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PG CBCS

M.Sc. Semester-IV Examination, 2022

PHYSICS

PAPER: PHS 402

(Nuclear Physics-II & Quantum Field Theory)

Full Marks: 40 **Time: 2 Hours**

Write the answer for each unit in separate sheet

The figures in the right-hand margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable.

PHS 402.1 Nuclear Physics-II

Marks: 20

GROUP-A

1. Answer any two question: **2×2=4**

a) Show that the D-state probability in deuteron is roughly 4%.

b) In n-p scattering, S-wave scattering is predominant in the energy range below10 MeV. Comment on this observation.

c) Appling shell model, find out the spin and parity of Be_4^9 nucleus.

d) Write down about Majorana exchange force.

GROUP-B

2. Answer any two questions: **2×4=8**

a) (i) How magic numbers are explained using the shell model? (ii) Estimate the Fermi energies of neutrons and protons in the center of $^{238}_{92}U$ nucleus. Assume the density of nuclear matter in the centre of ^{238}U to be 2 x10^{38} $nucleus.cm^3$. (1+3)

b) Sow how far the liquid-drop model is successful in explaining why U^{235} is fissile to slow neutrons but U^{238} is not? (4)

c) (i) Why the Breit-Wigner formula is called dispersion formula? (ii) Calculate the energy of the proton detected at 90° when 2.1 MeV deuterons are incident on ^{27}Al to produce ^{28}Al with an energy difference$Q = 5.5\ MeV$. (2+2)

d) (i) Why the energies of the neutrons generated from (α, n) sources are not mono-energetic? (ii) Calculate the average logarithmic energy decrement per collision and the number of collisions required to reduce the energy of neutrons from 5 MeV to 0.5 MeV in Carbon. Given $\xi = 0.16$ for carbon. (2+2)

GROUP-C

3. Answer any one questions: **1×8=8**

a) Derive the continuum theory of nuclear reaction by neutral particles. (ii) When ^{19}F nuclide bombarded with protons in (p, n) reaction with subsequent α-particles emission occurs. Calculate the excitation energy of the compound nucleus that corresponds to the resonance with a proton energy of4.99 MeV. (4+4)

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b) Write the failures of the shell model. (ii) Find the expression for the threshold energy (E_{th}) for an endo-ergic reaction. Hence, show that$(E_{th})_{\theta=0} = -Q(1 + m_x/M_X)$. Symbols have their usual meanings. (2+5+1)

PHS 402.2 Quantum Field Theory

Marks: 20

GROUP-A

1. Answer any <u>two</u> question: **2×2=4**

a) What do you mean by non-abelian symmetry?

b) State the usefulness of normal ordering of operator.

c) Prove that $L = \bar{\psi}(i\gamma_\mu \partial^\mu - m)\psi$ is invariant under phase transformation $\psi' = e^{i\theta}\psi$.

d) Find Noether current for the Lagrangian density $L = \bar{\psi}(i\gamma_\mu \partial^\mu - m)\psi$.

GROUP-B

2. Answer any <u>two</u> questions: **2×4=8**

a) Show that for complex Scaler field charge Q = $Q_{particle} - Q_{antiparticle}$

b) For real scalar field prove that $H = \hat{\pi}^2 + (\vec{\nabla}\phi)^2 + m^2\hat{\phi}^2$

c) Evaluate $\left[\hat{N}, \hat{H}\right]$ for real scalar field where $\hat{N} = \int d^3\vec{k}a^\dagger(\vec{k})a(\vec{k})$.

d) If $L_{e.m} = -\frac{1}{4}F_{\mu\nu}F^{\mu\nu}$ find equation of motion.

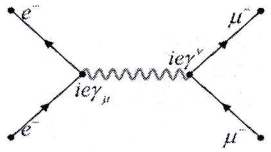
GROUP-C

3. Answer any <u>one</u> questions: **1×8=8**

a) For Dirac field, express the following quantities in terms of creation and annihilation operator (i) charge $Q = -e\int d^3x :\psi^+\psi:$

(ii) Energy $H = \int d^3x\left[:\bar{\psi}(-i\gamma^i\partial_i + m)\psi:\right]$

b) Find the scattering amplitude for the process



and explain the quantum interference terms.

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