KIBABII UNIVERSITY

MAIN UNIVERSITY EXAMINATIONS

ACADEMIC YEAR 2022/2023

FOURTH YEAR FIRST SEMESTER EXAMINATIONS

BACHELOR OF SCIENCE

COURSE CODE: SPH 418

COURSE TITLE: NUCLEAR PHYSICS

DATE: 20/05/2022 **TIME: 9:00AM-11:00AM**

INSTRUCTIONS TO CANDIDATES

Answer question ONE and any TWO of the remaining.

Time: 2 hours

KIBU observes ZERO tolerance to examination cheating

QUESTION ONE (30 MARKS)

a) State three fundamental particles of an atom (3 marks)

b) State any two difficulties of the Rutherford (nuclear) model (2 marks)

c) Calculate the number of protons, neutrons and electrons in $^{80}_{35}Br$ (2 marks)

d) State any three properties of X-rays (3 marks)

e) Using s, p, d, f notations, describe the orbital with the following quantum numbers, (3 marks)

i) n=2, l=1
ii) n=4, l=0
iii) n=3, l=2

f) Define radioactivity (2 marks)

g) Differentiate between isomers and isobers (2 marks)

h) Name any three gas filled nuclear radiation detectors (3 marks)

i) State the Pauli exclusion principle (2 marks)

j) Define ionization energy (2 marks)

k) Calculate the frequency and wavelength of a photon emitted during a transition from n = 5 state to n = 2 state in hydrogen atom. (3 marks)

l) 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)

QUESTION TWO (20 MARKS)

a) Discuss any five limitations of the Bohr's model (5 marks)

b) i) State and explain the two types of X-rays (3 marks)

ii) Using a well labelled diagram, describe how are X-rays are produced (12 marks)

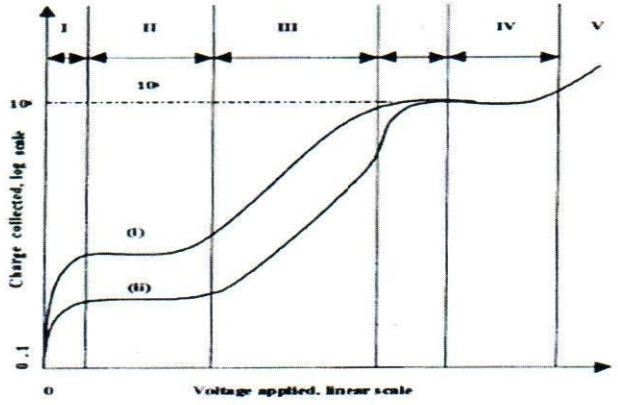
QUESTION THREE (20 MARKS)

a) What is the total number of orbitals associated with the principal quantum number n=3? (3marks)

b) (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? (4 marks)

(ii) The half-life of radium equal to 1590 years. Find its decay constant λ and determine the number of the nuclei in one gram of Radium. (4 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. (10 marks)



QUESTION FOUR (20 MARKS)

a) State Hund's Rule of maximum multiplicity. (2 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)

c) 20 g of carbon is extracted from a fossil and the C- 14 activity measured to be 100 decay/min. What is the age of the fossil? (4 marks)

QUESTION FIVE (20 MARKS)

a) State Zeeman effect (2 marks)

b) Discuss the properties of nuclear forces (12 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 λ 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.

$$^3_1H \rightarrow ^3_2He + e^- + \bar{\nu}$$

(Decay rate: 1 curie = 1 Ci = 3.7 x 10^{10}decay/s) (6 marks)