Physics 122: Electricity & Magnetism – Lecture 2 Electric Charge

Baris EMRE

Electricity in Nature

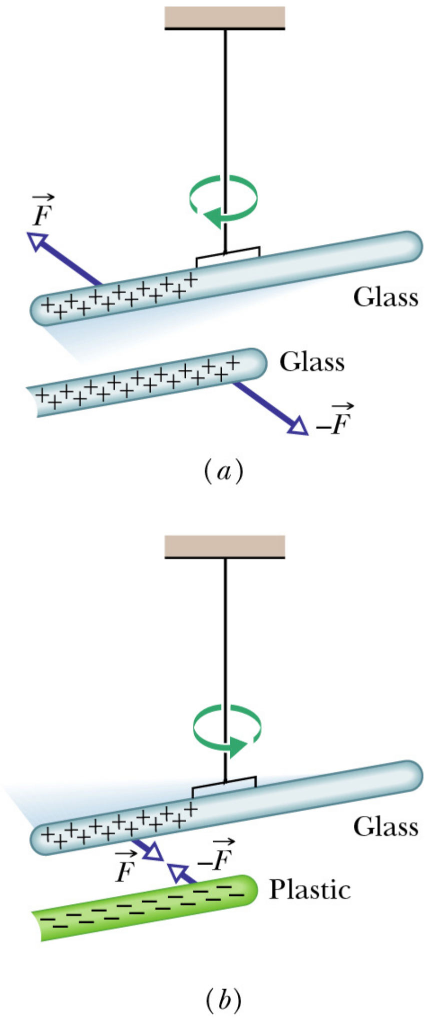
- Most dramatic natural electrical phenomenon is lightning.
- Static electricity (balloons, comb & paper, shock from a door knob)
- Uses—photocopying, ink-jet printing

Demonstrations of Electrostatics

- Balloon
- Glass rod/silk
- Plastic rod/fur
- Electroscope
- Van de Graaf Generator

Glass Rod/Plastic Rod

- A glass rod rubbed with silk gets a positive charge.
- A plastic rod rubbed with fur gets a negative charge.
- Suspend a charged glass rod from a thread, and another charged glass rod repels it.
- A charged plastic rod, however, attracts it.
- This mysterious force is called the electric force.
- Many similar experiments of all kinds led Benjamin Franklin (around 1750) to the conclusion that there are two types of charge, which he called *positive* and *negative*.
- He also discovered that charge was not created by rubbing, but rather the charge is transferred from the rubbing material to the rubbed object, or vice versa.

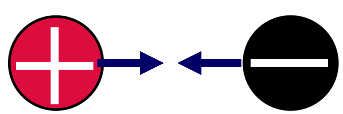


Forces Between Charges

- We observe that

Like charges repel each other

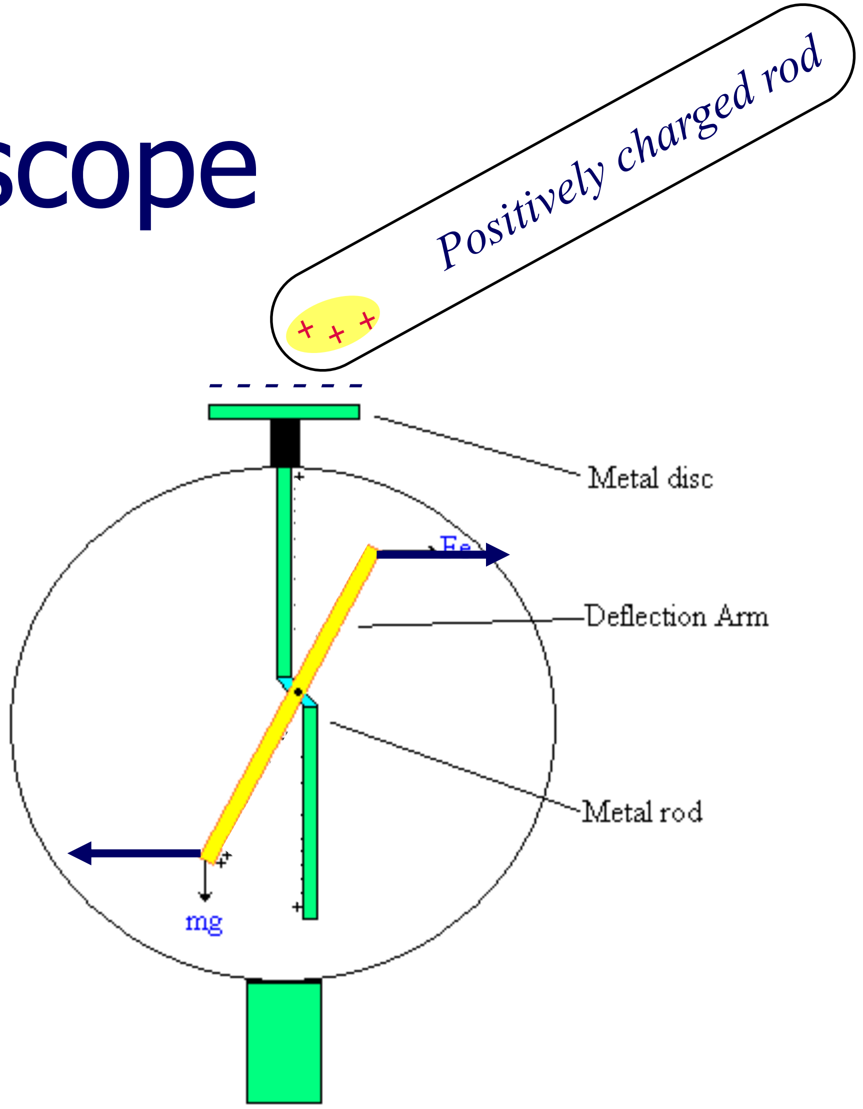
Opposite charges attract each other



Electroscope

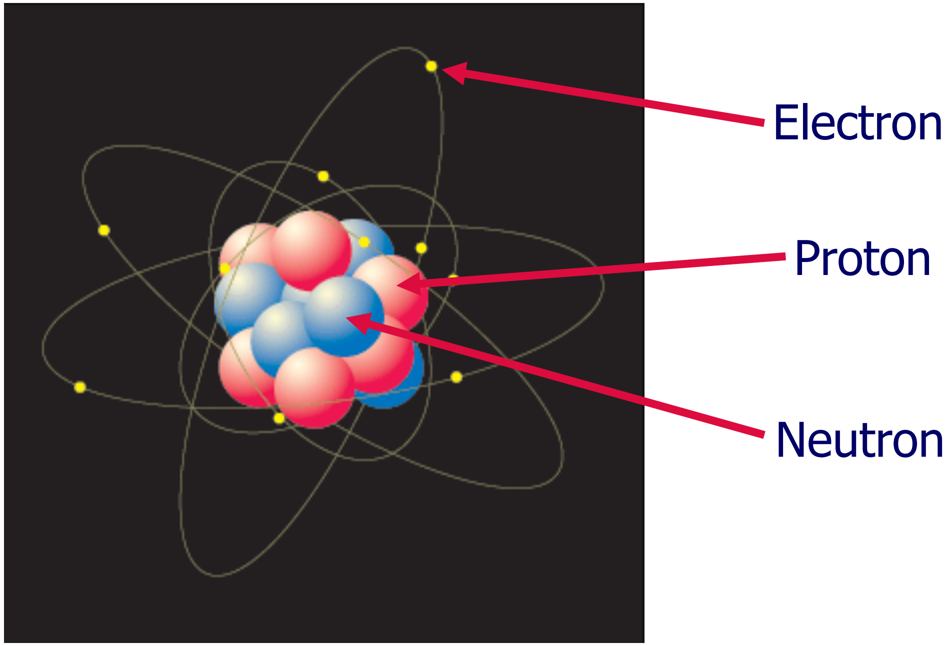
- This is a device that can visually show whether it is charged with static electricity.
- Here is an example charged positive.
- Notice that the charges collect near the ends, and since like charges repel, they exert a force sideways.
- You can make the deflection arm move by adding either positive or negative charge.
- BUT, we seem to be able to make it move without touching it.
- What is happening?

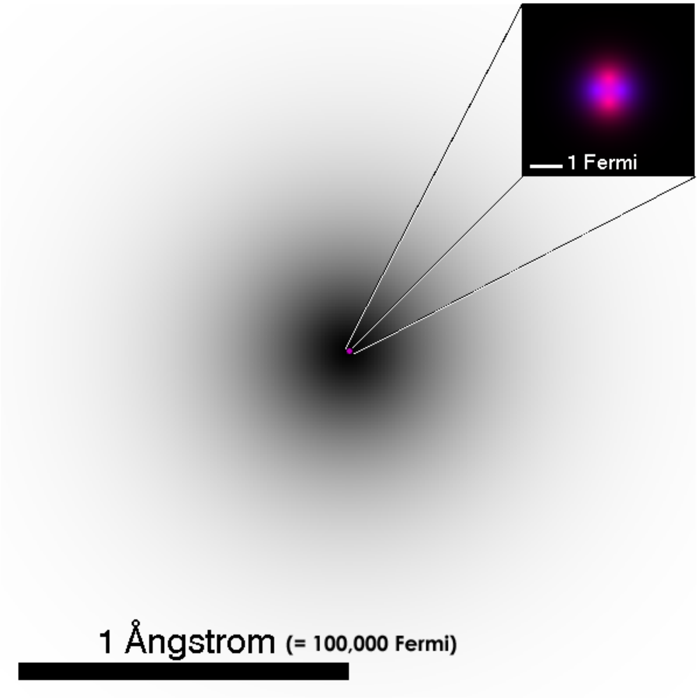
Electrostatic Induction



The Atom

- We now know that all atoms are made of positive charges in the nucleus, surrounded by a cloud of tiny electrons.





Proton charge +e, electron charge –e where $e = 1.602\times10^{-19}$ C

More accurate picture of the atom—the Helium atom

The Atom

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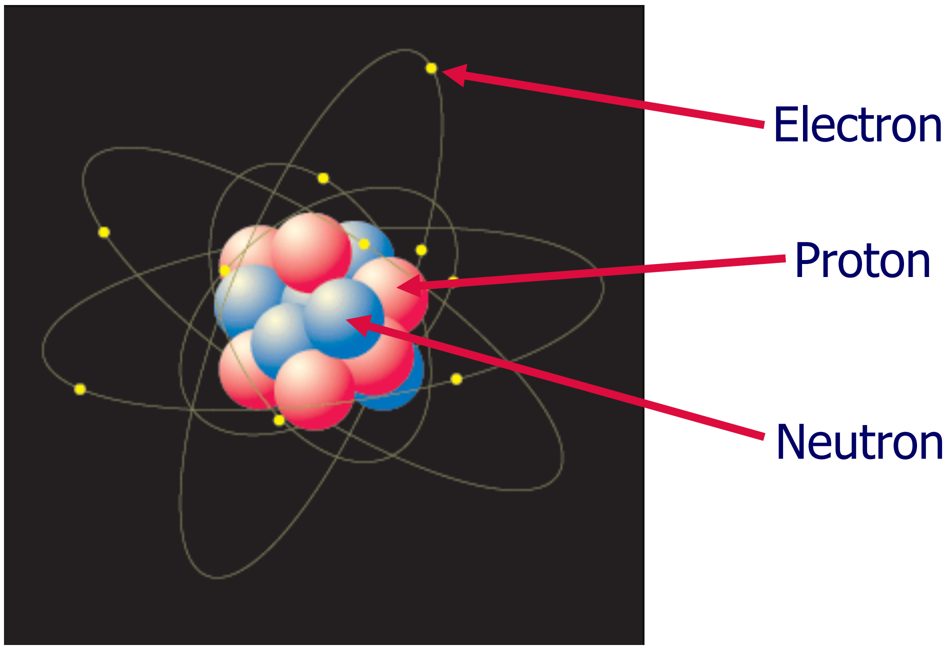


Proton charge +e, electron charge −e
where $e = 1.602 \times 10^{-19}$ C

- Atoms are normally neutral, meaning that they have exactly the same number of protons as they do electrons.
- The charges balance, and the atom has no net charge.

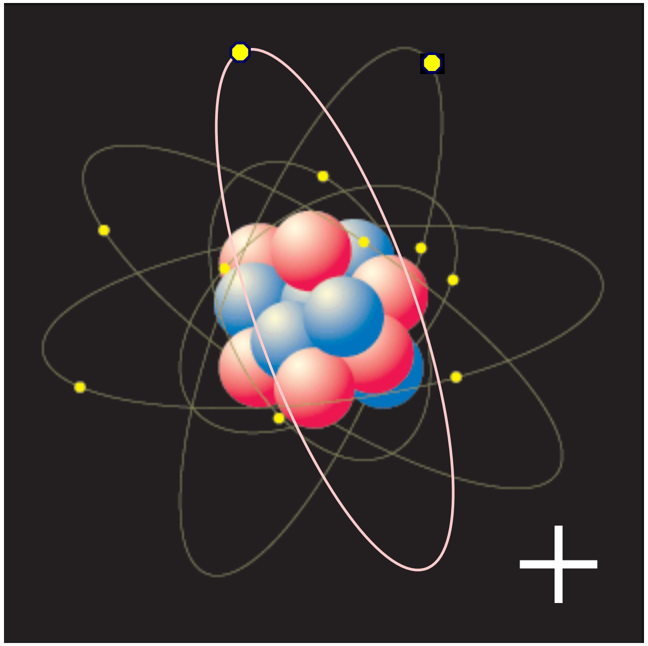
2. Which type of charge is easiest to remove from an atom?

A. Proton

B. Electron

The Atom

- In fact, protons are VASTLY more difficult to remove, and for all practical purposes it NEVER happens except in radioactive materials. In this course, we will ignore this case. Only electrons can be removed.



Proton charge $+e$, electron charge $-e$ where $e = 1.602 \times 10^{-19}$ C

3. If we remove an electron, what is the net charge on the atom?

A. Positive

B. Negative

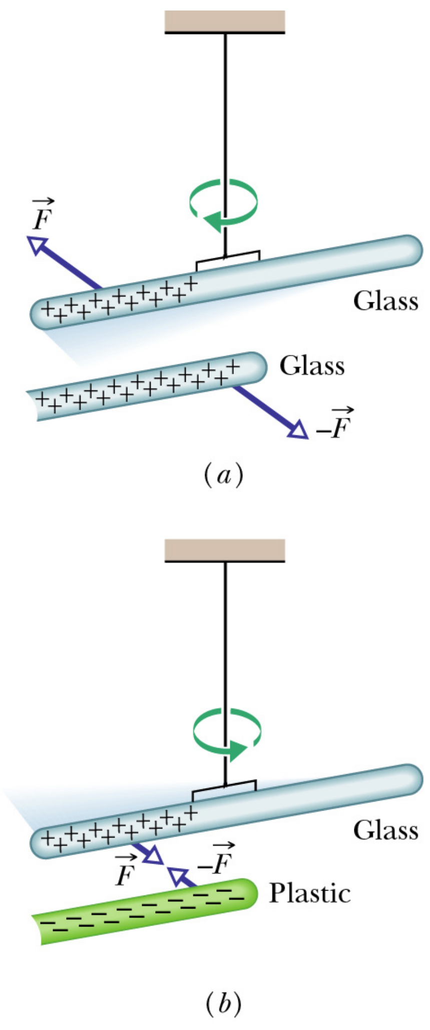
If we cannot remove a proton, how do we ever make something charged negatively? By adding an "extra" electron.

Glass Rod/Plastic Rod Again

- We can now interpret what is happening with the glass/plastic rod experiments.
- Glass happens to lose electrons easily, and silk grabs them away from the glass atoms, so after rubbing the glass becomes positively charged and the silk becomes negatively charged.
- Plastic has the opposite tendency. It easily grabs electrons from the fur, so that it becomes positively charged while the fur becomes negatively charged.

The ability to gain or lose electrons through rubbing is called *Triboelectricity*.

Tribo means rubbing



Triboelectric Series

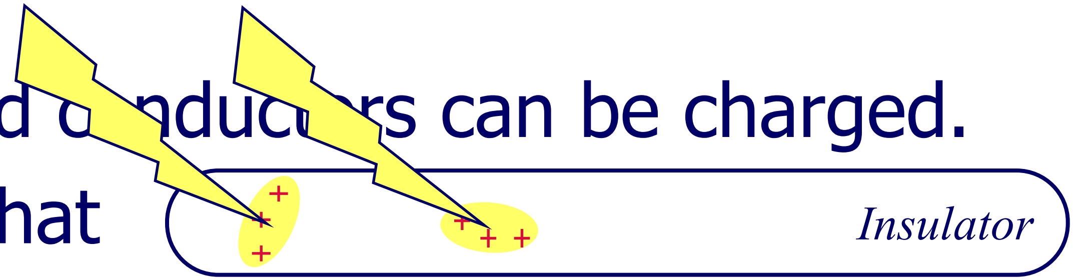
Most Positive
(items on this end lose electrons)

asbestos
rabbit fur
glass
hair
nylon
wool
silk
paper
cotton
hard rubber
synthetic rubber
polyester
styrofoam
orlon
saran
polyurethane
polyethylene
polypropylene
polyvinyl chloride (PVC pipe)
teflon
silicone rubber

Most Negative
(items on this end steal electrons)

Insulators and Conductors

- Both insulators and conductors can be charged.
- The difference is that



  - On an insulator charges are not able to move from place to place. If you charge an insulator, you are typically depositing (or removing) charges only from the surface, and they will stay where you put them.
  - On a conductor, charges can freely move. If you try to place charge on a conductor, it will quickly spread over the entire conductor.