Registration Number:

Date & Session:

ST JOSEPH'S UNIVERSITY, BENGALURU -27
M.Sc. PHYSICS – IV SEMESTER
SEMESTER EXAMINATION: APRIL 2024
(Examination conducted in May/June 2024)
PH 0220: NUCLEAR AND PARTICLE PHYSICS
(For current batch students only)

Time: 2 Hours **Max Marks: 50**

This paper contains TWO printed pages and TWO parts

PART-A

Answer any FIVE questions. Each question carries SEVEN marks

5×7=35

1. (a) Discuss how the value of nuclear radius parameter can be obtained from mirror nuclei method.

   (b) A nucleus ${}_zX^A$ splits into two fragments: ${}_{z1}Y^{A1}$ + ${}_{z2}Y^{A2}$, find the separation between the fragments at the moment of their separation. (5+2)

2. In a nuclear reaction a bombarding particle 'a' is incident on a target nucleus 'A'. After the reaction takes place, the ejected particle 'b' is emitted at an angle 'θ' and the residual nucleus 'B' recoils in such a way that the momentum is conserved. With a neat diagram, show that the Q-value of the reaction is given by

$$Q = k_b\left(1+\frac{m_b}{m_B}\right) - k_a\left(1-\frac{m_a}{m_B}\right) - \frac{2}{m_B}\left(k_a k_b m_a m_b\right)^{1/2}\cos\theta$$

3. (a) The total decay probability of emission per second of β-particles of all momentum from zero to maximum p_m is given by

$$\lambda = \int_0^{p_m} P(p_\beta)dp_\beta = \int_0^{p_m} \frac{g^2\left|m_{if}\right|^2}{2\pi^3 c^3 h^7}(w_m - w_k)^2 \times F(z,p_\beta)\,p_\beta dp_\beta$$

   Estimate the comparative life-time of β-decay.

   (b) A very small magnetic moment, which is much smaller than an electron magnetic moment, is being detected in the case of neutrinos. Why? (5+2)

4. (a) Describe the principle and working of a Geiger-Muller Counter with a neat diagram.

   (b) Generally, the practical limitation to which the electrons can be accelerated by the electron-synchrotron is governed by energy loss. Explain it. (5+2)

5. Derive the expression for nuclear reaction scattering cross-sections based on the partial wave analysis.

6. (a) Define an SU(3) group. Plot the octet representation of SU (3) group

   (b)Explain the concept of strangeness. Discuss the Gell-Mann-Nishijima relation (3+4)

7. (a) Write a brief note on optical model.

   (b) Contrast the direct nuclear reactions from compound nuclear reactions. (5+2)

PART-B

Answer any THREE questions. Each question carries FIVE marks

3×5=15

8. Establish the relation A~2Z for light nuclei using the semi-empirical mass formula. [Given: ac=0.71 MeV, an=22.7 MeV; M($_1H^1$)=1.0078 u; M(n)=1.0086 u].

9. (a) Compute the Q-value of the reaction $^9Be(d,n)^{10}B$. Given: atomic masses of $^9Be_4$, $^{10}B_5$,$^2H_1$ and $^0n_1$ are 9.012182u, 10.012983u, 2.014102u and 1.008665u respectively.

   (b) Calculate the energy released in the reaction: $_3Li^6+_0n^1 \rightarrow _2He^4+_1H^3$. [Given: Mass of $_3Li^6$, $_1H^3$, $_0n^1$, $_2He^4$ are 6.015123u, 3.016029u, 1.008665u and 4.002603u]

10. A mixed beam of protons and deuterons, which were accelerated to a potential of 10^5V is allowed to pass through a uniform magnetic field of 1.5 T in a direction at right angles to the field. Calculate the linear separation of deuteron beam from the proton beam, when each has described a semicircular path.

11. Find which one of the following elementary particle reactions is allowed and figure out the type of interaction also.

    (a) $\pi^+ + n^0 \rightarrow \Lambda^0 + K^+$

    (b) $\nu_e + p^+ \rightarrow n^0 + \mu^+$