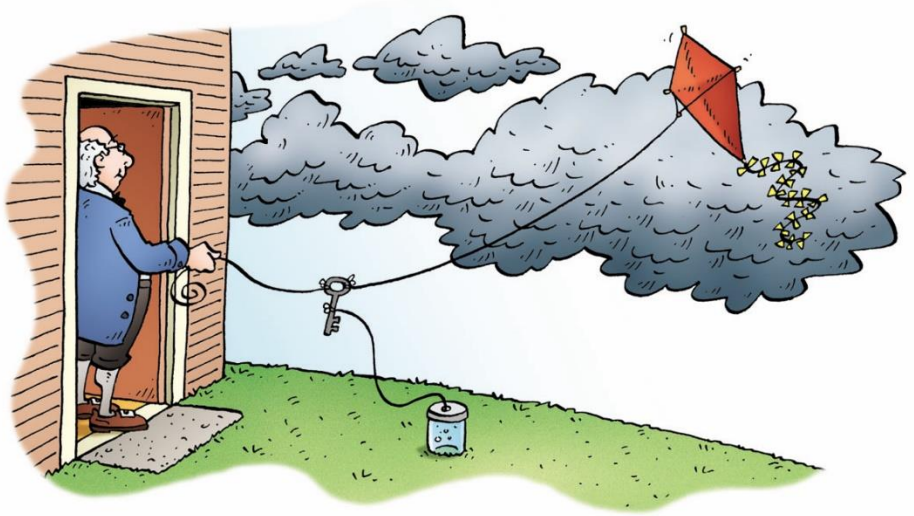

STATIC ELECTRICTY
FloridaLightning.com

9.1 Types of Electric Charge

- The effects of static electricity are all around you
  - e.g. clothes from dryer, lightning, shocks from metal doors
- A **static charge** is an electric charge that is stationary (not moving).
- Eventually static charges are **discharged**, or lost, to other objects or to the air.
- The study of static electric charge is called **electrostatics**.
- We cannot see electric charge directly.
- Instead, we observe its effects
  - e.g. lightning is a discharge of static electricity

Types of Electric Charge

- Benjamin Franklin showed that lightning is a form of electricity by flying a kite during a thunderstorm.
- Because of experiments by Franklin and others, it was determined that materials can be:
  - **Positively charged (+)**
  - **Negatively charged (-)**
  - **Uncharged or neutral (0)**



Atomic Structure and Electric Charge

- Recall from chemistry that all matter is made up of tiny particles called atoms.
  - Three smaller (subatomic) particles make up the atom: protons, neutrons and electrons.
- Protons and neutrons are strongly attached to the nucleus but electrons are outside of the nucleus are can be easily added or removed.

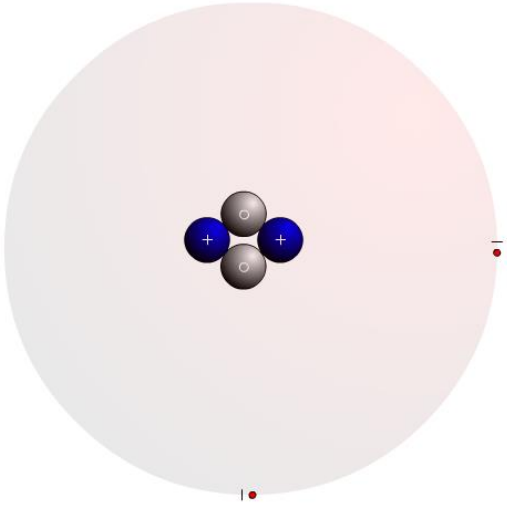
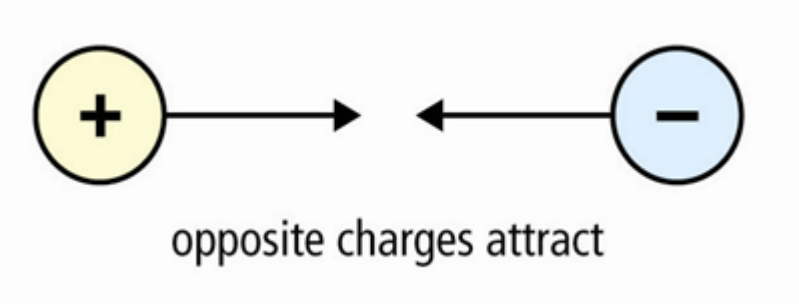


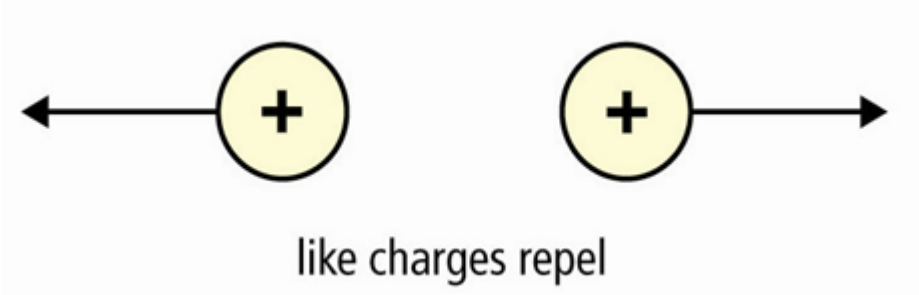
Figure 7.2 An atom

- Neutral objects are ones with equal numbers of protons and electrons.
- Charged objects have acquired a negative or positive charge depending on whether they gained (-) or lost (+) electrons.

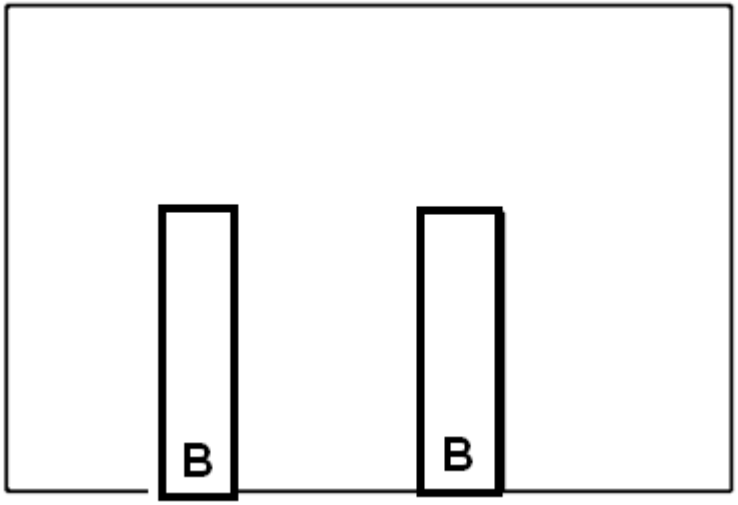
Laws of Electric Charges

- The law of electric charges states that “like charges repel and unlike charges attract”
- Two positive objects push away from each other
- Two negative objects push away from each other
- One positive and one negative will attract each other

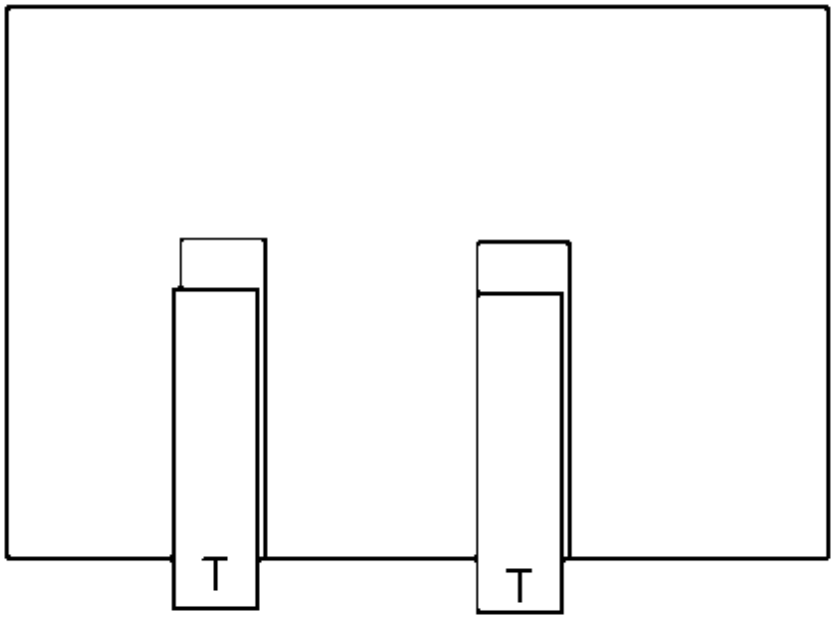




Exercise: Fun with Tape



- **Place 2 pieces of tape on your table and label the bottom ‘B’ for base**

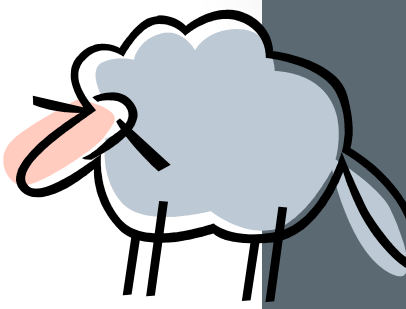


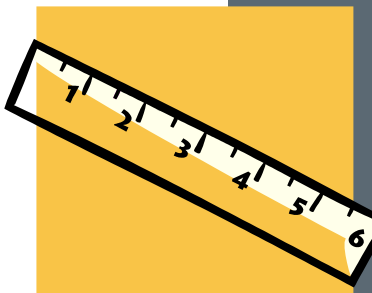
Put two tapes on top of the base tapes, call these top tapes, T.

A top, T, tape and a bottom, B tape ready to be pulled apart.

Static Electric Charge

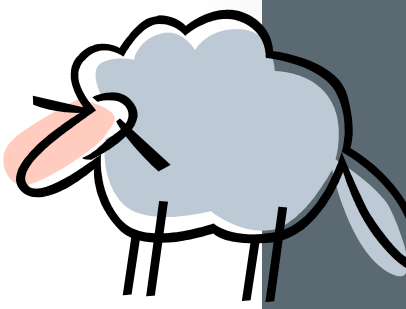
- An amber rod develops a negative charge when rubbed with wool or fur.
- A plastic rod develops a positive charge when rubbed with cotton
- When objects are rubbed against each other, they can transfer charge from one to another
  - only electrons move around – not protons.

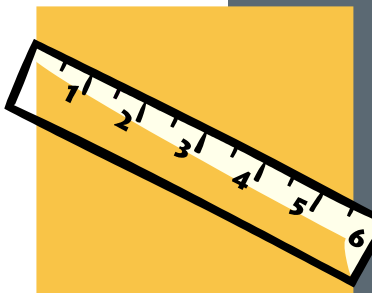




Static Electric Charge

- Some materials are more likely than others to give up electrons.
  - E.g. When acetate (a type of plastic used in overhead transparencies) is rubbed with paper, the acetate develops a **positive** (+) charge and the paper develops a **negative** (-) charge.
  - E.g. If rubber was rubbed with silk...silk is more likely to lose electrons so it would become **positively** charged, giving electrons to the rubber and making it **negatively** charged.



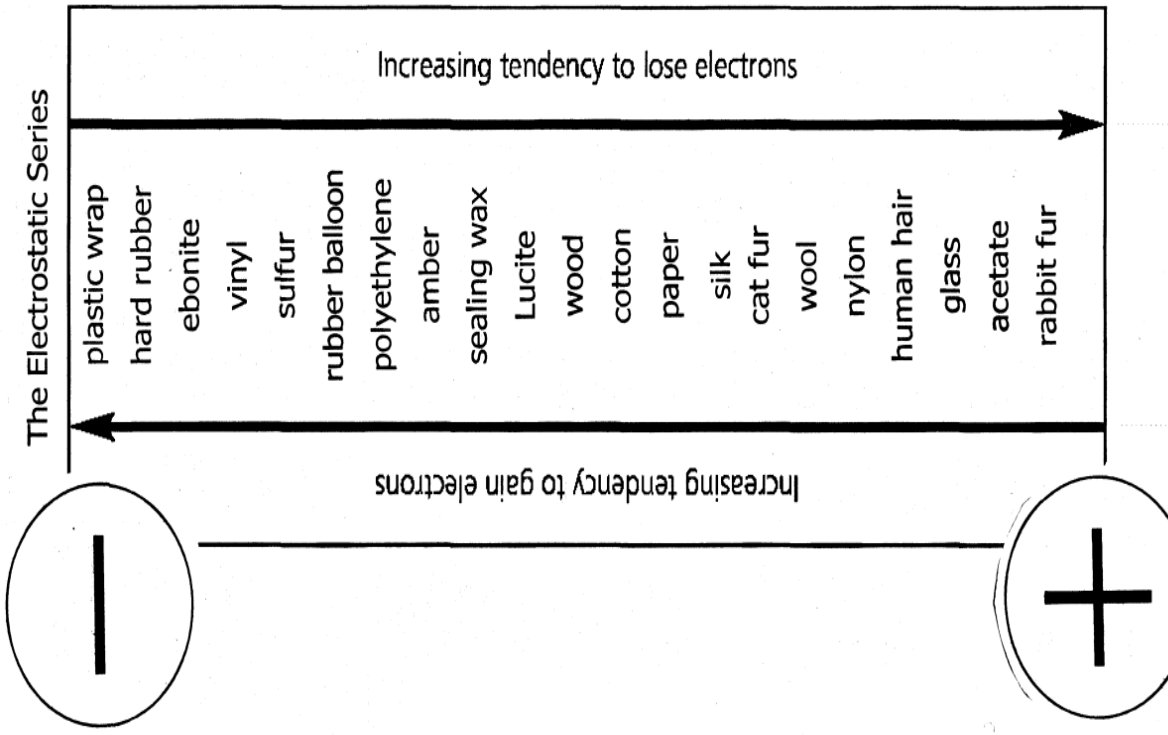


Electrostatic Series

- A list of materials in order of increasing attraction for electrons.
- It shows you which object is more likely to lose or gain electrons when two objects are rubbed against each other

due to movement

of electrons



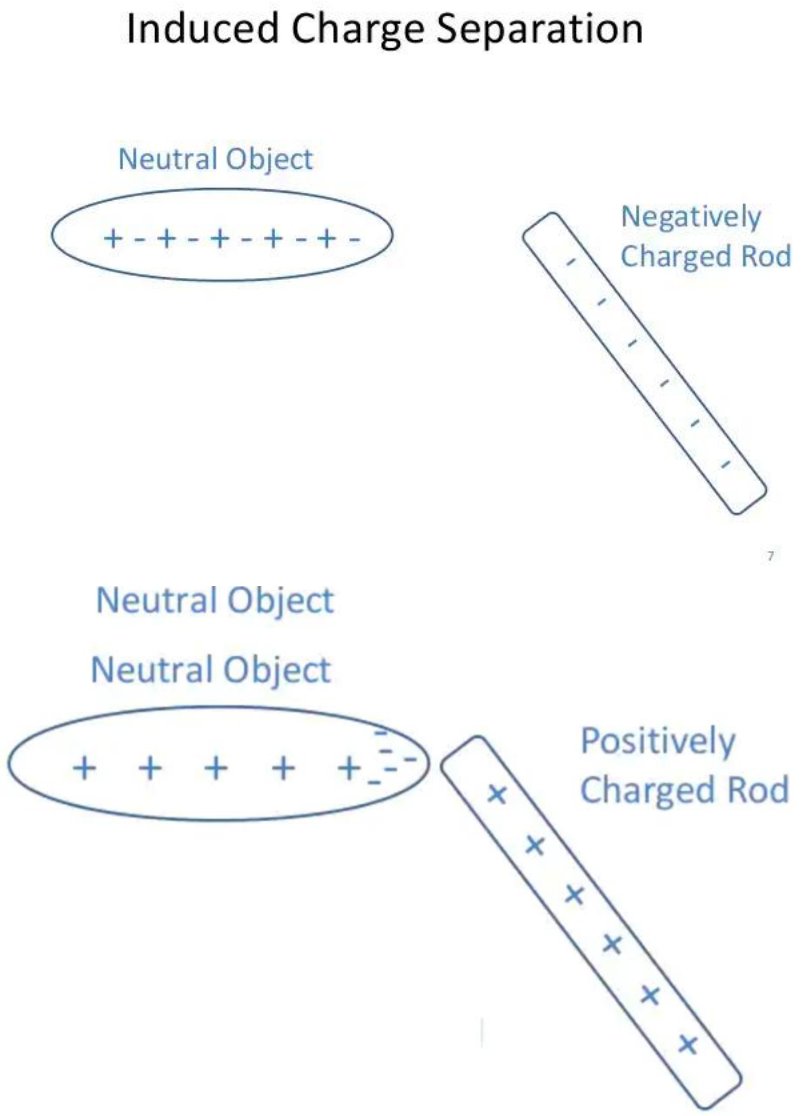
Electrostatic Series - Practice

Copy these questions onto a separate sheet of paper and answer them in full sentences. You may be asked to hand this in.

1. When the two pairs of objects are rubbed together, predict which will end up with a positive or negative charge.
2. Object A (vinyl) and Object B (amber) are both rubbed with wool for 10 seconds.
   a) What charge will the objects have before and after rubbing?
   b) Which object will have a greater (stronger) static charge?
3. How could you get glass to have a positive static charge? How could you get glass to have a negative static charge? (multiple correct answers)
4. Plastic wrap clings to practically *everything*. Use the electrostatic series to explain why this is the case.
5.
   a) What would you use to rub ebonite with to get the strongest static charge: silk, wool, human hair, or rabbit fur? Explain the science principles behind your answer.
   b) Perform the experiment you planned in 4a.
   You will measure the strength of the static charge by counting the number of hole punches stuck to the ebonite.
   c) Was your prediction correct? If NO, suggest 3 ways your experiment might have been improved to make the results more accurate.
6. Is it possible to get two rubber balloons to stick together? Draw and explain how this might be possible. Show this plan to your teacher, who may allow you to try this experiment.

Attraction of Neutral Objects to Charged Objects

- When a charged object is brought near to a neutral object, the electrons in the neutral object shift so that the end of the neutral object is attracted to the charged object.
- Although there is a slight shift of charges within the neutral object, it does not gain or lose electrons and is still neutral.
- This charging effect is known as **induced charge separation**.



9.2 Friction, Conduction, and Induction

Three methods of charging:

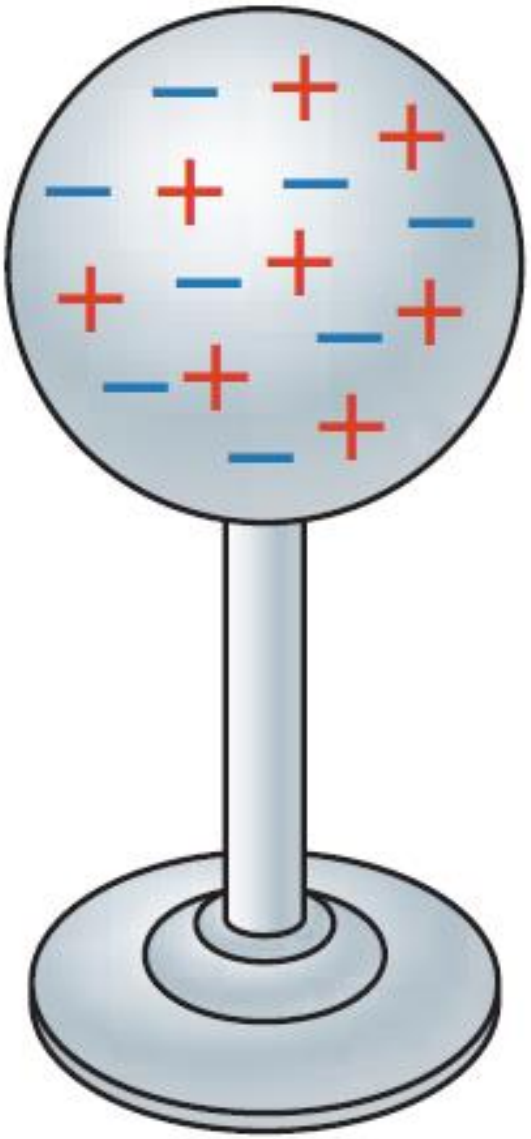
1. **Friction**: occurs when two objects are rubbed together
   - the objects will have opposite charges at the end
2. **Conduction** (contact): occurs when objects touch and an electric charge is transferred from one object to the other
   - both objects will have the same charge at the end
3. **Induction**: results from charging without touching or making any direct contact
   - creates areas of opposite charge on the objects

Conduction

- Occurs when objects touch and an electric charge is transferred from one object to the other.
  - E.g. When you walk across a carpet and get a spark by touching a metal doorknob, you are transferring some of your charge to the doorknob.

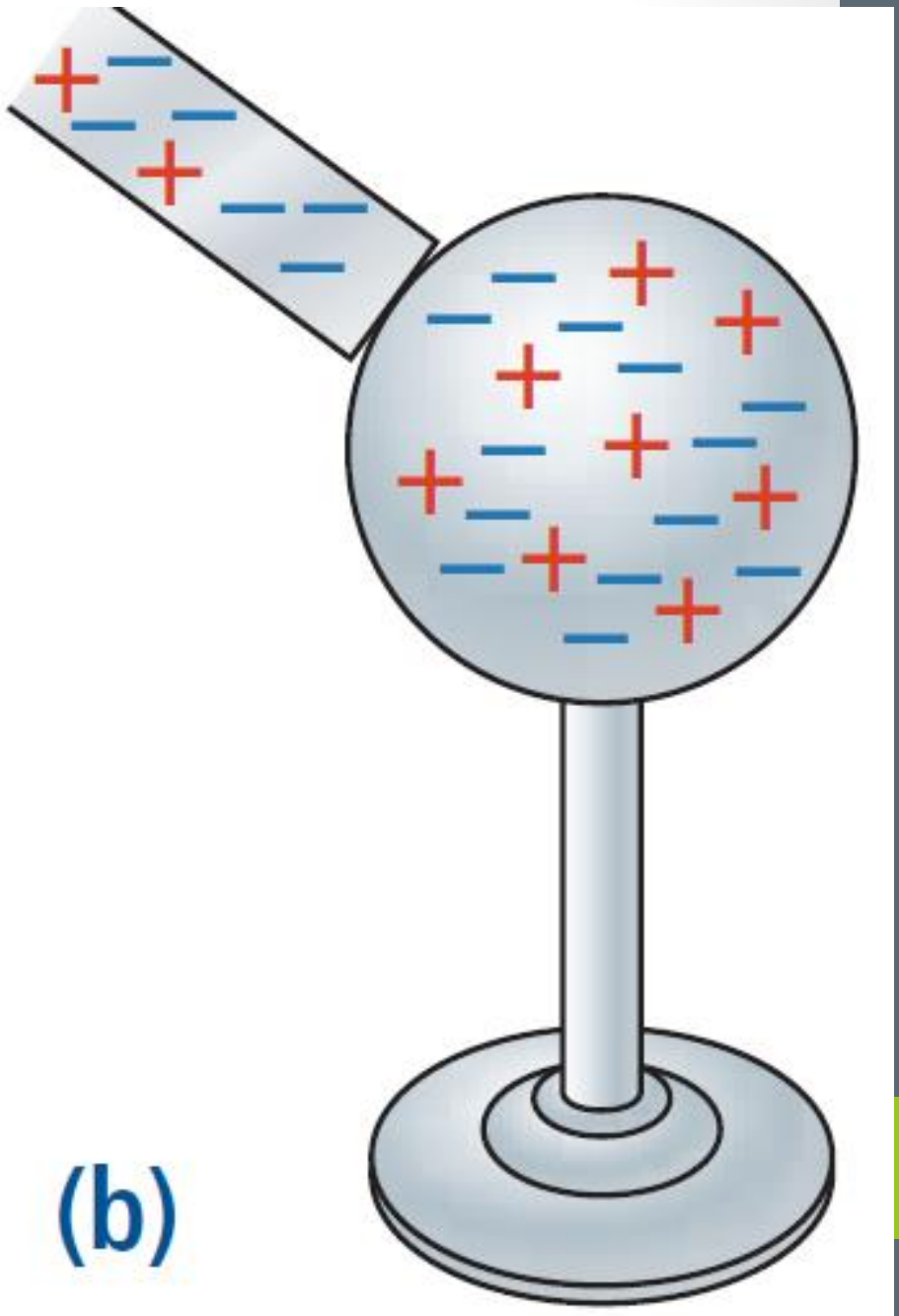
Charging by Conduction (contact)

A neutral metal sphere

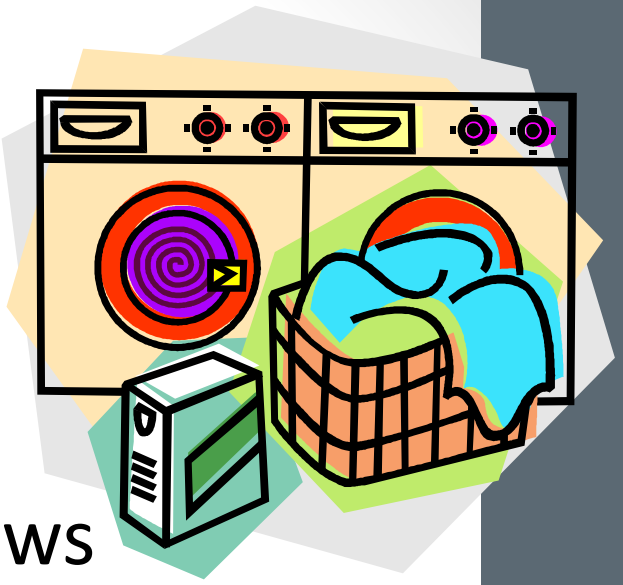


(a)

When a negatively charged bar contacts the sphere, some of the extra electrons move to the sphere, giving it a negative charge.



Charging by Friction

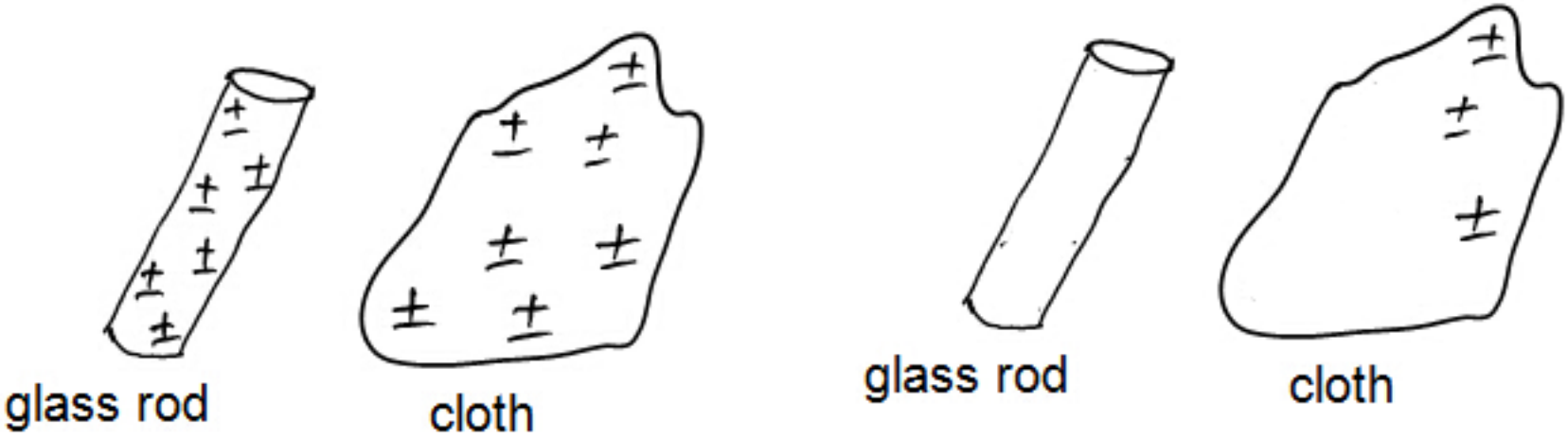


- This method of charging objects involves rubbing two neutral objects together. The contact allows electrons to be transferred from one substance to the other substance.
- One substance will gain negatively electrons (and become negatively charged) while the other will lose electrons (and become positively charged).

Charging by Friction

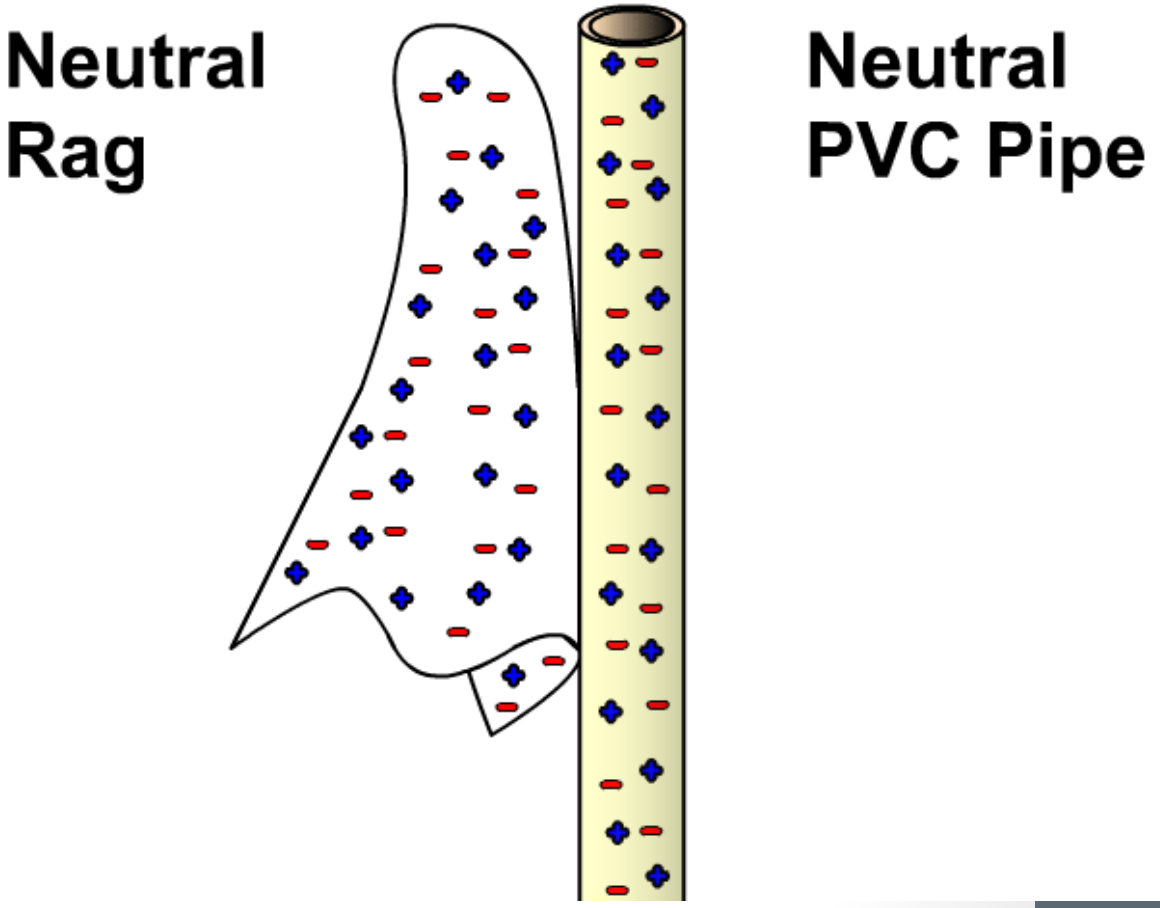
- Since the two objects have attract opposite charges, they will attract each other.

- Use the Electrostatic Series table to find out which material are more likely to lose electrons



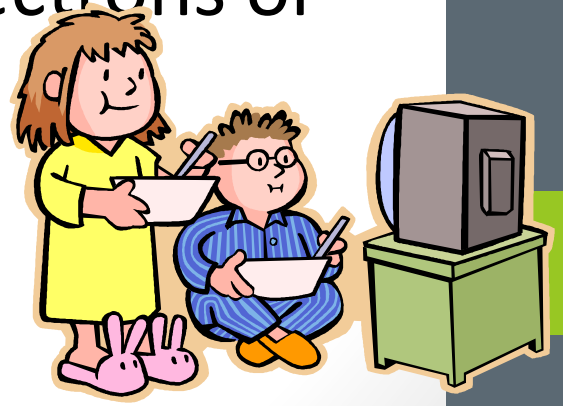
Charging by Friction

- The Rag tends to lose electrons and become positive
- The PVC gains electrons and become negative



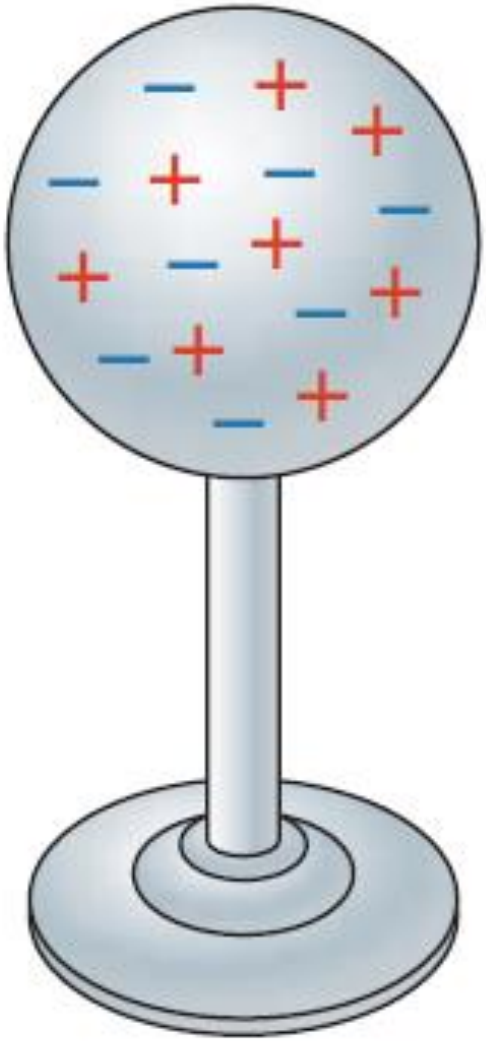
Induction

- When objects are charged without touching or making any direct contact (charge from a distance)
- If we bring a charged object near to a neutral object, we can induce a charge in the neutral object because electrons move to get farther away from other electrons or closer to protons.
  - E.g. Build-up of dust on a TV screen



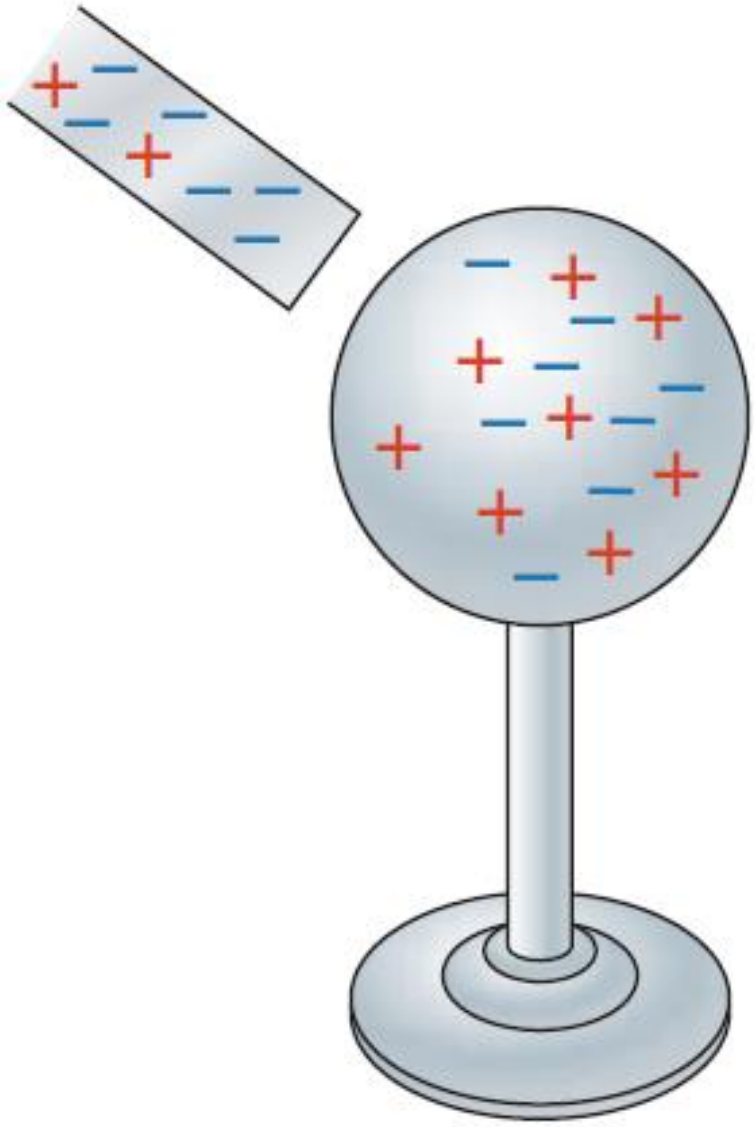
Charging by Induction

What happens when a negatively charged bar comes near the sphere?



(a) A neutral metal sphere

The charge on the bar causes, or induces, the electrons on the sphere to change their position.

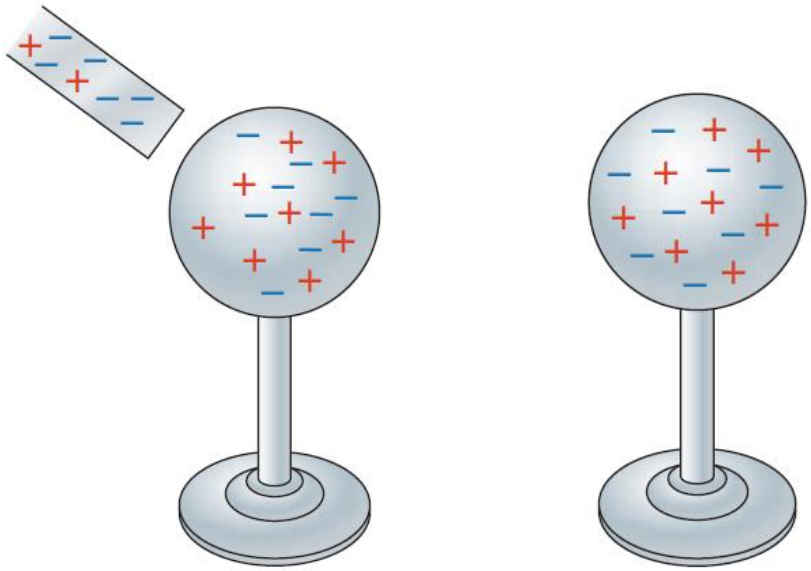


(b)

Article with animations: https://stickmanphysics.com/stickman-physics-home/unit-7-electrostatics/electrostatics-conduction-induction-and-friction/

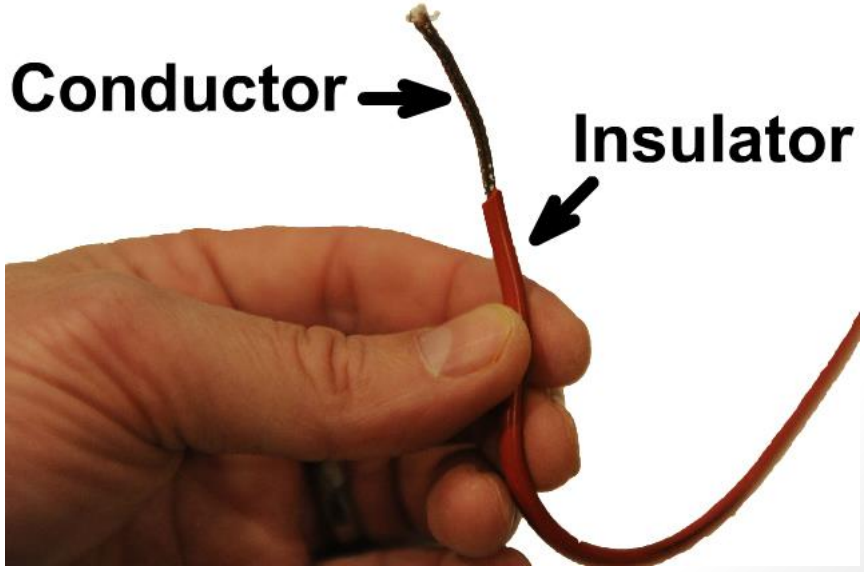
Induced Charge is Temporary

- An object that has been charged by induction is still electrically **neutral**, overall, because there are an equal number of positive and negative charges.
- When the **charged object is removed**, the charges on the neutral object will slowly spread out until they return to their original position.



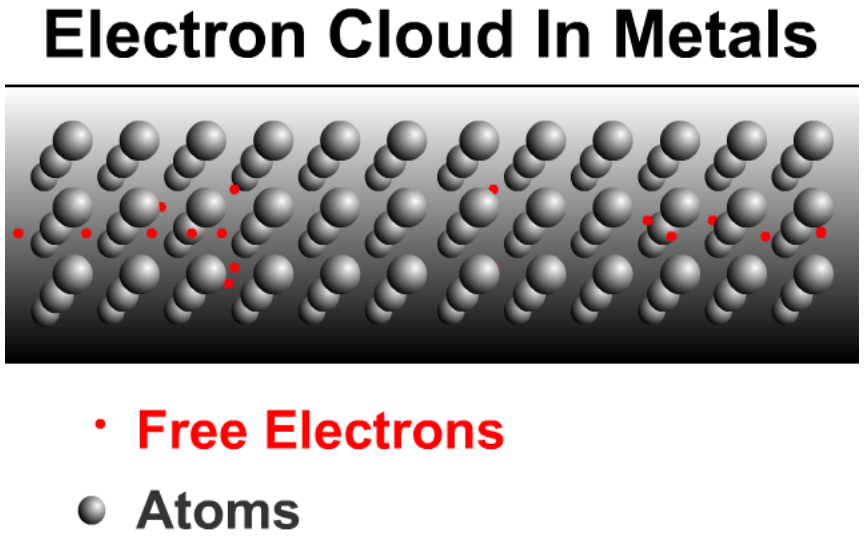
9.3 Insulators and Conductors

- Some materials are able to acquire electrical charges that stay on them for some time.
- These materials are called **insulators**.
- Insulators are substances in which the electrons are so tightly bound to the atoms making up the material that they are not free to move to a neighboring atom.
  - Rubber
  - Plastic
  - Glass
  - Wood
  - Air



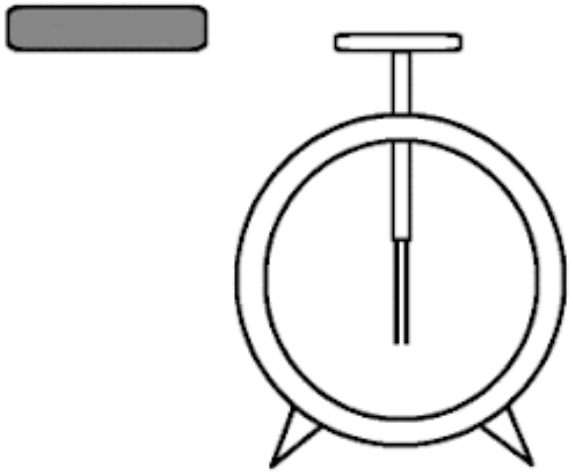
9.3 Insulators and Conductors

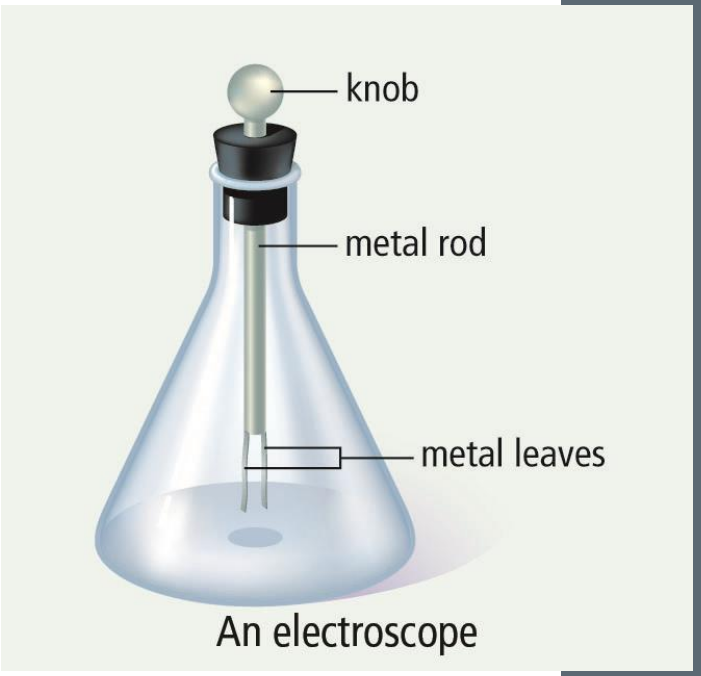
- Other materials, called **conductors**, allow electrons to flow freely from one atom to another E.g. metals
  - Silver
  - Copper
  - Gold
  - Aluminum



A Metal-Leaf Electroscope

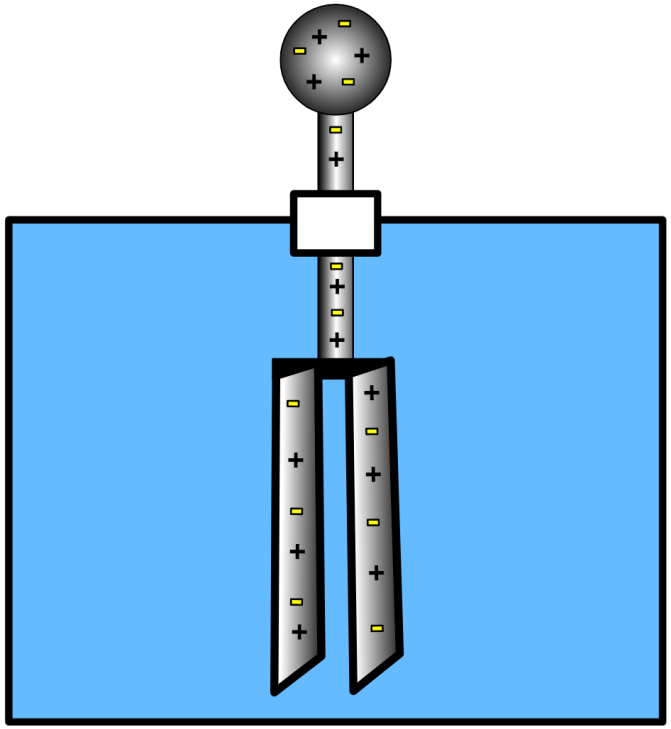
- Used to determine the presence of electric charges.





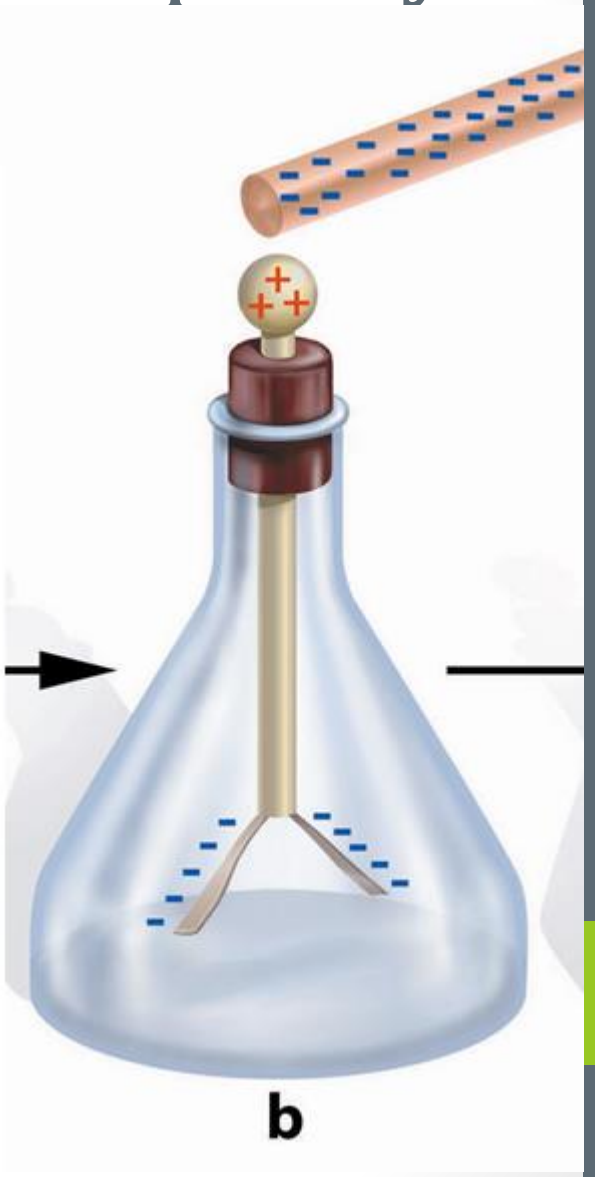
Charging by induction - Temporary

- In a neutral electroscope the leaves are not separated.
- Number of proton (+) equals to the number of electrons (-) on the leaves. --> Neutral!!



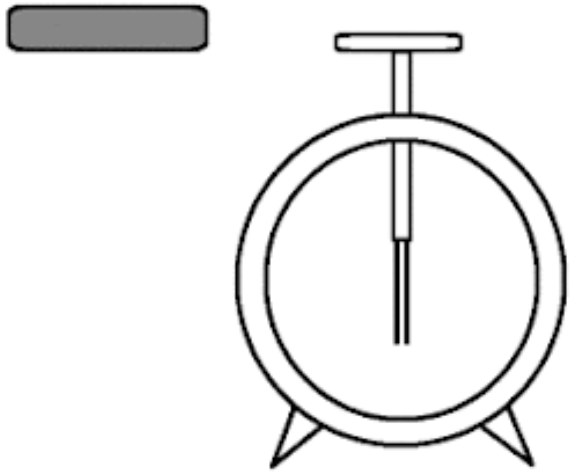
Charging by induction - Temporary

- When a negatively charged strip is brought near the electroscope, it induces a separation of charge.
- The ball on the top of the electroscope becomes positively charged and the two leaves become negatively charged.
- Since the two leaves have the same charge, they repel each other and spread out.



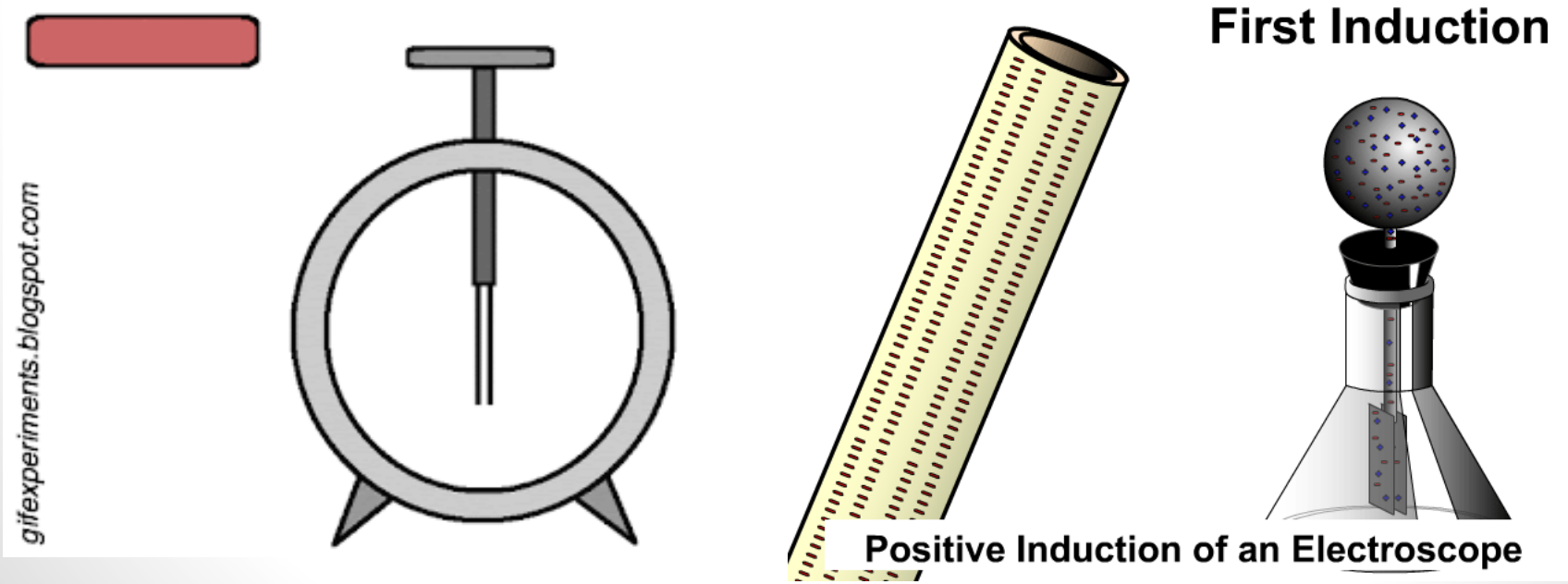
Charging by induction - Temporary

- When the charged object is removed, there is no longer an induced separation of charge and the leaves return to their original position.



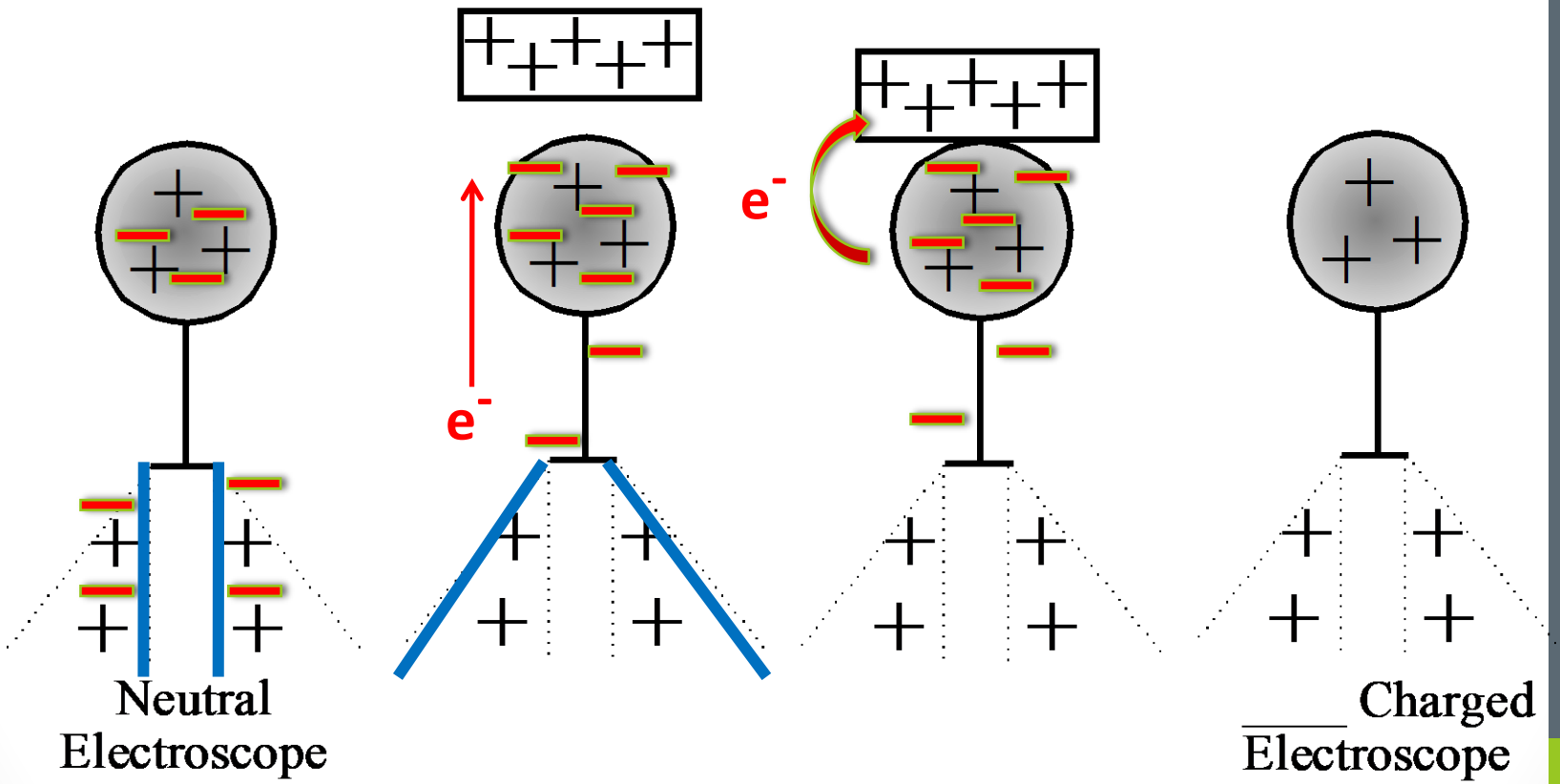
Charging by Conduction

- We can make the static charge stay on the leaves for longer if the charged object comes into contact with the metal knob on the electroscope.
- As soon as contact occurs there is **conduction**, electrons leap off a charge object making it negative as well



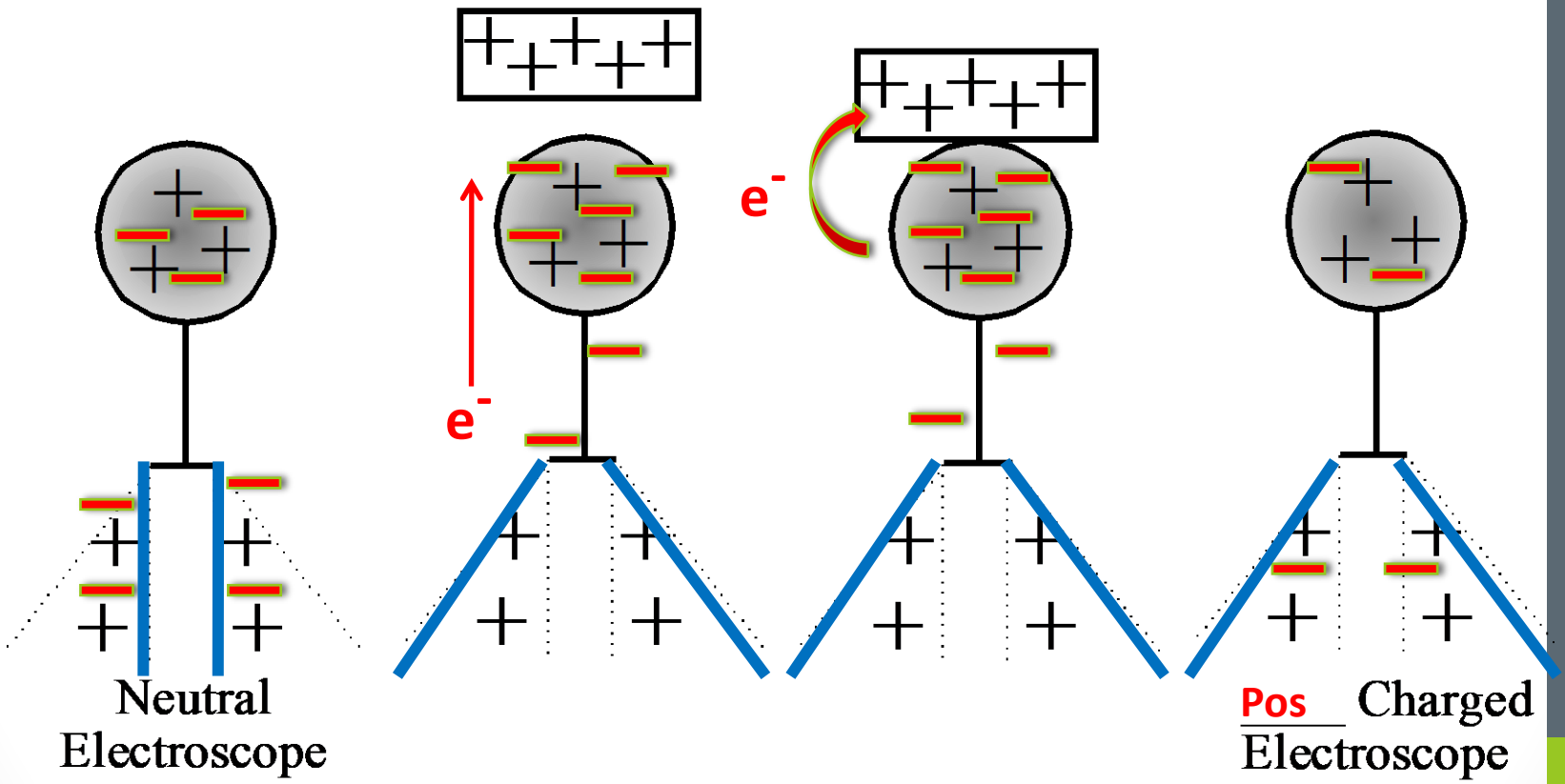
Charging by Conduction

Figure 2

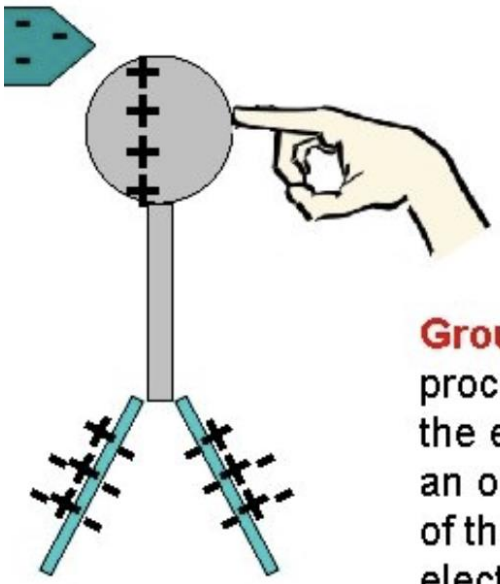


Charging by Conduction

Figure 2



Charging by Conduction

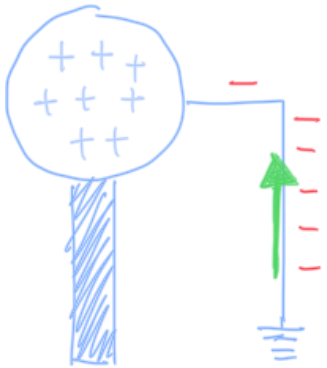


Grounding is the process of *removing* the excess charge on an object by means of the transfer of electrons between it and another object of substantial size.

- You can reset a charged electroscope to its neutral state by grounding it.
- This can be achieved by touching the metal knob with your finger to ensure all excess charges are removed or discharged to the ground.

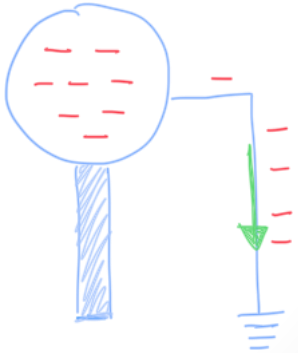
Grounding

- When a charged object touches a large neutral object such as Earth, the charged object becomes grounded and loses its net charge. ex) An object is **grounded** if it is connected to Earth by a conductor.



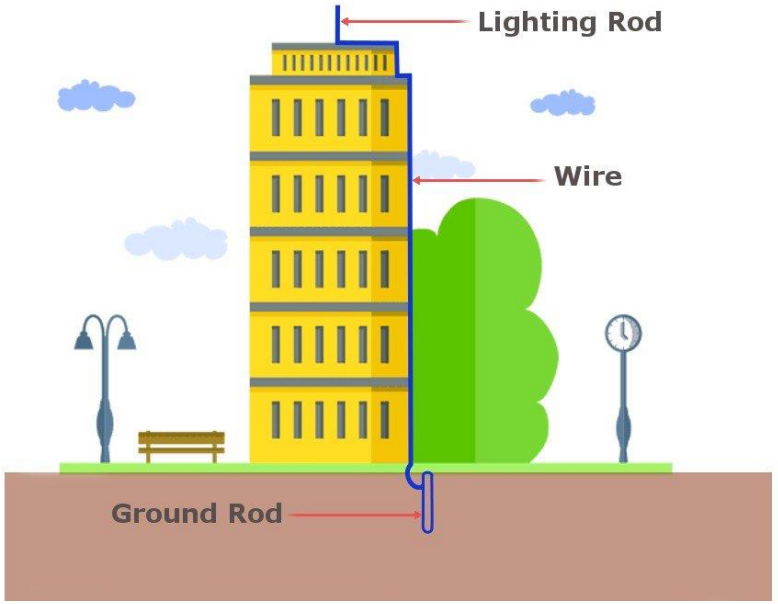
  - If the charged object was positively charged, electrons from the Earth move toward the charged object.

  - If the charged object was negatively charged, electrons move away from the charged object toward the Earth



Grounding

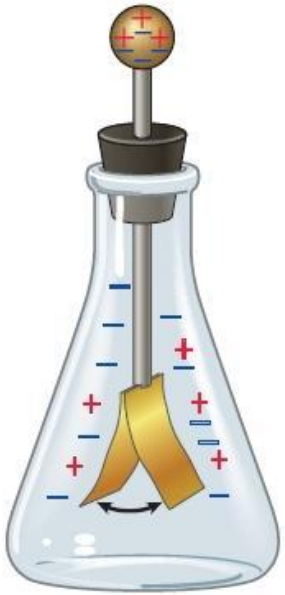
- If a conductor has a sharp point, that area receives a greater concentration of charge.
- This is why lightning rods placed on the top of buildings have a pointed end.
- A conductor goes from the rod to the ground which prevents the lightning from going through the building.



Charging by induction – Permanent

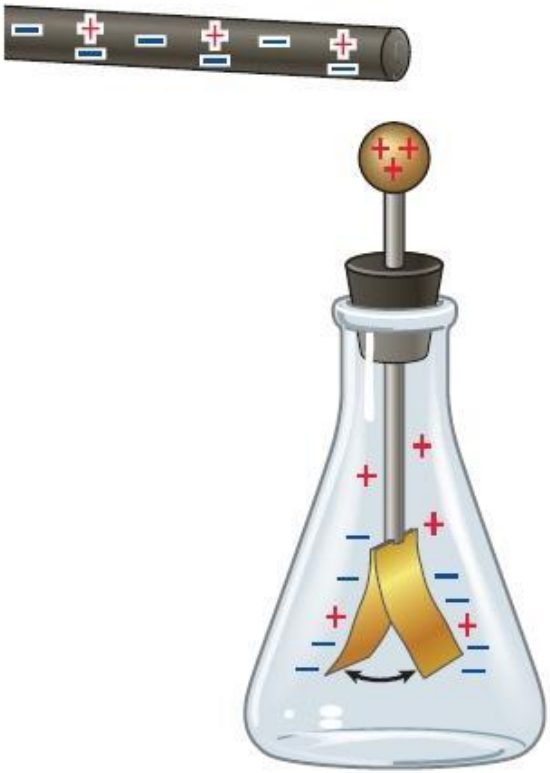
3 Steps for Permanent CHARGING BY INDUCTION

1. charged object induces a charge separation in the neutral object
2. the neutral object is grounded (i.e. electrons move to/from ground)
3. object now has the opposite charge to the charged object used



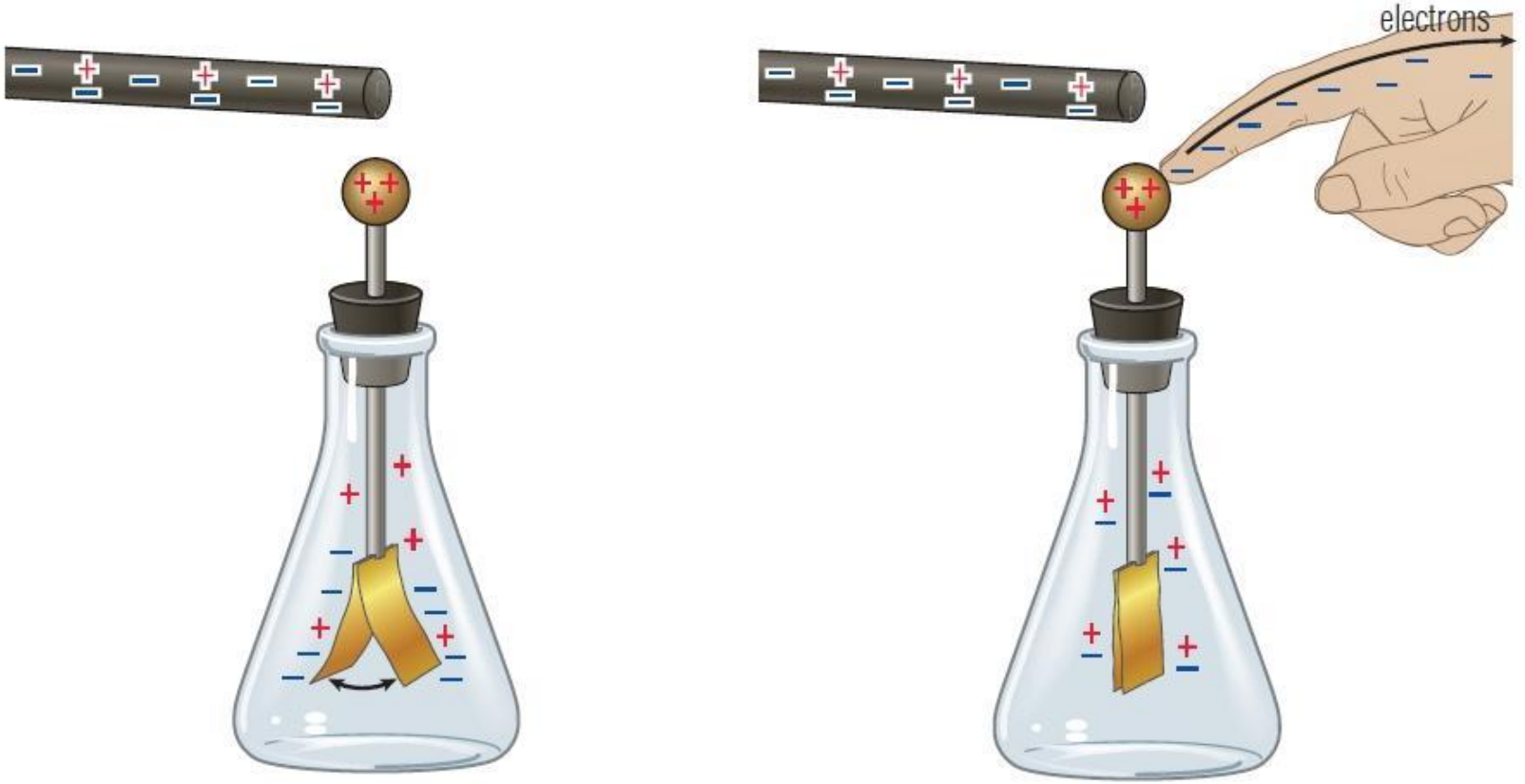
Charging by induction – Permanent

- Like we've seen, when a negatively charged object comes near a neutral electroscope, it repels the electrons in the neutral electroscope downwards. This causes the leaves to repel one another.



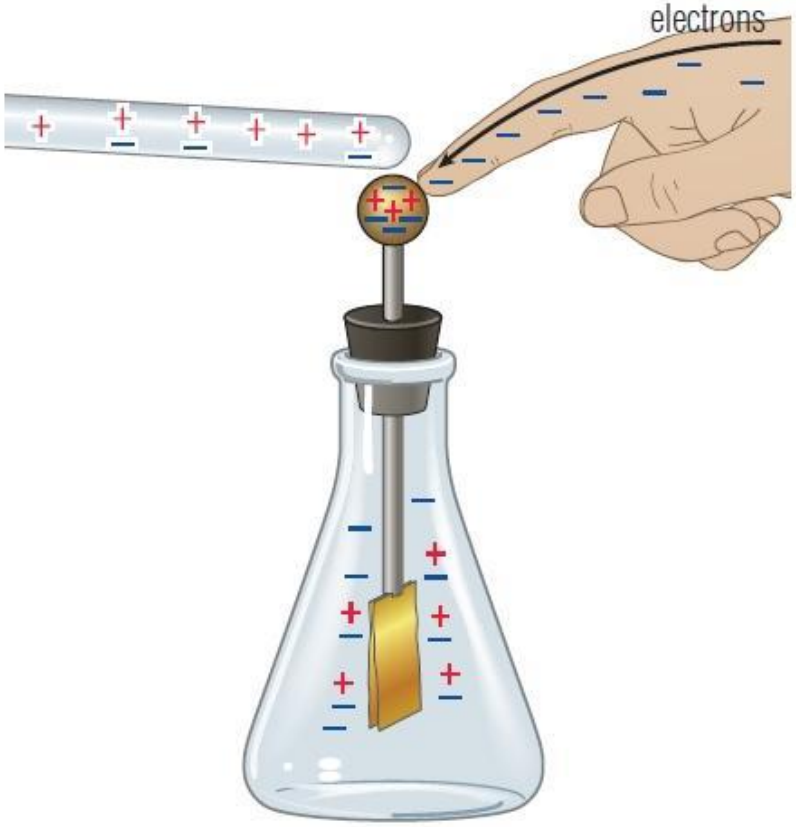
Charging by induction – Permanent

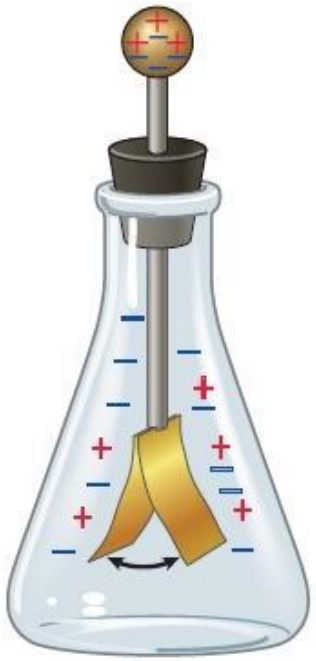
- When the neutral electroscope is grounded, its electrons are provided with a path away from the repulsive influence. As a result, some electrons leave the electroscope. The leaves now return to their neutral position.



Charging by induction – Permanent

- When the ground and charged object are removed, the electroscope is left with a Positive charge because it has lost electrons. The leaves once again repel each other.





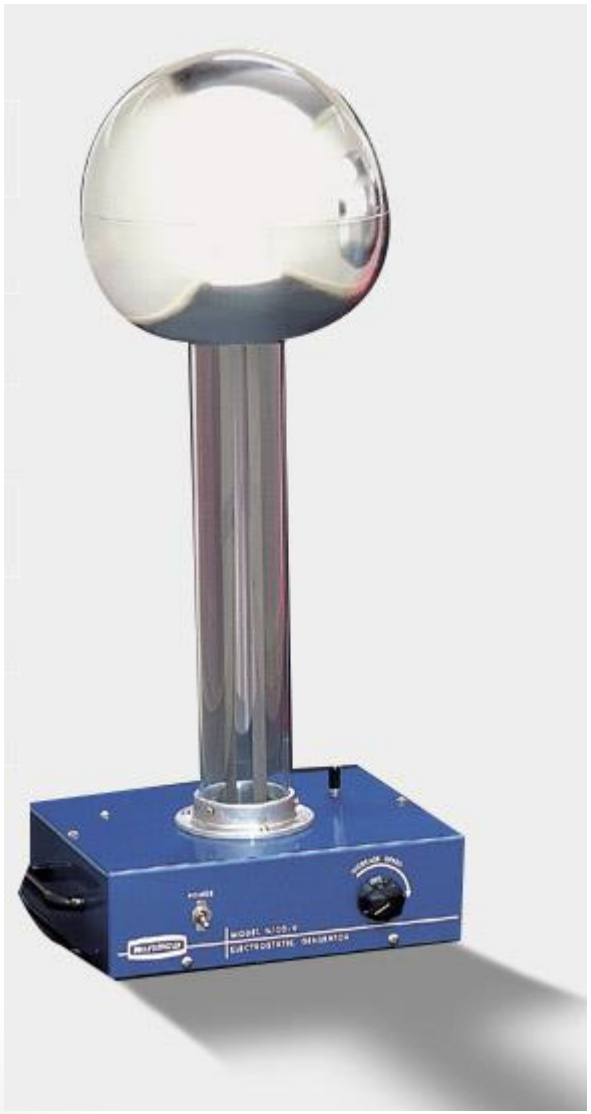
9.4 Electric Force

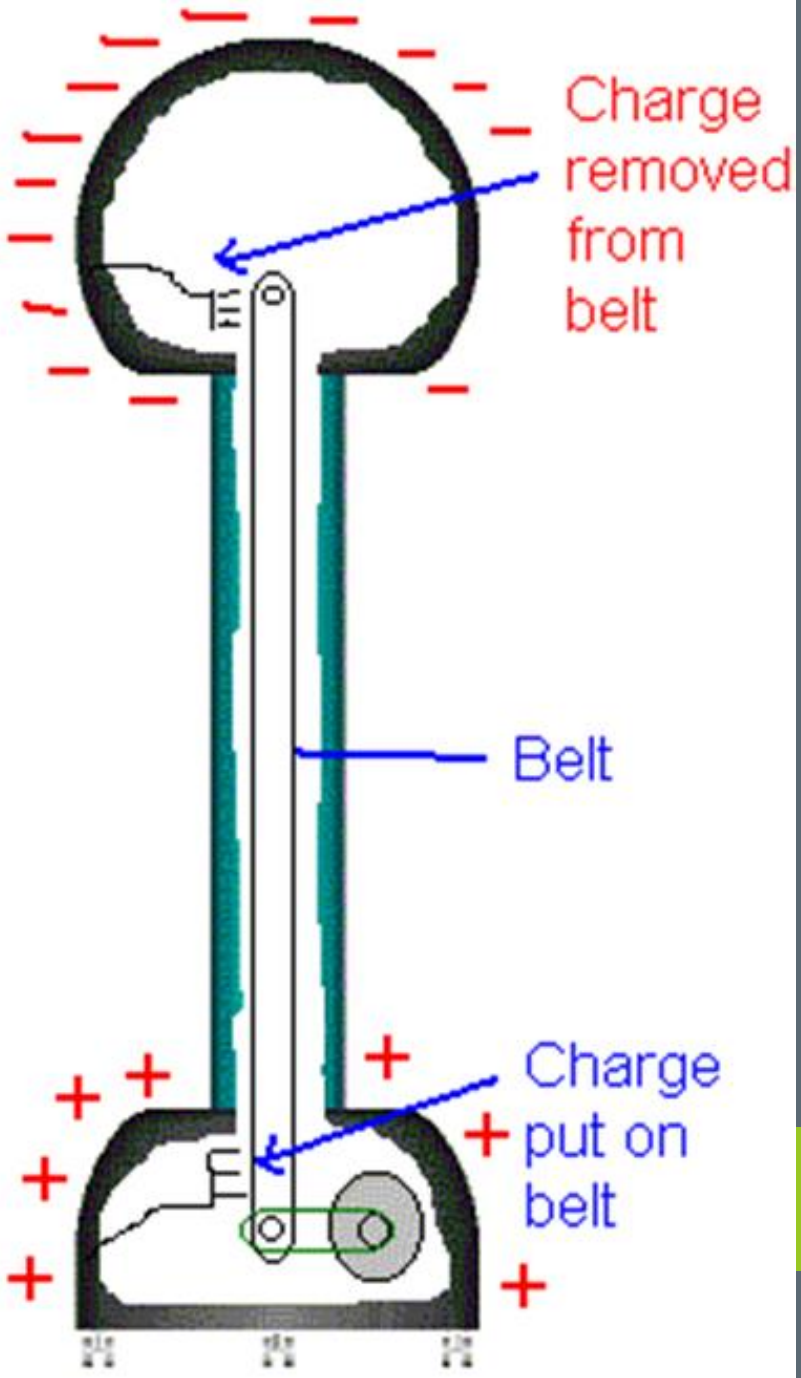
9.4 Electric Force

- The **Van de Graff generator** is a device that separates large quantities of electric charge.
- A charge (negative or positive) is transferred onto a moving belt at the base of the generator and is transferred off the belt onto the metal dome where they spread out across the outside surface.

- Can produce very large electric charges which can be used to investigate electric forces.

Van de Graff





- The **electric force** (aka electrostatic force) is the force that exists between static charges.
- It can either pull charges together (attraction) or push charges apart (repulsion)
- The strength of the electric force increases with increasing electric charge and decreases with increasing distance (**Coulomb's Law**)
- The SI unit for size of the electric charge is called the **Coulomb** (**C**)
  - **Q**: is the symbol for charge

9.5 Applications of Static Electricity

- There are several applications of static electricity such as
  - Lightning
  - laser printers
  - fabric softener sheets and static cling
  - electrostatic precipitators