First Year **RELATIVITY** **Classwork 2** 16Dec04

1) Express the following quantities in natural units, i.e. MeV/c^2 etc…
   ($c = 3\times10^8\,\text{ms}^{-1}, e = 1.6\times10^{-19}\,\text{C}$).
   a) Electron mass: $m_e = 9.1\times10^{-31}\,\text{kg}$.
   b) Proton mass: $m_p = 1.67\times10^{-27}\,\text{kg}$.
   c) Total energy of an electron with momentum $p = 1\text{MeV/c}$.
   d) Kinetic energy of a proton with momentum $p = 1\text{MeV/c}$.
   e) Repeat (d) using the Newtonian formula $K = p^2/2m$.
   f) Kinetic energy of a proton with speed $v = 0.5c$.
2) The sun produces energy by fusion of hydrogen into helium. One series of processes is:

$$p + p \quad \rightarrow \quad {}^2H + e^+ + \nu + 0.41\text{MeV}$$
$${}^2H + p \quad \rightarrow \quad {}^3He + \gamma + 5.51\text{MeV}$$
$${}^3He \ + \ {}^3He \quad \rightarrow \quad {}^4He + 2p + \gamma + 12.98\text{MeV}$$

   Calculate the total energy released in the formation of one α- particle (${}^4He$ nucleus). Note that the e^+ (positrons) will annihilate with electrons in the sun giving extra energy. (*Hint: how many times must each reaction occur in order to produce a single helium nucleus?).*
3) A π^0 decays at rest into 2 photons. If $m_{\pi^0} = 135\text{MeV/c}^2$, calculate
   a) The energy of each photon
   b) Their momenta
4) A K^0 decays at rest into 2 π^0's. If $m_{K^0} = 498\text{ MeV/c}^2$, calculate
   a) The energy of each π^0.
   b) Their momenta.

Answers

1) (a) 511 keV/c^2, (b) 939 MeV/c^2, (c) 1.12 MeV, (d) 530 eV, (e) 530 eV, (f) 145 MeV
2) 26.86 MeV
3) (a) 67.5 MeV, (b) 67.5 MeV/c.
4) (a) 249 MeV, (b) 209 MeV/c.