Answer on Question #51439, Physics, Solid State Physics

An electron which has a kinetic energy 1.0 MeV collides with a stationary positron. (A positron has a mass equal to an electron but the opposite charge). In the collision both particles annihilate each other releasing two photons of equal energy which travel at an angle of to the electron's direction of motion. Calculate the energy, momentum and for each photon.

Solution:

According to the law of conservation of energy

$$2m_0c^2 + E_K = 2\cdot\hbar\omega \tag{1}$$

where $2m_0c^2 = 2\cdot 0.511 = 1.022MeV$ is the rest energy of the electron and its antiparticle; E_K is a kinetic energy of the electron; $2\cdot\hbar\omega$ is the energy of two photons.

According the law of conservation of momentum (considering only one projection)

$$p_e = 2\frac{\hbar\omega}{c} \tag{2}$$

where p_e is momentum of electron; $c = 3\cdot 10^8 m/s$ is the velocity of light.

From Eq.(1) the energy of photon is given by Eq.(3)

$$\hbar\omega = \frac{2m_0c^2 + E_K}{2} = \left(1.022MeV + 1.000MeV\right)/2 = 1.011MeV = 3.235\cdot 10^{-13} J \tag{3}$$

The momentum of each photon is given by Eq.(4)

$$\hbar\omega / c = 1.6176\cdot 10^{-13} J / 3\cdot 10^8 m/s = 5.392\cdot 10^{-22} kg\cdot m/s \tag{4}$$

Answer: $\hbar\omega = \frac{2m_0c^2 + E_K}{2} = 1.011MeV = 1.6176\cdot 10^{-13} J$;

$\hbar\omega / c = 5.392\cdot 10^{-22} kg\cdot m/s$