PG Even Semester (CBCS) Exam., May—2017

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 **one** question from each Unit

UNIT—I

1. *(a)* A system is perturbed by a time-independent Hamiltonian, H' over its original non-degenerate Hamiltonian H_0. Calculate the change in the energy eigenvalue up to the second order approximation. 5

(b) A linear harmonic oscillator is perturbed by $H' = \frac{1}{2} bx^2$. Estimate the energy of the nth oscillator level up to second order. 4

(c) A time independent perturbation H' is applied on H_0, a two-fold degenerate Hamiltonian, obtain the condition where degeneracy is lifted by first order perturbation. 5

2. *(a)* A system in an initial state $|m\rangle$ is given an harmonic perturbation

$$H'(t) = 2H'(0)\sin \omega t$$

for $0 \le t \le t_0$. Show that the first-order probability of finding the system in the state $|k\rangle$ after perturbation is removed is given by

$$|a_k(t)|^2 = \frac{4\left|\langle k|H'|m\rangle\right|^2 \sin^2 \frac{1}{2}(\omega_{km} - \omega)t_0}{\hbar^2(\omega_{km} - \omega)^2}$$

where $\omega_{km} = (E_k - E_m)/\hbar$. 8

(b) Show that the adiabatic approximation breaks down when the Hamiltonian of the system oscillates in time with a frequency nearly equal to the transition frequency. 6

UNIT—II

3. *(a)* Explain briefly the variational approximation method and its uses. 7

(b) Using variational approximation method, estimate the ground state energy of hydrogen atom. 7

4. *(a)* What is the physical significance of connection formulas between WKB functions of different regions? 2

(b) Using Bohr-Sommerfeld quantization rule, show that WKB approximation gives the correct energy eigenvalues for all states of the harmonic oscillator. 5

(c) Using WKB method, derive a relation between half-life of an α-radioactive nucleus and the energy of the emitted α-particles. 7

UNIT—III

5. *(a)* Solve Schrödinger's equation for a scattering problem, using Green's function technique. Discuss the result. 7+2=9

(b) For low energy scattering by a square well potential, show that the scattering cross-section depends on the energy of the particle being scattered. 5

6. Using partial wave analysis, find the scattering amplitude in terms of phase shifts and hence obtain the expression for total scattering cross-section. Discuss the result for very low-energy limit. 10+4=14

UNIT—IV

7. *(a)* Derive Klein-Gordon equation and the corresponding conservation equation. Discuss how far the usual probability interpretation holds in Klein-Gordon theory. 3+3+3=9

(b) Write a detailed note on Dirac Hole theory. 5

8. On the basis of Dirac theory, discuss the fine structure of hydrogen. 14

UNIT—V

9. *(a)* Quantize the classical scalar field using basic quantization condition. 7

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

10. State Neother's theorem, using the theorem, find the energy-momentum tensor for the scalar field. 14

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