M.Sc. 3rd Semester Examination, 2013

PHYSICS

PAPER – PHS- 302(Gr. A + B)

Full Marks : 40

Time : 2 hours

The figures in the right hand margin indicate marks

Candidates are required to give their answers in their own words as far as practicable

Illustrate the answers wherever necessary

GROUP – A

[ Marks : 20 ]

Answer Q.No.1 and any one from the rest

1. Answer any four questions :

\[
\frac{21}{2} \times 4
\]

(a) Indicate, which of the following molecules are microwave active molecules. Justify.
(i) CO (ii) \( \text{H}_2 \) (iii) \( \text{D}_2 \) (iv) \( \text{CH}_4 \) (v) \( \text{HCl} \)

(Turn Over)
(b) Discuss, for which reason laser can not be obtained from a two level laser system. Give one example of three level laser.

(c) Rotational and centrifugal distortion constants of HCl molecule are $10.593 \text{ cm}^{-1}$ and $5.3 \times 10^{-4} \text{ cm}^{-1}$ respectively. Estimate the vibrational frequency and force constant of the molecule. Given the mass of hydrogen and chlorine atoms are $1.673 \times 10^{-27} \text{ kg}$ and $58.06 \times 10^{-27} \text{ kg}$ respectively.

(d) What is the average period of rotation of HCl molecule if it is in the $J=1$ state. The inter-nuclear distance of HCl is $0.1274 \text{ nm}$. Given the mass of hydrogen and chlorine atoms are $1.673 \times 10^{-27} \text{ kg}$ and $58.06 \times 10^{-27} \text{ kg}$ respectively.

(e) Show the allowed transitions and the Raman spectrum arising in a linear molecule.

(f) Write Born-Oppenheimer approximation for molecular rotational, vibrational and electronic
spectroscopy. If the above wave functions of a molecule are $\psi_r$, $\psi_v$, $\psi_e$ and the respective energies are $E_r$, $E_v$ and $E_e$, find the total wave function and energy of the molecule according to the principle.

2. Obtain the equation of population inversion in a three level laser system. Derive the expression for threshold pumping power required to start laser oscillation from a three level laser. Calculate the threshold power required for a Ruby laser with number of atom per cc is $1.6 \times 10^{19}$; spontaneous lifetime is $3 \times 10^{-3}$ s and operating frequency is $6.25 \times 10^{14}$ Hz. Describe the method of $Q$-switching by Electro optical shuttering.

3. Clearly express the change in the spectrum considering the effect of interaction of rotation and vibration in a molecule. Explain how intensity of vibrational-electronic spectra varies when the upper state inter-nuclear distance is greater than the ground state.
GROUP — B

[ Marks : 20 ]

Answer Q.No.1 and any one from the rest

1. Answer any four questions : $2 \frac{1}{2} \times 4$

(i) Discuss the principle of optical NOR logic operation with non-linear material.

(ii) Give a comparative study of single mode step index and single mode graded index optical fibres.

(iii) Describe the characteristics of a hologram.

(iv) The refractive indices of an optical fiber are 1.46 (core) and 1.44 (clad), Calculate the aperture angle of the optical fiber.

(v) Compare focusing by a convex lens with the self-focusing by a non-linear material.

(vi) Discuss, why there is no antisymmetric TE type of electromagnetic wave is found in a planar waveguide.
2. What is multipath broadening in an optical fiber? Obtain the expression of this multipath broadening of pulse. Obtain the expression of TE symmetric mode of light in a planar waveguide. 1 + 3 + 6

3. What do you mean by second harmonic generation of laser? What do you mean by phase matching condition? Discuss, the method of obtaining the second harmonic light from a non-linear material with supporting figure. 1 + 2 + 7