$$R = \int_0^{E} \frac{dx}{dE}\, dE \qquad \beta = \frac{v}{c}$$

$$R = \frac{1}{z^2} \int_0^{E} \frac{dE}{G(\beta)} \qquad E = \frac{Mc^2}{\sqrt{1-\beta^2}}$$

$$dE = M\, g(\beta)\, d\beta$$

$$R = \frac{M}{z^2} \int_0^{\beta} \frac{g(\beta)}{G(\beta)}\, d\beta = \frac{M}{z^2} f(\beta)$$

$$\frac{R_1}{R_2} = \frac{M_1}{M_2} \frac{(z_2)^2}{(z_1)^2}$$

↳ ukoliko čestice imaju iste poč. brzine v

$$R_2 = R_p \quad M_2 = 1\,(M) \quad z_2 = e$$

$$\frac{R_1}{R_2} = M_1 \frac{1}{z_1} = \frac{M_1}{z_1}$$

$$R_1(\beta) = \frac{M_1}{z_1} R_p(\beta)$$

$\ln \bar{I} = \sum N_i Z_i \ln I_i$

H_2O

$M_{H_2O} \ln \bar{I} = 2 \cdot m_e \cdot 1 \ln I_H + m_e \cdot 8 \ln I_O$

H

$\ln \bar{I}_{H_2O} = \frac{2}{10} \ln 19 + \frac{8}{10} \ln 105 = 4.3\,?$

O

$n = \frac{1 \frac{g}{cm^3}}{18} \cdot 6{,}022 \cdot 10^{23} \cdot 10$ → po broju mol. vode, broj elektrona

24.11.2011.

Elektron interakcije

Thomsonovo raspršenje $E_\gamma < 0.5\ MeV$

Comptonovo raspršenje $\frac{8\pi}{3} r_0^2$, $\frac{d\sigma}{d\Omega} = r_0^2 \frac{1+\cos^2\theta}{2}$

Apsorpcija

Fotoefekt $\sigma = \sigma_{thomson} \cdot \frac{8 Z^5}{137^4} \left(\frac{mc^2}{E}\right)^{7/2}$ $\frac{d\sigma}{d\Omega} = \frac{\sin^2\theta}{1-\frac{v}{c}\cos\theta}$

$E_k = E_\gamma - W_i$

tvorba parova $E_\gamma > 1.02\ MeV$

45. K

$\lambda_g = 0.577\ \mu m$

$E_p = ?$

e^-

metal

$E_p(min) = W_i = h \cdot \nu_{gr} = h \frac{c}{\lambda_{g(granična)}} = 4.14 \cdot$

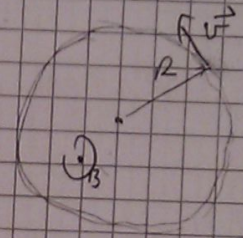
$\cdot 3 \cdot 10^8 \frac{m}{s} \cdot \frac{1 \cdot 10^6}{0.577 \cdot m} = 2.15\ eV$

46. $r = 10\ cm$

$B = 2 \cdot 10^{-2}\ T$

$W_i = B_e = 8.76 \cdot 12\ eV$

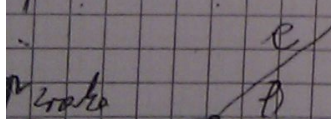
$E_p = ?$



$F_{cp} = \frac{m v^2}{R} = F_l(\text{Lorentzova sila}) = q \vec{v} \vec{B}$

$= e \cdot |\vec{v}| \cdot |\vec{B}|$

$p = e B \cdot R = m v$



$\frac{p_{elektrona}}{m_e \cdot c} = \frac{e B \cdot R}{m_e \cdot c} = \frac{1.6 \cdot 10^{-19} \cdot 2 \cdot 10^{-2} \cdot 6}{9.1 \cdot 10^{-31}(kg) \cdot 3 \cdot}$

$= 1.17$

Moramo se koristiti relativistički

$E_{kc} = \sqrt{p^2c^2 + m^2c^4} - mc^2 = \sqrt{(1.17)^2 \cdot$

$= \left(\sqrt{1.17^2 + 1} - 1\right) mc^2 = 0.511 MeV \cdot$

$= 0.274 MeV$

$E_\gamma = E_e + W_i = 0.274 MeV + 0.0876 MeV = 0.361 MeV$

$E_\gamma = 0.511 MeV \quad \vartheta = 60° \quad W_i = 5.74 eV$

$\left(\frac{d\sigma}{d\Omega}\right)_{60°} = 10 \frac{b}{Sterr}$

$E_\gamma = 80 MeV$

$\left(\frac{d\sigma}{d\Omega}\right)_{2,60°} = ?$

$\left(\frac{d\sigma}{d\Omega}\right)_{2,60°} = K \frac{\sin^2 60°}{1 - \frac{v_2}{c}\cos 60°}$

$\left(\frac{d\sigma}{d\Omega}\right)_{1,60°} = K \frac{\sin^2 60°}{1 - \frac{v_1}{c}\cos 60°}$

$\frac{\left(\frac{d\sigma}{d\Omega}\right)_{2,60°}}{\left(\frac{d\sigma}{d\Omega}\right)_{1,60°}} = \frac{1 - \frac{v_1}{c}\cos 60°}{1 - \frac{v_2}{c}\cos 60°} = \frac{2 - \beta_1}{2 - \beta_2}$

$$\left(\frac{d\sigma}{d\Omega}\right)_{2,60^\circ} = \left(\frac{d\sigma}{d\Omega}\right)_{1,60^\circ} \cdot \frac{z_1^2}{z_2^2}$$

$$E_{kin} = mc^2 \cdot \left(\frac{1}{\sqrt{1-\beta^2}} - 1\right) \rightarrow \beta =$$

$$\frac{E_k}{mc^2} + 1 = \frac{1}{\sqrt{1-\beta^2}}$$

$$\beta = \sqrt{1 - \frac{1}{1+\left(\frac{E_k}{mc^2}\right)^2}}$$

$$\frac{z_1-\beta_1}{z-\beta_2} = \frac{2 - \sqrt{1 - \frac{1}{\left(1+\frac{E_{p1}}{mc^2}\right)^2}}}{2 - \sqrt{1 - \frac{1}{1+\left(\frac{E_{p2}}{mc^2}\right)^2}}} = 7.6 \frac{b}{z_{Pb}}$$

8. $\sigma_{Pb} = 28\,b$

$E_p = \dots$

$z = 74$ $\sigma_w = ?$

$z = 13$ $\sigma_{Al} = ?$

$$\sigma_{Pb} = \frac{8 \cdot z_{Pb}}{137^4} \quad z_{Pb} = \left(\frac{mc^2}{\hbar}\right)^{1/2}$$

$$z_w = \frac{8\sigma_{Pb}}{137^4} \quad z_w^5 \left(\frac{mc^2}{\hbar}\right)^{1/2}$$

$$z_w = z_{Pb} \quad \frac{z_w^2}{z_{Pb}^5} = 28\left(\frac{74}{82}\right)^5 = 17\,b$$

$$z_{Al} = z_{Pb}\left(\frac{z_{Al}}{z_{Pb}}\right)^5 = 28\left(\frac{13}{82}\right)^5 = 2.58\,b$$

Rad. nuklid ^{28}Al čije je [illegible]

2,3 min

^{27}Al 100%

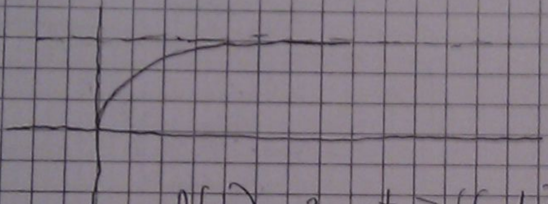
$m = 0.01 g$

$\phi = 3 \cdot 10^{8} \frac{n}{cm^2 s}$ $\sigma_a = 0.23 \cdot 10^{-28} m^2$

$N_A = 6.022 \cdot 10^{26} \frac{at}{kmol}$

$A_{max} = ?$

$A(t) = P_0 (1 - e^{-\lambda t})$



$A(t)$ za $t > (6 \text{ do } 7) \cdot T_{1/2}$ $A_{max} = P_0$

$R = \sigma \phi N$

$N = \frac{m}{M} N_A$

$R = \frac{\sigma \phi m N_A}{M} = A_{max}$

$A_{max} = P_0 = R$

$A_{max} = \frac{0.23 \cdot 10^{-28} \cdot 3 \cdot 10^{12} \cdot 10^{-5} \cdot 6.022 \cdot 10^{26}}{27}$

$= 1.6 \cdot 10^{4} Bq$

$E_\alpha = 10\,MeV$ $\quad M = 27$

$\delta x = \frac{1\,mg}{cm^2}$ $\quad \rho_{Al} = 2780\,\frac{kg}{m^3}$ $\quad h\nu = 150\,eV$

$m_\alpha = 4.0015\,u$

$\Delta G = ?$

$$\frac{e^4}{8\pi\varepsilon_0^2 m_e} \cdot \frac{M_\alpha z_\alpha^2}{E_\alpha} \cdot n \ln \frac{4\pi\varepsilon_0 m_e c}{M_\alpha h\nu}$$

$$\Delta G = \left(\frac{\Delta E}{\Delta x}\right) \cdot \Delta x$$

$$\Delta x = \frac{\delta\Delta x}{\rho} \qquad n = \frac{\rho}{M} N_A \cdot Z_{Al}$$

$m_e c^2 = 0.511\,MeV$

$m_\alpha c^2 = 3727\,MeV$

$$\Delta E = \left(\frac{e^2}{4\pi\varepsilon_0}\right)^2 \frac{M_\alpha c^2}{m_e c^2} \frac{z_\alpha^2}{E_\alpha} \cdot 2\pi \cdot \frac{\rho}{M} \cdot N_A z \cdot \ln \frac{4\pi\varepsilon_0 m_e c}{M_\alpha c^2 h\nu} \cdot \frac{\delta\Delta x}{\rho}$$

$$\frac{e^2}{4\pi\varepsilon_0} = 1.44\,MeV\,fm \qquad 1\,fm = 10^{-15}\,m$$

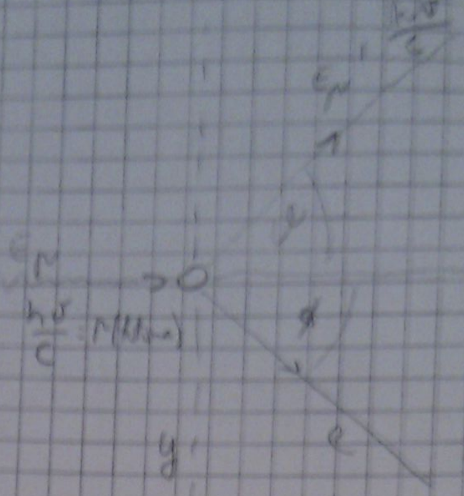
$$= (1.44)^2\,MeV^2 \cdot 10^{-26}\,m^2 \cdot \frac{3727}{0.511} \cdot \frac{4}{10\,MeV} \cdot 2\pi \cdot 6.0$$

$$\frac{\cdot 10^{23}}{27g} \cdot 13 \ln\left(\frac{4\pi \cdot 10^7\,eV \cdot 0.511\,MeV}{3727\,MeV \cdot 150\,eV}\right) \cdot 10^{-3}$$

$= 0.523\,MeV$

19. $\vartheta = 90^\circ$

$E_\gamma = 1.33\,MeV$



$E_{ke} = E_\gamma - E_\gamma' \qquad h\nu = h\nu' + E_{ke}$

$\vec{p}_\gamma = \vec{p}_\gamma' + \vec{p}_e$

$$\frac{h\nu}{c} = \frac{h\nu'}{c}\cos\vartheta + p\cos\phi$$

$$0 = \frac{h\nu'}{c}\sin\vartheta - p\sin\phi$$

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

ili $\Delta\lambda = \frac{h}{m_e c}(1-\cos\vartheta)$

$\lambda_C = 2.42 \cdot 10^{-1}$

comptonova valna duljina

$$\frac{d\sigma}{d\Omega} = \frac{r_e^2}{2}\left(\frac{E_\gamma'}{E_\gamma}\right)^2\left(\frac{E_\gamma}{E_\gamma'} + \frac{E_\gamma'}{E_\gamma} - \sin^2\vartheta\right)$$

$$E_\gamma' = \frac{1.33\,MeV}{1 + \frac{1.33}{0.511}(1-\cos 90^\circ)} = 0.369\,MeV$$

$E_{ke} = (1.33 - 0.795)\,MeV = 0.35\,MeV$

$\sin\phi = \frac{cp'}{pc}\sin\vartheta$

$E_{ue} = E_{ke} + m_e c^2 = (0.511 + 0.36)\,MeV = 1.47\,MeV$

$E^2 = (pc)^2 + (mc^2)^2$

$pc = \sqrt{E^2 - (mc^2)^2} = \sqrt{1.47^2 - 0.51^2}$

$= 1.38\,MeV$

$\sin\phi = \frac{0.36}{1.38}\sin 90°$

5. 1. $\lambda_p = 0.03\,Å = 3\cdot10^{-12}\,m \quad 1Å = 10^{-8}\,cm = 10^{-10}\,m$

$E_e = ?$ $\quad E_p = h\nu_p = h\cdot\frac{c}{\lambda_p} = \frac{4.14\cdot10^{-15}\,eVs\cdot3\cdot10^{8}\,\frac{m}{s}}{3\cdot10^{-12}\,m}$

$h = 4.14\cdot10^{-15}\,eVs$

$E_p = 414\,keV$

$E_p' \Rightarrow \vartheta = 60°$

$E_p = 414\,keV$

$E_p' = \frac{414\,keV}{1 + \frac{414\,keV}{511\,keV}(1 - \cos 60°)} = 294\,keV$

$E_{ke} = E_p - E_p' = 120\,keV$

53. $E_\gamma = 1{,}2\,\mathrm{MeV}$ (Compton-effekt)

$\vartheta = 0°$, $\vartheta = 90°$, $\vartheta = 180°$

$$\left(\frac{d\sigma}{d\Omega}\right) = \frac{r_0^2}{2}\left(\frac{E_\gamma'}{E_\gamma}\right)^2\left(\frac{E_\gamma}{E_\gamma'} + \frac{E_\gamma'}{E_\gamma} - \sin^2\vartheta\right)$$

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

$$\frac{E_\gamma'}{E_\gamma} = \frac{A}{1 + \frac{1{,}2}{0{,}51}\cdot(1-\cos\vartheta)} = 1$$

a) $\frac{d\sigma}{d\Omega} = \frac{r_0^2}{2}\cdot 1\,(1 + 1 - \cos 0) = r_0^2$

b) $\frac{E_\gamma'}{E_\gamma} = \frac{1}{1 + \frac{1{,}2}{0{,}51}(1-0)} \approx 0{,}3$

$\frac{d\sigma}{d\Omega} = 0{,}12\, r_0^2$

54. $E_\gamma = 3\,\mathrm{MeV}$ $\quad B = 0{,}01\,\mathrm{T}$

$e_1 N$ $\quad r = ?$

$E_{k,e} = E_{k,N}$ $\quad E_\gamma = 2mc^2 + E_{k,e} + \frac{E_{k,N}}{2E_{k,N}}$

$$E_k = \frac{E_p - 2mc^2}{2} = \frac{3 - 2 \cdot 0{,}51}{2} = 0{,}99 \text{ MeV}$$

$$F_L = q(\vec{v} \times \vec{B}) = F_{cf} = \frac{mv^2}{r}$$

$$\frac{mv^2}{r} = evB \Rightarrow p = eBr$$

$$r = \frac{p}{eB} = \frac{p \cdot c}{eBc}$$

$$E_{up} = mc^2 + E_{kp} = 1{,}5 \text{ MeV}$$

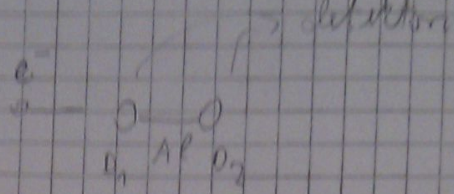
$$p \cdot c = \sqrt{E^2 - (mc^2)^2} = \sqrt{1{,}5^2 - 0{,}51^2} =$$

$$p \cdot c = 1{,}41 \text{ MeV}$$

$$r = \frac{1{,}41 \cdot 1{,}6 \cdot 10^{-13}}{1{,}6 \cdot 10^{-19} \cdot 0{,}01 \cdot 3 \cdot 10^8} = 4{,}7 \cdot 10^{-2} \text{ m}$$

[illegible]

β traka se ... [illegible]



$$(\rho \Delta x)_{det.\ stijenke} = 10 \frac{mg}{cm^2}$$

$$(\rho \Delta x)_{Al} = 150 \frac{mg}{cm^2}$$

$$R_0\left(\frac{g}{cm^2}\right) = 0.52 \quad E_e(MeV) - 0.09 \qquad 0.5\,MeV < E(MeV) < 3\,M..$$

$$R_0\left(\frac{g}{cm^2}\right) = 0.53\, E_e(MeV) - 0.106 \qquad 1\,MeV < E(MeV) < 20..$$

$$E_\gamma = E_e + W_i \qquad E_\gamma \approx E_e$$

za e reda veličine eV

↳ zanemarimo

R_0 (mora proći kroz 3 stijenke ① ② ①)

(da bi ga se detektiralo)

$$R_0 = 3(\rho \Delta x)_{st} + (\rho \Delta x)_{Al} = 3 \cdot 10 \frac{mg}{cm^2} + 150 \frac{mg}{cm^2}$$

$$= 0.18 \frac{g}{cm^2}$$

$$E_e(MeV) = \frac{R_0\left(\frac{g}{cm^2}\right) + 0.09}{0.52} = 0.519\,MeV$$

dobili smo energiju u intervalu $0.5 <\ \ <$ ...

$E_1 = 0.519$

63. $E = E_0 \, e^{-\frac{x}{l_{rad}}}$

$l_{rad} = f(Z)$ → radijacijska (karakteristična)

$(l_{rad})_{N_2} = ?$

$(l_{rad})_{Al} = ?$

$(l_{rad})_{Pb} = ?$

MeV $\left(\frac{dE}{dx}\right)_{rad} = \frac{4 r_0^2}{137} E N Z \ln \frac{183}{Z^{1/3}}$

$E = E_0 \, e^{-\frac{x}{l_{rad}}} \Big/ \frac{d}{dx}$

$\frac{dE}{dx} = E_0 \, e^{-\frac{x}{l_{rad}}} \cdot (-1) \cdot \frac{1}{l_{rad}} = -\frac{1}{l_{rad}} E$

$l_{rad} = \frac{E}{\left(-\frac{dE}{dx}\right)} = \frac{E}{\frac{4 r_0^2}{137} E N Z \ln \frac{183}{Z^{1/3}}}$

→ kroz koji put se u ... gubi el. polovicu

a) $(l_{rad})_{N_2} = \frac{137}{4 r_0^2 \cdot N Z \ln \frac{183}{Z^{1/3}}} =$

→ Z=7, 14 N, $r_0 = 2.818 \cdot 10^{-15}$ m → razmotriti uzeti ...

→ vrijednosti prema dobro formulama

[illegible] [illegible] plina ima vol 22.4 l [illegible]

→ pri norm. uvjetima

→ $6.022 \cdot 10^{23}$

u 22.4 l dušika ima N_A mol dušika

→ dušika molekula ima 2 atoma

→ ima → $6.022 \cdot 10^{23} \cdot 2$

N [illegible] u 1000 l

22.4 l ima $2 \cdot 6.022 \cdot 10^{23}$ atoma

$$N = \frac{2 \cdot 6.022 \cdot 10^{23} \cdot 1000}{22.4} = 5.375 \cdot 10^{25}$$

$$(l_{rad})_{N_2} = \frac{137}{4(2.818 \cdot 10^{-15})^2 \cdot 5.375 \cdot 10^{25} \cdot 7 \ln \frac{183}{7^{1/3}}} = 359$$

d) $_{82}Pb^{207}$ $\rho_{Pb} = 11.4 \frac{g}{cm^3} = 11400 \frac{kg}{m^3}$

→ olovo u [illegible] [illegible] stanju, [illegible] u N_{Pb} [illegible] ima

$$N_{Pb} = \frac{\rho}{m} \cdot N_A = 3.316 \cdot 10^{28} \, m^{-3}$$

$$l_{rad} = \frac{137}{4((2.818) \cdot 10^{-15})^2 \cdot 3.316 \cdot 10^{28} \cdot 82 \ln \frac{183}{82^{1/3}}} = 5$$

$x = 5\,mm$

$E = 42\,MeV$ $\qquad {}_{82}Pb^{207}$

$\Rightarrow$ velika energija - dominantan gubitak ener[gije] zakočnim / zračenjem

$$\frac{\left(\frac{dE}{dx}\right)_{RAD}}{\left(\frac{dE}{dx}\right)_{IONIZACIJA}} = \frac{Z\,E(MeV)}{800}$$

$\Rightarrow$ na $E = E_0\, e^{-\frac{x}{L_{rad}}} \Rightarrow E_0 = E\, e^{\frac{x}{L_{rad}}}$

$$= 42\, e^{1} = 114\,MeV$$

snop ter. nevtronov čigar je fluks

$10^{12} \frac{n}{cm^2 s}$ pada okomito na železno ploščo

debeline 1 cm kolikšen je fluks nevtr. snopa

ko je prešel brez[?] [illegible] brez interakcije

$S_{Fe} = 7870 \frac{kg}{m^3}$ σ (apsorpcija ter. nevtronov na železu) $\sigma_a = 2.55\ b = 2.55 \cdot$

$\phi_0 = 10^{12} \frac{n}{cm^2 s} = 10^{16} \frac{n}{m^2 s}$ σ_s (... Fe) $= 10.9\ b$ $10.9 \cdot 10^{-28}\ m$

$x = 1\ cm = 10^{-2}\ m$

$A(Fe) = 55.85$

$\phi = ?$ $\phi = \phi_0 e^{-\Sigma_t x}$ $\Sigma_t = N \sigma_{tot} = N(\sigma_a + \sigma_s)$

$\sigma_{tot} = \sigma_a + \sigma_s = 13.45\ b$

$N = \frac{\rho}{A} \cdot N_A$ $\phi = \phi_0 e^{-\frac{\rho}{A} N_A (\sigma_a + \sigma_s) \cdot x}$

$= 10^{16} \exp\left(-\frac{7870}{55.85} \cdot 6.022 \cdot 10^{26} \cdot 13.45 \cdot 10^{-2}\right.$

$= 10^{16} \exp(-1.1413) = 0.319 \cdot 10^{16} \frac{n}{m^2}$

$= 3.19 \cdot 10^{15} \frac{n}{m^2 s}$

32. $^{206}Pb\ (d, p)\ Pb$ $Q = 4.5\ MeV$

(d – deuteron, p – proton)

$^{206}Pb\ (n, \gamma)\ ^{207}Pb$ $\Delta A = 2.23\ MeV$

$E_\gamma = ?$

$$Q = \left(m_{Pu^{206}} + m_d - m_p - m_{Pu^{207}} \right) c^2$$

$$m_{Pu} c^2 + m_n c^2 + E_{kinetična} = m_{Pu^{207}} \cdot c^2 + E_{kPu^{207}} + E_p$$

$$B_d = (m_p + m_n) c^2 - m_d c^2$$

(vezavna energija)

energija vezanja

$$m_d c^2 = m_p c^2 + m_n c^2$$

$$E_p = m_{Pu^{206}} c^2 \; m_n c^2 - m_{Pu^{207}} c^2$$

$$Q = m_{Pu^{206}} c^2 + m_p c^2 + m_n c^2 + B_d - m_p c^2 - m_{Pu^{207}} c^2$$

$$= E_p - B_d \qquad E_p = Q + B_d = 6.73 \, MeV$$

$$^7_3Li \; (p,n) \; ^7_4Be \qquad Q = -1.647 \, MeV$$

$E_{prag} = ?$

$p_{Li} = 0$

$$\vec{p}_p + \vec{p}_{Li} = \vec{p}_n + \vec{p}_{Be}$$

$\vec{p}_{Li} \to 0$ (za prag reakcije = 0)

$$\vec{p}_p = \vec{p}_{Be}$$

$$m_{Li} c^2 + m_p c^2 + E_{prag} = m_n c^2 + m_{Be} c^2 + E_{kn} + E_{kBe}$$

($E_{kn} \to 0$)

$$m_{Li} c^2 + m_p c^2 + m_n c^2 - m_{Be} c^2 + E_{prag} = E_{kBe}$$

$Q + E_{proiect} = E_{inc}$

$E_{proiect} = Q + E_{inc}$

$E_{inc} = \frac{p_1^2}{2m_{inc}} = \frac{p_1^2}{2m_{inc}} \cdot \frac{m_p}{m_p} = \frac{m_p c^2 \cdot p_1^2}{m_p c^2 (2m_p)}$

$E_{proiect}\left(1 + \frac{m_p}{m_{inc}}\right) = |Q| \Rightarrow E_{proiect} = \frac{m_{inc}}{m_{inc} + m_p} \cdot |Q|$

$= \frac{8}{9} \cdot |Q|$

$= \frac{8}{9} \cdot 1.647$

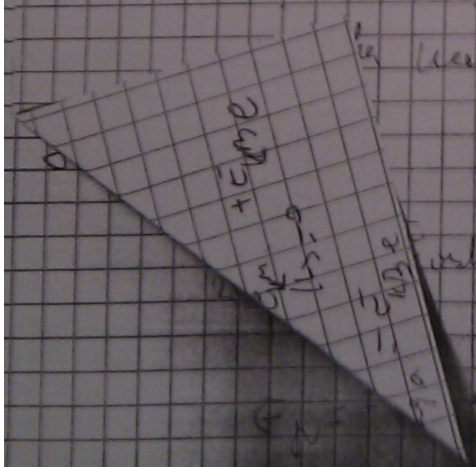
$= 1.463 \text{ MeV}$

84. $Q = 2.3 \text{ MeV}$

$S = 1 \text{ cm}^2$

$E_{cin} = 20 \text{ MeV}$

$\Phi = 10^5 \frac{\text{nr}}{\text{cm}^2 \text{ s}}$, $\Theta = 20°$, $\rho = ?$



Q energije

$m_B c^2 + m_n c^2 + E_{kin} + E_{kin}$ = $m_\alpha c^2 + m_{Li} c^2 + E_{k_{Li}} + E_{\alpha}$

$\downarrow$ 0

E oslobođena energija

$Q + E_{kn} = E_{oslobođeno}$ = 2.3 MeV + 20 MeV

= 21.3 MeV

(zanemaritiv 2)

zanemarit će se premala energija neutrona u odnosu na E_k

$Q = \Phi \cdot S \cdot \sigma \cdot n = 10^9 \cdot 1.2 \cdot 10^{23} \frac{2 \cdot 10^{3}}{10.8} \cdot 0.198$

→ broj jezgri mete po cm²

$\sigma = 2.0 \cdot 10^{-24}$ cm² → B^{10}

→ $\frac{g}{cm^2}$

$n = \rho d x \frac{1}{M_B} N_A \cdot \alpha =$

→ $M_B = 10.8$

$P = 1.7 \cdot 10^{-10}$ W

n

5/3

energija gama zraka i en. neutrina (9.6 MeV) se ne može iskoristiti (ΣE = 200 MeV)

85 $v_0 = 2200 \frac{m}{s}$ $\sigma_a \sim \frac{1}{v}$ $\sigma_a = \frac{K}{v}$

$\sigma_{a,2200} = 38.8\,b$

$E_n = 1\,keV$

$\sigma_a \cdot v = \sigma_{a,2200} \cdot v_0 \Rightarrow \sigma_a = \sigma_{a,2200} \cdot \frac{v_0}{v} = \sigma_{a,2200} \cdot \frac{v_0}{\sqrt{\frac{2E_n}{m_n}}}$

$E_n = \frac{1}{2} m_n v^2 \quad v = \sqrt{\frac{2E_n}{m_n}}$

$\sigma_a = \frac{v_0}{c} \sqrt{\frac{m_n c^2}{2E_n}} \cdot \sigma_{a,2200} = \frac{2200}{3 \cdot 10^8} \sqrt{\frac{939300\,keV}{2 \cdot 1\,keV}} = 38.8\,b$

$m_n c^2 = 939.3\,MeV$

$\boxed{\sigma_a = 0.4965\,b}$

86. $1\,kg\ U^{235}$ $m_{Spalt} = ?$ $1\,cal = 4.187\,J$

$E_{Spaltung} = ?$

$L = 7000 \frac{kcal}{kg}$

$E_{Spalt} = N_{U235} \cdot E_{Spaltung} = \frac{m}{M} N_A \cdot \nu = \frac{1}{235} \cdot 6.02 \cdot 10^{23} \cdot 200 \cdot 1.6 \cdot 10^{-13}\,J$

$m_{Spalt} = \frac{8.2 \cdot 10^{13}\,J}{7000 \cdot 10^3 \cdot 4.187 \frac{J}{kg}} = 0.2798 \cdot 10^{-9}\,kg = 279.8\,t$

38. m_{U235}

$m_{TNT} = 30\,000\,t = 3 \cdot 10^7\,kg$

$E_{TNT} = 1000\,\frac{kcal}{kg}$ $m_{U235} = ?$

$E = m\,E_{TNT} = 3 \cdot 10^7 \cdot 10^3 \cdot 10^3 \cdot 4.186$

$= 12.561 \cdot 10^{13}\,J$

$E = \frac{m}{M} \cdot N_A \cdot E_{fiss} \Rightarrow m = \frac{E \cdot M}{N_A\,E_f} = \frac{12.561 \cdot 10^{13} \cdot 235}{6.022 \cdot 10^{26} \cdot 200 \cdot 1.6 \cdot 10^{-13}}\,J/kg$

$= 1.53\,kg$

58. $I = 1\,Ci = 3.7 \cdot 10^{10}\,Bq$

a) $\frac{I}{I_0} = 10^{-6}$ $x = ?$ $E_\gamma = 2.42\,MeV$

b) $R = 3\,m$ $\phi_R / \phi_x = ?$

$\frac{I}{I_0} = e^{-\mu x} = e^{-\left(\frac{\mu}{\rho}\right)(x\rho)}$ – maseni koeficijent apsorpcije

Pb

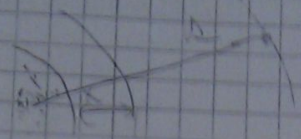
$\left(\frac{\mu}{\rho}\right)_{Pb,\,2.42\,MeV} = 0.042\,\frac{cm^2}{g}$ $\rho_{Pb} = 11.3\,\frac{g}{cm^3}$

$\ln\frac{I}{I_0} = -\left(\frac{\mu}{\rho}\right)(\rho x)$ $\rho x = \frac{-\ln I/I_0}{\left(\frac{\mu}{\rho}\right)} = \frac{-\ln 10^{-6}}{0.042}\,\frac{g}{cm^2}$

$= 328.94\,\frac{g}{cm^2}$

$x = \frac{\rho x}{\rho} = \frac{328.94}{11.3}\,cm = 29.1\,cm = 0.291\,m$

c)



$$\phi = \frac{I_0}{4\pi R^2}$$

$$\frac{\phi_x}{\phi_R} = \frac{\frac{I_0}{4\pi x^2}}{\frac{I_0}{4\pi R^2}}$$

$$\frac{\phi_x}{\phi_R} = \left(\frac{R}{x}\right)^2$$

$$\frac{\phi_R}{\phi_x} = \left(\frac{x}{R}\right)^2 = \left(\frac{0.29 \cdot 1}{3}\right)^2 = 9.4 \cdot 10^{-3}$$