LAB 1: ELECTRIC CHARGE

Equipment List:

Electrometer (ES-9078A)
Charge producers (ES-9057B) - the wands with dark and white disks on the ends
Proof plane - wand with aluminum coated disk on the end
Faraday ice pail (ES-9042A)
Signal input cable for electrometer - has two alligator clips
Black banana lead - grounding cable for electrometer
DC power supply (Pasco) - only used for ground port
Three prong power cable - for DC power supply

Purpose: To explore charge, charge transfer, and charge conservation.

Introduction: As with all experiments in this course, please proceed with caution. If you are ever uncertain, please ask for advice. If your equipment starts emitting a continuous beeping sound, disconnect it immediately and ask for help. For many experiments, including the electrostatic charge experiments, there are only a few sets of equipment which are used by many classes. If the equipment is broken, it will affect many other students and it will not be possible to replace it for some time because it is expensive. Please use the equipment with care.

In this lab you will create a charge imbalance on the charge producers and use the Faraday ice pail and electrometer to measure this charge. Make sure to answer the questions posed in this lab in your lab book.

The Faraday ice pail is a double layer Faraday cage. (Michael Faraday used a metal ice bucket in his original experiment.) When a charged object is placed inside the inner cage, free charge flows within the wires of the inner cage to neutralize this charge on the inside surface of the cage, leaving a residual charge on the outside of the inner cage that is equal to the charge placed inside the cage. The outer cage is used to shield the inner cage from stray electric fields in the lab environment. The electrometer will be connected to the inner cage and will measure this charge indirectly by indicating the potential difference (voltage) across a capacitor inside the electrometer. The voltage that is measured is directly proportional to the charge on the object placed in the inner cage.

Grounding is an important step in experiments to measure charge. As objects and the experimenter move around in the lab static charges can build up through friction. This stray charge should be removed before making measurements by drawing it off into a large neutral conducting reservoir. This is done in electronic equipment using the third (ground) prong. It can be done by touching objects that may have stray charge to conductors connected to the ground port (in this lab the outer cage of the Faraday ice pail), or for example by touching exposed pipes in the lab. Grounding is also an important step before repairing delicate

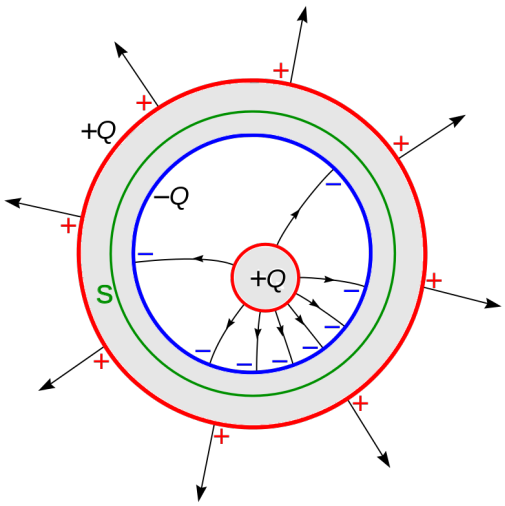

Figure 1: Diagram of the charges and electric field in a Faraday's ice pail experiment. Figure by Chris Burks, from Wikipedia.

electronic equipment, since a built up charge on people or tools can lead to a large current flow through components not designed to handle it. Such components will be damaged as a result.

Procedure:

1. Plug in the DC power supply to the wall mains power socket, but do not turn it on. Connect a black ground lead from the electrometer to the ground socket of the power supply.

2. Set up the Faraday ice pail and electrometer as show in the diagram (Figure 2). Ground the inner pail and electrometer circuitry by touching your finger across both pail layers and simultaneously press the "ZERO" button on the electrometer.

3. On the front edge of the electrometer is a button that adjusts the voltage range. Start each measurement on the largest voltage range and adjust downwards as necessary. Measurements tend to be most accurate when the readings are being taken around the middle of the voltage range, so choose your setting accordingly.

4. Ground the charge producer wand handles and necks by touching them to the grounded outer cage. Also ground yourself. Holding one charge producer in each hand, rub the white and dark surfaces of the disks together. Put the white charge producer down carefully on the lab desk far from the ice pail, not allowing it to touch any conductor.

5. Take the dark producer and move the disk down inside the cage, but do not let the disk touch the cage. Measure and record the voltage shown on the electrometer. Remove the disk. What happens to the voltage shown on the electrometer? Move the disk back into the cage and repeat your measurement. Do this three times in total.

6. Now put the dark charge producer to one side and repeat this procedure with the white charge producer. Which charge producer builds up a positive charge? Is there

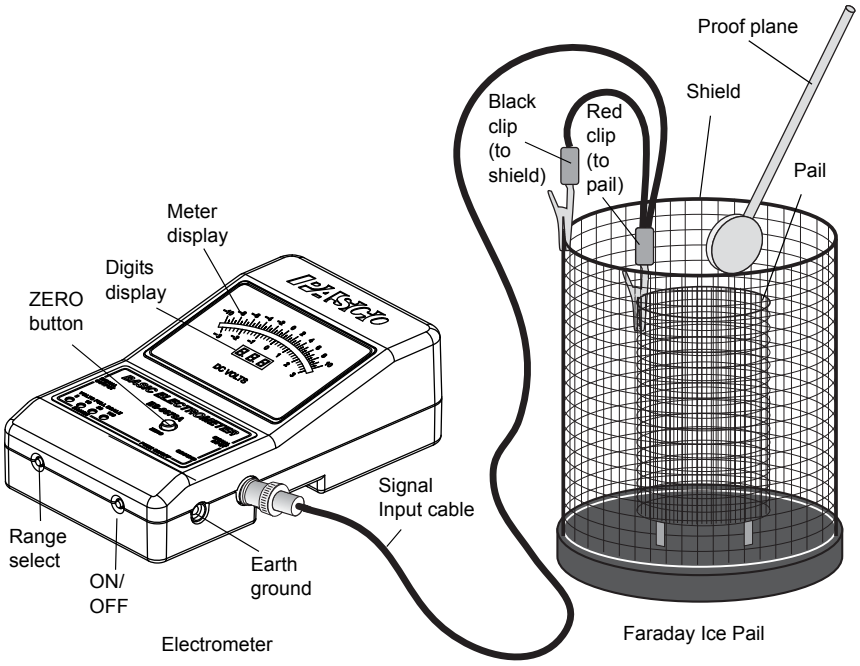

Figure 2: Faraday ice pail and electrometer setup. Figure from Pasco Electrostatics manual 9080A.

any relation between the potential difference measured with the dark producer and with the white producer?

7. Ground the charge producer disks, wand handles, and necks by touching them to the grounded outer cage and yourself. Ground the inner cage and zero the meter again. Reach both charge producer disks down into the inner pail and rub the disks together, being careful not to let the producers touch the cage. Keep the disks inside the cage and record the electrometer reading.

8. Remove the dark producer from the cage and note the electrometer reading. Return it to the cage without touching the cage or the other charge producer. Now remove the white producer and again record the electrometer reading. Explain your observations.

9. Again ground the charge producer disks, wand handles, and necks by touching them to the grounded outer cage and yourself, then ground the inner cage and zero the meter. Rub the charge producers together and put aside the dark charge producer. Reach the white charge producer into the inner cage and record the meter reading. Now touch the disk to the cage. Remove the disk from the cage. What is the reading on the electrometer now?

10. Ground the inner cage with your finger and zero the meter again. Now put the white charge producer disk back into the inner cage. Note the meter reading. Explain what happened to the charge on the disk.

11. Again, carefully ground yourself and your equipment and zero the meter. Rub the white charge producer together with the proof plane disk. Use the electrometer to

measure and record the potential differences associated with the charge on the white charge producer and then on the proof plane.

12. Ground the proof plane and yourself. Rub the dark charge producer with the proof plane disk and repeat the previous part. Among the white charge producer, dark charge producer, and proof plane, does one of the objects consistently develop a positive charge? Does one consistently develop a negative charge? List the three objects from the one that loses electrons most readily under friction to the one that is most inclined to gain electrons.

Conclusion: What do you observe about charge in this experiment? Comment on charge conservation if you think it is applicable. How do you think friction leads to objects becoming charged? If the dark charge producer was rubbed against a glass object, which do you think would develop a positive charge? What were possible sources of error in this experiment? Can you think of any ways to improve or extend this experiment?