<u>Assignment-I</u>

1. The ratio of population of two energy levels out of which one corresponds to metastable state is $1.059x10^{-30}$. Find the wavelength of light emitted at 330K.

   $\frac{N_2}{N_1} = 1.059x10^{-30}$, T=330K, λ=?

   Constants h=$6.63x10^{-34}$Js, K= $1.38x10^{-23}$J/K, C= $3x10^{8}$m/s

   Using the relation for Boltzmann's factor

   $\frac{N_2}{N_1} = e\frac{-h\nu}{kT} = e\frac{-hc}{\lambda kT}$; λ = 632.8nm.

2. Calculate the ratio of
   i) Einstein Coefficients,
   ii) Stimulated to spontaneous emissions, for a system at 300K in which radiations of wavelength 1.39μm are emitted.

   $$\frac{A_{21}}{B_{21}} = \frac{8\pi h\nu^3}{c^3} = \frac{8\pi h}{\lambda^3} = 6.2x10^{-15}$$

   Since $B_{12} = B_{21}$ we can write $\frac{A_{21}}{B_{21}} = 6.2x10^{-15}$

   We have

   Rate of stimulated emission/Rate of spontaneous emission= $\frac{B_{12}N_2U_\nu}{A_{21}N_2} = \frac{B_{21}}{A_{21}}U_\nu$

   But $U_\nu = \frac{8\pi h\nu^3}{c^3}\left[\frac{1}{e^{\frac{h\nu}{kT}}-1}\right] \Longrightarrow U_\nu = \frac{A_{21}}{B_{21}}\left[\frac{1}{e^{\frac{h\nu}{kT}}-1}\right]$

   Therefore rate of stimulated emission/rate of spontaneous emission= $\frac{B_{21}}{A_{21}} x \frac{A_{21}}{B_{21}}\left[\frac{1}{e^{\frac{h\nu}{kT}}-1}\right]$

   $$== \left[\frac{1}{e^{\frac{h\nu}{kT}}-1}\right] = 10^{-15}$$

3. Calculate on the basis of Einstein's theory, the number of photons emitted per second by a He-Ne laser source emitting light of wavelength 6328A^{o} with an optical power of 10mW.

   $$P = \frac{E}{t} = \frac{n\Delta E}{t} = \frac{nhc}{\Delta\lambda t}$$

   Hence $\frac{n}{t} = \frac{P\Delta\lambda}{hc}$

   = $3.182x10^{16}$

Calculate the number of photons, from green light of mercury (Λ = 4961 Å), required to do one joule of work. **Ans: N = $2.4961\times10^{18}/m^3$.**

Calculate the ratio of population densities of upper and lower energy level; assume that the material is in thermal equilibrium. It is given that the wavelength separation between the energy levels is 1µm at a temperature of 295K. **Ans: $6.21\text{x}10^{-22}$**

Consider a lower energy level situated at an energy 3.97 x 10^{-21} J from the ground state. There are no other energy levels nearby. Determine the fraction of the population found in this level compared to the ground state population at a temperature of 300 K. **Ans: Thus 38% of the population is in the lower energy level.**

Calculate on the basis of Einstein's theory, the number of photons emitted per second by an He-Ne laser source emitting light of 6328 Å wavelength with an optical power of 10mW. **Answer: 3.183 x 10^{16}**

A laser medium at thermal equilibrium temperature of 300K has two energy levels with a wavelength separation of 1µm. Find the ratio of population densities in the two energy levels. **Answer: 1.46 x 10^{-21}**

The ratio of population of two energy levels is 1.059 x 10^{-30}. Find the wavelength of light emitted at 300K. **Answer: 696 nm**

Using Einstein's theory, show that in the optical region say, at λ= 5000 Å and T= 300, the amplification is not possible. **Answer: 2.03 x 10^{-42}**

Find the ratio of the two energy levels in a laser if the transition between them produces light of 694.3 nm, wavelength assuming the ambient temperature at 27^oC. **Answer: 9.208 x 10^{-31}**

A He-Ne laser is emitting a laser beam with an average power of 4.5 mW. Find the number of photons emitted per second by the laser. The wavelength of the emitted radiation is 632.8 nm. **Answer: 1.42 x 10^{-16}**

A pulse from laser with 1 mW power lasts for 10 nS. If the number of photons emitted per second is 3.491 x 10^7, calculate the wavelength of laser. **Answer: 6942 Å**