EASTERN UNIVERSITY OF SRI LANKA

SPECIAL DEGREE EXAMINATION IN SCIENCE(Part II) 2006

PH 415: Particle Physics

Answer **all** questions. Time: **Two Hours**

Mass of proton = **940 MeV/c^2**
Mass of neutron = **940 MeV/c^2**
Mass of electron = **0.50 MeV/c^2**
Electron charge = **1.6×10^{-19} C**
Velocity of light = **3.0×10^{8} ms^{-1}**

(1). Discuss the principles of operation of a Cyclotron and its limitations in accelerating charged particles to very high energies. Explain how the energy limitation of cyclotron may be removed by modulating the frequency of the accelerating field.

A cyclotron machine which is used to accelerate protons, has a uniform magnetic field of 1.0T and a radius of 0.25m. In this machine protons make 250 revolutions before they emerge and receive equal acceleration each time when they cross the accelerating gap. Estimate the following:

(i) The energy of the protons when they emerge.
(ii) The frequency and the voltage of the accelerating potential.

(2) In a proton- neutron collision event a new particle , say X , was created along with two proton.

(a) Write down the particle reaction for the above collision event.
(b) Identify the baryon number B, electric charge Q ,third component of the Isospin I_3, Isospin and strangeness S of the particle X.
(c) Give possible quarks content of the particle X.
(d) Another experiment predicts that the mass of the particle X is 140 MeV/ c^2. Estimate the minimum kinetic energy of the incident proton required to produce the above reaction in a laboratory. Assume that the neutron is at rest in the laboratory.
(e) Give the decay mode of particle X.

3.

(a) Give the charge Q , baryon number B, isospin, I, third component of the isospin, I_3 and strangeness, S of u, d and s quarks.

(b) Determine the charge, baryon number, isospin, third component of the isospin and strangeness of particles having the following quark structure:

i. uus ii. uds

iii. $u\bar{d}$ iv. $d\bar{s}$

v. uss vi. sss

(c) Write down the expression relating

(i) the hypercharge, Y to S and B

(ii) the charge Q to I_3 and Y of particles.

What value does the hypercharge take for strange quark.

(d) The lowest lying baryons with spin-parity state of $\frac{1}{2}^+$ are $p, n., \Xi^-, \Xi^0, \Lambda^0, \Sigma^0, \Sigma^+$ *and* Σ^-. Identify Y and I_3 of these baryons and arrange them in a diagram according to their value of Y and I_3.

(e) Deduce the relationship $2m_N + 2m_\Xi = 3m_\Lambda + m_\Sigma$ for the masses of the members of the baryon octet with $\frac{1}{2}^+$, where the symbols have their usual meaning .

You may find the Gell-Mann-Okubo mass formula,

$m = m_0 + m_1 Y + m_2 \left\{ I(I+1) - \frac{1}{4} Y^2 \right\}$ with usual notation useful.

4. Giving reasons classify the following processes as strong, electromagnetic, weak or totally forbidden .

(a) $\Sigma^+ + n \rightarrow \Sigma^- + p$

(b) $\pi^- + p \rightarrow \kappa^0 + \Lambda^0$

(c) $\Sigma^0 \rightarrow \Lambda^0 + \gamma$

(d) $\Lambda^0 \rightarrow p + \pi^-$

, Draw Feynman diagrams for the processes (b) and (d).