Answer on Question #51442, Physics, Solid State Physics

An electron has a deBroglie wavelength equal to that of a photon. Show that the ratio of the kinetic energy of the electron to the energy of the photon is

$$\frac{\left[\left(m^2c^4+h^2\upsilon^2\right)^{1/2}-mc^2\right]}{h\upsilon}$$

Solution:

The de Broglie wavelength for electron is given by Eq.(1)

$$\lambda=\frac{h}{mu} \qquad (1)$$

where h is the Planck constant; m is the mass of electron; u is the velocity of electron.

The wavelength for photon

$$\lambda=c/\nu \qquad (2)$$

where c is the velocity of light.

Thus,

$$v=\frac{h\nu}{mc} \qquad (3)$$

The kinetic energy

$$E_K=\frac{1}{2}mu^2=\frac{m}{2}\left[\frac{h\nu}{mc}\right]^2 \qquad (4)$$

The kinetic energy for electron

$$E_e=\frac{h^2\upsilon^2}{2mc^2}=\frac{h^2\upsilon^2}{2mc^2}+mc^2-mc^2=mc^2\left[1+\frac{h^2\upsilon^2}{2m^2c^4}\right]-mc^2\approx$$
$$\approx mc^2\left[1+\frac{h^2\upsilon^2}{m^2c^4}\right]^{1/2}-mc^2=\left(m^2c^4+h^2\upsilon^2\right)^{1/2}-mc^2 \qquad (4)$$

For photon

$$E_p=h\upsilon \qquad (5)$$

So,

$$\frac{E_e}{E_p} = \frac{\left(m^2c^4 + h^2\upsilon^2\right)^{1/2} - mc^2}{h\upsilon} \qquad (6)$$