Electroscope

P6-1156

INSTRUCTIONAL GUIDE

Contents

- Stopper and post assembly
- 250 mL flask
- Leaves

Recommended for activities:

- Friction Rod Kit (P6-1600)
- Proof Plane, Small (96-3585)

Introduction

A very common type of electroscope, and one that has been around for a long time, is the flask electroscope. This item can be very sensitive and, because it is enclosed within a glass housing, it is not prone to being affected by air currents in the room.

Rather than using pith balls or cork balls for indicating the presence of charges, it uses very thin metal foil leaves. Another big difference is the way that the charge is induced on to these leaves. Rather than the object being tested coming in direct contact with the leaves, the charge is introduced to a metal post to which the leaves are attached. The charge is then transferred from the post to the leaves. The foil leaves then act in a similar manner to the cork balls.

Set-Up

1. Remove the stopper and post from the flask.
2. Carefully remove the aluminum leaves from the package. (Note: aluminum leaf can be quite fragile.) Pierce a hole (just large enough to accommodate the hook) near the end of each of the leaves. Flatten the leaves as much as possible.
3. Suspend the two leaves from the hook so that they hang loosely from the lowest point.
4. Replace the stopper in the flask.

Activities

Activity 1: Determining like and opposite charges

Create a charge using one set of objects (e.g. wool and rubber) and transfer the charge to the electroscope. Create a charge using a second set of objects (e.g. silk and glass) and transfer the charge to the electroscope. If the charges are alike, the leaves will repel further. If the two charges are opposite, the leaves will repel less (or not at all). Note: it is not possible to identify a charge specifically as positive or negative without a reference charge for comparison.

Activity 2: Charging by Induction

Charge an object and hold it near the ball without touching. The leaves will repel even though the electroscope is still neutral. Suppose the external object carries a negative charge (excess electrons). When held near the electroscope, free electrons in the metal are repelled from the charged object near the ball. They move down the post into the leaves, causing the leaves to carry an overall negative charge (The ball has a positive charge).

Activity 3: The Flask Electroscope

Note: The following activities require two flask electroscopes, a rubber, plastic, and glass rod, a piece of wool and silk cloth, an electrophorus (proof plane), as well as two metal disk terminals for using in place of the metal terminal ball found at the top of a standard flask electroscope. You will also need an acrylic sheet and a neon bulb.

First, set both flask electroscopes up with metal balls on the top of their post. Discharge the electroscope by touching the balls with your hand or against a metal disk or similar object. When the electroscopes are discharged both leaves should hang straight down.

Take a rubber or plastic rod and rub it with a piece of wool cloth or similar material. When the rod is rubbed with the material, electrons are rubbed off the cloth and onto the rod. When a rod is brought near the ball (but not touching) the electrons that are already present on the rod are forced toward the leaves. This is due to the repulsion of similar charges. When both leaves have an overabundance of electrons, they repel one another causing them to separate from one another. When the rod is removed the leaves should return to their earlier state.

Now bring the rod back to the ball but this time actually touch the ball. This time you should find that the leaves remain diverged when you remove the rod. This is because some of the electrons from the rod transfer to the post, which remains on the rod and leaves after you take the rod away. The electroscope will remain in this state until it is discharged. This can happen by touching the ball to something else that will attract some of the excess electrons or by leaking through the air. The time it takes to leak and return back to a normal state depends on the amount of charge and the humidity of the environment.

Now remove the balls from the electroscopes and replace them with metal disks. With the plates touching, charge one. Both electroscopes should now show a charge. Discharge one of the electroscopes by touching it with your hand. You should see that both discharge showing how the charges can transfer from one to the other. Finally, charge one of the electroscopes and then bring the charged electroscope to the other and allow the plates to touch again. You will find that some of the charge will transfer to the second electroscope. The movement of the foil leaves in the second electroscope will indicate this.

By using a glass rod rubbed with silk, you can generate an excess of positive charge on the rod. You will find that the electroscope will respond in the same way.

Next, take the electroscope and discharge it (to remove any residual charge) by touching it with your finger. The leaves should be hanging nearly straight down with only a small angle between them. Charge the electrophorus on the sheet, and bring it CLOSE to the electroscope. Do not touch the terminal! The leaves of the electroscope should move far away from each other slightly. The stronger the charge on the electrophorus the more they should repel each other. As you move the electrophorus away from the electroscope the leaves should return to a neutral state. Why does this happen? The high charge on the electrophorus (negative) repelled some positive charges on the terminal of the electroscope. The only place these positive charges could go was to the leaves of the electroscope. Since the two leaves then had the same charge, and since like charges repel each other, the leaves moved away from each other. When the electrophorus was removed, the positive charges could go

back, returning the electroscope to a neutral state.

Again, charge the electrophorus. This time touch the plate to the terminal of the electroscope. The leaves should move apart. However, this time the charge is due to an actual transfer of electrons, so it remains even when the electrophorus is removed. If this is repeated several times it is possible to build up a relatively strong charge on the electroscope, so that the leaves are standing well apart from each other. To return the electroscope to the uncharged state, touch the terminal with your finger. Charge it again, but this time discharge it by touching it with a neon bulb. If the charge was strong enough the bulb should light up briefly.

Charge an acrylic sheet again using the polyethylene rod. Take the transfer ball and rub it over the sheet, then touch it to the terminal of the electroscope. Repeat this several times, building a stronger charge on the electroscope. Note that each time you run the ball over the sheet you are collecting more electrons, which are transferred to the electroscope. This is the mechanical transfer of static charge. This cannot be done with current electricity.

Activity 5: Point Discharge and a Flask Electroscope

Note: This activity requires one flask electroscope and a discharge point.

To begin, discharge one of the flask electroscopes. Charge the transfer ball and move it near the electroscope. The leaves should deflect, showing an induced charge. Keeping the ball away from the electroscope, touch it with the back of the point. Now move the ball near the electroscope. This time the leaves should not move much, if at all. Obviously, the charge has been transferred to the point. Move it near the electroscope. Again, the leaves will not move, showing that the point has no charge. Where did the charge go?

Try one more thing. Charge the transfer ball and hold it near the electroscope. Now aim the sharp point at the disk of the electroscope and touch the transfer ball to the other end of the point. This time the charge should move to the electroscope, and some should remain even after the transfer ball and point are removed. Apparently, the charge on a point is rapidly transferred to the air, and if the electroscope is near enough the charge will go there. This is the principle behind lightning rods. The idea is not so much to attract lightning to a particular point as to remove as much charge as possible from the building the lightning rod is attached to.

Related Products

E-Field Detector (96-3580) Using the E-field detector, teachers and students can investigate the effects of positive and negative charge. The probe of this detector can "sniff out" unknown charges, demonstrate charging by induction, and even prove the inverse square dependence of Coulombs Law.

Demonstration Electroscope (P6-1170) This aluminum needle-based electroscope's design makes it superior to traditional leaf-style electroscopes in part because the needle stays put when experiments are being performed.

Dissectible Leyden Jar (P6-3380) Demonstrate storage of electrical charges! The inner and outer metal conductors are separated by a plastic insulator cup. Charge the aluminum terminal with a Van de Graaff Generator or Wimshurst Machine, and take the jar apart.