(32.) minimalna udaljenost α-č od jezgre?

$$E_\alpha = \frac{Z_\alpha \cdot Z_0 \cdot e^2}{4\pi\varepsilon_0 R}$$

$$R = \frac{Z_\alpha \cdot Z_0 \cdot e^2}{4\pi\varepsilon_0 E_\alpha} = \frac{92 \cdot 2 \cdot (1{,}44)\ \text{MeV fm}}{9\ \text{MeV}} = 30\ \text{fm}$$

(33.)

$$r = R_0 \sqrt[3]{A} \qquad R' = r + b = R_0 \sqrt[3]{A} + b = 1{,}2 \sqrt[3]{27} + 1 = 4{,}6\ \text{fm}$$

$$E_\alpha = \frac{Z_{Al} \cdot Z_\alpha \cdot e^2}{4\pi\varepsilon_0 R'} = \frac{13 \cdot 2 \cdot 1{,}44\ \text{MeV fm}}{4{,}6\ \text{fm}} = 8{,}1\ \text{MeV}$$

(34.)

$b = 10^{-11}\ \text{m}$ koliko energije predaje elektronu?

$E_p = 10\ \text{MeV}$

$$P = \frac{Z \cdot e^2}{2\pi\varepsilon_0 b\, v_p}$$

$$E_e = \frac{P e^2}{2m} = \frac{Z_p^2 \cdot e^4}{4\pi^2\varepsilon_0^2 b^2 v_p^2 \cdot 2m} \cdot \frac{4 M_p c^2}{4 M_p c^2} = \left(\frac{e^2}{4\pi\varepsilon_0}\right)^2 \cdot \frac{M_p \cdot e^2}{b^2 E_p \cdot mc^2} = 3{,}8\ \text{eV}$$

(35.) $E_\alpha = 20\ \text{MeV}$ $E_e = 0{,}31\ \text{eV}$

$$E_e = \left(\frac{e^2}{4\pi\varepsilon_0}\right)^2 \cdot \frac{Z^2 \cdot M_\alpha \cdot c^2}{b \cdot E_e \cdot mc^2}$$

$$b = (1{,}44)^2 \cdot 10^{-30} \cdot \frac{4 \cdot (2mnc^2 + 2mpc^2)}{20 \cdot 0{,}31 \cdot 10^{-6} \cdot 0{,}51} = 9{,}92 \cdot 10^{-11} \approx 10^{-10}.$$

(37.)

R_α (m)	1,6	1,2	0,8	0,4
E_α (MeV)	47,6	40,3	32,2	21,7

$$\frac{R_2}{R_1} = \frac{M_1 Z_2^2}{M_2 \cdot Z_1^2} \qquad \frac{E_2}{E_1} = \frac{M_2}{M_1}$$

(38.) $V_{He^3_2} = 1{,}8 \cdot 10^7$ m/s izračun domet u zraku?

$$E_\alpha = \frac{M_\alpha \cdot v^2}{2} = 6{,}7 \text{ MeV}$$

$$R_\alpha = 0{,}056 \text{ m}$$

$$R_{He^3_2} = \frac{3}{4} \cdot 0{,}056 = \underline{0{,}042 \text{ m}}$$

(39.) $R(\text{cm}) = 1{,}8 \cdot E_\alpha(\text{MeV}) - 6{,}8$

$E_p = 3{,}5$ MeV $E_\alpha = 4 \cdot E_p = 14$ MeV

$R(\text{cm}) = 1{,}8 \cdot 14 - 6{,}8 = 18{,}4$ cm.

(40.) $E_d = 10$ MeV ${}_{13}Al^{27}$ $\rho x = 2{,}7$ mg/cm^2 $I_d = 16\,\mu$A

$$-\frac{\Delta E}{\Delta x} = \frac{e^4}{8\pi \cdot \varepsilon_0^2 \cdot m_e} \cdot \frac{MZ^2}{E} \cdot \eta \cdot \ln \frac{2Em_e}{M\hbar\nu}$$

$(h\cdot\nu)_{Al} = 150$ eV

$$\eta = \frac{\rho_{Al}}{M_{Al}} \cdot N_A \cdot Z_{Al} = 7{,}8 \cdot 10^{23} \text{ cm}^{-3}$$

$$-\Delta E = 2\pi \cdot \frac{e^4}{16\pi^2 \cdot \varepsilon_0^2 \cdot m_e^2 \cdot c^4} \cdot \frac{m_e c^2 \cdot Mc}{E} \eta \cdot \ln \frac{2E m_e c^2}{Mc^2 \hbar\omega} \cdot \Delta x$$

$= 209$ keV

$$\dot{N}_d = \frac{I_d}{e}$$

$$P = \dot{N}_d \cdot \Delta E = \frac{I_d}{e} \Delta E = 3{,}3 \text{ W}$$

(41.) ${}_{13}Al^{27}$ ${}_{82}Pb^{207}$ $\eta = \frac{\rho \cdot Z \cdot N_A}{M}$

$$\frac{dE}{d(x\rho)_{Al}} \Big/ \frac{dE}{d(x\rho)_{Pb}} = \left(\frac{Z}{M}\right)_{Al} \Big/ \left(\frac{Z}{M}\right)_{Pb} = 0{,}823$$

$$\frac{dE}{d(x)_{Al}} \Big/ \frac{dE}{d(x)_{Pb}} = \frac{\rho \cdot \left(\frac{Z}{M}\right)_{Al}}{\rho \left(\frac{Z}{M}\right)_{Pb}} = 0{,}23$$

(42.) 1 mg/cm² gubi 100 keV

proton Al

koliko će izgubiti proton u 2 mg/cm² olova.

$$\frac{\frac{dE}{d(x\rho)_{Al}}}{\frac{dE}{d(x\rho)_{Pb}}} = \frac{\left(\frac{Z}{M}\right)_{Al}}{\left(\frac{Z}{M}\right)_{Pb}} = \frac{1}{0,825}$$

$\Delta E_{Pb} = 0,825 \cdot 100 = 82,5$ keV tok u 2 mg/cm gubi $E = 2 \cdot \Delta E_{Pb} = \underline{165 \text{ keV}}$.

(43.)

$E_\alpha = 10$ MeV $\quad \Delta x = 1 \text{ mg/cm}^2$

$$-\frac{\Delta E}{\Delta x} = \frac{e^4}{8\pi \cdot \varepsilon_0^2 \cdot m_e} \cdot \frac{Mz^2}{E} \cdot n \cdot \ln \frac{2Em_e}{M \cdot I}$$

$\Delta E = 320$ keV gubitak energije

(44.) pokažite da je nemoguć fotoefekt na slobodnom elektronu

Zakon o sačuvanju energije $E_\gamma = E_k$

$$E_k = \sqrt{p^2c^2 + m^2c^4} - mc^2 \Rightarrow p = \sqrt{\frac{E_\gamma^2}{c^2} + 2E_\gamma \cdot m}$$

$p = \frac{E_\gamma}{c}$ (sačuvanje količine gibanja). Što se ispunjava samo za $E_\gamma = 0$

(45.) $\boxed{E = 2{,}15\,eV}$

(46.) $r = 10\,cm = 0{,}1\,m$

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

$W_i = 87{,}6\,keV$

Wilsonova komora, kolika je energija gama kvanta?

$E_\gamma = ?$

$\boxed{E_\gamma = E_e + W_i}$ $\quad F = e \cdot v \cdot B = \frac{m \cdot v^2}{r} \Rightarrow r = \frac{m \cdot v}{e \cdot B} = \frac{p}{e \cdot B}$

$p = e \cdot B \cdot r$ $\quad \frac{pc}{mc^2} = 1{,}17$ $\quad \frac{eBr}{mc}$

$$E_k = \sqrt{p^2 \cdot c^2 + m^2c^4} - mc^2$$

$\boxed{E_\gamma = E_k + W_i = 361\,keV}$

(47.) kolimirani snop gama zraka $E_\gamma = 0{,}51\,MeV$ $\varphi = 60^\circ$ $\frac{d\sigma}{d\Omega} = 10\,barn/ster$

$\frac{d\sigma}{d\Omega} = ?$ $E_\gamma = 80\,keV$

$$\frac{d\sigma}{d\Omega} = k \frac{\sin^2\varphi}{(1 - \frac{v}{c}\cos\varphi)}$$

$$\frac{\left(\frac{d\sigma}{d\Omega}\right)_1}{\left(\frac{d\sigma}{d\Omega}\right)_2} = \frac{\frac{k \cdot \sin^2\varphi}{(1 - \beta_1\cos\varphi)}}{\frac{k\sin^2\varphi}{(1 - \beta_2\cos\varphi)}} = \frac{(1 - \beta_2\cos\varphi)}{(1 - \beta_1\cos\varphi)}$$

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

$= \frac{0{,}75}{0{,}567} \cdot 10 = 7{,}56\,barn/ster$

(48.) Pb^{207}_{82} $\sigma = 28$ barn

Koliko je udarni presjek u slučaju volframa

$$\sigma = \frac{Z^5}{E^{1/2}} \qquad E = \frac{82^5}{28\ \text{barn}} = 132 \cdot 10^6$$

$$\sigma_{Pb} / \sigma_W / \sigma_{Al} = Z_{Pb}^5 / Z_W^5 / Z_{Al}^5 \qquad \sigma_W = 16{,}71\ \text{barn}.$$

*

(49.) raspršenje gama zraka na slobodnim elektronima. detektor pod kut 90°

$\vartheta = 90°$ $E_\gamma = 1{,}33$ Mev

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

$$p_\gamma = p_\gamma' \cos(\vartheta) + p_e \cos(\varphi) \qquad p_\gamma' \sin\vartheta = p_e \sin\varphi$$

$$\sin\varphi = \frac{p_\gamma' \cdot \sin\vartheta}{p_e} = \frac{E_\gamma' \cdot \sin\vartheta}{p_e \cdot c}$$

$$p_e \cdot c = \sqrt{E^2 - (mc^2)^2} = \sqrt{(mc^2 + E_k)^2 - (mc^2)^2} = \sqrt{2mc^2 E_k + E_k^2}$$

(50.) $\varphi = 0$ ϑ (0 ili 180)

$$R_0\ (g/cm^2) = 0{,}52 \cdot E(\text{Mev}) - 0{,}09$$

$E_k = 0{,}94$ Mev

$$cp = \sqrt{E_k - m^2c^4} = 1{,}36\ \text{Mev}$$

$$E_0 = E\cos\vartheta + pc\cos\varphi \qquad E_0 = 1{,}15\ \text{Mev} \qquad E_\gamma = 0{,}21\ \text{Mev}$$

(51.) $\lambda_\gamma = 0{,}03\,\text{Å} = 3 \cdot 10^{-12}$ m $\qquad \text{Å} = 10^{-8}\,\text{cm} = 10^{-10}$ m

$\vartheta = 60°$

$E_k = ?$

$$E = h\cdot\nu = h\cdot\frac{c}{\lambda} \qquad h = 4{,}14 \cdot 10^{-15}\ \text{eVs} \qquad E_\gamma = h\cdot\frac{c}{\lambda} = 414\ \text{keV}$$

$$E_{ke} = E_\gamma - E_\gamma' \qquad E_\gamma' = \frac{E_\gamma}{1 + \frac{E_\gamma}{mc^2}(1 - \cos\vartheta)} = 294{,}6\ \text{keV}$$

(52.) Comptonski raspršeno $E_\gamma = 1\ MeV$

λ izmjeni za 25%. Kolika je energija raspršenog elektrona i smjer.?

$\lambda_0 = \frac{h \cdot c}{h \cdot \nu_0} = 1240\ fm$

$E = \frac{h \cdot c}{\lambda} \Rightarrow \lambda_0 = \frac{h \cdot c}{E} = \frac{6{,}626 \cdot 10^{-34} \cdot 3 \cdot 10^8 \to MeV}{1 \cdot MeV} = 1240\ fm$

$\lambda = 1{,}25 \cdot \lambda_0 = 1550\ fm$

$E_\gamma = \frac{hc}{\lambda} = 0{,}8\ MeV$

$E_k = 1 - 0{,}8 = 0{,}2\ MeV$

$\lambda - \lambda_0 = \frac{h}{mc}(1 - \cos\vartheta)$

$pc = \sqrt{(E_k + mc^2)^2 - m^2c^4} = 0{,}49\ MeV$

$\sin\varphi = \frac{E_\gamma}{pc} \sin\vartheta$

(53.) $E_\gamma = 1{,}2\ MeV$

$\frac{d\sigma}{d\Omega} = \frac{r_0^2}{2}\left(\frac{E_\gamma}{E_0}\right)^2\left(\frac{E_0}{E_\gamma} + \frac{E_\gamma}{E_0} - \sin^2\vartheta\right)$

$E = \frac{E_0}{1 + \frac{E_0}{mc}(1 - \cos\vartheta)}$ $\quad \cdot \frac{d\sigma}{d\Omega} = r_0^2$

(54.) $E_\gamma = 3\ MeV$

$E_{kp} = E_{ke}$

$B = 0{,}1\ T$

$E_\gamma = 2\,m_e c^2 + 2E_{k,p}$

$E_{k,p} = \frac{E_\gamma - 2mec^2}{2} = \frac{(3 - 1{,}02)}{2} = 0{,}99\ MeV$

$r = \frac{p}{eB} = \frac{pc}{eBc} = \frac{\sqrt{E - (mec^2)^2}}{eBc}$ $\quad E = E_{kp} + mc^2 = 1{,}5\ MeV$

$r = 4{,}7\ cm.$

(55.) $E_{kp} = 2\ MeV$

2 1,02 0,0785

$E_k + 2mc^2 - E_{B(k)} = 2E_\gamma$

$E_\gamma = 1{,}47\ MeV.$

APSORPCIJA EM ZRAČENJA

(56.) $^{152}Eu \rightarrow \gamma_1 = 0{,}5$ MeV, $\gamma_2 = 2{,}5$ MeV

$\rho_{Cu} = 8{,}96\ g/cm^3$

$x_1 = 8$ cm — 20 otkucaja/min

$x_1' = 1$ cm — ?

$\left(\frac{\mu_1}{\rho_{Cu}}\right)\Big|_{0{,}5\,MeV} = 0{,}0853\ cm^2/g \Rightarrow \mu_1 = 0{,}764\ cm^{-1}$

$\left(\frac{\mu_2}{\rho_{Cu}}\right)\Big|_{2{,}5\,MeV} = 0{,}0388\ cm^2/g \Rightarrow \mu_2 = 0{,}348\ cm^{-1}$

$N(x) = N_0 \cdot e^{-\mu x} = N_0 e^{-\left(\frac{\mu}{\rho}\right)(x\cdot\rho)}$

γ_1 (0,5 MeV) $\quad \frac{N_{10}}{N_1(8cm)} = \frac{N_{10}}{N_{10}\cdot e^{-\mu_1(8cm)}} = \frac{1}{e^{-0{,}7648}} = 951{,}24$

γ_2 (2,5 MeV) $= \frac{N_{20}}{N_2(8cm)} = \frac{N_{20}}{N_{20}\,e^{-\mu_2 8cm}} = 16{,}2$

$N_0 = N_{10} + N_{20} = 0{,}616 + 0{,}46$ $\qquad \frac{N_2}{N_1}\Big|_{8cm} = \left(\frac{\frac{0{,}4N_0}{16{,}2}}{\frac{0{,}6N_0}{451{,}24}}\right) \simeq 19 = 19:1$

$x_1' = 1$cm $\quad N_1' = N_{10}e^{-\mu_1 x_1'}$

$\frac{N_1'}{N_1} = \frac{N_{10}\,e^{-\mu_1 x_1'}}{N_{10}\cdot e^{-\mu_1 x_1}} = e^{\mu_1(x_1 - x_1')} = 210{,}19 \simeq 210$ otk./min

$\frac{N_2'}{N_2} = \frac{N_{20}\,e^{-\mu_2 x_1'}}{N_{20}\cdot e^{-\mu_2 x_1}} = e^{\mu_2(x_1 - x_1')} = 11{,}43 \cdot 1$

$= 217$ otk.

ukupno $210 + 217 = 427$ otk/min.

(58.) $1\,Ci = 1$ g radija $\qquad \rho_{Pb} = 11{,}4\ g/cm^2$

$1\,Ci = 3{,}7 \cdot 10^{10}$ Bq $\qquad$ max $E = 2{,}42$ MeV $\Rightarrow \left(\frac{\mu}{\rho}\right) = 0{,}042\ cm^2/g$

$N_i = N_0 \cdot e^{-\left(\frac{\mu}{\rho}\right)(x\cdot\rho)}$

$\frac{N_i}{10^6} = N_i \cdot e^{-0{,}042\,(x\rho)} = e^{-0{,}042\,(x\rho)} = 10^{-6}$

$-0{,}042\,(x\rho) = -6\ln 10$

$(x\rho) = 328{,}94\ g/cm^2$

$x = \frac{328{,}94}{11{,}4} = 29cm.$