2019

M.Sc.

4th Semester Examination

PHYSICS

PAPER – PHS-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.
Use separate answer scripts for Group A and Group B.

(Gr. A –*Nuclear Physics-II*)
Answer Q1 and any one from Q2 and Q3.

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

(a) Write down the characteristics of direct reactions.

(b) Using experimental evidences, show that deuteron ground state can be expressed as $\Psi_0 = a\Psi\,(l=0) + b\Psi\,(l=2)$.

(c) What is spontaneous fission? Write down the necessary condition.

(d) What do you mean by nuclear collective model? Write down the spin and parity of 1-phonon quadrupole vibration.

(e) Write down the importance of moderator in fission reactor. Give few examples of moderator.

(f) Find the ground state spin and parity of $^{33}_{16}Si$ using shell model.

(g) What do you mean by cross section of a nuclear reaction? Find the level width of a compound nucleus having lifetime is 10^{-14} s.

(Turn over)

(h) State Ghosal's explanation regarding compound nucleus hypothesis.

2. (a) If the elastic scattering of neutrons by hydrogen nuclei is isotropic in the centre of mass system, show that $\langle \ln (E_0/E) \rangle = 1$, where E_0 and E are the kinetic energies of a neutron before and after collision, respectively. (4)

(b) The Q-value of the following endoergic reaction is -1.342 MeV. ${}^{2}_{1}H + {}^{12}_{6}C \rightarrow {}^{10}_{5}B + {}^{4}_{2}He$. Calculate the mass of ${}^{10}B$ in u, if the masses of ${}^{2}H$ and ${}^{4}He$ are respectively 2.014192 and 4.002603 units on ${}^{12}C$-scale. (3)

(c) What range of nuclear force is mediated by π^0-particle (neutral pion) of mass 134.96 MeV ? (3)

3. (a) Discuss how from a study of deuteron one can arrive at the important conclusion that the force between a neutron and proton is spin dependent. (3)

(b) Show that for S-wave n-p scattering total cross-section can be written as $\sigma_{tot} = \frac{4\pi}{k^2}\sin^2\delta_0$ where $k = \sqrt{\frac{2mE}{\hbar^2}}$ and δ_0 is phase shift. (3)

(c) Which of the following weak decays is not possible for Ω^-? State reasons i) $\Omega^- \rightarrow \Lambda^0 + K^-$ ii) $\Omega^- \rightarrow \Sigma^- + K^0$. (2)

(d) Comment on the excited states of deuteron. (2)

(Gr. B – *Quantum field theory*)

Answer Q1 and any one from Q2 and Q3.

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

(a) State Wick's theorem for QFT.

(b) Calculate the conserved current for translational symmetry.

(c) Find the Euler-Lagrange equation for $\mathcal{L} = \frac{1}{2}(\partial_\mu\phi)(\partial^\mu\phi) - \frac{1}{2}m^2\phi^2 - \frac{1}{2}\lambda\phi^4$.

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

i) $\frac{(-ig)^2}{12}\int d^4y_1\, d^4y_2 i\Delta_F(x_1 - x_2) i\Delta_F(y_1 - y_2) i\Delta_F(y_1 - y_2)\, i\Delta_F(y_1 - y_2)$

ii) $\frac{(-i\delta m^2)^2}{8}\int d^4y_1\, d^4y_2 i\Delta_F(x_1 - x_2) i\Delta_F(y_1 - y_1) i\Delta_F(y_2 - y_2)$

(e) Write down the Lagrangian for Dirac field and show that it is not hermitian.

(f) State the GellMann-Low formula for perturbative expansion of Green's function.

(g) Explain briefly why quantum field theory is necessary in order to describe phenomena related to subatomic particles.

(h) Write down the defining relation of time ordered product of two bosonic and two fermionic fields. Is there any difference between them? If so, then explain the reason behind the difference.

2. (a) Write down the energy-momentum tensor and calculate it for $\mathcal{L} = \frac{1}{2}(\partial_\mu\varphi\partial^\mu\varphi - m^2\varphi^2)$. (4)

(b) Calculate the Feynman propagator for transverse photon. (6)

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 $\left[a(k), a^\dagger(k')\right] = \delta(\vec{k} - \vec{k}')$ (3)

(b) Construct the Hamiltonian for QED. (4)

(c) Write down the Hamiltonian for Dirac field in terms of creation and annihilation operators and discuss the particle picture of this field. (3)

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(Internal Assessment – 10)