Contributors
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Georgia Southern University, GA

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Claxton High School, GA

Intended Audience

<table>
<thead>
<tr>
<th>Grade</th>
<th></th>
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<tbody>
<tr>
<td>K-4</td>
<td></td>
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<tr>
<td>5-8</td>
<td></td>
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<tr>
<td>9-12</td>
<td>X</td>
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</table>

Activity Characteristics

<table>
<thead>
<tr>
<th>Activity Characteristic</th>
<th></th>
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<tbody>
<tr>
<td>Classroom Setting</td>
<td>X</td>
</tr>
<tr>
<td>Requires special equipment</td>
<td>X</td>
</tr>
<tr>
<td>Uses hands-on manipulatives</td>
<td>X</td>
</tr>
<tr>
<td>Requires mathematical skills</td>
<td></td>
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<tr>
<td>Can be performed individually</td>
<td>X</td>
</tr>
<tr>
<td>Requires group work</td>
<td></td>
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<tr>
<td>Requires more than one (45 min class) period</td>
<td></td>
</tr>
<tr>
<td>Appropriate for special needs student</td>
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</table>
Introduction

Description
Students use balloons, friction pads and rods made of different materials, to explore the concept of charging by friction and apply the triboelectric sequence to determine the direction of electron transfer between two objects.

Abstract
Students use rods and friction pads made of various materials to investigate the transfer of electrons when they are rubbed together. By using the triboelectric sequence, students can determine the direction of electron transfer and identify which object gained or lost electrons. Students also use an electroscope to distinguish between charging by conduction and induction.

Core Themes Addressed

<table>
<thead>
<tr>
<th>Microbial Cell Biology</th>
<th>Microbial Genetics</th>
<th>Microorganisms and Humans</th>
<th>Microorganisms and the Environment</th>
<th>Microbial Evolution and Diversity</th>
<th>Other - Electricity</th>
</tr>
</thead>
</table>

Keywords
friction, conduction, induction, triboelectric sequence, electroscope

Learning Objectives
At completion of this activity, learner will

1. Distinguish between charging by friction, conduction, and induction
2. Use the triboelectric sequence to determine the direction of electron transfer when two different substances are charged by friction
3. Explain how an electroscope works
National Science Education Standards Addressed

Standard A: Science as Inquiry
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Standard B: Physical Science
- Structure and properties of matter
Student Prior Knowledge

Students should have the following knowledge prior to completing this activity:

1. Have a basic understanding of the atomic structure
2. Know the Law of Conservation of Charge
3. Distinguish between conductors and insulators
4. Be familiar with static electricity

Teacher Background Information

Be familiar with the working of the electroscope and be able to use it to explain to students the differences between conductive and inductive charging. Students might have a difficult time visualizing the movement of electrons so an inclusion of a video or animation (see links under Extension/Additional Resources) that illustrates this phenomenon will be very helpful.

Class Time

This activity will require a minimum of one 45 minute class period.

1. The activity in which students investigate static electricity will take 20-25 minutes. It might take students a couple of minutes to hang up the two balloons and making sure that they are close to each other but not touching.
2. The activity involving the electroscope will take 15-20 minutes.

Teacher Preparation Time

This lesson will require approximately 10 minutes of preparation time.

1. Divide supplies so that each group will have each necessary component.

Safety Precautions

Students should be careful when hanging up the balloons on the ceiling.

Materials and Equipment

Have the following for each group of 2:

2 large round balloons
approx. 30 feet of string
1 fur friction pad
1 silk friction pad
1 glass rod
1 rubber rod
1 wool friction pad
electroscope

Methods

Static electricity activity:

1. Inflate two balloons and attach equal lengths of string to each balloon. Suspend both balloons (at the same height) so that they are near each other but NOT touching.
2. Rub both balloons with the fur friction pad. Which one of the two (balloon and fur) is charged positively and which one is charged negatively?

Possible Answer: The (rubber) balloon is negatively charged and the fur is positively charged.

3. What happens when you bring the two balloons close together? What happens when you bring the fur close to one of the balloons? Record your observations below.

Possible Answer: The balloons will repel each other since both have a negative charge. The fur will attract one of the balloons since both balloons have a negative charge and the fur has a positive charge.

4. Rub the glass rod with the silk friction pad. What happens when you hold the glass rod next to one of the balloons?

Possible Answer: Since the glass rod is positively charged when rubbed with the silk friction pad, the glass rod will attract one of the balloons because both balloons are negatively charged.

5. Rub the rubber rod with the fur friction pad. What happens when you hold the rubber rod next to one of the balloons?

Possible Answer: Since the rubber rod is negatively charged when rubbed with the fur friction pad, the rubber rod will repel the balloons since they are also negatively charged.

Electroscope activity:

1. Rub the rubber rod with the wool friction pad. Which one of the two is charged positively and which one is charged negatively?

Possible Answer: The rubber rod is negatively charged and the wool friction pad is positively charged.
2. Move the charged rubber rod toward the metal ball terminal of the electroscope WITHOUT touching. Record your observations and draw in the appropriate signs for the charges on the rod, metal ball, and leaves in the figure below.

*Possible Answer:* The leaves in the electroscope move away from each other.

![Image of electroscope before and after charging]

3. The electroscope is now charged. What method did you use to charge it? What method did you use to charge the rod?

*Possible Answer:* The electroscope is charged by induction and the rubber rod is charged by friction.

4. What happens when you move the rubber rod away from the electroscope? Why?

*Possible Answer:* The leaves in the electroscope move back to their original position, next to each other. The excess electrons on the rubber rod repel the free electrons on the metal ball terminal causing them to move as far as possible from the rod and toward the leaves. Therefore, the leaves repel each other but once the rubber rod is removed, the free electrons migrate back to where they were and the leaves becomes neutral again.

5. Predict what will happen when you rub the rod harder? Would the rubber rod lose more electrons to the wool? How could you test your predictions?

*Possible Answer:* Since wool and rubber have different affinities for electrons, if the two objects are rubbed together more, more electrons will be transferred to the rubber rod. To test this, bring the rod close to the electroscope. The larger the amount of charge on the rod, the larger the repulsion between the leaves in the electroscope.

6. What happens when you touch the metal ball terminal with a charged rod (i.e. the negatively charged rubber rod) and then remove it? Record your observations and draw the appropriate signs for the charges on the rod before it touches the ball and on the leaves. Also draw the relative position of the leaves.
Possible Answer: The excess electrons on the rubber rod are now transferred to the metal rod. As a result, the electroscope has now a net negative charge. The electrons migrate toward the leaves and cause the leaves to repel each other. Even after the rod is removed, the leaves will still stand apart since the electroscope is now negatively charged.

Tips/Suggestions

- Make sure that the balloons are as close as possible to each other without touching.
- The balloons can be hung from the ceiling if it is not too high.
- If only one electroscope is available, have one group start with the electroscope activity first and once that group finishes, rotate to another group. If more than one is available, adjust accordingly.

References


Extension/Additional Resources

- Charging by Friction, Induction, & Conduction: This file has an in-depth explanation on these concepts.
  http://www.studyphysics.ca/30/charging.pdf
- Electrical, Magnetic & Optical Properties: This website has another triboelectric sequence.
- Inductive Charging Using An Electroscope: This video has an in-depth explanation of inductive charging.
  http://www.youtube.com/watch?v=-JsVZwc1dOo
Introduction

In a neutral atom, the number of electrons is equal to the number of protons, the latter having a positive charge equal in magnitude to that of the electron. However, the electrons that are farther from the nucleus of the atom, where the protons are, along with the neutral neutrons, are also the easiest to be lost by the atom since they are not as strongly bound to it. Thus when two objects come in contact, one of them may lose some of its electrons while the other draws them into itself. By comparing how different materials behave when rubbed together, we have the following "triboelectric sequence" ("tribo" means "to rub" in Greek and thus "friction").

<table>
<thead>
<tr>
<th>The Triboelectric Sequence</th>
<th>(+) Freely gives up electrons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asbestos</td>
<td></td>
</tr>
<tr>
<td>Fur (rabbit)</td>
<td></td>
</tr>
<tr>
<td>Glass</td>
<td></td>
</tr>
<tr>
<td>Mica</td>
<td></td>
</tr>
<tr>
<td>Wool</td>
<td></td>
</tr>
<tr>
<td>Quartz</td>
<td></td>
</tr>
<tr>
<td>Fur (cat)</td>
<td></td>
</tr>
<tr>
<td>Lead</td>
<td></td>
</tr>
<tr>
<td>Silk</td>
<td></td>
</tr>
<tr>
<td>Human skin, aluminum</td>
<td></td>
</tr>
<tr>
<td>Cotton</td>
<td></td>
</tr>
<tr>
<td>Wood</td>
<td></td>
</tr>
<tr>
<td>Amber</td>
<td></td>
</tr>
<tr>
<td>Copper, brass</td>
<td></td>
</tr>
<tr>
<td>Rubber</td>
<td></td>
</tr>
<tr>
<td>Sulfur</td>
<td></td>
</tr>
<tr>
<td>Celluloid</td>
<td></td>
</tr>
<tr>
<td>Indian Rubber</td>
<td>(-) Reluctantly gives up electrons</td>
</tr>
</tbody>
</table>

Student Background Knowledge

Students should have the following knowledge prior to completing this activity:

1. Have a basic understanding of the atomic structure
2. Know the Law of Conservation of Charge
3. Distinguish between conductors and insulators
4. Be familiar with static electricity
Vocabulary

Friction: a force that holds back the movement of a sliding object; charging by friction refers to a process in which two different materials are rubbed together and both objects gain a slight charge, one positively and the other negatively.

Conduction: charging a conductor by coming in physical contact with a charged object, also known as "charging by contact".

Induction: charging a conductor without coming into direct contact with a charged object.

Triboelectric sequence: a list of different substances that shows how they behave when rubbed together; the one appearing above becomes positively charged, the one listed below becomes negatively charged.

Electroscope: an instrument used for detecting static electricity.

Safety Considerations

Students should be careful when hanging up the balloons on the ceiling.

Materials Checklist

<table>
<thead>
<tr>
<th>Item</th>
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<tbody>
<tr>
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<td>1 glass rod</td>
</tr>
<tr>
<td>1 rubber rod</td>
</tr>
<tr>
<td>1 wool friction pad</td>
</tr>
<tr>
<td>electroscope</td>
</tr>
</tbody>
</table>

Procedure

*Static electricity activity:*

1. Inflate two balloons and attach equal lengths of string to each balloon. Suspend both balloons (at the same height) so that they are near each other but NOT touching.

2. Rub both balloons with the fur friction pad. Which one of the two (balloon and fur) is charged positively and which one is charged negatively?
3. What happens when you bring the two balloons close together? What happens when you bring the fur close to one of the balloons? Record your observations below.

4. Rub the glass rod with the silk friction pad. What happens when you hold the glass rod next to one of the balloons?

5. Rub the rubber rod with the fur friction pad. What happens when you hold the rubber rod next to one of the balloons?

**Electroscope activity:**

7. Rub the rubber rod with the wool friction pad. Which one of the two is charged positively and which one is charged negatively?

8. Move the charged rubber rod toward the metal ball terminal of the electroscope WITHOUT touching. Record your observations and draw in the appropriate signs for the charges on the rod, metal ball, and leaves in the figure below.

9. The electroscope is now charged. What method did you use to charge it? What method did you use to charge the rod?
10. What happens when you move the rubber rod away from the electroscope? Why?

11. Predict what will happen when you rub the rubber rod harder? Would the glass rod lose more electrons to the wool? How could you test your predictions?

12. What happens when you touch the metal ball terminal with a charged rod (i.e. the negatively charged rubber rod) and then remove it? Record your observations and draw the appropriate signs for the charges on the rod before it touches the ball and on the leaves. Also draw the relative position of the leaves.