Q1 Write the difference between Laser light & ordinary Light?

A.

Laser Light	Normal Light
1. Monochromatic in nature. (single wavelength & frequency).	Polychromatic in nature.
2. Sharp in nature.	Diverge in nature.
3. Travels a long distance (like 500m)	Travels a less distance (like 20m)
4. Highly directional in nature	Less directional in nature
5. High intensity in nature	Less intensity in nature.

Q2 Derive an expression for Einsteins Co-efficient?

A. At thermal equilibrium number of upward transition is equal to number of downward transitions.

$$B_{12} N_1 f(v) = A_{21} N_2 + B_{21} N_2 f(v)$$

$$\rho(\nu) = \frac{A_{21}N_2}{B_{12}N_1 - B_{21}N_2}$$

$\div$ by $B_{21}N_2$ in N^r & D^r

$$= \frac{A_{21}N_2/B_{21}N_2}{B_{12}N_1/B_{21}N_2 - B_{21}N_2/B_{21}N_2}$$

$$= \frac{A_{21}/B_{21}}{B_{12}N/B_{21}N_2 - 1} \longrightarrow (1)$$

By using Boltzmen Distribution Law $N_i = N_0 e^{-E_i/KT}$

$$N_1 = N_0 e^{-E_1/KT}, \quad N_2 = N_0 e^{-E_2/KT}$$

$\div N_1/N_2$, we get

$$\frac{N_1}{N_2} = \frac{N_0 e^{-E_1/KT}}{N_0 e^{-E_2/KT}} = \frac{e^{-E_1/KT}}{e^{-E_2/KT}} = e^{-\frac{E_1+E_2}{KT}}$$

$$\frac{N_1}{N_2} = e^{\rho(\nu)/KT} \longrightarrow (2)$$

Substituting eqn (2) in eqn (1)

$$= \frac{A_{21}/B_{21}}{B_{12}/B_{21}e^{\rho(\nu)/KT} - 1} \longrightarrow (3)$$

According to Planks Radiation Law

$$\rho(\nu) = \frac{8\pi h\nu^3}{c^3} = \frac{1}{e^{h\nu/KT} - 1} \longrightarrow (4)$$

Comparing eqn (3) and (4) we get

$$\frac{A_{21}}{B_{21}} = \frac{8\pi h\nu^3}{c^3} \quad \text{and} \quad \frac{B_{12}}{B_{21}} = 1$$

To have a good Laser source stimulated should be greater than spontaneous emission.

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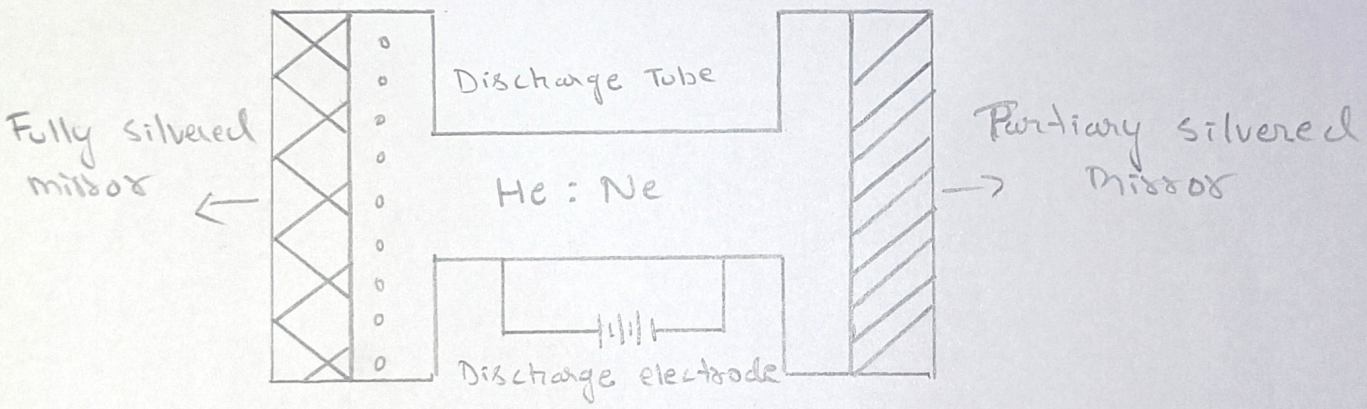
3) With neat Diagram explain He:Ne Laser?

A: **He:Ne LASER:**



Construction:

i) A He:Ne Laser consist a discharge tube.

ii) The length of the discharge tube is 80cm and the diameter is 1cm.

iii) The discharge tube is made up of quartz material.

iv) The ratio of the He:Ne gas is 10:1. (He > Ne).

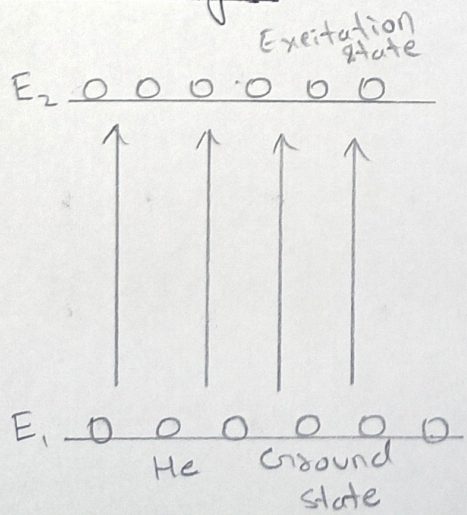
vi) The pressure of the He gas is 0.1mm of Hg and pressure of the Ne gas is 1mm of Hg.

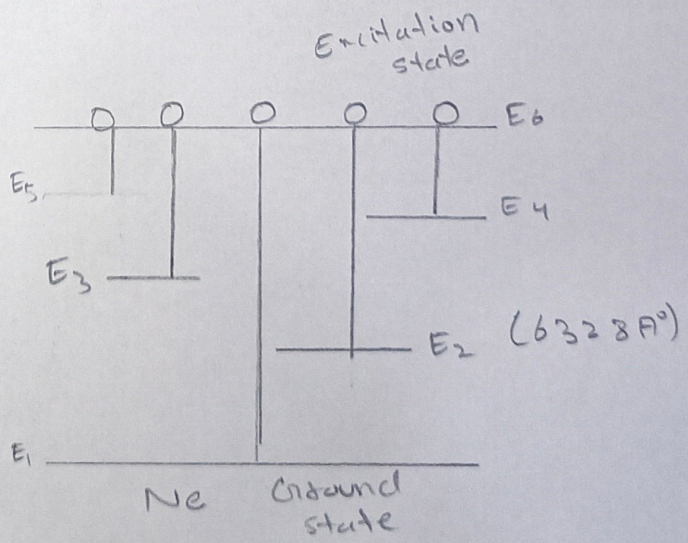
vii) Two mirrors are connected to the discharge tube one is partially silvered mirror and other is fully silvered mirror.

viii) Two electrodes are connected to the discharge tube.

ix) Output power of Laser is depends upon the length of the discharge tube & the pressure of the gas.

Working:





ii) When a certain amount of voltage enters into the discharge tube with the help of DC power supply.

iii) The energetic electron after entering inside the discharge tube called with He atom it supplies its energy to the He atom which is present in ground state.

iii) After taking the energy from the electron He atom which moves from ground state to excitation state.

iv) The excitation level of He and Ne are some due to that He atom supplies its energy to the Ne atom.

v) Then, Ne atom starts jumping from E_6 to E_5, E_6 to E_4, E_6 to E_3, E_6 to E_2 and E_6 to E_1.

vi) From E_6 to E_4 it releases very large amount of energy that is 6328 Å.

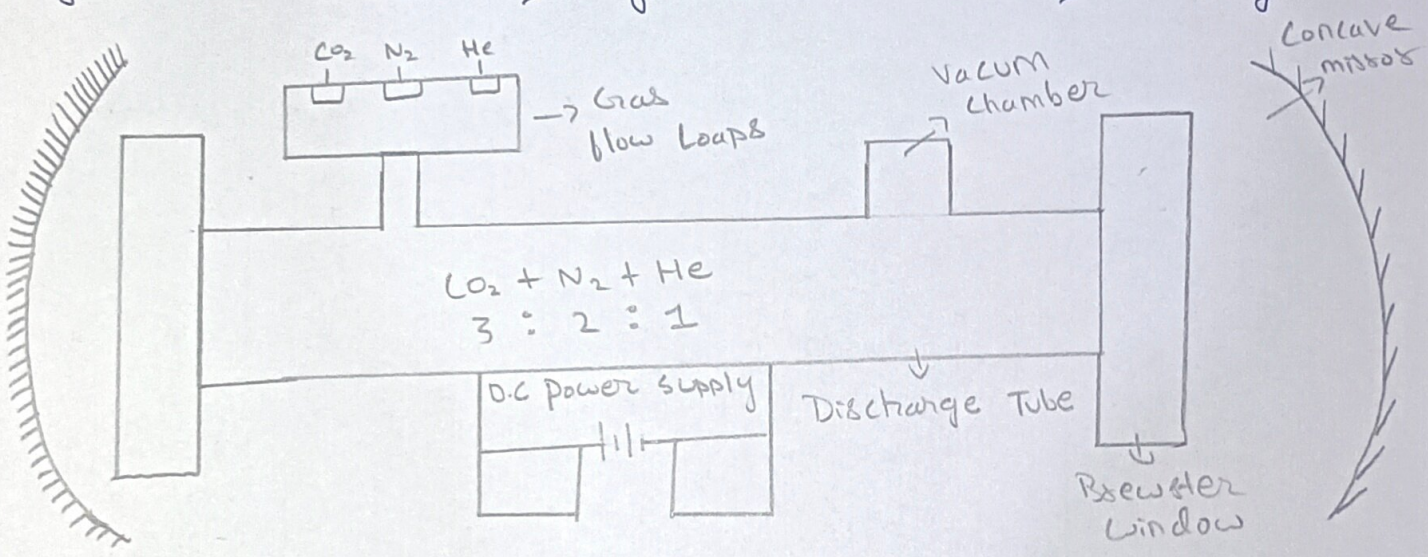
vii) Finally, the emitted phaton of energy bounce back from the fully silvered mirror and come from of laser beam.

Q4) With neat diagram explain CO_2 Laser?

A:- CO_2 is the 1st molecular laser which is discovered in Bell Laboratory in the year 1964.

- It has the ability to emmit 5w - 150000w power.
- CO_2 Laser works on 3 principles:

a) Symmetric Mode b) Asymmetric Mode c) Bending Mode

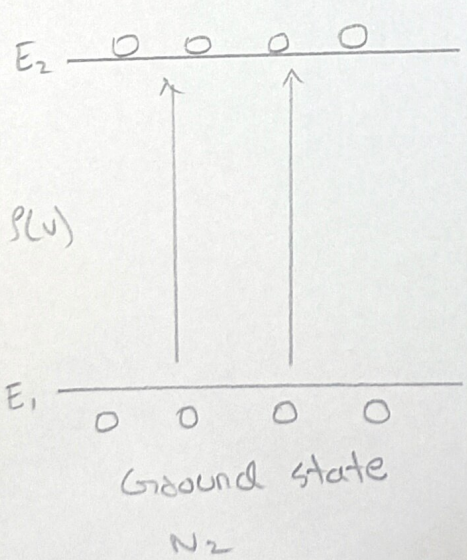


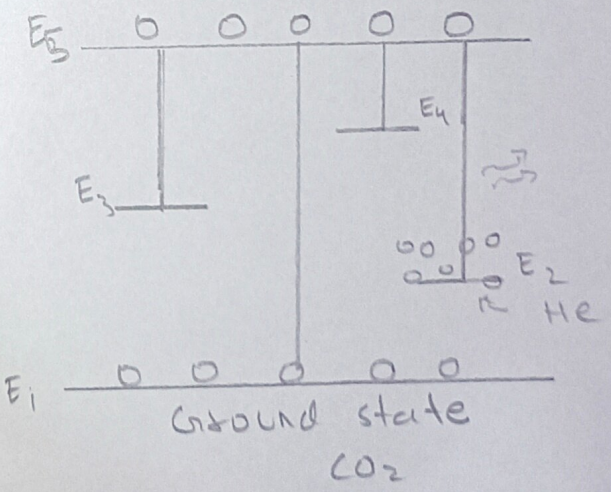
Construction:

1. It consist a quartz discharge tube.
2. The length of the discharge tube is 5m and diameter is 2-5 cm.
3. It consist of 3 gases in the ratio of 3:2:1.
4. It consist 2 brewester window to form a polarized beam of light.

5. The end of the discharge tube sealed with 2 concave mirrors.
6. It consist a vacuum chamber to eliminate the impurities inside the discharge tube.
7. A power supply used to stat a laser action.
8. Finally, CO_2 work as Lasing action, N_2 work as excitation of CO_2 molecule, He work as to absorb heat inside the discharge tube and deexite the CO_2 molecule.

Working:





- When a certain amount of voltage enters into the discharge tube, with the help of D.C power supply.

- The energetic electron after entering inside the discharge tube collide with N_2 atom supplies its energy to the N_2 atom which is present in ground state.
- After taking the energy from the electron N_2 atom which moves from ground state to excitation state.
- The excitation level of N_2 and CO_2 are same due to that N_2 atom supplies its energy to the CO_2 atom.
- Then, CO_2 atoms start jumping from E_5 to E_4, E_5 to E_3, E_5 to E_2, and E_5 to E_1.
- From E_5 to E_2 population inversion takes place.
- Finally the emitted photon of energy bounce back from the fully silvered mirror and come out from the partially silvered mirror in the form of Laser beam.

Q5] Write a note on classification of Optical fibre?

A. CLASSIFICATION OF OPTICAL FIBRE:

1] Based on material.

2] Based on mode.

3] Based on Refractive index.

01] Based on material:

a. Glass optical Fibre:

- It is made up of silicon dioxide (SiO_2).
- It is used for long range application.

b. Plastic Optical Fiber:

- It is made up of Polymethyl Methacrylate (PMM) or polystyrene.
- It is used for short range application.

02] Based on mode:

a Single Mode Optical Fiber:

- These are the simplest type of optical fiber.
- Light travels only in one direction.
- Core and cladding diameter are 5-10 cm.

b) Multi Mode Optical Fiber:

- It has the ability to transfer more number of beams in different directions.
- 10 times bigger then single mode optical fiber.
- Used for short range application.
- Ex: Link Computers together.

03) Based ON Refractive Index:

a) STEP Index of Optical Fibre:

- Core & Cladding has uniform index.
- Diameter of core & cladding is 50-200mm.
- They are easy to maintfacture.
- It has longer life time.

b) GRADED INDEX OF OPTICAL Fiber:

- Core & cladding has non-uniform index.
- Diameter of core & cladding is 50-10mm.
- They are difficult to manufacture.
- They are expensive.

Q6] Define optical fibre, induced absorption, spontinious emission and stimulated emission?

Ans: 1] Optical fibre: It is a material used for transmission of signals from one point to another point.

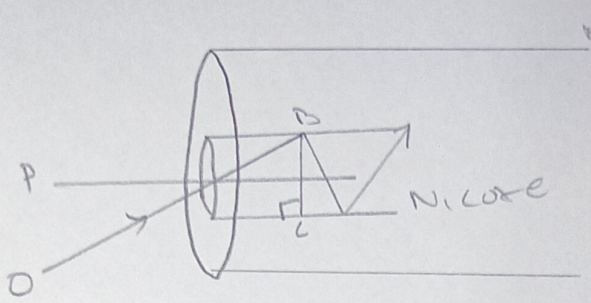
2] Induced absorption: ($B_{12}N_1\rho(\nu)$) The process in which an atom moves from ground state to excitation state after obsorbing a photon of energy.

3] Spontaneous ~~Abs~~ Emission: ($A_{21}N_2$) The process in which an atom moves from excitation state to ground state after completion of it's life time period that is 10^{-8} sec.

4] Stimulated emission: ($B_{21}N_2\rho(\nu)$) The process when an atom triggered by a photon of energy it moves from excitation state to ground state by releasing 2 photons of energy.

87] Derive an expression for Numerical Aperature?

Sol:



Consider a beam of light incident at O, ~~refle~~ reflected inside the core. when n_1 is core refractive index and n_2 is critical angle & $i = i_{max}$ is incident ray & no is medium of refractive index.

By Snell's law,

$$\sin i = \frac{n_1}{n_0} \quad \text{—①}$$
$$\sin r = n_0$$

Consider a Δ^{le} ABC

$$r = 90^\circ = \theta$$
$$\sin r = \sin(90 - \theta)$$
$$\sin r = \cos\theta$$
$$\sin r = \sqrt{1 - \sin^2\theta} \rightarrow ②$$

Put value of $\sin r$ in eqn ①

$$\frac{\sin i}{\sin^2\theta} = \frac{n_1}{n_0} \rightarrow ②$$

Where ;

$i = \theta_{acc} \mid \theta = \theta_c$

Put in eqn (2)

$$\frac{\sin i}{\sqrt{1-\sin^2\theta}} = \frac{n_1}{n_0} \Rightarrow \frac{\sin\theta_{ace}}{\sqrt{1-\sin^2\theta_c}} = \frac{n_1}{n_0} \rightarrow (3)$$

To find θ_e, Apply Snell's law at point B_2

$$\frac{\sin i}{\sin r} = \frac{\sin\theta_e}{\sin 90} = \frac{n_2}{n_1}$$

$$\sin\theta_e = \frac{n_2}{n_1} \Rightarrow \theta_c = \sin^{-1}\left(\frac{n_2}{n_1}\right)$$

Put in eqn (3) we get

$$\frac{\sin\theta_{ac}}{\sqrt{1-(n_2/n_1)^2}} = \frac{n_1}{n_0}$$

$$\sin\theta_{ac} = \frac{n_1}{n_0}\sqrt{\frac{(n_1)^2-(n_2)^2}{(n_1)^2}}$$

$$\sin\theta_{ace} = \frac{n_1}{n_0} \times \frac{1}{n_1} \times \sqrt{(n_1)^2-(n_2)^2}$$

$$\sin\theta_{ace} = \sqrt{(n_1)^2-(n_2)^2} \qquad (\because) n_0 = 1$$

$$N_A = \sqrt{(n_1)^2-(n_2)^2}$$

$$\theta_{ace} = \sin^{-1}(N_A)$$

* Problems

Q1) A He:Ne laser gives an output of 5mw. The wavelength of the emitted radiation is 6328A°. Find the number of photons emitted per second.

Sol: Given:

$P = 5mw = 5\times10^{-3}W$, $h = 6.63\times10^{-34}$

$\lambda = 6328A° = 6328\times10^{-10}m$, $c = 3\times10^{8}m/s$

$$N = \frac{P\lambda}{hc}$$

$$= \frac{5\times10^{-3}\times6328\times10^{-10}}{6.63\times10^{-34}\times3\times10^{8}}$$

$$= \frac{31640\times10^{-13}}{19.89\times10^{-26}}$$

$$= 1590.7\times10^{13}$$

$$N = 1.59\times10^{16}\ atoms$$

Q2) Calculate the NA of an optical fiber given the refractive index of core is 1.623 & cladding is 1.522 & also find the angle of acceptance.

Sol: Given: $n_1 = 1.623$, $n_2 = 1.522$, $\theta_{acc} = ?$, $NA = ?$

$$NA = \sqrt{(n_1)^2 - (n_2)^2}$$

$$= \sqrt{(1.623)^2 - (1.522)^2}$$

$= \sqrt{0.317645}$

$\boxed{NA = 0.5636}$

$\theta_{acc} = \sin^{-1}(NA)$

$= \sin^{-1}(0.5636)$

$\boxed{\theta_{acc} = 34.305}$

Q3] A step index fiber in air has a NA of 0.16. A core refractive index of 1.45 & a core diameter of 60 cm. Determine the V parameter for the fiber when light at a wavelength of 0.9 μm is transmitted.

Sol: Given: $d = 60cm = 0.6m$, $\lambda = 0.9\mu m = 0.9 \times 10^{-6} m$

$NA = 0.16$, $N_1 = 1.45$

$V = \frac{\pi d}{\lambda}(NA)$

$= \frac{3.14 \times 0.6 \times 0.16}{0.9 \times 10^{-6}}$

$= \frac{0.30144}{0.9} \times 10^{6}$

$= 0.334 \times 10^{6}$

$\boxed{V = 3.34 \times 10^{5}}$