and cause less air pollution. Some disadvantages are that the initial cost of buying a hybrid vehicle is high, and hybrid vehicles have less power than conventional vehicles.

Students may wonder what happens when the batteries "die." Modern hybrid vehicles do not have to be "plugged in" to recharge the batteries. As you drive the car, the batteries are being recharged. Recharging is accomplished by a process called regenerative braking. When the vehicle needs to slow down, an onboard computer connects the wheels to the electric motor. In this situation, the electric motor then acts like a generator that produces the electricity to recharge the batteries. Instead of the car's kinetic energy being transferred only into heat by brakes, like a conventional braking system, its kinetic energy is also transferred into electrical energy.

USING THE ACTIVITY

Find Out Activity

A New Spin on Motors, p. 225

Purpose

- Students investigate how electricity and magnetism can be used to produce an electric motor.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 day before	Organize materials.	For each group: – small neodymium disk magnet – C or D cell – 6–8 cm common iron nail – 20 cm length of braided copper wire (stripped at both ends)

Time Required

- 15 min

Safety Precautions

- If the wire becomes hot, ensure that students disconnect the wire from the battery immediately.

Science Background

All electric motors use the concept that, when a current passes through a magnetic field, a force acts on that current. If that force is a distance from a hinge point, that force will cause rotation (torque). When the wire is connected from the positive terminal of the battery and touched to the side of the magnet, current travels horizontally into the centre of the magnet before travelling up the nail into the negative terminal of the battery. This current experiences a force, perpendicular to the current, due to the vertical magnetic field. This force acts at a distance from the nail's centre of rotation and therefore causes the nail to rotate. In a real electric motor, the current travels in loops of wire that are free to rotate on the armature. The armature containing the loops of wire is placed inside a magnetic field.

Activity Notes

- Students can work together in small groups if desired.
- Using braided copper wire may be better than using single stranded wire. Be sure that the braided copper wire that is touching the magnet has been frayed so that it resembles brushes. The wire should lightly touch the side of the magnet.
- Although magnetism is not part of this unit, this activity demonstrates that electricity is a form of energy.

Supporting Diverse Student Needs

- Encourage English language learners to draw a sketch of the apparatus with labels for the materials. This is also good practice for students with artistic strengths or who may be visual learners.
- This is a very good hands-on activity for body-kinesthetic and visual-spacial learners.
- For enrichment, students could research the design of electric motors. As well, many inexpensive kits are available to build small electric motors.

What Did You Find Out? Answers

1. The nail started to spin when the magnet was in contact with the copper wire.
2. Small sparks appear where the wire contacts the magnet.
3. Students' answers may vary but could include that the nail might spin faster and the sparking might be greater.
4. Commercial motors might contain magnets, wires, and something that is allowed to spin.

USING A DEMONSTRATION

A good demonstration to start the unit on electricity is the Van de Graaff generator. With the generator turned off, place five or six aluminum pie plates on top of the Van de Graaff dome. Then turn the generator on and observe the pie plates. The pie plates will not all "fly off" at the same time. Instead, the plates will be removed one by one.

Ask students to explain their observations. The most obvious question is, "What caused the plates to repel each other?" Then ask, "Why did the plates come off one at a time?" Most students will understand that it is static electricity that caused the pie plates to be removed. The plates came off one at a time due to the fact that it takes time for charge to build up on the plates. Charges will move as far away from other charges as possible, and therefore charge collects on the farthest plate from the dome.

A good conclusion to this demonstration is to discuss the fact that electricity can apply a force and move objects at distances. Students should recognize this definition as a form of energy. Conclude by indicating that it was electrical energy that removed the plates.

CHAPTER 7 OPENER, pp. 226–227

USING THE PHOTO AND TEXT

You can use the opening photograph as an opportunity to talk with students about static charge. Elicit students' experiences with any type of static charge. These experiences could include taking clothes from the dryer, shuffling across the carpet, and combing their hair on a dry winter day. Ask students, "What has created the static electricity in these situations?" Friction is responsible for the build-up of static electricity in most examples. If friction has produced the static electricity in students' everyday experiences, then you might ask, "Is friction responsible for the build-up of static electricity in the clouds that results in lightning?" In fact, it is the friction of dust and ice crystals in the clouds that causes the build-up of static charge.

You could include in your discussion that when we see lightning, we are not seeing the electricity. The electric charge that travels between Earth and the clouds causes the atoms in the air to gain energy and then release that energy as light. This process is similar to electricity causing the gases in a fluorescent tube to glow. The thunder is caused by a rapid expansion of air due to an increase in temperature.

An interesting way to end this discussion may be for students to describe non-scientific explanations that they may have heard for lightning and thunder. For example, a bearded giant sits at the top of Mount Olympus and hurls thunderbolts at the mortals below.

USING THE WHAT YOU WILL LEARN/WHY IT IS IMPORTANT/SKILLS YOU WILL USE

Ask students to read the Why It Is Important section. Emphasize to the class that an understanding of static charge is necessary in order to use electricity in a safe, controlled manner. As well, after students have read the Skills You Will Use section, explain the importance of models in science. Students may remember models they have used to represent other scientific phenomena, such as the structure of an atom. In this chapter, the models will be diagrams that are used to understand the concept of charge and charge transfer.

USING THE FOLDABLES™ FEATURE

See the Foldables section of this resource.

7.1 STATIC CHARGE

BACKGROUND INFORMATION

Benjamin Franklin (shown in Figure 7.1, on page 229) first used the terms "positive" and "negative" to describe the amount of electric fluid in an object, but this notion was later replaced by our atomic view of charge. "Positive" and "negative" are words used to describe opposites. Franklin could have just as easily named charges "up" and "down." It is important to realize, therefore, that "positive" and "negative" are not numerical values.

Conductors and insulators are explained in this section. Students may ask about semiconductors. A semiconductor allows charge to travel more freely than in an insulator, but not as well as in a conductor. Silicon, a common semiconductor, is used in microchip technology.

Emphasize to students that, in solid materials, all charging occurs by electron transfer. With this important concept in mind, students may find the Van de Graaff generator diagram (Figure 7.5, page 233) confusing. When the belt travels over a roller covered in silicon tape at the base of the generator, electrons are pulled from the belt and therefore the belt has a positive charge. The positively charged belt continues to rotate toward the top of the generator. Metal brushes attached to the dome are positioned very close to the positive rubber belt. Electrons in the conducting dome are attracted toward the tips of the metal brushes. The electrons transfer onto the belt and return to the bottom roller where the process repeats itself. The dome now has a deficit of electrons and therefore becomes positively charged. No positive charges have left the belt, but we say that the belt has transferred a positive charge onto the dome. Again, in this whole process, it is only the electrons that have been allowed to move.

COMMON MISCONCEPTIONS

- Students may believe that we "make" electricity. It is important to emphasize that nothing has been created when we produce a static charge. Electrons added or removed from a material are what causes the imbalance and therefore produces a static charge. No energy has been created in this process.
- Students may believe that a neutral object has no charge. Explain that a neutral object has an equal number of protons and electrons.

- Students may believe that, if a negative 5 C charged object and a positive 5 C charged object are combined, the result is neutral because (+5) + (–5) = 0. Students should understand that "positive" and "negative" are not numeric values. The object becomes neutral because the number of protons and electrons in the combined object is equal.
- Students may interpret Figure 7.4A, on page 232, incorrectly by thinking that positive charges occur only at one end of the insulator. Emphasize to the class that positive charges do not move, so actually they are evenly distributed across the entire rod. In the diagram, however, they are not shown on the left side of the rod for visual clarity—it would be difficult to see the charges clearly if positive and negative signs were on top of each other. In reality, positive charges are evenly distributed across the whole rod, while many negative charges cluster on the left end of the rod. (There will likely still be some negative charges sparsely distributed on the right end of the rod.)

ADVANCE PREPARATION

- All activities dealing with static electricity work best in low humidity environments. If possible, teach Unit 3 during a drier part of the year.
- Consult the Unit front matter for a list of Blackline Masters that can be used when teaching this section.
- Activity 7-1A, on page 229, requires an electroscope. Electroscopes with metal leaves are easier to use than electroscopes with suspended pith balls. If you do not have enough electroscopes, this activity could be done as a demonstration.
- Activity 7-1C, on page 235, requires puffed rice, various conducting and insulating strips, and various soft materials. Gather these items ahead of time.

Useful research materials for advance preparation can be found at www.discoveringscience.ca.

INTRODUCING THE SECTION, pp. 228–229

Using the Text

Have students read page 228 of the student textbook. They can share other experiences they have had with static electricity that are not the same as the ones mentioned in the textbook.

Using the Key Terms and Section Summary

At the beginning of each section in the student textbook are the Key Terms and section summary. Both can be used as a pre-reading strategy and a review tool. Before reading the text in the section, students should be able to define the Key Terms by scanning the text and using the Glossary. The Key Terms include terms from the curriculum outcomes and additional terms that are important for students to know and understand.

The section summary provides an overview of the key concepts being covered in the section. Students may not know all the concepts and terms described in the summary, but they can use this information to help guide them through their reading.

After reading the section, students can go back to the Key Terms and section summary to consolidate their understanding and identify areas that require clarification. At the end of the chapter or unit, students can use the Key Terms and section summary for review. BLM 3-2, Unit 3 Key Terms, and BLM 3-3, Chapter 7 Key Terms, can be used to assist students.

Using the Did You Know, p. 228

Students may be fascinated with the speed at which lightning travels. At 220 000 km/h, it would take less than two tenths of a second to travel from cloud to ground. You may want to emphasize that you cannot outrun lightning. Have a discussion about the number of lightning strikes that occur per year. Then have students explain why they hear about so few strikes, considering lightning strikes Earth 100 times per second. Lightning is most prevalent in locations of warm climates and high altitudes. Students may be surprised that ocean lightning is not very common and the Arctic has almost no lightning. Point out that speed at which lightning travels and the speed of light are significantly different.

Using the Activity

Find Out Activity 7-1A

Detecting Static Charge, p. 229

Purpose

- Students investigate static charge using an electroscope.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 day before	Gather materials and apparatus.	For each group: – electroscope – inflated balloon – wool cloth

Time Required

- 15 min

Science Background

A neutral electroscope will have both of the leaves hanging straight down. When the balloon is rubbed with wool, a static charge is placed on the balloon. When the balloon is touched to the dome of the electroscope, the leaves will repel each other. This result occurs because both leaves gain the same charge and repel. Even after you remove the balloon, the leaves should stay separated. Since the charge has no way to leave the electroscope, it remains charged.

When you touch the electroscope, the leaves should move back to their neutral location. By touching the electroscope, you have allowed charge to transfer between you and the electroscope to make the electroscope neutral. This process is similar to grounding. The relatively small amount of charge on the electroscope can be transferred to your body without significantly changing your body's net charge. That is, your body will remain relatively neutral.

Depending on the humidity, when the wool cloth is touched to the neutral electroscope, the leaves should repel each other. This result occurs because whatever charge was placed on the balloon by rubbing, an equal but opposite charge is placed on the wool.

Activity Notes

- If you have enough electroscopes, have students work in groups. Sometimes the electroscopes that use suspended pith balls do not work as well as the metal leaf electroscopes. This activity could be successfully done as a demonstration.
- Touching the neutral electroscope with the wool might not produce much deflection in the leaves. This result occurs because some of the charge might have travelled into the students' hands. Humidity will have a large effect on this result.
- Make sure that students realize that the leaves on the electroscope repel only when a charge is present. The two leaves of the electroscope will always possess the same charge; therefore, they will always repel when charged.

Supporting Diverse Student Needs

- Encourage English language learners and visual learners to make a labelled sketch of their observations, including the parts of the electroscope.
- This is a good hands-on activity for body-kinesthetic and visual-spatial learners.
- For enrichment, students could test for static charge in other objects. As well, students could research the invention of the electroscope.

What Did You Find Out? Answers

1. The leaves of the electroscope should still be separated even after the balloon is removed. The amount of separation might decrease slightly, but the leaves still repel each other.
2. Touching the charged electroscope caused the leaves to return to the same position as before they were charged. The excess charge passes from the leaves through your finger and into your body.
3. Both the balloon and the wool should cause the neutral electroscope leaves to separate. Depending on the amount of humidity in the air, the wool might not have as great an effect on the electroscope as the balloon.

Using the Did You Know, p. 228

To make the large numbers in this feature more meaningful, invite students to compare them to speeds they are more familiar with, for example, lightning moves about 2000 times faster than a car on the highway.

TEACHING THE SECTION, pp. 229–234

Using Reading

Pre-reading—K-W-L (Know-Want to Know-Learned)

Have students create a three-column table. In the first column they can record things they already know about static electricity. In the second column, have them record questions that they would like to know the answers to. Later, students can share their questions as a class and together the class can discuss the answers to those questions.

During Reading—Note Taking

Encourage students to take notes as they read the assigned text material. It can be helpful to reword the topic titles as questions and then use the questions to guide note taking.

Supporting Diverse Student Needs

Remind students that they can use the Reading Check questions to help them decide if they have missed any important information in their reading. Have them read each question and share their answer with a classmate. For any question that their partner thinks they have not answered fully, both students should look up the information in the textbook that is required to develop a full answer.

After Reading—Reflect and Evaluate

When students have completed note taking, they can quietly review their notes and choose three interesting facts. Students can share these facts in a class or small group discussion. To represent what they have learned visually, students could complete BLM 3-6, Charge Transfer Diagrams.

Reading Check Answers, p. 231

1. (a) Proton—positive; electron—negative; neutron—neutral
   (b) The protons and neutrons are in the centre of the atom (nucleus). The electrons orbit the nucleus.
2. If the number of positive charges (protons) equals the number of negative charges (electrons), then the atom is neutral.
3. All solid materials are charged by the transfer of electrons.
4. If an atom has more protons than electrons, it has a positive charge.
5. When a neutral atom gains electrons, it has a negative charge.
6. When two objects are rubbed together (friction), electrons from one object can be transferred to the other object.

Reading Check Answers, p. 234

1. In an insulator, the electrons stay in one location. In a conductor, the electrons are able to move freely throughout the conductor.
2. As long as the number of electrons equals the number of protons, the object will be neutral.
3. The Van de Graaff generator is designed to generate large amounts of static charge.
4. Students' answers will vary. Four possible uses of static electricity may include the following: using plastic wrap to cover a sandwich, decreasing air pollution, air ionizers, painting automobiles
5. Objects that are positively or negatively charged become neutral when excess static charge flows away from the object.
6. Grounding is allowing charge to flow into Earth's surface.
7. The static charge on the truck or airplane needs to be removed so that a spark does not ignite the fuel.

USING THE ACTIVITIES

- Activity 7-1A, on page 229 of the student textbook, is best used as an introductory activity. Detailed information about this activity can be found in Introducing the Section.
- Activity 7-1B, on page 231 of the student textbook, is best used after students have learned about charging by electron transfer on page 230.
- Activity 7-1C, on page 235 of the student textbook, is best used after students have learned about insulators and conductors on page 232.

Detailed notes on doing these activities follow.

Think About It Activity 7-1B

Visualizing Charge Transfer, p. 231

Purpose

- Students investigate the concepts of charge and charge transfer by using diagrams.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
Day of instruction	No advance preparation necessary.	For each student: – ruler

Time Required

- 15 min

Science Background

The positive (+) and negative (–) signs in the diagrams represent the protons and electrons, respectively. By analyzing the diagrams, students realize that neutral objects have an equal number of protons and electrons. When an object is charged, it is the electrons that transfer from one object to the other. In any charge transfer, no charge is lost or gained. That is, the total number of charges remains constant. Finally, when students draw charge diagrams for solid objects, the positive charges in the object should remain in the same locations.

Activity Notes

- In solid objects, the positive charges (+) will remain in the same locations regardless of whether the object gains or loses electrons. In Part 1, Diagram 2A and Diagram 2B demonstrate how the positive charges in a solid object would behave.
- Emphasize that in Part 2, each student's diagrams could be different but still correct. In Part 2, stress that the neutral object has equal numbers of positive and negative charges.

Supporting Diverse Student Needs

- Visual-spatial learners will relate well to this activity. To engage students with other learning styles, students could model charging by placing two-coloured counters on shoebox lids (to represent positive and negative) and moving some of the negative ones to the other lid or by holding black and red (positive and negative) markers in their hands and passing some of the red ones to another student.

What To Do Answers

Part 1

1. Diagram 1 shows that both objects are neutral because they contain the same number of positive and negative charges.

2. (a) In Diagram 2, objects A and B are no longer neutral. This result is shown by an unequal number of positive and negative charges in each object.
   (b) Object A is now positive.
   (c) Object B is now negative.
3. The negative charge was transferred.
4. The location of the positive charges did not change in Diagram 2 as compared to Diagram 1.
5. No negative charges (electrons) were lost in this charging process.

Part 2

6.,7. (a) The diagram should have the same number of positive (+) charges as the initial neutral object. The difference should be that the positive object should have lost some negative (–) charges.
   (b) The diagram should have the same number of positive (+) charges as the initial neutral object. The difference should be that the negative object should have gained some negative (–) charges.
8. Students' diagrams do not need to be identical to be correct, since their diagrams could contain different amounts of positive and negative charges.

Find Out Activity 7-1C

Charging Insulators and Conductors, p. 235

Purpose

- Students investigate which materials are insulators and conductors by testing which materials retain their static charge.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 day before	Gather materials. Make sure that your choice of solid materials includes at least one conductor (metal).	For each group: – puffed rice cereal – solid materials such as a plastic straw, a comb, a plastic ruler, an acetate strip, a vinyl strip, a glass rod, an aluminum strip, an iron strip, a brass strip – soft materials such as wool, paper towel, plastic wrap, fur, nylon cloth

Time Required

- 45 min

Safety Precautions

- Remind students to never eat anything in the science room.

Science Background

When a charge is placed on an insulator, the charge will remain fixed in one place. Neutral objects such as the puffed rice will be attracted to the charged object. If a charge is placed on a conductor, the charge will spread evenly over its surface. If you are touching the conductor, the charge will dissipate into your body. Since no charge is left on the conductor, neutral objects such as the puffed rice will not be attracted to the conductor. In this activity, students can use this analysis to divide the tested solid materials into insulators and conductors.

Insulators can gain different amounts of charge depending on what is causing the friction. Some combinations of materials have a greater affinity for giving up electrons. The combination of materials that attracts the greatest number of puffed rice grains includes the insulator with the greatest amount of charge.

After each test, students are asked to wipe the surface of the object with their bare hand. The purpose of this step is to "ground" the object so that it is again neutral. Electrons from students' hands will be either added or removed in order to make the object neutral.

Activity Notes

- This activity works best in small groups so that all students have opportunities to test the materials. Since this activity involves static electricity, overall results will depend on the humidity.
- Remind students to rub each material in a similar way. Depending on the humidity, they may need to rub the objects more than 10 times. Shortly before students perform the activity, experiment to determine how many times the materials should be rubbed to produce sufficient charge.
- Tell students to gently bring the charged object in contact with the pile of puffed rice, and then to slowly draw the object away from the pile.
- Be sure that your solid materials contain at least one conductor (metal).

Supporting Diverse Student Needs

- You may wish to distribute BLM 3-7, Charging Insulators and Conductors, for students to use in recording their data.
- This is a good hands-on activity for body-kinesthetic and visual-spatial learners. Ensure that each group includes students with skills in these areas.
- For enrichment, students could be asked how to use an electroscope to detect the amount of charge. Once students determine that the amount of deflection is proportional to the amount of charge, they could verify their results from their activity. Another activity for enrichment could be to determine if surface area has any effect on the amount of static charge placed on an object.

What Did You Find Out? Answers

1. Students' answers may vary but can be verified by their data.
2. Rubbing the materials in a similar way creates a controlled experiment.
3. Using your bare hand to wipe each object removes the excess static charge (grounding).
4. Any solid material that was unable to pick up some puffed rice would be considered a conductor. A conductor will not allow the charge to stay in one location, and therefore, the excess charge will travel into the person.
5. Any solid material that was able to pick up some puffed rice would be considered an insulator. An insulator would allow the charge to stay in one location, and therefore, the puffed rice would be attracted to the charged insulator.

USING THE FEATURE

Science Watch: Franklin's Kite, p. 236

This feature is an excellent starting point for discussion or for further research. Have students read the feature, or read it together as a class. After reading, students could be asked to do the following:

- Answer the questions on page 236.
- Analyze Franklin's apparatus, and identify the conductors and insulators.
- Visit www.discoveringscience.ca for more information on Benjamin Franklin's contributions to science.

Science Watch Answers

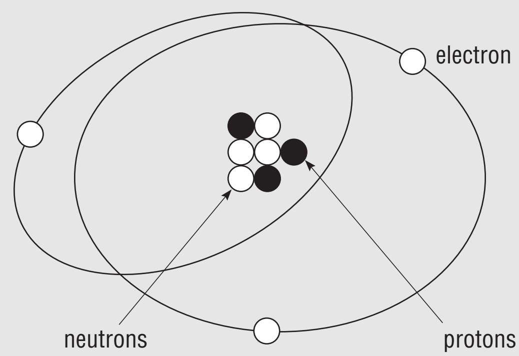
1. Franklin believed that lightning was electricity because the flash of lightning appeared to be a larger example of the spark produced by static electricity.
2. Students may mention any of the following precautions:
   (a) Franklin did not do his experiment during a lightning storm but instead flew his kite into a developing storm. If Franklin had allowed his kite to be hit by lightning, his precautions would not have kept him safe.
   (b) Franklin held onto a dry silk string and also stood under cover to remain dry. Because the string was dry, it acted as an insulator and did not allow the excess charge to reach his body.
   (c) Franklin attached his kite system to a Leyden jar. The Leyden jar provided an alternative path for excess charge. This way, the excess charge would flow into the jar rather than into Franklin.
3. Students' answers might describe a type of Leyden jar that is a glass bottle partly filled with water and closed by a cork that has a metal wire passing through it. The wire outside the bottle receives the collected static electricity. The electric charge flows down the wire into the water inside the bottle, because the wire and the water are both conductors. The Leyden jar stores the charge because the glass is an insulator and the charge cannot flow out to the ground. This stored electricity is released if you touch the top of the exposed wire with your hand.

SECTION 7.1 ASSESSMENT, p. 237

Check Your Understanding Answers

Checking Concepts

1. The word "static" means stationary or not moving.
2. An acetate strip acquires a negative charge.
3. (a) Students' diagrams may vary slightly but should be similar to the following.



   (b) electrons—negative; protons—positive; neutrons—neutral
4. The electrons are transferred when you charge an object.
5. (a) There should be an equal number of + and – signs.
   (b) There should be more – signs than + signs.
   (c) There should be more + signs than – signs.
6. A solid object that holds charge in one place is called an insulator.
7. A solid object that allows free electrons to move easily through it is called a conductor.
8. Static charge is measured in coulombs.
9. A conductor is grounded when it is connected to Earth's surface so that charge can flow between Earth and the conductor.
10. When a positively charged object is grounded, electrons flow from Earth's surface, along a

conductor, and then into the object until the object becomes neutral.

11. To make a negatively charged object neutral, you can ground it by allowing the extra electrons to flow into a conductor to the ground, or you can touch it so that the transfer of extra electrons flows from the object to your body in the form of a shock.
12. An electroscope is used to detect static charge.

Understanding Key Ideas

13. (a) Similarities between a proton and an electron include the following: both are part of the atom; both have a charge; and the magnitude of charge on both is the same.
    (b) Differences between a proton and an electron include the following: the proton is in the nucleus, and the electron orbits the nucleus; the proton is much heavier than the electron; the electron is more easily removed from the atom; the electron has a negative charge, and the proton has a positive charge.
14. A positively charged object has more protons than electrons, whereas a negatively charged object has more electrons than protons.
15. An object is neutral if it contains the same number of protons as electrons.
16. When a person walks across a carpet, he or she gains a static charge due to friction. This static charge will stay on the person until the person touches the metal doorknob. Since the doorknob is a conductor, the charge will flow upon contact and the person will receive a shock.
17. By touching a charged object with your hand, charge is transferred between your body and the object. Usually the charge flows through your body to the ground.
18. Both charged conductors and insulators have unequal amounts of positive and negative charges. The electrons (negative charges) would be evenly distributed on a conductor, whereas they may be unevenly distributed on an insulator.
19. It is unlikely that these two objects could gain a static charge. The reason is that they both have the same affinity to gain or lose electrons.

Pause and Reflect Answer

In an electroscope, the dome, rod, and leaves are made of metal because metal is a conductor. Charge placed on the dome needs to be able to travel down the rod to the leaves. Replacing the metal dome with a plastic dome would cause the electroscope to not function properly because plastic is an insulator. Charge placed on top of the plastic dome would remain stationary and not travel to the rod and leaves.

Other Assessment Opportunities

- Consult the Unit front matter for a list of applicable Assessment Blackline Masters.

7.2 ELECTRIC FORCE

BACKGROUND INFORMATION

Action-at-a-distance forces can be explained by field theory. Michael Faraday is credited with first using the concepts of fields to explain these forces. In the case of electrostatic forces, Faraday visualized field lines either entering or leaving all charges. Positive charges were said to have field lines that exited the charge, whereas negative charges were said to have field lines that entered the charge. Opposite charges, placed near each other, would have field lines that exit the positive charge and enter the negative charge. Field lines that connect charges in this way would cause a force of attraction. Like charges placed near each other would have field lines that do not connect the two charges. In this situation, the two charges would repel.

Coulomb's law explains how the amount of charge and the distance separating charges affects the force of interaction. When two charged objects interact, the amount of force is proportional to the magnitude of the charges. That is, if the charge on one of the objects is doubled, then the force-at-a-distance would double. If the charge on both objects is doubled, then the force-at-a-distance would quadruple. The relationship between the force and the distance of separation between the two objects is an inverse-square relationship. If two objects are moved twice as far apart, then the force between the two objects is one quarter of the original force. If the object separation is increased by five times, then the force between the two objects is 25 times less than the original force.

COMMON MISCONCEPTIONS

- Students may assume that if two objects attract they must have opposite charges. It is important that students understand that neutral objects are attracted to charged objects as well.
- Students may assume that if a negative object attracts a neutral object a positive charge would repel those same neutral objects. Neutral objects are always attracted to positive objects, since the charged object will induce an opposite charge on the surface of the neutral object nearest to the charged object.

ADVANCE PREPARATION

- Activities in this section require materials for producing static charge. Many of the activities require acetate strips and ebonite rods. As well, soft materials such as wool and fur will be required. Gather these materials ahead of time.
- Activity 7-2B, on page 242, requires plastic petri dishes with lids. Check to make sure that your school has plastic petri dishes, as glass petri dishes will not work for this activity.
- Activity 7-2C, on page 242, requires watch glasses. If watch glasses are not available, construct an apparatus that will allow the charged objects to rotate freely.

Useful research materials for advance preparation can be found at www.discoveringscience.ca.

INTRODUCING THE SECTION, p. 238

Using the Text

Have students read page 238 of the student textbook. Create a chart on the board, and ask students to contribute examples of contact forces for the chart. You may want to ask students, "How do you know this is a force?" Next, ask students if they can think of any forces, other than electrostatic force, that are action-at-a-distance forces. Possible answers are gravitational and magnetic forces.

Using the Key Terms and Section Summary

At the beginning of each section in the student textbook are the Key Terms and section summary. Both can be used as a pre-reading strategy and a review tool. Before reading the text in the section, students should be able to define the Key Terms by scanning the text and using the Glossary. The Key Terms include terms from the curriculum outcomes and additional terms that are important for students to know and understand.

The section summary provides an overview of the key concepts being covered in the section. Students may not know all the concepts and terms described in the summary, but they can use this information to help guide them through their reading.

After reading the section, students can go back to the Key Terms and section summary to consolidate their understanding and identify areas that require clarification. At the end of the chapter or unit, students can use the Key Terms and section summary for review. BLM 3-2, Unit 3 Key Terms, and BLM 3-3, Chapter 7 Key Terms, can be used to assist students.

Using the Activity

Find Out Activity 7-2A

What Is the Attraction to Water? p. 238

Purpose

- Students relate the concepts of action-at-a-distance forces and the attraction of neutral objects by charged objects by bending a stream of water.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 day before	Gather materials.	For each group: – water tap – acetate strip – paper towel – ebonite rod – fur

Time Required

- 15 min

Safety Precautions

- Ensure that students wipe up spills immediately.

Science Background

Rubbing an acetate strip with paper towel will cause the acetate to become negatively charged. A water molecule is neutral but polar, which means that one side of the water molecule is more positive than the other side. When the negative acetate is brought near the stream of water, the individual water molecules will realign so that the positive side of each water molecule is toward the acetate. The side of the water stream nearest the acetate will be positively charged, while the side farthest from the acetate will be negatively charged. Since the positive side of the stream is closer to the acetate than the negative side of the stream, there is a greater force on the positive side and the water is attracted to the acetate.

When a positive ebonite rod replaces the acetate, there is the same result but for a different reason. The side of the stream closest to the positive ebonite becomes negatively charged, while the farthest side becomes positively charged. The force of attraction between the positive rod and negative side of the stream is greater than the force of repulsion between the positive rod and the positive side of the stream, due to distance. Again, the stream of water will be attracted to the charged object.

Activity Notes

- This activity can be done individually, in groups, or even as a demonstration.
- This activity works best if the stream of water is as small as possible but in a continuous flow.

- Care should be taken that the stream of water is not allowed to touch the acetate or ebonite. If contact is made, thoroughly dry the strip, and repeat the procedure.
- As with all activities using static charge, best results are achieved when there is low humidity.

Supporting Diverse Student Needs

- English language learners could sketch the experimental set-up and label the parts. This is also a good practice for students with artistic strengths or who may be visual learners.
- Students could discuss Question 4 as a small group and agree on an answer.
- For enrichment, students could test different types of fluids to see if they behave the same as water. Students could research the polar structure of water molecules.

What Did You Find Out? Answers

1. The acetate strip attracted the stream of water.
2. The ebonite rod attracted the stream of water.
3. Both the acetate and ebonite attracted the water. Since acetate gains a negative charge and ebonite gains a positive charge, the water is attracted to both negative and positive charges.
4. No charged objects should be able to repel the stream of water. There are only two types of charges, positive and negative, and they both attracted the water.

Using the Did You Know, p. 239

The Did You Know feature could be enhanced by allowing students to experiment with both of these action-at-a-distance forces. A simple example would be dropping an object and asking, "What pushed or pulled this object?" Most students will respond "Gravity." Your next question should be, "Was anything that applied the force actually in contact with (touching) the object?" Some students will be confused with the effect of air and gravity. A common misconception is that if there were no air, then there would be no gravity. You could use the Moon as an example to dispel this misconception.

Using magnets also demonstrates action-at-a-distance forces. Allow students to feel the force between two magnets even when the magnets are not in direct contact.

Using a Demonstration

Several experiments can be performed to prompt discussion and careful examination of action-at-a-distance forces and the laws of electrostatics.

- An activity similar to Activity 7-2A, on page 238, uses salt and pepper to analyze forces on neutral objects. Place a mixture of salt and pepper on a clean, dry piece of white paper. Charge an acetate strip by rubbing it with paper towel, and slowly move it over top of the mixture. Students will observe that the static charge placed on the acetate will be able to separate the salt and pepper mixture. You could then repeat this activity using an ebonite rod rubbed with wool. The pepper should only stick to the acetate and the ebonite rod.
- Students can explore the interactions of charged objects by using transparent tape.
  - Using a length of adhesive tape about 10 cm long, fold over 1 cm on one end to be used as a handle, and stick the tape on a clean, dry desk. Stick a second, similar piece of tape next to the first. Using a quick motion, remove both pieces of tape from the desk and bring them near one another. Both pieces of tape now possess a static charge and since each piece of tape's charge was created the same way, they will each have a like charge. This activity demonstrates that like charges repel.
  - Using new tape, stick one strip of tape to the desk as before. This time, place the second strip on top of the first. Using the handle of the bottom strip, pull the two strips off the desk at the same time. Gently rub your fingers down both sides of the tape to remove the charge on the tape. You will know when you have made the two attached pieces neutral by the fact that they are no longer attracted to your hand. Once you have removed all the static charge, with one hand on the handle of one strip and the other hand on the handle of the second, quickly pull the two strips apart. If you now bring the two strips close together, the two strips will attract each other. In this method, the two strips were charged oppositely, and opposite charges attract.

TEACHING THE SECTION, pp. 239–242

Using Reading

Pre-reading—Predict-Read-Verify

Before reading, students can predict the answers to the following questions:

- In terms of attracting or repelling:
  - How does a positively charged object affect another positively charged object?
  - How does a negatively charged object affect another negatively charged object?
  - How does a positively charged object affect a negatively charged object?
  - How does a charged object affect a neutral object?
- How does the amount of charge on two objects or the distance between the objects affect the force between them?

- Can an object charge another object without touching it? How?
- How can a charged balloon "stick" to a wall?

During Reading—Note Taking

As students read this section, they can take notes to answer the questions provided in the Pre-reading section.

After Reading—Reflect and Evaluate

Have students create a compare-and-contrast chart, a Venn diagram, or another double-cell diagram comparing charging by induction and conduction. Students could complete any or all of BLM 3-8, Obeying the Laws of Static Charge; BLM 3-9, Conduction/Induction Venn Diagram; BLM 3-10, Conduction/Induction Charge Diagrams; and BLM 3-11, Forces and Electrical Charges.

Supporting Diverse Student Needs

- Draw students' attention to Science Skill 8, Organizing Your Learning: Using Graphic Organizers, on pages 495 to 496 of the textbook. It includes information about using Venn diagrams, as well as other graphic organizers, which will help students illustrate connections in what they read.
- Students can apply and extend what they have learned about electric charge using BLM 3-12, Pop Can Race.

Reading Check Answers, p. 242

1. An electric force is the push or pull between charged objects.
2. Action-at-a-distance forces can push or pull an object without touching the object.
3. (a) Like charges repel each other.
   (b) Opposite charges attract each other.
   (c) Neutral objects are attracted to charged objects.
4. Electric force is proportional to the amount of charge on each of the objects, and also to the distance between charged objects.
5. When charging by conduction, electrons transfer from one object to the other. When charging by induction, the electrons are rearranged in the object but no electrons actually transfer from one object to the other.
6. The wall becomes charged by induction.

USING THE ACTIVITIES

- Activity 7-2A, on page 238 of the student textbook, is best used as an introductory activity. Detailed information about this activity can be found in Introducing the Section.
- Activity 7-2B, on page 242 of the student textbook, is best used after students have read and discussed the Putting Static Charge to Work section on page 241.
- Activity 7-2C, on page 243 of the student textbook, may be used as an introductory or summary activity for The Laws of Static Charge section on page 239.

Detailed notes on doing these activities follow.

Find Out Activity 7-2B

Static Copier, p. 242

Purpose

- Students use static electricity to create an image on a petri dish. This application is then compared to the workings of a photocopy machine.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 day before Day of instruction	Gather materials. Have students read the Putting Static Charge to Work section on page 241 of the student textbook.	For each student: – plastic petri dish with lid – felt marker – dry yeast – acetate strip – paper towels

Time Required

- 20 min

Science Background

When a charged acetate strip is touched to a location on the petri dish, electrons will transfer from the acetate strip to the petri dish. Since the plastic petri dish is an insulator, the electrons will remain in a fixed location. When turned upside down, the neutral yeast will be attracted only to the locations on the petri dish that have a net negative charge. This process is similar to the method used to get the ink toner to "stick" onto a piece of paper in a photocopy machine. Charge is placed only in certain locations on a blank piece of paper as it passes through the machine. The neutral toner is then applied to the page and sticks only to the locations of charge. Heat is used to make the toner adhere.

Activity Notes

- Students might enjoy this activity most if given the opportunity to work on their own. This activity could be completed in larger groups as well.
- In order to get a substantial build-up of charge on the petri dish, students should trace over their marked initials several times.

- When tracing their initials, students should use the corner of the strip so that the charge is not spread over a large area of the petri dish.
- Care should be taken to handle the petri dish only by the edges. If contact is made with the top surface, charge will be removed.

Supporting Diverse Student Needs

- For enrichment, students could predict how a colour photocopier works. Students could then research the difference between a colour and a non-colour photocopier.

What Did You Find Out? Answers

1. The yeast is "stuck" to the lid of the petri dish where the initial is located.
2. The yeast took the shape of the initial because the lid of the petri dish is an insulator. The charge that you placed on the lid will stay where you placed it; therefore, the yeast will be attracted only to the initial.
3. In a photocopier, the ink is attracted to the paper only where a static charge has been placed on the paper.

Conduct an Investigation 7-2C

Investigating Static Electricity, p. 243

Purpose

- Students investigate the laws of static charge using various charged objects.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 day before	Gather materials.	For each group: – watch glass – plastic straws – wool – acetate strips – paper towels – glass rods – plastic bags – ebonite rods – fur

Time Required

- 60–80 min

Safety Precautions

- Handle the glass rods with care.

Science Background

When two objects that are charged the same way are positioned close together, they will repel each other. When two objects are charged oppositely, they will attract each other when positioned close to each other. An object placed on a watch glass is free to rotate. If the object on the watch glass is repelled by the charged object in the student's hand, then the two objects have the same charge. If the two objects attract, then they are oppositely charged. Since all the objects have been charged, the attraction is not due to neutral objects being attracted to charged objects.

Activity Notes

- This activity works best if students work in small groups. There are many tasks to perform, and students can take turns doing them.
- As with any static electricity activity, results are best if the humidity in the room is low.
- The two charged objects should never be allowed to touch. Students should be instructed to bring the charged object in their hand slowly toward the side of the object on the watch glass.
- Since some of the charged objects may be round, like the straw, students may find it difficult to keep them on the watch glass. This difficulty can be remedied by placing a small clump of modelling clay in the centre of the watch glass to hold the object in position.

Supporting Diverse Student Needs

- For this inquiry activity, it would be a good idea to partner English language learners and/or students with reading/organizational challenges with students who have stronger language skills.
- You may wish to distribute BLM 3-13, Investigating Static Electricity, for students to use when recording their data.
- This is a good hands-on activity for body-kinesthetic and visual-spatial learners, but also requires logical-mathematical skills to organize observations. Ensure that groups include students with skills in both areas.
- For enrichment, have students place a neutral wooden ruler on the watch glass. Have students bring a charged object near the ruler. Ask students to explain why the neutral ruler is attracted to the charged object. Next, have students place a neutral metal rod on the watch glass. When they bring the charged object near, the metal rod will not attract. Have students give an explanation for this observation.

Analyze Answers

1. Identically charged objects repelled each other.
2. Students' answers may vary but may include plastic/plastic, acetate/acetate, glass/glass, and ebonite/ebonite.
3. Students' answers may vary but may include acetate/ebonite and acetate/glass.

Conclude and Apply Answers

1. (a) Two objects with the same charge repel each other.
   (b) Two objects with opposite charges attract each other.
2. Students' answers should show a situation where like charges repel and unlike charges attract.

USING THE FEATURE

National Geographic: Visualizing Lightning, p. 244

This feature is an excellent starting point for discussion or for further research. Have students read the feature or read it together as a class. Several websites with more information and photographs about this topic can be found at www.discoveringscience.ca.

SECTION 7.2 ASSESSMENT, p. 245

Check Your Understanding Answers

Checking Concepts

1. (a) Contact forces require objects to touch, whereas action-at-a-distance forces push or pull without contact.
   (b) Students' answers may vary but could include shooting a basketball or pulling a desk.
   (c) Students' answers may vary but could include bringing a charged comb near small pieces of paper.
2. Like charges repel. Opposite charges attract. Neutral objects are attracted to charged objects.
3. The second object is positive.
4. When a charge is transferred from one conductor to another, it is called charging by conduction.
5. Charging due to the relocation of electrons within the object is called charging by induction.

Understanding Key Ideas

6. The attraction does not prove that the second object is negatively charged. Since neutral objects are attracted to charged objects, the second object could also be neutral.
7. If a negatively charged acetate strip or positively charged glass rod is brought near the unknown charge, then the charged object that repels the unknown material indicates that it has a similar charge.
8. The electroscope was initially negatively charged. When you bring a positively charged glass rod near the dome, excess electrons in the leaves will be attracted to the glass rod. Since the leaves now possess less negative charge than they originally did, they will move closer together.
9. Induction and conduction are both methods of charging. In conduction, the electrons transfer from one object to another. In induction, the electrons relocate within the object but do not transfer from one object to the other.
10. As the distance between two charged objects is increased, the force of interaction is decreased. Likewise, if the distance between two charged objects is decreased, the force of interaction is increased.
11. Plastic wrap clings to a neutral glass bowl because the plastic wrap has a static charge and therefore induces an opposite charge on the surface of the bowl. The plastic wrap and bowl therefore attract each other.
12. When the positively charged object is near one end of the neutral metal rod, electrons in the metal rod (conductor) will be attracted to the end near the positively charged object. This leaves the other end of the rod positively charged due to induction. When you touch the positive end of the metal rod, electrons from your body will be attracted to the positive rod and transfer onto the rod (conduction). When you remove your finger, the rod has excess electrons and is therefore negatively charged. (Note: the first printing of the student book says the rod will become positively charged. In fact, it will become negatively charged.)

Pause and Reflect Answer

Comb your hair and ensure that the comb has a static charge. Place the comb on a watch glass or something that will allow the charge to move freely. Bring a negatively charged acetate strip near the charged comb. If the comb repels the acetate strip, the comb is negative. If the comb is attracted to the acetate strip, then the comb is positive.

Other Assessment Opportunities

- Consult the Unit front matter for a list of applicable Assessment Blackline Masters.

CHAPTER 7 ASSESSMENT, pp. 246–247

PREPARE YOUR OWN SUMMARY

Students' summaries should incorporate the following main ideas:

1. Electric Charge and the Atom
   - The atom consists of three particles called neutrons, electrons, and protons.
   - Neutrons do not have a charge. Protons have a positive charge, and electrons have a negative charge.
   - A neutral atom has the same number of protons as electrons.
   - In a solid material, the protons stay in the same location and only the electrons are able to relocate. Therefore, all solid materials are charged by electron transfer.
   - If an electron is added to a neutral atom, the atom becomes negatively charged. If an electron is removed from a neutral atom, the atom becomes positively charged.
2. Charge Distribution in Neutral, Positive, and Negative Objects
   - A neutral object has the same number of positive charges (protons) as negative charges (electrons).
   - In solid objects, the positive charges (protons) are evenly distributed and remain fixed in the same location.
   - A positively charged object charged has fewer negative charges (electrons) than positive charges (protons).
   - A negatively object charged has more negative charges (electrons) than positive charges (protons).
   - The unit of electric charge is called the coulomb (C).
3. Transferring Charge
   - All solid materials are charged by electron transfer.
   - Friction is a common method of transferring electrons from one solid object to another.
   - The Van de Graaff generator uses friction to produce a large static charge on its metal dome.
   - Allowing charge to flow into Earth's surface is called grounding.
   - When a charged object transfers electrons to or from another object, the process is called charging by conduction.
   - When a charged object relocates the electrons within another object but no electrons are transferred between objects, the process is called charging by induction.
4. Laws of Static Charge
   - Electric force is an action-at-a-distance force.
   - Like charges repel. Opposite charges attract. Neutral objects are attracted to charged objects.
   - If the amount of charge is increased, the electric force increases. Likewise, if you decrease the amount of charge, the electric force decreases.
   - If the distance between charged objects is increased, the electric force decreases. Likewise, if you decrease the distance between charged objects, the electric force increases.
5. Insulators and Conductors
   - Materials that do not allow charges to move easily are called insulators.
   - Materials that allow charges to move easily are called conductors.
   - Since static electricity is charge that is held nearly fixed in one place, only insulators can retain a static charge.

CHAPTER REVIEW ANSWERS

Checking Concepts

1. Students' diagrams should show protons (positive) and neutrons (no charge) within the nucleus and electrons (negative) outside of the nucleus. Students may have indicated the overall charge of the nucleus to be positive.
2. Students' diagrams should show
   (a) an equal number of + and – signs.
   (b) more – than + signs.
   (c) more + signs than – signs.
3. Electrons are transferred during static charging.
4. Plastics, such as acetate, gain a negative charge when charged by friction.
5. The fur would possess a positive charge after charging the amber.
6. (a) An electroscope is used to detect static charge.
   (b) A Van de Graaff generator is used to produce large amounts of static charge.
7. Grounding a charged object makes the object neutral.
8. A positively charged object becomes neutral when electrons flow into the object and the negative charge balances the positive charge.
9. When a negatively charged object is grounded, the excess static charge flows into the ground and the object becomes neutral.
10. A conductor allows electrons to move freely. An insulator does not allow electrons to move freely.

11. (a) Repels
    (b) Attracts
    (c) Attracts
    (d) Repels
12. (a) Decreases
    (b) Increases
    (c) Increases
    (d) Decreases
13. (a) Electrons are transferred from one object to the other.
    (b) Electrons are relocated within the object but do not transfer between objects.
14. (a) Neutral
    (b) Positive
    (c) Negative

Understanding Key Ideas

15. As long as the number of electrons is equal to the number of protons, the object will be neutral.
16. Friction can cause static electricity. Clothes are rubbed against each other while they are drying in the dryer.
17. Metal fibres are conductors. Any static charge caused by friction will be transferred away from the person by these conducting fibres.
18. The picture tube is a conductor. Since the picture tube gains a static charge only when the television is on, the static charge has the ability to leave the tube. This ability to allow the charge to move makes it a conductor.
19. Lightning is produced by a static charge. The actual lightning bolt is the transfer of charge and therefore cannot be considered static.
20. Both electric force and the force of gravity are action-at-a-distance forces.
21. The unknown object is either negative or neutral.
22. Students' answers may vary but could include the following: Both are a method of charging an object. The major difference is that, in conduction, electrons are transferred from one object to the other, whereas induction does not allow electrons to transfer between objects. Accept all reasonable answers.
23. The wooden wall is an insulator. The charge on the balloon will not transfer to the wooden wall but only induce a charge in the wall. A metal wall would conduct the charge of the balloon and make the balloon neutral.
24. The static charge built up in the sweater causes the sparks and pops.
25. No, your hair does not remain neutral. If the comb has become positively charged, then your hair becomes negatively charged. The comb loses electrons and these electrons would now be in your hair.
26. (a) The leaves would move farther apart.
    (b) The leaves would move closer together.

Pause and Reflect Answer

When the person touches the positively charged Van de Graaff generator, electrons from the person's body (including hair) will be transferred onto the generator. The person's body, including individual hairs, will now be positively charged. The positively charged strands of hair will repel each other and therefore "stand on end."