Discussion 5

a) $E = \frac{Q}{\varepsilon_0 A}$, $Q = \eta A$ $\therefore$ $E = \frac{\eta}{\varepsilon_0}$ $\therefore$ $\boxed{E = \frac{\eta}{8.85\times10^{-12}\ \frac{C^2}{Nm^2}}}$

b) $Q_{proton} = E\varepsilon_0 A \rightarrow Q = \frac{\eta}{\varepsilon_0}\varepsilon_0 A$ $\therefore$ $\boxed{Q = \eta A = \eta a^2}$

$A = a^2$ ← area

$a = \frac{F}{m} = \frac{qE}{m} = \frac{\eta A E}{m_{proton}} = \frac{\eta a^2 \cdot \frac{\eta}{\varepsilon_0}}{1.67\times10^{-27}}$ $\boxed{= \frac{\eta^2 a^2}{\varepsilon_0(1.67\times10^{-27})}}$

← acceleration

c) $v_f^2 = 2a\Delta x \rightarrow v = 2\frac{\eta^2 a^2}{\varepsilon_0(1.67\times10^{-27})} \cdot a = \frac{2\eta^2 a^3}{\varepsilon_0(1.67\times10^{-27})}$

$v = \sqrt{2}$ $\quad v = \sqrt{\frac{2\eta^2 a^3}{\varepsilon_0(1.67\times10^{-27})}}$

~~$v_f = v_0 + at \rightarrow v_f = v + \frac{\eta^2 a^2}{\varepsilon_0}$~~

$v_f^2 = v^2 + 2\frac{\eta^2 a^3}{\varepsilon_0(1.67\times10^{-27})} \rightarrow v_f = \sqrt{v^2 + \frac{2\eta^2 a^3}{\varepsilon_0(1.67\times10^{-27})}}$

$v = \frac{\text{distance}}{\text{time}}$ $\therefore$ $t = \frac{\Delta x}{v_f}$

$a_x = 0$ $\therefore$ $v_f = v_0$, $v = \frac{\Delta x}{\text{time}}$ $\therefore$ $t = \frac{\Delta x}{v} = \boxed{\frac{a}{v}}$

d) $\Delta y = v_{y0}t + \frac{1}{2}a_y t^2 = \frac{v\cdot a}{v} + \frac{1}{2}\frac{\eta^2 a^2}{\varepsilon_0(1.67\times10^{-27})}\left(\frac{a}{v}\right)^2$ $\quad v_{y0} = 0$

$= a + \frac{1}{2}\frac{\eta^2 a^2}{\varepsilon_0(1.67\times10^{-27})}\cdot\frac{a^2}{v^2}$ $= a + \frac{\eta^2 a^4}{\varepsilon_0 v^2(1.67\times10^{-27})}$

$\Delta y = \frac{1}{2}a_y t^2 = \frac{1}{2}\frac{\eta^2 a^2}{\varepsilon_0(1.67\times10^{-27})}\frac{a^2}{v^2}$

DS

e) $v_x = v$, $v_y = at = \frac{\eta^2 a^3}{\varepsilon_0 (1.67\times10^{-27})} \cdot \frac{a}{v_x}$

$= \frac{\eta^2 a^3}{\varepsilon_0 (1.67\times10^{-27}) v_x} \rightarrow$ $\boxed{v = \sqrt{v^2 + \left(\frac{\eta^2 a^3}{\varepsilon_0 (1.67\times10^{-27}) v}\right)^2}}$

---

f) ~~$W = -\int F dx$~~ $W = F\Delta x = qE\Delta x = \eta a^2 \cdot \frac{\eta}{\varepsilon_0} \Delta x$

$W = \frac{\eta^2 a^2}{\varepsilon_0} \Delta x$ $\boxed{= \frac{1}{2} \frac{\eta^2 a^2 a^2}{\varepsilon_0 (1.67\times10^{-27}) v^2} \cdot \frac{\eta^2 a^3}{\varepsilon_0}}$