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PG (NEW) CBCS
M.Sc. Semester-IV Examination, 2019
PHYSICS
PAPER: PHS-402

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

Use Separate Answer Scripts for each unit

GROUP-A
NUCLEAR PHYSICS-II
Marks-20
Answer 1 and any one from 2 and 3

1. **Answer any five questions.** **5× 2 = 10**

   a) Explain why $1f_{7/2}$ level is in between $1f_{5/2}$ and $1d_{3/2}$. Find spin parity of ground state $_{29}Cu^{63}$.

   b) "No excited bound state of Deuteron exists" explain.

   c) Using Bartlett or spin exchange force, show that all triplet states are attractive.

   d) Derive the ground state spin and parity of $_6C^{13}$ using shell model.

   e) Show that in n-p scattering, the K.E. of the system in C.M. frame is ½ of the K.E. of the system in laboratory frame.

   f) Explain: Scattering cross section and reaction cross section.

   g) Estimate the energy released in binary fission of $_{92}U^{238}$ nucleus.

   h) Write about the tensor force in Deuteron.

2. Show that the mean logarithmic decrement in energy of neutron due to *collision with the nuclei in a medium is given by*

   $$E = 1 + \frac{(A-1)^2}{2A} \ln \frac{A-1}{A+1}$$

   How many collisions in graphite (C^{12}) are required to reduce the neutron energy from 1 MeV to 1eV?

(Turn over)

Write about the moderating ratio. (6+2+2)

3. Derive the ground state wave function of deuteron considering rectangular potential well and hence derive the depth of the potential well.

Estimate the radius of deuteron. (4+4+2)

GROUP-B

QUANTUM FIELD THEORY

Marks-20

Answer 1 and any one from 2 and 3

1. Answer any five questions. 5×2=10

a) Show how the SU(5) grand unified theory accommodates fractional charges of quarks.

b) If the Dirac field is quantized according to the Bose-Einstein rather than the Fermi-Dirac statistics, what would be the energy of the field?

c) Find the Euler Lagrange equations for

$\mathcal{L} = -\frac{1}{4}F_{\mu\nu}F^{\mu\nu} + \frac{1}{2}m^2A_\mu A^\mu$

where

$$F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu$$

d) What is the time ordering? Write down Feynman propagator in terms of time ordering.

e) Draw the lowest order Feynman diagram of the Compton scattering between an electron and a photon and write the corresponding amplitude from the Feynman rules of graphs.

f) Define gauge covariant derivative. Why was it introduced?

g) The Lagrangian density $\mathcal{L} = (\partial_\mu\phi^\dagger)(\partial_\mu\phi) - m^2\phi^\dagger\Phi$

where $\begin{pmatrix}\phi_1\\ \phi_2\end{pmatrix}$ is an SU(2) doublet.

(Turn over)

Show that Lagrangian density has SU(2) symmetry.

h) Find the Noether currents and charges of the Lagrangian density described in (g).

2. The Lagrangian density of a spinless Schrodinger field ψ is given by

$$\mathcal{L} = i\psi^{\dagger}\frac{\partial\psi}{\partial t} - \frac{1}{2m}\nabla\psi^{\dagger}\nabla\psi - V(r)\psi^{\dagger}\psi$$

i) Find the equation of motion. (2)

ii) Express the free field ψ and $\psi^{\dagger}$ in terms of creation and anhilation operators and find commutation relation between them. (4)

iii) Calculate the Green function

$G(x_0, \vec{x}, y_0, \vec{y}) = -i\langle 0|\psi(x_o, \vec{x})\psi^{\dagger}(y_0, \vec{y})|0\rangle\theta(x_o - y_0)$ (4)

3. a) Obtain the expression of the S-matrix operator in the covariant perturbation theory.

State Wick's theorem to write the time-ordered product of a number of fields in terms of the normal ordered products and the vacuum expectation values of time-ordered products. (5)

b) For e. m. field, prove that

$[A^{\mu}(t,\vec{x}), A^{\nu}(t,\vec{y})] = -i\, g^{\mu\nu}\delta^{(3)}(\vec{x} - \vec{y})$ (5)

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