PH253 S19
HW2

1. $\lambda_f - \lambda_i = \frac{hc}{E_f} - \frac{hc}{E_i} = \frac{h}{mc}(1-\cos\theta)$

$$\Rightarrow \frac{1}{E_f} = \frac{1}{E_i} + \left(\frac{1-\cos\theta}{mc^2}\right) \Rightarrow E_f \simeq 0.382\,MeV$$

$$K_e = E_i - E_f = 0.275\,MeV$$

2. $\lambda_i = 60\times10^{-12}\,m \quad \theta = 150°$

a) $\Delta\lambda = \frac{h}{mc}(1-\cos\theta) \simeq 4.53\,pm$

from notes: b) $\tan\varphi = \frac{1}{1+\alpha_i}\frac{1}{\tan(\theta/2)} = \frac{1}{1+\frac{hc}{\lambda mc^2}}\cdot\frac{1}{\tan\frac{\theta}{2}} \simeq 0.258$

$$\Rightarrow \varphi \simeq 14.4°$$

c) $K_e = \frac{hc}{\lambda} - \frac{hc}{\lambda_f} = \frac{hc(\lambda_f-\lambda_i)}{\lambda_i\lambda_f} = \frac{hc\Delta\lambda}{\lambda_i(\lambda_i+\Delta\lambda)} \simeq 1.41\,keV$

3. now $m_e \to m_p$, so $\Delta\lambda_{max} = \frac{h}{m_p c} \simeq 2.64\times10^{-15}\,m = 2.64\,fm$
v small; roughly the size of a nucleus

4. $K_e = \frac{1}{2}mv^2 \simeq 5.57\,eV$

$\frac{hc}{\lambda_i} \simeq 1551\,eV$ $\qquad E_f = \frac{hc}{\lambda_f} = \frac{hc}{\lambda_i} - K_e \simeq 1545.4\,eV$

b) $\lambda_f = \frac{hc}{E_f} \simeq 0.803\,nm \qquad \Delta\lambda = \lambda_f - \lambda_i \simeq 2.9\,pm$

c) $\cos\theta = 1 - \frac{\Delta\lambda}{\lambda_c}$ (rearrange Compton eqn, $\lambda_c = \frac{h}{mc}$)

$$\Rightarrow \theta \simeq 102°$$

5. assume non-relativistic

cons E: $q\Delta V = \frac{1}{2} m v^2 \Rightarrow v = \sqrt{\frac{2q\Delta V}{m}}$

$$\lambda = \frac{h}{p} = \frac{h}{mv} = \frac{h}{m}\sqrt{\frac{m}{2q\Delta V}} = \frac{h}{\sqrt{2qm\Delta V}}$$

6. $K_{max} = hf - \varphi \geq 0$ to observe, so $hf \geq \varphi$

$\lambda = 400\,nm \Rightarrow E = \frac{hc}{\lambda} \simeq 3.1\,eV = hf$

$\Rightarrow$ if $\varphi > hf = 3.1\,eV$, no photoelectric effect

$\Rightarrow$ only Li

for Li, $K_{max} = hf - \varphi \simeq 0.81\,eV$

7. $$E^2 = m^2c^4 + p^2c^2 = m^2c^4 + \frac{h^2c^2}{\lambda^2}$$

$$\frac{E^2}{h^2} = \frac{m^2c^4}{h^2} + \frac{c^2}{\lambda^2} = \frac{h^2f^2}{h^2} \qquad \frac{f^2}{c^2} = \left(\frac{mc}{h}\right)^2 + \frac{1}{\lambda^2} = \frac{1}{\lambda^2} + \frac{1}{\lambda_c^2}$$

for a photon $\lambda f = c$ or $\frac{f^2}{c^2} = \frac{1}{\lambda^2}$

this can only be true for a particle if $\frac{1}{\lambda_c} = 0$

which implies $m = 0$, so NO.

8. $\lambda = 10^{-14}\, m$ $\qquad \lambda = \frac{h}{p}, \; K = \sqrt{m^2c^4 + p^2c^2} - mc^2 = E_{tot} - E_{rest}$

a) $K = \sqrt{m^2c^4 + \frac{h^2c^2}{\lambda^2}} - mc^2 \simeq 120\, MeV$

b) at $10^{-14}\, m$, PE from nucleus is $U = \frac{ke^2}{r} \simeq 144\, keV$

$K \gg U$, so e^- easily escapes the nucleus

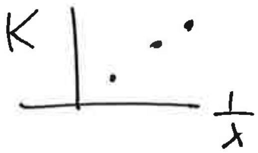
9. $\lambda = \frac{h}{p} = \frac{h}{\gamma m v} = \lambda_c = \frac{h}{mc}$ only true if $\frac{1}{\gamma v} = \frac{1}{c}$

or $\frac{1}{\gamma} = \frac{v}{c} = \sqrt{1 - v^2/c^2} \Rightarrow \frac{v^2}{c^2} = 1 - \frac{v^2}{c^2} \Rightarrow \frac{v}{c} = \frac{1}{\sqrt{2}}$

$\boxed{v = c/\sqrt{2}}$

10. $K_m = \frac{hc}{\lambda} - \varphi = a\left(\frac{1}{\lambda}\right) + b$ line! K vs $\frac{1}{\lambda}$ has slope $a = hc$
y intercept $b = -\varphi$

plot



with given data

$\Rightarrow hc = 1224.8\, eV \cdot nm$

$\Rightarrow h = 4.09 \times 10^{-15}\, eV \cdot s$ ~13% off

$\varphi = 1.41\, eV$ (very low, not an elemental metal. Probably Cs-coated metal film/filaments)