2016

M.Sc. 4th Seme. Examination

PHYSICS

PAPER—PHS-402

Full Marks : 40

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.

Illustrate the answers wherever necessary.

Use separate Answer-scripts for Group-A & Group-B

Group-A

[Marks : 20]

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

1. Answer any *five* bits : 5×2

(a) Which data showed that the singlet state potential is about 40% weaker than the triplet state potential ? How can the neutron have a non-zero magnetic moment on being the neutral charge ?

(b) What are exchange forces in Nuclear Physics ? Explain them.

(c) Explain why the decay $\Sigma^0 \rightarrow \wedge^0 + \gamma$ is observed but not $\Sigma^0 \rightarrow p + \pi^-$ or $\Sigma^0 \rightarrow n + \pi^0$.

(d) Calculate the Fermi energies of neutrons and protons in the centre of ${}^{238}_{92}U$. (density of nuclear matter is 2×10^{38} nucleons/c.c.)

(e) Calculate magnetic moment and quadrupole moment of ${}_8O^{17}$ nucleus.

(f) Deduce $\frac{1}{v}$-law of Neutron Physics.

(g) Why the Breit-Wigner formula is called dispersion formula ?

2. (a) Deduce Briet Wigner single resonance level formula for nuclear reaction.

(b) Cadmium has a resonance for neutrons of energy 0.178 ev and the peak value of the total cross-section is about

7000 b. Estimate the contribution of scattering to this resonance.

(c) When do you call the nucleus as black ? 4+4+2

3. (a) Derive an expression for scattering length and effective range in n-p scattering.

(b) Calculate the total cross-section for n-p scattering at neutron energy 2 MeV (lab).

Given $a_t = 5.38F$, $a_s = -23.7F$, $r_{ot} = 1.70F$ and $r_{os} = 2.40F$.

(c) Estimate the average number of collisions required to reduce fast fission neutrons of initial energy 2 MeV to thermal energy (0.025 eV) in graphite moderator.

4+4+2

Group-B

[Marks : 20]

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

1. Answer any *five* bits : 5×2

(a) Prove that $\not{a}^2 = a^2$.

(b) Find the Euler-Lagrange equation for the Lagrangian density

$$\mathcal{L} = -\left(\partial_\mu A^\nu\right)\left(\partial_\nu A^\mu\right) + \frac{1}{2} m^2 A_\mu A^\mu + \frac{\lambda}{2}\left(\partial_\mu A^\mu\right)^2$$

(c) For real scaler field $\hat{\phi}(\vec{x}, t)$

$$\text{if } u_{\vec{p}}(\vec{x}, t) = \frac{1}{\sqrt{2w_{\vec{p}}(2\pi)^3}} e^{-ip.x}$$

show that

$$a_{\vec{p}} = \left(u_{\vec{p}},\ \hat{\phi}(\vec{x},\ t)\right).$$

(d) Define Feynman propagator for Dirac field in terms of time-ordered product of fields.

(e) Draw the Feynman diagram for compton effect.

(f) Show that the current density

$$j_\mu = -\frac{i}{2}\left(\phi \partial_\mu \phi^* - \phi^* \partial_\mu \phi\right)$$

satisfies the continuity equation.

(g) In GSW group $SU(2)_L \times U(1)$ how photon and neutral gauge boson fields arise ?

2. The operator for Dirac field

$$\psi(x) = \frac{1}{\sqrt{(2\pi)^3}} \sum_{r=1}^{2} \int d^3\vec{p} \sqrt{\frac{m}{E_{\vec{p}}}}$$

$$\left(u_r(\vec{p})\, c_r(\vec{p})\, e^{-ip.x} + v_r(\vec{p})\, d_r^{+}(\vec{p})\, e^{ip.x}\right)$$

Or

2. (a) Express the following quantities interms of creation and annihilation operators :

(i) Charge $\hat{Q} = -e \int d^3\vec{x} : \psi^{+}\psi :$

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

(iii) Linear momentum $\hat{\vec{P}} = -i \int d^3\vec{x} : \psi^{+}\nabla\psi :$

3+3+2

(b) Evaluate $\left[\hat{H},\ C_r^{+}(\vec{p})\ C_r(\vec{p})\right]$. 2

3. (a) Starting from the commutation relations of e.m. field prove that

$$\left[A^{\mu}(t,\vec{x}), \dot{A}^{\nu}(t,\vec{y})\right] = -ig^{\mu\nu}\delta^{(3)}(\vec{x}-\vec{y}).$$

(b) Prove that $\left[p^{\mu}, A^{\nu}\right] = -i\partial^{\mu}A^{\nu}$

where p^{μ} is the linear momentum.

(c) Express $\left\langle O \left| T\left(\overline{\psi}(x)\, \psi(x)\, \overline{\psi}(y)\, \psi(y)\right) O\right.\right\rangle$

in terms of Feynman propagator (use Wick's theorem).

4+4+2