PG Even Semester (CBCS) Exam., May—2019

PHYSICS

(2nd Semester)

Course No. : PHYCC–202

(Quantum Mechanics—II)

Full Marks : 70
Pass Marks : 28

Time : 3 hours

The figures in the margin indicate full marks for the questions

Answer **five** questions, taking **one** from each Unit

UNIT—I

1. *(a)* A physical system with a non-degenerate Hamiltonian (H_0) is perturbed by a time independent Hamiltonian (H). Find the expression of the wave function and the energy of the system up to the second order approximation. 10

(b) A linear harmonic oscillator is perturbed by $H \quad cx$, where c being a constant. Estimate the energy of the nth oscillator level up to second order perturbation. 4

2. *(a)* Using time dependent perturbation theory, obtain Fermi's golden rule. 7

(b) In adiabatic approximation method, show that the probability amplitude for a state other than the initial state oscillates with time. 7

UNIT—II

3. *(a)* Explain briefly the WKB approximation and discuss the validity criteria of WKB approximation. 7

(b) Write the connection formulas and hence explain their physical significance. Obtain the Bohr-Sommerfeld quantization rule. 3+4=7

4. *(a)* Briefly explain the variational approximation method and its various uses. 5

(b) Using the variational approximation method, estimate the ground state energy of helium atom. 9

UNIT—III

5. Using Green's function technique, solve the Schrodinger's equation for quantum theory of scattering. Hence obtain the scattering amplitude in the first Born approximation. 14

6. Using partial wave analysis method, show that the total scattering cross-section ( ) is given by

$$\frac{4}{k^2}\ _l\ _0\ (2l\ \ 1)\sin^2\ _l$$

where the symbols have their usual meaning. 14

UNIT—IV

7. *(a)* Derive the Klein-Gordon equation in presence of an em-field and hence discuss its non-relativistic limit. 9

(b) Write a brief note on Dirac hole theory. 5

8. *(a)* Construct Dirac matrices of the smallest dimension and briefly discuss the properties of these matrices. 7

(b) From the plane wave solution of free particle, Dirac equation obtain the various possible Dirac spinors for both positive and negative energies. Interpret the result. 7

UNIT—V

9. *(a)* For a field $_a(x, t)$, obtain the Euler-Lagrange equations of motion. 5

(b) For a real scalar field (x, t), the Lagrangian is given by

$$\mathscr{L}\ \ \frac{1}{2}\qquad\qquad\frac{1}{2}m^2\ \ ^2$$

where

$$\begin{matrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{matrix}$$

Find the equations of motion. 5

(c) What is Noether's theorem in field theory? 4

10. *(a)* Using basic quantization condition, quantize the classical scalar field. 7

(b) Using the canonical commutation relation between fields and its conjugate momentum operators, derive the commutation relations for the creation and the annihilation operators. 7

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