10.1 - Electric Charge & Conservation

Classic balloon party trick - rub a balloon on your hair, and stick it to the smartboard.
I've established an electric charge on the balloon.

Two kinds of charge: positive(protons) and negative (electrons).

Like charges repel → unlike charges attract.

By convention, the charge on the balloon is negative, hair is positive.

Elementary Charge Data:

See Resources Page 5: (Note AP Resources)

Electron Charge: – 1.60 E-19 Coulombs (C)
Proton Charge: + 1.60 E-19 Coulombs (C)

Specific symbol of charge is q (quantity) in equations, general symbol is Q.

Other Details:
Electron Mass = 9.11 E -31 kg
Proton Mass = 1.67 E -27 kg

Electric Charge is Conserved

Atoms & molecules are neutral: electrons = protons.

Ions have a net charge: more or fewer electrons than a neutral atom or molecule.

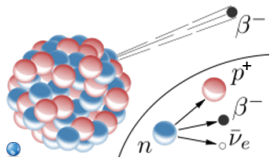
Charge has a tendency to transfer between unlike materials.

In the demonstration, positive (+) charge on hair equal in magnitude to negative (–) charge on balloon.

Electric Charge is Conserved

Law of Conservation of Charge: the net charge of an isolated system remains constant.

Even nuclear decays conserve charge!
Beta decay – a neutron spontaneously changes to a proton, ejecting an electron in the process.



Electrostatic Charging Methods

Ways to charge something:

1. Friction: Rubbing two materials together.
Ex: balloon and hair, scuffing feet across carpet.

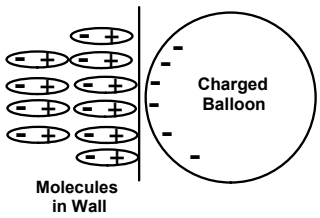
2. Conduction (Contact): Flow of electrons by touching one charged object to a non-charged object.
Ex: shocking a friend after scuffing feet across carpet.

Electrostatic Charging

3. Induction: Holding charged object near non-charged one, then grounding non-charged one.
(Electroscope Demo)

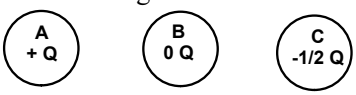
4. Polarization: Molecular charges shift as charged object approaches. Similar to induction, but no net charge occurs.
NOTE: Charged object (+ or -) is attracted to uncharged one.

Ex: Balloon stuck on board.



1. Charged Object Question A

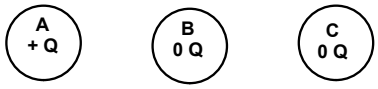
When three identical conducting spheres: A with a charge of +Q, B with a neutral charge, and C with a charge of -1/2 Q are brought into contact, then pulled apart, what's the charge on each conductor?



All are = + 1/6 Q

2. Charged Object Question B

Three identical conducting spheres A, B, and C:
A with a charge of +Q and the other two neutral, are sequentially brought into contact with each other.
A touches B briefly, B touches C briefly, and then C touches A briefly.
What's the charge distribution on the three spheres?



A = + 3/8 Q B = + 1/4 Q C = + 3/8 Q

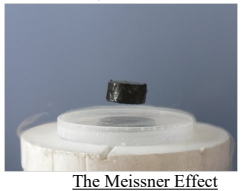
Terms

Conductors: Delocalized valence electrons move within metals.

Insulators: Valence electrons bound to nucleus and don't move. Ex: Wood, rubber, glass.

Semiconductors: Materials between metals and non-metals that conduct electrons. Ex: Si, Ge.

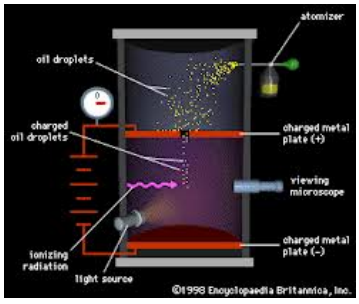
Superconductors: Materials acting as perfect conductors below a certain temperature.



The Meissner Effect

Robert Millikan's Oil Drop Experiment - 1911

Determined the mass to charge ratio of electrons.

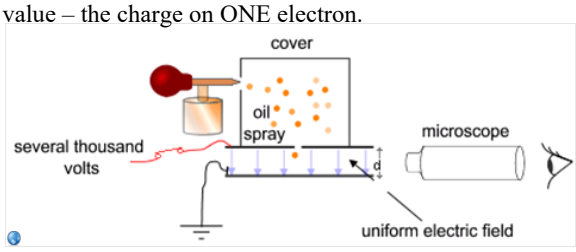


The motion of the oil droplets depends on their charge and size.

1. Oil droplets are sprayed into the upper chamber.
2. Some pass through a hole, entering an electric field between two plates.
3. X-rays charge the droplets, so they hover between the plates (like charges repel, opposites attract).
4. A calibrated microscope allows one to see the size of the droplets, and determine mass.

Millikan's Oil Drop Experiment:

By using differently sized droplets, he determined that the charges on the drops were multiples of some fundamental value – the charge on ONE electron.



His experimental value differs from today's accepted value by < 0.62%!

More Examples

3. What is the charge of 50 electrons?

$$50\,\cancel{electrons}\bullet\frac{-1.602E-19\,C}{1\,\cancel{electron}}=q=-8.01E-18\,C$$

4. How many electrons makes 1.0 coulomb of charge?

$$-1.0\,\cancel{C}\bullet\frac{1\,electron}{-1.602E-19\,\cancel{C}}=6.2E18\,electrons$$

Homework

10.1 Problems
Due: Next Class.