

PHYS 887

CHUKA



UNIVERSITY

UNIVERSITY EXAMINATIONS

**FIRST YEAR EXAMINATION FOR THE AWARD OF DEGREE OF MASTER OF SCIENCE IN PHYSICS
PHYS 887:NUCLEAR PHYSICS II**

STREAMS: MSc

TIME: 3 HOURS

DAY/DATE: THURSDAY 07/08/2025

2:30PM - 5:30 PM

Answer question ONE and any other TWO questions.

Clearly show your workings.

USEFUL CONSTANTSMass of proton = $1.007276u$ Mass of neutron = $1.008665u$ Mass of Deuterium = $3.32 \times 10^{-27}kg$ Mass of proton = $1.007276u$ Mass of neutron = $1.008665u$

The atomic masses of the particles :

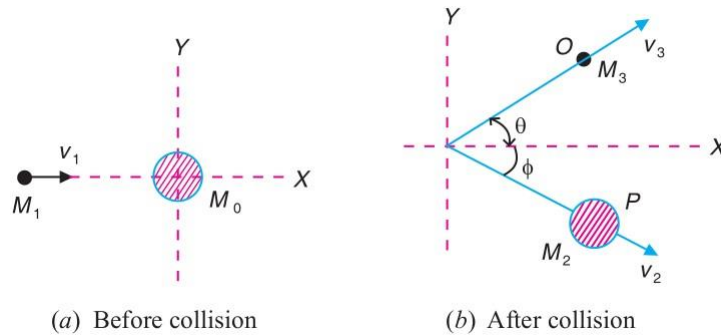
 $N^{14} = 14.003074, He^4 = 4.002604, O^{17} =$ $16.99913, H^1 = 1.007825u.$ **QUESTION ONE 15 MARKS**

- a) Explain the meaning of "Artificial Transmutation" (3 Marks)
- b) Explain the main characteristics of the nuclear forces as attributed by Yukawa (7 Marks)
- c) Use the 'Meson Theory of Nuclear Forces' to explain the observed nuclear stability. (5 Marks)

QUESTION TWO 15 MARKS

- a) With an example in each case, state and explain the five main types of nuclear reactions. (5 Marks)

- b) Consider a particle of mass M_1 moving with velocity v_1 collide with a target nucleus of mass M_0 at rest as in the figure below. After collision, the particle O of mass M_3 is emitted with velocity v_3 at an angle θ and the recoiling nucleus P of mass M_2 is emitted with a velocity v_2 at an angle ϕ .



Show that for $\theta = 90$ then the threshold energy will be given by $E_{th} = (1 + \frac{M_1}{M_0})|Q|$ (10 Marks)

QUESTION THREE 15 MARKS

- a) Explain 5 basic properties of the neutron (5 Marks)
- b) When a neutron is absorbed by a target nucleus, the resulting compound nucleus is more likely to emit a gamma ray than a proton, deuteron or alpha particle. explain (4 Marks)
- c) What is Q-value of a nuclear reaction and explain its significance (3 Marks)
- d) The atomic masses of boron 10 and lithium 7 are 10.01294 u and 7.01600 u respectively. The mass of a neutron is 1.00867 u. Show that the release of α -particles from boron 10 can be accomplished by neutrons of thermal energies. (3 Marks)

QUESTION FOUR 15 MARKS

- a) Discuss the use of nuclear techniques in medical imaging (e.g., PET and SPECT). (6 Marks)
- b) Describe one application of nuclear physics in archaeology or geology. (9 Marks)

QUESTION FIVE 15 MARKS

- a) Explain the conservation laws in nuclear reactions. (5 Marks)
- b) For the reaction ${}^7_3\text{Li} + {}^4_2\text{He} \rightarrow {}^{10}_5\text{B} + {}^1_1\text{H} + Q$ calculate the Q value (6 Marks)
- c) Using relevant reaction processes (where applicable), explain the four sources of neutrons. (4 Marks)