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**MAIN UNIVERSITY EXAMINATIONS**

**ACADEMIC YEAR 2022/2023**

**FOURTH YEAR FIRST SEMESTER EXAMINATIONS**

**BACHELOR OF EDUCATION SCIENCE**

**COURSE CODE: SPH 418**

**COURSE TITLE: NUCLEAR PHYSICS**

**DATE: 28/04/2023**

**TIME: 2:00-4:00PM**

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**INSTRUCTIONS TO CANDIDATES**

**Answer question ONE and any TWO of the remaining.**

**Time: 2 hours**

**QUESTION ONE (30 MARKS)**

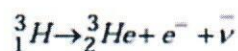
- a) Define radioactivity (2 marks)
- b) Differentiate between isomers and isobers (2 marks)
- c) Calculate the number of protons, neutrons and electrons in  ${}^{80}_{35}\text{Br}$  (3 marks)
- d) Name any three gas filled nuclear radiation detectors (3 marks)
- e) Define ionization energy (2 marks)
- f) The number of electrons, protons and neutrons in a species are equal to 18, 16 and 16 respectively. Assign the proper symbol to the species (3 marks)
- g) Show that nuclear density is constant for all nuclei? (3 marks)
- h) Give three differences between natural and artificial radioactivity? (3 marks)
- i) A Curie is very large and dangerous amount of radioactivity. How long would one have to wait for the tritium activity to reduce to 1 mCi? (3 marks)
- j) State any two medical applications of radioactivity? (2 marks)
- k) Differentiate between nuclear fission and nuclear fusion. (2 marks)
- l) Give any two achievements of the shell model of the nucleus? (2 marks)

**QUESTION TWO (20 MARKS)**

- a) What is meant by the term half life? (2 marks)
- b) The half-life of radium equal to 1590 years. Find its decay constant  $\lambda$  and determine the number of the nuclei in one gram of Radium. (4 marks)
- c) The half-life of a radioactive decay is given by

$$T_{1/2} = \frac{\ln(2)}{\lambda}$$

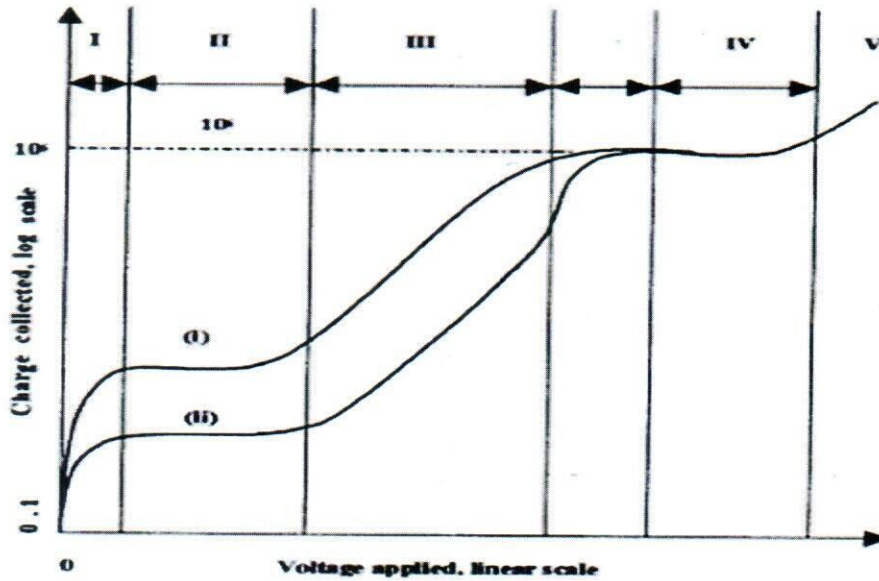
where  $T_{1/2}$  is half-life and  $\lambda$  is the decay constant, Calculate the decay rate (activity) of 1 mg of tritium (hydrogen -3 if it decays into helium- 3 by beta decay with a half-life of 12.3 years.



- (Decay rate: 1 curie = 1 Ci =  $3.7 \times 10^{10}$  decay/s) (5 marks)
- d) Discuss the characteristics of alpha, beta and Gamma decay? (9 marks)

**QUESTION THREE (20 MARKS)**

- a) State any three functions of nuclear detectors? (4 marks)
- b) Discuss the characteristics of a perfect nuclear detector. (6 marks)
- c) The Figure below shows characteristic curve for Gas Filled Radiation Detector (GFRD) with both (i) for alpha and (ii) for beta particle radiation. Increasing voltage between anode to cathode reveals five regions. Discuss the five regions: I, II, III, IV and V? (10 marks)



**QUESTION FOUR (20 MARKS)**

- a) Discuss the achievements and failures of the Liquid Drop Model of the nucleus? (8 marks)
- b) The Liquid Drop Model predicts the total binding energy of the number from values of atomic number ( $Z$ ), neutron number ( $N$ ) and mass number ( $A$ ) using the following empirical binding energy equation,

$$E_b = C_1 A - C_2 A^{2/3} - C_3 \frac{Z(Z-1)}{A^{1/3}} - C_4 \frac{(N-Z)^2}{A}$$

Discuss the constants and the origin of the terms in the equation (12 marks)

**QUESTION FIVE (20 MARKS)**

- a) What are nuclear forces? (2 marks)
- b) Discuss the properties of nuclear forces (12 marks)
- c) Particles in general are classified into two categories according to the statistics they obey (Fermions and Bosons). Discuss the features of the two classifications? (6 marks)