Experiment 13: Electrostatics

Figure 13.1

EQUIPMENT

Ebonite Rod (Hard Rubber)
Glass Rod (or Lucite Rod)
Rabbit Fur
Plastic Film
Silk
Electroscope

Front Table

Hair Dryer
Rubbing Alcohol
Paper Towels

Advance Reading

Text: Law of conservation of electric charge, electrostatic charge, electron, proton, neutron, atomic model, free electrons, ions, polarization, conductor, insulator, conduction, induction.

Objective

The objective of this lab is to qualitatively study conducting and insulating materials, electric charges, and charge transfer.

Theory

There are two kinds of charges in nature: positive charge carried by protons and negative charge carried by electrons. An object that has an excess of either is said to be charged. Like charges repel each other, and unlike charges attract.

Charge transfer is the exchange of charges between objects. In this experiment, only electrons are exchanged while protons remain stationary. These electrons may move around within materials or move between materials, but they can never be created or destroyed. This is known as the **law of conservation of charge**. The law of conservation of electric charge states that *the net amount of electric charge produced in any process is zero.*

A **conductor** is a material in which some loosely bound electrons can move freely (free electrons) while protons are tightly bound within the nucleus. An **insulator** is a material in which both electrons and protons are tightly bound. Conductors and insulators have the following properties:

Conductors

- Conductors are objects that allow the free flow of electrons throughout the object.
- Charges are easily transferred between conductors.
- Charge can collect at one end of an object in the presence of other charged objects.

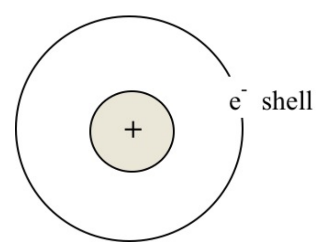
Insulators

- An insulator is a material in which electrons are tightly bound to the nucleus.
- Transferring charge between insulators requires a force, e.g. friction, and direct contact.
- Insulators brought near other charged objects experience **polarization**, a shifting of electrons to one side of an atom. (Fig. 13.2)

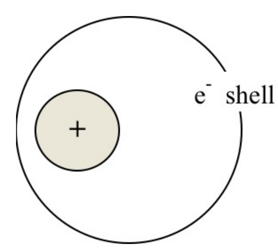
In this experiment, a glass rod or an ebonite rod (insulators) will be electrically charged by rubbing against another insulating material. Whether the rod gains or loses electrons will depend on the combination of materials used (refer to the **electrostatic series** provided in Table 13.1 on Page 67). The charged rod will be used to charge an **electroscope** (a conductor that indicates whether it is charged) by means of **conduction** and by means of **induction**.

To charge by conduction: Bring a charged rod close to, then touch, the electroscope. As the rod nears the electroscope, the free electrons in the electroscope are either attracted to or repelled by the charged rod (*induction*). When you touch the rod to the electroscope, the electroscope becomes charged as electrons transfer to (or from) the electroscope (*charge transfer*).

To charge by induction: Bring a charged rod close to, but do not touch, the electroscope. While holding the rod near the electroscope (*induction*), touch the opposite side of the electroscope with the tip of your finger (*charge transfer*). Your body will act as a reservoir of charge (ground), either giving or receiving electrons to the electroscope. Remove your finger *before* moving the rod from the proximity of the electroscope.



Atom charge distribution, normal



Atom charge distribution, polarized

Figure 13.2: Polarization

	↑
	Plastic Film
Materials tend to receive electrons and become **NEGATIVELY CHARGED**	Hard Rubber
	Celluloid
	Sulfur
	Rubber Balloon
	Polyethylene
	Polystyrene
	Amber
	Sealing Wax
	Lucite
	Wood
	Cotton
	Paper
	Silk
	Cat Fur
Materials tend to lose electrons and become **POSITIVELY CHARGED**	Wool
	Nylon
	Mica
	Glass
	Rabbit Fur
	↓

Table 13.1: Electrostatic Series

Name: ____

1. What are the objectives of this experiment? (5 pts.)

2. There are only two types of electric charge. Electrons carry a ______________________ charge,

   and protons carry a ______________________ charge. (5 pts.)

3. What is conservation of charge? (20 pts.)

4. Assuming both objects are initially neutral, use the concept of conservation of charge to explain what happens when an ebonite rod is rubbed with rabbit fur. (20 pts.)

5. Define the following: (10 pts. each)

   - conductor

   - insulator

   - conduction

   - induction

   - polarize

PROCEDURE

PART 1: Charging by Conduction

Negative by Conduction

1. Charge a rod negatively by rubbing it with a material that will give it extra electrons.
2. Bring the negatively charged rod close to the electroscope bulb without touching it. Observe how the leaves of the electroscope repel each other.
3. Touch the charged rod to the electroscope. Observe the behavior or the electroscope during conduction and as you remove the rod.
4. Draw a series of sketches showing the movement of charges during this process.

Positive by Conduction

5. Charge the electroscope positively by conduction using a glass rod.
6. Sketch the various stages of this process.

PART 2: Charging by Induction

Positive by Induction

7. Bring a negatively charged rod close to the electroscope, but do not touch it.
8. While the electroscope's leaves are separated, touch the electroscope bulb with your finger to ground it. Remove your finger.
9. Remove the charged rod from the vicinity of the electroscope; observe its final state.
10. Draw a series of sketches showing the movement of charges during this process.

Negative by Induction

11. Charge the electroscope negatively by induction. Which rod will be required?
12. Sketch the various stages of this process.

QUESTIONS

1. When using a negatively charged rod, explain what causes the leaves to repel each other before the rod contacts the bulb. How can this occur before electrons are conducted to the electroscope? In your answer, consider the charges in the electroscope and their behavior within a conductor.
2. What is different about electron flow when charging the electroscope positively? What causes the leaves to repel each other in this case?
3. When charging by induction, what is the final state of the electroscope if you remove the rod before removing your finger? What causes this?
4. Your finger acts as a ground, or large reservoir of charge, that allows the **system** (rod and electroscope) to reach neutral (leaf down). If the rod has a positive charge, what must be the charge of the electroscope when the rod/electroscope system is brought to neutral? Does it have an excess of electrons, a deficit, or neither? How do you know?