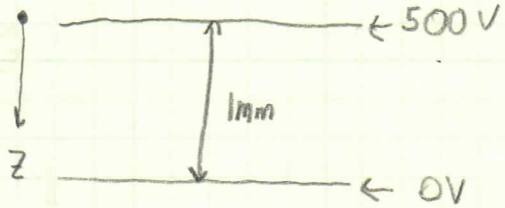
4.1



$V = 500 - \frac{500}{0.001} z$ for $z \in [0, 0.001]$

$\vec{E} = -\vec{\nabla} V = 0.5 \times 10^6 \hat{z} \frac{N}{C}$

a) $\vec{p} = \alpha \vec{E}$. $\alpha = (0.667 \times 10^{-30} m^3) 4\pi\varepsilon_0$

$\vec{p} = q\vec{d}$. Here $\hat{d} = \hat{E}$, so

$qd = \alpha E \Rightarrow d = \frac{\alpha}{q} E$. $q = 1.609 \times 10^{-19} C$; $\varepsilon_0 = 8.85 \times 10^{-12} \frac{C^2}{Nm^2}$

$$d = 4\pi \frac{(8.85 \times 10^{-12} \frac{C^2}{Nm^2})(0.66 \times 10^{-30} m^3)}{1.609 \times 10^{-19} C} (0.5 \times 10^6 \frac{N}{C})$$

$= 2.31 \times 10^{-16} m$. $a_r = 0.5 \text{Å} = 0.5 \times 10^{-10}$, $\therefore$

$$\frac{d}{a_r} = 4.62 \times 10^{-6}$$

b) To ionize set $d = a_r$

Then $E = \frac{qd}{\alpha} = \frac{qa_r}{\alpha} = \frac{(1.609 \times 10^{-19} C)(0.5 \times 10^{-10} m)}{4\pi (8.85 \times 10^{-12} \frac{C^2}{Nm^2})(0.667 \times 10^{-30} m^3)}$

$= 106.8 \times 10^9 \frac{N}{C}$. Using the form of V above:

$V = 106.8 \times 10^6 - 106.8 \times 10^9 z$.

Clearly, a voltage of ~ 107 MV is needed.