Problem Set #2 *A little energy and momentum practice (and units)*

Problems 1-2 deal with "rest" energy and relativity.

1. "Among friends," the mass of a proton or neutron is about 2000 times that of electron. Using the "among friends" rest energy of the electron (Fn2 p2), calculate the approximate rest energy of a carbon-60 buckyball in MeV. (A carbon-60 buckyball is a molecule consisting of 60 carbon atoms, each of which has 6 protons and 6 neutrons.)

2. A singly ionized carbon-60 buckyball (e.g., C-60$^+$) accelerates from rest through a potential difference of 100 V. Determine the buckyball's de Broglie wavelength after it reaches its final speed (do it like the example on Fn2 p5—i.e., no kg, m, J, etc., please). Compare this with the wavelength in the example on p5 of Fn2. Why are the values different?

3. The (kinetic) energy of a photon is 10 eV. An electron *has the same de Broglie wavelength* as the wavelength of the photon. What is the electron's kinetic energy (in eV). (No, kg, m, J, etc., please! Hint: use *pc* and mc^2—both in eV.)

4. The notes Fn2 say that the "total" energy of a mass *m* freely moving with momentum *p* is given by $E = [(pc)^2+(mc^2)^2]^{1/2}$. In classical physics a freely moving mass has kinetic energy $K=p^2/2m$. Interpret what the total energy *E* is for a classical free particle by approximating the square root as the first two terms of a binomial expansion in the classical regime where $mc^2>>pc$. (Hint: If $A >> B$, the binomial $(A+B)^x \approx A^x + xA^{x-1}B + \frac{1}{2}x(x-1)A^{x-2}B^2$, plus higher order (smaller) terms in B. So, what are *A*, *B*, and *x* for this problem?)