

## Lab: Charges and Electrostatics

### INTRODUCTION:

Most modern applications of electricity involve electric charges in motion or **current electricity**. Historically, however, the first studies of electricity involved static charges, or **electrostatics**. You certainly feel the effects of electrostatic charges every time you touch a doorknob in the wintertime and get zapped.

In this lab you will be introduced to an instrument called an *electroscope*, which is used to measure electric charge. By the end of this lab you should understand how the electroscope physically works, you should know how to use it to measure electric charge, and you should be able to use it as a tool to discover some electrical properties of various plastic materials.

### THE ELECTROSCOPE:

The instrument that you will use in this lab is called an electroscope, shown in Figure 1. The electroscope consists of a metal ball connected by a metal rod (the *stem*) to a very thin leaf of gold foil. The fragile part of the instrument is enclosed in a protective case. Electrons can flow freely within the ball, stem, and gold leaf. The leaf is very lightweight and floppy, so that an electrical repulsive force acting to lift it up can easily overcome the downward force of gravity.

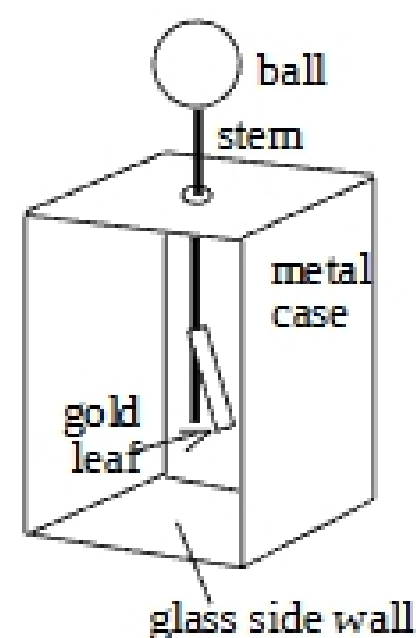


Fig.1. Electroscope

### PRECAUTIONS & NOTES:

- Never tilt the electroscope or turn it upside down. This can tear the foil off. Just leave it on the table.
- When you bring a charged object near the electroscope, do so from the top. Do not bring any charged object near the glass sides, as this can twist the gold foil and rip it off.
- In order to ground the electroscope (that is, remove all the net charge from it so it's neutral), touch the metal grounding plate to the metal ball on top of the electroscope. Touching your hand to the top of the electroscope can sometimes work, if you do not have any charge on your hands.
- Before charging and testing the plastic rods, make sure that they are neutral first. You can ground the plastic rods by covering the metal grounding plate with a damp towel and wipe the rods across the cloth. Always test the rod with the electroscope to make sure it is neutral first.
- If you rub two objects together to test the charge on each, make sure you hold the side that was rubbed near to the metal ball on the electroscope.

## PART I: USING THE ELECTROSCOPE

The simplest way to obtain an electric charge is to take almost any two materials and rub them together. Often, one of the materials becomes negatively charged and the other positively. For example, if you scuff the rubber soles of your shoes along a carpet, you will acquire some of the electrons from the rug. Your body will then have an excess of electrons – to get rid of these, just touch the nearest doorknob or metal bookcase. A similar effect occurs if you rub a teflon rod with a woolen cloth; the teflon rod acquires a negative charge and the wool acquires an equal amount of positive charge.

We know that all matter contains positive and negative charges. The positive charge is deep inside each atom in the atomic nucleus, while the negative charge is on the electrons that orbit outside the nucleus. In normal, neutral matter the amounts of positive and negative charge are equal, and we are unaware of either. Given any two different materials, it usually happens that one has a greater attraction, or **affinity**, for electrons than the other; when the two are rubbed together, the material with higher affinity captures some electrons from the material with lower affinity. For example, teflon has higher electron affinity than wool; when they are rubbed together the teflon captures a few electrons from the wool; the teflon therefore acquires an excess of electrons and is negatively charged, while the wool is left with a deficit of electrons and is therefore positively charged.

It is important to note here the difference between **insulators** and **conductors**: electrons can move freely within conductors (such as metal), but don't move very easily on insulators (like cloth or plastic rods). The preceding paragraph applies to insulators in this lab.

Make sure there is no charge on the electroscope so that its leaf hangs straight down as in Fig. 2a. Now rub the teflon rod with the wool and bring the rod close to (*but not touching*) the ball of the electroscope, causing the leaf to rise. Using Fig. 2 as a guide, explain what happens.

What forces are acting on the leaf?

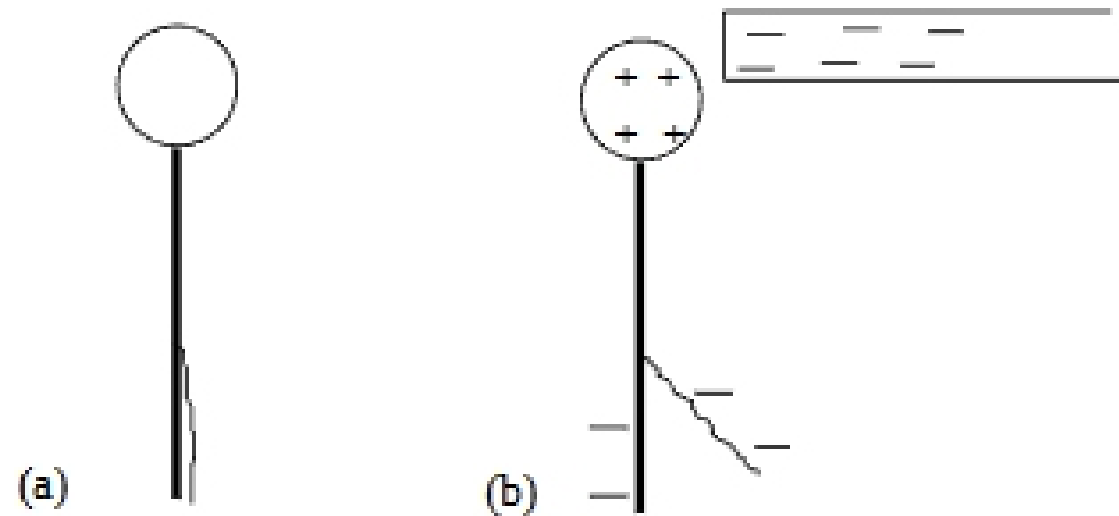


Fig. 2. a) If the electroscopes is neutral and no charges are close by, the leaf will hang straight down. b) A charged rod close to the ball causes the leaf to rise.

Take away the teflon rod, and bring the wool cloth close to (but not touching) the ball. (Because the charge is spread over the cloth, it is harder to get the leaf to rise this way.) Draw a diagram similar to Fig. 2b and explain what happens.

Using **just a neutral electroscopes** as you did here, can you tell the sign of the charge which is close to the ball? If so, how?

Take a charged rod and touch it to the metal ball on the electroscopes, then take the rod away. Using one or more diagrams similar to Fig. 2b, explain what happens.