Name: _____

Physics 203 Quiz 2

Jun 26, 2013

Word Problems

Show all your work and circle your final answer. (Ten points each.)

1. When an electron and a positron (its antimatter twin) collide they typically annihillate in a burst of electromagnetic energy. Assume all the energy from the mass of the pair (each equal to 9.11×10^{-31} kilograms) is converted into two photons of energy. What is the wavelength of these photons?

Answer: 2.43×10^{-12} meters

The total mass involved is twice the value given in the problem—one for each particle. Thus,

$$m = (2)(9.11 \times 10^{-31}) = 1.822 \times 10^{-30}$$

The energy involved in this mass is given by

$$E = mc^2 = (1.822 \times 10^{-30})(3.00 \times 10^8)^2 = 1.6398 \times 10^{-13}$$

But since there are two photons, each carries 8.199×10^{-14} joules of energy. Using Planck's formula, $E = hf$, the frequency must be

$$8.199 \times 10^{-14} = (6.626 \times 10^{-34})(f) \implies f = 1.2356 \times 10^{20}$$

The wavelength is given by $c = f\lambda$, so

$$3.00 \times 10^8 = (1.2356 \times 10^{20})(\lambda) \implies 2.4263 \times 10^{-12}$$

This is in the gamma ray portion of the electromagnetic spectrum.

2. An evil genius wants to shrink the Moon in order to steal it. He accidentally shrinks its below it Schwarzschild radius and the Moon is lost forever in a mini-black hole. What is this radius?

Answer: 0.109 millimeters

We simply use the definition of the Schwarzschild radius:

$$r_s = \frac{2GM}{c^2}$$

The GM value for the moon is

$$GM = (6.673 \times 10^{-11})(7.36 \times 10^{22}) = 4.9113 \times 10^{12}$$

So...

$$r_s = \frac{(2)(4.9113 \times 10^{12})}{(2.998 \times 10^{8})^2} = 1.0929 \times 10^{-4}$$