

# Electricity

*by*

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## **P3.7x Electric Charges — Interactions**

Charged objects can attract electrically neutral objects by induction.

**P3.7c** Draw the redistribution of electric charges on a neutral object when a charged object is brought near.

**P3.7d** Identify examples of induced static charges.

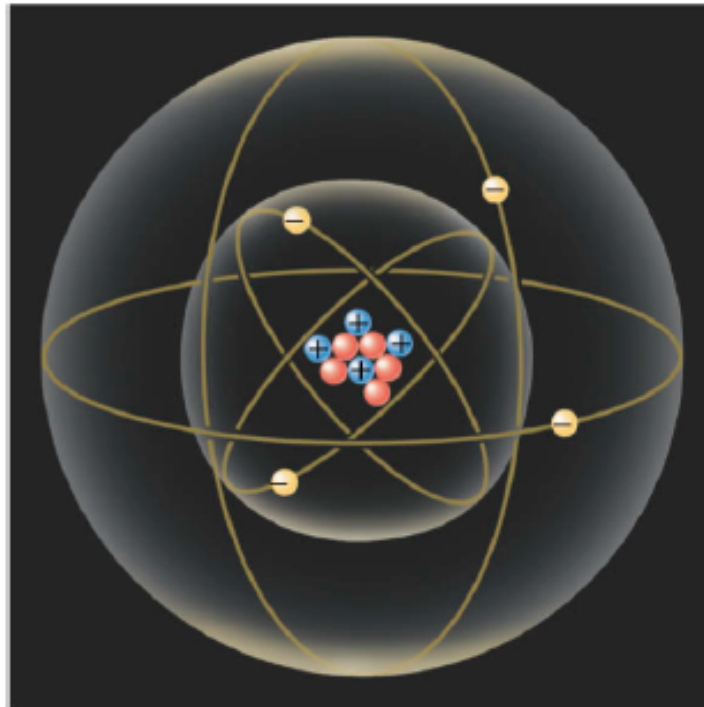
## **Items;**

- 1- Net Electric Charge.
- 2- Conductor and Insulators.
- 3- Charging by Contact, Friction, Induction.

## Atom and Charges

Atom is the smallest particle of a matter. The electric nature of matter comes from the structure of the atom (shown below) of all substances.

- ⊖ electron
- ⊕ proton
- neutron



An atom has a massive nucleus in the center and electrons (yellow spheres) orbiting in imaginary paths around the nucleus.

The nucleus contains protons (blue spheres) and neutrons (red sphere).

Proton carries a positive charge:  $e = 1.60 \times 10^{-19}$  coulomb (C).

Electron carries a negative charge:  $e = - 1.60 \times 10^{-19}$  coulomb (C).

So there are two kinds of electric charges: Positive and negative but equal in magnitude ( $1.60 \times 10^{-19}$ ).

In nature, atoms are normally found with equal numbers of protons (+) and electrons (-), so they are electrically neutral.

## Net Electric Charge ( $q$ )

By adding or removing electrons from an atom, matter will acquire a **net electric charge ( $q$ )** with magnitude equal to  $e$  times the number of electrons added or removed,  $N$ .

$$q = Ne$$

A matter that **loses electrons** has an excess of **positive charge**, so it becomes positively charged.

A matter that **gains electrons** has an excess of **negative charge**, so it becomes negatively charged.

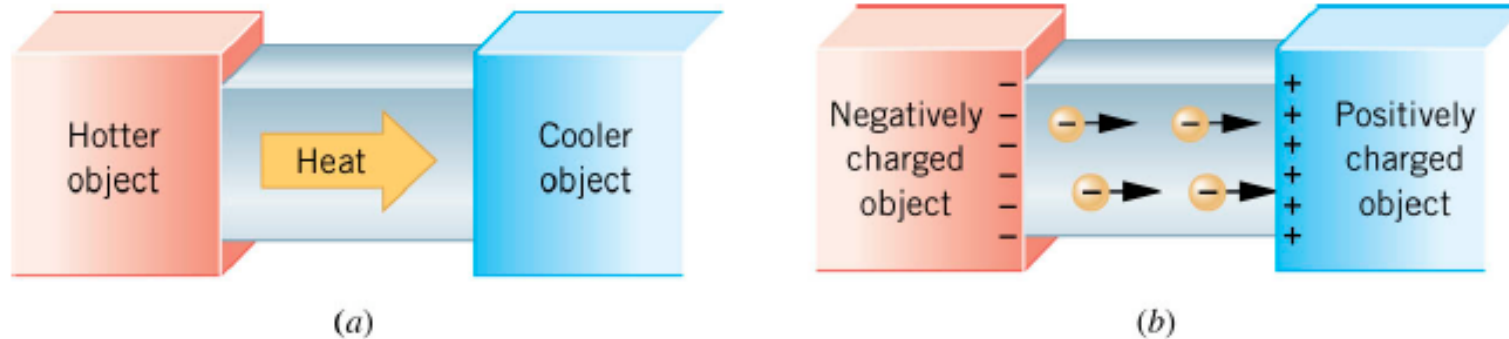
It is possible to transfer electric charge from one object to another by moving around **electrons (-)**, which move easier than positive charges.

## Law of Conservation of Electric Charge

During any process, the net electric charge of an isolated system remains constant ( is conserved).

Electric charges are involved in many situations such as chemical reactions, electric circuits and radioactive decay.

## Conductors and Insulators

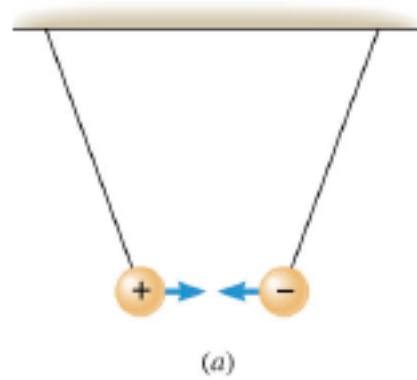


- a) Heat naturally move from hotter object to a cooler object. Likewise:  
b) Electric charge can exist **on an object**, and can also **move through an object**.

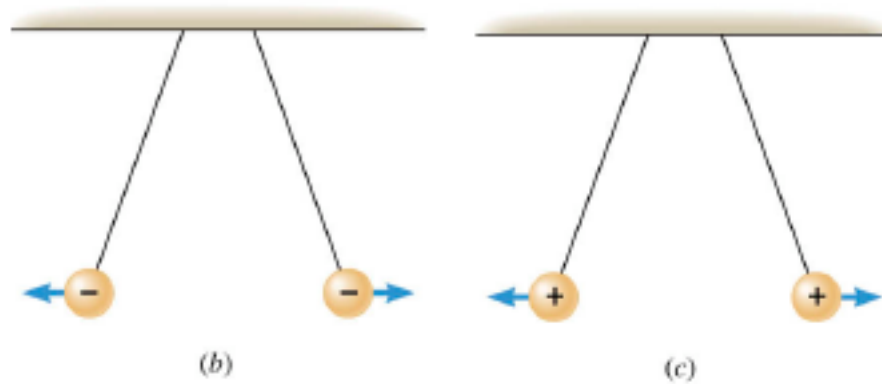
Substances that **readily** conduct electric charge are called electrical **conductors**.  
Their electrons are loosely held by their atoms and move freely.

Materials that **poorly** conduct electric charge are called electrical **insulators**.  
Their electrons are tightly held and can not move from atom to atom.

Unlike charges (+, -) attract each other.



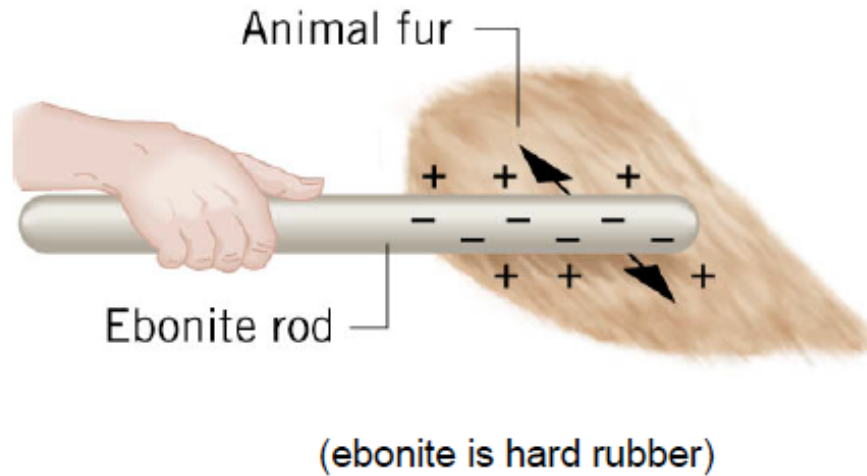
Like charges (-, -) or (+, +) repel each other.





## Charging by Friction

Some substance can be charged by rubbing them with another substance.



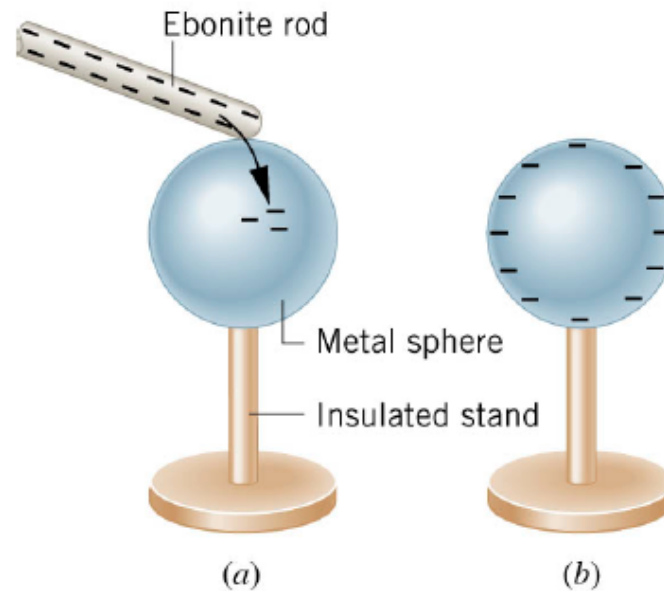
When you rub an ebonite rod against the fur of an animal, electrons from atoms of the fur are transferred to the rod.

The rod gains electrons. So, the rod gains negative charges.

The fur loses electrons. So, the fur has positive charges.

## Charging by Contact

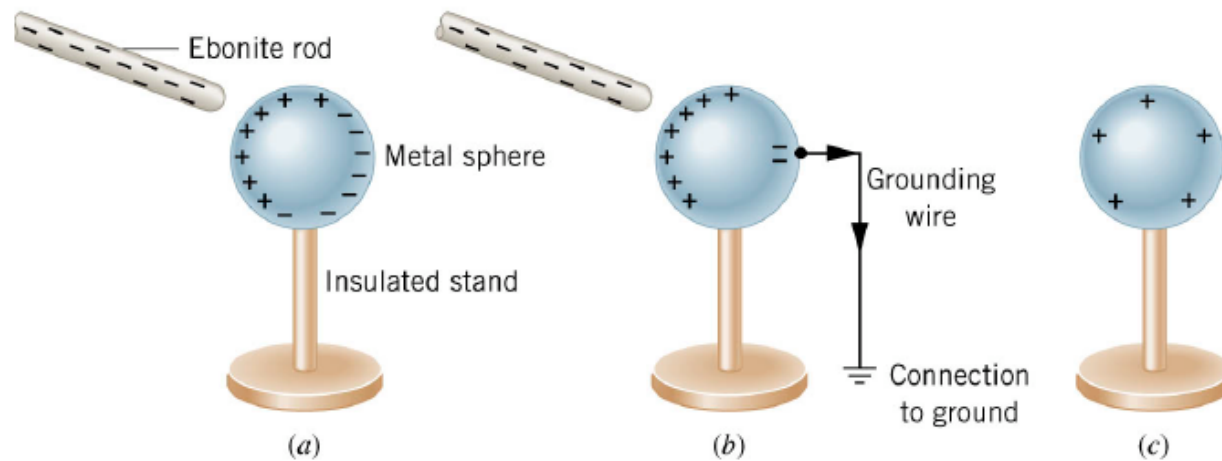
It is the process of giving one object a net electric charge by placing it in contact with a charged object.



- Electrons are transferred by rubbing the negatively charged rod on the metal sphere.
- When the rod is removed, the electrons distribute themselves over the surface of the sphere.

## Charging by Induction

It is the process of giving one object a net electric charge without touching the object to a second charged object.



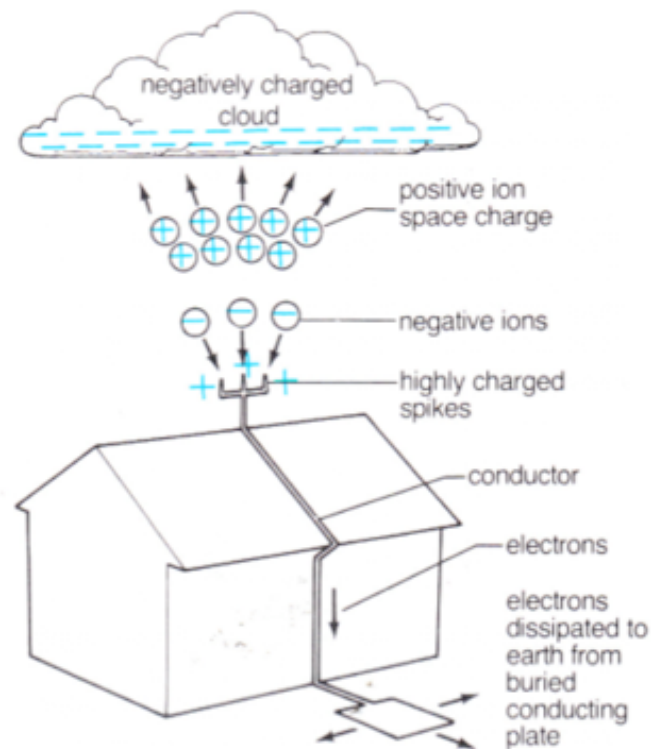
- When a charged rod is brought near the metal sphere without touching it, some of the positive and negative charges in the sphere are separated.
- Some of the electrons leaves the sphere through the grounding wire, with the result,
- that the sphere acquires a positive net charge.

**Example 1:** *Lightning Rods;*

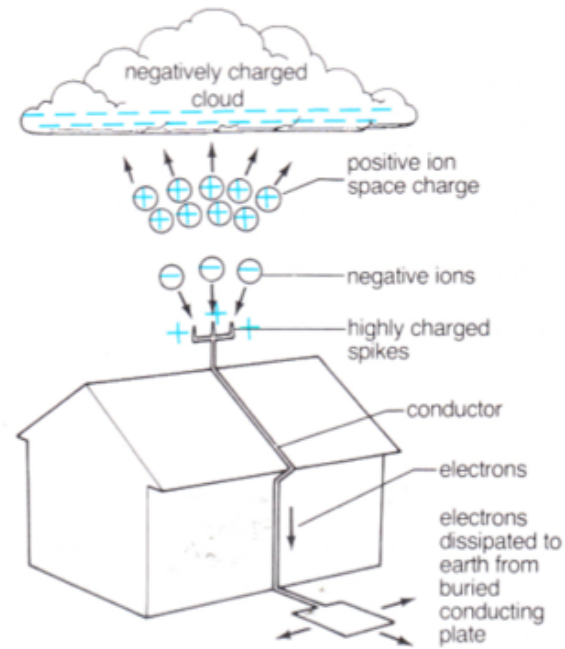
The charges presented by lightning are immense. The discharge takes the shortest path to Earth and therefore, usually strikes the tallest conductor in the vicinity. For this reason, pointed lightning rods are attached to the top of tall buildings and connected by good conductors to Earth. This protects the tall buildings and also prevent lightning from occurring in their vicinity.



The figure below shows the distribution of charges and how a lightning rod is used to protect tall building.



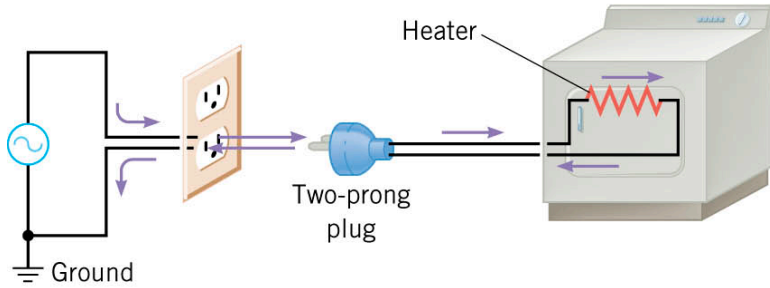
Formation of rain drops cause clouds to become electrically charged. If the charge increases to a certain point, a gigantic park discharge occurs in the form of lightning.



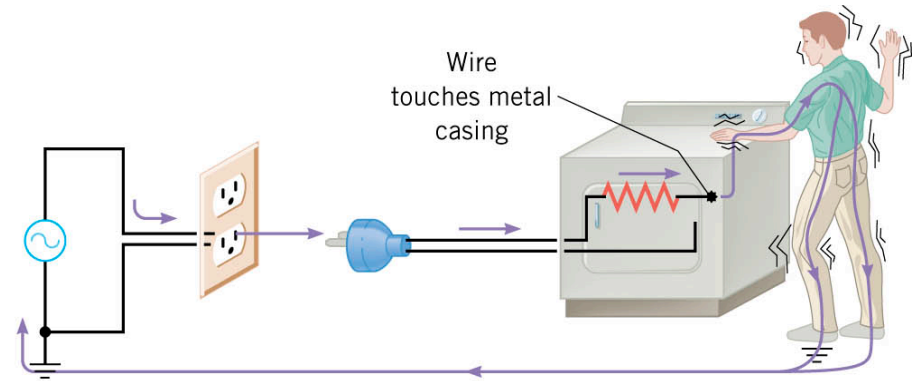
On the other hand, the negatively charged clouds induced a strong positive charge on the surface of the Earth directly underneath it. The positive charges will be concentrated in the pointing of the lightning rods. Negative ions in the air will be attracted to the rod and conducted to the ground. Positive charges will be repelled by the rod and concentrated below the cloud and reduce the strong electrical forces between the cloud and the Earth and prevent the lightning from occurring.

## Example 2: *Reducing Danger;*

To reduce the danger inherent in using circuits, proper electrical grounding is necessary.



(a)



(b)

## ***References:***

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2) Cutnell, J. D. & Johnson, K. W. (1998). *Cutnell & Johnson Physics, Fourth Edition*. New York: John Wiley & Sons, Inc.

*The edition was dedicated to the memory of Stella Kupferberg, Director of the Photo Department: “We miss you, Stella, and shall always remember that a well-chosen photograph should speak for itself, without the need for a lengthy explanation”*



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