



NATIONAL OPEN UNIVERSITY OF NIGERIA  
PLOT 91, CADASTRAL ZONE, NNAMDI AZIKIWE EXPRESSWAY, JABI - ABUJA  
FACULTY OF SCIENCES

DEPARTMENT OF PURE AND APPLIED SCIENCE

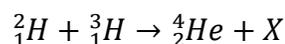
2019\_1 SEMESTER EXAMINATION

**COURSE CODE:** PHY 456  
**COURSE TITLE:** NUCLEAR REACTOR PHYSICS  
**CREDIT UNIT:** 3  
**TIME ALLOWED:** (2½ HRS)

**INSTRUCTION:** Answer question one (1) and any other four (4) questions

**QUESTION 1**

- (a). List five ways in which neutrons can interact with nuclei. **(2.5 marks)**
- (b). What is a moderator? **(4 marks)**
- (c). What is a nuclear reactor? **(4 marks)**
- (d). What is meant by the following terms: nuclear power, nuclear energy and atomic energy? **(4.5 marks)**
- (e). Consider the following nuclear fusion reaction that uses deuterium and tritium as fuel.



- (i). Complete the reaction equation. What is the name of the new particle released during the reaction? **(2 marks)**
- (ii). Given the following information;  
 ${}^2_1H = 2.0141 \text{ amu}$ ,  ${}^3_1H = 3.016049 \text{ amu}$ ,  ${}^4_2He = 4.0026 \text{ amu}$ ,  ${}^1_0n = 1.0087 \text{ amu}$   
Determine the mass defect of a single reaction **(2 marks)**
- (iii). Determine the energy in joules released during a single fusion reaction. **(3 marks)**

**QUESTION 2**

- (a). Explain, using your knowledge of criticality and nuclear reactions, why water makes a fantastic moderator. **(4 marks)**
- (b). What are the qualities of a good control rod material? **(2 marks)**

- (c). Define the following terms: (i) subcritical system; **(2 marks)**  
 (ii) critical system; **(2 marks)** and supercritical system **(2 marks)**

### QUESTION 3

- (a). If there are  $n$  scattering centers (nuclei) per unit volume, each of area  $\sigma$ , in a thin target of thickness  $dT$ , find the ratio  $R$  of the area covered by scattering centers to the total area of the targets. **(2 marks)**
- (b). Given that  $V = \frac{mV_0}{M+m}$  and  $V_c = \frac{MV_0}{M+m}$ . Show that  $V_1^2 = V^2(1 + A^2 - 2A\cos\phi)$ . It must be assumed that all symbols carry their usual meanings. **(7 marks)**
- (c). Describe moderation. **(3 marks)**

### QUESTION 4

- (a). What is macroscopic cross section? **(1.5 marks)**
- (b). Why is it possible to produce the fission of U-235 with slow neutrons whereas it is necessary to use fast neutrons to produce the fission of U-238? **(9 marks)**
- (c). Define cross section **(1.5 marks)**

### QUESTION 5

- (a). Concisely discuss the following as related to nuclear reaction:  
 (i) Radiative capture **(1.5marks)**; (ii) Charged-particle reactions **(1.5marks)**
- (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 equation  ${}_{13}^{27}\text{Al}(d, \alpha)$ . Comment on your result. (Masses of Al, Mg,  $d$  and  $\alpha$  are 26.9901 amu, 24.9936 amu, 2.0147 amu and 4.0039 amu respectively) **(5marks)**

### QUESTION 6

- (a). Determine the unknown particles  $X$  in the following nuclear reactions:
- i)  ${}_{8}^{18}\text{O} + {}_1^2\text{H} \rightarrow {}_1^1\text{H} + X$ , **(2 marks)**
- ii)  $X + {}_1^1\text{H} \rightarrow {}_2^4\text{He} + {}_{39}^{87}\text{Y}$ , **(2 marks)**
- iii)  ${}_{52}^{122}\text{Te} + X \rightarrow {}_1^2\text{H} + {}_{53}^{124}\text{I}$  **(2 marks)**
- (b). As observed in the laboratory system, a 8 MeV proton is incident on a stationary carbon-12 target. Find the velocity of the centre of mass system. Take the mass of the proton to be 1 amu. **(4 marks)**
- (c). State Fick's law. **(2 marks)**