3.A.1 - Electric Charge, & Conductors Review

Balloon party trick - a balloon rubbed on your hair will stick to walls and the ceiling.

I've established an electric charge on the balloon.

By spin-off effects of a historical, arbitrary decision by Ben Franklin, the charge on the balloon is negative, hair is positive.

Establishing Charge

Triboelectricity: static electricity, From Greek 'tribos' - to rub.

Triboelectric series: comparative scale of charging through friction, driven by a material's work function: the minimum amount of energy needed to remove an electron from a material (more later).

Materials with a high work function keep electrons; those with low work function lose them.

Charge transfers between unlike materials.

Triboelectric Series

Rabbit Fur
Glass
Human Hair
Nylon
Wool
Silk
Aluminum
Paper
Cotton
Steel
Wood
Wax
Hard Rubber
Copper
Brass
Polyester
Styrene
Acrylic
Polyethylene
Polypropylene
PVC
Silicon
Teflon
Silicon Rubber

⊕ (Lower Work Function)

Zero

(Higher Work Function) ⊖

Charged Object Demo:

A charged ball is repelled by another similarly charged object.

They attract each other when they have opposite charge.

Elementary Charge & Mass Data:

See AP Resources Page 1

Electron (symbol: e^-) Charge : – 1.60 E-19 Coulombs (C)
Proton (symbol: p^+) Charge: + 1.60 E-19 C
Equal and opposite!

Symbol of charge is q (quantity) in equations.

Other details from Resources:
Electron Mass = 9.11 E -31 kg
Proton & Neutron (symbol: n^0) Mass = 1.67 E -27 kg

Conservation of Charge

Electrons & protons are equal in neutral atoms.

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

A Net Charge exists if an object has an excess or deficiency of electrons.

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

Charge Example 1:

What is the charge (in Coulombs) of 50 electrons?

$$q = electron\ number \bullet electron\ charge$$

$$= 50e^- \bullet \frac{-1.60E-19C}{1e^-} = -8.01E-18C$$

Charge Example 2:

How many protons does it take to make 1.0 C of positive charge?

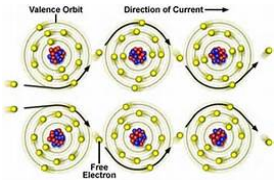
$$+1.0C \bullet \frac{1p^+}{+1.60E-19C} = 6.2E18\,p^+$$

Conductor Terms

Conductors: Materials that conduct electrons well: delocalized valence electrons freely move within the metal.

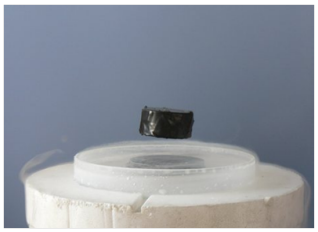
Insulators: Materials that conduct electrons poorly: valence electrons bound to nucleus – don't move.

Semiconductors: Elements that conduct electrons under certain circumstances.
Ex: Silicon, Germanium.



More Terms

Superconductors: Materials that act as perfect conductors (no energy loss) below a criti temperature.



The Meissner Effect

Electrostatic Charging (1)

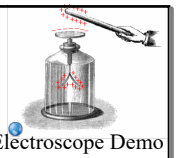
There are four major ways to establish charge:

1. Friction (triboelectricity): Rubbing two materials together. Ex: Scuffing feet across carpet.

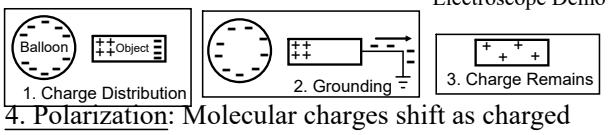
2. Conduction (Contact): Flow of electrons by touching one charged object to a non-charged one.
Ex: shocking a friend after scuffing feet across carpet.

Electrostatic Charging (2)

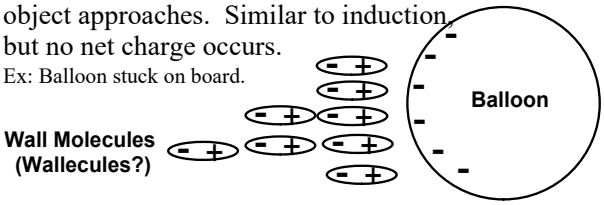
3. Induction: Holding charged object near non-charged one, then grounding non-charged one.



Electroscope Demo

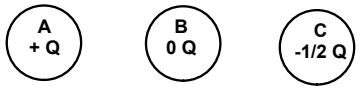


4. Polarization: Molecular charges shift as charged object approaches. Similar to induction, but no net charge occurs.
Ex: Balloon stuck on board.



Charged Object Question #1

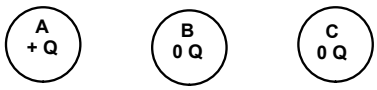
When three identical conducting spheres: A with a charge of +Q, B with a neutral charge, and C with a charge of -1/2 Q are brought into contact, then pulled apart, what's the charge on each conductor?



All are = + 1/6 Q

Charged Object Question #2

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

Homework 3.A.1 Problems
Due: Next Class.