HW #5

6-19 H atom in $n=5$ state

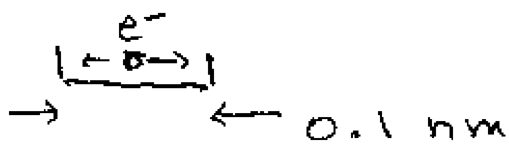
Energy of transition $5 \to n < 5$

$$\Delta E = -13.6\,\text{eV}\left(\frac{1}{5^2} - \frac{1}{n^2}\right)$$

$5 \to 4, 3, 2, 1$

$$\Delta E = -13.6\,\text{eV} \cdot \begin{cases} \left(\frac{1}{25} - \frac{1}{16}\right) \\ \left(\frac{1}{25} - \frac{1}{9}\right) \\ \left(\frac{1}{25} - \frac{1}{4}\right) \\ \left(\frac{1}{25} - 1\right) \end{cases} = \begin{cases} 0.306\,\text{eV} \\ 0.907 \\ 2.86 \\ 13.1 \end{cases}$$

4-15



a) $\Delta p \Delta x = \hbar$

$$\Delta p = \frac{\hbar}{\Delta x} = \frac{1}{c}\,\frac{hc}{2\pi \cdot 0.1\,\text{nm}}$$

$$= \frac{1}{c} \cdot \frac{1.24 \times 10^3\,\text{eV}\cdot\text{nm}}{0.628\,\text{nm}}$$

$$= 1.97 \frac{\times 10^3}{c}\,\text{eV} \ll mc$$

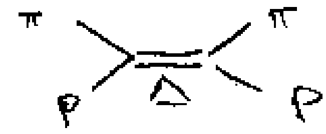
nonrelativ.

b) $$\frac{\Delta p^2}{2m} = \frac{(1.97 \times 10^3\,\text{eV}/c)^2}{2 \cdot 0.511 \times 10^6\,\text{eV}/c^2}$$

$$= 3.80\,\text{eV}$$

c) about same as $n=2$ state of H

4-17 $\Delta E \Delta t \sim \hbar$



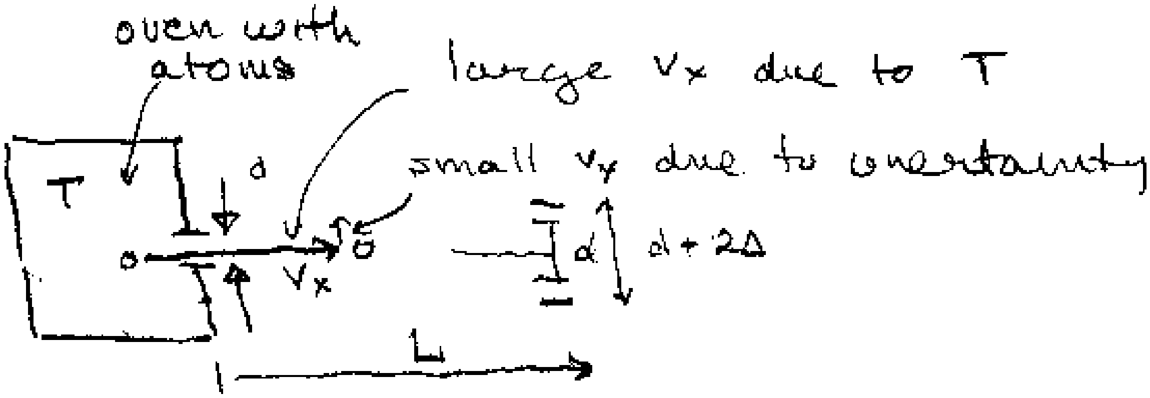
$\Delta t = \dfrac{\hbar}{\Delta E}$ (nothing to do with E)

$= \dfrac{6.58 \times 10^{-16}\,\text{eV}\cdot\text{s}}{120\ \text{MeV}}$

$\hookrightarrow 1.20 \times 10^{8}\,\text{eV}$

$= 5.4 \times 10^{-24}\,\text{s}$

4-24



To get out $v \simeq v_x$.

$\Delta = v_y t$ where t is time an atom takes to travel distance L

$t \simeq \dfrac{L}{v_x}$ get v_x from

$K = \frac{3}{2} kT$ Krane (1.15, p.6)

$\frac{1}{2} m v_x^2 = \frac{3}{2} kT$

$v_x = \sqrt{3kT/m}$

thus

$$\Delta = v_y \frac{L}{\sqrt{3kT/m}}$$

v_y from

$$\Delta p_y \, \Delta y = \hbar$$

$$m \underbrace{\Delta v_y}_{\text{take} = v_y} d = \hbar$$

$$v_y = \frac{\hbar}{md}$$

then

$$\Delta = \frac{\hbar}{md} \frac{L}{\sqrt{3kT/m}} = \frac{L\hbar}{d\sqrt{3mkT}} \checkmark$$

Estimate

$L = 2\,m$ $\quad k \sim 9 \times 10^{-5}\,eV/K$

$d = 3 \times 10^{-3}\,m$

$T = 1500\,K$

$m = 3u \sim 3 \times 10^{6}\,eV/c^2$

$$\frac{L\hbar c}{d\sqrt{3mc^2kT}} \qquad \Delta \sim \frac{L \quad (hc)}{2\pi d \sqrt{3(mc^2)\,kT}}$$

$$\sim \frac{2\,\cancel{m}}{6 \cdot 3 \times 10^{-3}\,\cancel{m}} \frac{1.2 \times 10^{3}\,\cancel{eV} \cdot nm}{\sqrt{3(10^6\,\cancel{eV}) \cdot 9 \times 10^{-5}\,\cancel{eV}\, 1.5 \times 10^3}}$$

$$\sim \frac{2(1.2)}{6 \cdot 3\sqrt{3 \cdot 9 \cdot 1.5}} \frac{10^3\,nm}{10^{-3} \cdot 10^{-3}} \sim 0.025 \times 10^{9}\,nm$$

$$\sim 2.5 \times 10^{-2}\,m$$