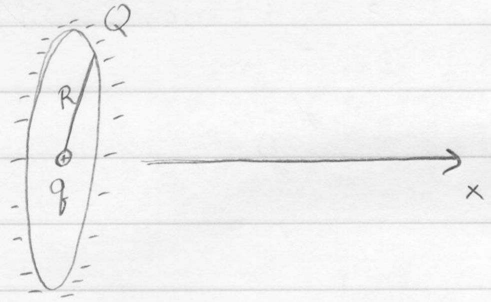
Physics 2b Quiz 3 Solutions #1



$Q = -800\,nC$

$q = +600\,nC$

$R = 2.4\,m$

$\longleftarrow -e\ (\infty)$

e^- projected from infinity along the axis of the ring comes to a halt 5.0 m in front of the ring. What was the initial speed?

We will use conservation of energy to solve this problem: $(KE + PE)_{start} = (KE + PE)_{finish}$ Eq. (1)

$KE_{start} = \frac{1}{2} m_e v_i^2$, m_e = mass of electron, v_i = initial velocity

$PE_{start} = 0$, because we are infinitely far away from a finite charge distribution

$KE_{finish} = 0$, the problem says that the e^- comes to a halt

$PE_{finish} = qV = (-e)V\Big|_{x=5.0m}$, where V is the electric potential from the point charge <u>and</u> the ring

From (1) we have $\frac{1}{2} m_e v_i^2 = -eV \Rightarrow v_i = \sqrt{\frac{-2eV}{m_e}}$ (2)

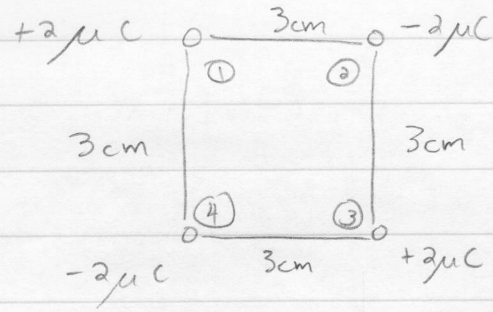
$$V = V_{ring} + V_{point\ charge} = \frac{kQ}{\sqrt{x^2+a^2}} + \frac{kq}{x} = \frac{k(-800nC)}{\sqrt{(5m)^2 + (2.4m)^2}} + \frac{k(600nC)}{5m}$$

$$= -218\ J/C$$

(2) $v_i = \sqrt{\frac{-2(1.6\times10^{-19}C)(-218\ J/C)}{(9.1\times10^{-31}kg)}} = 8.8\times10^{6}\ m/s$

closest is $\boxed{9\times10^{6}\ m/s}$

Physics 2b Quiz 3 Solutions #2



What is the electrostatic energy of this system?

$$U = \sum_{i}^{4} \sum_{j>i}^{4} q_i V_{ij}$$

Here the first sum runs over all (4) charges and the second sum runs over all charges with index greater than i (to avoid double counting).

$i=1 \rightarrow j = 2,3,4$

$i=2 \rightarrow j = 3,4$

$i=3 \rightarrow j = 4$

$q_i V_{ij}$ is the charge of i times the potential at i due to j

More explicitly, $V_{ij} = \frac{k q_j}{r_{ij}}$, $r_{ij} \equiv$ distance from i to j

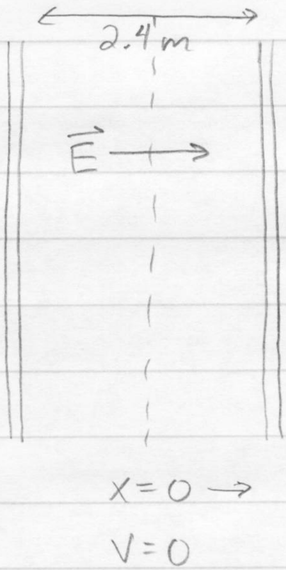
$$U = k\Bigg[(+2\times10^{-6}C)\left(\frac{-2\times10^{-6}C}{3\times10^{-2}m} + \frac{+2\times10^{-6}C}{4.24\times10^{-2}m} + \frac{-2\times10^{-6}C}{3\times10^{-2}m}\right)$$

$$+(-2\times10^{-6}C)\left(\frac{+2\times10^{-6}C}{3cm} + \frac{-2\times10^{-6}C}{4.24\times10^{-2}m}\right)$$

$$+(+2\times10^{-6}C)\left(\frac{-2\times10^{-6}C}{3cm}\right)\Bigg] = -3.10\ J$$

closest is $\boxed{-3.10\ J}$

Physics 2b Quiz 3 Solutions # 3



two large (infinite) conducting plates, $\vec{E} = 1500\ V/m$

Where is $V = +600V$?

You should immediately that the answer will be negative because the potential increases as we go <u>against</u> the $\vec{E}$ field.

For a uniform $\vec{E}$ field

$$\Delta V_{AB} = -E\,\Delta x$$

$$+600V = -(1500 V/m)\,\Delta x$$

$$\Rightarrow \boxed{\Delta x = -0.4m}$$

Physics 2b Quiz 3 Solutions # 4

From problem 1 we have

$$V = V_{ring} + V_{charge} = \frac{kQ}{\sqrt{x^2+a^2}} + \frac{kq}{x}$$

We are asked to find x such that V = 0

$$0 = \frac{kQ}{\sqrt{x^2+a^2}} + \frac{kq}{x}$$, divide through by k and subtract q/x

$$\Rightarrow \quad -\frac{q}{x} = \frac{Q}{\sqrt{x^2+a^2}}$$, cross multiply

$$\Rightarrow \quad \sqrt{1+\left(\frac{a}{x}\right)^2} = -\frac{Q}{q}$$, square both sides and subtract 1

$$\left(\frac{a}{x}\right)^2 = \left(\frac{Q}{q}\right)^2 - 1$$, solve for x

$$x = a\sqrt{\frac{1}{\left(\frac{Q}{q}\right)^2 - 1}} = \boxed{2.72\,m}$$

closest is $\boxed{2.7\,m}$