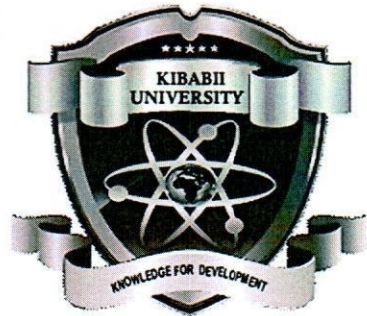


TS



KIBABII UNIVERSITY

**UNIVERSITY EXAMINATIONS
2021/2022 ACADEMIC YEAR**

**FIRST YEAR SECOND SEMESTER
MAIN EXAMINATIONS**

FOR THE DEGREE OF MASTERS IN SCIENCE (PHYSICS)

COURSE CODE: SPH 817

COURSE TITLE: NUCLEAR AND PARTICLE PHYSICS

DATE: 11/05/2022

TIME: 9:00AM-11:00AM

INSTRUCTIONS TO CANDIDATES

TIME: 2 HOURS

Answer any THREE questions

KIBU observes ZERO tolerance to examination cheating

QUESTION ONE [30 MARKS]

- a) Define the following terms:- [2 marks]
- (i) Mass defect
 - (ii) Binding fraction
 - (iii) Separation energy
 - (iv) Incident flux
- b) Using the semi empirical mass formula of the liquid drop nuclear model, show [3 marks]
that the most stable isobar for a given odd A is given by:- $Z = \frac{A}{2+0.0015A^{2/3}}$
[$b_3 = 0.58MeV$, $b_4 = 19.3MeV$]
- c) Calculate the nuclear binding energy of (3_2He). Find its neutron separation [3 marks]
energy.
[$m_p = 1.007825$, $m_n = 1.008665u$ of mass of ${}^3_2He = 3.01603u$]
- d) A beam of protons moves through a material whose refractive index is 1.8. [3 marks]
Cerenkov light is emitted at an angle of 11° to the beam. Find the kinetic
energy of the protons in MHz.
- e) Show that the expectation value of potential energy of a proton – neutron [4 marks]
system described by a square well of depth V_0 and width $0 \leq r \leq R$ is given by
 $\langle V \rangle = -V_0 A^2 \left[\frac{R}{2} - \frac{\sin 2kR}{4k} \right]$ using the trial wave function $\psi = A \sin kr$.
- f) In Fermi gas nuclear model, using the thermodynamic relation $P = -\frac{\partial U}{\partial V}$ show [3 marks]
that the pressure inside the nucleus is given by $\frac{2}{5} \rho_n E_F$ where ρ_n is the neutron
density.
- g) Identify particle X detected in the following nuclear reaction equation [1 marks]
 ${}^{150}_{62}Sm + {}^1_1H \rightarrow X + {}^{147}_{61}Pm$
- h) Find the ground state angular momentum of ${}^{20}_{10}Ne$. [2 marks]
- i) Calculate the magnetic field of a cyclotron which will accelerate protons at a [2 marks]
radio frequency of 8MHz [$q = 1.6 \times 10^{-19}C$, $m_p = 1.66 \times 10^{-27}kg$]
- j) A nuclear fission process is given by:- ${}^{235}_{92}U + {}^1_0n \rightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3{}^1_0n + Q$. [3 marks]
Calculate the energy Q released during the process.
[mass of ${}^{235}_{92}U = 235.04278u$, $m_n = 1.008665u$, mass of ${}^{141}_{56}Ba = 1409192u$ and
mass of ${}^{92}_{36}Kr = 91.81719u$]

- k) In nuclear scattering, calculate the angle of scattering in laboratory frame of reference due to two photons if the angle of scattering in centre of mass frame of reference is 10° . [2 marks]
- l) Indicate with an explanation whether the following interactions proceed through strong, electromagnetic or weak interactions. [2 marks]
- i) $\pi^- \rightarrow \mu^- + \bar{\nu}_\mu$
- ii) $\Sigma^0 \rightarrow \Lambda + \gamma$
- iii) $\pi^- + p \rightarrow K^0 + \Sigma^0$
- iv) $e^+ + e^- \rightarrow \mu^+ + \mu^-$

QUESTION TWO [15 MARKS]

Explain in detail any two nuclear models [15 marks]

QUESTION THREE [15 MARKS]

Discuss the properties of the nucleus under the subheadings:- [

- (i) Its size, mass, volume and density. [4 marks]
- (ii) Its composition [3 marks]
- (iii) Its binding energy [3 marks]
- (iv) Nuclear forces [5 marks]

QUESTION FOUR [15 MARKS]

In detail discuss and classify elementary particles [15 marks]

QUESTION FIVE [15 MARKS]

- a) The electric quadrupole moment of nuclear charge distribution which is symmetric about z-axis is given by:- [8 marks]
- $$\mu = \frac{1}{e} \int (3z^2 - r^2) \rho(x, y, z) dx dy dz$$
- for a uniformly charged ellipsoid of revolution defined by the equation:- $\frac{x^2+y^2}{a^2} + \frac{z^2}{b^2} = 1$. Show that the electric quadrupole moment is given by:- $\mu = \frac{6z}{5} R_0^2 \left(\frac{\delta R_0}{R_0} \right)$.
- b) Show that the Coulomb energy is given by:- $E_C = \frac{3}{5} \frac{kZ(Z-1)e^2}{R}$ for a proton in nucleus if the charge is uniformly spherically distributed. [7 marks]