- Boltzman equation: $\frac{N_2}{N_1} = e^{\frac{-h\nu}{kT}}$

  k - Boltzman constant
  T - Absolute temperature
  N_1 - Population density of atoms in lower state
  N_2 - Population density of atoms in higher state

- Distance between laser cavity mirrors

  $d = m \cdot \frac{\lambda}{2}$

  m – Laser cavity mode
  (Resonator cavity mode)

→ Numericals:

① A He-Ne laser is emitting a laser beam with an average power of 4.5mW. Find the number of photons emitted per second by the laser. Wavelength of light is 6328 A°.

Sol:

$$P = \frac{n \cdot h\nu}{t}$$

$$4.5 \times 10^{-3} = \frac{n \times 6.628 \times 10^{-34} \times 3 \times 10^{8}}{6328 \times 10^{-10}}$$

$$n = 1.43 \times 10^{16}.$$

② A medium at thermal equilibrium at T = 300 K has two energy levels with a wavelength separation of 1 μm. Find the ratio of population density of lower and upper energy states.

Sol:

$$\lambda = 1 \times 10^{-6}\ m \qquad T = 300K$$

$$\frac{N_2}{N_1} = e^{\frac{-h\nu}{kT}} = e^{\frac{-hc}{\lambda kT}} = e^{\frac{6.628 \times 10^{-34} \times 3 \times 10^{8}}{1 \times 10^{-6} \times 300 \times}} = 148.00$$

$$= 1.36 \times 16^{-21}$$

③ The ratio of population of two energy levels is 1.059×10^{-30}. Find the wavelength of light emitted by spontaneous emission at an ambient temperature of 27°C.

Sol: $\frac{N_2}{N_1} = 1.059 \times 10^{-30}$ $T = 27°C = 300K$ $\lambda = ?$

$$\frac{N_2}{N_1} = e^{-\frac{hc}{\lambda KT}}$$

Taking ln on both sides.

$$\ln\left(\frac{N_2}{N_1}\right) = -\frac{hc}{\lambda KT}$$

$$\lambda = 696\,nm.$$

④ A ruby laser emits pulses of 20ns duration with average power per pulse 100kW. If no. of photons in each pulse is 6.981×10^{15} Calculate wavelength.

Sol: $t = 20 \times 10^{-9}\,s.$ $P = 100 \times 10^{3}\,W$ $n = 6.981 \times 10^{15}$

$\lambda = ?$

$$P = \frac{nhc}{\lambda t}$$

$$100 \times 10^{3} = \frac{6.981 \times 10^{15} \times 6.628 \times 10^{-34} \times 3 \times 10^{8}}{\lambda \times 20 \times 10^{-9}}$$

$$\lambda = 6.9405 \times 10^{-7} = 694\,nm$$

⑤ Find the number of modes of standing wave in the resonant cavity of 1m length of a laser operating at a wavelength of 632.8nm. Distance between parallel mirror in the resonant cavity

Sol:

$$L = \frac{m\lambda}{2}$$

$$m = \frac{2L}{\lambda} = \frac{2 \times 1}{632.8 \times 10^{-9}} = 3.16 \times 10^{6}.$$