Assignment-2

1) i) Stimulated absorption

Ans) When a photon of light having energy $E_2 - E_1 = h\nu$ is incident on an atom in the ground state, the atom in the ground state E_1 may absorb the photon and jump to higher state E_2. This process is called stimulated absorption. This is called so because the incident photon has stimulated the atom to absorb the energy.

ii) Spontaneous Emission

Ans) Normally the excited state is an unstable state where the life time of an atom is very short around 10^{-8} sec. Hence the atom is in excited state, E_2 returns to the ground state spontaneously by releasing one photon of energy $h\nu$. This process is called spontaneous emission

iii) Stimulated Emission

Ans) In this process an incident photon is absorbed by an excited atom as a result of which atom becomes unstable in state E_2 and makes a transition to the ground state releasing two photons. This process is called stimulated emission

iv) Pumping

Ans) Optical pumping is a process in which light is used to raise electrons from a lower energy level in an atom or molecule to a higher one.

v) Meta-stable state

Ans) Meta stable state is an excited state of an atom

or other system with a longer lifetime than other excited states. However, it has shorter lifetime than other excited states.

vi) Population inversion :-

Ans Population inversion is the redistribution of atomic energy levels that take place in a system so that laser action can occur.

vii) Active medium

The active laser medium is the source of optical gain within a laser. The gain results from the stimulated emission of electronic or molecular transitions to a lower energy state from a higher energy state previously populated by a pump source.

2) In thermal, equation at temperature T with radiation frequency ν and energy density $u(\nu)$ let N_1 and N_2 be the number of atoms in energy states 1 and 2 respectively at any instant. The number of atoms in state 1 absorb a photon and give rise to absorption per unit time.

For eg.

$$P_{12} = P_{21}$$

$$N_1 B_{12} u(\nu) = N_2 [A_{21} + B_{21} u(\nu)].$$

$$\therefore \left[\frac{N_1 B_{12}}{N_2 B_{21}} - 1\right] u(\nu) = \frac{A_{21}}{B_{21}}$$

$$u(\nu) = \frac{A_{21}}{B_{21}\left[\frac{N_1 B_{12}}{N_2 B_{21}} - 1\right]} \quad -(1)$$

According to Boltzmann distribution law number of atoms N_1 and N_2 in energy states ϵ_1 and ϵ_2 in thermal equilibrium at temperature T is

$$\frac{N_1}{N_2} = e^{\frac{\epsilon_2 - \epsilon_1}{KT}}$$

Substituting $\frac{N_1}{N_2}$ in equation (1)

$$\therefore u(\nu) = \frac{A_{21}}{B_{21}\left[\frac{B_{12}}{B_{21}} e^{\frac{\epsilon_2 - \epsilon_1}{KT}} - 1\right]} \quad -(2)$$

According to planck's Radiation formula

$$u(\nu) = \frac{8\pi h \nu^3}{c^3 e^{\frac{\epsilon_2 - \epsilon_1}{KT}} - 1} \quad -(3)$$

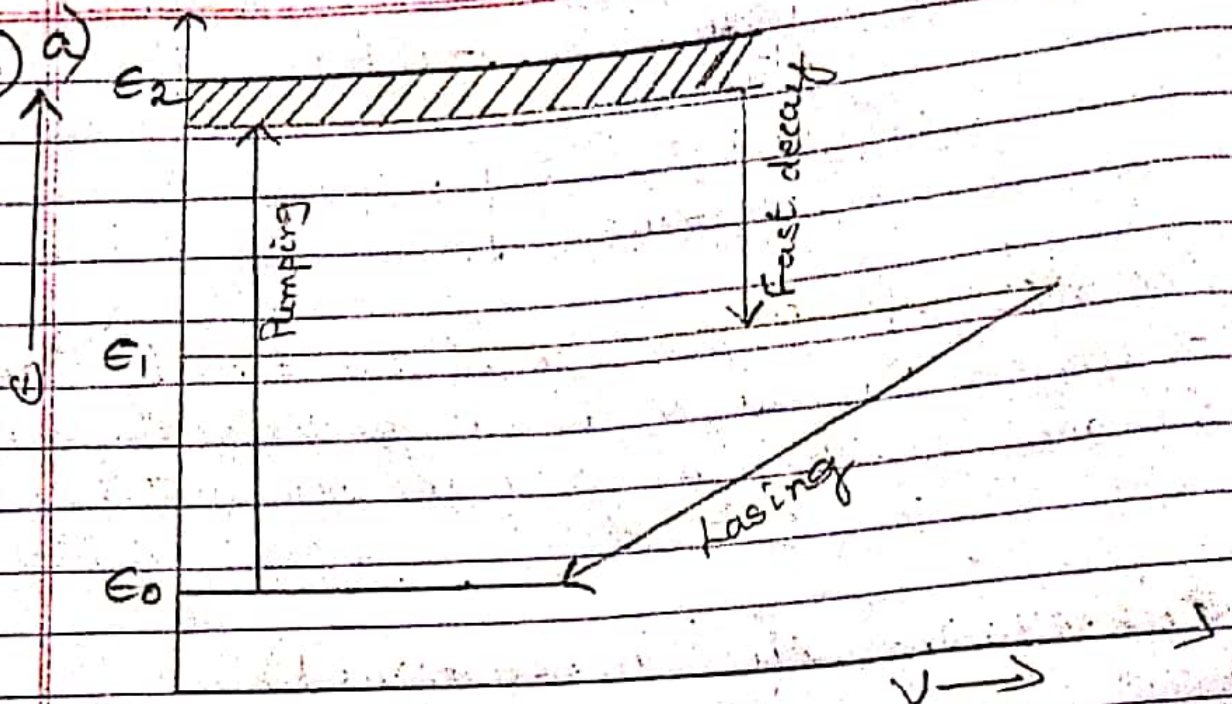
Comparing Eq (2) and (3) we get,

$$\frac{B_{12}}{B_{21}} = 1$$

$$\Rightarrow \boxed{B_{12} = B_{21}}$$

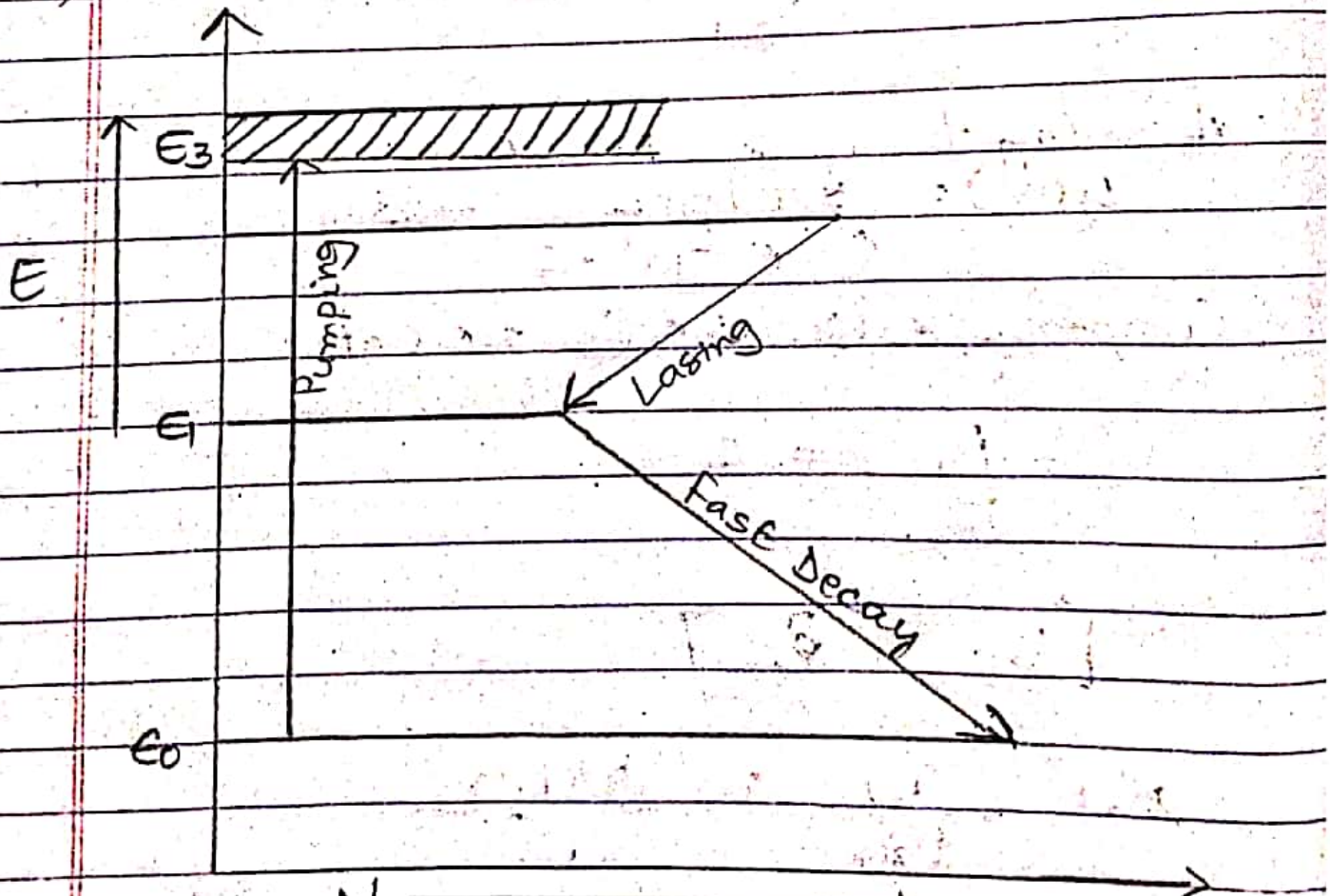
and $$\frac{A_{21}}{B_{21}} = \frac{8\pi h \nu^3}{c^3}$$

3) a)



Three level laser

b)



Four level laser

4) i) Construction and working →

The Ruby laser consist of a Ruby Rod which is made of chromium doped ruby material. At the opposite ends of this rod there are two silver mirrors. Whose one is fully polished and other one is partially polished. A spring is attached to the rod with fully polished end for adjustment of wavelength of laser light. Around the ruby rod a flash light is kept for the pump input. The whole assembly is kept in the glass tube. Around the neck of the glass tube the R.F source and switching control is desired in order to switch on and off the flash light for desired intervals.

ii) Energy level Diagram