



NATIONAL OPEN UNIVERSITY OF NIGERIA
PLOT 91, CADASTRAL ZONE, NNAMDI AZIKIWE EXPRESSWAY, JABI - ABUJA
FACULTY OF SCIENCES
DEPARTMENT OF PHYSICS
2025_2 EXAMINATIONS

COURSE CODE: PHY402
COURSE TITLE: NUCLEAR PHYSICS
CREDIT UNIT: 3
TIME ALLOWED: (3 HRS)
INSTRUCTION: Answer question 1 and any other three questions

Useful Constant: mass of proton, $m_p = 1.6726 \times 10^{-27} \text{ kg}$ (1.007825 u); Mass of neutron $m_n = 1.6750 \times 10^{-27} \text{ kg}$ (1.008665 u); $1u = 1.6606 \times 10^{-27} \text{ kg}$ (931.5 MeV / c^2); Avogadro's constant, $N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$; $R_o = 1.25 \times 10^{-15} \text{ m}$; $h = 6.623 \times 10^{-34} \text{ Js}$; Mass of electron $m_e = 9.11 \times 10^{-31} \text{ kg}$; $1 \text{ eV} = 1.602 \times 10^{-19} \text{ C}$.

QUESTION ONE

- a. What are the condition for attainment of Secular equilibrium? (6 marks)
- b. For the radioactive decay $A \xrightarrow{\lambda_A} B \xrightarrow{\lambda_B} C$, show that the number of radioactive nuclei B present at time $t > 0$, $N_B(t)$, is given as $N_B(t) = N_{B0}e^{-\lambda_B t} + \frac{N_{A0}\lambda_A}{\lambda_B - \lambda_A}(e^{-\lambda_A t} - e^{-\lambda_B t})$ where N_{A0} and N_{B0} are the numbers of atoms A and B at time $t = 0$. (14 marks)
- c. Determine the approximate density of a nucleus (Take the mass of a nucleon as $1.7 \times 10^{-27} \text{ kg}$) (5 marks)

QUESTION TWO

- a. i. Define the term Nucleons (2 marks)
ii. What is a Nuclide? (2 marks)
- b. i. What is the number of nucleons in a nucleus of radius $2.5 \times 10^{-15} \text{ m}$ (4 Marks)
ii. What will be the volume of such nucleus. (3 marks)
- c. Use the uncertainty principle to show that electron is not a constituent of the nucleus (4 marks)

QUESTION THREE

- a. on what does the determination of stability of a nucleus of a nucleus depend? (2 marks)

- b. Given that the number of nuclei of a given radioactive sample at time $t = 0$, is N_0 and λ is the decay constant, show that the number of nuclei varies with time according to the equation $N(t) = N_0 e^{-\lambda t}$ (7 marks)
- c. Many smoke detectors use small quantities of isotope ^{241}Am in the operation. The half-life of ^{241}Am is 432 years. How long will it take for the activity of this material to decrease to 1.0×10^{-3} of the original sample? (6 marks)

QUESTION FOUR

- a. Define the term specific ionization (2 marks)
- b. What is meant by “range of α - particle” (2 marks)
- c. show that the disintegration energy of the nuclei Q_α or total energy released in α - decay can be calculated from $Q_\alpha = E_\alpha \frac{A}{A-4}$. Where E_α – kinetic energy of α - particle (8 marks)
- d. Polonium (^{210}Po) decays to the ground state of lead (^{206}Pb) by the emission of 5.305 MeV α - particles ($^4_2\alpha$) with half-life of 138 days. Determine the Q-value for this decay. (3marks)

QUESTION FIVE

- a. What is nuclear reaction ? (3 marks)
- b. Determine the unknown particle in the following nuclear reaction.
- $^{18}_8\text{O} (d, p)x$ (2 marks)
 - $X (p, \alpha) ^{87}_{39}\text{Y}$ (2 marks)
 - $^{122}_{52}\text{Te} (x, d) ^{124}_{53}\text{I}$ (2 marks)
- c. Find the Q-value of the reaction $^{192}_{76}\text{Os} (d, t) ^{191}_{76}\text{Os}$ (6 marks)

$$\Delta m(^{192}_{76}\text{Os}) = -0.038550u; \Delta m(^{191}_{76}\text{Os}) = -0.039030u; \Delta m(^2\text{H}) = 0.014102 u;$$

$$\Delta m(^3\text{H}) = 0.016050 u$$

QUESTION SIX

- a. What makes radiation measurement possible (2 marks)
- b. What is the unit of cross- section of radiation (1 marks)
- c. A beam of 1.0 MeV neutrons of intensity $5 \times 10^8 \text{ neutrons/cm}^2 \text{sec}$ strikes a thin ^{12}C target. The area of the target is 0.5 cm^2 and is 0.05cm thick. The beam has a cross-sectional area of 0.1 cm^2 . At 1 MeV , the total X-section of ^{12}C is 2.6b.
- At what rate do interaction take place in the target? (6 marks)
 - What is the possibility that a neutron in the beam will have a collision in the target. $N = 0.80 \times 10^{24}$ for carbon (N = atom or molecule per cm^3) (6 marks)