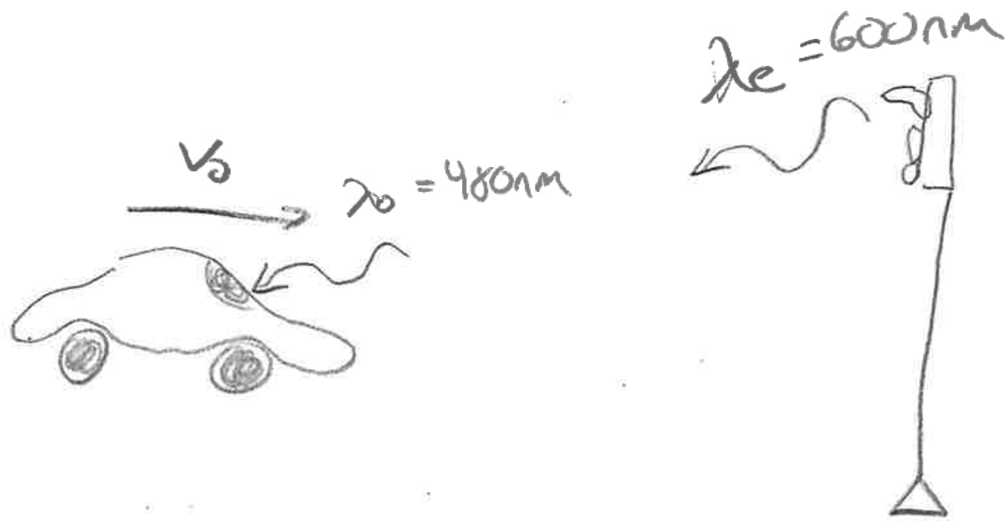
Warm up Problem

$\lambda_o = 480nm$

$\lambda e = 600nm$

$c = 3 \times 10^8 m/s$

$V_o = ?$



$$f_o = f_e \left(\frac{c \pm v_o}{c} \right)$$ - use plus, motion is towards source

$$f_o = f_e \left(\frac{c + v_o}{c} \right)$$

$$c = \lambda f$$

$$f = \frac{c}{\lambda}$$

$$\frac{\cancel{c}}{\lambda_o} = \frac{\cancel{c}}{\lambda e} \left(\frac{c + v_o}{c} \right)$$

②

$$\frac{1}{\lambda_o} = \frac{1}{\lambda_e}\left(\frac{c+v_o}{c}\right)$$

$$\frac{\lambda_e}{\lambda_o} = \frac{c+v_o}{c}$$

$$c\frac{\lambda_e}{\lambda_o} = c + v_o$$

$$v_o = c\frac{\lambda_e}{\lambda_o} - c$$

$$v_o = c\left[\frac{\lambda_e}{\lambda_o} - 1\right]$$

$$v_o = 7.5\times10^{7}\ m/s \times \frac{3.1\ \text{miles}}{5100} \times \frac{60\ \text{sec}}{1\ \text{min}} \times \frac{60\ \text{min}}{1\ \text{hr}}$$

$$v_o = 1.674\times10^{8}\ \text{mph}$$

$$\text{Fine} = \$5\left(1.67\times10^{8} - 30\right)$$

$$\text{Fine} = \$5\left(1.67\times10^{8}\right)$$

$$\boxed{\text{Fine} = \$8.37\ \text{billion}}$$

Static Electricity

- caused by electric charge
- charge can be positive or negative
- like charges repel, opposite attract
- charge is carried by atomic and subatomic particles

$$q = \text{Coulombs}$$

$$q_e = -1.6 \times 10^{-19}\ C$$

$$q_p = 1.6 \times 10^{-19}\ C$$

- Most materials have nearly equal numbers of protons and neutrons — net charge is zero.

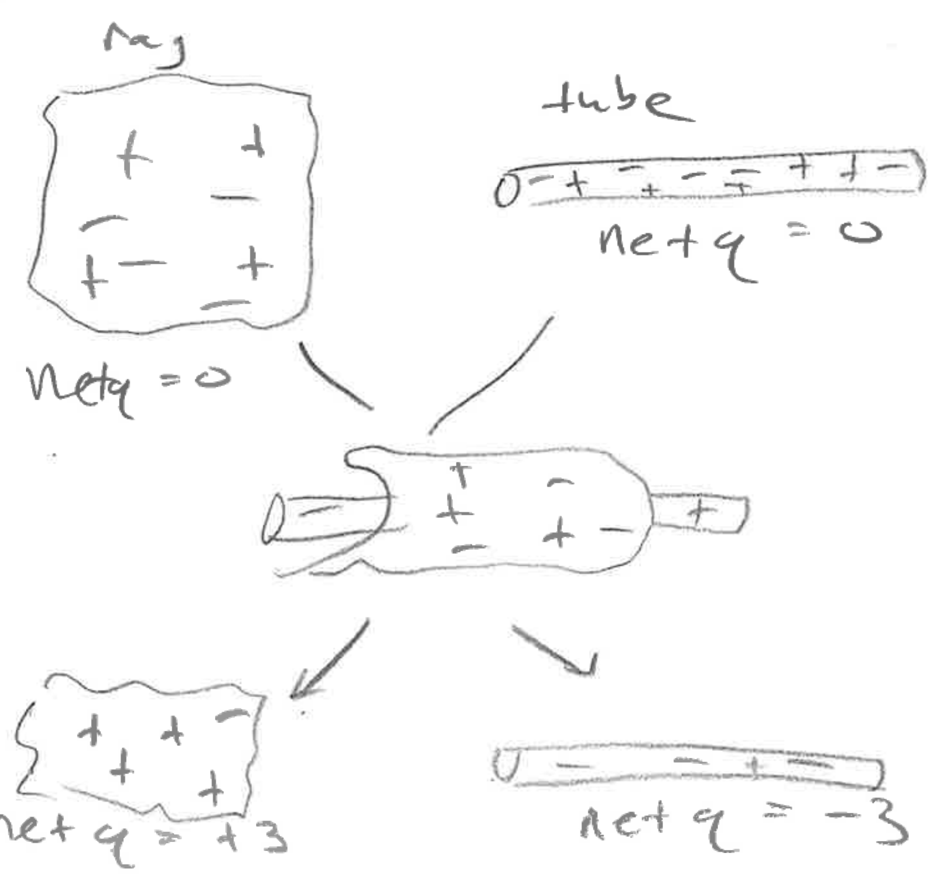
Law of Conservation of Charge

- total charge is conserved in every process.

- conductors allow for free transfer of charge

- Insulator do not let charges move through them.

Charging by contact



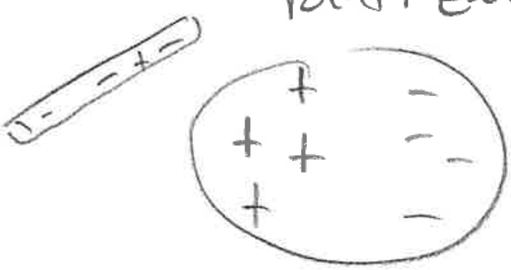
Direct contact of materials leads to transfer of charges, creating two equally but oppositely charged objects.

Induction

$net\ q = -3$

$net\ q = 0$

Polarization



$net\ q = 0$

No transfer of charges, charges separate in material.

Coulomb's Law

Force between two charges

$$F = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2}$$

$$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 \ N m^2 C^{-2} \longrightarrow k$$

$$F = k \frac{q_1 q_2}{r^2}$$

- use charge signs to determine direction.

Example

The proton and electron are separated by $r = 0.530 \times 10^{-10}\,m$ in the Hydrogen atom in its lowest energy state. Calculate the electrostatic force between the two particles. Calculate the acceleration on the electron.

$r = 0.530 \times 10^{-10}\,m$

$q_1 = 1.6 \times 10^{-19}\,C$

$q_2 = -1.6 \times 10^{-19}\,C$

$$F = k\frac{q_1 q_2}{r^2}$$

$$F = \frac{9 \times 10^{9}(1.6 \times 10^{-19})(1.6 \times 10^{-19})}{(0.530 \times 10^{-10})^2}$$

$$F = 8.20 \times 10^{-8}\,N$$

$$F = ma$$

$$a = \frac{F}{m} \qquad m = 9.11 \times 10^{-31}\ kg$$

$$\boxed{a = 9.00 \times 10^{22}\ m/s^2}$$

Example 2

Two charges are separated by 5mm. If the charge on one particle is 3 times the charge on the other, and the force between them is 1.08×10^{-3} N, what are the charges of the two particles?

$$F = \frac{k q_1 q_2}{r^2} \qquad q_1 = 3q_2$$

$$F = \frac{3 k q_2^2}{r^2}$$

$$q_2^2 = \frac{F r^2}{3k}$$

$$q_2 = r\sqrt{\frac{F}{3k}}$$

$$\boxed{q_2 = 1\times 10^{-9}\,C}$$

$$q_1 = 3q_2$$

$$\boxed{q_1 = 3\times 10^{-9}\,C}$$