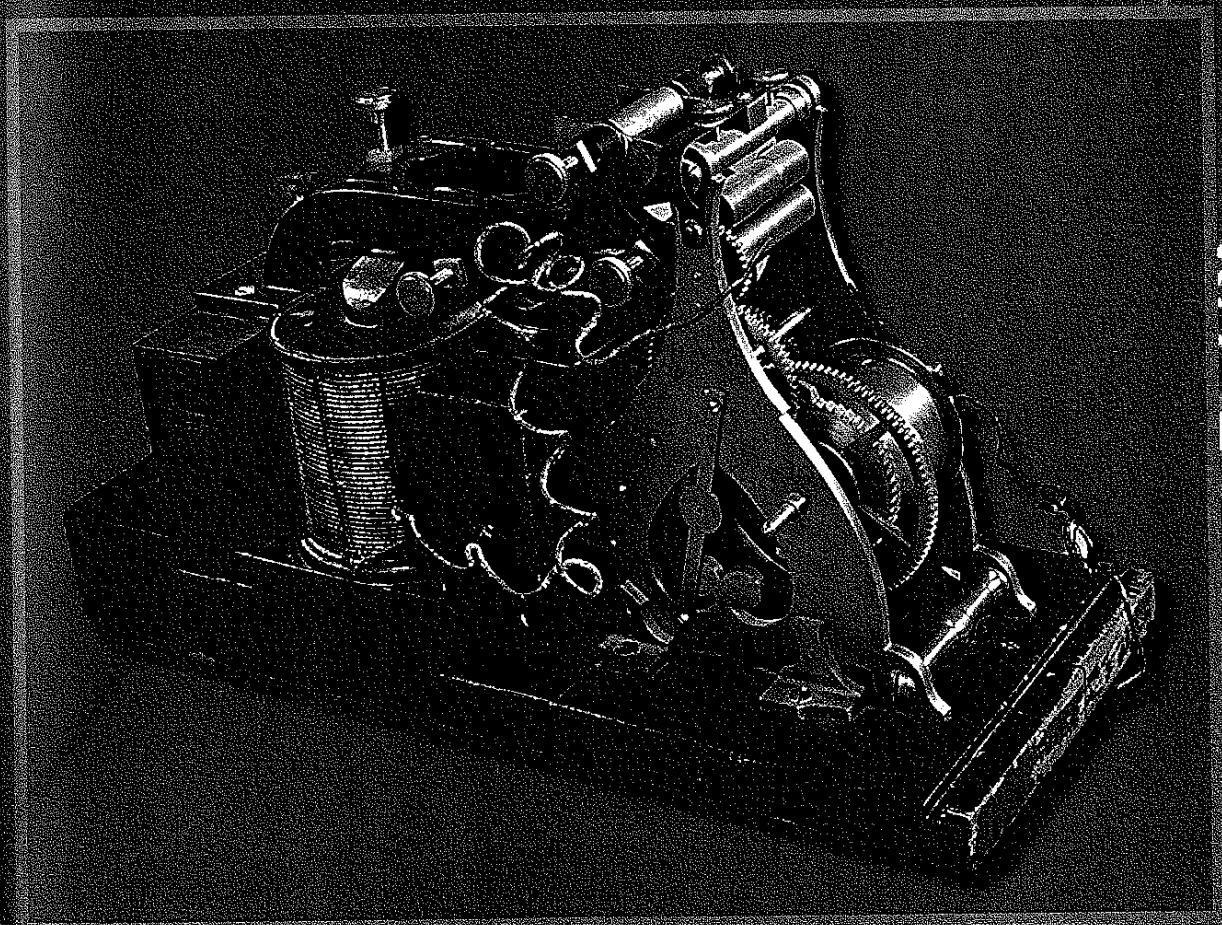
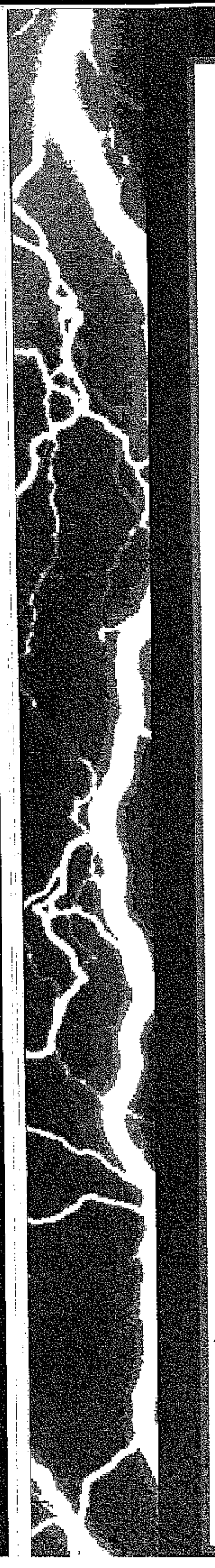
Physical Sciences

Magnetism and Electricity





Physical Sciences
Table of Contents

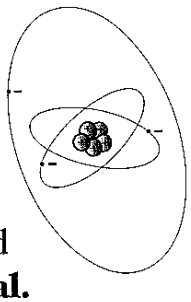
Magnetism and Electricity

PS1e. Students know electrically charged objects attract or repel each other.

Making Static

Did you ever reach for a doorknob and get a shock? Zap! Why does that happen? Because of **static electricity.**

Static electricity starts with atoms. Atoms are the small particles that everything is made of. Atoms have a nucleus in the center. The nucleus has **positive charge.** Atoms also have tiny **electrons** moving around the nucleus. Electrons have **negative charge.**

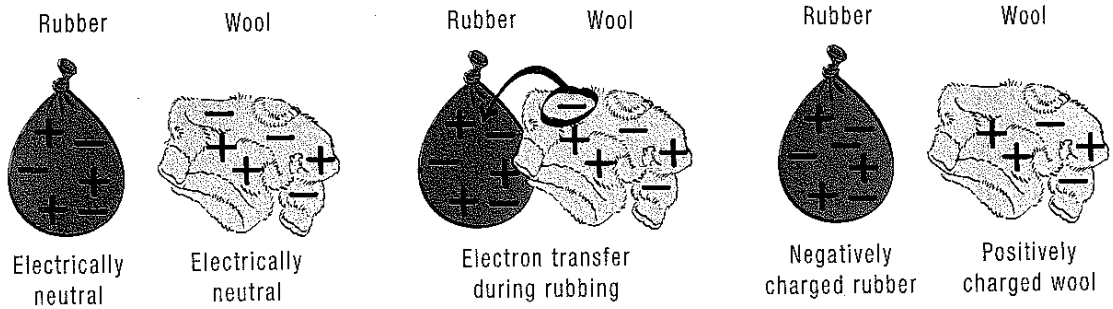


Most of the time, the number of positive charges in the nucleus is the same as the number of negative charges moving around the nucleus. When the positive and negative charges are equal, the atom is **electrically neutral.**

Electron Transfer

Sometimes an electron can leave one atom and move to another atom. When this happens, one atom has gained an electron and one has lost an electron. The atom that has gained an electron has negative charge. The atom that lost an electron has positive charge.

Rubbing two objects together can cause electrons to move or **transfer.** When a wool sweater is rubbed on a balloon, electrons transfer from the wool to the rubber. This transfer is how objects can get a static charge.



The Balloon Experiment

When two balloons hang from threads, they come to rest touching each other. The balloons are electrically neutral.

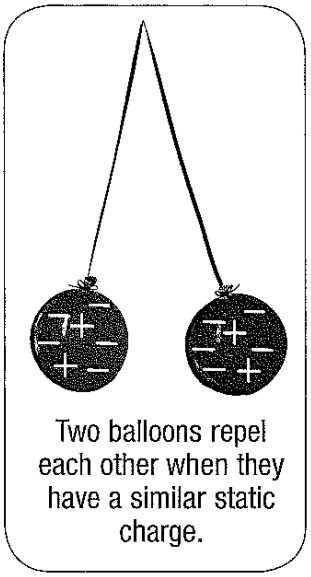
When both balloons are rubbed on a wool sweater or someone's hair, the balloons push each other apart. Why?

During rubbing, electrons transfer from the sweater to the balloons. Both balloons get a negative charge. Negative charges repel each other. That's why the balloons don't touch.

Do you think there is a charge on the wool sweater after rubbing the balloons? If so, is it a negative or positive charge? Remember, electrons transferred from the sweater to the balloons give the balloons a negative charge. That means the sweater lost electrons. The sweater has a positive charge.

What will happen when you bring the positively charged sweater close to the negatively charged balloons? The sweater will attract the balloons. The charge on the wool sweater is opposite to the charge on the balloons. Opposite charges attract.

Two balloons hang side by side when they are electrically neutral.



Two balloons repel each other when they have a similar static charge.

Review Questions

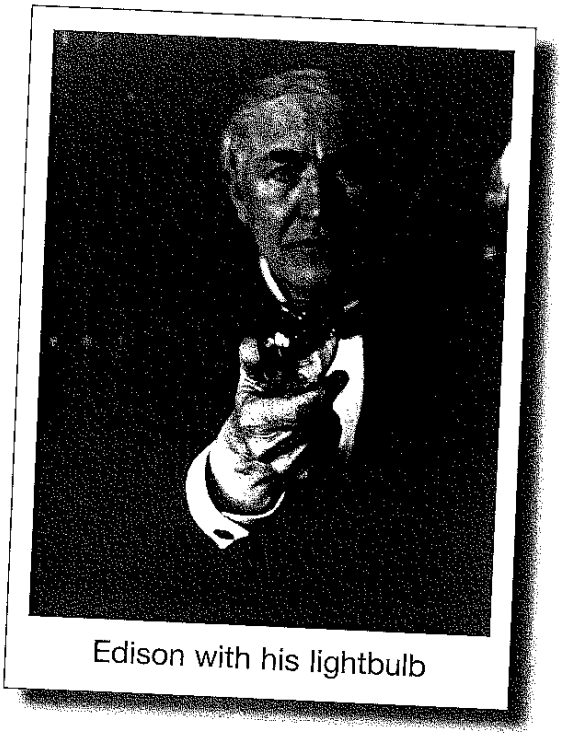
1. **Say you wear rubber-soled shoes and walk across a wool rug. What will happen when you reach toward a charged balloon hanging on a string? Why do you think so?**
2. **Say you wear wool slippers and walk across a rubber floor. What will happen when you reach toward a charged balloon hanging on a string? Why do you think so?**

INVESTIGATION 2

PS1a. Students know how to design and build simple series and parallel circuits by using components such as wires, batteries, and bulbs.

PS1g. Students know electrical energy can be converted to heat, light, and motion.

Edison Sees the Light



Edison with his lightbulb

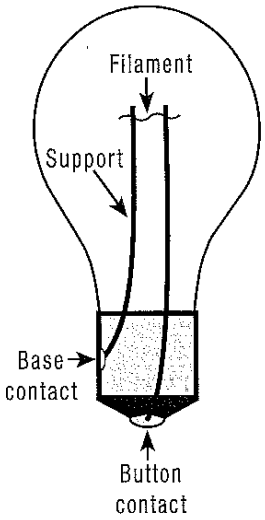
"The filament burns out too quickly," Mr. Edison said. "We have to find a better material to make the filament last longer."

Thomas Edison (1847–1931) was the most famous inventor of his time. He invented the phonograph, the motion picture camera, the first copy machine, and hundreds of other things. He is most famous, however, for improving a product he *didn't* invent, the electric **lightbulb.**

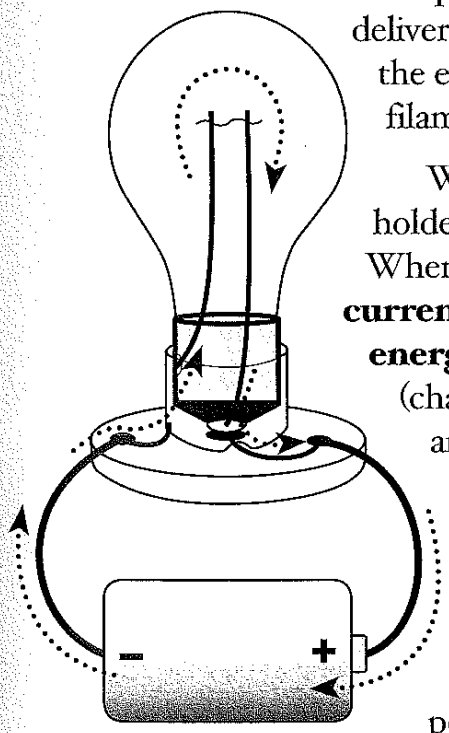
The problem with lightbulbs before 1879 was that they burned out too quickly. The **filament** is the part of the lightbulb that actually makes the light. When **current electricity** flows

through the filament, the filament gets so hot that it glows and gives off light. The hotter the filament gets, the brighter the light. But the hotter the filament gets, the faster it burns out.

Edison's short-lived lightbulb was a simple device. It was much like a modern bulb. In a modern bulb, the filament is held by two stiff support wires. A clear glass globe surrounds the filament for protection. The glass globe is attached to a metal base. The tricky part is how the filament support wires connect to the metal base.



One filament support wire attaches to the side of the metal base. The other support wire attaches to a small metal button at the bottom of the base. The metal button must not touch the main part of the metal base. This is important. When electricity is delivered to the lightbulb in a **circuit,** the electricity must flow *through* the filament.



A lightbulb in a circuit

When the lightbulb is placed in a bulb holder, electricity can be delivered to the bulb. When the circuit is complete, the **electric current** will flow. The electric current has **energy.** The **electric energy** is **converted** (changed) to **heat energy** and **light energy,** and the lightbulb does its job. This is **energy conversion.**

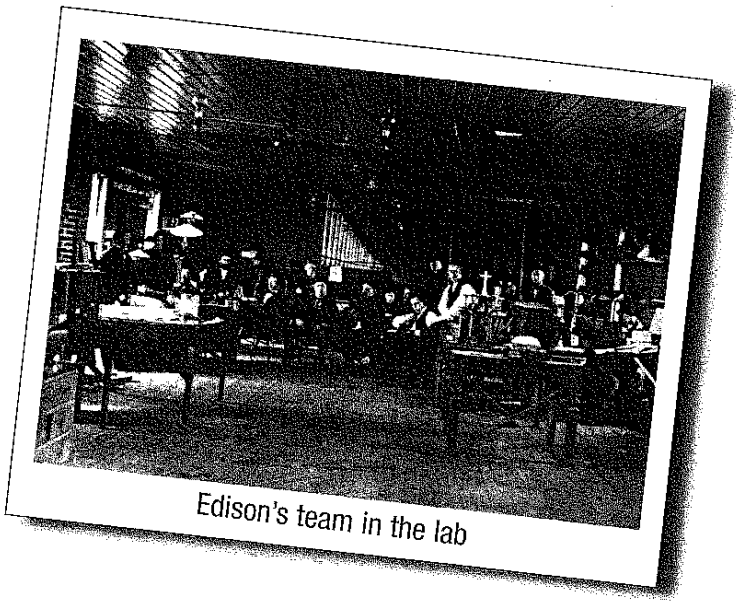
Edison tackled the filament problem in his usual way, with hard work. He is credited with saying, "Invention is one percent inspiration and ninety-nine percent perspiration." Edison directed his team to try every imaginable material to find the best filament. It is said that they tried and rejected 2,000 materials. Edison needed help.

Help came from Lewis Latimer (1848–1928). Latimer was an experienced draftsman and inventor. He had been working on the filament problem, too. Latimer discovered that a carbon-coated cotton thread made a good filament. He got a patent for the carbon filament. Inventors get patents from the government when they invent something new. When Edison tried the carbon filament in his lab, he agreed that it was the best. Edison bought the patent from Latimer so he could use the carbon filament in his lightbulb.


Lewis Latimer

Edison had to solve one more problem before the lightbulb could be used widely. He knew that things need oxygen to burn. If he could remove the air from the glass globe, there would be no oxygen and the filament would not burn up. He was right. This new lightbulb lasted months instead of days.

Thomas Edison had seen the light. Now it was time to show this new light source to the world. It was New Year's Eve, 1879. Edison's team strung lights from its lab to the train station. A crowd of over 3,000 people came to see what would happen.

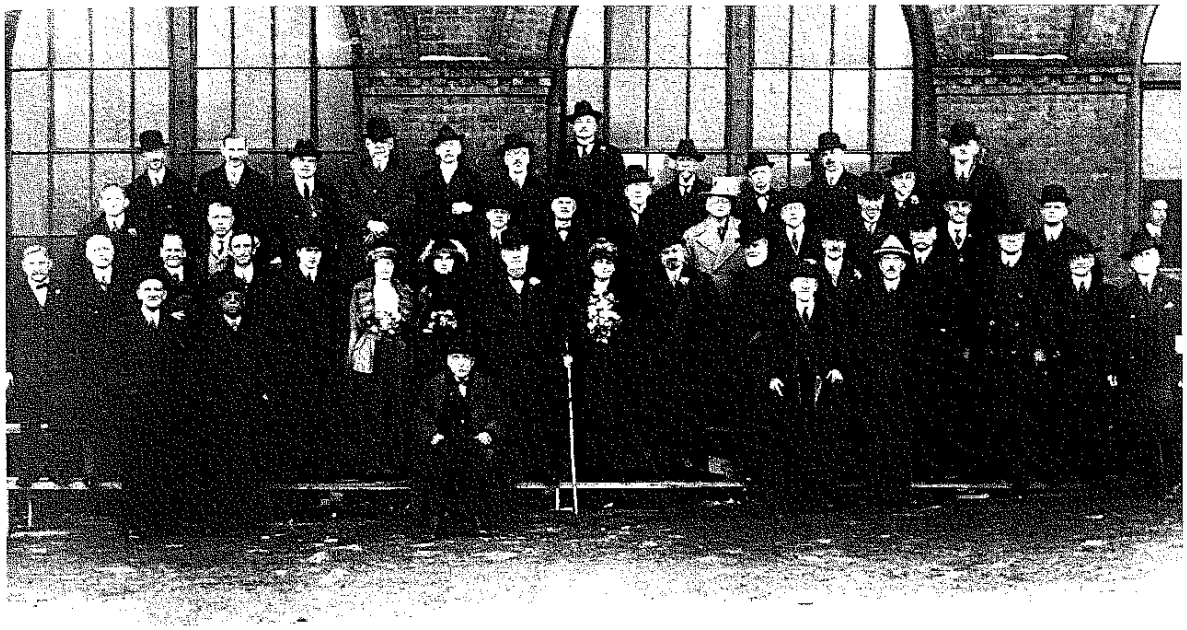

Edison's team in the lab

It was a very dark night, and all the gaslights had been turned off. Edison stepped up to the platform and threw the switch. All the lights came on. The crowd cheered.

Edison understood the importance of electric lighting. It could change the American way of life. That's why he asked Latimer to join his team

in 1884. Latimer stayed with Edison for years. He wrote patents for new inventions and books on electrical engineering.

Many years later, in 1918, the team of scientists and engineers gathered to celebrate Edison's birthday. They called themselves the Edison Pioneers. Lewis Latimer was the only African American among the engineers. He also was one of the 28 founding members.



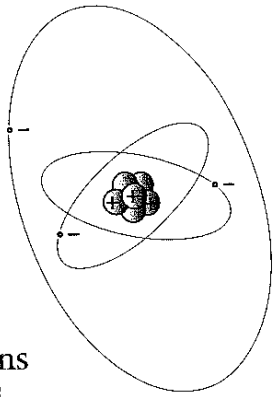
The Edison Pioneers—1920

Review Questions

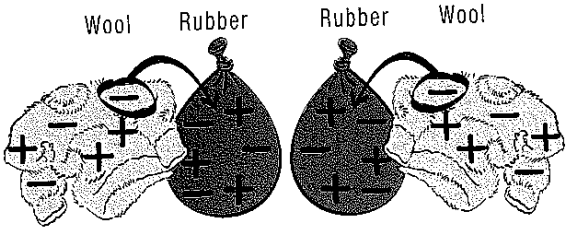
1. **Edison's lightbulb was an energy converter. What does that mean?**
2. **How does a lightbulb make light?**
3. **Describe the path taken by electricity through a lightbulb.**

Summary: Making Connections

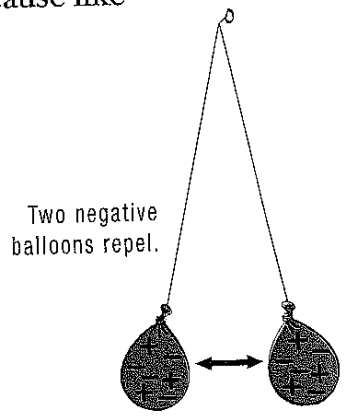
Electrons are the tiny particles that go around the larger nucleus of an atom. Electrons have **negative charge.** The nucleus has **positive charge.** When two materials, such as rubber and wool, are rubbed together, electrons will move from the wool to the rubber. The rubber has more electrons, so it has a negative charge. The wool has fewer electrons, so it has a positive charge.



When two rubber balloons are rubbed on wool, they both get a negative charge. When the two balloons come close to each other, they repel. That's because like charges repel.



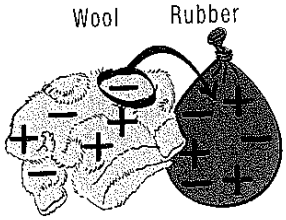
Electron transfer during rubbing



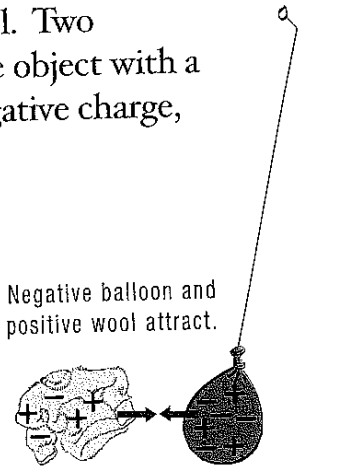
Negative charge on rubber

Negative charge on rubber

Two objects with a negative charge always repel. Two objects with a positive charge also repel. But if one object with a positive charge comes close to an object with a negative charge, the objects will attract. Opposite charges attract.



Electron transfer during rubbing

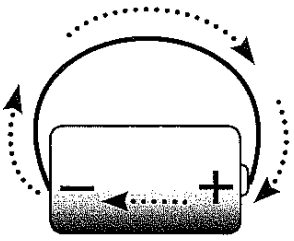


Positive charge on wool

Negative charge on rubber

Current Electricity

Charge on the move is **current electricity.** A D-cell is a source of current electricity. A copper wire is an electricity **conductor.** If a copper wire is connected from one end of the D-cell to the other, current electricity will flow from the negative end of the cell to the positive end of the cell. Electricity flows in a pathway called a **circuit.** A wire from one end of a cell to the other is the simplest circuit.



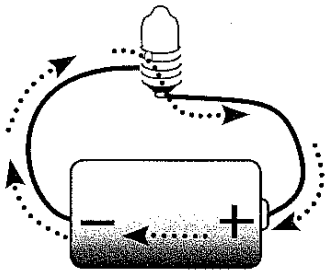
A short circuit

Making a circuit by connecting the two ends of a D-cell with a wire is not a good thing to do. This creates a **short circuit.** Short circuits drain the energy from D-cells very rapidly. You always want to have something like a lightbulb or a motor in the circuit.

Using Electric Energy

Electricity is a form of **energy. Electric energy** can be used to do work. By putting different lightbulbs or motors in circuits with an electricity source, we can turn electric energy into other kinds of energy. This is called **energy conversion.**

Conversion means change. When a lightbulb is put in a circuit with a D-cell, the electric energy is converted into **light energy.** When a motor is put in a circuit with a D-cell, the shaft turns. The electric energy is converted into **motion energy.** When you plug in a fan, electric energy is converted to motion energy. At home when you plug a toaster into the wall socket, electric energy is converted into **heat energy.**

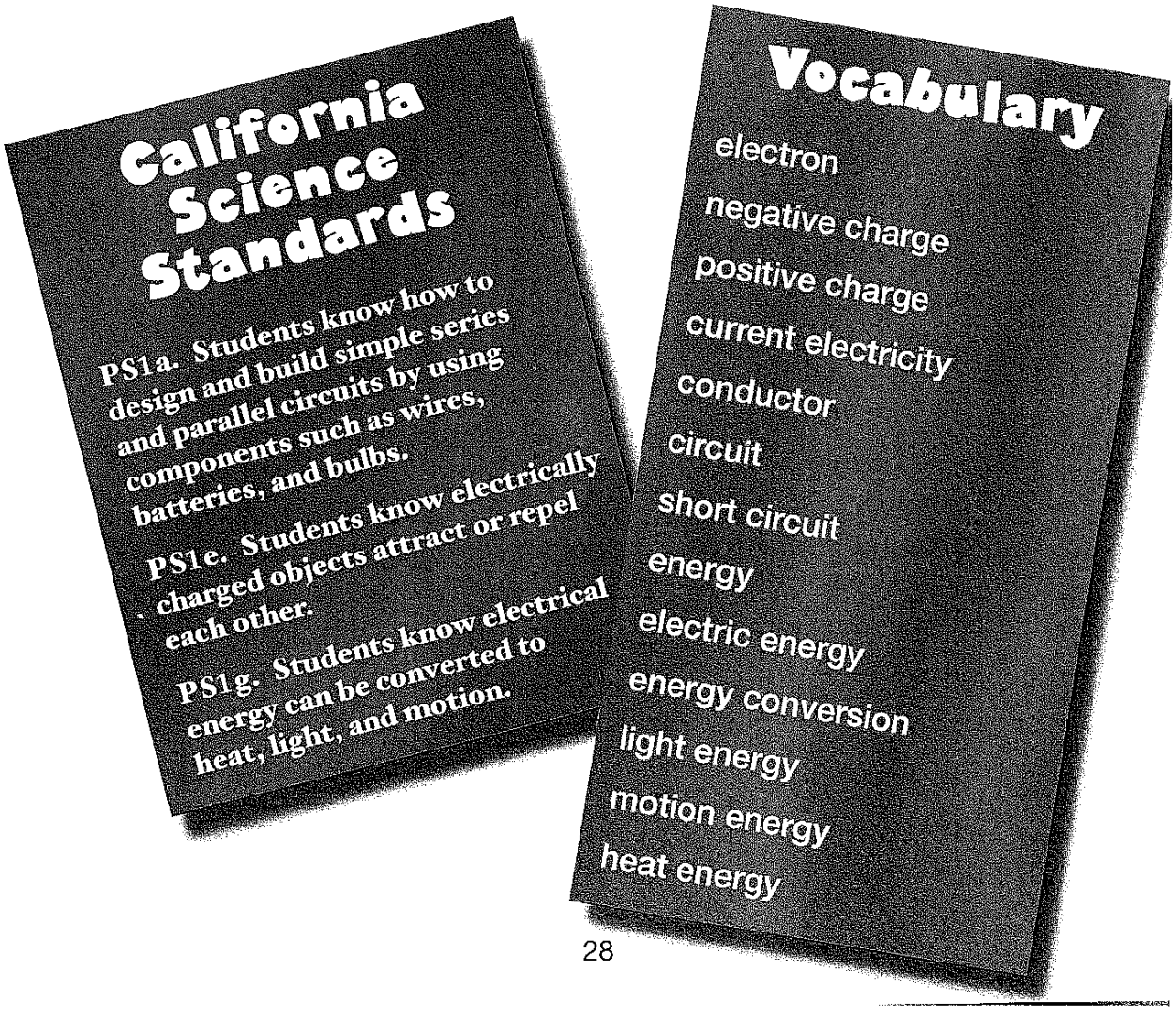


A circuit with a lightbulb

Summary Questions

Now is a good time to review what you have recorded in your science notebook. Think about the investigations you have conducted using electrically charged objects. Think about the circuits you built using D-cells, motors, lightbulbs, switches, and wires.

1. **What do you think would happen if you combed your hair with a rubber comb and then brought the comb near a balloon that had been rubbed on wool? Why would that happen?**
2. **What do you call a pathway through which electricity flows from one end of a cell to the other?**
3. **Electric lights get hot when they are used. What energy conversions are happening?**
4. **What are conductors and insulators?**



Extensions

Math Problem of the Week

A fourth-grade class wanted to find out how many hours different brands of C-cells would last. Students bought three Charger cells, three E-Z Volt cells, and three Amp-Champ cells. They hooked up each cell to a motor, let it run each day while they were in class, and unhooked it at night when they went home. Below is what they observed.

Charger 1	30 hours
Charger 2	25 hours
Charger 3	20 hours
E-Z Volt 1	30 hours
E-Z Volt 2	40 hours
E-Z Volt 3	35 hours
Amp-Champ 1	25 hours
Amp-Champ 2	40 hours
Amp-Champ 3	40 hours

Based on these data, which brand of cells would you buy? Explain why you chose that brand.

Home/School Connection

Where's the Electricity?

Make a list of electric fixtures and appliances in your home. Write some rules and practices for using electricity safely.

Use the Home/School Connection sheet called *Where's the Electricity?* to record the fixtures and appliances. Or make up your own way to organize your list.

Physical Sciences Glossary

Attract To pull toward one another.

Circuit A pathway for the flow of electricity.

Closed circuit A complete circuit through which electricity flows.

Code A set of signals that represents letters or words for sending messages.

Coil In an electromagnet, wire wound repeatedly around a central core.

Compass An instrument that uses a free-rotating magnetic needle to show direction.

Component One item in a circuit.

Conductor A substance through which electricity will flow. Metals are conductors.

Contact The place in a circuit where connections are made to allow electricity to flow.

Convert To change.

Core In an electromagnet, the material around which a coil of insulated wire is wound.

Current electricity A flow of electric charge.

Doorbell A device that uses an electromagnet to ring a bell.

Earphones A set of two tiny speakers in a headset.

Electrically neutral An object with equal numbers of positive and negative charges.

Electric current A flow of electricity through a conductor.

Electric energy A form of energy available in current electricity.

Electromagnet A piece of iron that becomes a temporary magnet when electricity flows through an insulated wire wrapped around it.

Electron A tiny particle with negative charge that goes around the nucleus of an atom.

Energy Energy is the ability to do work. Energy can take a number of forms and can be converted from one form to another.

Energy conversion Energy change from one form to another.

Filament The material in a lightbulb (usually a thin wire) that makes light when heated by an electric current.

Force A push or a pull.

Generator A device that converts motion into electric energy.

Heat energy A form of energy.

Induced magnetism The influence of a magnetic field on a piece of iron, which makes the iron a temporary magnet.

Insulator A material that prevents the flow of electricity. Plastic, rubber, glass, and air are insulators.

Interact To act on and be acted upon by one or more objects.

Iron A metal that sticks to a magnet.

Key A switch that completes the circuit in a telegraph system.

Lightbulb A filament held by two stiff wires and surrounded by a clear glass globe.

Light energy A form of energy.

Lodestone A form of the mineral magnetite that is magnetic.

Magnet An object that sticks to iron.

Magnetic field An invisible field around a magnet.

Magnetism A property of certain kinds of materials that causes them to attract iron or steel.

Magnetite An iron-rich mineral that sticks to a magnet.

Motion energy A form of energy.

Motor A device that converts electric energy into motion energy.

Negative charge The charge on an electron.

North pole The end of a magnet that orients toward Earth's magnetic north pole.

Open circuit An incomplete circuit through which electricity will not flow.

Orient To position an object in a certain way.

Parallel circuit A circuit with two or more pathways for current to flow.

Permanent magnet An object that sticks to iron.

Pole Either of the two ends of a magnet.

Positive charge The charge on an atom's nucleus.

Repel To push away from one another.

Schematic diagram A system of lines and symbols used to represent a circuit.

Series circuit A circuit with only one pathway for current flow.

Short circuit A circuit allowing current to flow directly from one end of a battery to the other.

South pole The end of a magnet that orients toward Earth's magnetic south pole.

Speaker A device that converts electric energy into motion.

Static electricity Positive and negative electric charges that are separated from each other and are not moving.

Striker A tiny hammer that hits the bell in a doorbell.

Telegraph A device that uses an electromagnet to send coded messages by closing and opening an electric circuit.

Temporary magnet A piece of iron that behaves like a magnet only when it is surrounded by a magnetic field. A temporary magnet can be a piece of iron that is touching a permanent magnet. A temporary magnet can be an electromagnet.

Terminal An electric contact point.

Transfer To move from one place or thing to another place or thing.

Vibration A quick back-and-forth movement.