22.10.2020

F.17-18. Rezolvări de pb. (EFE)

(Man. cl. XII-A11, pag. 49)

3.1/49. Se cunosc:

$L = 2eV$, $\lambda = 250\,nm$

$e = 1{,}6\cdot10^{-19}C$, $m_e = 9{,}1\cdot10^{-31}kg$, $h = 6{,}626\cdot10^{-34}J\cdot s$

a) $\lambda_0 = ?$, $\nu_0 = ?$ $c = 3\cdot10^8 m/s$

b) $v_e = ?$ $1eV = 1{,}6\cdot10^{-19}J$

a) Aplicăm ec. Einstein pt. EFE.

$$\begin{cases} E_f = L + E_c \\ h\nu = h\nu_0 + \frac{m_e v_e^2}{2} \end{cases}$$

$\boxed{E_c = \frac{m_e v_e^2}{2} = e\cdot U_s}$ unde: U_s – tensiune stopare

$E_f = h\nu = h\frac{c}{\lambda}$ – energia rad/foto

$L = h\nu_0 = h\frac{c}{\lambda_0}$ – l. mec. de extr.

$E_c = \frac{m_e v_e^2}{2}$ – energ. cinetică a fotoelectronului

h – const. Planck. $h = 6{,}626\cdot10^{-34}J\cdot s$

λ – lungimea de undă (m)

ν – frecvența (Hz)

deci $L = h\nu_0 = h\frac{c}{\lambda_0}$

$$\to \lambda_0 = \frac{hc}{L} = \frac{c}{\nu_0}$$

$$\lambda_0 = \frac{6{,}626\cdot10^{-34}J\cdot s\cdot 3\cdot10^8 m/s}{2\cdot1{,}6\cdot10^{-19}J} = \frac{6{,}626\cdot3}{3{,}2}\cdot10^{-7} m$$

$$\lambda_0 = 250\cdot10^{-9}m = 250\,nm$$

$$\boxed{\lambda_0 = \frac{c}{\nu_0}}$$

$$\to \nu_0 = \frac{c}{\lambda_0} = \frac{3\cdot10^8 m/s}{250\cdot10^{-9}m}$$

$$\nu_0 = \frac{30}{250}\frac{10^{17}}{s} = \frac{3000}{250}\cdot10^{15} = 12\cdot10^{15}Hz$$

b).

$$\begin{cases} E_f = L + E_c \\ \frac{hc}{\lambda} = L + \frac{m v_e^2}{2} \end{cases} \Rightarrow \frac{m v_e^2}{2} = \frac{hc}{\lambda} - L$$

$$v^2 = \frac{2}{m_e}\left(\frac{hc}{\lambda} - L\right) \to v = \sqrt{\frac{2}{m_e}\left(\frac{hc}{\lambda} - L\right)}$$

Înlocuim numeric utilizând u.m. ∈ S.I.

$$v = \sqrt{\frac{2}{9{,}1\cdot10^{-31}kg}\left(\frac{6{,}626\cdot10^{-34}J\cdot s\cdot3\cdot10^8 m/s}{250\cdot10^{-9}m} - 2\cdot1{,}6\cdot10^{-19}J\right)} \simeq 3{,}95\cdot10^5 m/s$$

3.2/49

$\lambda_1 = 136\,nm = 136\cdot10^{-9}m$

$U_{s1} = 6V$, $e = 1{,}6\cdot10^{-19}C$, $h = 6{,}626\cdot10^{-34}J\cdot s$

a) $U_{s2} = ?$ $(\lambda_2 = 106{,}5\,nm)$

b) $L = ?$

c) $\nu_0 = ?$

a) $\boxed{e\cdot U_s = E_c^{max} = \frac{m v_e^2}{2}}$

$$\begin{cases} E = L + eU_s \; * \\ E = L + E_c^{max} \end{cases}$$

$\boxed{E = L + E_c}$

$$\begin{cases} E_1 = h\nu_1 = \frac{hc}{\lambda_1} \\ E_2 = h\nu_2 = hc/\lambda_2 \end{cases}$$

$E_{c1} = (E_1 - L) = eU_{s1}$

$E_{c2} = (E_2 - L) = e\cdot U_{s2}$

deci
$$\begin{cases} E_1 - L = eU_{s1} \\ E_2 - L = eU_{s2} \end{cases}$$

$$E_1 - E_2 = e\cdot U_{s1} - e\cdot U_{s2} \to -(E_1 - E_2) + eU_{s1} = eU_{s2}$$

$$\Rightarrow U_{s2} = U_{s1} - \left(\frac{E_1 - E_2}{e}\right) \to U_{s2} = U_{s1} - \left(\frac{hc}{\lambda_1} - \frac{hc}{\lambda_2}\right)/e = U_{s1} - \frac{hc}{e}\left(\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right)$$

deci
$$U_s = 6V - \frac{6{,}626\cdot10^{-34}J\cdot s\; 3\cdot10^8 m/s}{1{,}6\cdot10^{-19}C}\left(\frac{1}{136\cdot10^{-9}m} - \frac{1}{106{,}5\cdot10^{-9}m}\right) \simeq 8{,}5V$$

b).
$$\begin{cases} E_1 = L + eU_{s1} \\ h\frac{c}{\lambda_1} = L + eU_{s1} \end{cases} \to L = \left(\frac{hc}{\lambda_1} - eU_{s1}\right) = \left(\frac{6{,}626\cdot10^{-34}\cdot3\cdot10^8}{136\cdot10^{-9}} - 1{,}6\cdot10^{-19}\cdot6V\right) \simeq 3eV$$

$\{1eV \simeq 1{,}6\cdot10^{-19}J\}$

c) $L = h\nu_0 = \frac{hc}{\lambda_0} \to \nu_0 = \frac{L}{h} = \frac{3\cdot1{,}6\cdot10^{-19}}{6{,}626\cdot10^{-34}} \simeq 7{,}5\cdot10^{14}Hz$

$\boxed{\lambda = \frac{c}{\nu};\; \nu = \frac{c}{\lambda};\; \nu = 1/T}$

$$\lambda_0 = \frac{hc}{L} = \frac{c}{\nu_0} = \frac{3\cdot10^8}{7{,}5\cdot10^{14}} = \frac{30}{75}\cdot10^{-6}$$

U_s - tensiunea de stopare este o măsură a frânării/stopării fotoelectronilor din spațiul Katod-Anod.

(3.3/49)

$$\begin{cases} E = L + E_c \\ E_c = e U_s \end{cases} \rightarrow \underline{E = L + eU_s} \qquad \boxed{eU_s = E_c^{max} = \frac{m \cdot v_e^2}{2}}$$

$\lambda_1 = 400\,nm$

$\lambda_2 = 360\,nm$

$\Delta U_s = U_{s2} - U_{s1} = ?$

$$\begin{cases} E_1 = \frac{hc}{\lambda_1} \\ E_2 = \frac{hc}{\lambda_2} \end{cases} \qquad \begin{cases} E_1 = L + eU_{s1} \\ E_2 = L + eU_{s2} \end{cases}$$

$$\underline{E_2 - E_1 = U_{s2} - U_{s1} = \Delta U_s}$$

deci: $\Delta U_s = (U_{s2} - U_{s1}) = E_2 - E_1 = \frac{hc}{\lambda_2} - \frac{hc}{\lambda_1} = \boxed{hc\left(\frac{1}{\lambda_2} - \frac{1}{\lambda_1}\right) = \Delta U_s}$

înlocuind: $\Delta U_s = 6{,}626 \cdot 10^{-34}\,Js \cdot 3 \cdot 10^8\,m/s \left(\frac{1}{360 \cdot 10^{-9}m} - \frac{1}{400 \cdot 10^{-9}m}\right) \simeq 0{,}345\,V.$

(3.4/49.)

Na - placă sodiu

$\nu = 10^{15}\,Hz$

$\nu_0(Na) = 6 \cdot 10^{13}\,Hz.$

a) $L = ?$ | $m_e = 9{,}1 \cdot 10^{-31}\,kg$

b) $v_e = ?$ | $h = 6{,}626 \cdot 10^{-34}\,Js.$

c) $p_f = \left(\frac{h}{\lambda}\right) = ?$

d) $P = ?$ $(N = 10^{10}\,fot/m^2 s)$

a) $\underline{E = L + E_c\ ;\ E = L + eU_s\ ;\ E = L + \frac{m v_e^2}{2}}$

$L = h\nu_0 = \frac{hc}{\lambda_0} \qquad \boxed{E_c = \frac{m v_e^2}{2} = eU_s.}$

deci $L = h\nu_0 = 6{,}626 \cdot 10^{-34}\,Js \cdot 6 \cdot 10^{13}\,Hz \simeq 2{,}49\,eV$

$1\,eV = 1{,}6 \cdot 10^{-19}\,J \cdot 1V = 1{,}6 \cdot 10^{-19}\,J$

b) $E = L + E_c\ ;\ E_c = \frac{m v_e^2}{2}$

$E = L + \frac{m v_e^2}{2} \rightarrow \left(\frac{m v_e^2}{2}\right) = E - L$

$E = h\nu\ ;\ L = h\nu_0 \qquad \frac{m v_e^2}{2} = h\nu - h\nu_0$

$v_e^2 = \frac{2}{m_e}(h\nu - h\nu_0) = \frac{2h}{m_e}(\nu - \nu_0)$

deci: $\boxed{v = \sqrt{\frac{2h}{m_e}(\nu - \nu_0)}} = \sqrt{\frac{2 \cdot 6{,}626 \cdot 10^{-34}\,Js}{9{,}1 \cdot 10^{-31}\,kg}(10^{15} - 6 \cdot 10^{13})} \simeq 7{,}57 \cdot 10^5\,m/s \simeq 757\,Km/s$

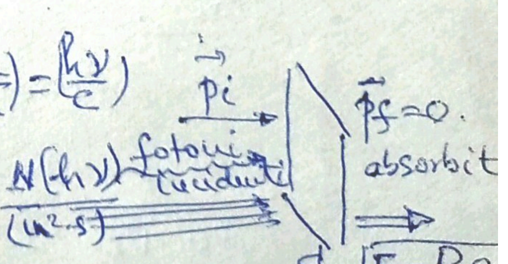
c) impulsul fotonului radiației incidente $\boxed{p = h/\lambda = h\nu/c}$

$$\begin{cases} p = \left(\frac{h}{\lambda}\right) \\ \lambda = \left(\frac{c}{\nu}\right) \end{cases} \rightarrow p = \left(\frac{h}{\lambda}\right) = \left(\frac{h\nu}{c}\right) = \frac{6{,}626 \cdot 10^{-34}(J \cdot s) \cdot 10^{15}\,Hz}{3 \cdot 10^8\,m/s} \simeq 2{,}2 \cdot 10^{-27}\,N \cdot s$$

d) $\boxed{P \overset{def}{=} \frac{F}{S}\ ,\left(\frac{N}{m^2}\right) = Pa.}$ | $P = \frac{(\Delta p/\Delta t)}{S}$, $p = \left(\frac{h}{\lambda}\right) = \left(\frac{h\nu}{c}\right)$

$F = \left(\frac{\Delta p}{\Delta t}\right) = m \cdot a$

$\Delta p = (\underbrace{p_f}_{=0} - p_i) = p_i$



Forța F exercitată de cei N - fotoni care cad pe suprafața S de $1\,m^2$ în fiecare secundă ce a suferit câte o variație de impuls $\Delta p = p_f = \frac{h\nu}{c} = h/\lambda$ fiecare, prin însumare conduce la:

$P = \frac{F}{S} = \frac{N \cdot \Delta p}{S = 1m^2} = N \cdot \frac{h\nu}{c} = 10^{10}\,\frac{fotoni}{m^2 \cdot s} \cdot \frac{6{,}626 \cdot 10^{-34}\,Js\,10^{15}\,Hz}{3 \cdot 10^8\,m/s} = 2{,}2 \cdot 10^{-19}\,Pa\,(N/m^2)$