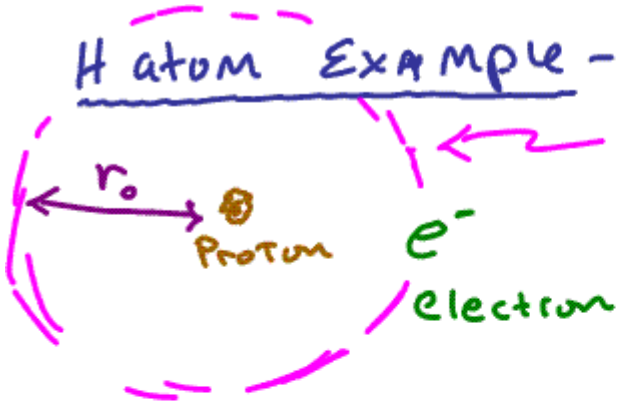
Physics 142 - Sept. 6, 2007

- Email Listserve ← Let me know if you are NOT getting class emails
- Workshops start Next week
- P.S. 1 on web ... still need to put up Coulomb Java applet

Last time:

Coulomb's Law $\vec{F} = \frac{k q_1 q_2}{r^2} \hat{r}$

H atom Example -



(a) $\frac{F_{EM}}{F_{grav}} = 2.3 \times 10^{39}$

(b)

$$F_{centripetal} = F_{em} = \frac{m_e v_e^2}{r_o^2}$$

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

(c) Energy to ionize H atom

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

move differential length $d\vec{s}$ applying force $\vec{F}$, do work dw

$dw = \vec{F} \cdot d\vec{s} = F\,ds$

$$\text{work} = \int_{r_0}^{\infty} dw = \int_{r_0}^{\infty} F\,ds = \int_{r_0}^{\infty} F\,dr = \int_{r_0}^{\infty} \frac{k q_1 q_2}{r^2}\,dr$$

$$|k q_e q_p| \int_{r_0}^{\infty} \frac{1}{r^2}\,dr = |k q_e q_p| \left[\frac{-1}{r}\right]_{r_0}^{\infty}$$

$$= \frac{|k q_e q_p|}{r_0} = \frac{k e^2}{r_0} = \frac{\left(8.99\times10^{9}\ \frac{N m^2}{C^2}\right)\left(1.6\times10^{-19}\ C\right)^2}{5.29\times10^{-11}\ m}$$

$$= 4.3\times10^{-18}\ \text{Joules}$$

$$1\ \text{Joule} = 6.2\times10^{18}\ eV = \text{electron-Volt}$$

$$= 26.9\ eV$$

True value $\rightarrow$ 13.6 eV

But

e^- already moving

$$KE\ \text{of}\ e^- = \frac{1}{2} m_e v_e^2 = \frac{1}{2}\left(9.11\times10^{-31}\ kg\right)\left(2.2\times10^{6}\ m/s\right)^2$$

$$= 2.0\times10^{-18}\ J = 13.6\ eV$$

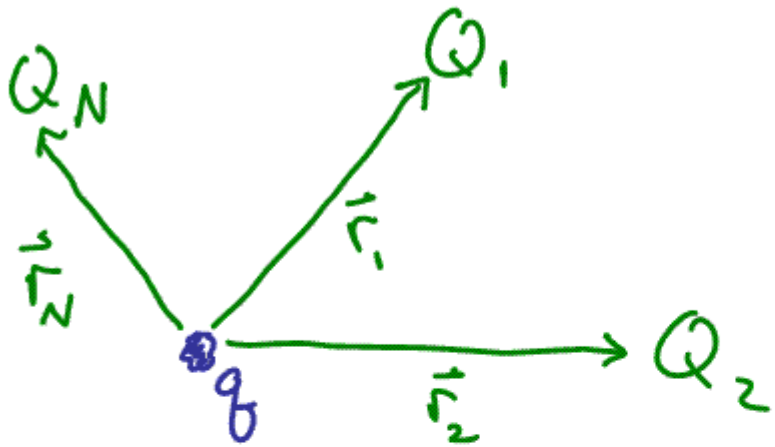
Work I do to remove e^- is

$$26.9\ eV - 13.6\ eV = 13.3\ eV$$

Close!

Impt # sets energy scale for chemistry

Electrostatics is a vector force

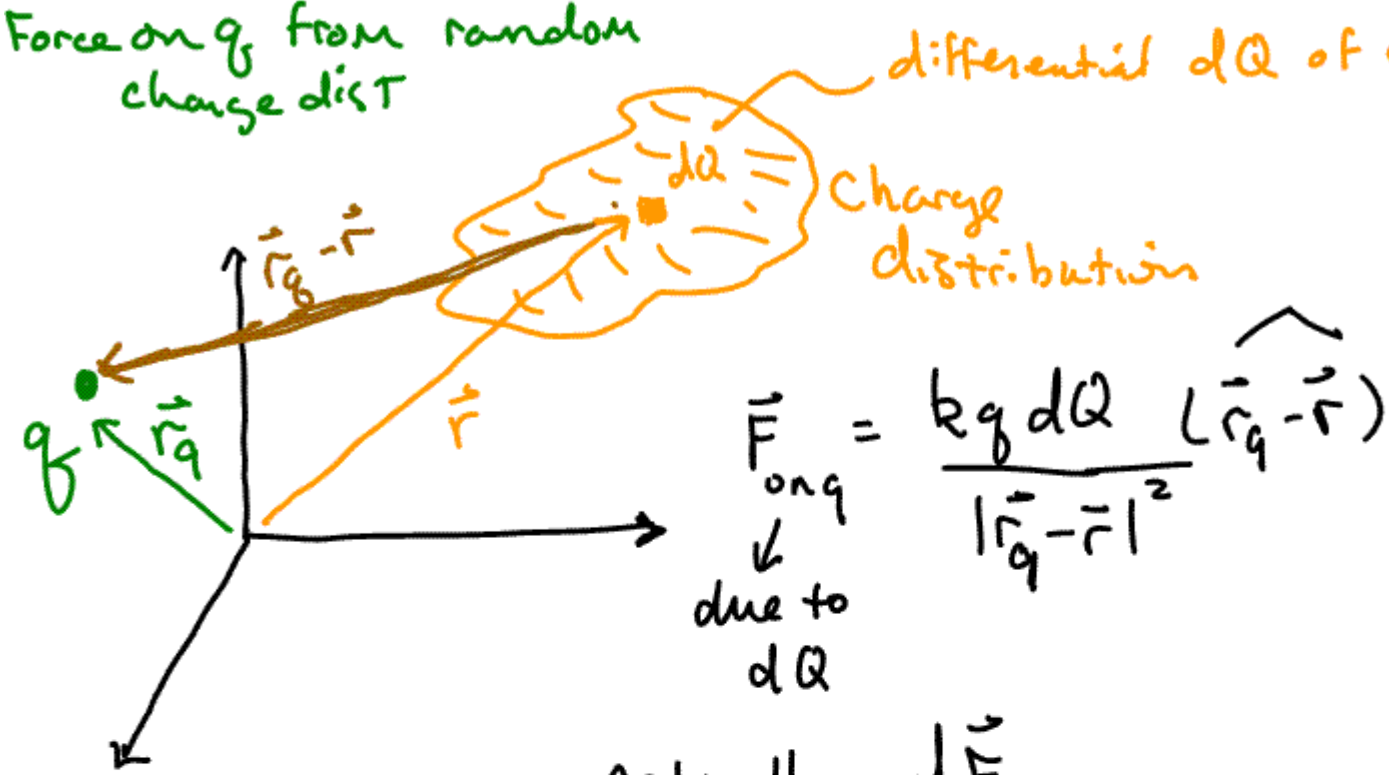


$$\vec{F}_{\substack{\text{NET} \\ \text{on} \\ q}} = \vec{F}_{Q_1} + \vec{F}_{Q_2} + \cdots + \vec{F}_{Q_N}$$

Force of Q_1 on little q

$$= \frac{kQ_1q}{r_1^2}\hat{r}_1 + \frac{kQ_2q}{r_2^2}\hat{r}_2 + \cdots + \frac{kQ_Nq}{r_N^2}\hat{r}_N$$

Force on q from random charge dist



$$\vec{F}_{on\,q} = \frac{k q\, dQ}{|\vec{r}_q - \vec{r}|^2} \hat{(\vec{r}_q - \vec{r})}$$

$\vec{F}_{on\,q}$ ↓ due to dQ

Actually $d\vec{F}_{on\,q}$

use whichever form is appropriate for given charge distribution

$dQ = \rho(\vec{r})\, dV$ — ρ: volume charge density

$dQ = \sigma(\vec{r})\, da$ — σ: area charge density

$dQ = \lambda(\vec{r})\, dx$ — λ: linear charge density

$$d\vec{F}_q = \frac{k_q \rho(\vec{r})\, dV}{|\vec{r}_q - \vec{r}|^2} \hat{(\vec{r}_q - \vec{r})}$$

$$\vec{F}_q = \int_{\text{vol of charge}} \frac{k_q \rho(\vec{r})\, dV}{|\vec{r}_q - \vec{r}|^2} \hat{(\vec{r}_q - \vec{r})}$$

Very general expression

Computing this can vary dramatically in difficulty

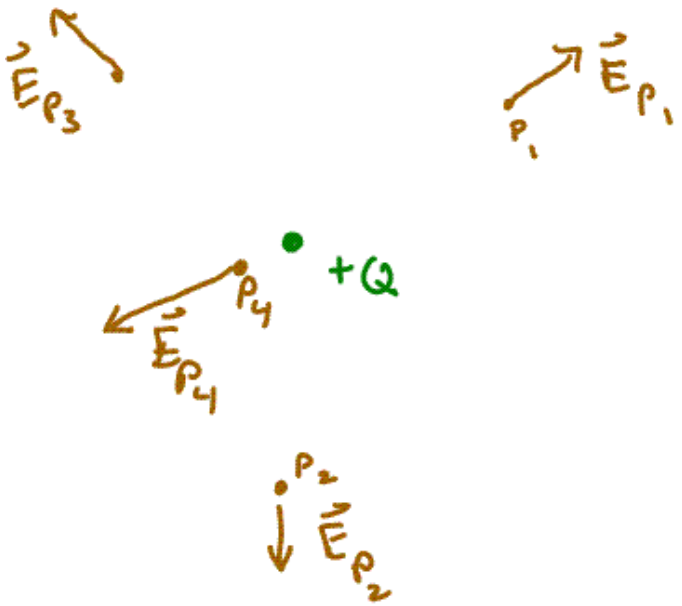
Electric Field

q

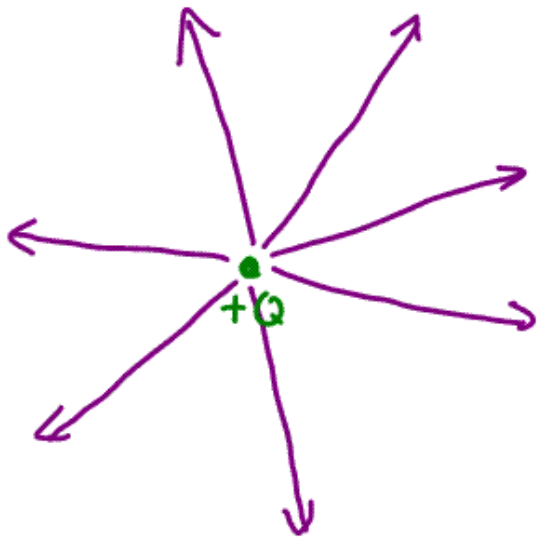
P

$$\vec{E}_P \equiv \frac{\vec{F}_q}{q}$$

≡ Electric field at P



Learn to "visualize" the electric field lines in order to use your "mechanical" intuition

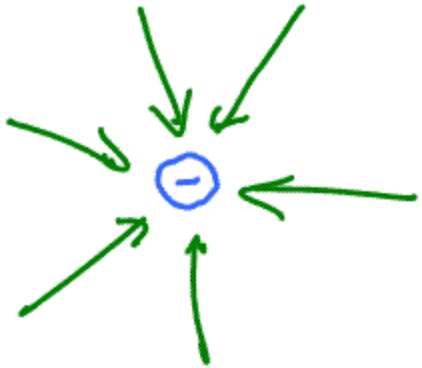


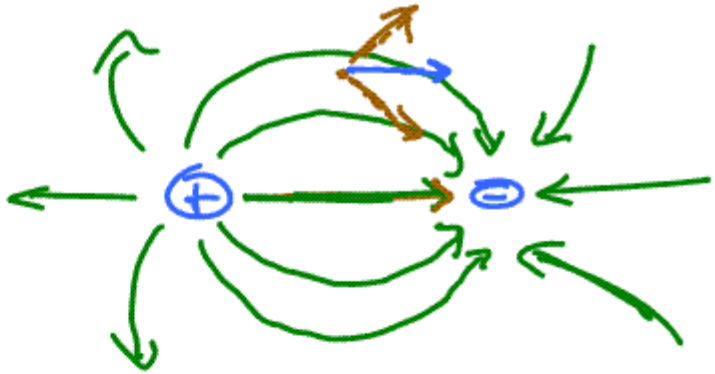
lines of "force"

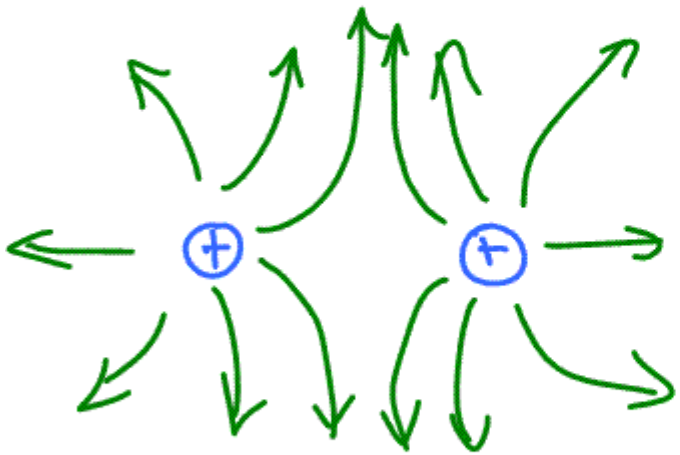
Electric field lines

Force on test charge in direction of line of force

$|\vec{F}|$ on test chg $\propto$ density of lines of force







electric field lines of force around different charge distributions