Physics 492 Spring 2016

Recitation #1 Solutions

1) $\psi(\vec{x}) = \psi_x(x)\,\psi_y(y)\,\psi_z(z)$

$$E = \frac{\hbar^2 k^2}{2m} = \frac{\hbar^2}{2m}\left(k_x^2 + k_y^2 + k_z^2\right)$$

for ground state, $k_i = \frac{\pi}{L}$

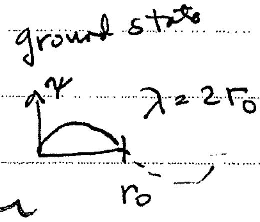
$$E = 3\left(\frac{\pi}{L}\right)^2 \frac{\hbar^2 c^2}{2m_e c^2}$$

$$L^2 = \frac{3}{2}\,\frac{\pi^2 \hbar^2 c^2}{E\,(m_e c^2)} = \frac{3}{2}\,\frac{\pi^2\,(197\,\text{eV}\cdot\text{nm})^2}{(13.6\,\text{eV})(\frac{1}{2}\times 10^6\,\text{eV})}$$

$$\cong \frac{3}{2}\,\frac{3^2 \cdot 4\times 10^{4-6}}{7}\ \text{nm}^2$$

$$L = \sqrt{\frac{3}{14}\,\frac{6}{10}}\ \text{nm} = 0.28\ \text{nm}$$

2×



2) Set de Broglie wavelength to nuclear radius (~2 fm)

$$pc = \frac{hc}{\lambda} = \frac{2\pi\,(197\,\text{MeV}\cdot\text{fm})}{2(2\,\text{fm})} \cong 300\ \text{MeV}$$

$pc \gg mc^2$, so electron is ultra-relativistic

$$KE \cong E \cong pc = 300\ \text{MeV}$$

3) $E = L^2/2I \qquad I = \mu r_0^2$

$$= \frac{\hbar^2 \ell(\ell+1)}{2\mu r^2} \qquad \mu = \frac{12(14)}{12+14} = 6.5\,u$$

$$E_1 - E_0 = \frac{\hbar^2}{\mu r^2} = \frac{2\pi\hbar c}{\lambda}$$

$$r^2 = \frac{1}{\mu c^2}\,\frac{\hbar^2 c^2}{1}\left(\frac{\lambda}{2\pi\hbar c}\right)$$

$$= \frac{2.6\times10^6\,\text{nm}\,(200\ \text{eV}\cdot\text{nm})}{2\pi(6.5)(931.5\times10^6\,\text{eV})}$$

$r = 0.12$ nm