2019

PG

4th Semester Examination

PHYSICS

Paper - PHS 402

Full Marks : 20 Time : 2 Hours

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

Group - A

Answer Q. No. 1 and any *one* from the rest.

1. Answer any *five* bits : 5×2=10

(a) The only bound two-nucleon configuration that occurs in nature is the deuteron ${}^{2}_{1}D$, with total angular momentum $J = 1$ and binding energy = 2.224 MeV. Show that the n-p force must be spin dependent. 2

(b) What do you understand by the level width (Γ) and level separation (D) between the levels of a continuum in nuclear reactions ? 2

(c) Give the range of life-time and nucleon traverse-time on the formation and disintegration of the compound nucleus. 2

(d) Compare the spin and parity predicted by the extreme single particle shell model for the ground states of the nuclei with the experimental values given in the parenthesis : ${}_9F^{17}\left(\frac{5^+}{2}\right)$ 2

(e) Write the disadvantages of reactor as a neutron source. 2

(f) Diagramatically present the p-p interactions system at below 10 MeV scattering energy. 2

(g) Find the magnetic moment of the ground state of ${}_8O^{17}$ due to odd neutron considering shell model. 2

(h) State the principles of velocity selector neutron monochromator. 2

2. (a) Experimentally the study of p-p scattering, is capable of much higher accuracy than n-p scattering, why? 2

(b) Deduce Bohr-Wheeler's theory of nuclear fission. 4

(c) Derive the relation between refractive index (μ) and scattering length (a) of a material with nuclei per unit volume (N) due to neutron for wavelength 'λ'. 4

3. (a) How magic numbers are explained using shell model ? 4

(b) Classify the following processes as strong, electromagnetic, and weak.

(i) $\pi^- + p \rightarrow \Lambda^0 + K^0$

(ii) $p + \gamma \rightarrow p + \pi^0$

(iii) $\Lambda^0 \rightarrow p + \pi^-$ 3

(c) Calculate the average energy loss for neutrons which have made one collision with carbon nuclei, for carbon is 0.158. 3

[Turn Over]

Group - B

Answer Q. No. 1 and any *one* from the rest.

1. Answer any *five* bits : 2×5=10

(a) Write down momentum and angular momentum of the Dirac field.

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

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

(d) For e.m. field, Prove that

$$T^{00} = \frac{1}{2}(\vec{E}^2 + \vec{B}^2)$$

(e) Prove that Feynman propagator for photon is

$$D_F^{\mu\nu}(\kappa) = \frac{-g_{\mu\nu}}{\kappa^2 + i\epsilon}$$

(f) Prove that $\not{p}^2 = p^2$

(g) Evaluate $\left[\sigma_{\mu\nu}, \sigma_{\rho\lambda}\right]$ where $\sigma_{\mu\nu} = \frac{i}{2}\left[\gamma_\mu, \gamma_\nu\right]$.

(h) Find the transformation law $V_\mu(x) = \bar{\psi}\,\gamma_\mu\psi(x)$ under Lorentz transformation.

2. (a) Let the Lagrangian density be given by $\mathcal{L} = i\bar{\psi}\gamma^\mu\,\partial_\mu\psi - gx^2\bar{\psi}\psi$ where g is a constant.

(i) Derive the expression for the energy momentum tensor $T_{\mu\nu}$. Find its divergence $\partial_\mu T^{\mu\nu}$. Comment on this result.

(b) Calculate the commutator $[P^0(t), P^i(t)]$.

(c) Find the four divergence of the angular momentum operator $M^{\mu\alpha\beta}$. 3+5+2

3. (a) Find the differential cross section for scattering of an electron in the external potential $A^\mu = \left(0, 0, 0, ae^{-k^2x^2}\right)$. where the vertex is $ie\gamma_\mu(1-\gamma_5)$. The initial electron is moving along z-axis. 5+3+2

[Turn Over]

(b) Using Wick's theorem evaluate

(i) $\langle 0 | T\left(\phi^4(x)\,\phi^4(y)\right) | 0 \rangle$

(ii) $T\left(:\phi^4(x)::\phi^4(y):\right)$