1. (a) Derive the relativistic kinetic energy of a particle of rest mass \( m_0 \) moving with velocity \( v \).

(b) A quarter wave plate is designed for 6000 Å. Find phase retardation for 4500 Å if change in refractive index is negligible.

(c) What is the de Broglie wavelength associated with electrons made to move from rest under a potential difference of 500 volts?

2. Write down Maxwell’s field equations, explaining the terms used. Show that in vacuum both electric and magnetic vectors obey wave equation. Assuming a plane wave solution, show that magnetic field is always orthogonal to the electric field.

3. (a) What do you mean by diffraction of light? Can X-ray produce diffraction of light?
4. (a) State Malus’ law and prove it.
(b) Discuss Nicol prism as polarizer and analyzer.
(c) How are unpolarized, plane polarized, circularly polarized and elliptically polarized light distinguished?

5. (a) Explain three-level and four-level laser schemes.
(b) Can we have two-level laser? Justify your answer.
(c) Explain the working principle and construction of a ruby laser.

6. (a) What are inertial frames of reference? Discuss the basic postulates of a special theory of relativity. Mention some of the consequences of special theory of relativity.
(b) Derive Lorentz transformation equations on the basis of postulates of special theory of relativity.

7. (a) Obtain the expression for stationary energy levels for particle of mass \( m \) which is free to move in a region of zero potential between two rigid walls at \( x = 0 \) and \( x = 1 \). Are the energy levels degenerate?
(b) Prove that the wave function \( \psi(x,t) = A \cos(kx - \omega t) \) does not satisfy the time-dependent Schrödinger equation for a free particle.

8. (a) State Wien’s radiation formula and give its limitations.
(b) State clearly explaining all the terms Planck’s law, Rayleigh–Jeans law and Wien’s displacement law for radiation. Find out the two limits at which the Planck’s formula reduces to the other two.

9. Write short notes on the following:
(a) Scalar and vector potentials
(b) Quantum confinement effects in nano-materials