2018

M.Sc.

4th Semester Examination

PHYSICS

PAPER – PGS-402 (Gr. – A + B)

Full Marks : 50

Time : 2 Hours

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.

(Gr. A –*Nuclear Physics-II*)

Answer Q1 and any one from Q2 and Q3.

1. Answer any five bits: 5 X 2 = 10

(i) What are the essential differences between the low energy n-p and p-p scattering?

(ii) What is the compound nucleus hypothesis of Bohr? Write down the expression for cross section of nuclear reaction on the basis of this hypothesis.

(iii) What is stripping reaction? Give an example.

(iv) Draw the nuclear energy states for 1-phonon and 2-phonon quadrupole vibration.

(v) What is neutron moderating ratio?

(vi) Find the ground state spin and particles of ${}^{42}_{19}K$.

(vii) Calculate the excitation energy of the compound nucleus ${}^{20}_{10}Ne^*$ formed by bombarding protons of energy 5.0MeV according to the following reaction ${}^{19}_{9}F + {}^{1}_{1}H \rightarrow {}^{20}_{10}Ne^* \rightarrow {}^{19}_{10}Ne + {}^{1}_{0}n$. Given masses: ${}^{1}_{1}H = 1.008146\ amu$, ${}^{19}_{9}F = 19.004444\ amu$, ${}^{20}_{10}Ne = 19.998772\ amu$.

(Turn over)

(viii) Find the unknown particle in the reaction given below, using the conservation laws $\pi^- + p \rightarrow K^0 + ?$.

2. (a) Using square well potential and appropriate boundary conditions find the wave function of the bound state of deuteron. Represent it graphically. Find the relation between range and depth of the potential. (3+1+2)

(b) Using experimental evidences, show that deuteron bound state is mixed of 96% s-state (l = 0) and only 4% d-state (l = 2). (4)

3. (a) Discuss the Bohr-Wheeler theory of nuclear fission. (4)

(b) Show that total spin-orbit splitting $\Delta E = E_{nl}\,(j - 1/2) - E_{nl}\,(j + 1/2)$ is proportional to $(2l + 1)$ where the symbols have their usual meaning. (3)

(c) State the principle of the time of flight velocity selector. (3)

(Gr. B – *Quantum field theory*)

Answer Q1 and any one from Q2 and Q3.

1. Answer any five bits: 5 X 2 = 10

(i) State the Wick's theorem for QFT.

(ii) Show that for complex scalar field the Hamiltonian density is $\mathcal{H} = \pi^\dagger \pi + \vec{\nabla}\phi^\dagger . \vec{\nabla}\phi + m^2 \phi^\dagger \phi$ (symbols have their usual meaning).

(iii) Show that for the odd number of fields, vacuum expectation value (VEV) of time ordered product of the field operators vanishes.

(iv) Write down the Feynman diagram from the following terms:

(a) $\frac{(-ig)^2}{2} \int d^4y_1\, d^4y_2\, i\Delta_F(x_1 - y_1) i\Delta_F(y_1 - y_2) i\Delta_F(y_2 - y_1)\, i\Delta_F(y_2 - x_2)$

(b) $\frac{(-i\delta m^2)^2}{4} \int d^4y_1\, d^4y_2\, i\Delta_F(x_1 - x_2) i\Delta_F(y_1 - y_2) i\Delta_F(y_1 - y_2)$

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(v) Show that the Lagrangian $\mathcal{L} = \frac{1}{2}\bar{\psi}\left(i\gamma^\mu \partial_\mu - m\right)\psi - \frac{1}{2}\bar{\psi}\left(i\gamma^\mu \overleftarrow{\partial_\mu} + m\right)\psi$ is Lorentz invariant and hermitian.

(vi) Consider a complex scalar field theory described by the Lagrangian density $\mathcal{L} = \left(\partial_\mu \phi^*\right)(\partial^\mu \phi) - m^2 \phi^* \phi - V(\phi^* \phi)$, $\mathcal{L}$ remains invariant under the transformation $\phi \rightarrow e^{-iq\theta}\phi$ *and* $\phi^* \rightarrow e^{iq\theta}\phi^*$. Use Noether's theorem to find the corresponding conserved current J^μ.

(vii) Consider the following operator in the case of free real scalar field theory: $a(p) = i \int d^3x\, f_p^*(x) \overleftrightarrow{\partial_0} \phi(x)$ where $p^\mu = \left(\omega_p, \vec{p}\right)$, $\omega_p = \sqrt{(\vec{p})^2 + m^2}$ *and* $f_p = \frac{e^{-ip.x}}{\sqrt{(2\pi)^3 2\omega_p}}$. Show that $a(p)$ is time independent.

(viii) Show that the current $J^\mu = q\bar{\psi}(x)\gamma^\mu \psi(x)$ remains conserved for Dirac fermions interaction with electromagnetic fields.

2.(a) State and prove Noether's theorem. (3)

(b) Calculate the Feynman propagator for transverse photon. (7)

3.(a) The form of the real scalar field is $\phi(x) = \int d^3k \left[a(k) f_k(x) + a^\dagger(k) f_k^*(x)\right]$ *where* $f_k(x) = \frac{1}{2\pi^{3/2}} \frac{1}{\sqrt{2\omega_k}} e^{-ik.x}$, show that i) $\left[a(k), a^\dagger\left(k'\right)\right] = \delta(\vec{k} - \vec{k}')$, ii) $[\phi(x,t), \pi(x',t)] = i\delta^3(\vec{x} - \vec{x}')$ (3+3)

(b) Compute $[\phi(x), \phi(y)]$ and show that it vanishes when x-y is space-like separated, where $\phi(x)$ and $\phi(y)$ are two real scalar fields. (4)

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(Internal Assessment – 10)