

UNIVERSITY EXAMINATIONS

1ST SEMESTER 2022/2023 ACADEMIC YEAR

FOURTH YEAR EXAMINATION FOR THE DEGREE OF
BACHELOR OF EDUCATION (SCIENCE)

PHYS 413: ATOMIC AND NUCLEAR PHYSICS

STREAM: R

TIME: 2 HRS

DAY: THURS [8.30AM – 10.30AM] DATE: 08/12/2022

THIS QUESTION PAPER CONSISTS OF THREE (3) PAGES

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SECTION A: (Compulsory) TOTAL MARKS FOR THIS SECTION IS 40 MARKS.

QUESTION ONE

- (a) (i) Give three characteristics of an alpha particle. (3 marks)
 (ii) Explain why decay rate of radioactive nuclei is not changed by heating. (3 marks)
- (b) Show that the half-life of a radioactive substance is give by $T_{\frac{1}{2}} = \frac{0.693}{\lambda}$ (6 marks)
- (c) (i) Give the differences between natural and artificial radioactivity. (3 marks)
 (ii) Give three characteristics of nuclear forces. (3 marks)
- (d) Calculate the binding energy per nucleon in $^{12}\text{C}_6$ (6 marks)
- (e) State the decay law and hence derive the decay equation (6 marks)
- (f) The nuclear force between two nucleons is charge independent. Explain. (4 marks)
- (g) State **FOUR** between artificial radioactivity and natural radioactivity. (4 marks)

QUESTION TWO

The liquid drop model expresses the binding energy of a nucleus as

$$BE = -a_1 A + a_2 A^{\frac{2}{3}} + a_3 ZA^{-\frac{1}{3}} + a_4 \frac{(N-Z)^2}{A} \pm a_5 A^{-\frac{3}{4}}$$

Explain what the 5 terms represent (10 marks)

Give FOUR fundamental forces. Explain one basic characteristic of all fundamental forces. (5 marks)

QUESTION THREE

- (a) The isotope Carbon-14, ^{14}C , is radioactive and has a half-life of 5730 years. If initially the sample has 1000 carbon nuclei, how many will still be undecayed in 2500 years? (10 marks)
- (b) A GM Counter reads 472 counts per minute when 500 charged particles are incident per minute on it Find the efficiency of GM Counter. (5 marks)

QUESTION FOUR

a) Explain two applications of nuclear physics in the following fields:

- i. Medicine (2 marks)
 ii. Agriculture (2 marks)
 iii. Manufacturing industries (2 marks)

- b) Explain how radioactivity is used in carbon dating (4 marks)
- c) Explain the Liquid Drop Model . (5 marks)

QUESTION FIVE

- a) In 1991, German tourists discovered the well-preserved remains of a man, now called “Ötzi the Iceman,” trapped in a glacier in the Italian Alps. Radioactive dating with ^{14}C revealed that this person was alive approximately 5 300 years ago. Why did scientists date a sample of Ötzi using ^{14}C rather than ^{11}C , which is a beta emitter having a half-life of 20.4 min? (15 marks)

