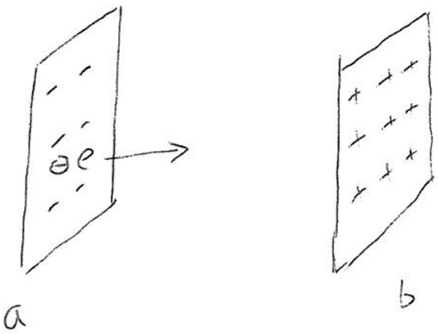
e.g. Electron in a Cathode Ray Tube (CRT).

an electron e: $q = -1.6 \times 10^{-19}$ C.

$V_b - V_a = V_{ba} = 5000\,V$.



a) $\Delta U = q \cdot V_{ba}$

$= q\,(V_{final} - V_{initial})$

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

$\therefore \Delta U = -1.6 \times 10^{-19} \times 5000 = -8.0 \times 10^{-16}$ J.

↑ P.E. decreases.

b). Conservation of mechanical energy.

$\Delta KE + \Delta PE = 0$.

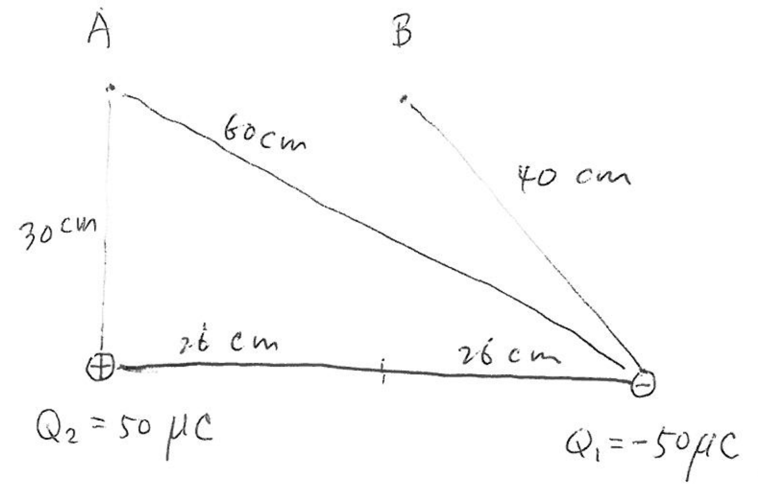
$\Delta KE = \frac{1}{2} m v^2 - 0 = -\Delta PE = -\Delta U$.

$v^2 = -\frac{2\Delta U}{m} = \frac{2 \times 8.0 \times 10^{-16}}{9.1 \times 10^{-31}} =$

$v = \sqrt{\frac{-2\Delta U}{m}} = \sqrt{\frac{2 \times 8.0 \times 10^{-16}}{9.1 \times 10^{-31}}} = 4.2 \times 10^{7}$ m/s.

e.g. potential due to two charges.

a). Electric potential at A.



$$V_A = V_{A2} + V_{A1}$$

$$= \frac{1}{4\pi\varepsilon_0}\frac{Q_2}{r_{A2}} + \frac{1}{4\pi\varepsilon_0}\frac{Q_1}{r_{A1}}$$

$$= \frac{1}{4\pi\varepsilon_0}\left(\frac{50\times10^{-6}}{3\times10^{-1}} - \frac{5.0\times10^{-7}}{0.6}\right)$$

$$= 7.5\times10^{5}\ V$$

b). $V_B = V_{B2} + V_{B1}$

$$= \frac{1}{4\pi\varepsilon_0}\left(\frac{5\times10^{-7}}{0.4} - \frac{5\times10^{-7}}{0.4}\right)$$

$$= 0.$$

(Note: at ∞, $V = 0$).

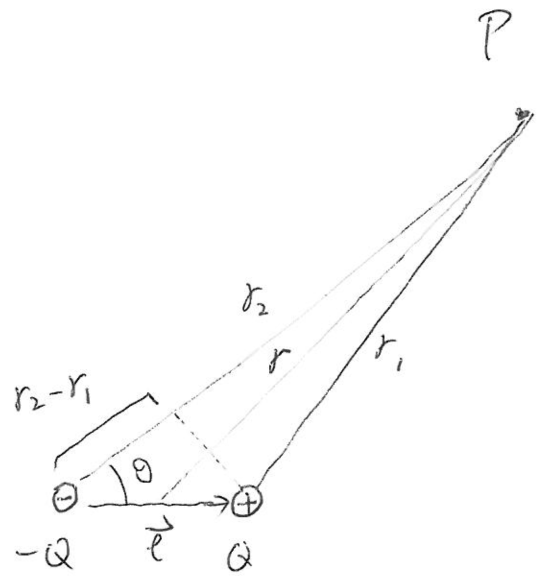
Electric dipole potential .

$$V = V_- + V_+$$

$$= \frac{1}{4\pi\varepsilon_0}\left(\frac{-Q}{r_2} + \frac{Q}{r_1}\right)$$

$$= \frac{Q}{4\pi\varepsilon_0}\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$$

$$= \frac{Q}{4\pi\varepsilon_0}\left(\frac{r_2 - r_1}{r_1 r_2}\right)$$



for $r \gg l$, $\quad r_1 r_2 \approx r^2$

$$r_2 - r_1 \approx l\cos\theta \; .$$

$$\therefore \; V = \frac{Q}{4\pi\varepsilon_0}\,\frac{l\cos\theta}{r^2} = \frac{1}{4\pi\varepsilon_0}\cdot\frac{p\cos\theta}{r^2}$$

dipole moment: $p = Ql$.

Note: for a charge q, $\quad V \propto \frac{1}{r}$.

for a dipole p: $\quad V \propto \frac{1}{r^2}$ — die out more quickly.

e.g. Disassembling a hydrogen atom

Work needed = total energy as atom − total energy when far apart.

$$P.E. = U = \frac{1}{4\pi\varepsilon_0}\frac{Q_1 Q_2}{r} = \frac{1}{4\pi\varepsilon_0}\frac{e(-e)}{r} =$$

$$= -27.2 \times 1.6 \times 10^{-19}\ J = -27.e\ eV.$$

K.E.: $K = \frac{1}{2} m v^2$.

uniform circular motion: $\vec{F} = m\vec{a}$ $\qquad F_c = m a_c$

$$\frac{1}{4\pi\varepsilon_0}\frac{e^2}{r^2} = \frac{m v^2}{r}$$

$$\therefore K = \frac{1}{2} m v^2 = \frac{1}{2}\cdot\left(\frac{1}{4\pi\varepsilon_0}\right)\frac{e^2}{r} = \frac{1}{2}(-U)$$

$$= 13.6\ eV.$$

Total Energy: $U + K = -27.2 + 13.6 = -13.6\ eV$.

far apart: $U + K = 0$.

difference: $\Delta(\text{Energy}) = \text{Energy (final)} - \text{Energy (initial)}$

$$= 0 - (-13.6\ eV)$$

$$= 13.6\ eV.$$

$\therefore$ Work required $= 13.6\ eV$.