PHY-551

Nuclear Physics and Analytical Techniques

M.Sc. Physics (MSCPHY-13/16/17)

Second Year, Examination, 2018

Time : 3 Hours

Max. Marks: 80

Note: This paper is of eighty (80) marks containing three (03) Sections A, B, C. 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.
- Enumerate the properties of nuclear forces. Set up the wave equation for deuteron system and find a reasonable well depth and width, which would predict the correct B. E. Also, mention about the features of nuclear forces, which may be explained based on the experimental facts about deuteron.
- 2. Calculate the values of E_{th} , E_{max} , θ_{max} and the energy of the product neutrons, for the following endoergic

reaction, which is used for lithium analysis and for neutron production,

 ${}^{7}_{3}\text{Li} + p \rightarrow {}^{7}_{4}\text{Be} + n - 1.643 \text{ MeV}$

What will be the threshold energy for the appearance of neutrons in the 90° direction ?

- 3. Write short notes on any *two* of the following :
 - (i) Non-conservation of parity in β -decay
 - (ii) Auger electron
 - (iii) Internal conversion
- 4. Certain nuclei A decay into daughter nuclei B, which are also unstable. The respective decay constants are λ_A and $\lambda_B = 2 \lambda_A$; calculate the time (in terms of λ_A) and the number of nuclides of B (in terms of N_{A0}) when the number of B nuclides are maximum. Assume initially we have a pure sample of A.

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. Derive the relations for Q-value expressions for β^+ and EC decay processes, and show that β^+ is always associated with EC, while the reverse is not true.
- Discuss Pauli's hypothesis to explain the β-spectrum. Derive an expression of 'λ' for the β-emitter following Fermi's theory.

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3. For the reaction A(a, b) B, show that :

$$Q = E_{b} \left(\frac{M_{b} + M_{B}}{M_{B}} \right) - E_{a} \left(\frac{M_{B} - M_{a}}{M_{B}} \right) - \frac{2\sqrt{M_{a}M_{b}}}{M_{B}}$$
$$\sqrt{E_{a}E_{b}} \cos \theta$$

where the E's and M's are the laboratory system kinetic energies and the rest mass energies of particles a, b and the nuclei A, B and θ is the angle between the directions of particles a and b.

- 4. Why is ³P₁ not a component of the ground state of the deuteron ?
- 5. A 0.01 mm thick ${}^7_{3}L_i$ target is bombarded with 10^{13} protons/s. As a result, 10^8 neutrons/s are produced. Evaluate σ for this reaction. (density of Li = 500 kg/m³)
- 6. Plot \overline{B} vs. A. On the basis of it, explain the emission of energy in fission and fusion.
- 7. Why are solid-state detectors preferred over scintillation detectors ?
- 8. Explain the NMR technique. Explain NMR spectra of pure methyl alcohol at low temperature.

Section-C

(Objective Type Questions)

Note : Section 'C' contains ten (10) objective type questions of one (1) mark each. All the questions of this Section are compulsory.

Choose the correct alternative :

- 1. Discontinuities in the nuclear binding energy curves is best explained by :
 - (a) LDM

- (b) Single particle model
- (c) Rotational model
- (d) Vibrational model
- 2. ⁸₂He is a halo nuclide with independent and loosely bound neutrons.
 - (a) 1
 - (b) 2
 - (c) 3
 - (d) 4
- 3. Rotational bands have been observed in nuclei with :
 - (a) A < 150
 - (b) 150 < A < 190 and A > 230
 - (c) 190 < A < 230
 - (d) A < 100
- 4. What is the energy required to split an ${}^{16}_{8}$ O nucleus into an α -particle and a ${}^{12}_{6}$ C nucleus ? Given : B. E. of ${}^{16}_{8}$ O , ${}^{12}_{6}$ C and ${}^{4}_{2}$ He nuclei are 127.62, 92.16 and 28.3 MeV, respectively :
 - (a) 7.16 MeV
 - (b) 8 MeV
 - (c) 28.3 MeV
 - (d) 63.76 MeV
- 5. Which of the following is NOT conserved in nuclear reactions ?
 - (a) Magnetic dipole moment

- Baryon (b)
- (c) **Statistics**
- (d) Angular momentum
- 6. Assuming that the entire $\frac{206}{82}$ Pb in a given sample of uranium ore resulted from decay of $^{238}_{92}$ U , find out how is old the ore if the ratio of $^{238}_{92}U$ to $^{206}_{82}Pb$ isotopes is 0.5. Given: $T_{1/2}$ of $_{92}^{238} \upsilon \ = 4.47 \times 10^9 \ y.$
 - 86 million years (a)
 - (b) 2.6 billion years
 - (c) 1.6 billion years
 - (d) 3 billion years
- 7. Most probable multiple order transitions between
 - $\frac{3^+}{2} \rightarrow \frac{7^-}{2}$ nuclear states will be :
 - (a) E2 M1
 - (b) M2 E3
 - (c) E5 M4
 - (d) M5 E4
- Surface energy term in LDM is : 8.
 - (a) $-a_s A^{2/3}$
 - (b) $+a_s A^{2/3}$
 - (c) $+a_s A^{-2/3}$ (d) $-a_s A^{-2/3}$

- 9. The entire kinetic energy of a projectile is for the nuclear reaction to take place.
 - (a) Available in the lab system
 - (b) Non available in the lab system
 - (c) Available in the CM system
 - (d) Not available in the CM system
- 10. De-excitation of a nucleus with $0^+ \rightarrow 0^+$ states is via :
 - (a) γ -transition
 - (b) X-ray transition
 - (c) Internal conversion
 - (d) Forbidden transition