

LOYOLA COLLEGE (AUTONOMOUS), CHENNAI – 600 034



B.Sc. DEGREE EXAMINATION – PHYSICS

FIFTH SEMESTER – NOVEMBER 2016

PH 5510 – QUANTUM MECHANICS AND RELATIVITY

Date: 01-11-2016

Dept. No.

Max. : 100 Marks

Time: 09:00-12:00

PART-A

Answer ALL Questions

(10x2=20 marks)

1. Find the de Broglie wavelength associated with a 46 gm golf ball travelling with a velocity of 36 m/s.
2. State Heisenberg's uncertainty principle.
3. What is meant by wave velocity and group velocity?
4. Define expectation value of a dynamical quantity? Write the expectation value of momentum and energy.
5. What is α -decay? Write the expression of α -decay mode.
6. Write the selection rule for allowed transition of electron in hydrogen atom.
7. Show that acceleration is invariant under Galilean transformation.
8. A rod 1 metre long is moving along its length with a velocity $0.6c$. Calculate its length as it appears to an observer on the earth.
9. Calculate the energy produced when 4 kg of a substance is fully annihilated.
10. State the principle of equivalence in general theory of relativity.

PART-B

Answer ANY FOUR Questions

(4x7.5=30 marks)

11. With a neat diagram, explain G.P. Thompson experiment and its importance in establishing the existence of matter waves.
12. i) Use uncertainty principle to prove that the electrons cannot exist in the nucleus. (5)
ii) Calculate the uncertainty with position of an electron weighing 9×10^{-28} gm and moving with an uncertainty in speed of 3×10^9 cm/sec. (2.5)
13. State any five fundamental postulates of quantum mechanics.
14. Derive energy Eigen values and normalized wave functions for a particle in a one dimensional square well potential of finite depth.
15. Derive the Lorentz space time transformation formulae.
16. i) Derive an expression for gravitational red shift. (5.5)
ii) Write short note on black hole. (2)

PART-C

Answer **ANY FOUR** Questions :

(4x12.5 = 50 marks)

17. i) What is Compton effect? Derive an expression for the change in the wave length of a scattered photon. (7.5)

ii) Explain in detail the Einstein's theory of photoelectric effect. (5)

18. State and prove Ehrenfest's theorems.

19. i) Show that the probability current density together with probability density $\rho = \psi \psi^*$ satisfies the equation of continuity $\frac{\partial \rho}{\partial t} + \nabla \cdot j = 0$. (4.5)

ii) Show that the eigen functions of a Hermitian operator are orthogonal if they correspond to distinct eigen values. (4)

iii) Normalize the one dimensional wave function given by (4)

$$\psi(x) = \begin{cases} A \sin\left(\frac{\pi x}{L}\right), & 0 < x < L \\ 0, & \text{outside.} \end{cases}$$

20. Establish Schrodinger equation for a linear harmonic oscillator and solve it to obtain eigen value and eigen functions. Discuss the significance of zero point energy.

21. Describe the Michelson-Morley experiment and explain the physical significance of negative results.

22. i) Deduce the formula for relativistic variation of mass with velocity. Briefly explain its significance. (9+1.5)

ii) At what speed is a particle moving if the mass is equal to three times its rest mass. (2)

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