



NATIONAL OPEN UNIVERSITY OF NIGERIA
PLOT 91, CADASTRAL ZONE, NNAMDI AZIKIWE EXPRESSWAY, JABI - ABUJA
FACULTY OF SCIENCES
DEPARTMENT OF PHYSICS
2025_2 EXAMINATIONS

COURSE CODE: PHY401
COURSE TITLE: NUCLEAR AND PARTICLE PHYSICS
CREDIT UNIT: 3
TIME ALLOWED: (3 HRS)
INSTRUCTION: Answer question 1 and any other three questions

Useful Constant: mass of proton, $m_p = 1.6726 \times 10^{-27} \text{ kg}$ (1.007825 u); Mass of neutron $m_n = 1.6750 \times 10^{-27} \text{ kg}$ (1.008665 u); $1u = 1.6606 \times 10^{-27} \text{ kg}$ (931.5 MeV/c²); Avogadro's constant, $N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$; $R_0 = 1.25 \times 10^{-15} \text{ m}$; $h = 6.623 \times 10^{-34} \text{ Js}$; Mass of electron $m_e = 9.11 \times 10^{-31} \text{ kg}$; $1 \text{ eV} = 1.602 \times 10^{-19} \text{ C}$.

QUESTION ONE

- a. i. Why are elementary particles termed Elementary? (2 marks)
- ii. What is used to classify elementary particles and list 2 classes of elementary particles. (3 marks)
- b. What criteria are used to group elementary particles into different families. (2 marks)
- c. A 175 MeV k^+ particles decays into $2\pi^+ + \pi^-$. K.E of π^+ are measured to be 68.6 MeV and 80.8 MeV, and that of the π^- as 75.5 MeV. find the Q for the reaction and the mass of the k^+ ($m(\pi) = 139.6 \text{ MeV}/c^2$). (10 marks)
- d. Find the reaction $\pi^- + P \rightarrow n + \gamma$ determine the possible value of the spin of π^- meson.
- $$s_n = \frac{1}{2} \quad s_\gamma = 1 \quad s_p = \frac{1}{2} \quad (8 \text{ marks})$$

QUESTION TWO

- a. Use the law of conservation of baryon number to determine whether each of the following reactions can occur
- i. $P + n \rightarrow P + P + n + \bar{p}$ (3 marks)
- ii. $P + n \rightarrow P + P + \bar{p}$ (3 marks)
- b. Use the law of conservation of lepton numbers to determine whether each of the following decay schemes can occur

- i. $\mu^- \rightarrow e^- + \bar{\nu}_e + \nu_\mu$ 3marks
- ii. $\pi^- \rightarrow \mu^+ + \nu_\mu + \nu_e$ 3mark

c. What are hyperons?

QUESTION THREE

a. Using strangeness conservation law, determine whether the following reactions can occur.

- i. $\pi^0 + n \rightarrow k^+ + \varepsilon^-$
- ii. $\pi^- + P \rightarrow \pi^- + \varepsilon^+$ (6 marks)

b. Analyze the following reaction in terms of constituents' quarks

$$\pi^- + P \rightarrow k^0 + \Lambda^0 \quad 3\text{marks}$$

$$\pi^+ + P \rightarrow k^+ + \varepsilon^+ \quad 3\text{marks}$$

c. Write the decay mode of Ω^- (3 marks)

QUESTION FOUR

- (a) List all the approximate conservation laws. (3½mks)
- (b) What are the major conservation laws used to test the validity of the laws. (4½mks)
- (c) Use the reaction, $p + n \rightarrow p + p + \pi^-$ to test if the reaction can occur in nature. (4mks)

QUESTION FIVE

- (a) A certain quantum state is defined by a wave function $\psi(r) = \sin 2\pi r$. If a parity operator acts on $\psi(r)$, what will be possible eigen states of parity? (3mks)
- (b) Show that the electrostatic force law is invariant under parity (7mks)
- (c) What are the resonances? (5mks)

QUESTION SIX

- (a) State the three rules for adding quantized angular momenta (6mks)
- (b) Explain whether or not, spin is conserved in the reaction $p + \pi^- \rightarrow e^+ + e^-$ (4mks)

(c) Assume the neutrino mass is exactly zero. Does the neutrino have a magnetic moment? (2 mks) Along what direction(s) does the neutrino spin point ? (1.5 mks) Along what direction(s) does the antineutrino spin point? (1.5 mks). (Total = 5 marks)