M.Sc. Examination, 2018
Semester – III
Physics
Course: MPC-353
(Quantum Electronics-I)

Time: Three Hours **Full Marks: 40**

Questions are of value as indicated in the margin.

Answer ***any four*** questions.

1. What you mean by a coherent state? Show that the coherent state $|\alpha\rangle = \exp\left(\alpha a^{\dagger} - \alpha^{*} a\right)|0\rangle$. Establish the following identities:

   $$|\alpha\rangle\langle\alpha|a = \left(\alpha + \frac{\partial}{\partial \alpha^{*}}\right)|\alpha\rangle\langle\alpha|$$ 2+6+2

2. a) Establish the relation between the gain and the lineshape function g(v).
   b) The pump arrangement of a ruby crystal causes an inversion $5\times10^{17}\,\text{cm}^{-3}$. The wavelength, spontaneous decay time and the index of refraction are $\lambda = 0.6943\mu\text{m}$, $t_{spon} = 3\times10^{-3}$ sec and $n = 1.77$. Calculate the gain constant for $\text{FWHM} = 2\times10^{11}\,\text{Hz}$. 6+4

3. a) Discuss the gain saturation of homogeneous broadening.
   b) Obtain the gain saturation of a ruby later at $\lambda = 0.6943\mu\text{m}$ and $\Delta\nu = 2\times10^{11}\,\text{Hz}$ at 300^{o}K.
   (Given $\tau = t_{spon} = 3\times10^{-3}$ sec, $n = 1.77$ and $\eta = 1$). 6+4

4. By using the rate equation or otherwise, obtain the optimum coupling and hence the optimum power of a gas laser (neglect the effects of spontaneous emission, if any)? 10

5. a) Explain the meaning of threshold condition for a laser to oscillate. Obtain the threshold inversion density at line centre.
   b) Obtain the expression for threshold inversion density at line centre for a He-Ne laser with resonator length $l = 10$ cm oscillating at $\lambda = 6328\,\text{A}^{o}$. 1+6+3
   (Given; $\alpha = 0, r_1 r_2\, 0.98$, $\eta = 1$, $t_{spon} = 10^{-7}$ sec, $\Delta\nu = 1.5\times10^{9}\,\text{Hz}$).

6. Show that the optical transitions in a semiconductor takes place for $\vec{k} = \vec{k}'$, where the symbols are of usual meaning. 10

7. What are the significances of Rabi Model? Using Rabi Model, obtain the atomic inversion of a two-level atom. 1+9

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