QUANTUM MECHANICS

Q: What is meant by Dual nature of matter ?

Matter is made up of particles like electrons, protons, neutrons, atoms etc also waves are associated with these matter particles under suitable conditions. Thus matter exhibiting both particle & wave nature is called dual nature of matter.

Q: What are de-Broglie (matter) waves ?

de-Broglie(matter) waves are the waves associated with material particles in motion.

Q: Derive an expression for de-broglie wavelength(λ).

According to Einstein's mass-energy relation E=mC^2……(1)

where m=mass, C=speed of light.

also, from Planck's quantum theory, E = $\frac{hC}{\lambda}$ …………(2)

where h=planck's contant,

v=frequency. From eqns 1&2, mC^2 = $\frac{hC}{\lambda}$

$$\therefore \ \boldsymbol{\lambda = \frac{h}{mC}}$$

Similarly, for a particle of mass **'m'** moving with a velocity **'v'**,

De-broglie wavelength, **λ = $\frac{h}{mV}$ or λ = $\frac{h}{P}$ since P= mv**

Q: Expression for De-broglie's wavelength of an electron accelerated in a potential difference 'V' volt OR **Show that λ = $\frac{12.28}{\sqrt{V}}$ Å for an electron accelerated in a potential difference 'V' volt**

The K.E of an electron of mass 'm', charge 'e' accelerated in a potential 'V' volt is given by $\frac{1}{2}mv^2 = eV$, multiplying both Nr. and Dr. of LHS by 'm'

we get, $\frac{m^2v^2}{2m} = eV$

$ie;\ m^2v^2 = 2meV$

$P^2 = 2meV \ \because mv = P$

$\boldsymbol{P = \sqrt{2meV}}$

But **λ = $\frac{h}{P}$** $\therefore \ \boldsymbol{\lambda = \frac{h}{\sqrt{2meV}}}$

$$= \frac{6.625x10^{-34}}{\sqrt{2x\,9.1x10^{-31}x1.6x10^{-19}V}}$$

$$= \frac{1.228x10^{-9}}{\sqrt{V}} \text{ m}$$

$$= \frac{1.228}{\sqrt{V}} nm = \frac{12.28}{\sqrt{V}} \text{Å}$$

Q: State & explain Heisenberg's Uncertainty Principle (HUP). Mention its significance.

HUP states that "the product of the uncertainties in the simultaneous measurement of the position (Δx) in the position and momentum(ΔP_x) of a particle is equal to or greater than (h/4**π**) "

i.e.: $\Delta x \, \Delta P_x \geq \frac{h}{4\pi}$,Where h is Planck's constant.

The significance of HUP is that, it is impossible to determine simultaneously both the position and momentum of the particle accurately at the same instant.

NOTE : Other HUP relations are $\Delta E . \Delta t \geq \frac{h}{4\pi}$, $\boldsymbol{where\ \Delta E = energy, \Delta t}$**= time,**

and $\Delta L . \Delta \theta \geq \frac{h}{4\pi}$ **, where** , $\boldsymbol{\Delta L = angular\ momentum\ \&\ \Delta\theta = displacement.}$

Q: Show that electrons do not present in the nucleus using Heisenberg's Uncertainty Principle.

Electron to be present in the nucleus, maximum uncertainty in position $\Delta x = 10^{-14}$ m (diameter)

According to HUP,

The minimum uncertainty in momentum $\Delta P_x \geq \frac{h}{4\pi \ \Delta x}$

$$\geq \frac{6.625 \ x \ 10^{-34}}{4 \ x \ 3.14 \ x \ 10^{-14}}$$

$\Delta P_x \geq 5.275 \times 10^{-21}$ kg m/s = P(say)

The minimum energy of the electron in the nucleus is given by

$$\therefore E \geq \frac{P^2}{2m}$$

$$\geq \frac{(5.275 \ x \ 10^{-21})^2}{2x9.11x10^{-31}}$$

$$\geq 1.527 \ x 10^{-11} \ J$$

$$\geq \frac{1.527 \ x 10^{-11}}{1.6 \ x \ 10^{-13}} MeV \geq 95.45 \ MeV \approx 95 \ MeV$$

But the maximum kinetic energy of the electrons(**β**-particle) emitted from the nucleus does not exceed 4MeV,hence electrons do not present in the nucleus.

Q: What is a wave function and mention it's properties/limitations

The variable quantity that characterizes the de-broglie wave of the particle is called a '**Wave function**' denoted by the symbol '**Ψ**'(Psi)

Mathematically wave function '**Ψ**' describes the motion of a particle.

Ψ is called probability amplitude which is space and time dependent.

Properties of the wave functions are:-

1. Wave function (**Ψ**) is single valued everywhere .
2. **Ψ** is finite everywhere.
3. **Ψ** is continuous everywhere.

4. First derivatives of are continuous and single valued everywhere.
5. $I\Psi I^2$ is called probability density.
6. $Probability\ of\ finding\ particle\ in\ space\ is\ given\ by\ \int_{-\infty}^{+\infty} I\Psi I^2 dV = 1$
7. Probability , P = $\int_{-\infty}^{+\infty} I\Psi I^2 dx$

Max Born's interpretation of wave function.

1. A satisfactory interpretation of the wave function Ψ associated with a moving particle was given by Max Born in 1926.
2. Max Born postulated that the square of the magnitude of the wave function $|\Psi|^2$ evaluated at a particular point represents the probability of finding the particle at that point.
3. $|\Psi|^2$ is called probability density and Ψ is called the probability amplitude.
4. According to Max Born interpretation the probability of finding the particle in space is given by $\int_{-\infty}^{+\infty} |\Psi|^2\, dv = 1$
5. Any wave function that obeys this equation is said to be' normalised'. Every acceptable wave function must be normalisable.
6. The normalized function must be Finite, Single valued and continuous everywhere.

Q: Set up 1D time independent Schrodinger wave equation for a free particle.

One dimensional wave function **Ψ** for the de-broglie wave of a particle moving along the positive direction of x-axis is given by

$$\mathbf{\Psi} = Ae^{i(kx-\omega t)}$$

$$= Ae^{ikx}\ e^{-i\omega t},$$

Where Ae^{ikx} represent the time independent part of the wave function and is represented by $\psi = Ae^{ikx}$ ...... (1)

differentiating eqn (1) w.r.t 'x' twice we get

$$\frac{d\psi}{dx} = A(ik)\ e^{ikx} \quad \text{and}$$

$$\frac{d^2\psi}{dx^2} = A(ik)\ (ik)\ e^{ikx}$$

$$= i^2\ k^2\ Ae^{ikx} \quad ....(2)$$

From eqns 1 & 2 we get

$$\frac{d^2\psi}{dx^2} = -\frac{4\pi^2}{\lambda^2}\ \psi \quad ....(3) \because \boldsymbol{i^2} = -1\ \&\ \boldsymbol{k} = \frac{2\pi}{\lambda}$$

But, de-broglie wave length $\lambda = \frac{h}{mv}$

$$\therefore \frac{1}{\lambda^2} = \frac{m^2v^2}{h^2}$$

$$= \frac{2m(½mv^2)}{h^2}$$

also,the kinetic energy in terms of the total energy (E) & the potential energy(V) is given by ($\frac{1}{2}mv^2$=(E−$\boldsymbol{V}$)

$$\therefore \frac{1}{\lambda^2} = \frac{2m(E-\boldsymbol{V})}{h^2} \;\ldots\ldots(4)$$

From eqns 3 & 4 ,we get $\frac{d^2\psi}{dx^2} = -\frac{4\pi^2 2m(E-\boldsymbol{V})}{h^2}\psi$

$$\frac{d^2\psi}{dx^2} + \frac{8\pi^2 m(E-\boldsymbol{V})}{h^2}\psi = 0 \;\ldots\ldots(5)$$

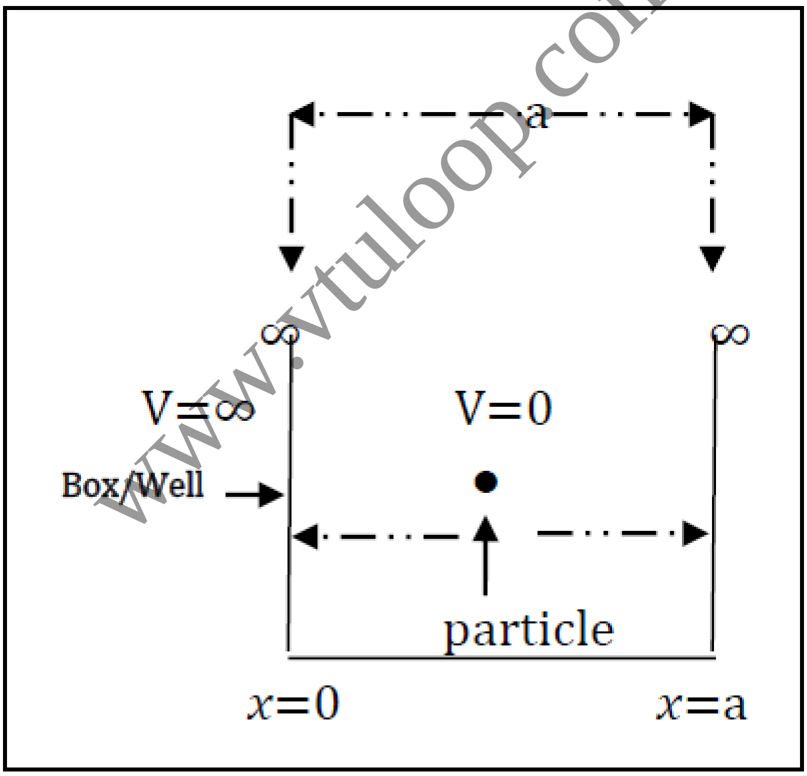
This is Schrodinger time independent equation for a particle

For a free particle ,V=0

$$\therefore \frac{d^2\psi}{dx^2} + \frac{8\pi^2 mE}{h^2}\psi = 0$$

This is Schrodinger time independent equation for free particle.

Q: Obtain normalized wave function for a free particle in a infinite walled potential Box/Well using Schrodinger 1D time independent equation.



Consider a particle of mass 'm' moving by reflection at infinitely high walls of a Box/well of width 'a' moving between x=0 & x=a Potential V=0 inside the Box/well and V=∞ outside the Box/well .one dimensional Schrodinger equation for particle is given by

$$\frac{d^2\psi}{dx^2} + \frac{8\pi^2 m(E-\boldsymbol{V})}{h^2}\psi = 0 \quad \ldots\ldots(1).$$

For a particle inside the Box/well V=0

$\therefore \frac{d^2\psi}{dx^2} + \frac{8\pi^2 mE}{h^2}\psi = 0$ ....(2)

Putting $\frac{8\pi^2 mE}{h^2} = K^2$ .....(3) in equation (2) ,

we get $\frac{d^2\psi}{dx^2} + K^2\psi = 0$ ......(4)

The general solution of the quadratic equation (4) is of the form

ψ (x)=A sin(Kx) +B Cos(Kx) ......(5)

where A & B are constants determined from boundary conditions as follows :

ψ (x)=0 at x=0 from eqn (5), 0=A x 0 +B x 1

∴ B=0

also, ψ (x)=0 at x=a ∴ from eqn(5) 0=A Sin(Ka)+0xCos(Ka)

0= A Sin(Ka)

Sin(Ka) = 0 as A$\neq 0$

∴ Sin(Ka) =0= Sin(nπ)

ie: Ka=nπ or K=$\frac{n\pi}{a}$ .....(6)

From eqns 3 & 6 ,we get $\frac{8\pi^2 mE}{h^2} = \frac{n^2\pi^2}{a^2}$

∴ E = $\frac{n^2h^2}{8a^2m}$ or

In general E_n= $\frac{n^2h^2}{8a^2m}$ ...(7)

where n=1,2,3..called quantum number.

The values of E_n are called **Eigen energy values** which satisfy Schrodinger wave equation.

Substituting the values of B=0 & K= $\frac{n\pi}{a}$ in eqn 5, we get

$\psi_n(x)$ = A Sin($\frac{n\pi x}{a}$) ....(8)

To find 'A' by normalization:

Applying the normalization condition $\int_{-\infty}^{+\infty} I\Psi I^2 dx = 1$ to eqn 8 for x=0 & x=a, we get

$$\int_0^a A^2\, Sin^2\left(\frac{n\pi x}{a}\right)dx = 1$$

$$A^2 \int_0^a ½[1 - Cos\left(\frac{2n\pi x}{a}\right)]dx = 1 \quad \because \; Sin^2(\theta)=½[1\text{-}Cos(2\theta)]$$

$$½A^2 \left[\int_0^a 1dx - \int_0^a Cos\left(\frac{2n\pi x}{a}\right)dx\right] = 1$$

$$½A^2 \{ [x]_0^a - [\frac{a}{2n\pi} \text{Sin}(\frac{2n\pi x}{a})]_0^a \} = 1 \quad \because \int Cos(mx)\, dx = \frac{Sin(mx)}{m}$$

$$½A^2 \{ [a-0] - [\frac{a}{2n\pi}\text{Sin}(2n\pi) - \frac{a}{2n\pi}\text{Sin}(0)] \}=1$$

$$½A^2 \{ [a-0] - [0 - 0] \}=1$$

$$A^2 a = 2 \Rightarrow A^2 = 2/a \text{ or } \mathbf{A} = \sqrt{2/a} \quad ...(9)$$

From eqns 8 &9,the normalized **Eigen functions** are *given by*

$\boldsymbol{\psi_n(x)}$**=** $\sqrt{2/a}$ **Sin(**$\frac{n\pi x}{a}$**)** .....(10)

Eigen energy values and Eigen wave functions :

Eigen energy values are the energy values which satify Schrodinger wave equation and are given by $E_n = \frac{n^2h^2}{8a^2m}$

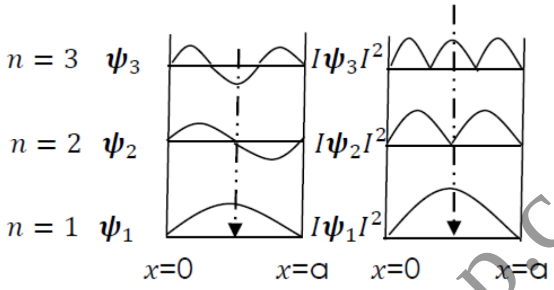
For n=1 gives $E_1 = \frac{h^2}{8a^2m}$ = E_o called end point /ground state energy

n=2 gives $E_2 = \frac{4h^2}{8a^2m}$ = 4 E_o called 1[st] excited state energy

n=3 gives $E_3 = \frac{9h^2}{8a^2m}$ =9 E_o ,called 2[nd] excited state energy & so on

Eigen wave functions are the wave functions which have single finite value and continuous

Everywhere and is given by $\psi_n(x) = \sqrt{2/a}\,\text{Sin}(\frac{n\pi x}{a})$



$Eigen\ functions\ \ \psi_1, \psi_2, \psi_3, \dots and$

$their\ probability\ densities\ I\psi_1I^2, I\psi_2I^2, I\psi_3I^2$ ... are represented as shown in the diagrams.The probability of finding the particle at the anti-nodes is maximum and at nodes is zero.(The particle never found at nodes)

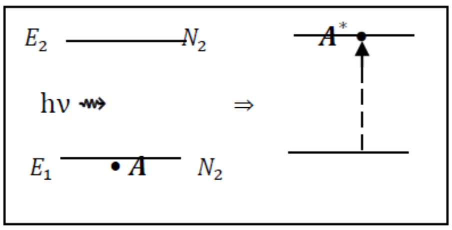
LASERS

Q: Explain Einstein's explanation of interaction of radiation with matter (or) Explain Induced absorption , Spontaneous emission &Stimulated emission.

Consider a system of energy density U_ν and Let N_1 & N_2 be the population of the energy states E_1 & E_2 respectively so that $(E_2 - E_1) = h\nu$ & $E_2 > E_1$

According to Einstein radiation interacts with matter in 3 ways namely:

1) Induced absorption:

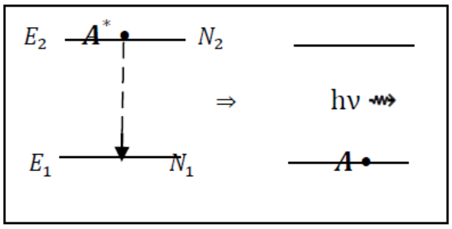


Induced absorption is the phenomenon in which an atom(A) in the lower energy state E_1 absorb the incident photon of energy 'hν' & excite to the higher energy state E_2 if $(E_2 - E_1) = h\nu$ .Mathematically it(induced absorption) is represented as

hν +A → A^* **or** photon +atom→ $atom^*$

Also, Rate of induced absorption = $B_{12} N_1 U_\nu$,where $U_\nu = energy\ density$ &
$B_{12} = Einstein's\ induced\ absorption\ coefficient.$

2.Spontaneous emission:



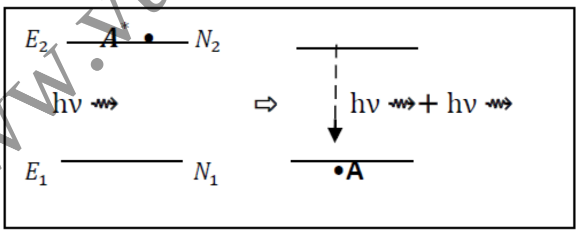
Spontaneous emission is the phenomenon in which an atom (A) in the excited state of energy E_2 de-excite to the lower energy state E_1 without any external influence by emitting a photon of energy $h\nu = (E_2 - E_1)$.

Mathematically, it is represented as $A^* \rightarrow$ **A + hν**

Also, Rate of Spontaneous emission = $A_{21} N_2$

$where\ A_{21} = Einstein's\ spontaneous\ emission\ coefficient.$

3.Stimulated emission:



Stimulated emission is the phenomenon in which an atom (A^*) in the excited state of energy E_2 de-excite to the lower energy state E_1 under the influence of an external photon (hν) by emitting an identical photon of energy $h\nu = (E_2 - E_1)$.

Mathematically,$it\ is\ represented\ as$ $h\nu + A^* \rightarrow$ **A +2 hν**

Also, Rate of Stimulated emission= $B_{21} N_2 U_\nu$,where $U_\nu = energy\ density$ &
$B_{21} = Einstein's\ Spontaneous\ emission\ coefficient.$

Q: Explain the terms : Active medium ; Population Inversion ; Pumping ; Meta stable state and Laser Cavity(Optical resonator) Or Explain the requisites of a laser system.

The requisites of a laser system are :

1. **Active medium** is a Solid/Liquid/Gas medium in which stimulated emission and amplification of the radiations can be achieved.

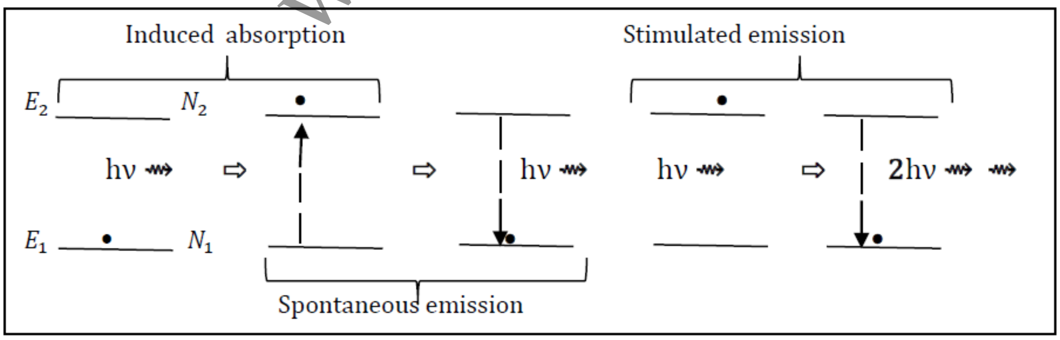
2. **Pumping** is the supply of energy to the atoms in the lower states in order to excite them to higher states. The methods of pumping are Optical pumping, Electrical pumping, Forward bias pumping ,Chemical pumping, Elastic one-one collisions.

3. **Population Inversion** is condition of system in which the population of higher energy states exceed the population of lower states.

4. **Meta stable state** is an intermediate state in which the average life of the atoms is of the order of 10^{-3}s ie: their life is 10^{5} times more than that of normal states.

5. **Laser Cavity(Optical resonator)** is a pair of parallel/con-focal/concentric mirrors between which active medium is placed so that stimulated emitting photons are used to cause further Stimulated emissions and to amplify the beam.
   One mirror is highly silvered and the other partially silvered. The distance between the mirrors is given by L = $\frac{n\lambda}{2}$,where λ = wavelength and n = number of stationary waves produced.

***Q*:Derive an expression for energy density in terms of Einstein's coefficients (or) Derive the relation between Einstein's coefficients**



Consider a system of energy density U_ν in thermal equilibrium. Let N_1 & N_2 be the population of the energy states E_1 & E_2 respectively, where ($E_2 > E_1$)

WKT,

Rate of induced absorption = $B_{12}\, N_1 U_\nu$,

where B_{12} = $Einstein's\ coefficient\ of\ induced\ absorption$.

Rate of Spontaneous emission = $A_{21} N_2$ where A_{21} = *Einstein's coefficient of spontaneous emission* and

Rate of Stimulated emission= $B_{21} N_2 U_\nu$,

where $B_{21} = Einstein's\ coefficient\ of\ Stimulated\ emission$.

At thermal equilibrium,

Rate of induced absorption = $\begin{Bmatrix} Rate\ of\ Spontaneous \\ emission \end{Bmatrix} + \begin{Bmatrix} Rate\ of\ Stimulated \\ emission \end{Bmatrix}$

ie: $B_{12} N_1 U_\nu = A_{21} N_2 + B_{21} N_2 U_\nu$

$\therefore U_\nu (B_{12} N_1 - B_{21} N_2) = A_{21} N_2$

$ie: U_\nu = \frac{A_{21} N_2}{(B_{12} N_1 - B_{21} N_2)}$ dividing both Nr & Dr by $B_{21} N_2$,we get

$$= \frac{A_{21}}{B_{21}} \frac{1}{\left[\frac{B_{12}}{B_{21}}\frac{N_1}{N_2} - 1\right]} \quad ....(1)$$

According to Boltzmann's law, $\frac{N_1}{N_2} = e^{(E2-E1)/KT} = e^{h\nu/KT}$ ....(2)

From eqns 1 &2 , we get. $U_\nu = \frac{A_{21}}{B_{21}} \frac{1}{\left[\frac{B_{12}}{B_{21}} e^{h\nu/KT} - 1\right]}$ ....(3)

But .the energy density given by Planck's law is $U_\nu = \frac{8\pi h\nu^3}{c^3} \frac{1}{(e^{h\nu/KT} - 1)}$ ......(4)

Comparing eqns 3 & 4 ,we get $\boldsymbol{B_{12} = B_{21}}$

Thus coefficient of Induced absorption = coefficient of stimulated emission.

and $\frac{8\pi h\nu^3}{c^3} = \frac{A_{21}}{B_{21}} = U_\nu \left(e^{\frac{h\nu}{KT}} - 1\right)$

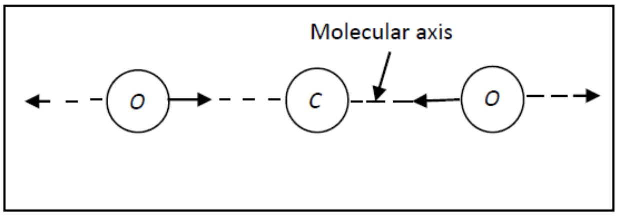
Thus, energy density $\boldsymbol{U_\nu = \frac{A_{21}}{B_{21}} \frac{1}{[e^{h\nu/KT} - 1]}}$

This is the expression for energy density in terms of Einstein's coefficients or relation between Einstein's coefficients.

Q:Explain the fundamental mode of vibration in CO_2 molecule.

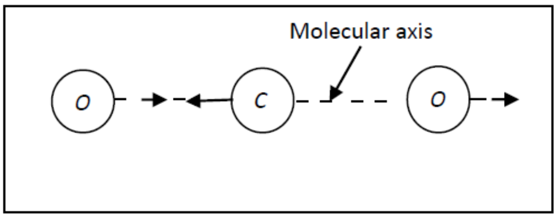
In CO_2 molecule there are three fundamental modes of vibrations, namely

1. **Symmetric mode :**



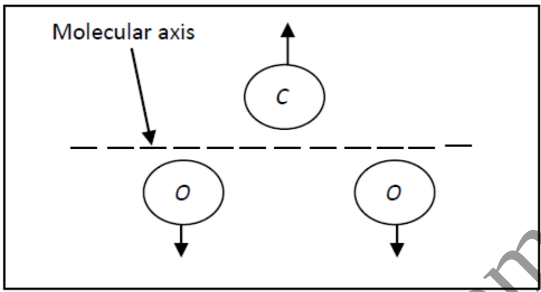
Symmetric mode is the mode in which both the oxygen atoms oscillate simultaneously to & fro about the stationary carbon atom along the molecular axis.

2. Asymmetric mode:



Asymmetric mode is the mode in which both the oxygen atoms move in one direction and the carbon atom move in the opposite direction along the molecular axis.

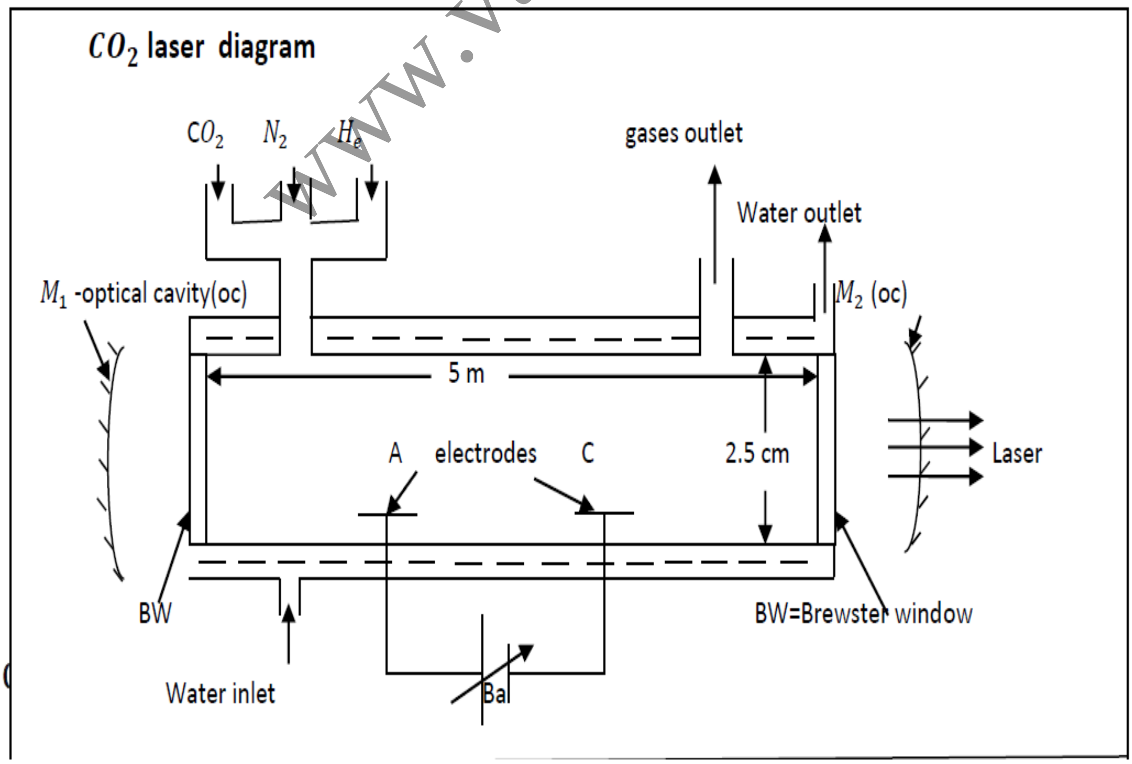
3. Bending mode:

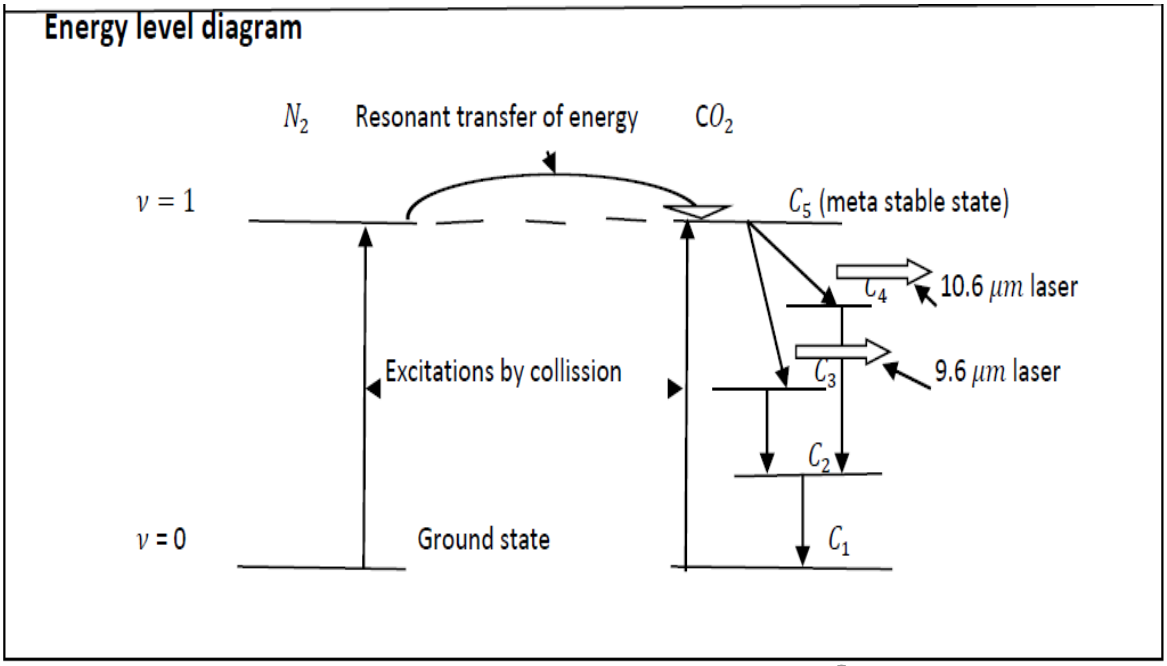


Bending mode is the mode in which both oxygen atoms and carbon atom move in opposite directions perpendicular to the molecular axis.

The internal vibrations of CO_2 molecule are the combination of the above three modes.

Q:Explain the principal, construction and working of CO_2 laser.





Principle : CO_2 laser works on the principle of stimulated emission.

Construction:

1) The schematic diagram **CO_2 Laser** is as shown in the diagram invented by CKN Patel an Indian engineer
2) It consists of a (glass)discharge tube of length 5 m & diameter 2.5 cm filled with a mixture of gases CO_2 ,N_2 ,He in the ratio 1:2:3
3) High DC voltage can be applied to the gas between the electrodes A&C .
4) Ends of the tube is fitted with (NaCl) Brewster windows to get polarized laser beam
5) Two con-focal silicon mirrors coated with aluminum are provided at the ends of the tube which act as optical resonators.
6) Cold water is circulated through a tube surrounding the discharge tube

Working:

1) CO_2 Laser is a four level molecular gas laser which produce continuous or pulsed laser beam.
2) It works on the principle of stimulated emission between the rotational sublevels of an upper & lower vibrational levels of CO_2 molecules.
3) Ionisation takes place due to electric discharge when high DC voltage is applied between electrodes producing electrons.
4) The accelerated electrons excite both N_2& CO_2 atoms to their higher energy levels ' ν =1 & C_5 from their ground states 0 & C_1 due to collision as follows:

$$e+N_2 \rightarrow N_2^*+e' \quad \text{and}$$

$$e+CO_2 \rightarrow CO_2^*+e'$$

where e& e 'are the energies of electron before and after collision.

5) N_2^* molecule in excited level collide with CO_2 molecules in their ground state C_1 & excite it to metastable state C_5 by resonant energy transfer as level C_5 of CO_2 is same as level ν=1 of N_2 given by

$$N_2^* + CO_2 \rightarrow CO_2^* + N_2$$

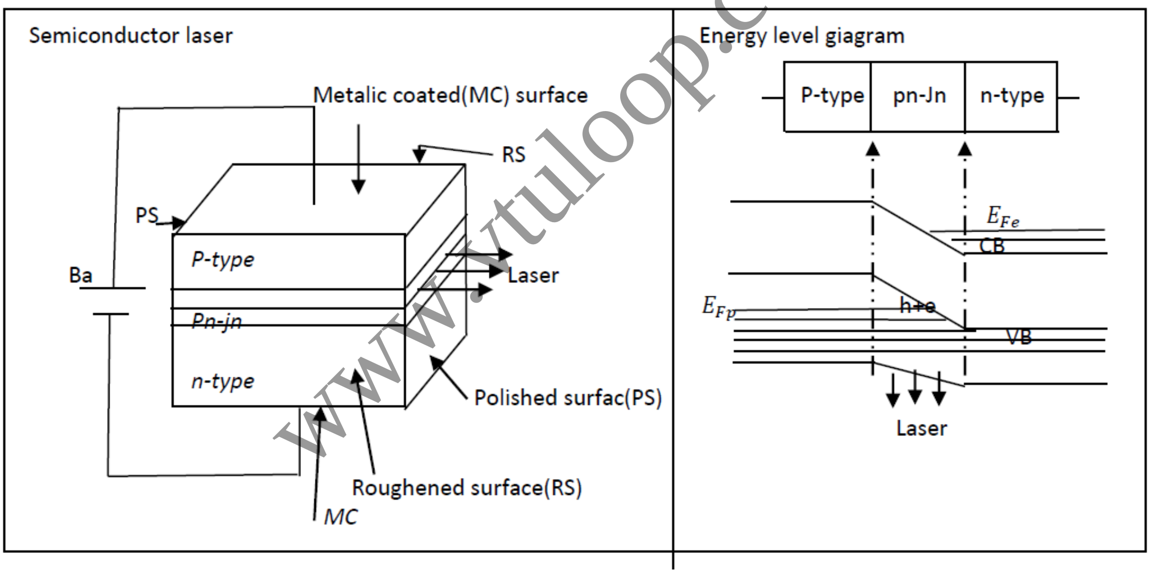
6) As this process continues due to electric discharge pumping , population inversion takes place betweenC_5 &C_4 and C_5 & C_3.
7) The transitions/de-excitations takes place as follows:

$C_5 \rightarrow C_4$ producing laser 10.6μm (IR region)
$C_5 \rightarrow C_3$ producing laser 9.6μm (IR region)

$$\left.\begin{array}{l} C_4 \rightarrow C_2 \\ C_3 \rightarrow C_2 \\ C_2 \rightarrow C_1 \end{array}\right\} \text{Radiation less transitions}$$

8) Due to high thermal conductivity of He, it removes heat from mixture and de-populate the lower states C_3 &C_2 quickly .
9) Laser beam is amplified by using optical resonators.
10) The laser output is 100kW for continuous mode and 10 kW in pulsed mode.

Q: Explain the Principle,construction and working of Semi-conductor laser.



Principle: SC laser works on the principle of stimulated emission.

Construction:

1. The schematic diagram of GaAs semi-conductor device is as shown in the diagram.
2. It consists of heavily doped n-region of GaAs doped with tellurium and p-region of GaAs doped with zinc.
3. The upper and lower surfaces are metalized so that pn-junction is forward biased .
4. Two surfaces perpendicular to the Jn are polished so that they act as optical resonators and the other two surfaces roughened to prevent lasing in that direction.

Working:

1. Semi-conductor laser are made up of highly de-generate semi-conductors having direct band gap like Gallium Arsenide (GaAs).
2. When GaAS diode is forward biased with voltage nearly equal to the energy gap voltage, electrons from n-region & holes from p-region flow across the junction creating population inversion in the active jn region.
3. As the voltage is gradually increased due to forward biasing population inversion is achieved between the valence band and conduction band which in turn result in stimulated emission.
4. Photons produced are amplified between polished optical resonator surfaces producing laser beam.
5. GaAs laser produce laser beam of wavelength 8870Å in IR region , GaAsP produce laser beam of 6500Å in visible region etc.

Q:Mention the characteristics of laser beam.

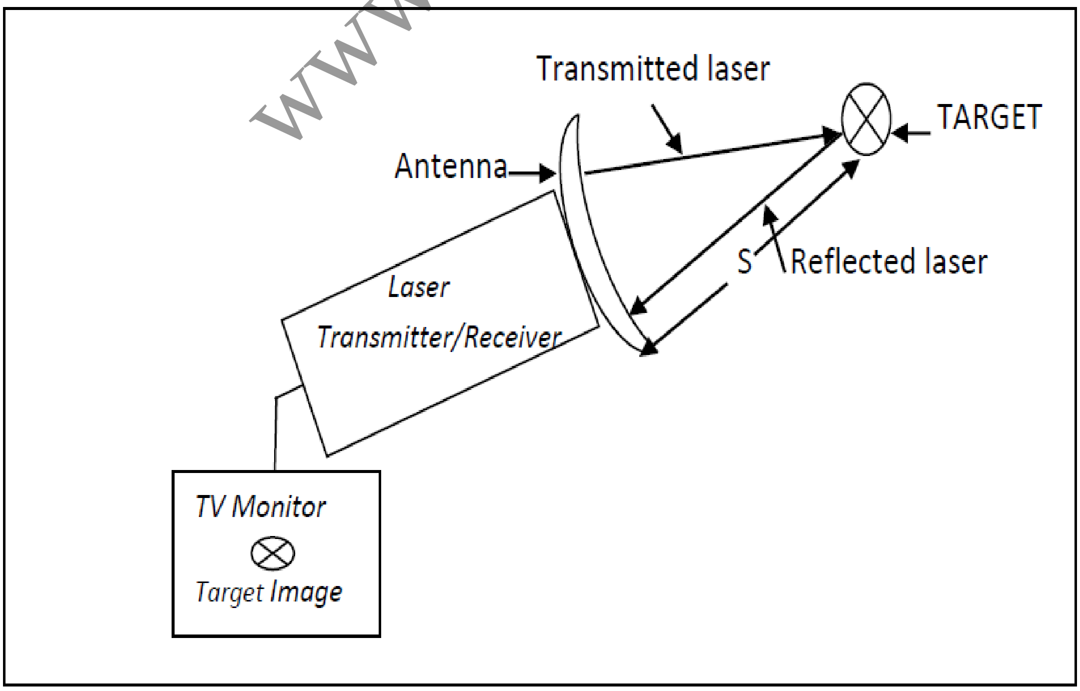
The laser beam characteristics are:

1. They are highly monochromatic.
2. They are highly coherent.
3. They are highly directional.
4. They are highly focusable.
5. They are least divergent.

Q:Mention the uses of laser beam.

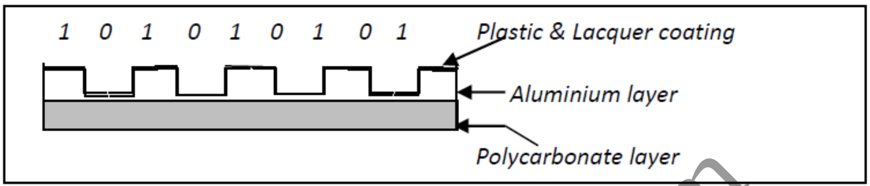
Application of laser in Defence as range finder

High intensity, High coherence and High directionality of laser is made use of in Defence range finder.



The schematic diagram of range finder is as shown in the diagram.
Range finder works on the principle that, Distance = Velocity X time. Laser beam is transmitted towards the target and the reflected laser beam from the target is received. The time (t)elapsed between the transmitting laser and receiving the beam is measured. If 'S' be the distance of the target, then the range of the target is given by S = $\frac{vt}{2}$
In practice computer aided calibrated devices are used to display the distance and direction on the monitor screen directly and accurately.
Tankers, Fighter planes, Guided missiles are equipped with range finders to destroy the enemy targets without bringing to the pre-notice of enemy.

Use of laser in data storage in CDs(Compact Discs) and DVDs(Digital Varsatile Discs) :



1. High intensity, High focussability of laser is made use of for storing data in CDs and DVDs.
2. CD and DVDs are made up of three layers as shown in the diagram.
3. CDs and DVDs are thin circular discs of about 12 cm diameter metal disc usually aluminium on which digital information such as computer files, audio and video data etc are recorded. The data is stored as minute 'Pits' (0s)and 'Lands'(1s) binary language in spiral track on the surface of the disc. The data is read with low power laser device focused on the tracks.
4. The bottom layer is made of polycarbonate which is tough and brittle. Above this is aluminium layer coated with plastic and Lacquer(synthetic substance which dries to form a hard protecting coating).
5. To store data laser beam burn and create tiny bumps of space in the track called "Pits" which denote '0' and un burnt space in the track called "Lands' which denote '1' along the spiral track. Thus data is stored in binary language as 0s and 1s.
6. Data can be reproduced by scanning the pits and lands along the spiral track using a low power laser .An electronic circuit generate 0s and 1s and decoder convert these binary numbers in to original data.
7. Storage capacity of CD is 700 MB and that of DVDs is about 4.7 GB .Blu- ray Disc Xtra Large(BDXL) can store data more than 50GB.