

**M.Sc. Examination, 2018**  
**Semester – III**  
**Physics**  
**Elective Course: MPE-364**  
**( Laser Physics )**

**Time: Three Hours**

**Full Marks: 40**

*Questions are of value as indicated in the margin.*

Answer **any four** of the following questions.

1. Following Einstein's idea of spontaneous and stimulated emission, find out a relation between A and B coefficients. Hence determine the spontaneous transition rate in terms of the life time ( $t_{sp}$ ), line shape function ( $g$ ) and frequency for an atomic system interacting with a monochromatic radiation field. 5+5

2. Electric field associated with a classical radiating electron is given by

$$E(t) = E_0 e^{-\frac{\gamma_0 t}{2}} e^{-i\omega_0 t} \text{ for } t \geq 0$$
$$= 0 \text{ for } t < 0.$$

Find out the corresponding intensity distribution of the radiated energy as a function of frequency. Determine an analytic expression of the width of this intensity distribution. Suppose the life time of an electron in an excited state of an atom is  $2 \times 10^{-6}$  sec. Determine the corresponding spontaneous decay rate and width of the emission line profile. 6+2+2

3. Can lasing be achieved with a two-level system? Describe a four-level system with the help of level diagram. Assume that the population is pumped from the ground level to the uppermost energy level and lasing action is taking place between the two intermediate energy levels. Construct the corresponding rate equations for this system (do not solve). Why is it advantageous to have a band like level as the uppermost energy level? Why is it beneficial to employ a four-level system instead of a three-level system to make a laser? 2+3+2+2+1
4. By considering the atom-field interaction Hamiltonian to be of the form of  $-e\mathbf{E}\cdot\mathbf{r}$  for a two-level atomic system, determine the time evolution of the system in terms of the time-dependent coefficients. What is the main problem in interpreting the result? How do we remove this problem? Define the associated density matrix elements for this problem and evaluate an expression for the average dipole moment of the atom. 4+1+1+4
5. What is mode locking? Derive an expression for the intensity of a mode locked laser. Determine the maximum intensity and separation between consecutive pulses of a mode locked laser. Why an active medium, which provides gain over a large bandwidth, is used for mode locking? 1+6+2+1
6. Derive the Beer-Lambert law:  $I_\omega(z) = I_\omega(0) \exp(-\alpha_\omega z)$ . Here the symbols have their usual meaning. Discuss the condition of optical amplification or gain in a medium. 8+2
7. A medium having finite conductivity ( $\sigma$ ) is present within an optical resonator. Find out the threshold condition starting from Maxwell's equations without neglecting the polarization of the medium. 10