Josh Whitehead
U10693473
NUCI 3100

HW 2

1) a.) $E_{th}^{\alpha} = \left[\left(1 - \frac{v^2}{c^2}\right)^{-1/2} - 1\right] m_0 c^2$

$v \geq \frac{c}{n} \rightarrow E = \left[\left(1 - \frac{\cancel{c^2}}{n^2 \cancel{c^2}}\right)^{-1/2} - 1\right] m_0 c^2$

$= \left[\left(1 - \frac{1}{1.3^2}\right)^{-1/2} - 1\right] 3727 \boxed{= 2105.814968 \text{ MeV}}$

b.) $\cos(\theta) = \frac{1}{\beta n}$ where $\beta = \frac{v}{c}$ ~~max θ @ β = 1~~

~~$\therefore \theta^{max} = \arccos\left(\frac{1}{n}\right) = 39.7^\circ$~~

$\cos(\theta) = \frac{1}{\beta n}$ $\beta = \frac{2.3 \times 10^8}{2.99 \times 10^8} = 0.769$

$\therefore \theta = \arccos\left(\frac{1}{0.769 \cdot 1.3}\right) \boxed{= 1.207 \times 10^{-6}\ ^\circ}$

c.) small angle $\therefore$ not reasonable to make Cherenkov detector for α particle

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2.) $E_{\gamma th} \geq 2 m_e c^2 = 2(0.511) \boxed{= 1.022 \text{ MeV}}$

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3) a) $E_\gamma = E_{e^-} + E_{\gamma'}$ $\boxed{E_{\gamma'} = 120 \text{ keV}}$

b) $\frac{1}{E_{\gamma'}} - \frac{1}{E_\gamma} = \frac{1 - \cos\theta}{m_e c^2}$

$\frac{1}{120} - \frac{1}{190} = \frac{1 - \cos\theta}{511}$

$\cos\theta = 1 - 511\left(\frac{1}{120} - \frac{1}{190}\right)$

$\boxed{\theta = 124.7^\circ}$

Josh Whitehead
u1069343
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4) $\cot\left(\frac{\theta}{2}\right) = \left(1 + \frac{E_\gamma}{m_e c^2}\right) \tan(\phi)$

$\tan\phi = \frac{\cot\left(\frac{35^\circ}{2}\right)}{1 + \frac{200}{511}} \Rightarrow \boxed{\phi = 66.3^\circ}$

$\frac{1}{E_\gamma'} = \frac{1 - \cos(35^\circ)}{m_e c^2} + \frac{1}{E_\gamma} = 0.00535 \frac{1}{keV} \rightarrow E_\gamma' = 186.779 \text{ keV}$

$\therefore E_{e^-} = 200 - 186.8 \boxed{= 13.220645 \text{ keV}}$

5) $\frac{1}{E_\gamma'} = \frac{1 - \cos(\theta)}{0.511 \text{ MeV}} + \frac{1}{E_\gamma}$

@ $\theta = 30^\circ$: $E_\gamma' = 0.912813079$ MeV
@ $\theta = 60^\circ$: $E_\gamma' = 0.551935194$ MeV
@ $\theta = 90^\circ$: $E_\gamma' = 0.358386908$ MeV

Josh Whitehead
V10693343
Nucl 3100

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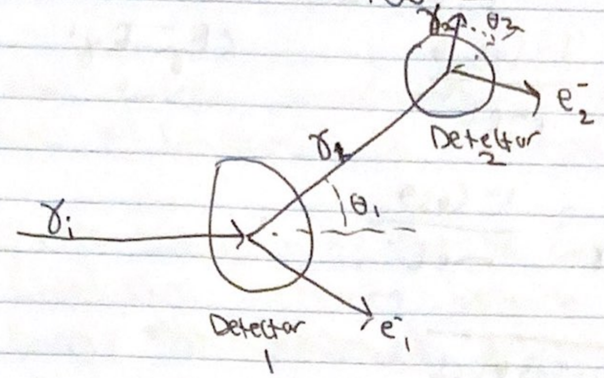
6)

$\theta_2 = 20°$



$$\frac{1}{E\gamma'} - \frac{1}{E\gamma} = \frac{1-\cos\theta}{0.511\text{ MeV}}$$

$E\gamma_1$: $E\gamma_1 = 0.8\,E\gamma_i \Rightarrow \boxed{E\gamma_1 = 1.6\text{ MeV}}$

Ee_1: $Ee_1 = E\gamma_i - E\gamma_1 = 2 - 1.6 \Rightarrow \boxed{Ee_1 = 0.4\text{ MeV}}$

$E\gamma_2$: $\dfrac{1}{E\gamma_2} = \dfrac{1-\cos(20°)}{0.511} + \dfrac{1}{1.6} = 0.743\ \dfrac{1}{\text{MeV}}$

$$\boxed{\therefore E\gamma_2 = 1.345861773\text{ MeV}}$$

Ee_2: $Ee_2 = E\gamma_1 - E\gamma_2 \Rightarrow \boxed{Ee_2 = 0.254138227\text{ MeV}}$

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U1069343
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7.) $\frac{1}{E_\gamma'} - \frac{1}{E_\gamma} = \frac{1-\cos\theta}{m_e c^2}$ $\quad x E_\gamma = E_\gamma'$

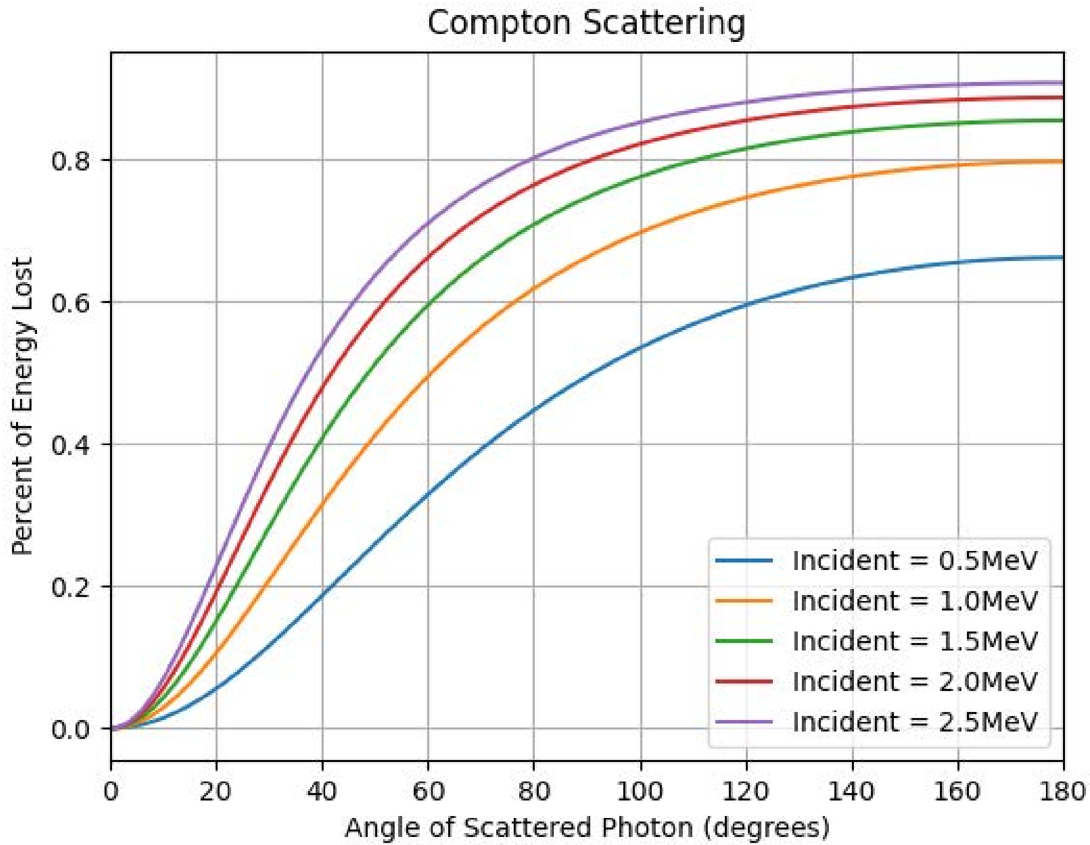
$$\therefore \frac{1}{xE_\gamma} - \frac{1}{E_\gamma} = \frac{1-\cos\theta}{m_e c^2}$$

$$x = \frac{1}{E_\gamma\left(\frac{1-\cos\theta}{0.511}\right) + \frac{1}{E_\gamma}}$$

Percent energy lost is function of θ and E_γ

$$\frac{1}{E_\gamma'} = \frac{1-\cos\theta}{511} + \frac{1}{E_\gamma} \qquad \frac{1-\cos\theta}{511}$$

$$\frac{E_\gamma}{E_\gamma'} = 1 + \frac{(1-\cos\theta)E_\gamma}{511}$$



Compton Scattering
Percent of Energy Lost
Angle of Scattered Photon (degrees)
0.0
0.2
0.4
0.6
0.8
0
20
40
60
80
100
120
140
160
180
Incident = 0.5MeV
Incident = 1.0MeV
Incident = 1.5MeV
Incident = 2.0MeV
Incident = 2.5MeV

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u1069343
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8) Total energy, momentum, and electronic charge are all conserved in radiation interactions.

Kinetic energy may not be conserved during Inelastic Scattering because some of the kinetic energy ~~[illegible]~~ excites the target atom to a higher state.

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9) $\Omega_{circ} = \frac{A}{r^2} = \frac{\pi(0.05^2)}{2^2} = 0.001963$

$\Omega_{sph} = 4\pi = 12.57$

$\rightarrow \text{frac} = \frac{0.001963}{12.57} = 0.00015625$

$\boxed{\rightarrow 0.0156\%}$