How do objects become Charged?

Imagine you walk on a carpet shuffling feet. Reach for a metal door knob what happens?

Assume carpet has 500 protons / 500 e^-

you have 50 protons / 50 e^-

shuffling your feet causes 20 e^- to attach to you You are now net −20 charges carpet is now net +20 charges.

Door knob is net 0 charges

So some negative charge jumps from you to door knob.

Charge by friction / Rubbing

$M_{person} = 100kg$ 75% water

75 kg

Mole of water has 18 g

K mole 18 kg

$$\frac{75\ kg}{18\ kg} = \sim 4\ K\ moles$$

$$1\ K\ mole = 10^3\ moles = 10^3 \left(6.02 \times 10^{23} \frac{mol}{mole}\right)$$

10^{27} molecules 18 e^- Per molecule

$10^{27}\ e^-$

For electricity to cross Air MUST exceed Breakdown Voltage of

Air ~ 1 Million Volts Per meter

or ~ 20 Thousand Per inch.

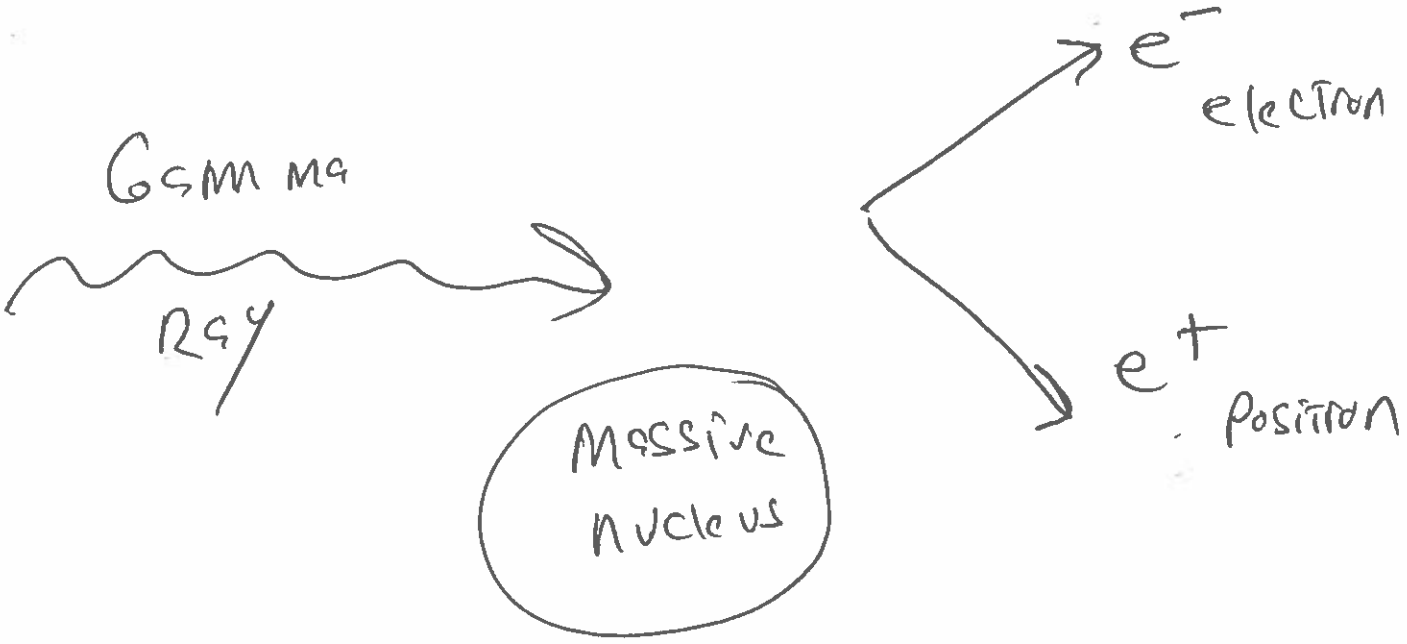
After walking with your feet on carpet

You have	70 e^-	50 protons
Carpet	480 e^-	500 protons
Total	550 e^-	550 protons

No net charge in total charge

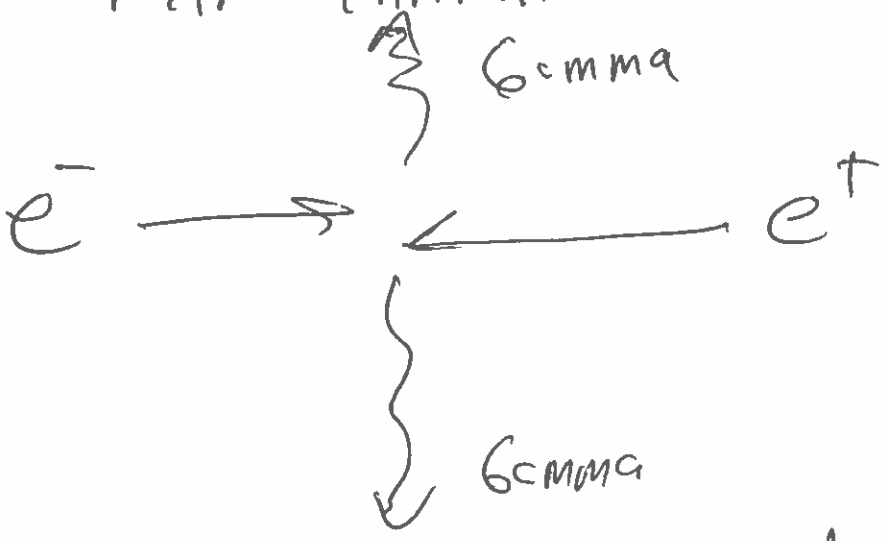
Law of conservation of electrical charge

The net charge does not change!



Pair creation

Pair annihilation

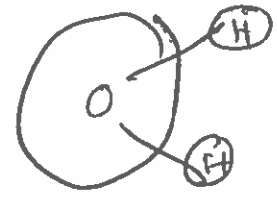


Conserves Both Charge and Momentum

Ground is a term referring to a large supply of free charges. Earth itself

Best electrical Ground made Driving a metal Pole ~ 4 feet into Ground

Water is a Good conductor because H_2O



conduct charge well.

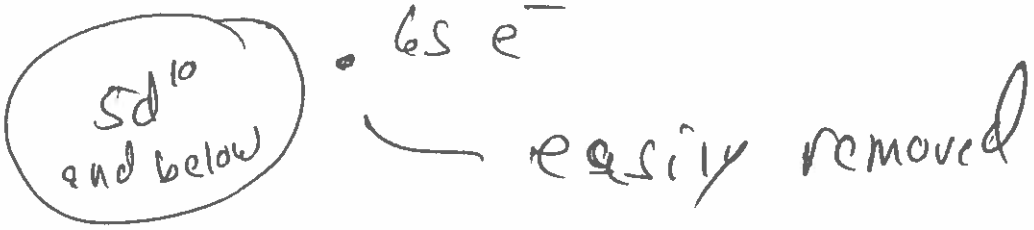
— +

A <u>Conductor</u> is a material that allows charges to move easily.

Metals are best conductors.

Gold is great conductor

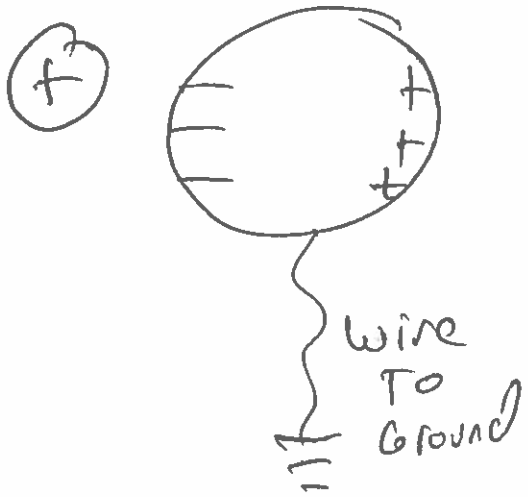
Gold $5d^{10}\ 6s^1\ e^-$

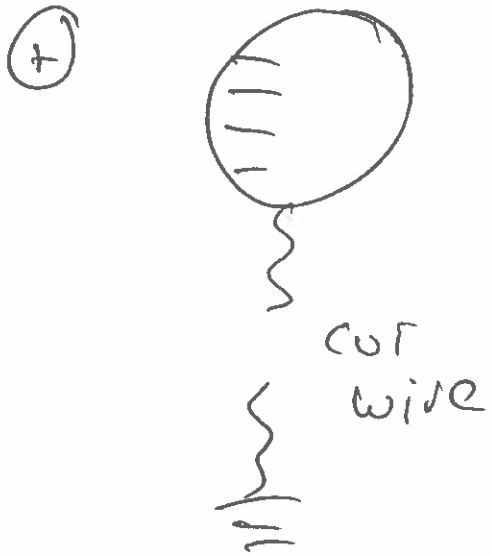


An <u>insulator</u> does not allow charges move easily.

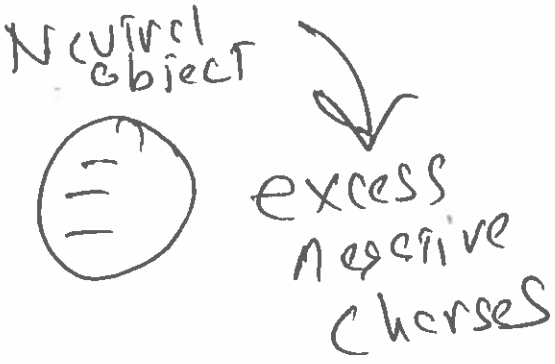
<u>Charging by Induction</u>

+ Charged object



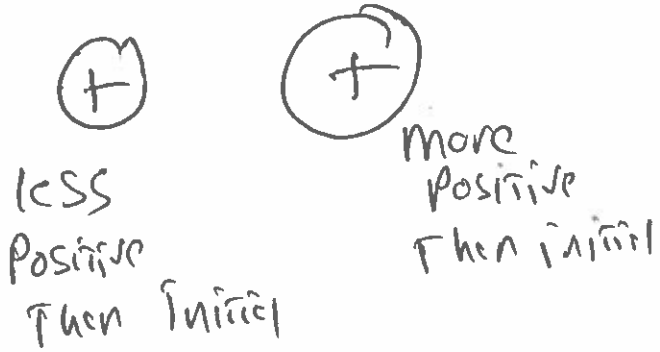


Charged by Induction

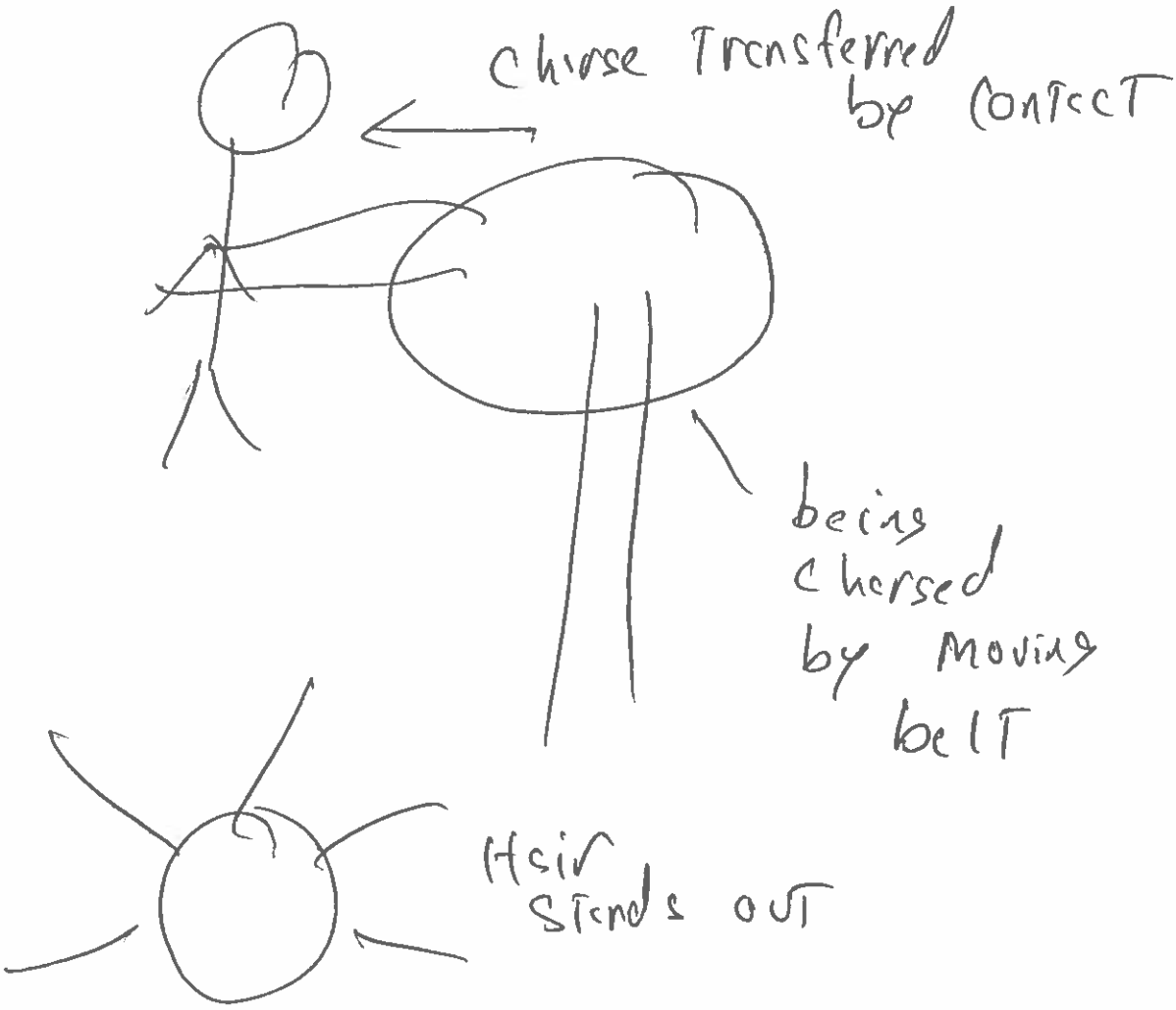


Charge by Contact

Positively Charged



Van de Graaf



Like charges repel so excess charge looks to get as far apart as possible

Coulomb's Law

$$\vec{F}_{ab} = \frac{k\, Q_A Q_B}{r_{AB}^2}\, \hat{r}$$

k is a constant $= 8.99 \times 10^9 \frac{N m^2}{C^2}$

$$F_G = G\frac{m_A m_B}{r_{AB}^2}\,(-\hat{r})$$

$$G = 6.67 \times 10^{-11} \frac{N m^2}{kg^2}$$

$$\vec{F}_{p e^-} = \frac{k Q_p Q_e}{r^2}$$
in H

$$= \frac{\left(8.99 \times 10^9 \frac{N m^2}{C^2}\right)\left(1.6 \times 10^{-19} C\right)\left(-1.6 \times 10^{-19} C\right)}{\left(5.11 \times 10^{-11} m\right)^2}$$

$$= 8.8 \times 10^{-12} N$$

$$F_G = \frac{\left(6.67 \times 10^{-11} \frac{N m^2}{kg^2}\right)\left(1.67 \times 10^{-27} kg\right)\left(9.1 \times 10^{-31} kg\right)}{\left(5.11 \times 10^{-11} m\right)^2}$$

$$= 3.9 \times 10^{-47}$$

$$\frac{F_e}{F_g} = \frac{8.8 \times 10^{-12} N}{3.9 \times 10^{-47} N} = 2.3 \times 10^{35}$$

$$F_E \sim 10^{40} F_G$$

Coloumb's Law

$$\vec{F} = k \frac{Q_1 Q_2}{r_{12}^2} (\hat{r})$$

$$\vec{F} = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r_{12}^2} (\hat{r})$$

$$k = \frac{1}{4\pi\varepsilon_0}$$

$$\varepsilon_0 = 8.85 \times 10^{-12} \frac{C^2}{Nm^2}$$

Permittivity of free space

ε_0 is a measure of how easily electric fields travel in a medium.