(b) Explain Bohr's correspondence principle. Prove that for very large quantum numbers, the quantum theory frequency and classical orbit frequency become equal. (5)

7. (a) Describe the principle, construction and working of He-Ne laser with its applications. (12)

(b) Explain the role of pumping mechanisms in laser operation. (3)

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May-2026

B.Sc. (Physics) IV SEMESTER

Elements of Modern Physics (PHU-206-V)

Time: 3 Hours] [Max. Marks : 75

Instructions :

1. *It is compulsory to answer all the questions (1.5 marks each) of Part-A in short.*
2. *Answer any four questions from Part-B in detail.*
3. *Different sub-parts of a question are to be attempted adjacent to each other.*

PART—A

1. (a) Classical theory predicted infinite energy at short wavelength for black body radiation. Why is this prediction incorrect? (1.5)

(b) Why are the energy levels of a particle in a box quantized? (1.5)

(c) If the temperature of a black body increases, how does the peak wavelength of radiation change? (1.5)

(d) Calculate the energy of a photon of wavelength 500 nm. (1.5)

(e) For a particle in a box, how does energy change if the box length is doubled? (1.5)

(f) Estimate minimum uncertainty in momentum if position uncertainty is 10^{-9}m. (1.5)

(g) Explain why energy of a particle in a box cannot be zero? (1.5)

(h) If the mass of the particle increases, what happens to energy levels in a box? (1.5)

(i) If the reflection coefficient of a particle is 0.2, calculate the transmission coefficient. (1.5)

(j) Why are metastable states important in laser operation? (1.5)

PART–B

2. (a) Explain the concept of black body radiation and discuss the failure of classical theory. Derive Planck's radiation law and explain how it resolves the ultraviolet catastrophe. (8)

(b) Derive the time dependent Schrodinger equation for a particle moving in one dimension and explain the significance of each term. (7)

3. (a) Describe Heisenberg's uncertainty principle. Explain the gamma ray microscope thought experiment and discuss its implications with any two applications. (9)

(b) An electron is confined to a box of length 10^{-8} m, calculate the minimum uncertainty in its velocity. (3)

(c) The average time that an atom retains excess excitation energy before emitting radiations is 10^{-8} sec. Find the uncertainty in the frequency of radiation emitted. (3)

4. (a) Describe the production of X-rays and explain the difference between continuous and characteristic X-rays. (5)

(b) Explain the Sommerfeld model of the hydrogen atom with relativistic correction and discuss how elliptical orbits improve Bohr's theory. (10)

5. (a) A particle of energy E is incident on a rectangular potential barrier. Explain how the wave function behaves in the three regions and obtain expressions for reflection and transmission coefficients? (10)

(b) Discuss Einstein's coefficients. Derive relation between them. (5)

6. (a) Define one-dimension potential box. Using Schrodinger's equation, calculate the energy eigen values and the normalized wave functions for a particle in box. Explain zero-point energy for the particle in the box. (10)