HW5 Chapter 3 and 4

KEY

3-43 $pc = 25\text{ keV} = 25\times10^{3}\text{ eV}$

$$\lambda = \frac{hc}{pc} = \frac{1240\text{ eV-nm}}{25\times10^{3}\text{ eV}} = 0.0496\text{ nm}$$

3-47 $\xrightarrow{\gamma} \overset{e}{\bullet} \qquad \xleftarrow{\gamma'} \quad \xrightarrow{e} \qquad E(\gamma) = 40\text{ keV}$

maximum when $\theta = \pi$

$$\lambda' - \lambda = \frac{h}{mc}(1-\cos\theta) \qquad \text{max @ } \theta = \pi$$

$$\lambda' = \lambda + \frac{h}{mc}(2) = \lambda + \frac{2h}{mc}$$

need $\lambda = \dfrac{hc}{E} = \dfrac{1240\text{ eV.nm}}{40\times10^{3}\text{ eV}}$

$\lambda = 0.031\text{ nm}$

$= 0.031\times10^{-9}\text{ m}$

$\lambda = 3.1\times10^{-11}\text{ m}$

$$= 3.1\times10^{-11}\text{ m} + \frac{2hc}{mc^2}$$

$$= 3.11\times10^{-11} + \frac{(2)(1240)}{0.511\times10^{6}} = 3.11\times10^{-11} + 4.9\times10^{-3}\text{ nm} \quad (\times10^{-12}\text{ m})$$

$$\lambda' = 3.11\times10^{-11} + 0.49\times10^{-11} = 3.6\times10^{-11}\text{ m}$$

K, electron recoil = change in γ energy

$$K_e = \frac{hc}{\lambda} - \frac{hc}{\lambda'} = \frac{1240 \text{ eV}\cdot\text{nm}}{3.1\times10^{-2}\text{ nm}} - \frac{1240 \text{ eV}\cdot\text{nm}}{3.6\times10^{-2}\text{ nm}}$$

$$K_e \cong 5400 \text{ eV} = 5.4 \text{ keV}$$

3-48

Compton formula, but proton mass for $\theta = \pi/2$

$$\Delta\lambda = \frac{h}{m_p c}(1-\cos\theta) = \frac{hc}{m_p c^2}$$

$\cos\pi/2 = 0$

$m_p = 0.938 \text{ MeV}/c^2$

$$\Delta\lambda = \frac{1240 \text{ eV}\cdot\text{nm}}{0.938\times10^{6}\text{ eV}}$$

$$\Delta\lambda = 1.3\times10^{-3}\text{ nm} = 1.3\times10^{-12}\text{ m} = 1.3 \text{ fm}$$

4-5

$$b = \frac{z_1 z_2 e^2}{4\pi\epsilon_0 m v^2} \cot \theta/2$$

$Z_1 = 2$, $Z_2 = 79$ $\theta = 1°$ & $90°$

$K = 7.7$ MeV

$$= \frac{Z_1 Z_2}{8\pi\epsilon_0 K} \cot \theta/2$$

$$\frac{e^2}{4\pi\epsilon_0} = 1.44 \times 10^{-9} \text{ eV}\cdot\text{m (cover book)}$$

$$= \frac{(2)(79)(1.44 \times 10^{-9})}{(2)(7.7 \times 10^6)}$$

$$b = 1.5 \times 10^{-14} \cot \theta/2$$

$\theta = 1°$ $\theta = 90°$

$b =$ 1.72×10^{-12} m 1.5×10^{-14} m

4-8 $\quad K = 5\text{ MeV } \alpha \qquad t = 10^{-8}\text{ m} \qquad \rho = 19.3\text{ g/cm}^3$

$Z_2 = 79$

$$f = \pi n t \left(\frac{Z_1 Z_2 e^2}{8\pi\epsilon_0 K}\right)^2 \cot^2 \theta/2$$

from example 4.2 $\quad n = 5.9\times10^{28}\text{ m}^{-3}$

$$= \pi\,(5.9\times10^{28}\text{ m}^{-3})(10^{-8}\text{ m})\left[\frac{(2)(79)(1.44\times10^{-9}\text{ eV.m})}{(2)(5\times10^{6}\text{ eV})}\right]^2 \cot^2(4^\circ)$$

$$f \cong 2\times10^{-4}$$

4-14 $\quad r = 1.2\times10^{-15}\text{ m}$

a) $$v = \frac{e}{\sqrt{4\pi\epsilon_0 m r}} = \frac{ec}{\sqrt{4\pi\epsilon_0 mc^2 r}} = \frac{\sqrt{1.44\text{ eV}\cdot\text{nm}}}{\sqrt{(0.511\times10^{6}\text{ eV})(1.2\times10^{-6}\text{ nm})}}\,c$$

$v = 1.5c$ a) which can't happen.

b) $$E = -\frac{e^2}{8\pi\epsilon_0 r}$$

$$= -\frac{1.44\text{ eV}\cdot\text{nm}}{2(1.2\times10^{-6}\text{ nm})} \cong -600\text{ keV}$$

c) that's way too much energy

4-22 For hydrogen-like atom

$$E = \frac{-Z^2}{n^2} E_0 \qquad E_0 = 13.6\ eV.$$

H: $E = -13.6\ eV.$

He^+: $E = -4(13.6) = -54.4\ eV$

Li^{++}: $E = -9(13.6) = -122.5\ eV$

4-23 H absorbs γ: $\lambda = 410\ nm$

$$E = \frac{hc}{\lambda} = \frac{1240}{410} = 3.0\ eV$$

from energy diagram this looks like

$n=6 \rightarrow n=3$

$E_6 = -0.38\ eV - E_2 = -3.40\ eV$

pretty close

4-24 $\lambda = 95\,nm$

$$E = \frac{hc}{\lambda} = \frac{1240}{95} = 13.05\ eV$$

looks like $n = 5 \rightarrow n = 1$

4-25 $E = Z^2 E_0$

D_2 $E = 1^2 E_0 = 13.6\,eV$

He^+ $E = 54.4\,eV$

Be^{+++} $E = 4^2 E_0 = 218\,eV$

4-30 $\lambda = 397\,nm$

$$E = \frac{hc}{\lambda} = \frac{1240}{397} = 3.12\,eV$$

$$E_7 - E_2 \sim 3.12\,eV$$