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: **PHY456**
COURSE TITLE: **NUCLEAR REACTOR PHYSICS**
CREDIT UNIT: **3**
TIME ALLOWED: **(3 HRS)**
INSTRUCTION: ***Answer question 1 and any other three questions***
CONSTANTS

$\hbar$ (Planck's constant divide by 2π)	= 1.055 x 10^{-34}Js
$\frac{1}{4\pi\varepsilon_o}$	= 9.0 x 10^9 N.m^2/C^2
Electron charge (e)	= 1.6 x 10^{-19}C
Electron mass	= 9.1 x 10^{-31} kg
Mass of Hydrogen	= 1.007825 u
Mass of neutron	= 1.008665 u
Boltzmann constant (k_B)	= 1.381 x 10^{-23} J/K
Avogadros Number (N_A)	= 6.022 x 10^{-23} atoms/mole
1 eV	= 1.6 x 10^{-19} J
1 u	=1.66 x 10^{-27} kg

QUESTION 1

A Identify A, B, C, and D from the following nuclear reactions.

i. $^{27}_{13}Al + A \rightarrow ^{30}_{15}P + B$
ii. $^{24}_{12}Al + B \rightarrow ^{24}_{11}Na + C$
iii. $^{238}_{92}U + B \rightarrow ^{239}_{93}Np + D$ (6 mks)

B. Differentiate between thermal and fast neutron (6mks)

C. What is a thermal utilization factor? (4mks)

D. Calculate the disintegration energy Q for the beta decay of ^{32}P, as described by equation ^{32}P→^{32}S + e$^-$ + ν. Take atomic masses of ^{32}P and ^{32}S to be 31.97391 u and 31.97207 u respectively.

(7 marks)

E. What is Neutron slow down power? (2 mks)

QUESTION 2

A. Write a short note on reactor control control (5 marks)

B. What do you understand by the term critical mass? What happens when the critical mass is reached? (4 marks)

C. What does the following terms in nuclear physics mean: criticality, subcriticality and supercriticality? (6 marks)

QUESTION 3

A. Calculate the energy released if a single helium nucleus is formed by the fusion of two deuterium nuclei. (mass of ^2_1H = 2.014102 amu; mass of ^4_2H = 4.002604 amu) (5 marks)

B. Write a mathematical expression for Fick's law and define its parameters. (5 marks)
C. Why is heavy water used as a moderator? (5 marks)

QUESTION 4

A. A reactor is developing energy at the rate of 3000 kW.
   i. How many atoms of $^{235}_{92}U$ undergo fission per second?
   ii. How many kilograms of $^{235}_{92}U$ would be used in 1000 hours of operation assuming that on an average energy of 200 MeV is released per fission? (10 marks)

B. What are the differences and similarities between nuclear fission and nuclear fusion? (4 marks)

QUESTION 5

A. Briefly discuss the following as related to neutron reactions
   (i) Radiative capture (2marks);
   (ii) Charged-particle reactions (2 marks)

B. Write a short note on:
   i. Nuclear fission (2 marks)
   ii. Nuclear fusion (2 marks)

C. Determine the product nucleus and Q value in the reaction $^{27}_{13}Al(d,\alpha)Mg$. Comment on your result. (Masses of Al, Mg, d and α are 26.9901 amu, 24.9936 amu, 2.0147 amu and 4.0039 amu respectively) (7marks)

QUESTION 6

A. If there are n scattering centers (nuclei) per unit volume, each of area σ, in a thin target of thickness dx, find the ratio R of the area covered by scattering centers to the total area of the target. (3 marks)

B Given that $V = \frac{mV_o}{M+m}$ and $V_c = \frac{MV_o}{M+m}$. Show that $V_1^2 = V^2(1 + A^2 - 2Acos\phi)$. It must be assumed that all symbols carried their usual meanings. (9 marks)

C. Describe moderation. (3 marks)