

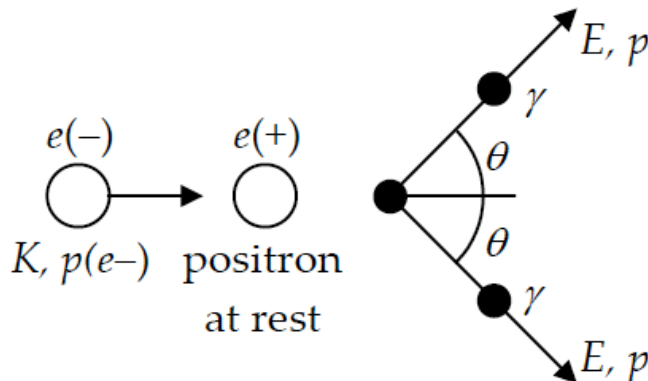
Notes: $c=3 \times 10^8 \text{ m/s} = 1 \text{ lightyear/year}$, $1 \text{ nanometer} = 10^{-9} \text{ meters}$,
 $h=6.626 \times 10^{-34} \text{ J}\cdot\text{s} = 4.136 \times 10^{-15} \text{ eV}\cdot\text{s}$, $m_e c^2 = 0.511 \text{ MeV}$, $1 \text{ eV} = 1.602 \times 10^{-19} \text{ J}$,
 $e = 1.602 \times 10^{-19} \text{ C}$, $hc = 1240 \text{ eV}\cdot\text{nm}$, and $1u = 931.49 \text{ MeV}$

There are 10 points in total.

Remember to write your quiz code # and your name on the front of your blue book, student ID number is not needed.

-----Please write clearly. Show your work for problems 1-4.-----

1. An electron that has kinetic energy, $K=1.000 \text{ MeV}$, and momentum, $p_e = 1.422 \text{ MeV}/c$, collides with a positron at rest. (A positron is an antimatter particle that has the same mass as an electron but opposite charge.) In the collision the two particles annihilate each other and turn into two photons of equal energy, each traveling at an angle θ from the electrons original motion (see picture below). ($m_e c^2 = 0.511 \text{ MeV}$)



- (1 point) Set up the conservation of energy equation and the conservation of momentum equation.
- (1 point) Find the energy of one of the photons created by this collision in MeV.
- (1 point) Find the angle of emission, θ , for a photon.

2. Light of wavelength 500 nm is incident on a metallic surface. If the stopping potential for the photoelectric effect is 0.45 V , find ($e = 1.602 \times 10^{-19} \text{ C}$, $1 \text{ eV} = 1.602 \times 10^{-19} \text{ J}$, $J = \text{V}\cdot\text{C}$, and $hc = 1240 \text{ eV}\cdot\text{nm}$)

- (1 point) the maximum energy of the emitted electrons in eV.
- (1 point) the work function in eV.
- (1 point) the cutoff wavelength in nanometers.

3. (1 point) A helium nucleus is composed of 2 protons and 2 neutrons with an atomic mass of 4.002602u. How much energy would it take to pull apart all of the nucleons in a helium atom, or in other words, what is the binding energy of helium in MeV? (The mass of a proton is 1.007276u, the mass of a neutron is 1.008665u, and $1u=931.49$ MeV.)

4. Incident light of wavelength $\lambda_0 = 0.03$ nm scatters upon an electron at rest. ($hc=1240$ eV*nm and $h/(m_e c)=0.00243$ nm)

a. (1 point) What is the wavelength of the scattered light when measured at an angle of 90° ?

b. (1 point) In eV, how much kinetic energy is transferred to the electron when the photon is scattered at 90° ?

-----Multiple Choice – no work needed -----

5. (1 point) An object is observed to glow white when heated to a certain temperature. The object is then allowed to cool 1000 Kelvin. What can we infer about the light radiating from the object?

- The glow will be dimmer and the peak light output will be at a higher frequency.
- The glow will be dimmer and the peak light output will have a longer wavelength.
- The glow will be dimmer and the peak light output will have a shorter wavelength.
- The glow will be brighter and the peak light output will have a longer wavelength.
- The glow will be dimmer and the peak light output will stay the same.