Physics 142 - Sept. 4, 2008

Things I forgot to mention at start of last class

- PRS
- Any other questions about course?

Last Time

Electrostatics

- two types of charge

- Coulombs law

$$\vec{F}_{12} = \frac{k\, q_1 q_2}{r_{12}^2}\,\hat{r}_{12}$$

$k = \frac{1}{4\pi\epsilon_0}$ = CONSTANT

Proportionality const.
Sets scale
Not to be confused
w/ k ... Boltzmann's
constant

Permitivity
of
Free space

inverse square
force ... just like
gravitation

$q_1 \xrightarrow{\vec{r}_{12}} q_2$

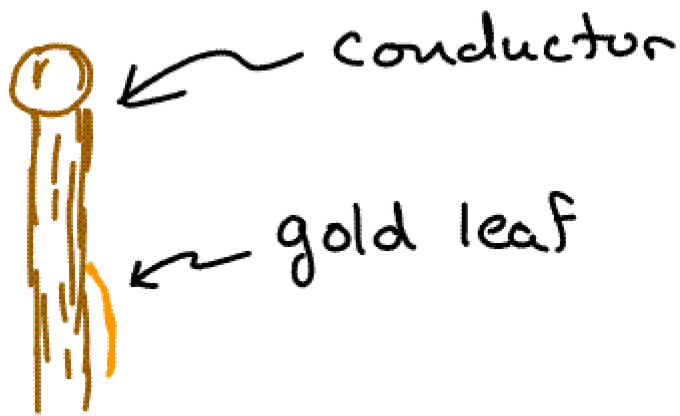
- Electric charge is conserved

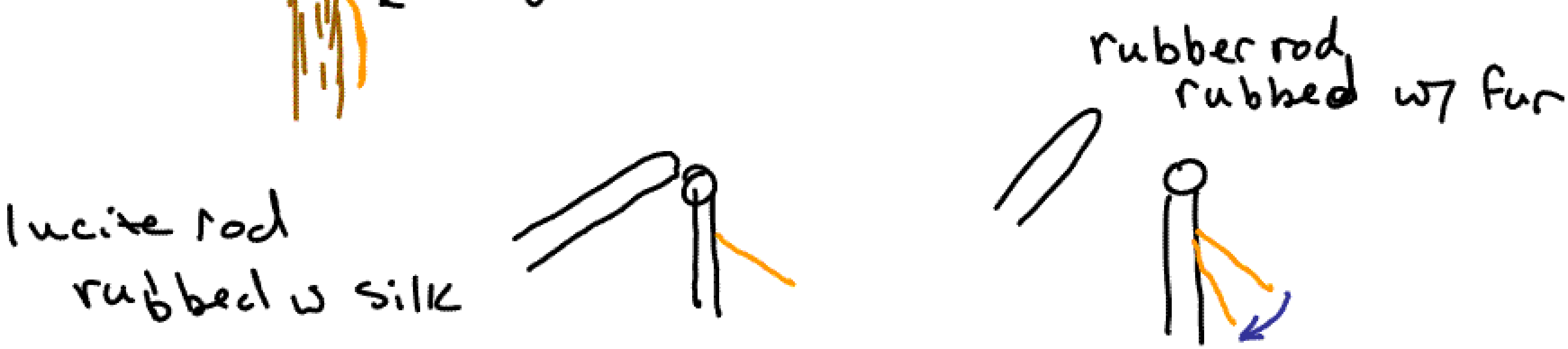
$|e| = 1.6 \times 10^{-19}$ C

c ≡ coulomb
not to be conf.
w/ speed of
light c

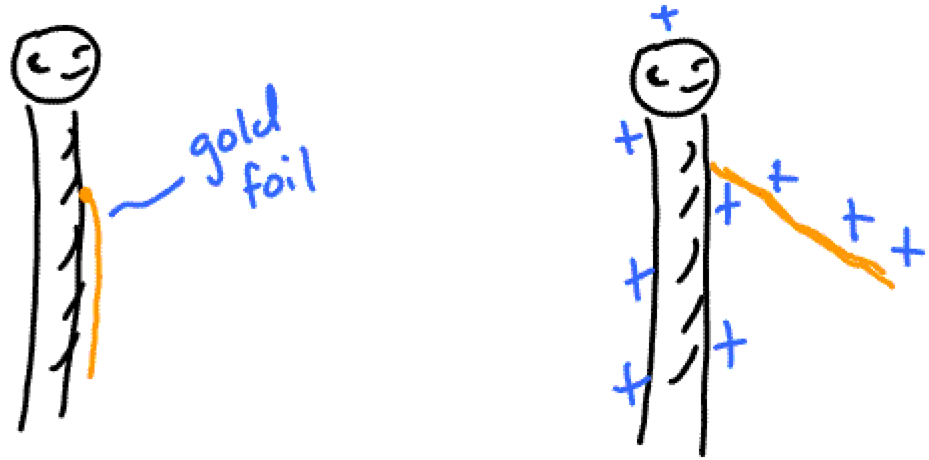
- Electric charge is quantized

Electric charge + Electroscopes





Vice versa we start w/ other rod



H atom (Bohr)

$Q = -|e| = -1.6\times10^{-19}\,C$

$Q = +|e| = +1.6\times10^{-19}\,C$

$r_0 \equiv$ Bohr Radius $= 5.29\times10^{-11}\,m$

(a) How does em force compare to grav. force between e^- and p?

$$F_{eM} = \frac{k\,q_1 q_2}{r_{12}^2} = \frac{8.99\times10^{-9}\,\frac{NM}{c^2}\,(1.6\times10^{-19})^2}{(5.29\times10^{-11}\,m)^2}$$

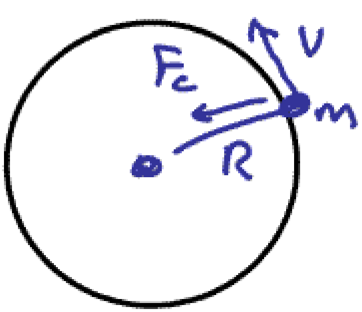
$$F_{em} = 8.2 \times 10^{-8}\ N$$

$$F_{gr} = \frac{G M_e M_p}{r^2} = 3.6 \times 10^{-47}\ N$$

$$\boxed{\frac{F_{em}}{F_{gr}} = 2.3 \times 10^{39}}$$

gravitation is vastly weaker than the other known forces of Nature

(b) what is the speed of e^- ?



m_e

$$F_c = m\frac{v^2}{R}$$

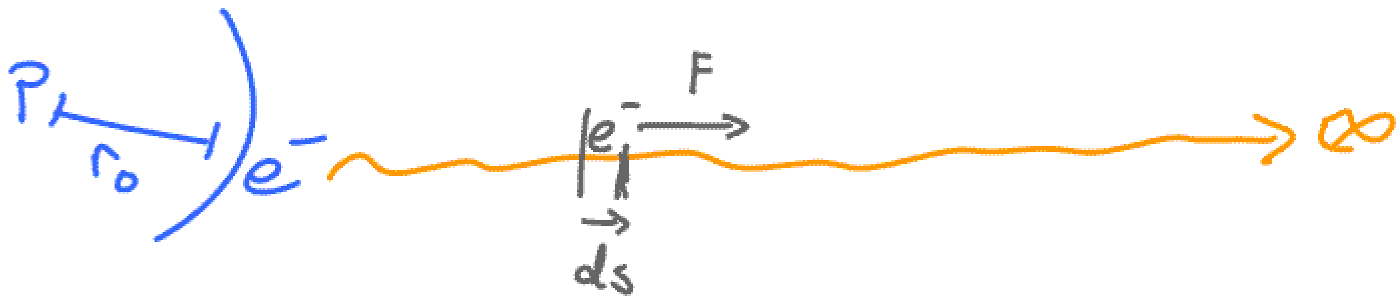
F_{em} $\quad$ r_0

$$V_e = 2.2 \times 10^{6}\ m/s$$

$\sim 1\%$ speed of light

(c) energy it takes to ionize the H atom

$$\text{Energy} \sim \text{work} = \int \vec{F}\cdot d\vec{s}$$



$$W = \int_{r_0}^{\infty} \vec{F}\cdot d\vec{s} = \int_{r_0}^{\infty} \frac{k|e|^2}{r^2}\,dr = k|e|^2 \int_{r_0}^{\infty} \frac{1}{r^2}\,dr$$

$$W = k|e|^2 \left[-\frac{1}{r}\right]_{r_0}^{\infty} = k|e|^2 \left[-\cancelto{0}{\frac{1}{\infty}} - -\frac{1}{r_0}\right]$$

$$W = \frac{1}{2}|e|^2 \frac{1}{r_0} = 4.3 \times 10^{-18} \text{ Joules}$$

$$1 \text{ Joule} = 6.2 \times 10^{18} \text{ eV} \quad (\text{electron-Volt})$$

$$W = 26.9 \text{ eV}$$

True Value = $\underline{\underline{13.6 \text{ eV}}}$

good # to know – sets scale of energy for chemistry

Too big ... what are we missing?

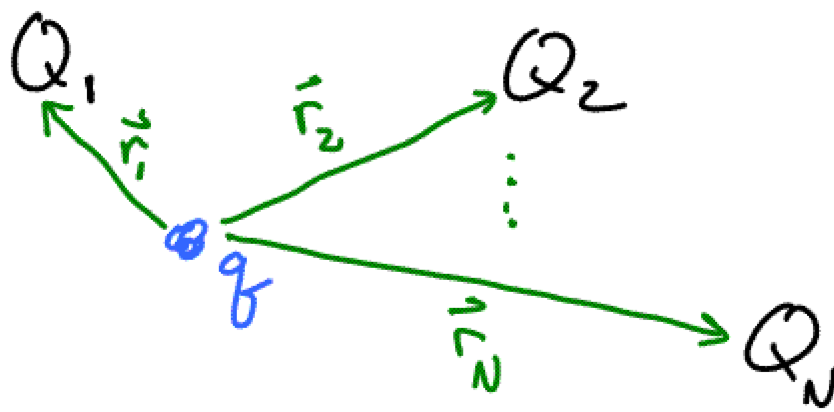
e^- already moving ... already has energy

$$KE \text{ of } e^- = \frac{1}{2} m_e v_e^2 = \frac{1}{2}(9.11 \times 10^{-31} \text{ kg})(2.2 \times 10^6 \text{ m/s})^2$$

$$= 13.6 \text{ eV}$$

$$W - KE_{e^-} = 13.3 \text{ eV}$$

Electrostatis is a Vector Force

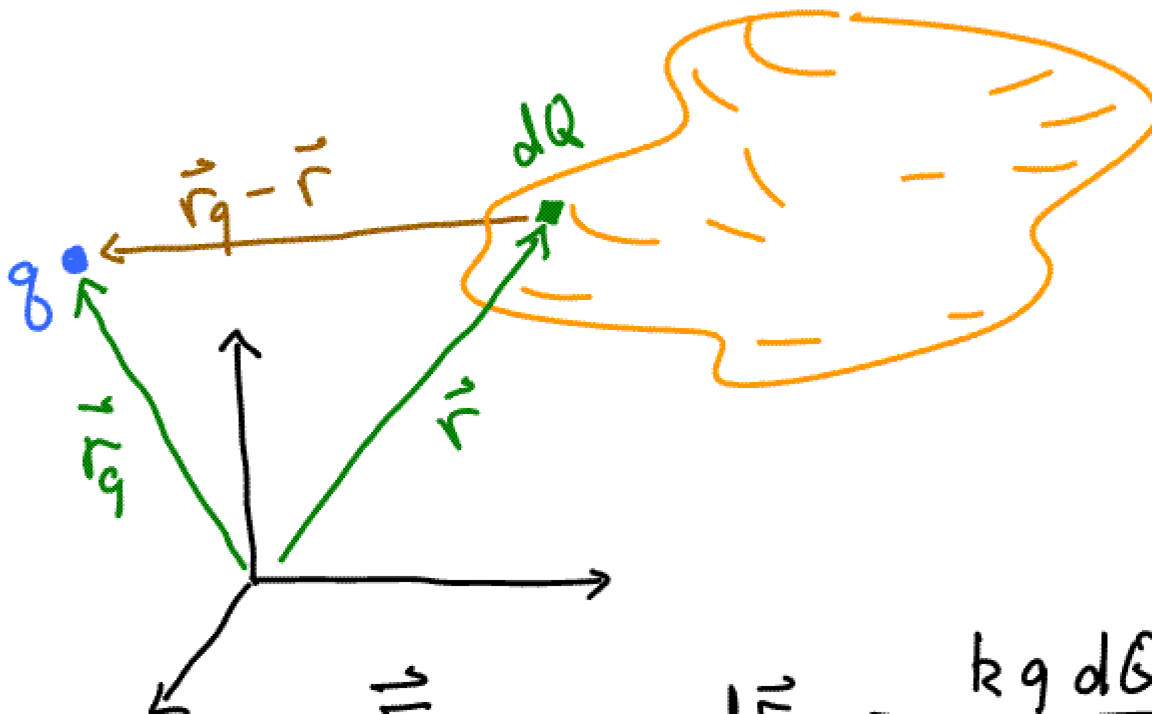


Force on q due to distribution of discrete Point charges

$$\vec{F}_{\substack{Net\\ on\\ q}} = \vec{F}_{Q_1} + \vec{F}_{Q_2} + \cdots + \vec{F}_{Q_N}$$

$$\vec{F}_{NeT} = \frac{kQ_1 q}{r_1^2}\hat{r}_1 + \frac{kQ_2 q}{r_2^2}\hat{r}_2 + \cdots + \frac{kQ_N q}{r_N^2}\hat{r}_N$$

F on q from charge distribution
continuous



$$\vec F_{\substack{\text{on } q \\ \text{from } dQ}} = d\vec F_{\substack{\text{due} \\ \text{to} \\ dQ}} = \frac{k\, q\, dQ}{|\vec r_q - \vec r|^2}\,\widehat{(\vec r_q - \vec r)}$$

general

$$\boxed{\vec F_{\text{on } q} = \int_V \frac{k\, q\, dQ}{|\vec r_q - \vec r|^2}\,\widehat{(\vec r_q - \vec r)}}$$

V = chg volume

$$dQ = \underbrace{\rho(\vec{r})}_{\text{volume charge density}}\, dv \qquad \text{(volumes)}$$

volume charge density C/m^3

$$dQ = \underbrace{\sigma(\vec{r})}_{\text{area charge density}}\, dA$$

area charge density C/m^2

$$dQ = \underbrace{\lambda(\vec{r})}_{\text{linear charge density}}\, dl$$

linear charge density C/m

$$\vec{F}_q = \int_{\text{vol of charge}} \frac{kq\,\rho(\vec{r})\,dv}{|\vec{r}_q - \vec{r}|^2}\,\widehat{(\vec{r}_q - \vec{r})}$$

very general

$q \equiv$ "test" charge

$\cdot\, P$

Q

$$\vec{F}_q = \frac{kQq}{r^2}\hat{r}$$

Electric Field $= \vec{E}_P = \vec{F}_q / q$

$$\vec{E}_P = \frac{kQ\cancel{q}}{r^2}\hat{r}$$

For point charge Q