Quantum Physics PHY4215 - Exercise Sheet 5

1. The rest mass of an electron is $m = 9.11 \times 10^{-31}$kg. Find, to three significant figures, the rest energy in MeV. You may use $c = 2.998 \times 10^{8}$ms^{-1} and the magnitude of the electron charge is $e = 1.602 \times 10^{-19}C$. Hence write the mass in MeV/c^2

2. (a) The relativistic formulae for momentum and energy of a particle of rest mass m are

$$p = \gamma m v$$
$$E = \gamma m c^2$$

Show that

$$E^2 = p^2c^2 + m^2c^4$$

The kinetic energy is $K = E - mc^2$. In the non-relativistic limit $v/c << 1$, where $\gamma \sim 1$, show that

$$K << mc^2$$

In the ultra-relativistic limit $\gamma >> 1$ ($v/c \sim 1$), show that

$$K >> mc^2, \quad E >> mc^2$$

(b) Use the formulae $K = E - mc^2$ and $E^2 = p^2c^2 + m^2c^4$ to derive an expression for p in terms of K

$$p^2 = 2Km(1 + \frac{K}{2mc^2})$$

4. For an electron with kinetic energy $K = 2.00eV$, $K = 0.30MeV$ and $K = 800MeV$, calculate the de Broglie wavelength $\lambda = \frac{h}{p}$, using approximations where appropriate.