PHY-551

Nuclear Physics and Analytical Techniques

M.Sc. Physics (MSCPHY-12/13/16/17)

2nd Year Examination, 2019 (June)

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

Note : This paper is of Eighty (80) marks divided into three (03) sections A, B and 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 any two (02) questions only.

$(2 \times 19 = 38)$

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

2. Write short notes on any two of the following :

   (i)   Conservation Laws

   (ii)   Classification of neutrons

   (iii) Selection rules for gamma decay

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.
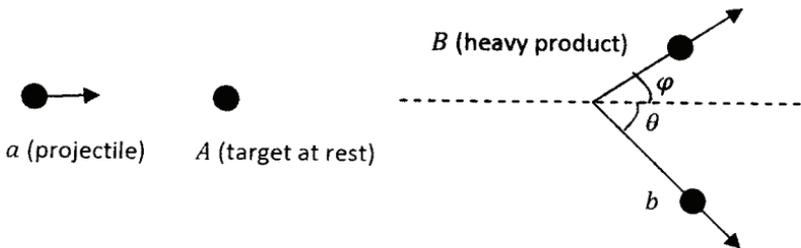
4. Discuss low energy n-p scattering and derive a formula for $\sigma(n, p)$ based on the partial wave analysis.

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 any four (04) questions only. (4×8=32)

1. What is electric quadrupole moment of a nucleus? Discuss the shapes of the nucleus on its basis.

2. If a 5 MeV α-particle is passing through an air-filled detector, on an average how many primary ion-pairs have to be formed before the incident particle is stopped? Given: ion-pair generating energy for air = 33.9 eV.

3. What is a compound nucleus? Write down the Bohr's hypothesis of compound nucleus.

4. Describe one method to determine the size of the nucleus.

5. Using SEMF, explain why $^{238}_{92}U$ nuclide is an α-emitter and not a β⁻ emitter?

6. State the various assumptions involved in (a) shell model, and (b) collective model.

7. Plot $\vec{B}$ vs. A. On the basis of it, explain the emission of energy in fission and fusion.

8. Write short note on spin-orbit coupling.

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. (10×1=10)

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 ground state of an $^{16}_{7}\text{N}$ nuclide based on shell model is

(a) $1^{\pi} = \dfrac{5^{+}}{2}$

(b) $1^{\pi} = \dfrac{3^{+}}{2}$

(c) $1^{\pi} = 3^{-}$

(d) $1^{\pi} = 2^{-}$.

3. For a representative case of $\left({}^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}He \right)$, calculate

the distance between the α-particle and the ${}^{234}_{90}Th$ nuclide at the point of separation.

(a) 9.3 fm

(b) 8.4 fm

(c) 2.9 fm

(d) 4.2 fm.

4. Is the α-decay of 1^+ level in ${}^{20}_{10}Ne$ to 0^+ ${}^{16}_{8}O$ ground state possible?

(a) The transition is possible.

(b) The transition is possible only under certain conditions.

(c) The transition is forbidden

(d) The information is insufficient to reach to any conclusion..

5. Electron capture process is studied by detecting

(a) v

(b) orbital electron

(c) X-rays

(d) y-rays.

6. Classify the following β-decay transition,

$$_2^6 He(O^+) \rightarrow \, _3^6 Li(1^+)$$
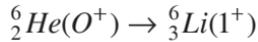
(a) 1st forbidden transition

(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 projeetile 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 α-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.

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