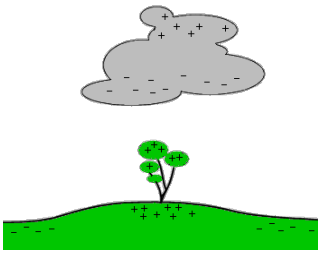
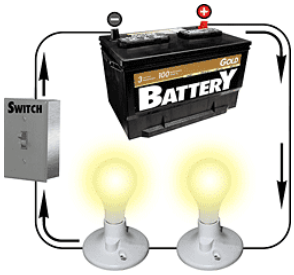
Electricity

electrostatics - the study of electric charges that are *not moving*

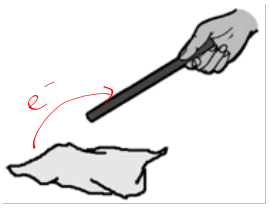
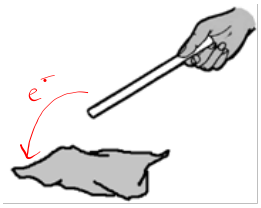


electrodynamics (circuits) - the study of *moving* electric charges



Electrostatics

1. What happens in each case below when the two objects are rubbed together?

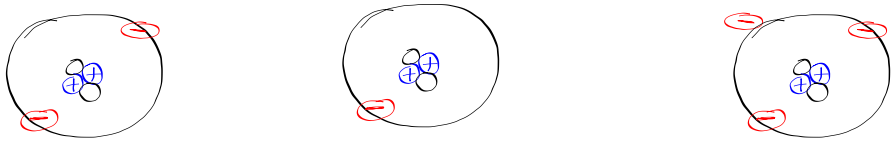
Rubber Rod and Fur	Plastic Strip (or glass) and Fabric
	

Electrostatics

2. What is the only particle that is normally transferred when an object is charged? electrons - protons are tightly bound in nucleus

3. Sketch each of the following:

Neutral Atom **Positive Ion** **Negative Ion**



Elementary charge: a proton (p^+) or an electron (e)

	Proton	Electron	Neutron
Symbol	p^+	e^-	n^0
Charge (e)	+1	−1	0
Charge (C)	$q = 1.60 \times 10^{-19}$ C	$q = -1.6 \times 10^{-19}$ C	0
Mass (kg)	1.673×10^{-27} kg	9.11×10^{-31} kg	1.675×10^{-27} kg

Electric charge

Symbol: Q, q Units: [C] or [e.c.]

Types of materials:
a) **Conductors**: materials in which electric charges move freely (e.g. metals, graphite)
b) **Insulators**: materials in which electric charges do not mo ve freely (e.g. plastic, rubber, dry wood, glass, ceramic)
c) **Semiconductors**: materials with electrical properties between those of conductors and insulators (e.g. silicon)
d) **Superconductors**: materials in which electrical charges move without resistance (e.g. some

Triboelectric Series

Asbestos
Fur (rabbit)
Glass
Mica
Wool
Quartz
Fur (cat)
Lead
Silk
Human Skin, Aluminum
Cotton
Wood
Amber
Copper, Brass
Rubber
Sulfur
Celluloid
India Rubber

On contact between any two substances shown in the column, the one appearing above becomes positively charged, the one below becomes negatively charged.

Charging by Friction: transfer of electrons by rubbing two objects together

Charging by Conduction: charging by "touching" two objects together so that electrons are *transferred*

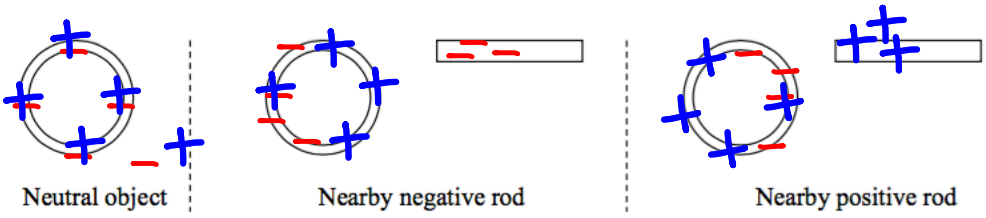
Electrostatics

Two ways an object can be discharged:

Grounding — allowing electrons to flow into or out of an object by connecting it to the Earth or another large object

Leakage — discharge of an object due to electrons being transferred to or from the air

4. Sketch what happens when a charged rod is brought near a soda can.



Neutral object | Nearby negative rod | Nearby positive rod

One side of object is positive and one side is negative but object is net neutral

Polar:

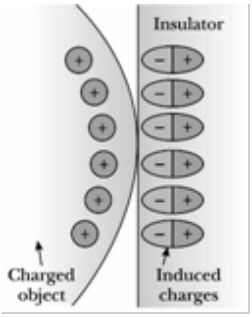
Induction (Separation of charge): The separation of charge caused by a nearby charged object. The object retains its original charge.

General Conclusion

neutral objects are always attracted to charged objects.

5. Why do rubbed balloons stick to walls?

a 'surface charge' can be induced on an insulator

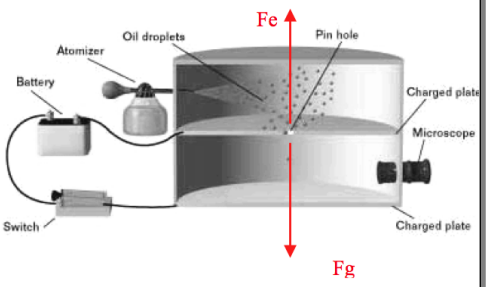


Measuring Charge

IB 11

Robert Millikan's Oil Drop Experiment

In 1909, Robert Millikan performed an experiment at the University of Chicago in which he observed the motion of tiny oil droplets between two parallel metal plates. The oil droplets were charged by friction in an atomizer and allowed to pass through a hole in the top plate. Initially the droplets fell due to their weight. The top plate was given a positive charge as the droplets fell, and the droplets with a negative charge were attracted back upward toward the positively charged plate. By turning the battery on and off, Millikan was able to watch individual oil droplets for many hours as they were suspended in mid-air and alternately rose and fell. By analyzing many measurements, he was able to make an important conclusion about electric charge.



Conclusion: Electric charge is *quantized* - occurs in integer multiples of a base unit

Also, found charge of a single electron!

Sample data for the charge on each oil droplet:

$q = -3.2 \times 10^{-19}$ C
$q = -1.6 \times 10^{-19}$ C
$q = -4.8 \times 10^{-19}$ C
$q = -6.4 \times 10^{-19}$ C

Measuring Charge

1. An object has acquired a charge of -3.2×10^{-17} C. How many excess electrons are on the object?

$$-3.2\times10^{-17}\,C \cdot \frac{1\,e.c.}{1.6\times10^{-19}\,C} = -200\,e.c.$$

2. A glass rod loses 2500 electrons after being rubbed with silk. What is the charge on the rod? The silk?

$$2500\,e.c. \cdot \frac{1.6\times10^{-19}\,C}{1\,e.c.} = 4.0\times10^{-16}\,C$$

3. How many elementary charges are in one coulomb of charge?

$$6.25\times10^{28}$$

Measuring Charge

4. Which of the following charges are possible for an object to have?

a) -8.0×10^{-19} C b) 4.8×10^{-17} C c) -5.6×10^{-19} C

d) 1.6×10^{-20} C e) -5.6 C

5. How can you determine if a charge is possible?

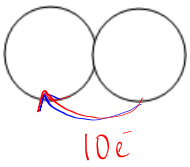
divide by e.c., see if whole #

Conservation of Electric Charge

Initial State	Conduction	Final State

6.

$q = 0$



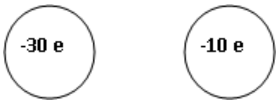
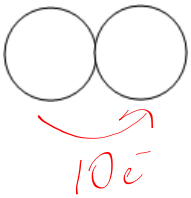
$q = 0$

Total charge =

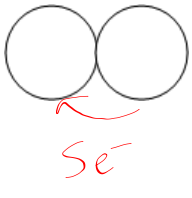
Charge transfer

Total charge =

Conservation of Electric Charge

Initial State	Conduction	Final State
7. 		
Total charge =	Charge transfer	Total charge =

Conservation of Electric Charge

Initial State	Conduction	Final State
8. 		
Total charge =	Charge transfer	Total charge =

Conservation of Electric Charge

Principle of Conservation of Electric Charge

The total electric charge of an isolated system remains constant.

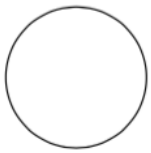
Method of finding final charge

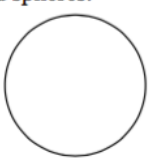
If objects are identical, final charge on each is the average charge (total charge divided by number of objects)

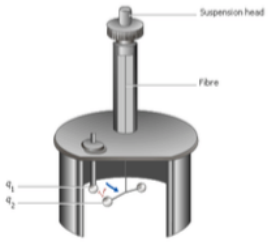
The Electrostatic Force

Coulomb's torsion balance was used to establish the relationship for the electric force between two charged spheres.

Charles Coulomb
(1736 – 1806)







The charged spheres act as if they were *point charges*.

Point charge: An object whose charge is concentrated at a single point (r=0)

Coulomb's torsion balance (youtube)