F 6524 (Pages : 2) Reg. No.....

Name.....

M.Sc. DEGREE (C.S.S.) EXAMINATION, JANUARY 2015

Faculty of Science

Third Semester

Branch II : Physics–A—Pure Physics

PH 3C 09—QUANTUM MECHANICS–II

(2012 Admission onwards)

Time : Three Hours Maximum Weight : 30

Part A

Answer any **five** *questions.*
Each question carries a weight of 1.

1. Explain Fermi golden rule.
2. What is an electric dipole transition moment ?
3. What are partial waves ?
4. Explain optical theorem.
5. Express Dirac's equation in the covariant form.
6. Obtain expression for probability density.
7. What is phase shift ?
8. Write the Euler—Lagrange equation for fields.
9. Define Noether's theorem.
10. What is meant by Dyson's series ?

(6 × 1 = 6)

Part B

Answer any **four** *questions.*
Weight 2 each.

11. Which of the following transitions is electric dipole allowed ?
    (i) $1s \rightarrow 2s$. (ii) $1s \rightarrow 2p$.
    (iii) $2p \rightarrow 3d$. (iv) $3s \rightarrow 5d$.
12. Evaluate the scattering amplitude in the Born Approximation, for scattering by the Yukawa potential. $V(r) = \frac{Vo e^{-ar}}{r}$ where V_0 and α are constants. Also show that $\sigma(\theta)$ peaks in the forward direction ($\theta = 0$) except at zero energy and decreases monotonically as θ varies from 0 to π.

Turn over

13. Show that an attractive potential leads to positive phase shifts whereas a repulsive potential to negative phase shifts.

14. Show that the following matrices from a representation of Dirac's matrices :

$$\alpha_x = \begin{pmatrix} \sigma_x & 0 \\ 0 & -\sigma_x \end{pmatrix}, \alpha_y = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}, \alpha_z = \begin{pmatrix} \sigma_z & 0 \\ 0 & -\sigma_z \end{pmatrix}, \beta = \begin{pmatrix} 0 & il \\ -il & 0 \end{pmatrix}$$

15. Derive the expression for Dirac's relativistic equation for a free particle.

16. For a real scalar field φ, the Legrangian is $L = \frac{1}{2} (\partial_\mu \varphi)(\partial^\mu \varphi) - \frac{1}{2} m^2 \varphi^2 - V(\varphi)$. Find the Euler's Legrangian equations.

$(4 \times 2 = 8)$

Part C (Essay)

Answer **all** *questions.*
Weight 4 each.

17. (a) Explain the wave solution of Dirac equations.

Or

(b) Using time dependent perturbation theory explains the fine structure of hydrogen atom.

18. (a) (i) Explain Hamiltonian formulation.

(ii) Explain functional derivatives.

Or

(b) Explain relativistic quantum field theory.

19. (a) Derive the expression for *s*–wave scattering for the finite potential well and explain.

Or

(b) Show that it is possible to study the emission *or* absorption of radiation by subjecting the system to a harmonic perturbation ? Explain.

20. (a) Discuss the Euler's Lagrange equation in field theory.

Or

(b) What are the functions of Dirac equation ? Check the relativistic covariance of Dirac equation.

$(4 \times 4 = 16)$