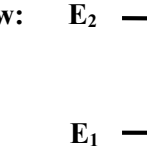
TUTORIAL -1 (LASERS)

(h= 6.6 x 10^{-34} J.s ; c= 3 x 10^{8} m/s ; k =1.38 x 10^{-23} J/K)

Review: E_2 ——— **(no. of atoms /m^3 = N_2)**



λ = hc / (E_2 – E_1) is the wavelength of emitted spectral line

E_1 ——— **(no. of atoms/m^3= N_1)**

- **Boltzmann Ratio or the ratio of atomic populations** $\frac{N_2}{N_1} = e^{-(\frac{hc}{\lambda kT})} = e^{-(\frac{\Delta E}{kT})}$
- **Ratio of stimulated to spontaneous emissions =** $1/[e^{hc/\lambda kT} - 1]$
- **Power (J/s or W) = (no. of photons emitted per sec) . (energy of each photon) = nhc/λ**

Numerical Problems

1. A laser beam emits an average power of 15 mW. If the laser spot is of diameter 5 μm, calculate intensity of laser beam.
2. A laser beam emits an average power of 25 mW. If the laser spot is of diameter 8 μm, calculate intensity of laser beam.
3. Wavelength of a laser is 6500Å. Number of photons emitted in two minutes by the laser is 10^{17}. Calculate the power of the laser. If the input power is 1.5W, what is the fraction of power converted to output?
4. Wavelength of a laser is 520nm. Number of photons emitted in two minutes by the laser is 10^{12}. Calculate the power of the laser. If the input power is 8.5W, what is the fraction of power converted to output?
5. A photon of wavelength 4000Å is emitted when an atom in an excited state transits to ground state. Calculate the energy and momentum of the photon. What is the ratio of populations of the two states at 300 K?
6. A photon of wavelength 580nm is emitted when an atom in an excited state transits to ground state. Calculate the energy and momentum of the photon. What is the ratio of populations of the two states at 360 K?
7. Two energy levels are separated by 1.05 eV. Calculate the ratio of spontaneous to stimulated emission at 400 K.
8. Two energy levels are separated by 0.85 eV. Calculate the ratio of spontaneous to stimulated emission at 600 K.

9. Energy of level E_2 is 2 eV and the energy of level E_1 is 0 eV. Calculate the ratio of populations N_2/ N_1 at a temperature of 400 K and at what temperature will this ratio be 0.01?
10. Energy of an excited state with respect to that of ground state is 2.5 eV. Calculate the Boltzmann factor at 600 K and at what temperature will this ratio be 0.09?
11. The output power of a continuous wave laser is 10 kW at a lasing wavelength of 635nm. How many photons are emitted per second?
12. The output power of a continuous wave laser is 50 kW at a lasing wavelength of 1064μm. How many photons are emitted in two seconds?
13. The ratio of stimulated emission to spontaneous emission is 10^{-34}. Calculate the ratio of populations. If the difference in energy corresponds to a wavelength of 6000Å, calculate the temperature.
14. The ratio of stimulated emission to spontaneous emission is 2×10^{-32}. Calculate the Boltzmann factor. If the difference in energy corresponds to a wavelength of 7600Å, calculate the temperature.
15. Two energy levels are separated by 1.95 eV. At what temperature will the ratio of populations be 10^{-29}?

    Calculate A_{21}/B_{12}.
16. Two energy levels are separated by 2.1 eV. At what temperature will the ratio of populations be 10^{-34}?

    Calculate A_{21}/B_{12}.
17. A laser pulse of duration 1 ns has a power of 10 mW. If the number of photons emitted in a pulse is 10^{15}, calculate the wavelength of emitted photons.
18. A laser pulse of duration 4 ns has a power of 60 mW. If the number of photons emitted in a pulse is 10^{18}, calculate the wavelength of emitted photons.
19. The efficiency of He-Ne laser is 0.17. If it is operated with a current of 10 mA at 3 kV. Neglecting loss of power, calculate power output in mW.
20. The efficiency of He-Ne laser is 0.35. If it is operated with a current of 19 mA at 8 kV. Neglecting loss of power, calculate power output in mW.