Physics 197 Chapter #34 Homework Solutions

Problem #1 (P3):

$$hf - \phi = 0$$

$$\frac{hc}{\lambda_T} - \phi = 0$$

$$\frac{hc}{\lambda_T} = \phi$$

$$\boxed{\lambda_T = \frac{hc}{\phi}}$$

Problem #2 (P15): $E = hf$

(a) $91\,MHz = 91\times10^{6}\,Hz$ $\quad E = (4.138\times10^{-15}\,eV\cdot s)(91\times10^{6}\,Hz)$

$$\boxed{E = 3.77\times10^{-7}\,eV}$$

(b) $730\,KHz = 730\times10^{3}\,Hz$ $\quad E = (4.138\times10^{-15}\,eV\cdot s)(730\times10^{3}\,Hz)$

$$\boxed{E = 3.02\times10^{-9}\,eV}$$

Problem #3 (P21): $\lambda = 250\,nm.$ $\quad KE = 2.66\,eV$

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

(a) $E = \frac{hc}{\lambda} = \frac{1240\,eV\cdot nm}{250\,nm} = \boxed{4.96\,eV}$

(b). $\phi = \cancel{KE - \frac{hc}{\lambda} = 2.}$ $\quad \frac{hc}{\lambda} - KE = 4.96\,eV - 2.66\,eV = \boxed{2.30\,eV}$

(c). $KE = \frac{hc}{\lambda} - \phi = \frac{1240\,eV\cdot nm}{420\,nm} - 2.30\,eV = \boxed{.65\,eV}$

(d). $\frac{hc}{\lambda_T} = \phi$ $\quad \lambda_T = \frac{hc}{\phi_T} = \frac{1240\,eV\cdot nm}{2.30\,eV} = \boxed{539\,nm}$

Problem #4 (P27): Scattered angle $= 130^\circ$ (Scattered λ should be longer)

$\cancel{\lambda_2 - \lambda_1, \lambda_2 = .026\,\lambda_1}$ $\quad \lambda_2 = .026\,\lambda_1$

$$\Delta\lambda = \lambda_2 - \lambda_1 = h/mc\,(1-\cos\theta), \quad \frac{\Delta\lambda}{\lambda} = .026, \quad \Delta\lambda = .026\,\lambda$$

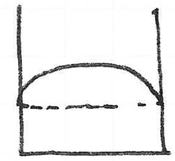
$hc = 1240\,eV\cdot nm$, $mc^2 = .511\,MeV.$

$$.026\,\lambda = \frac{hc}{mc^2}(1-\cos\theta) \Rightarrow \lambda = \frac{1}{.026}\left(\frac{hc}{mc^2}(1-\cos\theta)\right) = \boxed{.153\,nm}$$

Problem #5 (P31) electron moving at $v = 4.0\times10^5 \frac{m}{s}$. Determine λ_D

$$\lambda_D = \frac{h}{P} = \frac{6.626\times10^{-34}\,J\cdot s}{(9.11\times10^{-31}kg)(4\times10^5\,m/s)} = 1.82\times10^{-9}\,m = \boxed{1.8\,nm}$$

Problem #6 (P43)



$x=0$ $x=L$

$$\psi_1(x) = \sqrt{\frac{2}{L}}\sin\frac{\pi x}{L}$$

$$P(x) = \psi_1^2(x) = \frac{2}{L}\sin^2\frac{\pi x}{L}$$

Determine Probability of finding the particle in an interval of length $\Delta x = .0021L$ and centered on the following values of x

(a) $x = \frac{L}{2}$ $P(x) = \psi^2(x)\,\Delta x$

$$P(x) = \frac{2}{L}\sin^2\frac{\pi x}{L}(.0021L) = \frac{2(.0021)}{\cancel{L}}\cancel{L}\sin^2\frac{\pi x}{L}$$

$$P(x) = (.0042)\sin^2\frac{\pi x}{L} = .0042\sin^2\frac{\pi}{2} = \boxed{.0042}$$

(b) $x = \frac{2}{3}L$ $P(x) = .0042\sin^2\left(\frac{2\pi}{3}\right) = \boxed{.00315}$

(c) $x = L$ $P(x) = .0042\sin^2(\pi) = \boxed{0}$

Problem #7 (1E003) $\psi(x) = \sqrt{\frac{30}{L^5}}\,x(L-x)$, $L=3$

$$P(1nm \le x \le 2.4nm) = \int_1^{2.4}\psi^2(x)\,dx$$

$$P(1\le x\le 2.4) = \int_1^{2.4}\left(\frac{30}{L^5}\right)x^2\left(L^2-2Lx+x^2\right)dx$$

$$P(1\le x\le 2.4) = \frac{30}{L^5}\int_1^{2.4}\left(x^2L^2-2Lx^3+x^4\right)dx$$

$$P(1\le x\le 2.4) = \frac{30}{L^5}\left[\frac{x^3L^2}{3}-\frac{Lx^4}{2}+\frac{x^5}{5}\right]_1^{2.4}$$

$$P(1\le x\le 2.4) = \frac{30}{3^5}\left[\left[\frac{(2.4^3)9}{3}-\frac{3(2.4)^4}{2}+\frac{(2.4)^5}{5}\right]-\left[\frac{9}{3}-\frac{3}{2}+\frac{1}{5}\right]\right] = \boxed{.7322}$$

Problem#8 (P34): Six sided die: 5 painted on 3 sides, 6 painted on 3 sides.

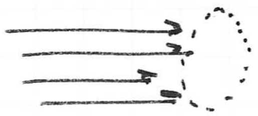
(a) $P(x=5) = \frac{3}{6} = \boxed{\frac{1}{2}}$

(b) $\langle x \rangle = \frac{3\times(5) + 3(6)}{6} = \frac{15+18}{6} = \frac{33}{6} = \boxed{5.5}$

(c) $\langle x^3 \rangle = \frac{3\times(5)^3 + 3\times(6)^3}{6} = \boxed{170.5}$

Problem #9 (P55): Photons in 4.00 cm diameter beam
$\lambda = 405\,nm$, $I = 115\,\frac{W}{m^2}$.

(a). Energy of each photon: $E = hf = \frac{hc}{\lambda} = \frac{1240\,eV\cdot nm}{405\,nm} = \boxed{3.06\,eV}$

(b).  $1.00\,cm^2$ $\Delta t = 1.00\,sec.$

$Power = \frac{Energy}{time}$, ~~Power = Ener~~

$Energy = Power \times time.$

$Intensity = \frac{Power}{Area}$, $Power = Intensity \times Area$

$Energy = Intensity \times Area \times time$

$Energy = 115\,\frac{W}{m^2} \times 1\times10^{-4}\,m^2 \times 1.00\,sec = 1.15\times10^{-2}\,Joule$

$\boxed{E = 7.19\times10^{16}\,eV}$

(c). $n\,E_{photon} = 7.19\times10^{16}\,eV$

$n\,(3.06\,eV) = 7.19\times10^{16}\,eV \quad > n = 2.35\times10^{16}\,\frac{photons}{second}$

Problem#10 (P39): electron microscope energy = 80 keV. Find λ_D of electrons: Assume non-relativistic electrons. $\lambda_D = h/p$

$\lambda_D = \frac{hc}{pc}$, $K = \frac{P^2}{2m}$, $p = \sqrt{2Km} > \lambda_D = \frac{hc}{\sqrt{2Km}\,c} = \frac{hc}{\sqrt{2Kmc^2}}$, $hc = 1240\,eV\cdot nm$, $mc^2 = .511\,MeV$

$\lambda_D = \frac{1240}{\sqrt{K}\sqrt{2(.511\,MeV)}} = \frac{1.23}{\sqrt{K}}$, $\lambda_D = \frac{1.23}{\sqrt{80\times10^3\,eV}} = 4.35\times10^{-3}\,nm = 4.35\,pm$