(1)

Radius of an electrons orbit.

$$r_n = \frac{n^2 h^2}{4\pi m_e k Z e^2}$$

$n$ = principle quantum number
$h$ = plancks constant
$m_e$ = mass of electron
$k$ = $9\times10^9\ Nm^2/c$
$Z$ = atomic number
$e$ = electric charge

$$\Rightarrow n^2h^2 = r_n 4\pi m_e k Z e^2$$

The total energy of electrons in orbit

$$E_n = \frac{-2\pi m_e e^4 Z^2 k^2}{n^2 h^2}$$

$$= \frac{-\cancel{2}\cancel{\pi}\cancel{m_e}\, e^{\cancel{4}2} Z^{\cancel{2}} k^{\cancel{2}}}{r_n \overset{2}{\cancel{4}}\cancel{\pi}\cancel{m_e}\, \cancel{k}\cancel{Z}\, \cancel{e^2}} = -\frac{e^2 \cancel{Z} k}{\cancel{2} r_n}$$, here He. $Z = 2$

$$= -\frac{e^2 k}{r_n}$$, $r_1 = 0.30\,nm$, $r_2 = 0.20\,nm$

$$\therefore E_1 - E_2 = -\left(\frac{e^2k}{r_1} - \frac{e^2k}{r_2}\right)$$

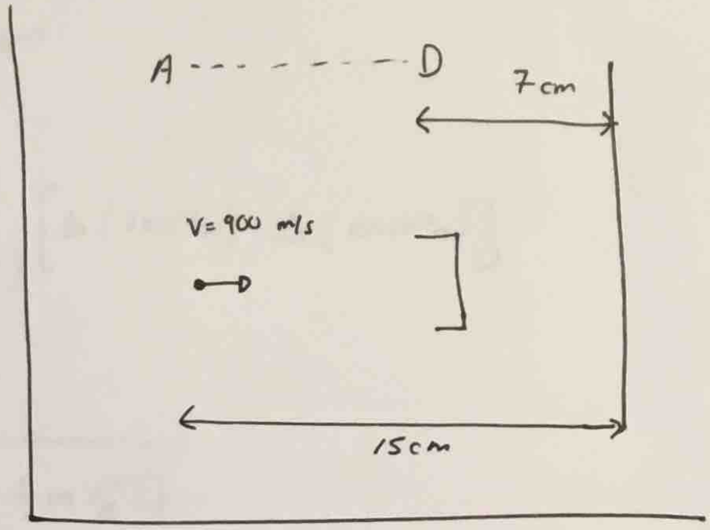
$$= \frac{e^2k}{r_2} - \frac{e^2k}{r_1}$$

$$= \left[\frac{(1.6\times10^{-19}\,C)(9\times10^9\,Nm^2/C^2)}{0.30\times10^{-9}\,m} - \frac{(1.6\times10^{-19}\,C)(9\times10^9\,Nm^2/C^2)}{0.20\times10^{-9}\,m}\right]$$

$$= 3.84\times10^{-12}\,J \cdot (6.242\times10^{18}\,eV/J)$$

$$= 2.84\,eV$$

②




Here $W = qVd$

$= qV(A - D)$

where here A & D are the electrical potential difference.

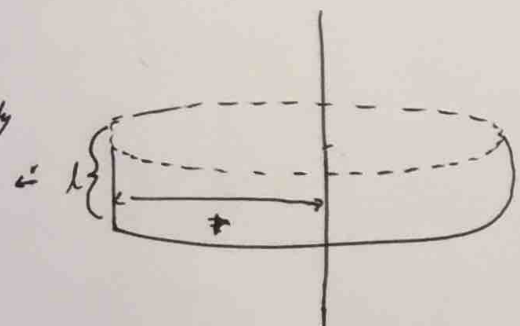
$W = K_D - K_A$ of kinetic energy from the work energy theorem.

$\therefore K_D - K_A = qV(A-D)$

$= \frac{1}{2}mV_D^2 - \frac{1}{2}mV_A^2 = qV(A-D)$

$V_D = \sqrt{\frac{2}{m}\left[qV(A-D) + \frac{1}{2}mV_A^2\right.}$

line charge $\lambda$ with linear charge density




Gauss's theorem of a cylindrical surface length ($\ell$) & radius (r)

$E(2\pi r\ell) = \frac{\lambda \ell}{\varepsilon_0}$

$E = \frac{\lambda \ell}{2\pi r \ell \varepsilon_0}$

$W = \cancel{q}V(A-D) = \int_A^D qE \cdot dr$

$= V(A-D) = \int_A^D \frac{\lambda \ell}{2\pi r \ell \varepsilon_0} dr \quad = V(A-D) = \frac{\lambda}{2\pi\varepsilon_0} \ln(r)\Big|_{15\text{ cm}}^{7\text{ cm}}$ $\quad 7\text{ cm} \to 7\times10^{-2}\text{ m}$, $\quad 15\text{ cm} \to 15\times10^{-2}\text{ m}$

$\lambda = -8 \times 10^{-6}$ , $\varepsilon_0 = 8.85 \times 10^{-12}$

$$V(A-D) = \frac{(-8 \times 10^{-6})}{2\pi(8.85 \times 10^{-12})}\left[\ln(7 \times 10^{-2}\,m) - \ln(15 \times 10^{-2}\,m)\right]$$

$$V(A-D) = 109648.232$$

$$\therefore \quad V_D = \sqrt{\frac{2}{m}\left[q(109648.232 + \frac{1}{2} m V_A^2)\right]}$$

$$= \sqrt{\frac{2}{6 \times 10^{-9}\,kg}\left[(3.\cdot 10^{-4}\,c\,(109648.232)) + \frac{1}{2}(6.0 \times 10^{-9})(900)^2\right]}$$

$$\boxed{V_D = 1380.7\ m/s}$$

The speed the particle will be when it hits the detector

(3)

$P = VI$

$P = V \times \frac{\partial q}{\partial t}$

$E = Pt$

$E = V\frac{\partial q}{dt}\, dt$

$E = V dq$

$= 108 \times 50 \; J/C$

$E = 5400 \; J$

w/ 1% of energy transferred $5400 \times .01 = 54 J$

How much energy is converted to have the water evaporated?

$54 = m S dT + mL$

$= m(S dT + L)$

S = specific heat
L = heat of vaporization

$$\frac{54}{(S dT + L)} = m$$

$$m = \frac{54 J}{4200\,(J/kg\,K)(100-30)K + 2.3\times10^{6} J/kg}$$

$$\boxed{m = 2.082\times10^{-5}\ kg}$$

④ with 4 charges

$$U_i = \frac{1}{4\pi\varepsilon_0} \frac{4 \times 4q^2}{\sqrt{(15)^2 + (5/\sqrt{2})^2}}$$

The final potential energy when the satellite is at the center

$$U_f = \frac{1}{4\pi\varepsilon_0} \frac{4 \times 4q^2}{(5/\sqrt{2})}$$

$$\Delta U = U_f - U_i = \frac{16q^2}{4\pi\varepsilon_0}\left(\frac{\sqrt{2}}{5} - \frac{1}{\sqrt{(15)^2 + (5/\sqrt{2})^2}}\right)$$

$$= q^2(31.35 \times 10^9 J)$$

The energy needed to raise the satellite of 100kg to 300 km

$$= \frac{GMm}{R} - \frac{GMm}{R+h}$$

$$= (6.67 \times 10^{-11})(6. \times 10^{24})(100)\left(\frac{1}{6400 \times 1000} - \frac{1}{6700 \cdot 1000}\right)$$

$$= 0.028 \times 10^{10} J$$

Thus

$$q^2(31.35 \times 10^9 J) = (0.028 \times 10^{10} J)$$

$$q = \sqrt{\frac{(0.028 \times 10^{10})J}{(31.35 \times 10^9)J}}$$

$$\boxed{q = 0.0945\ C}$$