Lösn. anv. till FYSIK del 2 för E2 (2001-12-17)

(1.)

$2d_{hkl}\sin\theta = \lambda$ där $d_{hkl} = \frac{a}{\sqrt{h^2+k^2+l^2}} \Rightarrow \frac{\sin^2\theta}{h^2+k^2+l^2} = \frac{\lambda^2}{4a^2} = \text{konst.}$

diamant: $h^2+k^2+l^2 = 3, 8, 11, 16, 19, \ldots$ θ-vinklar: θ_1 15°, θ_2 24,5°, θ_3 29°, θ_4 36°
~~reflexer~~

$\therefore \frac{\sin^2 15°}{3} = \frac{\sin^2 24{,}5°}{8} = \frac{\sin^2 29°}{11} = \frac{\sin^2 36°}{16} = 0{,}0215 = \frac{\lambda^2}{4a^2}$

men $a = 5{,}66$ Å $\Rightarrow \lambda = 2a\cdot\sqrt{0{,}0215} \approx 1{,}66$ Å; $p = \frac{h}{\lambda}$ och $E_k = \frac{p^2}{2m_n} \Rightarrow$

a) $\Rightarrow E_k = \frac{h^2}{2m_n\lambda^2} = \frac{6{,}63\cdot10^{-34}}{2\cdot1{,}67\cdot10^{-27}(1{,}66\cdot10^{-10})^2\cdot1{,}6\cdot10^{-19}}$ eV $= 0{,}0298$ eV $\approx$ **30 meV**

b) ~~Nästa reflex~~ $\theta_5 = ?$ $\quad \frac{\sin^2\theta_5}{19} = 0{,}0215 \Rightarrow \theta_5 = 39{,}7 \Rightarrow 2\theta_5 \approx 80°$ Svar

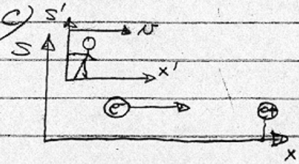
(2.)

e^- $\xrightarrow{E_k}$ e^+ $\Rightarrow$ två fotoner energier $3E_0$ och $0{,}6E_0$
(där $E_0 = m_0c^2 = 0{,}511$ MeV)

a) $Q = [\text{vilomassa före} - \text{vilomassa efter}]c^2 = 2m_0c^2 = 1{,}022$ MeV

b) $E_k + E_0 + E_0 = 3{,}6E_0 \Rightarrow E_k = 1{,}6E_0 = 0{,}8176$ MeV

c)



Sätt: {Obs. i vila i S'
{e^+ i vila i S

Då är: u_x = el. hast rel positronen
(beräknas: $E_k = E_0\left[\frac{1}{\sqrt{1-u_x^2/c^2}} - 1\right]$)

och: {v = obs. hast. rel positronen, dvs labbet.
{u'_x = el. hast. rel. obs.
{där $v = u'_x$

Beräkna u_x:
$1{,}6E_0 = E_0\left[\frac{1}{\sqrt{1-\frac{u_x^2}{c^2}}} - 1\right] \Rightarrow$
$\Rightarrow \frac{1}{2{,}6} = \sqrt{1 - \frac{u_x^2}{c^2}} \Rightarrow$
$\Rightarrow \left(\frac{5}{13}\right)^2 = 1 - \frac{u_x^2}{c^2} \Rightarrow \frac{u_x}{c} = \frac{12}{13}$

Formel: $u_x = \frac{u'_x + v}{1 + \frac{v}{c^2}u'_x} = \frac{2v}{1 + \frac{v^2}{c^2}}$

$\Rightarrow \frac{12}{13} = \frac{2\cdot\frac{v}{c}}{1 + \frac{v^2}{c^2}} \Rightarrow \frac{v^2}{c^2} - \frac{13}{6}\frac{v}{c} + 1 = 0 \Rightarrow$ Obs. hast skall vara $\frac{2}{3}c$ rel. labbet = Svar
$\Rightarrow \frac{v}{c} = \frac{2}{3}$

(3.)

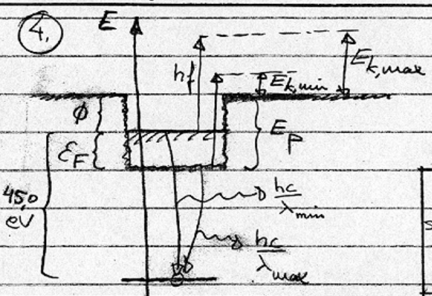
$^{60}_{27}Co \rightarrow {}^{60}_{28}Ni + e^- + \bar{\nu} + \gamma_1 + \gamma_2$

$Q = [m^a(^{60}Co) - m^a(^{60}Ni)]c^2 = [59{,}933822 - 59{,}930789]\,u\cdot c^2 =$ (där $u\cdot c^2$ = 931,48 MeV)

$= 2{,}825$ MeV $= E_{k,Ni} + E_{k,e,max} + E_{\bar{\nu},min} + E_{\gamma_1} + E_{\gamma_2}$
($E_{k,Ni} \approx 0$; $E_{k,e,max}$ = 0,320 MeV; $E_{\bar{\nu},min} \approx 0$; E_{γ_1} = 1,332 MeV)

$\Rightarrow E_{\gamma_2} = 2{,}825 - 0{,}320 - 1{,}332 = 1{,}173$ MeV = Svar

(4.)



Vi har: $hf = \frac{hc}{\lambda} = (\lambda = 118\text{ nm}) = 10{,}5$ eV

$E_{k,max} = \frac{1}{2}mv_{max}^2 = \left(v_{max} = 1{,}5\cdot10^6 \frac{m}{s}\right) = 6{,}4$ eV

$E_{k,min} = \frac{1}{2}mv_{min}^2 = \left(v_{min} = 7{,}9\cdot10^5 \frac{m}{s}\right) = 1{,}8$ eV

$\therefore \varepsilon_F = E_{k,max} - E_{k,min} = 6{,}4 - 1{,}8 = 4{,}6$ eV
se fig.

men $\varepsilon_F = \frac{1}{2}mv_F^2 \Rightarrow v_F = 1{,}3\cdot10^6$ m/s = Svar i (a)

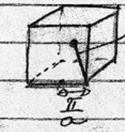
b) $E_P = \phi + \varepsilon_F$ där $\varepsilon_F = 4{,}6$ eV och
ϕ är: $E_{k,max} = hf - \phi \Rightarrow \phi = 10{,}5 - 6{,}4 = 4{,}1$ eV
$\therefore$ Pot.steget $= 4{,}6 + 4{,}1 = 8{,}7$ eV = Svar i (b)

Svar i (c):
$\frac{hc}{\lambda_{min}} = 45$ eV $\Rightarrow \lambda_{min} = 28$ nm (275 Å)
$\frac{hc}{\lambda_{max}} = 40{,}4$ eV $\Rightarrow \lambda_{max} = 31$ nm (307 Å)

(5)

s.c.:
1 atom/cell och X el/atom $\Rightarrow \frac{N_e}{V} = \frac{1\cdot X}{a^3}$ och $k_F = \left(3\pi^2\frac{N_e}{V}\right)^{1/3}$

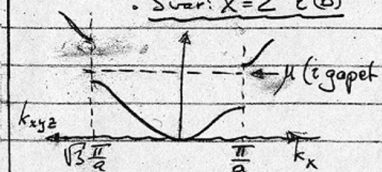
1:a B-zonen har formen av kub: ~~en rec.gitterpkt (=origo) i centrum~~



avstånd ut till ett hörn $= \sqrt{3}\cdot\frac{\pi}{a}$

a) $k_F = \sqrt{3}\cdot\frac{\pi}{a} \Rightarrow \left(3\pi^2\frac{X}{a^3}\right)^{1/3} = \sqrt{3}\frac{\pi}{a}$
$\Rightarrow X = \sqrt{3}\pi \approx 5{,}4$ = Svar i (a)

$\frac{\frac{(2\pi)^3}{a}}{\frac{(2\pi)^3}{V}} =$ b) max 2 el/atom i en B-zon
$\therefore$ Svar: $X = 2$ i (b)



(6.)

$n\cdot p = n_i^2 = \text{konst.}$
$n = p + N_d^+ = p + N_d$
$\sigma = ne\mu_e + pe\mu_h$
$\mu_e = 0{,}14$ m²/Vs
$\mu_h = 0{,}06$ m²/Vs

$\sigma_i = n_i e(\mu_e + \mu_h) = 5\cdot10^{-4}(\Omega m)^{-1}$
$\Rightarrow n_i = 1{,}56\cdot10^{16} \Rightarrow n_i^2 = 2{,}44\cdot10^{32}$ m⁻⁶

$\therefore \sigma = ne\mu_e + \frac{n_i^2}{n}e\mu_h = 1{,}8\sigma_i \Rightarrow$
$\Rightarrow n = 3{,}7(2)\cdot10^{16}$ m⁻³ $\Rightarrow p = \frac{n_i^2}{n} = 0{,}7\cdot10^{16}$ m⁻³
$\therefore N_d = n - p = 3{,}0\cdot10^{16}$ m⁻³ = Svar