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, $m_p = 1.6726\times10^{-27}kg\,(1.007825\text{ u})$; Mass of neutron $m_n = 1.6750\times10^{-27}kg\,(1.008665\text{ u})$; $1u = 1.6606\times10^{-27}kg(931.5MeV/c^2)$; Avogadro's constant, $N_A = 6.02\times10^{23}mol^{-1}$; $R_o = 1.25\times10^{-15}m$; $h = 6.623\times10^{-34}Js$; Mass of electron$m_e = 9.11\times10^{-31}kg$; $1\,eV = 1.602\times10^{-19}C$.

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 $1.7\times10^{-27}kg$) (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 $2.5\times10^{-15}m$ (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$1.0 \times 10^{-3}$of the original sample? (6 marks)

QUESTION FOUR

a. Define the term specific ionization (2 marks)

b. What is meant by "range of $\propto$ - particle" (2 marks)

c. show that the disintegration energy of the nuclei Q_α or total energy released in $\propto$ - decay can be calculated from $Q_\alpha = E_\alpha \frac{A}{A-4}$. Where $E_\alpha -$ kinetic energy of $\propto$- particle (8 marks)

d. Polonium (^{210}Po) decays to the ground state of lead(^{206}Pb) by the emission of 5.305 MeV $\propto$ - particles ($^4_2\propto$) 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.

i. $^{18}_8O\ (d,p)x$ (2 marks)

ii. $X\ (p,\alpha)\ ^{87}_{39}Y$ (2 marks)

iii. $^{122}_{52}Te(x,d)\ ^{124}_{53}I$ (2 marks)

c. Find the Q-value of the reaction $^{192}_{76}Os\ (d,t)\ ^{191}_{76}Os$ (6 marks)

$\Delta m(^{192}_{76}Os) = -0.038550u; \Delta m(^{191}_{76}Os) = -0.039030u; \Delta m(^2\text{H}) = 0.014102$ 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 $5 \times 10^8 neutrons/cm^2 sec$ 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.

i. At what rate do interaction take place in the target? (6 marks)

ii. What is the possibility that a neutron in the beam will have a collision in the target.N= 0.80×10^{24} for carbon (N = atom or molecule per cm^3) (6 marks)