LOYOLA COLLEGE (AUTONOMOUS), CHENNAI – 600 034

M.Sc. DEGREE EXAMINATION – **PHYSICS**

FOURTH SEMESTER – **APRIL 2018**

16PPH4MC01 / PH 4810 – QUANTUM MECHANICS II

Date: 18-04-2018 Dept. No. Max. : 100 Marks
Time: 01:00-04:00

PART A

Answer **ALL** questions: **(10 x 2 = 20)**

1. Prove that spontaneous emission far exceeds stimulated emission in the visible region (Temp = 300K).
2. Explain Fermi golden rule.
3. A beam of particles of half-life 2 x 10^{-6} s travel in the laboratory frame with a speed of 0.96c. How much distance the beam would travel before the flux falls to half its initial flux?
4. A vector in the S' frame is represented by 8 $\vec{\imath}$ + 6 $\vec{\jmath}$. Represented it in the S frame while S' is moving with velocity of 0.8 c $\hat{\imath}$ with respect to S. $\hat{\imath}$ *and* $\hat{\jmath}$ being unit vector along the respective directions.
5. What do you understand by Zitterbewegung?
6. Write a short note on Lamb shift.
7. What is symmetry transformation?
8. Prove that particle exchange operator is a constant of motion.
9. Write a short note on Bhaba scattering.
10. What are creation and annihilation operators?

PART B

Answer any **FOUR** questions: **(4 x 7.5 = 30)**

11. A system in an unperturbed state n is suddenly subjected to a constant perturbation H′(r) which exists during time 0 $\longrightarrow$ t. Find the probability for transition from state 'n' to state 'k' and show that it varies simple harmonically.
12. (a)A particle of mass 'm' whose total energy is twice its rest energy collides with an identical particle at rest. If they stick together what is the mass of the resulting composite particle. What is the velocity of the composite particle?

    (b)Outline the Green's function method of obtaining a formal solution of Schrodinger wave equation in scattering theory.

13. Starting from the Klein-Gordon equation, obtain the equation of continuity and interpret it.

14. The energy momentum tensor for fields is defined by

$$T_{\mu\gamma} = \sum_{\alpha} \pi_{\mu\alpha} \partial_{\gamma} \psi_{\alpha} - L\, \partial_{\mu\gamma}. \text{Show that } \frac{\partial T_{\mu\gamma}}{\partial x_{\mu}} = 0$$

15. Consider a one dimensional infinite square well potential of width 1cm with free electrons in it. If its Fermi energy is 2 eV, what is the number of electrons inside the well?

16. Using four-vector notation, show that $x^2 + y^2 + z^2 - c^2t^2$ is invariant under Lorentz transformation.

PART C

Answer any **FOUR** questions: **(4 x 12.5 = 50)**

17. (a) Explain Einstein's transition probability. **(3 marks)**

    (b) Find the relation between Einstein's coefficients. **(6 marks)**

    (c) Find the condition under which stimulated emission equals spontaneous emission. If the temperature of the source is 500K, at what wavelength will both the emissions be equal? **(3.5 marks)**

18. (a) Give the complete set of transformation rules for electromagnetic fields. **(2.5 marks)**

    (b) Show that E.B and ($E^2 - c^2B^2$) are relativistically invariant **(10 marks)**

19. Show that Dirac equation possesses positive and negative energy solutions. Explain pair production and pair annihilation by interpreting the negative energy spectrum of a free Dirac particle.

20. Consider a system having three identical particles. Its wave function ψ (1,2,3) is 3! fold degenerate due to exchange degeneracy. (i) Form symmetric and antisymmetric combinations of the degenerate functions. (ii) If the Hamiltonian H(1,2,3) = H(1) + H(2) + H(3) and ψ (1,2,3) = $u_a(1)\, u_b(2)\, u_c(3)$, where $u_a(1)\, u_b(2)\, u_c(3)$ are the Eigen functions of H_1, H_2, H_3 respectively, what are the symmetric and anti-symmetric combinations?

21. List the conditions for a valid physical process. Discuss Feynman's theory of positron emission.

22. Explain the structure of space time in detail.

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