EITHER **Question 19** Two large parallel metal plates, one positively charged, the other negatively charged, are placed 3.7 cm apart in a near vacuum. In a region near the centre of the plates, an electron and a proton are released simultaneously (from rest) from the negative and positive plate respectively. How far are the two particles from the positive plate when they pass each other? (You can neglect gravitational effects, and any interaction between the electron and the proton.)

OR **Question 20** In the Bohr model of the hydrogen atom, the electron moves around the proton in uniform circular motion. In an orbit characterized by the quantum number n, the radius of the orbit is

$$r_n = n^2 a_0, \quad \text{where } a_0 = \frac{h^2 \varepsilon_0}{\pi m_e e^2}.$$

Use this fact, and any of the postulates of Bohr's model, to find the ratio of the kinetic and potential energies (i.e. $E_{\text{trans}}/E_{\text{pot}}$) of the electron in an orbit with Bohr quantum number n.

[END OF QUESTION PAPER]

$KE = \frac{1}{2}mv^2$ $\quad PE = \frac{q_1 q_2}{4\pi\varepsilon_0 r} = \frac{+e^2}{4\pi\varepsilon_0 r}$

$L = \frac{nh}{2\pi}$ $\quad mvr \therefore r = \frac{nh}{2\pi mv}$

$r = n^2 a_0 = \frac{n^2 h^2 \varepsilon_0}{\pi m e^2} = \frac{nh}{2\pi mv}$ $\quad \frac{nh\varepsilon_0}{e^2} = \frac{1}{2v}$

$v = \frac{e^2}{2nh\varepsilon_0}$

$PE = \frac{e^2}{4\pi\varepsilon_0 r} = \frac{e^2}{4\pi\varepsilon_0}\left(\frac{\pi m e^2}{n^2 h^2 \varepsilon_0}\right) = \frac{me^4}{4\varepsilon_0^2 n^2 h^2}$

$\frac{1}{2}mv^2 = \frac{me^4}{8n^2h^2\varepsilon_0^2}$

$\frac{E_K}{E_P} = \frac{e^4 m}{8n^2h^2\varepsilon_0^2} \times \frac{4\varepsilon_0^2 n^2 h^2}{me^4}$

$= \frac{1}{2}$

$F = qE = \frac{qV}{d}$

$a_e = \frac{F}{m} = \frac{qV}{dm_e}$

$s_e = \frac{1}{2}a_e t^2 = \frac{1}{2}\frac{qV}{dm_e}t^2$

$a_p = \frac{F}{m} = \frac{qV}{dm_p}$

$s_p = \frac{1}{2}at^2 = \frac{1}{2}\frac{qV}{dm_p}t^2$

$s_e = 3.7 - s_p$

$\frac{1}{2}\frac{qV}{dm_e}t^2 = 3.7 - \frac{1}{2}\frac{qV}{dm_p}t^2$

$\frac{1}{2}\frac{qVt^2}{d}\left(\frac{1}{m_e} - \frac{1}{m_p}\right) = 3.7$

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