Camlin Page
Date / /

Q1

$m = 4\,kg$

$K = 196$

$x = 1/4\ m$

$K = m\omega^2$

$\cancel{196}^{49} = \cancel{4} \times \omega^2$

$\omega = 7$

$2\pi f = 7$

$f = \frac{7}{2\pi}$

$v = A\omega$

$TE = \frac{1}{2} m v^2 + \frac{1}{2} k x^2$

$= \frac{1}{2} m A^2 \omega^2 + \frac{1}{2} k x^2$

$\frac{nhc}{\lambda} = E_2 - E_1$

Q2

$\lambda T = b = 2898\ \mu m K$

$I = \sigma T^4$

$\sigma = 5.67 \times 10^{-8}\ W m^{-2} K^{-4}$

Q3

$\frac{dQ}{dt} = e\sigma T^4$

$\frac{ms(20.5 - 20)}{60(8)} = e\sigma T^4$ —— (1)

$\frac{ms(\theta - 20.5)}{60(8)} = e\sigma (27)^4$ —— (2)

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(1)(2)

$$\frac{0.5}{Q-20.5} = \frac{1}{16}$$

$$8 = Q - 20.5$$

$$\boxed{Q = 28.5}$$

Q4

$$\lambda T = b = 2898\ \mu mK$$

T = Temp in Kelvin,

Q5.

$P = 0.5W$

$\lambda = 632 \times 10^{-9} m$

$$E = \frac{nhc}{\lambda}$$

$$P = \frac{E}{t} = \frac{nhc}{\lambda t}$$

$t = 20ms$

$$\frac{n \times 6.64 \times 10^{-34} \times 3 \times 10^{8}}{632 \times 10^{-9} \times 20 \times 10^{-3}} = 0.5$$

$$n = 317.26 \times 10^{14}$$

Q6.

$$K_{max} = h\nu - \phi$$

(a)

$$K_{max} = \frac{hc}{\lambda} - \phi$$

ϕ = Work f^n.

K_{max} = Max K.E

$$11.390 = \frac{hc}{80 \times 10^{-9}} - \phi \quad (1)$$

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$$7.154 = \frac{hc}{110\times10^{-9}} - \phi \quad \text{—— (2)}$$

Subtract (1) − (2)

$$1.6\times10^{-19} \times 4.236 = \frac{hc}{10^{-9}}\left[\frac{1}{80} - \frac{1}{110}\right].$$

(Because given energies are in eV not in J.)

$$6.786\times10^{-19} = \frac{h\times3\times10^{8}}{10^{-9}} \times 34.09\times10^{-4}$$

$$h = 0.06635\times10^{-32}$$
$$= 6.635\times10^{-34}\ \text{Js}.$$

(b). Put h in eq (1) & find ϕ.

Cut off freq (ν_0) : $\quad \phi = h\nu_0$

find ν_0 from this

Cutoff wavelength (λ_0) ; $\quad$ & $\phi = \frac{hc}{\lambda_0}$

find λ_0 from this.

Q7.

$d = 1.5\times10^{-11}\ m$

$I = \frac{P}{A} = 1.4\times10^{3}\ W/m^2.$

Intensity

$\nu = 5 \times 10^{14}\ Hz$

(a) $A = 1\,m^2$, $t = 1s$ (Given).

n = no. of photon = ?

~~$t = 1s$~~

$P = I \times 1m^2 = 1.4 \times 10^3\ W$

$nh\nu = E = Pt$

$n \times 6.64 \times 10^{-34} \times 5 \times 10^{14} = 1.4 \times 10^3 \times 1$

$\underline{n = 42.168 \times 10^{20}}$

(b) P = Power per area $\times$ Area of earth obital sphere

$= 1.4 \times 10^3 \times 4\pi \times (1.5 \times 10^{11})^2$

$= 3.958 \times 10^{26}\ W$

No. of photons per second emitted, $n = P/h\nu = 1.2 \times 10^{45}$

(c)

?

Q8

$\lambda' - \lambda = \lambda_c (1 - \cos\phi)$

$\lambda' = \lambda + \lambda_c (1 - \cos\phi)$

$\lambda_c = 2.426 \times 10^{-12}\ m$

$\lambda' = 55.8 \times 10^{-12} + 2.426 \times 10^{-12} \times (1 - \cos 46^\circ)$

$\lambda' = 56.541\ pm$

Date / /

Q9. $E = 3\times10^{3}$ eV.

$= 3\times10^{3} \times 1.6\times10^{-19}$ J.

$\phi = 60^{\circ}$.

(a). $$\lambda' - \lambda = \frac{h}{m_e c}(1-\cos\phi)$$

$$= \frac{6.64\times10^{-34}}{9.1\times10^{-31}\times3\times10^{8}}(1-\cos60^{\circ})$$

$$\lambda' - \lambda = 1.216\times10^{-12}\,m \quad \text{——} \; (1)$$

$$E = \frac{hc}{\lambda}$$

$$\cancel{3}\times10^{3}\times1.6\times10^{-19} = \frac{6.64\times10^{-34}\times\cancel{3}\times10^{8}}{\lambda}$$

$$\lambda = 4.15\times10^{-10}\,m = 415\times10^{-12}\,m$$

From (1) $$\lambda' = \lambda + 1.216\times10^{-12}$$

$$\lambda' = 416.216\times10^{-12}\,m$$

$$\therefore \boxed{E' = \frac{hc}{\lambda'}}$$

(b) By LMC In x-direction

$\theta = ?$

$$pc\cos\theta = h\nu - h\nu'\cos\phi. \quad \text{——} \; (2)$$

By LMC in Y-dir.

$$pc \sin\theta = h\nu' \sin\phi \quad \text{--- (3)}$$

(2)/(3)

$$\tan\theta = \frac{\nu - \nu'\cos\phi}{\nu' \sin\phi}$$

$$= \frac{\frac{c}{\lambda} - \frac{c}{\lambda'}\cos\phi}{\frac{c}{\lambda'}\sin\phi}$$

$$= \frac{(\lambda' - \lambda\cos\phi)}{\lambda\sin\phi}$$

$$= \frac{(416.216 - 415 \times \cos 60^\circ) \times 10^{-12}}{415 \times \left(\frac{\sqrt{3}}{2}\right) \times 10^{-12}}$$

$$\tan\theta = 0.58$$

$$\theta = \tan^{-1}(0.58)$$

Q10. X-Rays (λ less)

$\lambda = 10\,pm$

$\lambda' = 10.5\,pm$

$$\lambda' - \lambda' = \frac{h}{mc}(1 - \cos\phi).$$

$$10^{-12} \times \frac{1}{2} = \frac{h}{mc}(1 - \cos\phi) \quad \text{--- (1)}$$

$$10^{-12} \times \frac{1}{2} = 2.426 \times 10^{-12}(1 - \cos\phi).$$

& $\tan\theta = \left(\frac{\lambda' - \lambda\cos\phi}{\lambda\sin\phi}\right)$

then find p using

$pc \sin\theta = h\nu' \sin\phi.$

(L.M.C. in y-dir.)

Q12(a) $p = \frac{\hbar}{a}$ a = ~~order of the position~~

$$KE = \frac{1}{2}mv^2 = \frac{p^2}{2m} = \frac{\hbar^2}{2ma^2}$$

$$PE = -\frac{Kq^2}{a} = -\frac{e^2}{4\pi\varepsilon_0 a}$$

$$TE = KE + PE$$

(TE), $\underline{E} = \frac{\hbar^2}{2ma^2} - \left(\frac{e^2}{4\pi\varepsilon_0}\right)\frac{1}{a}$,

E should be minimum.

Put $\frac{dE}{da} = 0$

$$\frac{dE}{da} = \frac{-\hbar^2}{ma^3} + \frac{e^2}{4\pi\varepsilon_0}\cdot\frac{1}{a^2} = 0$$

$a = 0.528$ Å (Ground state).

$$K_p + \frac{K_p (m_p c^2)}{2h\nu} = h\nu$$

Put a in T.E & get the Total energy,

(13) (a)

$r = 0.01 \times 10^{-3} = 10^{-5}\,m$

$Z = 1$

$$r = 0.529 \times \frac{n^2}{Z}\ \mathring{A}$$

$$10^{-5} = 0.529 \times n^2 \times 10^{-10}$$

$$n = 434.78$$
$$\simeq 435.$$

(b)

$$E = -13.6 \times \frac{Z^2}{n^2}\ eV$$

$$= 7.187 \times 10^{-5}\ eV$$

(14)

$$\lambda' - \lambda = \frac{h}{m_p c}(1 - \cos\phi)$$ [Compton formula]

$$\frac{1}{\nu'} - \frac{1}{\nu} = \frac{h}{m_p c^2}(1 - \cos\phi).$$

$$h\nu' = \frac{h\nu}{1 + (h\nu / m_p c^2)(1 - \cos\phi)}$$

K.E transferred to proton: $K_p = h\nu - h\nu'$

$$\therefore K_p = h\nu - \frac{h\nu}{1 + (h\nu/m_p c^2)(1 - \cos\theta)}$$

For max. Put $\theta = 180°$.

$$\boxed{K_p = \frac{h\nu}{1 + \frac{m_p c^2}{2h\nu}}}$$

16 (a) By symmetry, $P_2 = P$

(b) If the slit ~~so~~ through which particle passes is observed, then the prob. of the particle arriving at point Q is the sum of P_1 & P_2

$$\text{i.e. } P_1 + P_2 = 2P$$

17

$$\langle x|S\rangle = \sum \left(\langle x|\alpha\rangle\langle\alpha|i\rangle\langle i|S\rangle\right)$$

$i = 1, 2$

$\alpha = a, b, c$

Q 11

$$E' = h\nu' = \frac{h\nu}{2} \quad \text{—} ①$$

From

$$\lambda' - \lambda = \frac{h}{m_e c}(1-\cos\phi)$$

$$h\nu' = \frac{h\nu}{1 + \left(h\nu / m_e c^2\right)(1-\cos\phi)} \quad \text{—} ②$$

Equating ① & ②

$$\frac{h\nu}{1 + \frac{h\nu}{m_e c^2}(1-\cos\phi)} = \frac{h\nu}{2}.$$

$$\therefore E = h\nu = (1-\cos\phi) m_e c^2$$

$E = mc^2 = 1.66 \times 10^{-27} \times 9 \times 10^{16}\ J = 931\ MeV$

931 MeV = 1 atomic mass unit

$m = 1\,amu = 1.66 \times 10^{-27}\ kg$

For ~~max~~ min E, $\phi = 90^\circ$.

($c^2 = 931\ MeV$ when mass is taken in MeV)

$$\therefore E = h\nu = m_e c^2$$
$$= 0.5\ MeV \times 931\ MeV$$
$$= 465.5\ MeV.$$

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