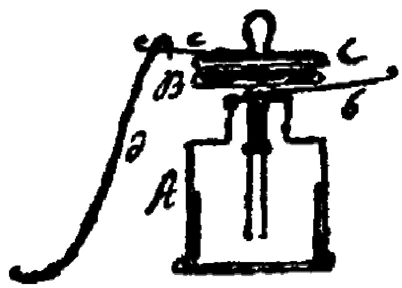
Electroscopes

Name:
Period:

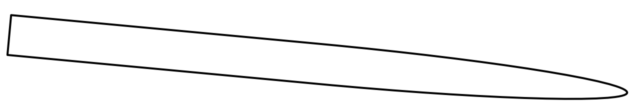
Below is a sketch of an electroscope similar to the one we use in class. The sketch was made by Alessandro Volta who, among other things, discovered methane and created the first ‘voltaic pile,’ an early form of the battery. We take our electrostatics unit of ‘Volt’ from his name.

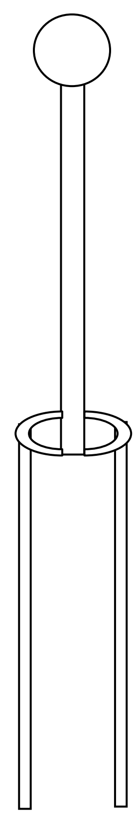


The two hanging foil leaves are free to move upwards, making an upside-down Y shape. They are connected by conducting metal to the knob at the top, and this entire metal portion is electrically insulated by stopper ℬ from the glass container 𝒜 and the table on which it rests. If the metal leaves and knob gain a net positive or negative charge, the charge will not easily leak away.

We add and subtract charges from the electroscope using a rod made of hard rubber.

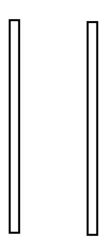
Below, sketch the positions of the positively charged nuclei in each of these objects by placing several + signs on each one. These should be equally distributed through each object. Then, draw in enough – signs throughout to make each object electrically *neutral*.





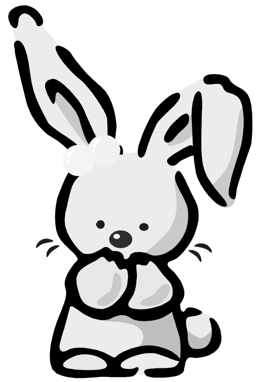
When thinking about these objects, think of the nuclei of these atoms as fixed in location – this is basically true for materials such as aluminum (Z = 13, A = 27) and hard rubber [$(C_5H_8)_n$ mixed with Sulfur]. The electrons are free to move in the aluminum, which is a conductor, but not free to move in the hard rubber. Of course, the electrons will only accelerate if a force is applied to them.

Below, draw a free body diagram for each of the foil leaves as they hang vertically. You may draw the force vectors out from the center of each object.



Electroscopes

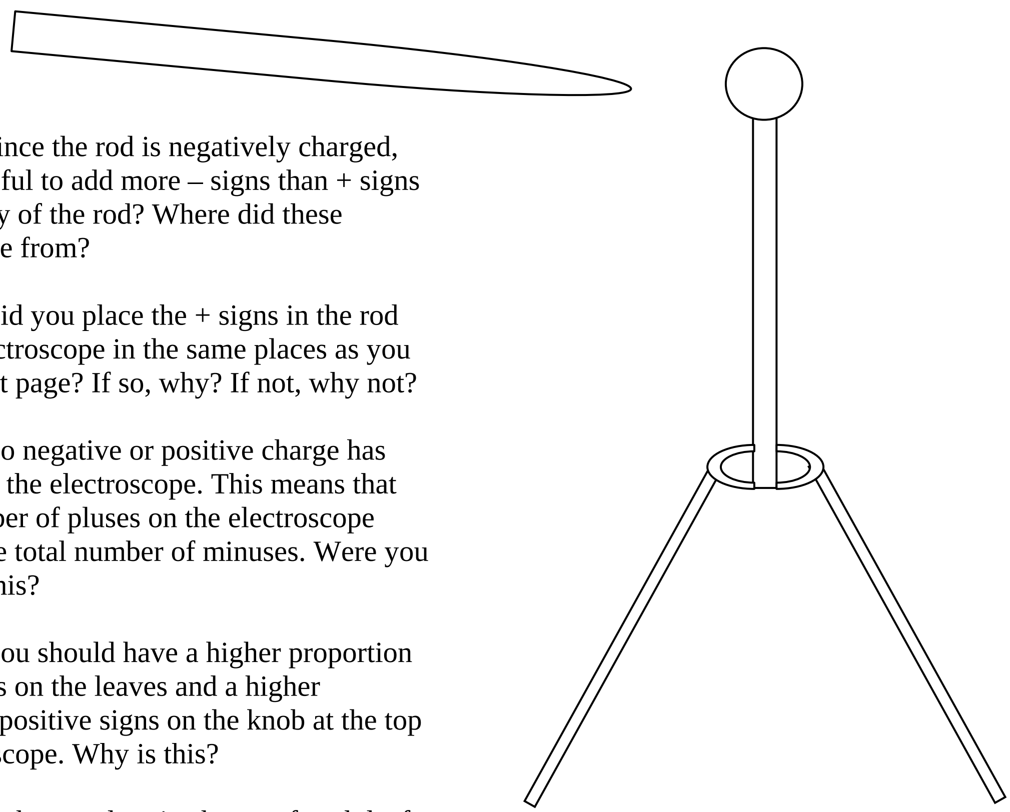
Name:
Period:



Now, let's imagine what happens when we rub the rubber rod with rabbit fur. Animal hair consists largely of the protein alpha-keratin. Alpha-keratin is made from cysteine, an amino acid built with sulfur, hydrogen, carbon, nitrogen, and oxygen. Rabbit fur, when brought into contact with most other materials, sheds electrons like crazy. The reason for this is that the hair is rather fine, almost taking on a one-dimensional character.

Suppose the rod gains a negative charge of 10^{-8} C. How many electrons have been deposited on the rod by the fur?

The negatively charged rod is brought close to the electroscope a second time. Below, sketch (in pencil) the distribution of positive and negative charges in the configuration shown. After you have finished, read and answer the set of questions below.



Question 1: Since the rod is negatively charged, were you careful to add more – signs than + signs along the body of the rod? Where did these electrons come from?

Question 2: Did you place the + signs in the rod and in the electroscope in the same places as you did on the first page? If so, why? If not, why not?

Question 3: No negative or positive charge has been added to the electroscope. This means that the total number of pluses on the electroscope must equal the total number of minuses. Were you careful with this?

Question 4: You should have a higher proportion of minus signs on the leaves and a higher proportion of positive signs on the knob at the top of the electroscope. Why is this?

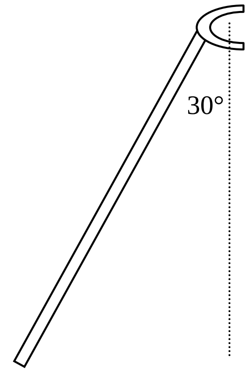
Question 5: Is the net electric charge of each leaf positive or negative? Why are these leaves sticking out at an angle?

Question 6: Do both leaves carry the same charge? If so, why? If not, why not, and how big a difference is there between the charges of the two leaves?

Electroscopes

Name:
Period:

Let's consider all the forces acting on a single electroleaf when it is hanging at an angle of 30°, as shown. Draw a free body diagram on the sketch to the right, giving a name to each of the three forces acting on the electroleaf.



What are the net forces in the *x*- and *y*-directions?

Assume the electroleaf has a mass of 1 gram = 0.001 kg. The distance between the centers of the two leaves is 1 cm = 0.01 m. Assume each leaf has the same charge *q*. What is this charge, in Coulombs (C)? (You will need to use Coulomb's Law for this problem.)

Applications

1. My brother doesn't like to dust his bookshelf. Instead, he has this plan of just taking the entire bookshelf and turning it upside down, so that the dust falls off. Then he can vacuum up the dust. Of course, you know and I know the dust will just stick to the bookshelf. Why?

2. When a student stood on a book and touched a Van de Graff generator, she was given a huge electric charge. Her hair stood on end. Why?

3. If you shock yourself on a door handle in a dark room, you might actually see the spark. Describe, in terms of the movement of electrons, what is happening. Is it easy to tell whether electrons are flowing from the door to your hand, or if it is the other way around?