

**PHY-551****Nuclear Physics and Analytical Techniques**

M. Sc. PHYSICS (MSCPHY-12)

Second Year, Examination, 2017

**Time : 3 Hours****Max. Marks : 80**

**Note :** This paper is of **eighty (80)** marks containing **three (03)** Sections A, B and C. Learners are required to attempt the questions contained in these Sections according to the detailed instructions given therein.

**Section-A****(Long Answer Type Questions)**

**Note :** Section ‘A’ contains four (04) long answer type questions of nineteen (19) marks each. Learners are required to answer *two* (02) questions only.

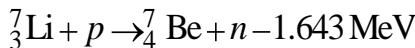
1. Discuss the Fermi theory of  $\beta$ -decay and derive the following form :

$$\left[ \frac{P(p_e)}{F(Z, E_e) p_e^2} \right]^{1/2} \propto (E_0 - E_e)$$

can we find the end-point energy of the  $\beta$ -particles based on the above equation ?

2. Derive the SEMF (semi-empirical mass formula) based on the liquid drop model. Show that spontaneous fission is possible for  $A \geq 100$  nuclides.

3. Calculate the values  $E_{\text{th}}$ ,  $E_{\text{max}}$ ,  $\theta_{\text{max}}$  and the energy of the neutrons, for the following endoergic reaction, which is used for lithium analysis and for neutron production,



What will be the threshold energy for appearance of neutrons in the  $90^\circ$  direction ?

4. Write short notes on any *two* of the following :
- (i) Non-conservation of parity in  $\beta$ -decay
  - (ii) Thermonuclear reactions
  - (iii) Internal conversion

### Section-B

#### (Short Answer Type Questions)

**Note :** Section ‘B’ contains eight (08) short answer type questions of eight (08) marks each. Learners are required to answer *four* (04) questions only.

1. Show that the nuclear forces are spin-dependent.
2. Is it possible to detect the Yukawa mesons in actual practice ? Under what conditions can they be detected ?
3. Show that for low energy hard sphere scattering, the cross-section is equal to  $4\pi R^2$ , where  $R$  is the radius of the potential well.
4. Why is  ${}^3P_1$  not a component of the ground state of the deuteron ?
5. Using SEMF, explain why  ${}^{238}_{92}\text{U}$  nuclide is an  $\alpha$ -emitter not a  $\beta$ -emitter.

6. State the various assumptions involved in (a) shell model and (b) collective model.
7. Give the schematic sketch of TEM. Explain the construction and working of TEM.
8. Discuss the reason and usefulness of isomer shift in Mossbauer spectrum.

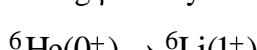
### Section-C

#### (Objective Type Questions)

**Note :** Section ‘C’ contains ten (10) objective type questions of one (01) mark each. All the questions of this Section are compulsory.

1. What should be the kinetic energy of protons to probe the size of  $^{40}_{20}\text{Ca}$ ? Given : rest mass of proton = 938 MeV :
  - (a) 154 MeV
  - (b) 950 MeV
  - (c) 12 MeV
  - (d) 938 MeV
2. The spin-parity for the found state of an  $^{16}_7\text{N}$  nuclide is :
  - (a)  $I^\pi = \frac{5}{2}^+$
  - (b)  $I^\pi = \frac{3}{2}^+$
  - (c)  $I^\pi = 3^-$
  - (d)  $I^\pi = 2^-$

3. For a representative case of  $^{238}_{92}\text{U} \rightarrow ^{234}_{90}\text{Th} + ^4_2\text{He}$  , calculate the distance between the  $\alpha$ -particle and the  $^{234}_{90}\text{Th}$  nuclide at the point of separation :
- 9.3 fm
  - 8.4 fm
  - 2.9 fm
  - 4.2 fm
4. Is the  $\alpha$ -decay of  $1^+$  level in  $^{20}_{10}\text{Ne}$  to  $0^{+16}_8\text{O}$  ground state possible ?
- The transition is possible.
  - The transition is possible only under certain conditions.
  - The transition is forbidden.
  - The information is insufficient to reach to any conclusion.
5. Electron capture process is studied by detecting :
- $\nu$
  - Orbital electron
  - X-rays
  - $\gamma$ -rays
6. Classify the following  $\beta$ -decay transition :



- 1st forbidden transition

- (b) Allowed transition : Pure Fermi transition
  - (c) Allowed transition : Pure Gamow-Teller transition
  - (d) Allowed transition : Both Fermi and Gamow-Teller transitions
7. Nuclear fission is explained by :
- (a) LDM
  - (b) Shell model
  - (c) Collective model
  - (d) All of the above
8. The entire kinetic energy of a projectile is ..... for the nuclear reaction to take place.
- (a) Available in the lab system
  - (b) Not available in the lab system
  - (c) Available in the CM system
  - (d) Not available in the CM system
9. Are thermal neutrons mono-energetic ?
- (a) Yes, they have an energy of 0.4 eV
  - (b) Yes, they have an energy of 0.25 eV
  - (c) Yes, they have an energy of 0.025 eV
  - (d) No
10. Calculate the mean range of 40 MeV  $\alpha$ -particles, if the mean range of 10 MeV protons in lead is 0.316 mm :
- (a) 0.632 mm
  - (b) 0.316 mm
  - (c) 0.448 mm
  - (d) 0.948 mm

