Lab 4 - Detection of Charge

Relevant SOLs: PS.11 a, 3.1a, 3.1j, 4.1a, 4.1b, 4.3a, 4.3c

Overview

An electroscope is an instrument that detects the presence of charge on an object, either through actual contact (conduction) or through induction. When the electroscope itself is charged, its two conductive components (which vary from electroscope to electroscope) will acquire like charge and deflect from the vertical position of gravitational equilibrium. See Fig. 2.0.1 and Fig. 2.0.2 for an illustration of the standard metal leaf electroscope and the UVa electroscope that we will use.

The base of the UVa electroscope in Figure 4.2 is made of acrylic, an insulator, to eliminate charge leakage to the table. Both the brownish brass and the aluminized mylar tube are conductors. Electrical charge can easily move along the tube and brass support causing a repulsive force to separate them. The angle separating them is a measure of how much charge is present.
Activity 4-1: Using the UVa electroscope to detect the presence of charge

Objective: Use the electroscope to detect the presence of charge.

Materials:

- Electroscope
- Acrylic Rod
- Teflon Rod
- Silk

SOLS: PS.11 a, 3.1a, 3.1j, 4.1a, 4.1b, 4.3a, 4.3c

Prediction:

1. Predict the behavior of the electroscope when you touch the charged Teflon rod to the top of the brass support on the electroscope. (Figure 4.3). Explain.

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2. In what ways will a negatively charged electroscope look different from a positively charged electroscope? Explain.

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Procedure:

1. Assemble the electroscope according to Figure 4.2. Set the tube in the vertical position by touching the top of the brass support with your finger. Your finger is a conductor and therefore will drain any electric charge on the electroscope so it becomes neutral after you touch it.

2. Rub the Teflon rod on silk.
3. Touch the charged Teflon rod to the top of the brass support on the electroscope. Describe the behavior of the electroscope.

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4. Repeat the process of charging the Teflon rod and touching the electroscope several times to accumulate more charge. Describe how the angle of the tube changes as you add charge. Is there a maximum angle?

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5. Touch the top of the brass support with your finger to make it become neutral. Now rub the acrylic rod with silk and repeat step 3 and 4. You may have to repeat the process a few times for the effect to be evident. Describe the behavior of the electroscope.

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6. Touch the upper lip of the brass support to make it neutral. Then, using the

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Teflon rod, charge up the electroscope until the tube goes out as far as it can.

7. Rub the acrylic rod on silk. Then slowly slide the rod on the upper lip of the brass support while watching the movement of the tube very closely. Describe the behavior of the tube as more charge gets rubbed off the acrylic tube.

Explanation

1. Explain why the tube of the electroscope rotates when a charged rod touches the top of the brass support.

2. In Step 4, explain why there is a maximum angle that the tube of the electroscope will rotate through.

3. Compare the behavior of the electroscope after being charged by a Teflon rod and an acrylic rod. Explain the reasons for the similarities and differences.

4. When the polarity of the charge on the electroscope was negative what real particle was being transferred to or from the electroscope? When the polarity of the charge on the electroscope is positive what real particle was being transferred to or from the electroscope?

5. What happens when an equal amount of positive charge meets an equal amount of negative charge?
Activity 4-2: Conductor or Insulator?

Introduction:
The main difference between a conductor and an insulator is that a conductor allows charge to move through it while an insulator doesn’t. While the atoms in an object are stationary, the electrons can sometimes escape the grasp of the atomic nuclei and drift through the material. A material whose electrons can easily move through is said to conduct electricity. Conversely, a material whose atomic nuclei are strongly attached to all the electrons is an insulator since they are not allowed to move.

Objective: Determine whether an object is a conductor or insulator.

Materials:

- Teflon Rod
- Silk
- Electroscope
- 100% Metal Object such as Knife, Fork, or Spoon (from home)
- 100% Plastic Object such as a Plastic Knife, Fork, or Spoon (from home)
- Wooden Rod
- Acrylic Rod

SOLs: PS.11 a, 3.1a, 3.1j, 4.1a, 4.1b, 4.3a, 4.3c

Prediction:

1. Use Table 4.1 to record your predictions as to whether certain materials are electrical conductors or insulators.

Table 4.1 Conductor/Insulator Predictions

<table>
<thead>
<tr>
<th>Material</th>
<th>Conductor/Insulator?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Your Finger</td>
<td></td>
</tr>
<tr>
<td>Wood</td>
<td></td>
</tr>
<tr>
<td>Acrylic</td>
<td></td>
</tr>
<tr>
<td>Teflon</td>
<td></td>
</tr>
<tr>
<td>Metal object</td>
<td></td>
</tr>
</tbody>
</table>
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Name ___________________________ Date ______________________

<table>
<thead>
<tr>
<th>Plastic object</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Which predictions are you certain about? Why?</td>
</tr>
<tr>
<td>____________________________________________________________</td>
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<tr>
<td>____________________________________________________________</td>
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<td>____________________________________________________________</td>
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</tbody>
</table>

3. For the objects that you are uncertain about, state the reasons that contributed to your predictions.

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Observation and Procedure:

1. Assemble the electroscope according to Figure 4.2.1 Set the tube in the vertical position by touching the top of the brass support with your finger. Your finger is a conductor and therefore will drain any electric charge on the electroscope so it becomes neutral after you touch it.

![Fig. 4.2.1](image)

2. Using the Teflon rod, charge the electroscope again so it resides at a large angle as possible.

3. Hold one end of the wooden rod in your hand. Touch the top lip of the
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4. Recharge the electroscope again using the Teflon rod. Hold one end of the acrylic rod in your hand. Touch the top lip of the electroscope with the other end of the acrylic rod. Describe the behavior of the tube.

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5. Recharge the electroscope again using the Teflon rod. Hold one end of the other Teflon rod in your hand. Touch the top lip of the electroscope with the other end of the neutral Teflon rod. Describe the behavior of the tube.

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6. Repeat Step 2. Touch the top lip of the electroscope with your metal object. Describe the behavior of the tube.

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Fig. 4.2.2 Touching the scope with the wooden rod

4. Recharge the electroscope with the wooden rod as shown in Fig 4.2.2. Describe the behavior of the tube.

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7. Repeat Step 2. Touch the top lip of the electroscope with your plastic. Describe the behavior of the tube.

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Explain

1. How do you decide whether a material is a conductor or insulator based on the behavior of the tube in the experiments above? State your line of reasoning.

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2. Fill in Table 4.2.2. with your conclusions.

<table>
<thead>
<tr>
<th>Material</th>
<th>Conductor/Insulator?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Your Finger</td>
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<tr>
<td>Wood</td>
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<tr>
<td>Acrylic</td>
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<tr>
<td>Metal object</td>
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<tr>
<td>Plastic object</td>
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</table>

3. Which of your predictions were incorrect? Explain.

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Electroscope Calibration - Extra credit

4. Below is a curve that was determined from experiment and then fitted with a curve that give the amount of charge on the electroscope as a function of angle. The units on the ordinate are nC which stands for nanoCoulombs. A nanoCoulomb is $10^{-9}$ Coulombs. If the vertical angle of your electroscope reads 30 degrees, then the amount of charge on it in Coulombs is ________________

The number of electrons can be calculated by dividing the amount of charge by the charge of an electron. The number of electrons is ____________________________
Activity 4 – 3: Movement of Charges in a Conductor

Introduction:

We already know that the fundamental characteristic of a conductor is that charges can move freely through it. If a charged object is placed close to a conductor, it will affect the spatial distribution of the charges in the conductor by attracting opposite charge while pushing similar charge away. See Fig. 4.6 and Figure 4.7

**Fig. 4.6** A negatively charged rod is brought near a neutral electroscope. Some of the electrons from the top of the electroscope tube are repelled to the opposite end of the tube.

**Fig. 4.7** Similar to in Figure 4.6, a negative rod is brought near to an initially neutral electroscope. Some of the electroscope’s electrons are repelled to the opposite side of the tube.
SOLs: PS.11 a, 3.1a, 3.1j, 4.1a, 4.1b, 4.3a, 4.3c

Objective: Show that the spatial distribution of charges in a conductor can change easily.

Materials:
- Electroscope
- Teflon Rod
- Silk

Prediction:
1. Predict the behavior of the electroscope when the charged Teflon rod is brought near to the top of the similarly charged electroscope tube. Explain your prediction.

Procedure:
1. Rub the Teflon rod on silk. Rub the Teflon rod across the lip of the electroscope to charge it up.

2. Rub the Teflon rod on silk again. Starting from 10 cm away, slowly move the Teflon rod close to the top of the electroscope tube. Describe the behavior of the tube in the entire process.

3. Pull the rod away. If the electroscope is still charged, move on to Step 4. If the electroscope seems to have lost its charge, recharge it as in Step 1 before moving on to Step 4.

4. Recharge the Teflon rod and slowly move it close to the bottom of the tube, also starting from 10 cm away. Describe the behavior of the tube in the entire process.
Explain

1. Were your observations in Step 2 in agreement with your prediction? Why or why not?

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2. Were your observations in Step 4 similar to your observations in Step 2? Why or why not?

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3. How can the tube be repelled and then attracted, while having the same amount of net charge on it? Explain the mystery by drawing reference to the movement of charges in a conductor.

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