



NATIONAL OPEN UNIVERSITY OF NIGERIA
PLOT 91, CADASTRAL ZONE, NNAMDI AZIKIWE EXPRESSWAY, JABI - ABUJA
FACULTY OF SCIENCES

DEPARTMENT OF PURE AND APPLIED SCIENCE

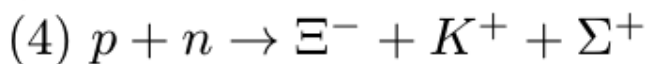
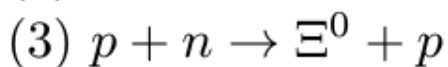
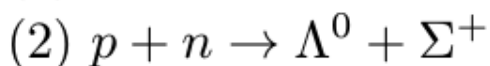
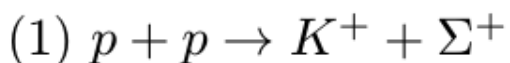
2021_1 EXAMINATIONS

COURSE CODE: PHY401
COURSE TITLE: ELEMENTARY PARTICLES PHYSICS
CREDIT UNIT: 3
TIME ALLOWED: (2½ HRS)

INSTRUCTION: *Answer question 1 and any other four questions*

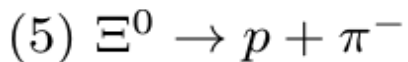
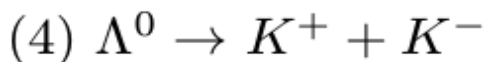
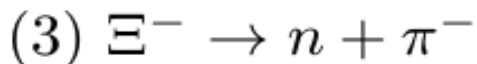
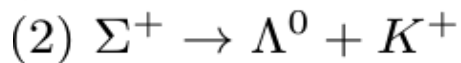
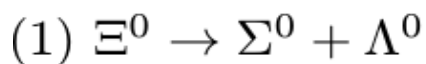
QUESTION 1

(a) Explain why the following reactions are not observed, even if the kinetic energy of the first proton is several BeV:



(8 marks)

(b) Explain why the following decay processes are not observed:



(10marks)

(c) What conservation laws, invariance principles, or other mechanisms account for the suppressing or forbidding of the processes below? (4marks)

$$(1) \quad \pi^+ \rightarrow e^+ + \nu_e \text{ (relative to } \pi^+ \rightarrow \mu^+ + \nu_\mu)$$

$$(2) \quad K_L^0 \rightarrow e^+ + e^-$$

QUESTION 2

Give a non-trivial (rate greater than 5%) decay mode for each particle in the following list. If you

$n \rightarrow, \pi^+ \rightarrow, \rho^0 \rightarrow, K^0 \rightarrow, \Lambda^0 \rightarrow, \Delta^{++} \rightarrow, \mu^- \rightarrow, \phi \rightarrow, \Omega^- \rightarrow, J/\Psi \rightarrow$
include neutrinos in the final state, be sure to specify their type. (12Marks)

QUESTION 3

(a) How many neutrino types are known to exist? What is the spin of a neutrino? (4 marks)

(b) What properties of neutrinos are conserved in scattering processes? What is the difference between a neutrino and an antineutrino? Illustrate this by filling in the missing particle:

$$\nu_\mu + e^- \rightarrow \mu^- + ? . \quad (4 \text{ marks})$$

(c) Assume the neutrino mass is exactly zero. Does the neutrino have a magnetic moment? Along what direction(s) does the neutrino spin point? Along what direction(s) does the antineutrino spin point? (3 marks)

(d) What is the velocity of a 3 ° K neutrino in the universe if the neutrino mass is 0.1 eV? (1 mark)

QUESTION 4

(a) List all of the known leptons. (4 marks)

(b) How does μ^+ decay? Considering this decay and the fact that $\nu_\mu + n \rightarrow e^- + p$ found to be forbidden, discuss possible lepton quantum number assignments that satisfy additive quantum number conservation laws. (4 marks)

(c) How could ν_μ produce a new charged “heavy lepton”? (4 marks)

QUESTION 5

Which of the following reactions are allowed? If forbidden, state the reason.

(a) $\pi^- + p \rightarrow K^- + \Sigma^+$

(b) $d + d \rightarrow {}^4\text{He} + \pi^0$

(c) $K^- + p \rightarrow \Xi^- + K^+$

(12 marks)

QUESTION 6

(a) The decay $K \rightarrow \pi\gamma$ is absolutely forbidden by a certain conservation law, which is believed to hold exactly. Which conservation law is this? **(4marks)**

(b) There are no known mesons of electric charge two. Can you give a simple explanation of this? **(4marks)**

(c) To a very high accuracy, the cross section for $e - p$ scattering equals the cross section for $e + p$ scattering. Is this equality a consequence of a conservation law? If so, which one? If not, explain the observed equality. To what extent (if any at all) do you expect this equality to be violated? **(4marks)**