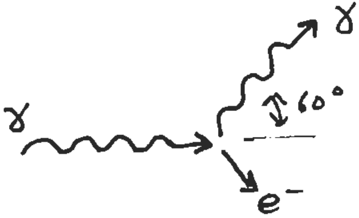
AP 4010 INTRO NUC SCIENCE

HOMEWORK #3 — SOLUTIONS

5.7)



$$\frac{E_\gamma'}{E_\gamma} = \frac{1}{2} = \frac{1}{1 + \left(\frac{E_\gamma}{mc^2}\right)(1-\cos 60°)}$$

$$\therefore \quad \frac{E_\gamma}{mc^2} = 2 \qquad E_\gamma \sim 1.022\ \text{MeV}$$

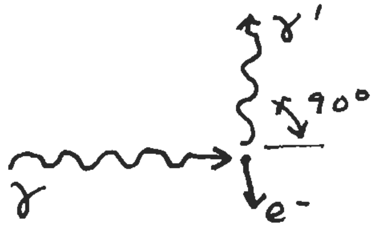
5.8)

$$\frac{E_\gamma'}{E_\gamma} = \frac{1}{2\left(\frac{E_\gamma}{mc^2}\right) + 1}$$

AS $E_\gamma \to \infty$, THEN $E_\gamma' \simeq \dfrac{E_\gamma}{2\left(\frac{E_\gamma}{mc^2}\right)} \sim \frac{1}{2} mc^2$

$\sim 255.5\ \text{keV}$

5.9)



$$E_\gamma = \frac{2\pi\ 197.33 \times 10^{-15}}{\lambda(m)} (\text{MeV})$$

$$\lambda = 10^{-6}\ m \Rightarrow E_\gamma = 1.24\ eV$$

$$E_{e^-} = E_\gamma - E_{\gamma'} = E_\gamma - E_\gamma / (1 + E_\gamma / mc^2)$$

$$\cong E_\gamma - E_\gamma\left(1 - \frac{E_\gamma}{mc^2} + \cdots\right) \simeq \frac{E_\gamma^2}{mc^2}$$

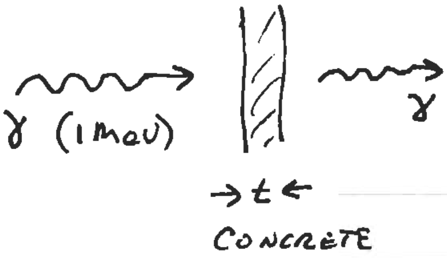
$$= 3 \times 10^{-6}\ eV \quad \text{(LESS THAN ROOM TEMP)}$$

$$V \sim \sqrt{2E/m_e} \sim \sqrt{2c^2\left(\frac{E_\gamma}{mc^2}\right)^2} \sim \sqrt{2}\, c \left(\frac{E_\gamma}{mc^2}\right)$$

$\sim 1030\ m/s$

~ 0.64 MILES/SEC (VERY SLOW FOR AN ELECTRON)

5.10

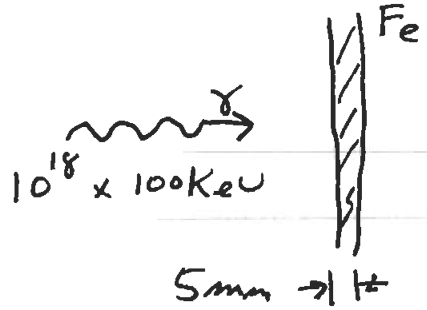


$$10^{-6} = e^{-\mu_m \rho t}$$

$$t = \frac{6 \ln(10)}{\mu_m \rho}$$

$$= \frac{6 \ln(10)}{0.064 \;\; 2.29} = 98\,cm$$

5.11



ENERGY OF X-RAY PULSE

$$= 10^{18} \; 10^{5}\, eV \;\; 1.6\times10^{-19} \frac{J}{eV}$$

$$= 1.6\times10^{4}\ J/m^2$$

$$\text{ENERGY ABSORBED} = 1.6\times10^{4}\left(1 - e^{-\mu_m \rho t}\right)$$

$$= 1.6\times10^{4}\left(1 - e^{-0.04 \;\; 7870 \;\; 10^{-3}\, 5}\right)$$

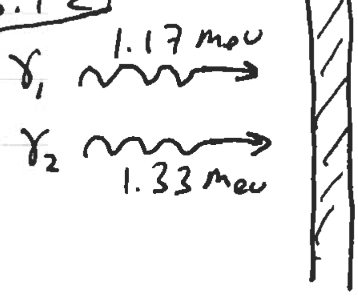
$$= 1.6\times10^{4}\,(1 - 0.207)$$

$$= 1.27\times10^{4}\ J/m^2$$

$$\text{TEMPERATURE RISE} = \left(\frac{\text{ENERGY}}{\text{THICKNESS}}\right) \frac{1}{C\rho}$$

$$= \frac{1.27\times10^{4}}{5\times10^{-3}} \; \frac{1}{106} \; \frac{1}{7870} = 3.04\ ^{\circ}K$$

5.12



$$e^{-\mu_1 t} = 0.62$$

$$e^{-\mu_2 t} = 0.65$$

$$\therefore \quad \frac{\mu_1}{\mu_2} = \frac{\ln(0.62)}{\ln(0.65)} = 1.11$$

TWO SLABS $\Rightarrow$ $(0.62)^2 = 0.38$

$(0.65)^2 = 0.42$

5.13) ATTENUATION $= e^{-x/\lambda}$ WHERE $\lambda = \frac{1}{n\sigma}$

CADMIUM $\Rightarrow$ $\sigma = 3000 \times 10^{-28}\ m^2$

$$n = 8650\,\frac{kg}{m^3}\ \frac{1}{112.4}\ \frac{1}{1.66\times10^{-27}\,\frac{kg}{Amu}}$$

$$= 4.64 \times 10^{28}\ \text{NUCLEI}/m^3$$

$$\therefore\ 10^{-3} = e^{-xn\sigma}$$

$$3\ln(10) = x n\sigma \Rightarrow x = \frac{3\ln(10)}{3\times10^{-25}\ 4.64\times10^{28}}$$

$$= 0.5\,mm$$

5.14) $\lambda = \frac{1}{n\sigma} \Rightarrow \sigma = \frac{1}{n\lambda}$

(a)

$$\lambda = 2\,cm$$

$$n = 18.9\,\frac{g}{cm^3}\ \frac{1}{238}\ \frac{1}{1.66\times10^{-24}\,g/Amu}$$

$$= 4.78\times10^{22}\ \text{NUCLEI}/cm^3$$

$$\therefore\ \sigma = \frac{1}{2\ \ 4.78\times10^{22}} = 10.45\times10^{-24}\,cm^2 = 10.45\,b$$

5.15)

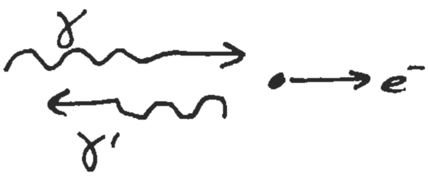
PART b)

$$\frac{1}{\lambda} = \frac{1}{\lambda_s} + \frac{1}{\lambda_a} = \frac{7}{\lambda_a} \quad \therefore\ \lambda_a = 7\lambda$$

	A	n(1 eV)	n(R.T.)	ξ
Be	9	3.4	88	0.21
Fe	56	14.6	516	0.035
Pb	207	72	1889	0.0096

$$n(E') \equiv \frac{1}{\xi}\ln\left(\frac{E_0}{E'}\right) \quad \text{AND} \quad \xi \simeq \frac{2}{A} - \frac{4}{3A^2}$$

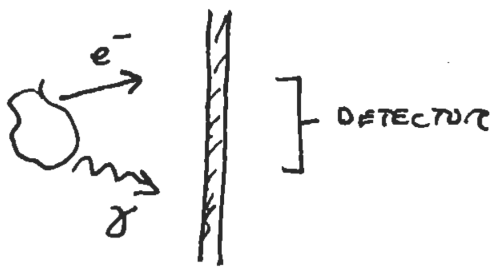
PROBLEM #2

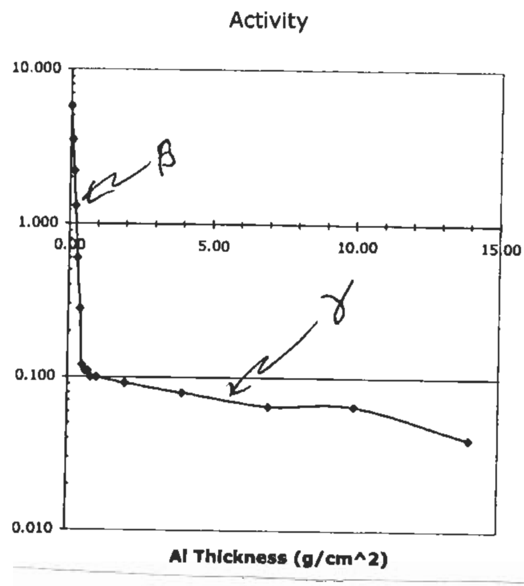


$$E_\gamma' = \frac{E_\gamma}{1 + 2(E_\gamma / mc^2)}$$

E_γ	E_γ' (MeV)
0.01	0.0096
0.1	0.072
1.0	0.204
10.0	0.249
100.0	0.2548

PROBLEM #3





FROM THE PLOT ON RIGHT, THE β'S ARE SHIELDED WITH Al-FOIL $\approx 0.45\ g/cm^{-2}$ THICKNESS. FROM FIG 5.5, THIS RANGE CORRESPONDS TO ABOUT 0.9 - 1.0 MeV ELECTRONS.

TO ESTIMATE THE ABSORPTION COEFFICIENT FOR γ'S WE USE $I(x) \sim e^{-\mu_m \rho t}$ WITH $I(\rho t = 1) = 0.1$ AND $I(\rho t = 14) = 0.04$. $\therefore \frac{0.1}{0.04} = e^{-\mu_m (1-14)} \Rightarrow \mu_m = 0.07\ cm^2/g$

FIG 5-6 GIVES $E_\gamma = 0.9$ to 1.0 MeV