3-5. (a) $$R = \frac{mu}{qB} = \frac{\left[\left(2E_k/e\right)\left(e/m\right)\right]^{1/2}}{\left(e/m\right)\left(B\right)}$$

$$= \frac{1}{B}\sqrt{\frac{2E_k/e}{e/m}} = \frac{1}{0.325T}\left[\frac{(2)\left(4.5\times10^4 eV/e\right)}{1.76\times10^{11}kg}\right]^{1/2} = 2.2\times10^{-3}m = 2.2mm$$

(b)

frequency $$f = \frac{u}{2\pi R} = \frac{\sqrt{\left(2E_k/e\right)\left(e/m\right)}}{2\pi R}$$

$$= \frac{\left[(2)\left(4.5\times10^4 eV/e\right)\left(1.76\times10^{11}C/kg\right)\right]^{1/2}}{2\pi\left(2.2\times10^{-3}m\right)} = 9.1\times10^9 Hz$$

period $T = 1/f = 1.1\times10^{-10}s$

3-6. (a) $1/2mu^2 = E_k$, so $u = \sqrt{\left(2E_k/e\right)\left(e/m\right)}$

$$\therefore\quad u = \left[(2)\left(2000eV/e\right)\left(1.76\times10^{11}C/kg\right)\right]^{1/2} = 2.65\times10^7 m/s$$

(b) $$\Delta t_1 = \frac{x_1}{u} = \frac{0.05m}{2.65\times10^7 m/s} = 1.89\times10^{-9}s = 1.89ns$$

(c) $mu_y = F\Delta t_1 = e\mathcal{E}\Delta t_1$

$$\therefore \quad u_y = (e/m)\mathcal{E}\Delta t_1 = \left(1.76\times10^{11} C/kg\right)\left(3.33\times10^{3} V/m\right)\left(1.89\times10^{-9} s\right) = 1.11\times10^{6} m/s$$

3-24. Photon energy $E = hf = hc/\lambda$

(a) For $\lambda = 380nm$: $E = (1240eV \cdot nm)/380nm = 3.26eV$

For $\lambda = 750nm$: $E = (1240eV \cdot nm)/750nm = 1.65eV$

(b) $E = hf = (4.14\times10^{-15}eV\cdot s)(100\times10^{6}s^{-1}) = 4.14\times10^{-7}eV$

3-26. (a) $\lambda_t = \frac{hc}{\phi} = \frac{1240eV \cdot nm}{1.9ev} = 653nm, \quad f_t = \frac{\phi}{h} = \frac{1.9eV}{4.136 \times 10^{-15} eV \cdot s} = 4.59 \times 10^{4} Hz$

(b) $V_0 = \frac{1}{e}\left(\frac{hc}{\lambda} - \phi\right) = \frac{1}{e}\left(\frac{1240eV \cdot nm}{300nm} - 1.9eV\right) = 2.23V$

(c) $V_0 = \frac{1}{e}\left(\frac{hc}{\lambda} - \phi\right) = \frac{1}{e}\left(\frac{1240eV \cdot nm}{400nm} - 1.9eV\right) = 1.20V$

3-27. (a) Choose λ =550*nm* for visible light. $nhf = E \rightarrow \frac{dn}{dt} hf = \frac{dE}{dt} = P$

$$\frac{dn}{dt} = \frac{P}{hf} = \frac{P\lambda}{hc} = \frac{(0.05 \times 100W)(550 \times 10^{-9} m)}{(6.63 \times 10^{-34} J \cdot s)(3.00 \times 10^{8} m/s)} = 1.38 \times 10^{19} / s$$

(b) $flux = \frac{number\ \ radiated\ /\ unit\ time}{area\ of\ \ the\ sphere} = \frac{1.38 \times 10^{19} / s}{4\pi (2m)^2} = 2.75 \times 10^{17} / m^2 \cdot s$

3-28. (a) $hf = \phi \quad \therefore \quad f_t = \frac{\phi}{h} = \frac{4.22eV}{4.14\times10^{-15}eV\cdot s} = 1.02\times10^{15}Hz$

(b) $f = c/\lambda = \frac{3.00\times10^{8}m/s}{560\times10^{-9}m} = 5.36\times10^{14}Hz$ No.

Available energy/photon $hf = \left(4.14\times10^{-15}eV\cdot s\right)\left(5.36\times10^{14}Hz\right) = 2.22eV.$

This is less than ϕ.

3-31. $$E = n\frac{hc}{\lambda} = \frac{(60)(6.63\times10^{-34}\,J\bullet s)(3.00\times10^{8}\,m/s)}{550\times10^{-9}\,m} = 2.17\times10^{-17}\,J$$

3-32. (a) $$\phi = \frac{hc}{\lambda} = \frac{1240eV\bullet nm}{653nm} = 1.90eV$$

(b) $$E_k = \frac{hc}{\lambda} - \phi = \frac{1240eV\bullet nm}{300nm} - 1.90eV = 2.23eV$$

3-34. Equation 3-24: $\lambda_m = \dfrac{1.24\times10^3}{V}nm = \dfrac{1.24\times10^3}{80\times10^3 V} = 0.016nm$

3-36. $$\lambda_2-\lambda_1=\frac{h}{mc}(1-\cos\theta)=\frac{(6.63\times10^{-34}J\bullet s)(1-\cos110°)}{(9.11\times10^{-31}kg)(3.00\times10^{8}m/s)}=3.26\times10^{-12}m$$

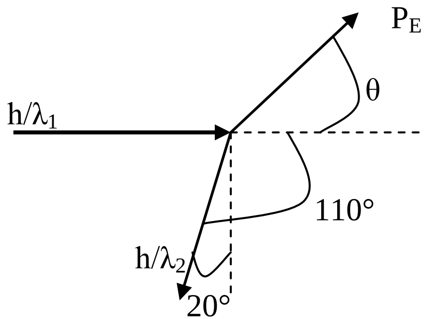
$$\lambda_1=\frac{hc}{E_1}=\frac{(6.63\times10^{-34}J\bullet s)(3\times10^{8}m/s)}{(0.511\times10^{6}eV)(1.60\times10^{-19}J/eV)}=2.43\times10^{-12}m$$

$$\lambda_2=\lambda_1+3.26\times10^{-12}m=(2.43+3.26)\times10^{-12}m=5.69\times10^{-12}m$$

$$E_2 = \frac{hc}{\lambda_2} = \frac{1240 eV \bullet nm}{5.69 \times 10^{-3} nm} = 2.18 \times 10^5 eV = 0.218 MeV$$

Electron recoil energy $E_e = E_1 - E_2$ (Conservation of energy)

$E_e = 0.511 MeV - 0.218 MeV = 0.293 MeV$. The recoil electron momentum makes an angle θ with the direction of the initial photon.



$$\frac{h}{\lambda_2} \cos 20° = p_e \sin\theta = (1/c)\sqrt{E^2 - (mc^2)^2} \sin\theta \qquad \text{(Conservation of momentum)}$$

$$\sin\theta = \frac{(3.00 \times 10^8 m/s)(6.63 \times 10^{-34} J \bullet s)\cos 20°}{(5.69 \times 10^{-12} m)\left[(0.804 MeV)^2 - (0.511 MeV)^2\right]^{1/2}(1.60 \times 10^{-13} J/MeV)}$$

$= 0.330$ or $\theta = 19.3°$

3-38. $\Delta\lambda = \lambda_2 - \lambda_1 = \Delta\lambda = \frac{h}{mc}(1-\cos\theta) = 0.01\lambda_1$ Equation 3-25

$$\lambda_1 = (100)\frac{h}{mc}(1-\cos\theta) = (100)(0.00243nm)(1-\cos 90°) = 0.243nm$$

3-39. (a) $E_1 = \frac{hc}{\lambda_1} = \frac{1240eV \bullet nm}{0.0711nm} = 1.747\times10^4 eV$

(b) $\lambda_2 = \lambda_1 + \frac{h}{mc}(1-\cos\theta) = 0.0711nm + (0.00243nm)(1-\cos180°) = 0.0760nm$

(c) $E_2 = \frac{hc}{\lambda_2} = \frac{1240eV \bullet nm}{0.0760nm} = 1.634\times10^4 eV$

(d) $E_e = E_1 - E_2 = 1.128\times10^3 eV$

3-42. (a) Compton wavelength = $\frac{h}{mc}$

electron: $$\frac{h}{mc} = \frac{6.63\times10^{-34}\,J\bullet s}{\left(9.11\times10^{-31}\,kg\right)\left(3.00\times10^{8}\,m/s\right)} = 2.43\times10^{-12}\,m = 0.00243nm$$

proton: $$\frac{h}{mc} = \frac{6.63\times10^{-34}\,J\bullet s}{\left(1.67\times10^{-27}\,kg\right)\left(3.00\times10^{8}\,m/s\right)} = 1.32\times10^{-15}\,m = 1.32\,fm$$

(b) $E = \frac{hc}{\lambda}$

(i) electron: $$E = \frac{1240eV\bullet nm}{0.00243nm} = 5.10\times10^{5}\,eV = 0.510MeV$$

(ii) proton: $$E = \frac{1240eV\bullet nm}{1.32\times10^{-6}\,nm} = 9.39\times10^{8}\,eV = 939MeV$$