

# 11.4

## Conductors and Insulators

**conductor** a material that lets electrons move easily through it

**insulator** a material that does not easily allow the movement of electrons through it

### DID YOU KNOW?

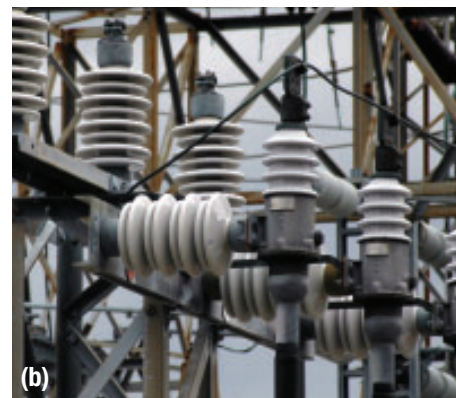
#### Superconductors

As electrons move in a conductor, some of their energy is lost as thermal energy. Scientists have discovered that some conductors, when cooled below a critical temperature, conduct electricity without losing energy. These conductors are called superconductors and are essential in high-speed computers. Modern superconductors work best at temperatures of about  $-150\text{ }^{\circ}\text{C}$ . However, chilling these devices is costly. So, Canadian researchers, like Michael Thewalt at Simon Fraser University in British Columbia, are developing a room temperature superconductor.

Scientists have categorized most materials into two categories: conductors and insulators (Figure 1). **Conductors** are materials that allow the movement of electrons. **Insulators** are materials that inhibit or prevent the movement of electrons. Both conductors and insulators have practical applications.



(a)



(b)

**Figure 1** (a) Copper wire is a conductor. (b) Ceramic is an insulator.

### Conductors

Good conductors allow electrons to move through them with ease. Fair conductors allow electrons to move through them with a small amount of difficulty. The most familiar conductors are metals such as copper and aluminum. These metals can be used in the wiring that appears in electrical cords in appliances, such as lamps and televisions, and in the walls of your home. Some non-metals such as graphite (a form of carbon) are also reasonably good conductors of electricity. Graphite and silicon are examples of materials called semiconductors because they allow electrons to move through them, although not as easily as in a good conductor. Table 1 lists some common conductors.

Could you place a charge on a conductor if you were holding it in your hand? No—any charge would immediately pass through the conductor into your hand. If you think back to the Try This Activity in Section 11.1, this is why the copper pipe did not pick up any paper pieces. Any excess charge travelled to your hand.

You have probably heard or read warning labels stating that you should never use an electrical appliance near water. Why? Consider the conductive property of water. Table 1 lists salt water as a fair conductor. This is because it contains ions (recall that ions are charged atoms). Ions pass through salt water easily. Pure water, which has no ions, is non-conductive. The water in a typical home contains minerals and ions and is a fair conductor of water. Touching an electrical appliance when you are near water, or damp from a bath or shower, puts you at greater risk of injury from the movement of a large amount of electric charge through your body.

**Table 1** Common Conductors

Good conductors	Fair conductors
silver	graphite (carbon)
copper	nichrome
gold	the human body
aluminum	damp skin
magnesium	acid solutions
tungsten	salt water
nickel	Earth
mercury	water vapour in air
platinum	silicon
iron	germanium

## Insulators

Insulators are the answer to using electricity safely. In an insulator, the electrons are tightly bound to the atoms that make up the material, so they are not free to move to neighbouring atoms. Insulators include non-metals such as plastic, ebonite, wood, and glass (Table 2).

From about 1880 to the 1930s, copper conductors in the walls of homes were passed through protective porcelain insulating tubes, and supported along their length on nailed-down porcelain knob insulators. This type of electrical wiring is known as “knob and tube” wiring (Figure 2). Today, electrical wires in homes are coated with an insulating material, such as plastic. Electricity distribution also uses insulators. For example, electricity transmission wires are connected to poles using insulating materials (Figure 3). Insulators protect us from the danger of having large amounts of electric charge move through our bodies if we come in contact with a conductor. Placing a plastic insulator around a copper wire prevents electrons from escaping the conductor. In this way, the electrons stay in the conductor and discharges are avoided.



**Figure 2** Knob and tube wiring was common in homes up to about 1930.



**Figure 3** These workers are installing new wires and insulators on this hydro pole.

## Using Conductors and Insulators

Different types of technology use conducting and insulating materials to work properly. For example, technologies such as lightning rods and automobile frames and bodies are made of conducting materials. Glass has been used as an insulator in telegraph wiring since the 1800s. The telecommunications industry uses teflon and silicon dioxide as electrical insulators to protect against exposed wiring.

A laser printer is a common household electrical device that requires the properties of both insulators and conductors.

### Laser Printers

Laser printers use conductors and insulators, as well as the Law of Electric Charges, to work (Figure 4). A laser printer consists of a drum made of a positively charged photoconductor. A photoconductor is a special class of conductor that conducts electrons only when a light shines on it. If no light shines on it, it remains an insulator.



**Figure 4** Laser printers use conductors and insulators to produce images.

**Table 2** Common Insulators

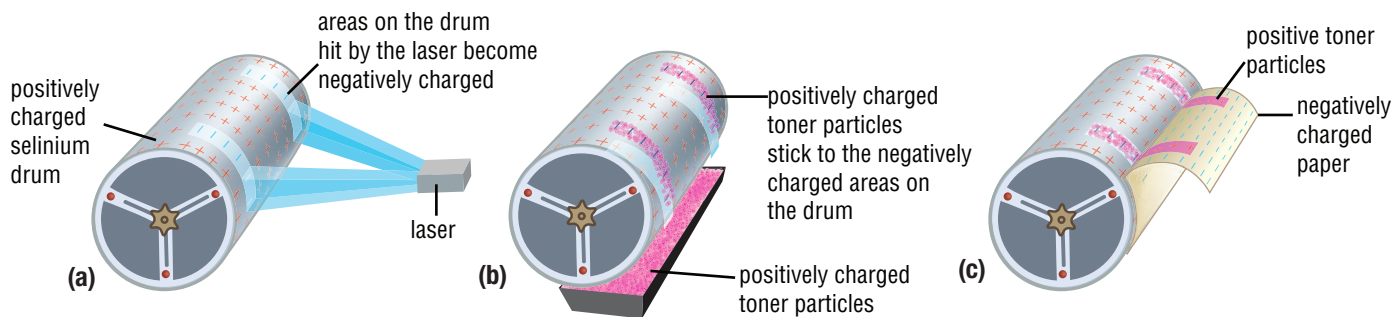
Good insulators	
oil	plastic
fur	wood
silk	paper
wool	wax
rubber	ebonite
porcelain, glass	pure water

## WRITING TIP

### State Key Points

When writing persuasive text, use the body of the text to explain the key points of your argument. State your point clearly, and then support your point with detailed evidence. Use connecting words to show the relationship between ideas.

In this case, the light is a laser. The laser light quickly “draws” the image to be printed across a positively charged selenium drum, causing these areas to become negatively charged (Figure 5(a)). The drum is then rolled across positively charged toner particles that are attracted to the negatively charged areas on the drum and are repelled by the positive areas (Figure 5(b)). When the drum is rolled over paper that has been given a larger negative charge than the drum, the positive toner particles become attracted to the negative paper (Figure 5(c)). The paper then passes through a fuser that melts the toner particles, which are made from plastic, onto the paper using temperatures of over 200 °C. The paper does not catch fire because of how quickly this process happens. There is also a fan that keeps the area around the fuser cool.



**Figure 5** (a) The laser “draws” the image on the drum, making these areas negatively charged. (b) The drum rolls across the positively charged toner, which sticks to the negatively charged laser “drawing.” (c) The drum rolls across paper with a higher negative charge and the toner particles “stick” to the paper.

## UNIT TASK Bookmark

How can you apply what you have learned about conductors and insulators to the Unit Task described on page 586?

## IN SUMMARY

- Conductors allow electrons to pass through them easily.
- Insulators inhibit or prevent the movement of electrons.
- Semiconductors have special properties that make them fair conductors, not good conductors.
- Technologies such as laser printing use conductors and insulators.

## CHECK YOUR LEARNING

1. Provide a brief explanation of conductors and insulators, giving at least two examples of each. [K/U](#)
2. Compare the conductivity of pure water and salt water. Relate this information to the conductivity of water in and around your home. [T/I](#) [A](#)
3. If you use an insulator to touch a conductor that is carrying electricity, will you receive a shock? Explain. [K/U](#)
4. Two new materials have been discovered. One is shiny and has a metallic look, while the other is dull and has a non-metallic look. Although you think that one is a conductor and the other an insulator, you want to be certain. Describe a test you could do to test the conductivity of these two materials. [T/I](#)
5. Create a pamphlet to explain how laser printers operate using electric charges. Include diagrams in your explanation. [K/U](#) [C](#)
6. Electricians often use screwdrivers that have thick rubber handles. Explain why. [K/U](#)
7. A golfer and her caddy see lightning nearby. The golfer is about to take a shot with a metal club, while her caddy is holding a plastic-handled umbrella. Which person is at greater risk? Explain your answer. [K/U](#)