Solusi Tutorial 8 Fisika Dasar 2B ITB

A. Pertanyaan

① Efek fotolistrik

$$E_{foton} = K_{elektron} + W_o$$

Syarat terjadi elektron terlontar

$$E_{foton} > W_o$$

karena E_{foton} sama

sehingga $W_{o1} < W_{o2}$

Jawab : B

② Dalam efek fotolistrik,

$$E_{foton} = K_{elektron} + W_o$$

Syarat terjadinya $E_{foton} > W_o$

Jadi, Jawabannya (5) jenis logam

③ $\lambda' - \lambda = \frac{h}{mc}(1 - \cos\theta)$ $\quad \delta\lambda \sim \frac{1}{m}$

$m_{elektron} < m_{proton}$ maka $\delta\lambda \rightarrow$ lebih kecil

④ Panjang gelombang de broglie

$$\lambda = \frac{h}{p}$$

Saat dijatuhkan $\vec{V}$ → membesar maka $\vec{p}$ membesar,

sehingga λ akan mengecil / berkurang

⑤ $$\lambda = \frac{h}{mV}$$

λ bisa sama jika kombinasi mV → sama

m ↓ beda dan V ↓ beda

Jawaban : (B)

dibuat oleh : Wawan K

B. SOAL

① Energi foton yang datang :

$$hf = Ek_{maks} + W_0$$

$$hf = 0{,}68\ eV + 2{,}75\ eV$$

$$hf = 3{,}43\ eV$$

-) untuk fungsi kerja logam yang lain ($\phi_0 = W_0 = 2{,}17\ eV$), maka :

$$Ek_{maks} = hf - W_0$$

$$Ek_{maks} = 3{,}43\ eV - 2{,}17\ eV$$

$$Ek_{maks} = 1{,}26\ eV$$

② a) kita asumsikan seluruh daya menghasilkan produksi foton pada $\lambda = 589\ nm$

R = laju produksi foton , E = energi foton tunggal

$$P = RE = \frac{Rhc}{\lambda}$$

$$R = \frac{\lambda P}{hc} = \frac{589 \times 10^{-9}\ m\ (100\ W)}{(6{,}63 \times 10^{-34}\ J.s)(3 \times 10^{8}\ m/s)}$$

$$R = 2{,}96 \times 10^{20}\ foton/s$$

(2) b) I = fluks foton pada jarak r dari sumber

$$R = 4\pi r^2 I$$

$$r = \sqrt{\frac{R}{4\pi I}} = \sqrt{\frac{2{,}96 \times 10^{20}}{4\pi\ (1 \times 10^{4})}} = 4{,}86 \times 10^{7}\ m$$

c) fluks foton adalah :

$$I = \frac{R}{4\pi r^2}$$

$$= \frac{2{,}96 \times 10^{20}\ \text{foton/s}}{4\pi\ (2m)^2}$$

$$= 5{,}89 \times 10^{18}\ \text{foton}/m^2.s$$

(3) Percobaan (1)

$$\frac{hc}{\lambda_1} = \phi + K_{m1}$$

Percobaan (2)

$$\frac{hc}{\lambda_2} = \phi + K_{m2}$$

(3) a) dari persamaan (1) kita peroleh :

$$\phi = \left(\frac{hc}{\lambda_1}\right) - k_{m1}$$

kemudian substitusi ke persamaan (2), maka :

$$\frac{hc}{\lambda_2} = \frac{hc}{\lambda_1} - k_{m1} + k_{m2}$$

$$\lambda_2 = \frac{hc\,\lambda_1}{hc + \lambda_1 (k_{m2} - k_{m1})}$$

$$= \frac{1240\ V_{nm}\ (491\ nm)}{1240\ eV\,nm + (491\ nm)(1,43\ eV - 0,71\ eV)}$$

$$\lambda_2 = 382\ nm$$

dengan $hc = 1240\ eV\,nm$

b) Dari persamaan (1) diperoleh :

$$\phi = \frac{hc}{\lambda_1} - k_{m1}$$

$$\phi = \frac{1240\ eV\,nm}{491\ nm} - 0,710\ eV$$

$$\phi = 1,82\ eV$$

④

$hf = Ek_{max} + W_o$ → fungsi kerja

↓ energi foton

↓ energi kinetik maksimum elektron

atau $\frac{hc}{\lambda} = \frac{1}{2} m V_{max}^2 + W_o$

$$\lambda = \frac{hc}{\frac{1}{2} m V_{max}^2 + W_o}$$

$$\lambda_A = \frac{(6{,}63 \times 10^{-34})(3 \times 10^8)}{\frac{1}{2}(9{,}11 \times 10^{-31})(7{,}30 \times 10^5)^2 + 4{,}80 \times 10^{-19}\ J}$$

$$\lambda_A = 2{,}75 \times 10^{-7}\ m$$

untuk gelombang B :

$$\lambda_B = \frac{6{,}63 \times 10^{-34}\ (3 \times 10^8)}{\frac{1}{2}(9{,}11 \times 10^{-31})(5 \times 10^5)^2 + 4{,}80 \times 10^{-19}\ J}$$

$$\lambda_B = 3{,}35 \times 10^{-7}\ m$$

⑤ Momentum foton

$$P = \frac{h}{\lambda}$$

momentum bola

$$P = mv$$

karena $P_{foton} = P_{bola}$

$$\frac{h}{\lambda} = mv$$

$$v = \frac{h}{\lambda m} = \frac{6,63 \times 10^{-34}\ Js}{(720 \times 10^{-9}\ m)(2,2 \times 10^{-3}\ kg)}$$

$$v = 4,2 \times 10^{-25}\ m/s$$

⑥ .) Tidak ada gaya eksternal yang bekerja pada sistem, maka berlaku kekekalan momentum. foton terpental pada $\theta = 180°$

.) Seluruh tumbukan terjadi pada sumbu x. Asumsikan foton datang ke arah +x.

Sehingga : $P_{awal} = P_{akhir}$

$$p = -p' + P_{elektron}$$

$$P_{elektron} = p + p'$$

$$= \frac{h}{\lambda} + \frac{h}{\lambda'} = h\left(\frac{1}{\lambda} + \frac{1}{\lambda'}\right)$$

⑥ $P_{elektron} = 6{,}63 \times 10^{-34} \left(\frac{1}{0{,}2750 \times 10^{-9}\ m} + \frac{1}{0{,}2835 \times 10^{-9}\ m} \right)$

$P_{elektron} = 4{,}755 \times 10^{-24}\ kg\ m/s$

⑦ Perubahan panjang gelombang (sesuai efek Compton):

$$\lambda' - \lambda = \frac{h}{mc}(1 - \cos\theta) \quad \text{---- 1)}$$

$$\lambda' - \lambda = \frac{h}{mc}(1 - \cos 180^\circ) = \frac{2h}{mc} \quad \text{--- 2)}$$

Konservasi total energi dapat ditulis,

$$\underbrace{\frac{hc}{\lambda}}_{\text{energi datang foton}} + \underbrace{0}_{\text{energi kinetik awal elektron}} = \underbrace{\frac{hc}{\lambda'}}_{\text{energi hamburan foton}} + \underbrace{\frac{1}{2}mV^2}_{\text{energi kinetik akhir foton}} \quad \text{---- 3)}$$

dari persamaan (2),

$\lambda' = \frac{2h}{mc} + \lambda$ maka:

$$\frac{hc}{\lambda} = \frac{hc}{\frac{2h}{mc} + \lambda} + \frac{1}{2}mV^2$$

(7) $\frac{hc}{\lambda} = \frac{hc}{\frac{2h}{mc} + \lambda} + \frac{1}{2}mv^2$

misal : $a = \frac{2h}{mc}$

$b = \frac{1}{2}mv^2$

Maka : $\frac{hc}{\lambda} = \frac{hc}{a+\lambda} + b$

$\frac{1}{\lambda} = \frac{1}{a+\lambda} + \frac{b}{hc}$

$\frac{1}{\lambda} - \frac{1}{a+\lambda} = \frac{b}{hc}$

$\frac{(a+\lambda) - \lambda}{a\lambda + \lambda^2} = \frac{b}{hc}$

$\frac{a}{a\lambda + \lambda^2} = \frac{b}{hc}$

$\lambda^2 + a\lambda = \frac{hc}{b} \times a$

$\lambda^2 + \left(\frac{2h}{mc}\right)\lambda = \frac{hc}{\frac{1}{2}mv^2} \times \frac{2h}{mc}$

$\lambda^2 + \frac{2h}{mc}\lambda - \frac{2h^2}{m\left(\frac{1}{2}mv^2\right)} = 0$

(7) $\frac{2h}{mc} = 4{,}85 \times 10^{-12}\ m$

$$\frac{2h^2}{m\left(\frac{1}{2}mv^2\right)} = 9{,}70 \times 10^{-20}\ m^2$$

dengan $h = 6{,}63 \times 10^{-34}\ J.s$

$m = 9{,}11 \times 10^{-31}\ kg$

$c = 3 \times 10^{8}\ m/s$

$v = 4{,}67 \times 10^{6}\ m/s$

Sehingga diperoleh : $\lambda = 3{,}09 \times 10^{-10}\ m$

(8) Panjang gelombang de broglie adalah :

$$\lambda = \frac{h}{p}$$

$$E_k = \frac{1}{2}mv^2 = \frac{m^2v^2}{2m} = \frac{p^2}{2m}$$

$$p = \sqrt{2mk}$$

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mE_k}}$$

(8)

$$\lambda_f = \frac{h}{\sqrt{2m\,(K)_f}}$$

$$\lambda_i = \frac{h}{\sqrt{2m\,(K)_i}}$$

bagi kedua persamaan,

$$\frac{\lambda_f}{\lambda_i} = \frac{\frac{h}{\sqrt{2m K_f}}}{\frac{h}{\sqrt{2m K_i}}}$$

$$\frac{\lambda_f}{\lambda_i} = \sqrt{\frac{K_i}{K_f}}$$

atau $\lambda_f = \lambda_i \sqrt{\frac{K_i}{K_f}}$

$$\lambda_f = \lambda_i \sqrt{\frac{K_i}{2K_i}}$$

$$= 2{,}7 \times 10^{-10}\ m \sqrt{\frac{1}{2}}$$

$$\boxed{\lambda_f = 1{,}9 \times 10^{-10}\ m}$$

(9)

Total energi akhir = Total energi awal

$$\frac{1}{2}mv^2 = eV$$

$$v = \sqrt{\frac{2eV}{m}}$$

$$\lambda = \frac{h}{p} = \frac{h}{mv} = \frac{h}{\sqrt{2meV}}$$

$$\lambda = \frac{6{,}63 \times 10^{-34}}{\sqrt{2(9{,}11 \times 10^{-31})(1{,}6 \times 10^{-19})(418)}}$$

$$\lambda = 6{,}01 \times 10^{-11}\ m$$

(10) Energi awal foton

$$E = \frac{hc}{\lambda} = \frac{1240\ eV\,nm}{0{,}00300\ nm}$$

$hc = 1240\ eV\,nm$

$$E = 4{,}13 \times 10^{5}\ eV$$

Pergeseran Compton → $\Delta\lambda = \frac{h}{m_e c}(1 - \cos\phi) = \frac{h}{m_e c}(1 - \cos 90^\circ)$

$$= \frac{hc}{m_e c^2} = \frac{1240\ eV\,nm}{511 \times 10^3\ eV} = 2{,}43\ pm$$

(10) Sehingga panjang gelombang foton yang baru,

$$\lambda' = 3\,pm + 2{,}43\,pm = 5{,}43\,pm$$

Sehingga

$$E' = \frac{hc}{\lambda'} = \frac{1240\ eV\,nm}{0{,}00543\ nm} = 2{,}28 \times 10^5\ eV$$

dengan konservasi energi

$$K_{elektron} = \Delta E = E - E'$$

$$= 4{,}13 \times 10^5 - 2{,}28 \times 10^5\ eV$$

$$= 1{,}85 \times 10^5\ eV$$

$$\boxed{EK_{elektron} \approx 3 \times 10^{-14}\ J}$$