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Q1. Define Lasers.

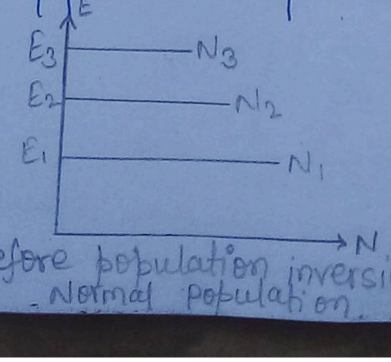
Ans:→ laser is a monochromatic light. It is a coherent in a nature. It is a full from of Light Amplification by Stimulated Emission of Radiation. It was Invented in 1959 and 1960. first laser device developed by "T.H. Maiman".

Q2. what is metastable state?

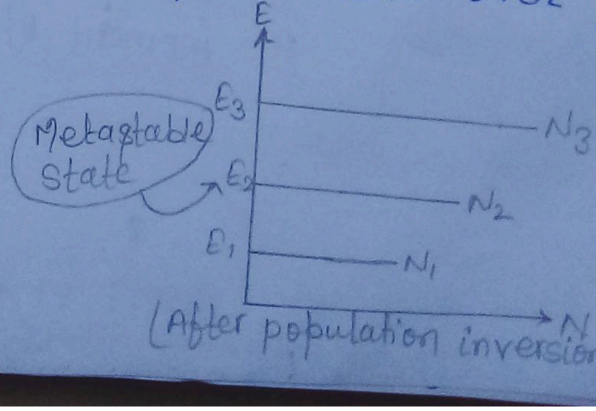
Ans:→ Normaly, mean life time (τ) for spontaneous Emission by excited atoms is of the order of 10^{-8} sec. However there are some status for which life time is much longer, perhaps 10^{-3} secs. we call such status as. Metastable states.

Q3. Define population Inversion? How it is achieved?

Ans:- The process of ~~eek~~ for laser action to take place the stimulated emission should predominate over spontaneous emission.



(Before population inversion)
Normal population.



(After population inversion)

The process of achieving greater population density of atoms in the higher energy state as compared to lower energy state is called population Inversion.

Q4. What is optical pumping?

Ans:→ optical pumping is the use of light energy to raise the atoms of a system from one energy level to another. A system may consist of atoms having a random orientation of their individual magnetic field.

Q5. Define wave particle duality?

Ans:- wave-particle duality is the concept in quantum mechanics that every particle or quantum entity may be described as either a particle or a wave. It expresses the inability of the classical concepts "particle" or "wave" to fully describe the behaviour of quantum-scale objects.

Q6. What are matter waves?

Ans:→ <u>matter waves</u>:→ According to De-Broglie, a wave is associated with each moving particle which is called matter waves. This wave has wave length $\lambda = \frac{h}{p}$.

Here,

h = planck's constant

P = moment of the moving partical.

Q7. Derive an expression For particle in a Box.

Ans:- The difference between classical machanics and quantum mechanics is huge. while in classical mechanics particles and objects have clearly- defined positions, in quantum mechanics (prior to a measurement) a particle can only be said to have a range of possible positions. which are described in terms of probabilities by the wave function.

The schrodinger equation defines the wave function of quantum mechanical system, and learning how to use and interpret it is an important part of any Course in quantum mechanics. one of the simplest examples of solution to this equation is for a particle in a box.

- The particle in a Box (Infinite square well).

one of the simplest solutions to the time-Independent schrodinger equation is for a particle in an infinitely deep square well (i.e. an infinite potential well), or a one dimensional box of base length L. of Course, these are theoretical idealizations, but it gives a basic idea of how you solve the Schrodinger equations without accounting for many of the complications that exist in nature. with the potential energy set to '0' outside the well where probability density is also '0', the Schrodinger equation for this situation becomes:

$$H(\psi) = i\hbar\frac{\partial\psi}{\partial t} \quad [\because H \text{ is the Hamiltonian operator.}]$$

$$H = \frac{-\hbar}{2m}\frac{\partial^2}{\partial x^2} + v(x)$$

Here, m is the mass and $\hbar$ is planck's Constant and $v(x)$ is a general function for the potential energy of system

$H(\psi)(x) = E(\psi(x))$

$f(t) = e^{-iEt/\hbar}$

$$\frac{-\hbar^2}{2m} \cdot \frac{d^2\psi(x)}{dx^2} = E(\psi)(x)$$

$\psi(x) = A\sin(kx) + B\cos(kx)$ [∴ constant B must be equal zero.]

$\psi(x) = A\sin(kx)$

you can also use the boundary conditions to get a value for k. since the sin fuction goes to zero at values $n\pi$,

$$\psi(x) = \sqrt{\frac{2}{L}} \sin\left(\frac{n\pi}{L} x\right)$$

using the original equation and this result, you can then solve for E, which yields:

$$\boxed{E = \frac{n^2 h^2}{8mL^2}}$$

~~Note~~ n is the expression means that the energy levels are quantized, so the can't take any value, but only a discrete set of specific energy level values depending on the mass of the particle and the length of the Box.

particle in a Box (Finite square well).

The Same problem gets a little more complicated If the potential well has a finite wall height. for example, if the potential $v(x)$ takes the value V_0 outside the potential well and '0' inside it, the wave function can be determined in the three maine regions covered by the problem. This is a more involved process, though, so here you'll only be able to see the results rather than run through the whole process.

if the well is at $x=0$ to $x=L$ again, for the regions where $x<0$ the solution is:

$$\boxed{\psi(x) = Be^{kx}}$$

for the region $x>L$, it is:

$$\boxed{\psi(x) = Ae^{-kx}}$$

where,

$$\boxed{k = \sqrt{\frac{2me}{h^2}}}$$

for the region inside the well, where $0<x<L$, the general solution is:

$$\psi(x) = C\sin(wx) + D\cos(wx)$$

where

$$\boxed{w = \sqrt{\frac{-2m(E+V_0)}{h^2}}}$$

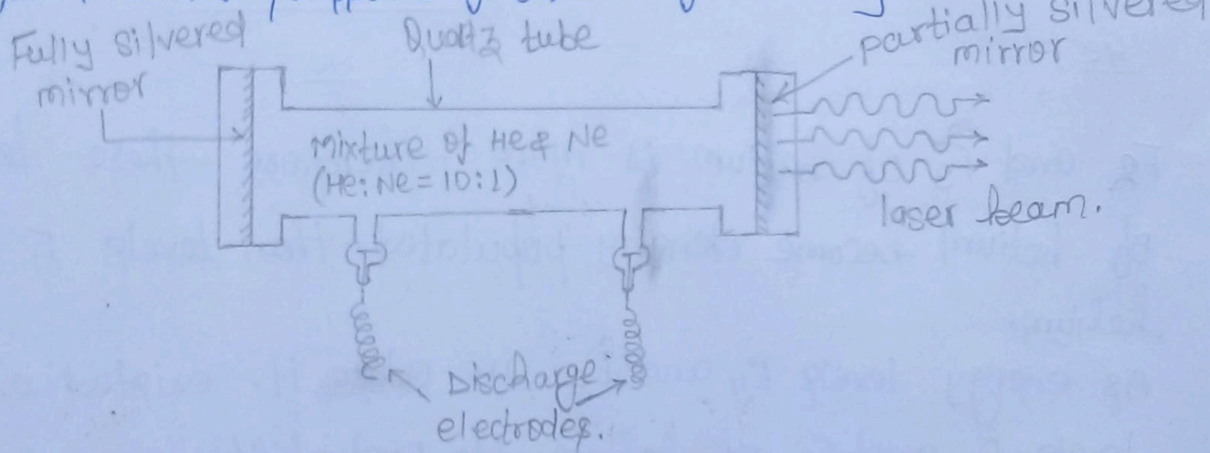
you can then use the boundary conditions to determine the values of the constants A, B, C and D, nothing that as well as having defined values at the walls of the well, the wave function and its first derivative has to be continuous everywhere, and the wave function has to be finite everywhere.

Q8. Describe Construction, working along with energy levels diagram of Gas Laser.

Ans:→ Helium-Neon laser was developed by A. Javan and his cowerbers in Bell labs in U.S.A in 1961.

He-Ne laser is a four level laser. He-Ne Laser is a gas laser consists of He and Neon atoms in ratio 10:1 enclosed in a long narrow tube made of Quartz.

He is filled under pressure of 1 mm of mercury and Ne is filled under pressure of 0.1 mm of mercury.



He-Ne LASER.

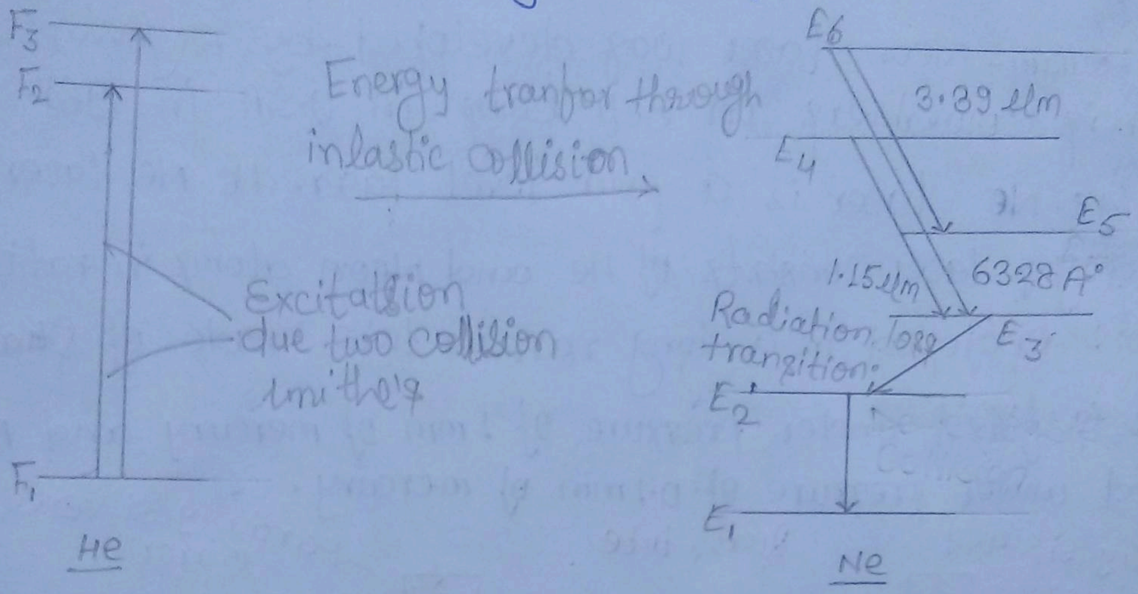
one end of tube is fully reflecting and other end is particially reflecting end plate.

-This gas laser is the commonly used low power laser, hence no cooling arrangements are required.

OPERATION OR WORKING

A high voltage is applied across the gas mixture produces electrical breakdown If gas into ions and electrons. Sperated fast moving electrons Collide with He and Ne atoms and excitue then to high energy levels. Helium atoms are more readily excitable than

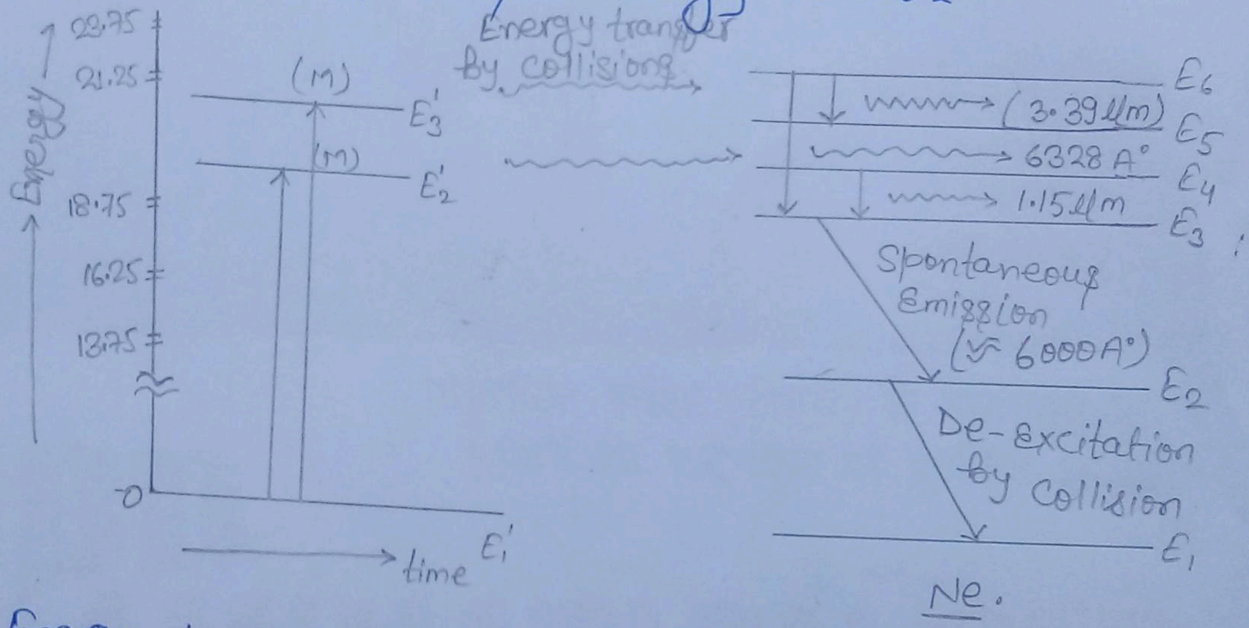
Neon atoms as they are lighter.
The life time of energy levels.



F2 and F3 of helium is more therefore these levels of helium become density populated than levels F_1 of helium.
As energy levels E_4 and E_6 are close it. existed energy levels F_2 and F_3 of helium. the probability of helium. atoms transforming their energy to neon atoms by inclastic collision is greater than probability of exicted helium atom to ground state F_1 by spontaneous emission.
since pressure of helium atoms is tem times greater than pressure of neon, the levels E_6 and E_4 of neon are density populated than other energy levels.
photos which energy $E_6 - E_3 = h\nu$ stimulate transition. to level E_3. During this transition radiation is emitted with wavelength 6328 A°. which is very popular line of He- Ne laser.
from energy level E_3 emission of radiations is

observed spontaneously to energy level E_2. Since level E_2 of neon is a metastable state then possibility of atoms in level E_2 getting reexcited again to higher level E_3 if it happens than it may disturb the population inversion between levels E_6 and E_3.

This can be protected by reducing the diameter of ~~the~~ tube so that atoms in energy level E_2.



Energy transition directly to lower energy level E_1 mainly through collisions which walls of tube instead of exciting atoms from level E_2 to level E_3.

He-Ne laser can be operated at any wavelengths.

(i) $\lambda = 6328$ A°

(2) $\lambda = 3.39\ \mu m$

(3) $\lambda = 1.15\ \mu m$

This multiplication process results and a very large no. of photons of exactly same frequency, same direction and same phase are produced as a laser output. Power output is in the range of 1 to 10,000 milliwatts.