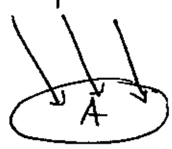
HW Solution Chapter 38
Phys 201 Term 112

38.2 $\lambda = 633\text{ nm}$ $\quad d = 3.5\text{ mm}$ $\quad P = 5\times10^{-3}\text{ W}$



$A = \pi r^2 = \pi \dfrac{d^2}{4}$

$$P = \frac{N}{t}\frac{hc}{\lambda} = \left(\frac{\text{Energy}}{t}\right)$$

$$\text{rate} = \frac{N}{t} = \frac{P\lambda}{hc}$$

$$\text{rate/unit area} = \frac{N}{tA} = \frac{P\lambda}{hcA} = \frac{P\lambda}{\left(\frac{\pi d^2}{4}\right)hc} = \frac{4\times5\times10^{-3}\times 633}{\pi\times(3.5\times10^{-3})^2\times 1240\times1.6\times10^{-19}}$$

$$= \underline{\underline{1.65\times10^{21}\text{ photons/s.m}^2}}$$

38.7 $\lambda = 400\text{ nm}$ $\quad P = 400\text{ W}$

$\lambda = 700\text{ nm}$ $\quad P = 400\text{ W}$

$$\frac{N}{t} = \frac{P\lambda}{hc}$$

larger λ, larger rate since P is the same

infrared lamp emits photons at the greater rate.

$$\text{The rate} = \frac{N}{t} = \frac{P\lambda}{hc} = \frac{400\times700}{1240\times1.6\times10^{-19}} = \underline{\underline{1.41\times10^{21}\text{ photons/s}}}$$

38.18

$$K_{max} = eV_s = hf - \phi = 4.14\times10^{-15}\times3\times10^{15} - 2.3$$

K_{max}: max. kinetic energy of photoelectrons

V_s: stopping potential

h in eV.s

$$K_{max} = 12.42 - 2.3 = \underline{\underline{10.12\text{ eV}}}$$

PHYS 201 – FORMULA SHEET – MAJOR 1

$$\Phi_B = \int \vec{B}.d\vec{A} \quad \Phi = BA \quad \mathcal{E} = -N\frac{d\Phi_B}{dt} \quad \oint \vec{E}.d\vec{s} = -\frac{d\Phi_B}{dt}$$

$$L = \frac{N\Phi_B}{i} \quad \frac{L}{l} = \mu_0 n^2 A \quad \mathcal{E}_L = -L\frac{di}{dt} \quad i = \frac{\mathcal{E}}{R}\left(1 - e^{-\frac{t}{\tau_L}}\right) \quad i = i_0 e^{-\frac{t}{\tau_L}}$$

$$U_B = \frac{1}{2}Li^2 \quad u_B = \frac{B^2}{2\mu_0} \quad \mathcal{E}_1 = -M\frac{di_2}{dt} \quad \mathcal{E}_2 = -M\frac{di_1}{dt}$$

38.26

$V_{s_1} = 1.85\ V \quad \lambda_1 = 300\ nm$

$V_{s_2} = 0.82\ V \quad \lambda_2 = 400\ nm$

$eV_s = hf - \phi = \frac{hc}{\lambda} - \phi$

a) $V_s = \left(\frac{hc}{e}\right)\frac{1}{\lambda} - \frac{\phi}{e}$ of the form $y = ax + b$

$V_1 - V_2$

$\frac{\Delta V_s}{\left(\frac{1}{\lambda_2} - \frac{1}{\lambda_1}\right)} = \frac{hc}{e} \Rightarrow h = \frac{\Delta V_s\, e}{c\left(\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right)}$

$h = \underline{6.59 \times 10^{-34}\ J.s} = 4.12 \times 10^{-15}\ eV.s$

b)

$\phi = -eV_{s_1} + \frac{hc}{\lambda_1} = -1.85\ eV + \frac{1240\ eV.nm}{300\ nm}$

$= \underline{2.28\ eV}$

c) $\lambda_0 = ?$ $\quad hf_0 = \phi = \frac{hc}{\lambda_0}$

$\Rightarrow \lambda_0 = \frac{hc}{\phi} = \frac{1240\ eV.nm}{2.28\ eV} = \underline{543.\ nm}$

38.27

$\lambda = 35\ pm$ $\quad$ a) $f = \frac{c}{\lambda} = \frac{3 \times 10^8}{35 \times 10^{-12}} = \underline{8.57 \times 10^{18}\ HZ}$

b) $E = hf = \frac{hc}{\lambda} = \frac{1240\ eV.nm}{0.035\ nm} = \underline{3.5 \times 10^4\ eV}$

c) $p = \frac{h}{\lambda} = \frac{6.602 \times 10^{-34}}{35 \times 10^{-12}} =$

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PHYSICS DEPARTMENT
PHYS 201- Term 112
QUIZ #1 – CHAPTER 31

Name: ID#:

1. A coil with inductance $L = 1.0$ H and a resistance $R = 20\ \Omega$ is suddenly connected to an ideal battery with $\mathcal{E} = 20$ V. At $t = 0.5$ s after the connection is made, what is the **rate** at which

(a) Energy is being stored in the magnetic field

(b) Thermal energy is appearing in the resistance

(c) Energy is being delivered by the battery

2. An elastic conducting material is stretched into a circular loop of 15 cm radius. It is placed with its plane perpendicular to a uniform 1.0 T magnetic field. When released, the radius of the loop starts to shrink at an instantaneous rate of 85 cm/s. What is the emf induced in the loop at that instant.

c) $E = pc \Rightarrow p = \frac{E}{c} = 3.5\times10^4 \frac{eV}{c}$

$p = 0.035 \frac{MeV}{c} = 35 \frac{keV}{c}$

38.30 $\lambda = 0.01 nm$

a) Compton shift is $\Delta\lambda = \lambda_c(1-\cos\theta)$ $\qquad \lambda_c = \frac{h}{m_e c}$

$\lambda_c = 2.43 pm$ = Constant / value for electrons ONLY!

$\theta = 180°$ $\qquad \Delta\lambda = 2\lambda_c = \underline{4.86 pm}$

b) $\Delta E = c(p - p') = \frac{hc}{\lambda} - \frac{hc}{\lambda'} = hc\left(\frac{1}{\lambda} - \frac{1}{\lambda'}\right)$

$\lambda = 0.01 nm$ $\qquad \lambda' = \lambda + \Delta\lambda = 0.01 + 0.00486$

$= 0.01486 nm$

$\Delta E = 1240 eV.nm\left(\frac{1}{0.01 nm} - \frac{1}{0.01486 nm}\right)$

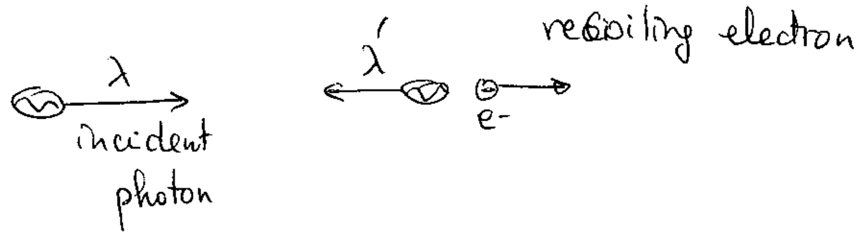
$= \underline{40.55 keV}$

c) Kinetic energy of recoiling electron = $\Delta E = \underline{40.55 keV}$

Conservation of energy - energy lost by the incoming photon is transferred to the lose electron.

d) Since $\theta = 180°$

ϕ is $\underline{0°}$



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38.42

a) electron

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

K: kinetic energy = 1 keV

$$\lambda = \frac{hc}{\sqrt{2(mc^2)K}} = \frac{1240 \text{ eV nm}}{\sqrt{2 \times 0.511\times10^6 \times 1\times10^3 \text{ eV}^2}}$$

hc: 1240 eV.nm; mc^2: 0.511 MeV = 0.511×10^6 eV; K: 1 keV = 1×10^3 eV

$= 0.0388 \text{ nm} = \underline{38.8 \text{ pm}}$

b) photon

$$\lambda = \frac{h}{p} = \frac{hc}{pc} = \frac{hc}{E} = \frac{1240 \text{ eV.nm}}{1\times10^3 \text{ eV}}$$

$\lambda = \underline{1.24 \text{ nm}}$

c) neutron

$$\lambda = \frac{hc}{\sqrt{2(mc^2)K}} = \frac{1240 \text{ eV.nm}}{\sqrt{2\times938\times10^9 \text{ eV}^2}}$$

mc^2: 938 MeV; K: 1 keV

$\lambda = \underline{9.05\times10^{-4} \text{ nm}}$

38.46

a) For both the momentum is $p = \frac{h}{\lambda} = \frac{6.6\times10^{-34}}{0.2\times10^{-9}} = \underline{3.3\times10^{-24} \text{ kg}}$

b)

c) electron $K = \frac{p^2}{2m_e} = \frac{(3.3\times10^{-24})^2}{2\times9.1\times10^{-31}} = \underline{5.98\times10^{-18} \text{ J}} = \underline{37.4 \text{ eV}}$

d) photon

$K = E = pc = \underline{9.9\times10^{-16} \text{ J}} = \underline{6.2 \text{ keV}}$

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38.57

The matter wave $\psi(x) = A e^{ikx} + B e^{-ikx}$ for a free particle

S. E. $\Rightarrow \frac{d^2\psi}{dx^2} + k^2\psi = 0$ for a free particle — ①

k is the wave number $= \frac{2\pi}{\lambda}$

the energy of the particle is $E = \frac{p^2}{2m} = \frac{\hbar^2 k^2}{2m}$

$$\frac{d\psi}{dx} = ikAe^{ikx} - ikBe^{-ikx}$$

$$\frac{d^2\psi}{dx^2} = \underbrace{i^2}_{-1} k^2 A e^{ikx} + \underbrace{i^2}_{-1} k^2 B e^{-ikx} = -k^2 \underbrace{(Ae^{ikx} + Be^{-ikx})}_{\psi(x)}$$

$\Rightarrow \; -k^2\psi + k^2\psi = 0$ (proved !)

38.61

S.E. $\frac{d^2\psi}{dx^2} + \underbrace{\frac{8\pi^2 m}{h^2}(E - U_b)}_{k^2}\psi = 0$ let $U_b = U_0$ = Constan[t]

so $k = \sqrt{\frac{8\pi^2 m}{h^2}(E - U_0)} = \frac{2\pi}{h}\sqrt{2m(E-U_0)}$

38.63

Heisenberg's uncertainty principle $\Delta x \cdot \Delta p_x \geq \hbar$

least uncertainty $\Rightarrow \Delta x \cdot \Delta p_x = \hbar \Rightarrow \Delta p_x = \frac{\hbar}{\Delta x}$

$$\Delta p_x = \frac{1.06 \times 10^{-34}}{50 \times 10^{-12}} = 2.1 \times 10^{-24} \, kg \cdot \frac{m}{s}$$

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