15.1 Electric Charges, Insulators, and Conductors

Properties of Electric Charges

There are two kinds of electric charges, namely, positive and negative. The **electron** has a charge of **-*e*** and the **proton** has an **equal and opposite** charge of **+*e***. $e = 1.60218 \times 10^{-19} C$ (SI unit - Coulomb)

The electric charge is **quantized**, i.e., it can be expressed as $\pm e,\ \pm 2e,\ \pm 3e$, and so on. Electric charge is always **conserved**. Charge isn't created. **Negative charge** is transferred from one object to the other. Like charges repel one another and unlike charges attract one another.

In a solid, **protons never move** from one material to another. Electrons are far lighter than protons and hence more easily accelerated by forces. The objects become charged by gaining or losing electrons.

The following experiments work best on a dry day because excessive moisture can facilitate a leaking away of the charge -

- Rubbing a plastic comb through your hair, the comb attracts bits of paper.
- Rubbing your shoes on a wool rug or by sliding across a car seat.

Particle	Charge (C)	Mass (kg)
Electron	-1.6×10^{-19}	9.1×10^{-31}
Proton	$+1.6 \times 10^{-19}$	1.67×10^{-27}
Neutron	0	1.67×10^{-27}

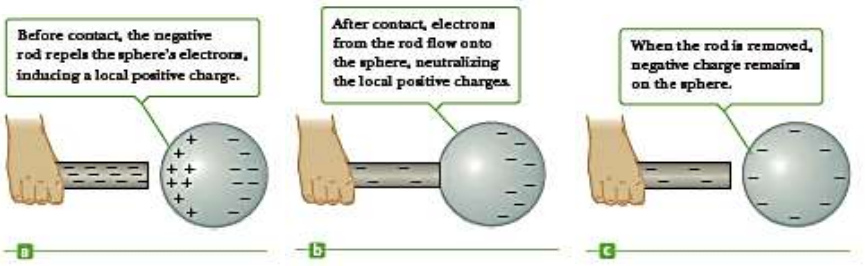
Charge and Mass of the electron, proton and neutron

Insulators and conductors

In **conductors** electric charges move freely in response to an electric force. (copper, aluminum and silver are good conductors). All other materials that don't readily conduct electricity are **insulators.** (paper, plastic, glass, rubber, etc.) **Semiconductors** are a third class of materials and their electrical properties are somewhere between those of insulators and those of conductors and that are widely used in the fabrication of a variety of electronic devices. (e.g., Silicon and germanium)

Charging by Conduction

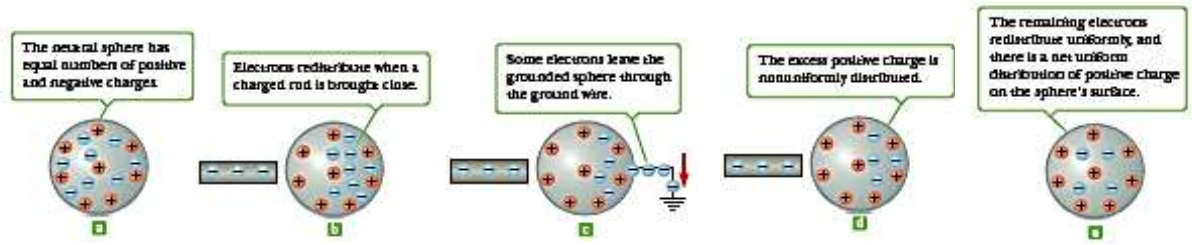
When a negatively charged rubber rod is brought into contact with an insulated neutral conducting sphere, the excess electrons on the rod repel electrons on the sphere. On contact, some electrons on



the rod move onto the sphere and neutralize the positive charges on it. When the rod is removed, the sphere is left with a net negative charge. This process is referred to as charging by conduction.

Charging by Induction

When a negatively charged rubber rod is brought near a neutral conducting sphere which is connected to a grounded conducting wire, it makes the electrons on the sphere to move farthest away from the rod with some of them leaving the sphere and travel to ground. If the grounded conducting wire is removed, the sphere is left with an excess of induced positive charge. This process is known as charging by induction.



Quick Quiz 15.1 A suspended object ***A*** is attracted to a neutral wall. It's also attracted to a positively - charged object ***B***. Which of the following is true about object ***A***? (a) It is uncharged. (b) It has a negative charge. (c) It has a positive charge. (d) It may be either charged or uncharged.

Solution- The correct answer is (b). Object A must have a net charge because two neutral objects do not attract each other. Since object A is attracted to positively-charged object B, the net charge on A must be negative.