STATIC ELECTRICITY

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STATIC ELECTRICITY

It's a Snap

WHY TEACH IT?

If you have avoided this topic in the past because you felt you lacked the necessary background to explain it to your students, here are some reasons why you should reconsider:

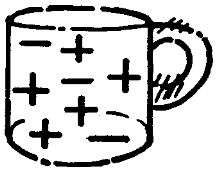
- **Most Students Have Encountered Static Electricity in Their Daily Lives.** As a result, relevance is built-in. Unlike some other science units we teach that have pupils asking 'Why do we have to study this?" there is genuine interest on the part of students based on their previous experiences with static electricity You can capitalize on this.
- **It Is Inexpensive to Teach in a Hands-On Fashion** (the only way to teach). If you read through the booklet you will see that a plastic comb per student, a roll of aluminum foil, large glass jars, plastic margarine-tub lids, thread, ground black pepper, tape, and some common stranded wire are just about all you will need. Wool fabric scraps (about six inches square) are needed as well, but check with a home economics teacher for remnants before you buy any If you must visit the fabric store, buy the ugliest (usually the cheapest) wool remnant you can find for students to use. They'll love thinking it was once part of your wardrobe. It would also be nice to have other types of fabrics available later for comparison.
- **There's Really Nothing to It.** The shocking truth about static electricity, if you'll pardon the pun, is that it is an easy unit to teach. All you need to know to do a creditable job is condensed into the following paragraphs:

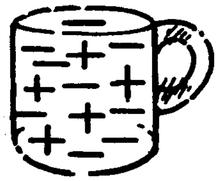
BACKGROUND INFORMATION

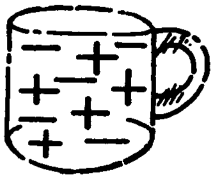
Two parts of an atom are responsible for the effect we call static electricity: the proton and the electron. Protons have one kind of charge, called positive (+); and electrons have an opposite kind, called negative (-). Normally, an object has equal numbers of protons and electrons. Therefore, it doesn't exhibit any electric charge. Such an object is neutral.

Electrons are rather loosely held by atoms, unlike protons. So if you think of them as the only particles that are free to move, you'll find it much easier to explain how entire objects can be charged. Think of a negatively charged object as having gained electrons by some action, thus giving it more electrons than protons. Think of a positively charged object as having lost some of its electrons by some action, so now it has more protons by comparison.

The drawings below illustrate what determines the charge, if any, on an object. By nature, the number of protons (+) in each cup remains constant. (Protons don't move, remember? They can't enter or leave the cup.) If the zillions of protons and electrons are represented as shown, notice that it is the relative number of electrons that makes each cup positive, negative, or neutral. Your students should have this concept firmly fixed in their minds.


Positive


Negative


Neutral

Electrons are added or taken away through friction, such as when clothes tumble in a dryer, feet scuff a carpet, or a comb moves through hair. Not all objects or materials can be charged, though. For example, materials that conduct electricity well, like metals, are hard to charge because the extra electrons generated by friction will flow out of that material if it happens to be grounded or is touched by another conductor (which includes you).

Whenever objects become charged, the charges must obey the following two rules:

- Opposite charges attract each other.
- Like (same) charges repel each other.

Neutral objects can behave like they are charged when they are near a charged object. (Don't worry. Think electrons.) If a negatively charged (-) comb is brought near a neutral object, some of the electrons on the neutral object are repelled to the side away from the negatively charged comb. (Why? because same charges repel.) That leaves mostly protons (+), which don't move, on the side facing the negatively charged comb. Since opposite charges attract, the neutral object will be attracted to the comb even though the object's overall balance of electrons and protons hasn't changed. Technically, it's still neutral.

The same thing would happen if the comb were positively charged, only now some of the electrons would be drawn toward the side of the neutral object facing the comb (instead of being repelled to the opposite side, as in the preceding paragraph). So the neutral object also would be attracted to the positively charged comb. This process, called *induction,* **ALWAYS** results in a neutral object being attracted to a charged object. The kind of charge on the charged object doesn't matter. The neutral object will always behave like it has the opposite charge.

TEACHING TIPS

Science vocabulary seems an insurmountable hurdle for many students. This unit has been intentionally written to minimize reliance on special terms. Therefore, place the emphasis on understanding the process. Demand explanations instead of memorization of terms.

Break down the action into a series of steps to enhance the cause-and-effect nature of what seems to be one event, like charging the electroscope. This will give you an opportunity to ask students what is happening, the sequence of actions, and most importantly WHY things are happening. It might be a good idea to make copies of the accompanying explanation titled *How the Electroscope Works* to give to your students.

Require them to explain what is happening in each picture and why it is happening. But the electroscope drawings on the board the next day and have volunteers explain them to the class without consulting their explanation sheets. Let the class catch and correct any mistakes after each student's presentation. Then erase the charges from the diagrams and challenge a student to fill them in and make the correct explanations.

This process of questioning and subsequent application of theory will give you a much better assessment of whether students are absorbing the material than administering a short answer test. Students will develop a better understanding and be able to apply that understanding to different situations with this approach. That should be our goal in teaching all science.

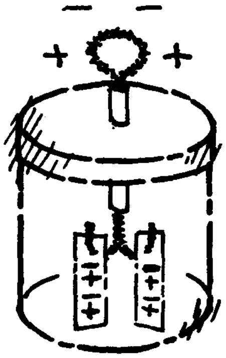
Despite your best efforts, some students will insist that they have no idea why a neutral aluminum-foil ball is attracted to a negatively charged comb, or why a balloon rubbed on their hair sticks to the wall. Simply remind them that electrons are the charges that move, and that there are only two reasons why anything happens in static electricity, as highlighted on page 2: opposite charges attract, and same charges repel. Then help them brainstorm the answer. Remember to break the action down into steps and stick to the rules, and they'll discover they DO know the answers.

Don't be concerned with the thought that you won't be able to tell whether a charge on something is positive or negative. No one can tell the type of charge just by looking at it. You must test it with a-charge you already know is positive or negative and see how the unknown charge behaves. (For example, glass rubbed with silk always becomes positively charged. And hard rubber stroked with fur always becomes negatively charged.)

Remember, charges must follow the two rules above. Either kind of charge will attract neutral objects as well as its opposite charge, and either kind of charge will repel a charge of its own kind. So if an object is repelled by a positively charged glass rod, for example, that object must have the same charge as the rod. If the object is attracted, it must have an opposite charge (or be neutral).

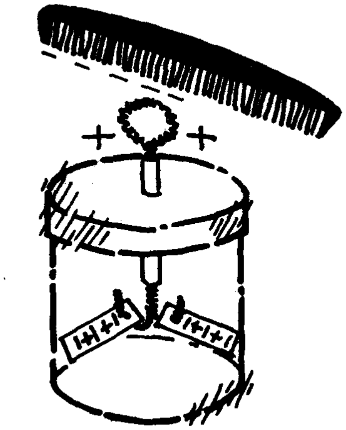
Well are you convinced yet? Give this approach a try. Both you and your students will enjoy the experience and learn some serious science at the same time.

HOW THE ELECTROSCOPE WORKS



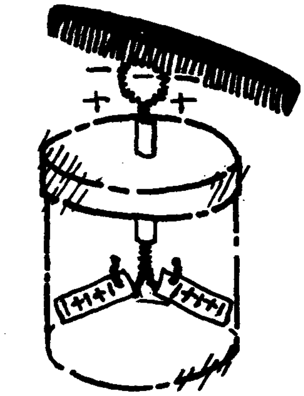
1.

The electroscope is neutral. The foil leaves hang freely because they have the same number of positive and negative charges.



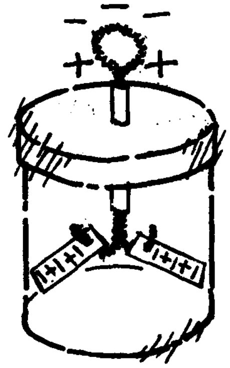
2.

A comb that has been negatively charged (by passing it several times through hair) is brought near the loop of the electroscope. Electrons (negative charges) in the loop are repelled down to the leaves. Each leaf now has more negative charges than positive, so the leaves repel each other. Meanwhile, the loop is left with a positive charge.



3.

When the comb makes contact, electrons rush from the comb onto the loop (opposite charges attract). The leaves remain apart; they still have an excess of electrons with nowhere to go and nothing to do but repel one another.



4.

Removing the comb now imparts a negative charge to the entire electroscope (the scope is charged). Since that includes each leaf, the excess electrons in the leaves keep them spread because, as you know, negative charges repel each other.

How do you discharge the scope? Simply touch the loop with any conductor, like your finger. This allows the excess electrons to flow into the conductor, thus rendering the electroscope neutral and dropping the leaves.

THOMAS ALVA EDISON SCIENCE EDUCATION BOOKLETS

Science is a way of knowing about, understanding, interacting with, and appreciating the, world around us. Science learning begins by probing, questioning, and discovering the wonders of the world in which we live.

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Dr. LaMoine L. Motz
Director of Science Education
Oakland County Schools, Michigan

Past President
National Science Teachers Association
National Science Supervisors Association
Michigan Science Teachers Association

Tom Edison, pictured here at the age of 14, with lots of curiosity and determination led the way for the young scientists of today!

TO AMERICA'S YOUTH

We're all familiar with "everyday" static electricity: getting a spark after sliding across a car seat . . . a piece of plastic film you can't shake off your hand . . . lightning, of course.

In this book, you will explore static electricity. It's more than just a nuisance. You may be surprised to learn that through understanding the theories of positive and negative charges in atoms, scientists were able to develop the photocopy machine.

The Edison Electric Institute, in cooperation with the investor-owned electric companies all over America, is pleased to offer this publication to you. This book is designed to inspire and challenge you, the scientists and engineers of the future. It is our hope that you, like Tom Edison, will experience the "joy of discovery" as you go through the activities and experiments herein.

Best wishes as you continue your journey through the fascinating world of science.

Thomas R. Kuhn
President
Edison Electric Institute

Did You Ever . . .

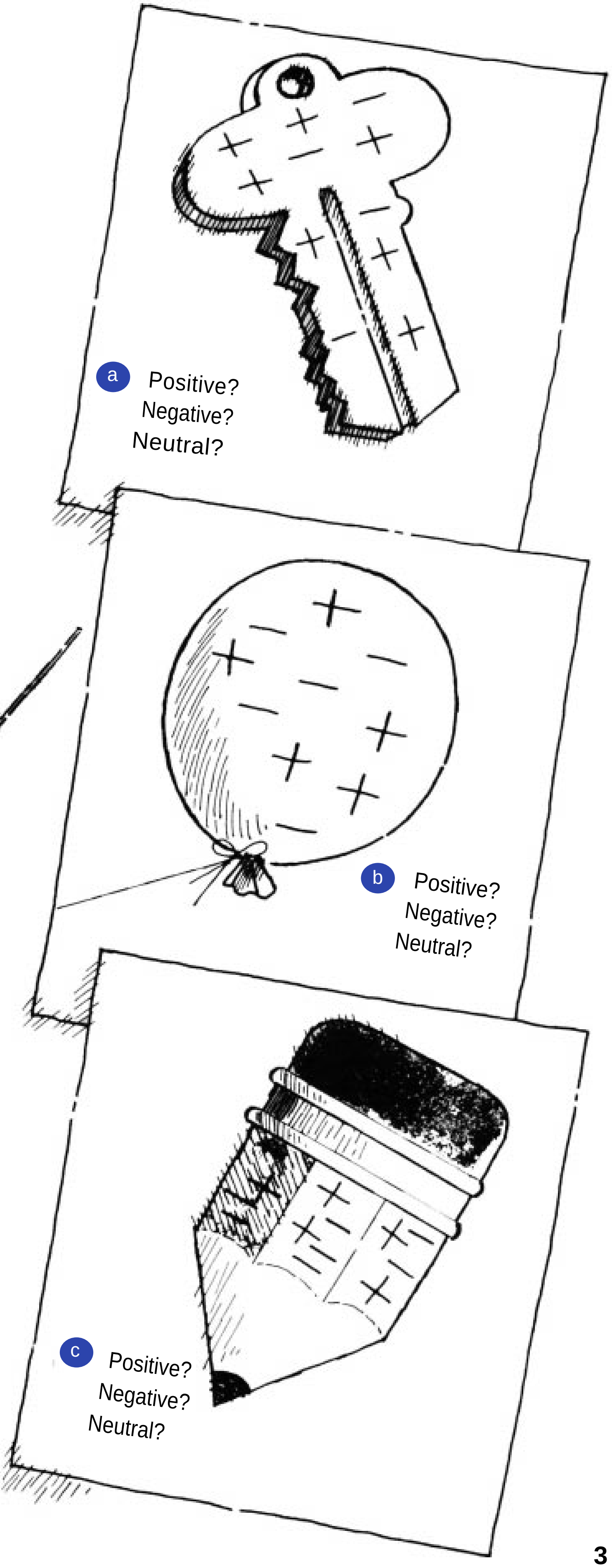
Well, all these different experiences are caused by the same thing: static electricity. Anytime two different materials rub together, the friction can cause an electric charge (a kind of electricity) to build up on each object. Let's take a quick look at what causes this charge.

You may remember that all matter is made up of tiny particles called atoms. But did you know that atoms are composed of even smaller particles? Two of these smaller particles, the proton and the electron, have electric charges that are exact opposites. Protons have a positive (+) charge, and electrons have a negative (-) charge.

Most objects contain the same number of protons and electrons and, therefore, have the same number of positive (+) and negative (-) charges. Since a positive charge is the electrical opposite of a negative charge, equal numbers of positive and negative charges offset each other. As a result, most objects behave as if they have no charge at all. Scientists say these objects are neutral (like uncombed hair).

But if a neutral object loses electrons, then it will have more protons and will have become positively charged. If a neutral object gains electrons, then it will have become negatively charged.

Do you understand all that? Then let's see if you can identify the charge on each object pictured. Check your answers on the inside back cover.



So How Does Neutral Hair, Get Charged?

When you comb your hair, friction changes the number of electrons on it. The friction takes electrons off the hair and puts them on the comb, especially if your hair is dry. So both your hair and the comb become charged objects.

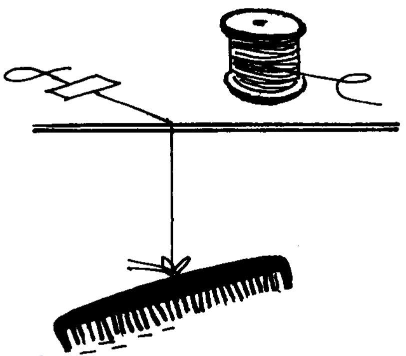
Well, that's it for the theory. Now you're ready to discover the simple rules that all charged objects must obey. For this investigation you'll need:

- Two plastic combs
- Some thread
- Dry hair
- Piece of wool cloth

Before we begin, you should be aware that high humidity reduces static electricity. Best results will be obtained during the drier months.

1.

Tie a piece of thread to the center of one comb. Charge the comb by running it through your hair briskly several times. Hang the comb as pictured, being careful not to touch the part of the comb that went through your hair (the charged part).

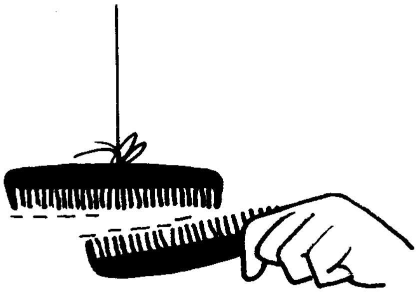


2.

Charge up a second comb in the same way.

3.

Bring it near the charged side of the hanging comb, but don't let the two combs touch. Remember what you see.



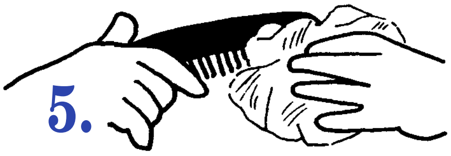
Since both combs had the same charge, you now know how two objects with the same charges will act:

SAME CHARGES?

ⓐ ____________________

Remember this rule. Any two objects with the same charge will react the same way.

Try rubbing the second comb briskly with a piece of wool cloth (sheep hair). As with human hair, the comb removes electrons from the wool, which leaves the wool with a charge opposite that of the comb.



5.

Bring the wool cloth near the charged side of the hanging comb. Do you get the same result as before?

ⓑ ____________________

What happens?

ⓒ ____________________

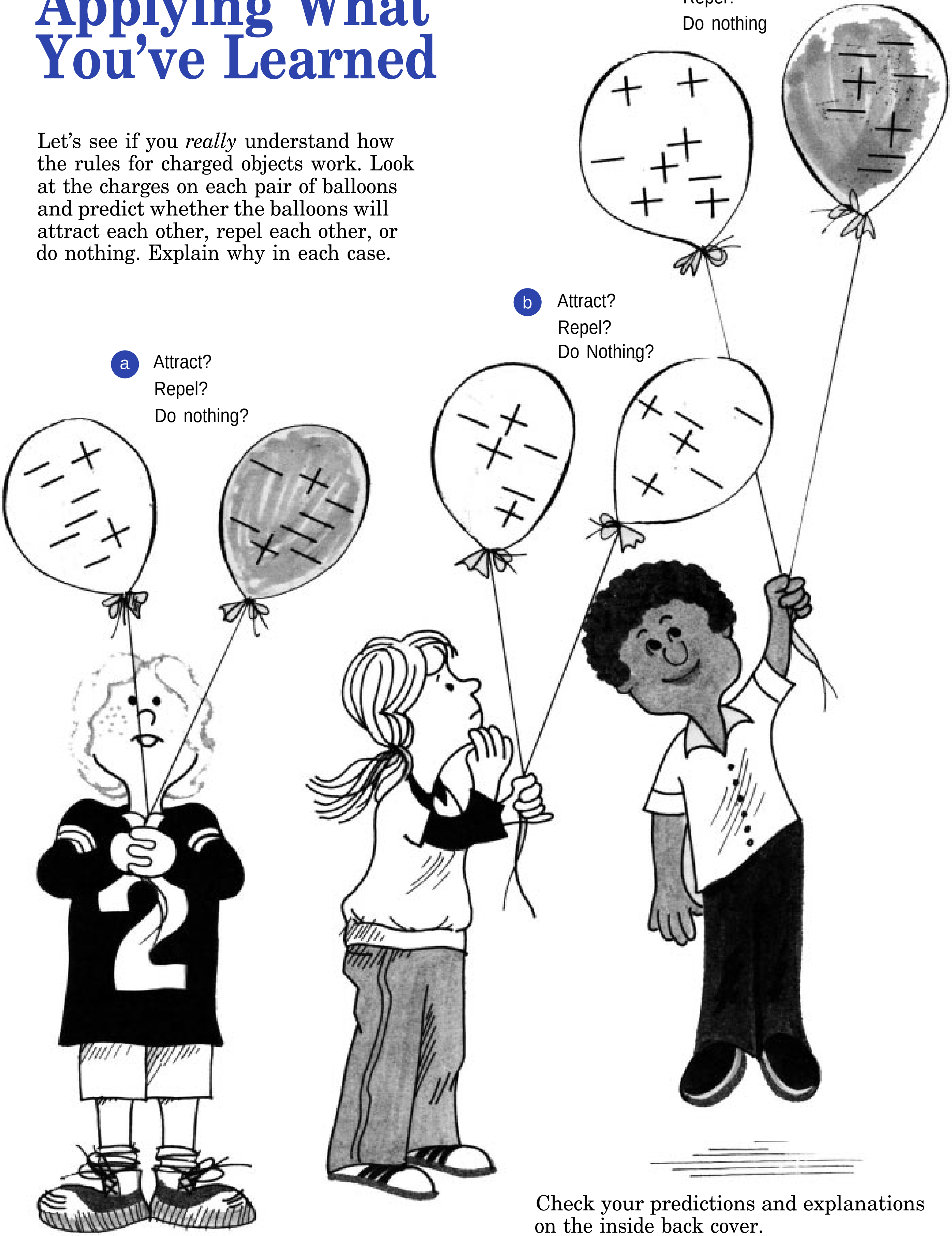
So you've got another important rule:

OPPOSITE CHARGES?

ⓓ ____________________

Applying What You've Learned

Let's see if you *really* understand how the rules for charged objects work. Look at the charges on each pair of balloons and predict whether the balloons will attract each other, repel each other, or do nothing. Explain why in each case.



c
Attract?
Repel?
Do nothing

b
Attract?
Repel?
Do Nothing?

a
Attract?
Repel?
Do nothing?

Check your predictions and explanations on the inside back cover.

No doubt you've noticed that when a comb is charged with static electricity, it acts differently than when it was neutral even though it looks the same. That's not so strange when you think about it. The electrons and protons responsible for the charges are so small that they are invisible to our eyes.

So how do we tell if something is charged? You could always touch it, but if it had a big charge you could get shocked! Since our other senses can't easily detect static electricity, we need to build something that can safely tell if an object is charged.

Building an Electroscope

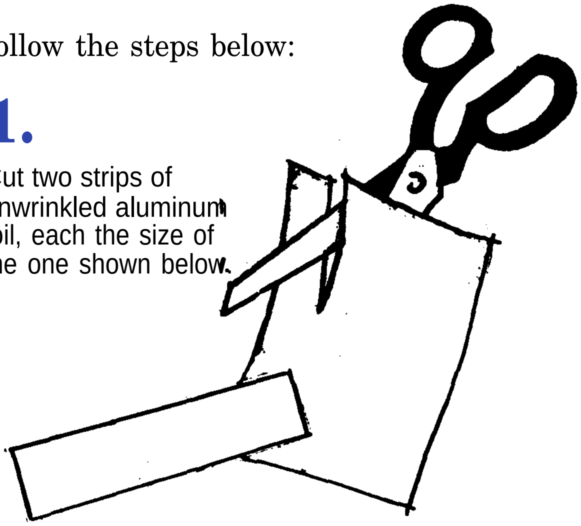
Nothing to it. You'll need these materials:

- Large glass jar
- Aluminum foil
- Stranded wire
- Plastic lid

Follow the steps below:

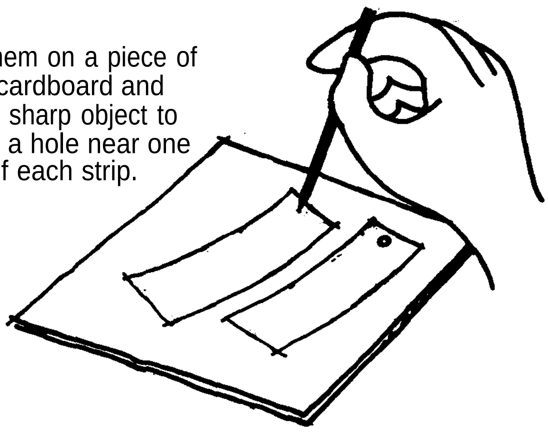
1.

Cut two strips of unwrinkled aluminum foil, each the size of the one shown below.



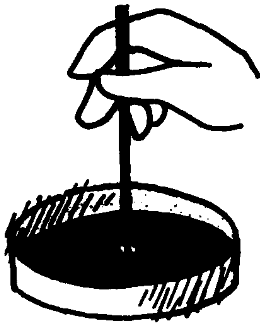
2.

Put them on a piece of thick cardboard and use a sharp object to make a hole near one end of each strip.



3.

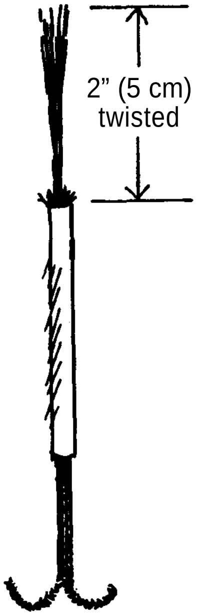
Also make a small hole in the center of the plastic lid.



4.

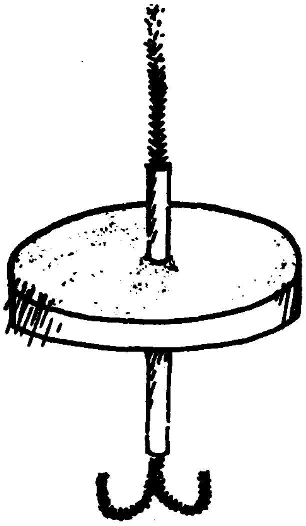
Cut a piece of stranded wire to about the same length as the one in this drawing. Strip the insulation from each end and twist all the strands at one end.

At the other end, divide the strands into two groups. Twist each group separately and form two hooks, as shown.



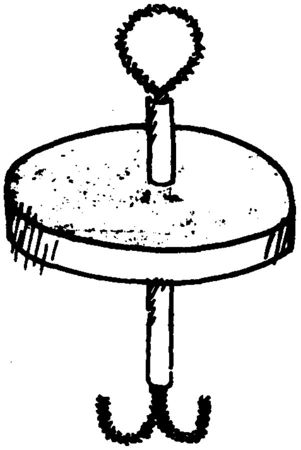
5.

Thread the twisted end through the hole in the plastic lid, and pull the wire through so it fits snugly in the lid.



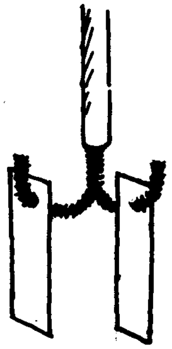
6.

Form a loop at the top with the twisted end.



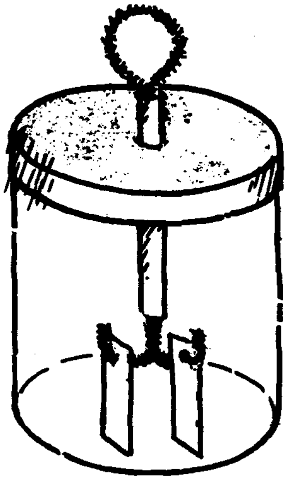
7.

Hang the foil leaves on the two hooks of the wire. Be sure that the leaves hang straight, are close *together,* and move freely. Enlarge the holes if necessary.



8.

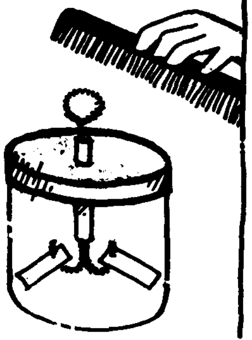
Put the lid assembly on the jar and tape it in place.



Testing Your "Scope"

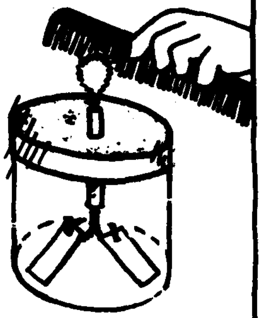
1.

Now let's see if the electroscope works. Comb your hair briskly, and bring the charged comb near the loop. Watch the leaves. If they swing out, the scope works. If nothing happens, check to make sure the leaves are hanging straight and are free to move on the wire. Try again.



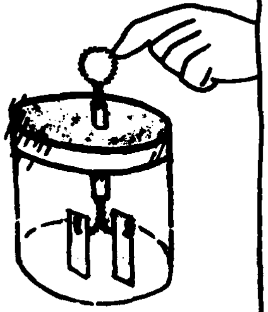
2.

OK, the scope appears able to detect a charge. But can it hold a charge? Find out by recharging your comb, only this time pass it gently along and against the loop. If the leaves stay out when you remove the comb, you're in business.



3.

To discharge your electroscope, simply touch the loop with your finger. The leaves should drop immediately.



So your electroscope works. But do you know WHY? This is what science is all about, trying to make sense out of what we see around us. That's why scientists develop theories, or models, to help explain what they observe. Theories may have to be changed if new facts are discovered, but that's also part of science.

Quiz Time

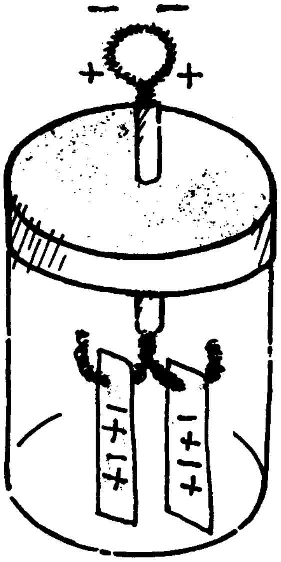
Below are diagrams of an electroscope at rest and receiving a charge. Next to each picture is an explanation (theory) of what may be happening to the protons and electrons. Now that you have learned something about static electricity, see if you can answer the questions and give reasons that support the theory.

1.

This diagram shows an electroscope with the same number of + and - charges.

What word describes this condition?

ⓐ

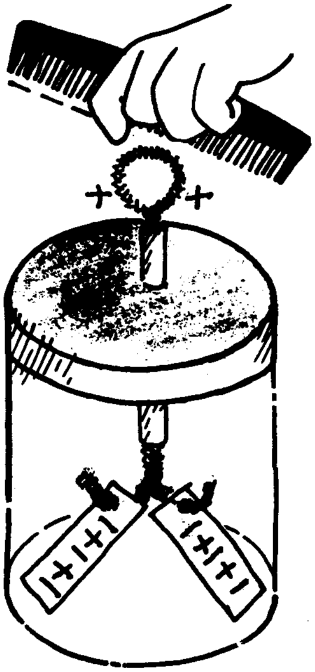


2.

A negatively (-) charged comb is brought near the loop (not too close). The electrons already on the loop move down to the leaves causing them to swing out.

Explain the reaction in terms of electrons and protons.

ⓑ



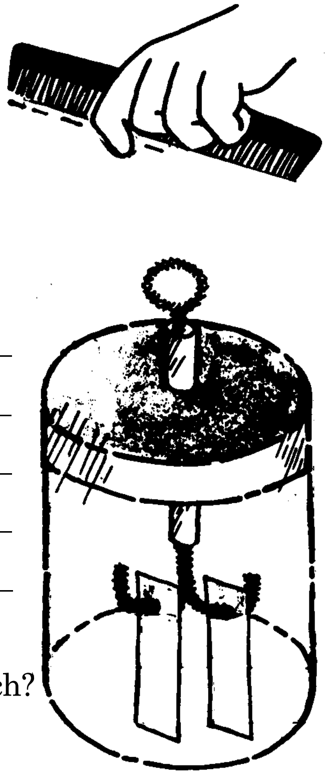
Which of the two rules that you discovered on page 4 explains this action?

ⓒ

3.

If you take the comb away, the leaves now go back down. Why? explain the reaction in terms of electrons and protons.

ⓓ



Can you correctly draw the charges on the sketch? Try it.

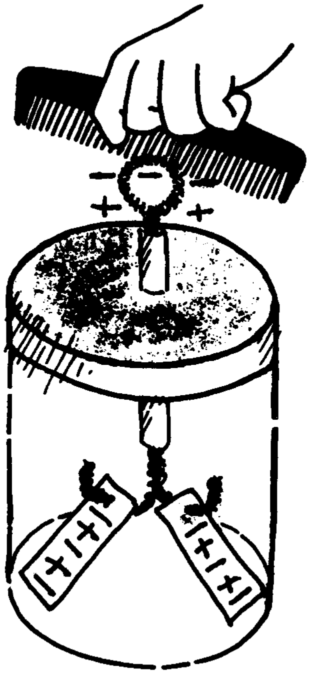
(See ⓔ for the solution.)

4.

However, if you touch the charged comb to the loop before you take it away, the leaves will stay apart. Study the diagram closely, and you will see that negative charges (electrons) were added to the electroscope.

Why did electrons pass onto the loop and then down to the leaves?

ⓕ



Why did the leaves stay apart?

ⓖ

Detective Work with Your Electroscope

1.

Try rubbing any small object with a different material.

2.

Then touch the electroscope loop with the rubbed object, and watch the leaves. If they swing out, that combination produced a charge. If nothing happens, try again to be certain.

3.

Repeat the above steps using as many different objects and materials as you can (glass, plastic, wood, metal, nylon, wool, fur, polyester, silk, etc.).

NOTE: When using the electroscope in this investigation, always begin each trial by discharging the scope (touching the loop with your finger) to make sure it's neutral

4.

Keep track of the combinations you try in a table like the one below. If information is organized, patterns are easier to see.

OBJECT USED	MATERIAL	CHARGE?
plastic comb	hair	yes
wood pencil	wool	
glass jar	silk	

Take a look at your results. Do you see any patterns? For instance, wool charges your comb, but does it charge everything you rub it with?

Which groups of objects seem to charge up? Plastics? Glass? Wood? Metals? Rubber?

Can you explain what must be happening to the electrons and protons on objects that do charge up?

ⓐ ______________________________

____

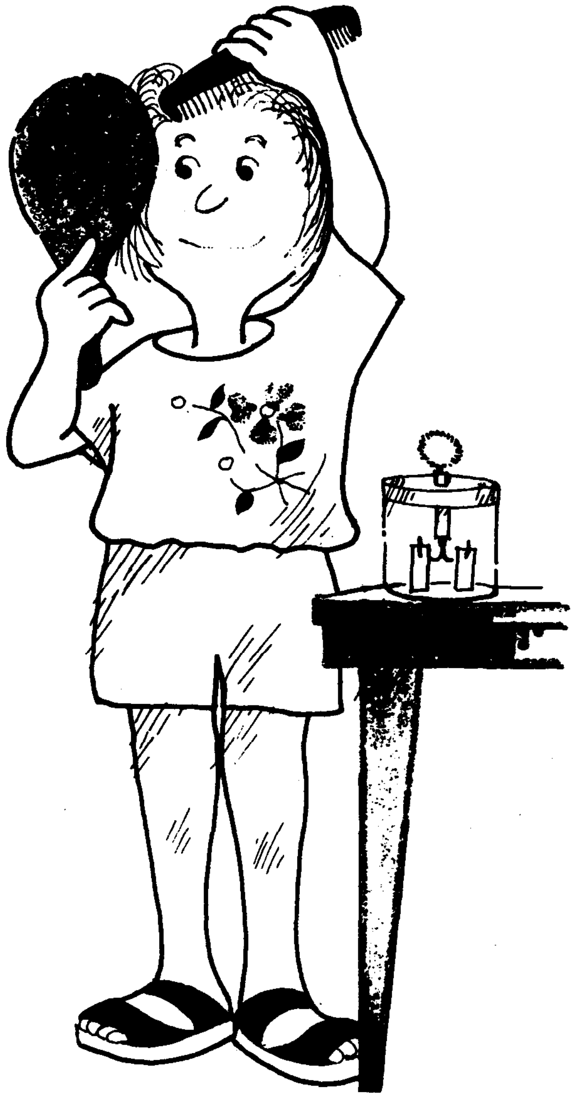
____

The Difference Between Conductors and Insulators

Let's examine your results from a different point of view by doing another activity.

1.

Start by charging your electroscope with your comb.



2.

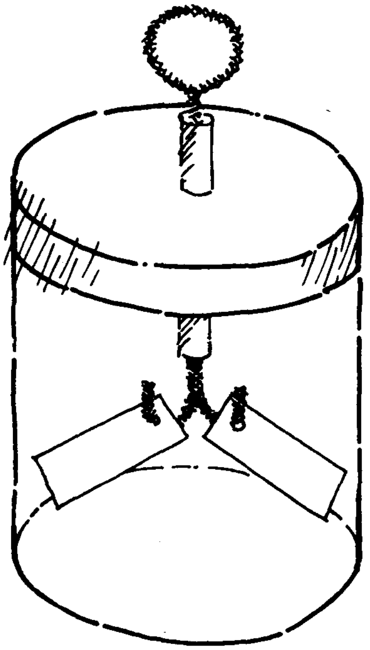
With the leaves of the scope spread out, touch the loop with some object. Did the leaves drop?

If they did, the object you used was a conductor; that is, it allows electrons to pass through it. As a result, the charges on the leaves became equal.

How?

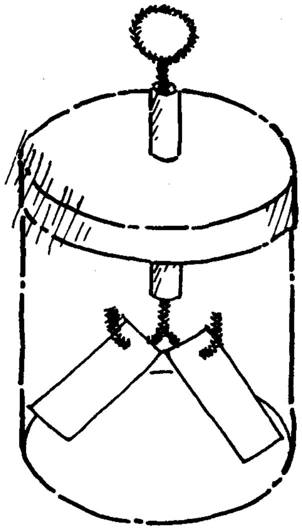
Since the scope had a negative charge, the extra electrons on the leaves repelled one another up through the loop and into the conductor. At that point the leaves became neutral and dropped.

But if the object you used didn't make the leaves go down, then that object would have been an insulator; that is, a material that doesn't allow electrons to pass through it easily. In this case, the charges on the leaves would remain there because the insulator neither accepted nor gave up enough electrons to make the leaves neutral.



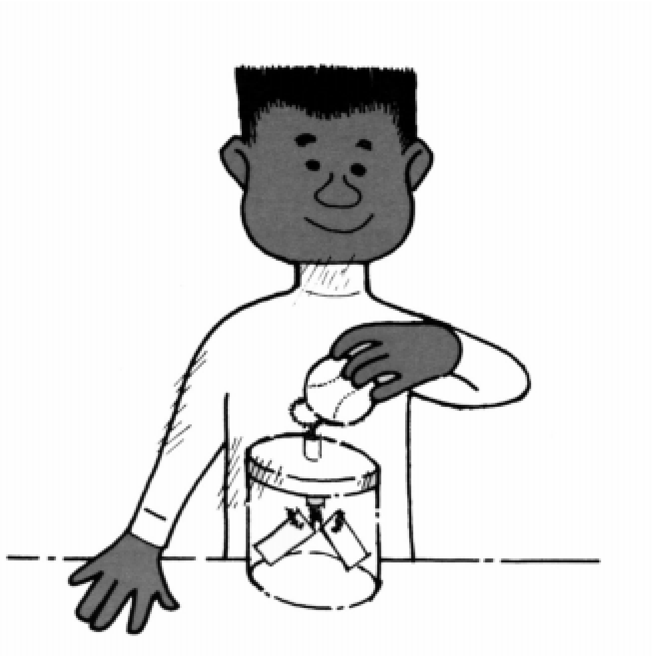
Keep this in mind regarding some insulators: Even though they always resist the flow of electrons, they do not *stop* the flow. Some electron movement may occur, depending on the material. Think of these insulators as poor conductors.

Which Materials Conduct? Which Don't?



1.

Once again start with the electroscope charged (the leaves spread out).



2.

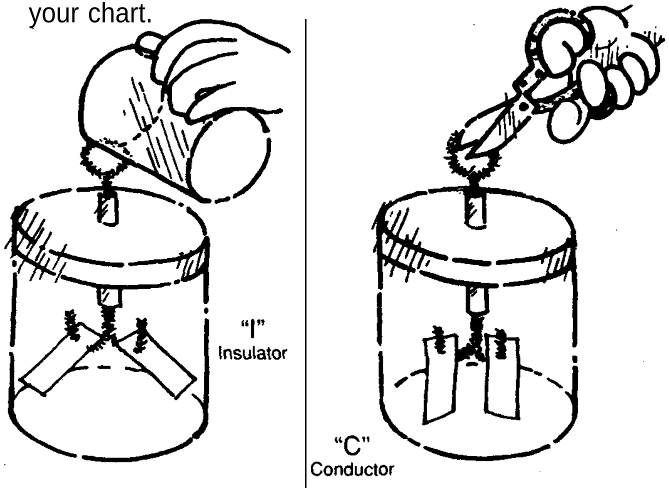
Touch all the objects you used in the last activity, one by one, to the loop.

3.

Watch the leaves. If they remain apart, the object you're holding is an insulator. If they go down, you're holding a conductor. (Don't forget to recharge the scope each time the leaves go down.)

4.

After testing each object, record an "I" or "C" on your chart.



Got them all tested? Good. But there's much more to an experiment than just doing it. Trying to make sense of what you've found is the real challenge. Look at your data table again and ask yourself some questions:

Would you classify metals as conductors or insulators? How about plastics and glass? Why?

ⓐ ______________________________

____

____

Do any patterns present themselves? Look hard. For example, did you find that the objects that discharged your electroscope were conductors or insulators? Why do you think that is so? Describe it in terms of electron movement.

ⓑ ______________________________

____

By the way, are you a conductor or an insulator? How do you know?

ⓒ ______________________________

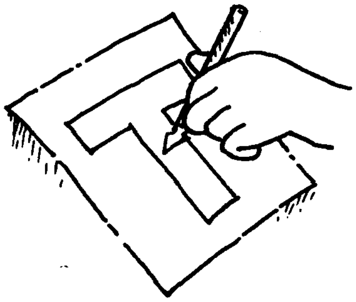
____

An “Attractive” Discovery

Ready to try something a little different now?

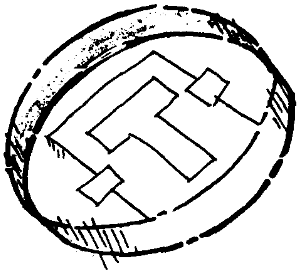
You’ll need:

- A plastic lid (like from a margarine tub)
- Wool cloth
- Ground pepper
- Stiff paper (index card)



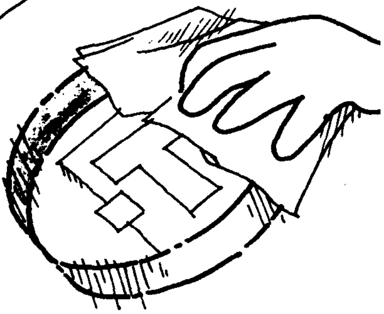
1.

Cut out a large capital "7" from the center of the card.



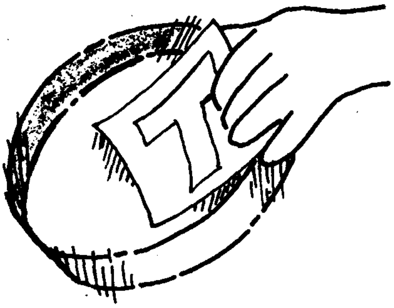
2.

Tape the resulting stencil to the inside of the lid.



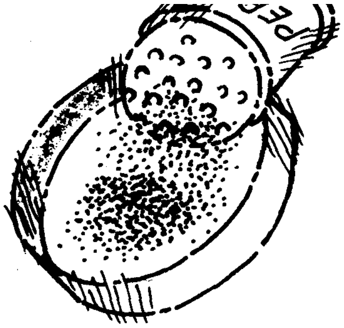
3.

Now vigorously rub the wool on the plastic that shows through the stencil.



4.

Remove the stand without touching the rubbed part of the plastic.

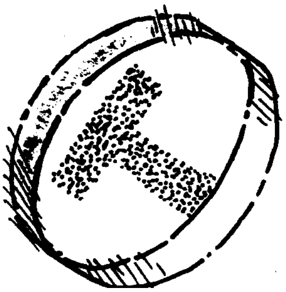


5.

Sprinkle pepper on the entire surface of the lid and shake the lid to distribute the pepper evenly.

6.

invert the lid and tap it to remove the loose pepper.



7.

Do you see your letter in pepper?

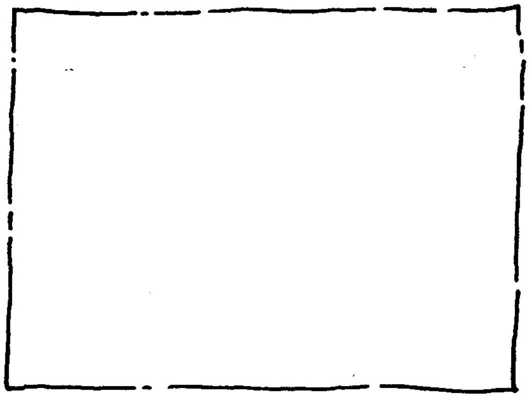
Are you surprised that some of the pepper is still clinging to the lid? Our investigations have shown that opposite charges attract. By rubbing the plastic lid with wool, we can reasonably expect that it developed a charge. But what about the pepper? It was neutral (had no charge) to start with. Why is it sticking to the charged plastic? Let’s find out.

A New Question Pops up

It has been said that one of the certainties of science is that finding the answer to one question usually means raising more new questions as well. Let's investigate this new question about neutral objects being attracted by charges.

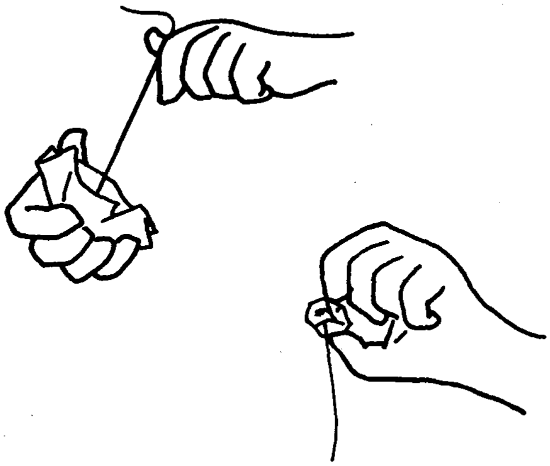
1.

Get a piece of regular aluminum foil (heavy duty won't work) about the size pictured here.



2.

Put the end of an 8-inch piece of thread inside, and then form the foil into a ball.

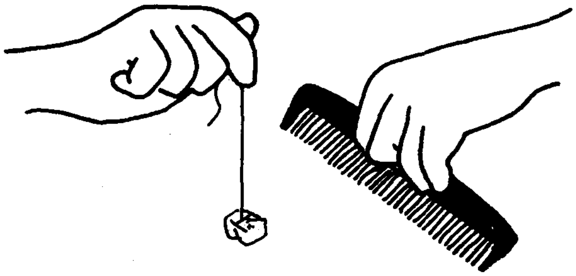


3.

Hold the other end of the thread in your hand and comb your hair.

4.

Hold your comb near the neutral foil ball (don't let them touch one another). What does the ball do?



a ______________________________

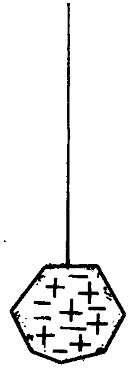
____

Thinking It Through

By now you should have a pretty good understanding of how electrostatic charges behave. See if you can apply the rules you've discovered to the drawings below and explain what's happening to the neutral foil ball (and the pepper on page 12, too).

Don't forget to use the rules:

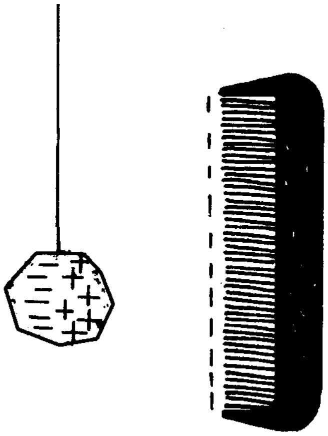
- Same charges repel.
- Opposite charges attract.



1.

The foil ball is neutral. What makes it neutral?

ⓐ ________________



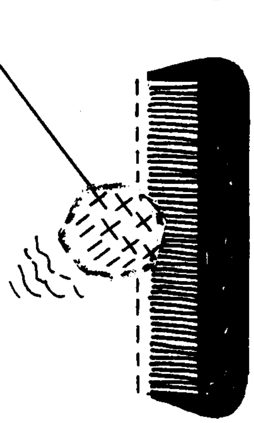
2.

Why are the negative charges clustered on the left side of the ball away from the negatively charged comb?

ⓑ ________________

So what kind of charge is left to face the negative comb?

ⓒ ________________



3.

Why then does the ball swing toward the comb?

ⓓ ________________

Our investigation shows that some neutral objects can be made to act like they have a charge.

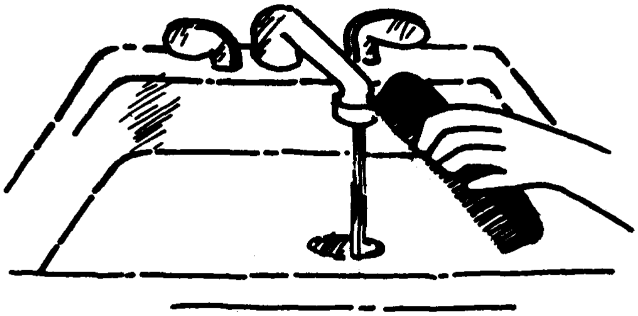
All that is required is to expose a neutral object, in this case the ball, to a strongly charged object (the comb) without touching the two.

The strong charge seems to separate the positive and negative charges on the neutral object, causing the neutral object to behave as though charged1

Need More Proof? Give These a Try

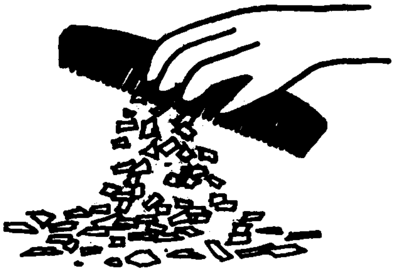
1.

Adjust a water faucet until you get a very thin stream. Now charge up your trusty comb one last time, bring it near the stream, and observe.



2.

Tear some paper into very small pieces. Lay them on a table and bring your charged comb near them. What happens?



Are you seeing a pattern here? So far you've tested four different neutral objects: pepper, foil, water, and paper. Yet every time you brought your charged comb near them, the same thing happened. The neutral object was attracted to the charged object.

You're now an expert on the rules for static electricity, so this next question should be easy: Do these neutral objects 4 behave like they have the *same* or *opposite* charge as your comb?

ⓐ ______________________________

By the way, this process has a special name. It's called *induction.* Based on your experiences, would you agree that induction causes a neutral object to be attracted to a charged object brought near it?

Like the neutral foil ball that was attracted to the charged comb, we saw neutral pepper particles attracted to the charged portion of the plastic lid. Describe what the electrons must do for this to happen.

ⓑ ______________________________

____

____

____

____

OK, OK So What?

By now you must be wondering, is static electricity good for anything practical?

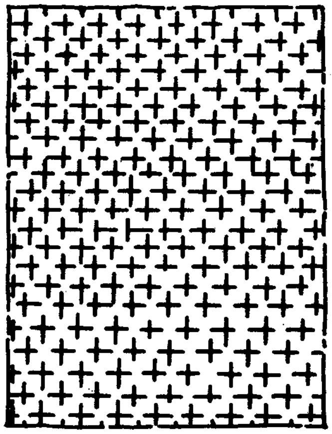
Well, refer back to the experiment on page 12. If we substitute negatively charged black powder for the pepper and, instead of the plastic lid, have a specially coated surface that loses its charge when bright light strikes it, we now have the basic idea of how a photocopy machine works.

It’s Not Magic, It’s Static Electricity!

Here's a simplified version of how the photocopy machine works:

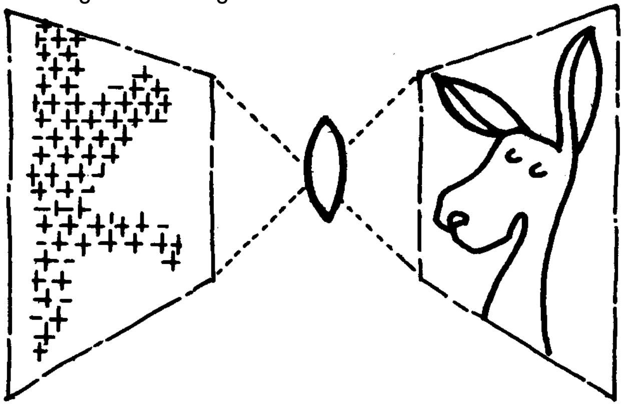
1.

The surface of a specially coated plate is given a positive charge.



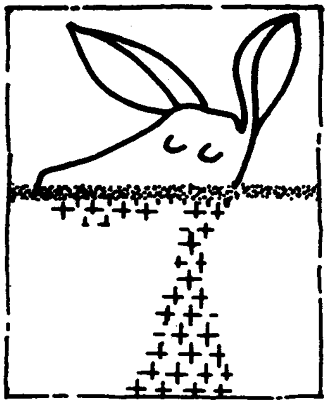
2.

A bright light projects an image of the document to be copied through a lens onto the plate. Because of the plate’s special coating, positive charges remain only in the dark areas, forming a charge image of the original document.



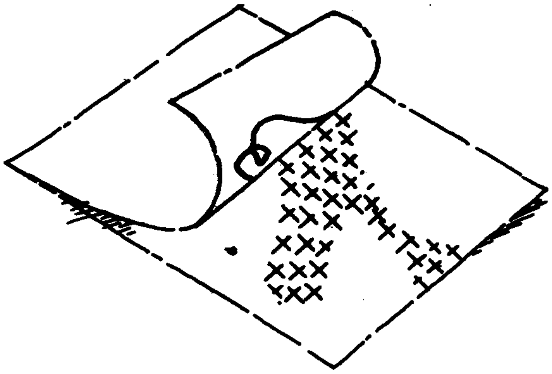
3.

The negatively charged black powder is deposited on the plate and is attracted only to the charged areas.



4.

A neutral piece of paper is given a positive charge. When the charged paper is pressed against the plate, the black powder is attracted to it; and the image is transferred from the plate to the paper. The paper is then heated, melting the powder in place on the paper to form the copy.



The first image of this kind was made in 1938. Copiers have since gotten fancier. But the process is essentially the same: It involves a specially coated plate, strong light, charged black powder, and . . . static electricity!

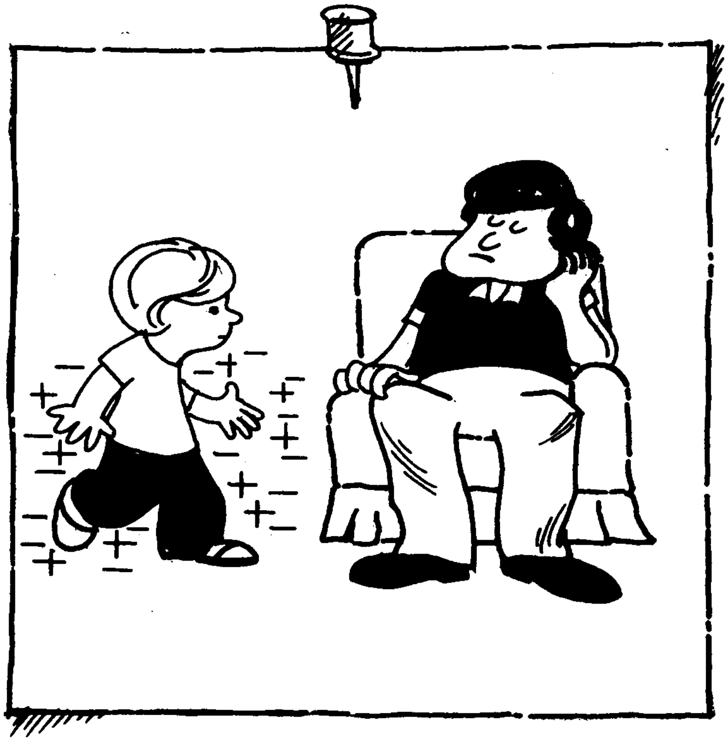
It Was Just the Beginning

This idea of attracting small particles has other intriguing uses too. If you are an automobile manufacturer, you need to paint your products. By giving the cars a strong positive charge and the paint the opposite charge, you can greatly improve the paint coverage. Why? Now you know! Since opposite charges attract, more paint ends up on the car and less floats away in the air.

Which bring up air quality. The ash particles that used to come from the chimneys of many large power and industrial plants are now captured by . . . you got it . . . static electricity. The same techniques are being used on a smaller scale to reduce tobacco smoke and trap airborne pollen and dust. That's how desk-top "air purifiers" and electronic furnace filters work.

In fact, there are many examples of how we employ static electricity not only for our benefit but our amusement as well. Remember the last time you purposely shuffled across a carpet and zapped someone. That bit of fun wouldn't have been possible unless the large charge you built up on yourself induced the opposite charge on the other person.

Too much static electricity is sometimes a problem though, so a lot of research has been done on ways to reduce it. For example, manufacturers have developed chemicals to treat carpets, the clothes you wear, even the clothes in your dryer to counteract annoying effects like sparking and clinging.



Antistatic sprays help counteract the effects of static electricity on the small scale we usually find around our homes.

As effective as antistatic treatments are, though, they can't possibly provide any protection against Nature's premier example of static electricity: lightning.

And Now for the Main Attraction

Just what is lightning, anyway?

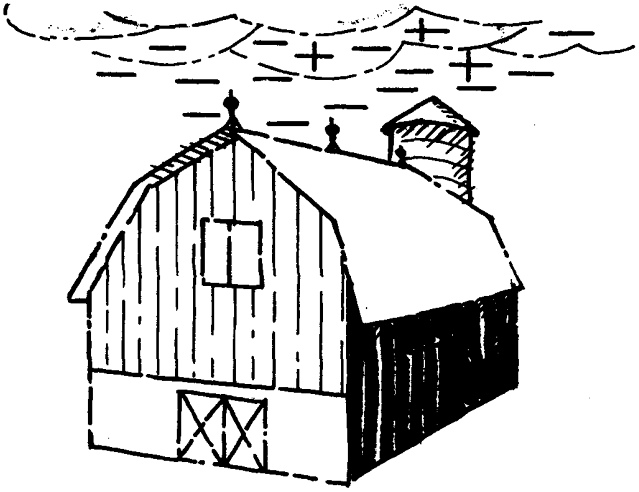
You've probably heard a snapping sound and felt a shock when touching a door knob or metallic object after walking across a carpet. If the room was sufficiently dark, you may have seen a little spark of light at the same time.

It's no coincidence. The spark, the snap, and the shock were all caused by the same thing. You built up such a large charge through friction with the carpet that electrons were able to jump the gap between the doorknob and your hand.

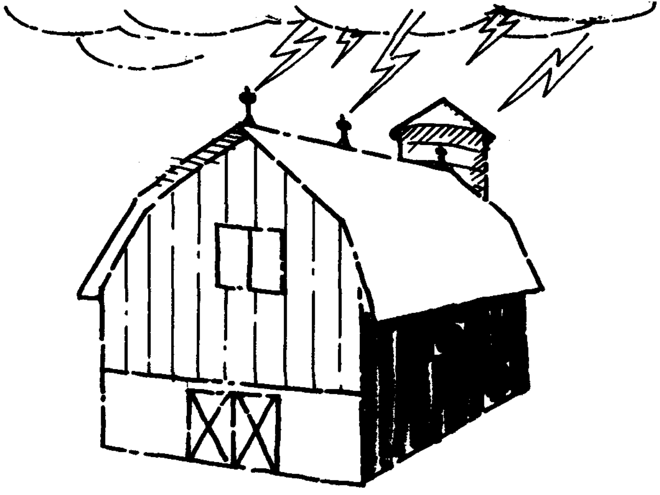
Thunderstorms cause a tremendous buildup of charges in the clouds (all those water molecules rubbing together). Like your walking across the carpet, when the charge difference becomes great enough, a spark (electrons) will jump the gap to neutralize the charge. In this case, however, the spark will be a FLASH! the snap will be a BOOM! and the shock could very well be FATAL!

The brilliant flash of light is the sudden flow of electrons between a charged cloud and the earth or between one cloud and another of opposite charge. And the thunder? In passing through the air, lightning superheats it to sun-like temperatures. This causes the air to expand rapidly, with a sound much like that of an explosion.

Lightning and Inspiration Both Strike



Why would lightning, a flow of electrons, tend to strike neutral objects like trees, buildings, or the earth? (Does the word “induction” sound familiar? See page 15.)



See if you can draw the charges on the top of the barn in the picture above. Hint: Look at the charges on the cloud and remember induction.

(See ⓐ for the solution.)

Is the barn destined to be struck by lightning? Not if the owners have installed lightning rods. Invented by Benjamin Franklin over 200 years ago, the system makes use of pointed metal rods placed atop a building. The rods are “grounded.” That is, they are connected by thick wires to metal stakes buried in the ground. If lightning does strike, it will tend to hit the rods instead of the building and pass harmlessly into the earth. The pointed metal rods can also discharge a cloud before it has a chance to build up a charge big enough to cause a lightning strike.

Did this idea or inspiration, just “strike” Franklin out of the blue? Probably not. You see, Franklin is also credited with discovering that lightning is really electricity By flying a kite in a storm, he induced a flash of lightning to flow along the string to the earth. (DON’T even think of attempting this experiment! Franklin was very fortunate he wasn’t killed. Others trying to duplicate his findings were!) The idea for the lightning rod resulted from his kite-flying experiment.

Science is the search for knowledge. Using that knowledge to better our lives is called technology. In this case, Franklin discovered a new fact: lightning is electricity. He then devised a practical application for it: the lightning rod.

Plenty of people knew that a charged comb would attract neutral objects. But only a few used that fact to filter air, paint cars better, and reproduce paper images.

Let Inspiration Strike You

Design a machine that uses static electricity to perform a useful function. You now know the basics of static electricity. Just use the rules you discovered along with your imagination, and it should be a “snap.”

Glossary

Charge
A quantity of electricity produced by either a surplus or shortage of electrons in an object.

Conductor
A material that allows electrons (electric charges) to pass through it easily.

Discharge
To remove the charge on an object (neutralize it). This can be done by touching the charged object with a conductor. If positively charged, the object will gain electrons from the conductor. If negatively charged, the object will give up electrons to the conductor. This transfer will continue until the numbers of protons and electrons on the object are equal.

Electron
A part of the atom that orbits the nucleus, or center. An electron has a negative charge.

Electroscope
A device for detecting the presence of static electricity.

Induction
A process that produces the effect of charge in a neutral object when that object is approached by a second object having a strong charge. The induced charge is always opposite to the charge used to produce it. For example, a neutral object tends to behave like it is negatively charged if a strong positive charge is brought near it.

Insulator
A material that does not allow electrons (electric charges) to pass through it

Lightning
The flash of light that accompanies an electric discharge between two clouds or between a cloud and the earth. It is produced by static electricity built up during a thunderstorm.

Negative
The type of electric charge carried by an electron.

Neutral
A condition that exists when an object has no electric charge. In other words, the object contains equal numbers of electrons (-) and protons (+).

Proton
A part of the atom found in the atom's nucleus, or center. A proton has a positive charge.

Positive
The type of electric charge carried by a proton.

Static Electricity
A type of electricity that can occur when two objects rub together. The friction removes electrons from one object and deposits them on the other.

Answers

Page 3

- ⓐ Positive. Key has more protons (+).
- ⓑ Neutral. Balloon has equal numbers of protons and electrons.
- ⓒ Negative. Pencil has more electrons (-).

Page 4

- ⓐ Repel.
- ⓑ No.
- ⓒ Comb swings toward wool.
- ⓓ Attract.

Page 5

- ⓐ Repel. Both balloons have the same charge, and same charges repel.
- ⓑ Do nothing. Both balloons are neutral.
- ⓒ Attract. The balloons have opposite charges, and opposite charges attract.

Page 8

- ⓐ Neutral.
- ⓑ Electrons on the loop are forced down to the leaves by electrons on the comb because same charges repel. Leaves now have an excess of electrons, so they swing out by repulsion.
- ⓒ Same charges repel.
- ⓓ The extra electrons on the leaves are attracted back to the protons on the loop because opposite charges attract. The scope is neutral again.
- ⓔ Loop and leaves should have equal numbers of electrons and protons.
- ⓕ As the negatively charged comb approaches, electrons on it repel electrons on the loop down to the leaves, forcing them apart (same charges repel). When contact is made, electrons on the comb then enter the loop because they are attracted by the excess protons there (opposite charges attract).
- ⓖ After the comb is removed, the scope contains an excess of electrons, which keeps the leaves apart.

Page 9

- ⓐ More electrons are being added to give the objects a negative charge. Or some electrons are being removed, leaving more protons on the objects, which gives them a positive charge.

Page 11

- ⓐ Metals are conductors. They pass electrons, allowing the spread leaves of the scope to discharge and drop. Plastics and glass are insulators. They do not pass electrons and, so, do not affect charged leaves.
- ⓑ Objects that discharged the scope completely were all conductors because they allowed electron movement.
- ⓒ You are a conductor because you make the leaves drop (remember on page 7?).

Page 13

- ⓐ The ball is attracted to the comb.

Page 14

- ⓐ Ball is neutral because it has the same number of + and - charges.
- ⓑ Electrons on the ball shifted to the left because of repulsion by the comb's electrons.
- ⓒ Positive.
- ⓓ The protons on the right side of the ball are attracted to the electrons on the comb because opposites attract.

Page 15

- ⓐ Opposite.
- ⓑ Some of the electrons on each pepper particle must move to the side of the particle away from the negatively charged lid. That leaves more + charges on the other side of the pepper to be attracted to the - charges on the lid.

Page 19

- ⓐ Charges at the roof of the barn should be mostly positive because the cloud's electrons repelled some of the roof's electrons downward.