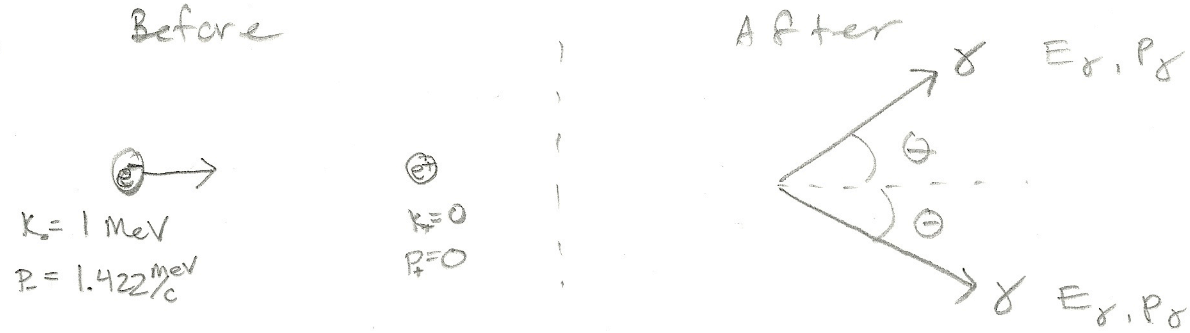
Quiz 2 Solutions

2D – Dr. Sutterley

1.



A. Conservation of energy $E_{total-before} = E_{total-after}$

$$\underbrace{KE_- + m_e c^2}_{\text{for the moving electron}} + \underbrace{m_e c^2}_{\text{for the positron @ rest}} = E_\gamma + E_\gamma$$

or you could write $\sqrt{(p_- c)^2 + (m_e c^2)^2} + m_e c^2 = 2E_\gamma$

$$\Rightarrow KE + 2m_e c^2 = 2E_\gamma$$

cons. of momentum

x-direction

$$P_{e^-} = 2p_\gamma \cos\theta$$

y-direction

$0 = P_\gamma \sin\theta - P_\gamma \sin\theta \rightarrow$ no information

B. Since $KE + 2m_e c^2 = 2E_\gamma$

$$E_\gamma = \frac{KE}{2} + m_e c^2 = \frac{1\text{ MeV}}{2} + 0.511\text{ MeV} = \boxed{1.011\text{ MeV}}$$

C. using momentum consv.

$$P_{e^-} = 2p_\gamma \cos\theta$$

and $P_\gamma = \dfrac{E_\gamma}{c}$ because $E_\gamma^2 = (p_\gamma c)^2 + \cancel{(mc^2)^2}$ ($\rightarrow 0$ for a photon)

$$E_\gamma = P_\gamma c$$

so $\cos\theta = \dfrac{P_{e^-}}{2p_\gamma} = \dfrac{1.422\text{ MeV/c}}{2(1.011\text{ MeV/c})} = 0.703$

$$\Rightarrow \boxed{\theta = 45.3^\circ}$$

Answer in Radians is ok too...

2. $\lambda = 500\,nm$, $V_s = 0.45\,V$

A. Since $V_s e = KE_{max} = hf - \phi$

$$KE_{max} = (0.45\,V)(1.602\times10^{-19}\,C)(1\,eV/1.602\times10^{-19}\,J)$$

$$\boxed{KE_{max} = 0.45\,eV}$$

B. $\phi = hf - KE_{max} = \frac{hc}{\lambda} - KE_{max} = \frac{1240\,eV\cdot nm}{500\,nm} - 0.45\,eV$

$$\boxed{\phi = 2.03\,eV}$$

C. λ_{cutoff} corresponds to the minimum energy the light must have to break out an electron w/ zero kinetic energy.

$$KE_{max} \nearrow^{0} = hf_{cut} - \phi \Rightarrow \phi = \frac{hc}{\lambda_{cutoff}}$$

$$\lambda_{cutoff} = \frac{hc}{\phi} = \frac{1240\,eV\cdot nm}{2.03\,eV} = \boxed{611\,nm}$$

3. Binding Energy is the difference in the mass between all the individual nucleons and the atomic mass.

$$B.E = \Delta m = [2m_p + 2m_n] - m_{HE} =$$

$$[2(1.007276u) + 2(1.008665u)] - 4.002602u =$$

$$= 0.02928\,u\,(931.49\,MeV/u)$$

$$\boxed{BE = 27.27\,MeV}$$

4. $\lambda_0 = 0.03\ nm$

A.

$$\Delta\lambda = \lambda' - \lambda_0 = \frac{h}{m_e c}(1-\cos\theta) =$$

$$\lambda' = (0.00243nm)(1-\cos 90) + 0.03nm$$

$$\boxed{\lambda' = 0.03243nm}$$

B. Conservation of energy

$$\underbrace{E_{\gamma_0} + m_e c^2}_{\text{Before}} = \underbrace{KE_e + m_e c^2 + E_{\gamma'}}_{\text{after}}$$

so $KE_e = E_{\gamma_0} - E_{\gamma'} = \frac{hc}{\lambda_0} - \frac{hc}{\lambda'} = (1240\ nm\cdot eV)\left[\frac{1}{0.03nm} - \frac{1}{0.03243nm}\right]$

$$\boxed{KE = 3097eV}$$

5. B.