LOYOLA COLLEGE (AUTONOMOUS), CHENNAI – 600 034

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

FOURTH SEMESTER – **APRIL 2022**

PPH 4501 – QUANTUM MECHANICS - II

Date: 15-06-2022 Dept. No. Max. : 100 Marks

Time: 01:00 PM - 04:00 PM

PART – A

Q. No. Answer **ALL** the Questions **(10 x 2 = 20 Marks)**

1	Distinguish between stimulated emission and spontaneous emission.
2	State Fermi's golden rule.
3	Two lumps of clay, each of rest mass m, collide head on at $\frac{3}{5}$ c. If they stick together, find the mass (M) of the composite lump.
4	The vector in system S' is represented by $8\,\vec{i} + 6\,\vec{j}$. How can a vector represented in a system S while S' moving with velocity 0.8 c $\vec{i}$ with respect to S.
5	Write a short note on Zitterbewegung.
6	What is Lamb shift?
7	What are orthohelium and parahelium?
8	Explain Fermi hole and Fermi heap.
9	What are Feynman graphs?
10	What do you understand by Bremsstrahlung radiation?

PART – B

Answer any **FOUR** Questions **(4 x 7.5 = 30 Marks)**

11	Find the condition under which stimulated emission equals spontaneous emission. If the temperature of the source is 500 K, at what wavelength will both the emissions be equal? (3+4.5)
12	Show that $x^2 + y^2 + z^2 - c^2t^2$ is invariant under Lorentz transformation.
13	Give the energy spectrum of a free Dirac particle and explain pair production and pair annihilation.
14	Consider a one dimensional infinite square well of width one cm with free electrons in it. If its Fermi energy is 2 eV, find the number of electrons inside the well.
15	Obtain the selection rules for allowed transitions of a linear harmonic oscillator. Caluclate the life time of an oscillator in first excited state.
16	The half life of a particular particle as measured in the laboratory comes out to be 4.0 x 10^{-8} s when its speed is 0.8c, find the half life of the particle when its speed is 0.6c.

PART – C

Answer any **FOUR** Questions **(4 x 12.5 = 50 Marks)**

17 Discuss the time dependent perturbation theory and derive an expression for transition to continuum of states.

18 (i) Find the velocity at which the mass of a particle double its rest mass.

(ii) 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? Also, find its velocity. **(2.5 + 10)**

19 (i) Starting from the Klein-Gordan equation, obtain the equation of continuity.

(ii) Show that Dirac’s Hamiltonian for a free particle commute with the operator $\sigma.p$, where p is the momentum operator and σ is the Pauli spin operator.

20 (i) Consider a system having three identical particles. Its wave function Ψ (1, 2, 3) is a 3! fold degenerate due to exchange degeneracy. Form symmetric and antisymmetric combinations of the degenerate functions.

(ii) N non-interacting bosons are in an infinite potential well defined by $V(x) = 0$ for $0<x<a$, $V(x) = \infty$ for $x<0$ and for $x>a$. Find the ground state energy of the system. What would be the ground state energy if the particles are fermions?

21 Discuss the procedure for quantization of complex scalar field. From the discussion explain the annihilation, creation and particle number operators.

22 Give the complete set of transformation rules for electric and magnetic fields. Prove the invariance of the electromagnetic fields (i) $\mathbf{E}^2 - c^2\mathbf{B}^2$ and (ii) **E.B**. **(2.5 + 5 + 5)**

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