PY 203 Test #2

NAME_______________________

Wally is an electron. He has a mass of $9.11 \times 10^{-31}$ kg and a charge of $1.602 \times 10^{-19}$ C.

1) We begin our story with Wally trapped on the surface of a silver coin. What wavelength of light will set him free? [The work function of silver is 4.73 eV.]

2) Wally is hit by a photon with an energy equal to that of Wally’s rest energy. The photon is scattered by an angle of 110 degrees in Wally’s initial rest frame. [$\cos(110) = -0.342$]

   A. What is the wavelength of the photon before the collision in terms of the Compton wavelength of an electron, $\lambda_C = h/mc$?
   B. What is the wavelength of the scattered photon in terms of $\lambda_C$?
   C. What is Wally’s kinetic energy after the collision (in units of $mc^2$)?
   D. What is the magnitude of Wally’s momentum after the collision (in units of $mc$)?
   E. What is Wally’s de Broglie wavelength after the collision?

3) Wally is confined to move along a one-dimensional wire of length $L$. Assume he can only exist in states for which his de Broglie wavelength has a node at each end of the wire.

   A. Sketch the three longest possible wavelengths Wally can have in this wire.
   B. Derive an expression for possible wavelengths in terms of $L$ and an integer, $n$, where $n=1$ is the longest wavelength, $n=2$ the next longest, etc.
   C. Derive the momentum for each of these states in terms of $n$, $L$ and Planck’s constant.
   D. Assuming these states have sufficiently low energy that Wally remains non-relativistic, derive the energy in terms of $n$.
   E. If Wally transitions from the first excited state ($n=2$) to his ground state ($n=1$), how much energy must be emitted in the transition?
   F. What is the wavelength of a photon with this emitted energy?

4) Wally collides with his anti-self (a positron) and annihilates to produce two photons of equal energy. The electron and positron are moving toward each other with equal speeds of $v=0.2c$ just before the collision.

   A. Why must the photons have equal energy?
   B. What is the energy of each photon?
   C. What is the wavelength of each photon?