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MPH-017

M. SC. (PHYSICS)

(MSCPH)

Term-End Examination

December, 2025

MPH-017 : NUCLEAR AND PARTICLE PHYSICS

Time : 2 Hours

Maximum Marks : 50

Note : Answer any **five** questions. Marks are indicated against each question. You may use a calculator. Symbols have their usual meanings. The values of physical constants are given at the end.

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Note : Answer any five questions. $5 \times 10 = 50$

1. (a) The mass defect for ^{240}Pu is 50.123 MeV and ^{24}Na is – 8.418 MeV. Calculate the corresponding atomic mass. 4

- (b) Write the Weiszaäcker semi-empirical mass formula and explain its various terms. Draw the contribution of various terms of this formula on B.E/A vs. mass number(A) curve. 6

2. (a) Obtain the charge form factor and $\langle r^2 \rangle$ for the nuclear charge density

$$\rho_{ch}(r) = \rho_0 \frac{e^{-\mu r}}{r}, \text{ where } \mu \text{ and } \rho_0 \text{ are}$$

constants. You may use : 6

$$\int_0^\infty x^n e^{-x} dx = \Gamma(n+1) = n!.$$

- (b) Show that : 4

$$[L_z, L_x] = i\hbar L_y$$

3. Assuming the following square well potential for the deuteron :

$$V(r) = \begin{cases} -V_0, & r \leq r_0 \\ 0, & r > r_0 \end{cases}$$

derive the relationship among V_0 , r_0 and E_B .

Estimate the potential depth assuming the deuteron to be a just bound system ($E_B \sim 0$)

. Also, estimate the radius (decay length, R_D) of deuteron.

Given : The binding energy (E_B) of deuteron is 2.225 MeV and $r_0 = 2$ fm. 6+3+1

4. (a) Explain the significance of phase shift (δ_l) in scattering. How does attractive and repulsive potential affect the phase of an incident plane wave ? 3+2

- (b) Using the effective range formula, evaluate the total n - p scattering cross-section for a neutron interacting with a free proton in center of mass frame at a relative energy of 2.5 MeV. 5

Given : Scattering lengths : $a_t = 5.38$ fm,

$$a_s = -23.7 \text{ fm.}$$

Effective range : $r_{ot} = 1.78$ fm,

$$r_{os} = 2.40 \text{ fm.}$$

5. (a) Discuss the shell model and its limitations. 3+2
- (b) The ground state energy and spin of a nucleus ${}_Z^AX$ is 0.025 MeV and $\left(\frac{1}{2}\right)^+$ respectively. Estimate the spin and energy of the first three rotational bands. 5

6. (a) Describe the experiment which confirmed parity violation in beta decay. 5

- (b) Write short notes on the following :

$$2\frac{1}{2} + 2\frac{1}{2}$$

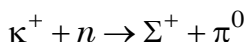
(i) Nuclear isomerism

(ii) Internal conversion

7. (a) What are different types of lepton flavor quantum numbers ? State whether lepton numbers are conserved in strong, weak and electromagnetic interactions. Hence, explain whether the following reaction is allowed : 5

$$p \rightarrow e^+ + \gamma$$

- (b) Describe strong interactions and the quantities conserved in strong interactions. Explain whether the following reaction is allowed : 5



8. (a) What is charge conjugation ? Derive the eigenvalues of the charge conjugation operator. 5

- (b) What is the quark hypothesis ? Write down the quark composition of the π^+, π^0 and π^- mesons. 5

Physical Constants :

$$1\mu = 931.5 \text{ MeV}/c^2$$

$$h = 6.626 \times 10^{-34} \text{ Js}$$

$$\hbar = 1.054 \times 10^{-34} \text{ Js}$$

$$c = 3 \times 10^8 \text{ ms}^{-1}$$

$$1\text{eV} = 1.6 \times 10^{-19} \text{ J}$$

$$1\text{fm} = 10^{-15} \text{ m}$$

$$\text{Mass of nucleon : } Mc^2 = 938 \text{ MeV}$$

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