No. of Printed Pages : 7

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.*

Note : *Answer any five questions.* 5×10=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 Weiszačker 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 $< r^2 >$ for the nuclear charge density $\rho_{ch}(r) = \rho_0 \frac{e^{-\mu r}}{r}$, where μ and ρ_0 are constants. You may use : 6

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

   (b) Show that : 4

$$\left[L_z, L_x \right] = i\hbar L y$$

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

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

derive the relationship among V_0, r_0 and E_B. Estimate the potential depth assuming the deuteron to be a just bound system $\left(E_B \sim 0\right)$. Also, estimate the radius (decay length, R_D) of deuteron.

Given : The bending 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 fm.

Effective range : r_{ot} = 1.78 fm,

r_{os} = 2.40 fm.

5. (a) Discuss the shell model and its limitations. 3+2

(b) The ground state energy and spin of a nucleus ${}^{A}_{Z}X$ 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

$$\kappa^+ + n \rightarrow \Sigma^+ + \pi^0$$

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 :

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

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

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

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

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

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

Mass of nucleon : $Mc^2 = 938$ MeV

× × × × ×