



K.R. MANGALAM UNIVERSITY

THE COMPLETE WORLD OF EDUCATION

Roll No:

End Semester Examination, December 2024
B.Sc. (Hons./Hons. with Research) Physics-3rd Semester
NUCLEAR PHYSICS (SCPH205)

Time: 2 hrs. 30 mins.

Max. Marks: 50

Note: *All Questions are compulsory. Marks are indicated against each question.*

PART-A

Q.1 Attempt any 5 questions:

5x2 = 10

- (a) What is the half-life of a radioactive substance? [CO-1] [L-1] 2
- (b) What are the general properties of nuclei? [CO-2] [L-1] 2
- (c) Explain the basic idea of the Liquid Drop Model. [CO-2] [L-2] 2
- (d) A nuclear reaction is represented as: [CO-3] [L-3] 2
$${}_3^7\text{Li} + {}_1^1\text{H} \rightarrow {}_2^4\text{He} + {}_2^4\text{He}$$
Verify the conservation of mass number and atomic number in this reaction.
- (e) Analyze why alpha particles have a shorter range in matter compared to beta particles. [CO-3] [L-4] 2
- (f) Evaluate the advantages and limitations of using a Geiger-Müller (GM) counter for detecting nuclear radiation. [CO-4] [L-5] 2
- (g) Design a basic setup for a radiation detection system using a scintillation detector and explain how it works. [CO-4] [L-6] 2

PART-B

Q.2

Derive the formula for the radius of a nucleus and calculate the radius of a gold nucleus (${}_{79}^{197}\text{Au}$) using the derived formula. [CO-1] [L-3] 10

OR

Apply the liquid drop model to explain the semi-empirical mass formula and calculate the binding energy of ${}^{56}\text{Fe}$ using the formula. The coefficients are: [CO-1] [L-3] 10

Volume term $a_v = 15.8$ MeV,

Surface term $a_s = 18.3$ MeV,

Coulomb term $a_c = 0.714$ MeV,

Asymmetry term $a_a = 23.2$ MeV

Pairing term $a_p = 0$ MeV (for odd-A nuclei).

The mass number $A = 56$, atomic number $Z = 26$.

Q.3

Analyze the process of alpha decay in terms of energy conservation. Calculate the Q-value of the alpha decay of Uranium-238 to Thorium-234. Given: [CO-2] [L-4] **10**

Mass of 238-U = 238.02891 u

Mass of 234-Th = 234.04359 u

Mass of α particle = 4.00260 u.

OR

Analyze the behavior of a radioactive substance with a half-life of 10 years. Calculate the remaining amount of substance after 30 years, if the initial amount is 100g. [CO-2] [L-4] **10**

Q.4

Evaluate the feasibility of the nuclear reaction

[CO-3] [L-5] **10**

${}^3_2\text{He} + {}^2_1\text{H} \rightarrow {}^4_2\text{He} + p$ by calculating its Q-value. Given:

Mass of ${}^3_2\text{He}$ = 3.01603 u

Mass of ${}^2_1\text{H}$ = 2.01410 u

Mass of ${}^4_2\text{He}$ = 4.00260 u

Mass of p = 1.00783 u.

OR

Evaluate the energy loss of a 5 MeV alpha particle as it travels through air. Assume the stopping power of air for alpha particles is 2 MeV/cm. Calculate the range of the particle and discuss its implications in radiation shielding. [CO-3] [L-5] **10**

Q.5

Design a gas-filled ionization chamber to measure radiation intensity. Describe the necessary parameters for the design, such as the applied voltage, type of gas, and detector dimensions, ensuring optimal performance. [CO-4] [L-6] **10**

OR

Create a scintillation detector setup for gamma radiation detection. Specify the scintillation material, photomultiplier tube (PMT) design, and calibration procedure. [CO-4] [L-6] **10**
