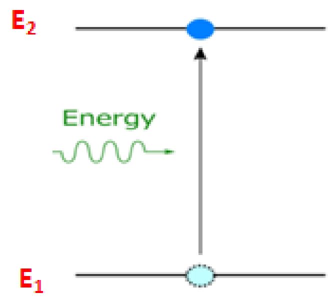
CL34_Q1. With a neat diagram explain the process of stimulated absorption and emission.

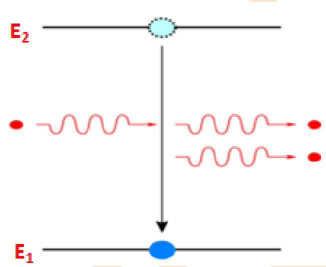
Ans:

Induced absorption (stimulated absorption) :



In the induced absorption process an atom in the ground state (E_1) absorbs radiation and is excited to the higher state (E_2). The rate of absorption is dependent on the population of the ground state N_1 and the energy density of radiation $\rho(\vartheta)$ of the appropriate frequency such that $E_2 - E_1 = h\nu$

Stimulated emission:



An atom in the excited state can have a life time in the excited state for longer periods of time of the order of milliseconds. These states are referred to as Meta stable states. Such excited atoms have to be stimulated to return to the lower energy state with an external intervention in the form of a photon whose energy is equal to $E_2 - E_1$. In this process the energy of the excited atom is released as a photon whose characteristics remain the same as that of the stimulating photon. This process sets in a chain of photon emission where all the photons are in the same state. The rate of stimulated emission is then dependent on the population of atoms in the excited state and the energy density of radiation

CL34_Q2. The two energy states at 293 K has a relative population of 1/e. Compute the wavelength of the radiation emitted at that temperature.

Ans:

$\frac{N_2}{N_1} = e^{-\frac{h\vartheta}{kT}}$ given data $\frac{N_2}{N_1} = \frac{1}{e}$

$\frac{1}{e} = e^{\frac{h\vartheta}{kT}}$

$1 = \frac{hc}{\lambda kT}$ or $\lambda = \frac{hc}{kT}$ substituting the values we get

$$\lambda = \frac{6.623 \times 10^{-34} \times 3 \times 10^{8}}{1.38 \times 10^{-23} \times 293}$$

$\lambda = 49.14\ \mu m$

CL34_Q3. How is the energy density of electromagnetic radiation described in terms of Planck's quantum theory?

Ans:

Planck suggested that the oscillating atoms could emit or absorb energy in tiny bursts called quanta and the energy of a quantum will be an integral multiple of hv. Thus the radiations are from a collection of harmonic oscillators (oscillating atoms) of different frequencies and the energy of the radiations from the oscillators has to be packets of hv.

With this concept of energy of the radiations the average energy of the oscillators can be evaluated as $\langle \boldsymbol{E} \rangle = \frac{\boldsymbol{h\nu}}{\boldsymbol{e^{\frac{h\nu}{kT}}-1}}$ and the energy density of radiations can be evaluated as $\boldsymbol{\rho(\nu)d\nu} = \langle \boldsymbol{E} \rangle \boldsymbol{dN} = \frac{\boldsymbol{8\pi}}{\boldsymbol{c^3}}\boldsymbol{\nu^2 d\nu}\left(\frac{\boldsymbol{h\nu}}{\boldsymbol{e^{h\nu/kT}-1}}\right)$

$$= \frac{\boldsymbol{8\pi h\nu^3}}{\boldsymbol{c^3}}\left(\frac{\boldsymbol{1}}{\boldsymbol{e^{h\nu/kT}-1}}\right)\boldsymbol{d\nu}$$