CMR INSTITUTE OF TECHNOLOGY

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Internal Assesment Test - II

Sub:	Engineering Physics							Code:	15PHY12
Date:	04/ 11 / 2016	Duration:	90 mins	Max Marks:	50	Sem:	I^{st}	Branch:	All

Answer Any FIVE FULL Questions

Note: Value of Constants: $h = 6.625\times10^{-34}$ Js $k = 1.38\times10^{-23}$ J/K $m = 9.11\times10^{-31}$ kg. $\varepsilon_o = 8.85\times10^{-12}$ Fm^{-1}		Marks	OBE CO	OBE RBT
1 (a)	Define superconductivity. Describe how BCS theory explains superconductivity.	[5]	CO3	L2
(b)	Distinguish between Type I and Type II superconductors.	[5]	CO3	L3
2 (a)	Derive an expression for conductivity in an intrinsic semiconductor. State and explain law of mass action for semiconductors.	[6]	CO3	L2
(b)	The electron and hole mobility of silicon are 0.19 $m^2 V^{-1} s^{-1}$ and 0.08 $m^2 V^{-1} s^{-1}$ respectively at a certain temperature. If the electron density is 1.5×10^{16} electron/ m^3, calculate the resistivity of silicon.	[4]	CO3	L2
3 (a)	Obtain an expression for energy density of radiation under equilibrium condition in terms of Einstein's coefficients.	[6]	CO4	L2
(b)	Describe briefly the applications of lasers in welding, cutting and drilling.	[4]	CO4	L2
4 (a)	Describe the construction of CO_2 laser and explain its working with the help of energy level diagram.	[7]	CO4	L2
(b)	Find the ratio of population of the two energy levels in a medium in thermal equilibrium if the transition between them produces light of wavelength 6928 Å. Assume the ambient temperature as 27^oC.	[3]	CO4	L2
5 (a)	What is numerical aperture? Obtain an expression for numerical aperture and arrive at the condition for propagation of signal in an optical fiber.	[6]	CO4	L2
(b)	The attenuation in an optical-fiber is 5.6 dB/km. What fractional of its initial intensity remains after 8 km?	[4]	CO4	L2
6 (a)	What are modes of propagation? With neat diagrams explain the different types of optical fibers.	[6]	CO4	L2
(b)	Describe point to point communication system using optical fibers with the help of a block diagram.	[4]	CO4	L2
7 (a)	Explain in brief the seven crystal system with neat diagrams.	[7]	CO5	L2
(b)	Sketch the following planes in a cubic unit cell. **(2 0 0), (0 1 1) & (1 $\bar{1}$ 0)**	[3]	CO5	L3

8 (a)	What are Miller indices? Derive an expression for interplanar spacing in terms of Miller indices for a cubic lattice.	[6]	CO5	L3
(b)	Calculate the energy of X-ray photons that produce Bragg's diffraction of first order at an angle of 25^o when incident on a crystal with interplanar spacing of 2.1 Å.	[4]	CO5	L2

Course Outcomes		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1:	Summarize concepts of Modern Physics using examples of practical applications like electron microscopes	3	1	0	2	0	0	0	0	1	1	0	2
CO2:	Explain mathematical formulation of quantum mechanics using simple illustrative application	3	1	0	2	0	0	0	0	1	1	0	2
CO3:	Analyze RLC electrical circuits, electrical properties of materials, electronic devices like Zener Diode, Photo-diode, transistor	3	1	0	2	0	0	0	0	1	1	0	2
CO4:	Analyze principles, production and application of laser in optical communication, manufacturing industry, medicine using lab setup	3	1	0	2	0	0	0	0	1	1	0	2
CO5:	Explain crystal systems and X-ray diffraction	3	1	0	2	0	0	0	0	1	1	0	2
CO6:	Recognize emerging trends in field of nanotechnology, shock waves and its applications.	3	1	0	2	0	0	0	0	1	1	0	2

Cognitive level	KEYWORDS
L1	List, define, tell, describe, identify, show, label, collect, examine, tabulate, quote, name, who, when, where, etc.
L2	summarize, describe, interpret, contrast, predict, associate, distinguish, estimate, differentiate, discuss, extend
L3	Apply, demonstrate, calculate, complete, illustrate, show, solve, examine, modify, relate, change, classify, experiment, discover.
L4	Analyze, separate, order, explain, connect, classify, arrange, divide, compare, select, explain, infer.
L5	Assess, decide, rank, grade, test, measure, recommend, convince, select, judge, explain, discriminate, support, conclude, compare, summarize.

PO1 - *Engineering knowledge*; PO2 - *Problem analysis*; PO3 - *Design/development of solutions*; PO4 - *Conduct investigations of complex problems*; PO5 - *Modern tool usage*; PO6 - *The Engineer and society*; PO7- *Environment and sustainability*; PO8 – *Ethics*; PO9 - *Individual and team work*; PO10 - *Communication*; PO11 - *Project management and finance*; PO12 - *Life-long learning*

Solutions to 2nd INTERNAL TEST

1a.

Superconductivity is a phenomenon in which some materials lose their resistance completely below certain temperature.[1]

BCS Theory :[Bardeen , Cooper, Schrieffer]

According to this theory,as the temperature is reduced, the kinetic energy of electrons decreases and they experience feeble attraction towards positively charged lattice atoms. In the lattice, an electron passing close to a lattice atom is attracted towards it and displaces it and sets up lattice vibrations known as phonons. This lattice atom will interact with another electron and in turn forms an **electron – lattice –interaction.** This system of two electrons of equal and opposite momentum attached to a lattice atom is known as a **cooper pair**. All the cooper pairs attain a lower energy state. The electrons are bound to the lattice atom through the exchange of phonons (Lattice vibrations). [2] Each Cooper pair possesses a single wave function and wave functions associated with similar cooper pairs start overlapping and may extend over the entire super conductor. This leads to union of vast number of cooper pairs resulting in the entire union moving as a single unit. These Cooper pairs behave as bosons with net spin zero. As we know that any number of Cooper pairs can occupy single energy state, all Cooper pairs occupy lower energy state called superconducting state. When electrons flow in the form of cooper pairs in materials, they do not suffer any scattering & hence resistance of material becomes zero.

The theory predicted an existence of **energy gap Δ** between ground state (superconducting state) and first excited state (normal state). According to BCS theory, the energy gap at 0 K is given by

$$E_g(0) = 2\Delta = 3.52kT_c$$

The binding energy of Copper pairs is also equal to this energy gap & when that energy is available Cooper pairs breaks leading to normal behavior. Hence large energy gap correspond to more stable superconductors. The energy gap is maximum at 0K and is equal to zero at the critical temperature. [2]

1b.

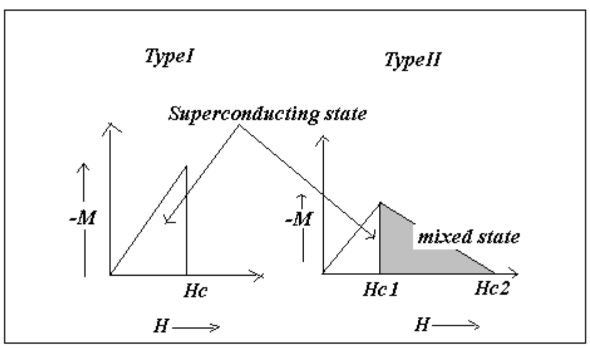
Type 1 Superconductors:

These are pure superconductors.

When kept in magnetic field, initially they continue to exhibit superconductivity and the negative magnetic moment increases. At critical magnetic field there is a sharp transition to normal state due to the penetration of magnetic flux lines. The transition is sharp.

These possess low critical magnetic fields. Their critical temperatures also low.They are generally pure metals. Type I superconductors are also known as soft superconductors.

Ex: Al, Pb [1+1(fig)]



Type 2 superconductor:

These are generally alloys.

When kept in magnetic field, initially they continue to exhibit superconductivity and the negative magnetic moment increases. At lower critical magnetic field H_{C1}, the flux lines start penetrating .As the magnetic field is increased, the super conductivity coexists with magnetic field and this phase is known as mixed state(vortex state). At higher critical magnetic field H_{C2}, the penetration is complete and the material transforms to normal state. They possess higher critical magnetic fields. Their critical temperatures are high. Therefore Type II superconductors are preferred in the fabrication of superconducting magnets. Type II superconductors are also known as hard superconductors.

Ex: Nb_3Ge, YBaCu2O3 [2+1(fig)]

2a.

For an intrinsic semiconductor (no impurities) is semiconductor crystal in which electrical conduction arises due to thermally excited electrons and holes. A single event of bond breaking leads to generation of an electron-hole pair. As the two charge carrier concentration are equal (i.e. no of electron will be equal to no of holes), they are denoted by symbol ni, which is intrinsic concentration. Thus

n=p=ni [1]

The current density due to electrons (Jn) and holes (Jp)

Jn= nevdn

= ne μnE

Jp= pevdp

= pe μpE

where n and p are concentrations of electrons and holes, vdn and vdpare drift velocities of electrons and holes and given by vdn = μnE, vdp = μpE here μn= mobility of electrons and μp= mobility of holes.

Comparing with ohm's law J=σE , where σ is the conductivity of material

So in semiconductor, conductivity due to electrons is, σn= neμn

Conductivity due to holes is, σp= peμp

Total current through the semiconductor due to electrons (In) drifting in conduction band and holes (Ip) drifting in valence band is given by

I=In+Ip

So Total current density J= Jn+ Jp [1]

= (ne μn+pe μp)E

Therefore total conductivity of semiconductor is σ= σn+ σpusing (4) and (5)

= neμn+ peμp

For intrinsic semiconductor n=p =ni[using (1)]

so electrical conductivity is given by, σ= nie(μn+ μp) [2]

2b.

Law of mass action:

The product of electron and hole concentration is constant at any given temperature independent of Fermi energy. This principle is used to calculate hole and electron densities.

In an intrinsic semiconductor at any temperature electron generated by an event of bond breaking will be equal to no. of holes generated. As the two charge carrier concentrations are equal, they are denoted by n_i, which is intrinsic density.

$$n=p=n_i$$

$$np=n_i^2$$

$$= N_C \exp\left[\frac{-(E_C - E_F)}{kT}\right] N_V \exp\left[\frac{-(E_F - E_V)}{kT}\right]$$

$$= N_C N_V \exp\left[\frac{-(E_C - E_V)}{kT}\right]$$

$$= 4\left[\frac{2\pi kT}{h^2}\right]^3 \left(m_e^* m_h^*\right)^{3/2} \exp\left(-\frac{E_g}{kT}\right)$$

E_c-E_v=E_g stands for difference in energy between top level of valence band and bottom level of conduction band which is band gap. [2]

2b.

σ= $n_i e(\mu_n + \mu_p)$ [1]

$$\rho = \frac{1}{\text{nie}(\mu n + \mu p)}$$ [2]

=1543.2Ω-m [1]

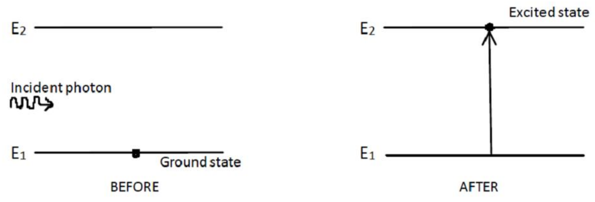
3a.

Expression for energy density:

Induced absorption:

It is a process in which an atom at a lower level absorbs a photon to get excited to the higher level.

Let E_1 and E_2 be the energy levels in an atom and N_1 and N_2 be the number density in these levels respectively. Let U_γ be the energy density of the radiation incident.



Rate of absorption is proportional to the number of atoms in lower state and also on the energy density U_{γ}.

$$\text{Rate of absorption} = B_{12} N_1 U_{\gamma}$$

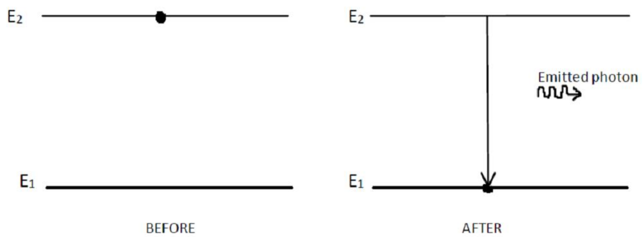
Here B_{12} is a constant known as Einsteins coefficient of spontaneous absorption.

Spontaneous emission:

It is a process in which ,atoms at the higher level voluntarily get excited emitting a photon. The rate of spontaneous emission representing the number of such deexcitations is proportional to number of atoms in the excited state.

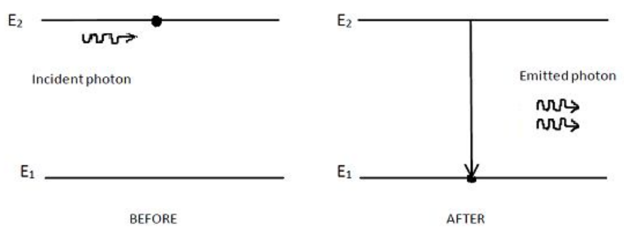
$$\text{Rate of spontaneous absorption} = A_{21} N_2$$

Here B_{12} is a constant known as Einsteins coefficient of spontaneous emission.



Stimulated emission:

In this process, an atom at the excited state gets deexcited in the presence of a photon of same energy as that of difference between the two states.



The number of stimulated emissions is proportional to the number of atoms in higher state and also on the energy density U_{γ}.

$$\text{Rate of stimulated emission} = B_{21} N_2 U_{\gamma}$$

Here B_{21} is the constant known as Einsteins coefficient of stimulated emission.

[1+1+1]

At thermal equilibrium,

Rate of absorption = Rate of spontaneous emission + Rate of stimulated emission

$$B_{12} N_1 U_{\gamma} = A_{21} N_2 + B_{21} N_2 U_{\gamma}$$

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

Rearranging this, we get

$$U_\gamma = \frac{A_{21}}{B_{21}}\left[\frac{1}{\frac{B_{12}N_1}{B_{21}N_2}-1}\right]$$

By Boltzmans law , $\frac{N_1}{N_2} = e^{\frac{h\gamma}{kT}}$

Hence

$$U_\gamma = \frac{A_{21}}{B_{21}}\left[\frac{1}{\frac{B_{12}}{B_{21}}e^{\frac{h\gamma}{kT}}-1}\right]$$

From Planck's radiation law,

$$U_\gamma = \frac{8\pi h\gamma^3}{c^3}\left[\frac{1}{e^{\left[\frac{h\gamma}{kT}\right]}-1}\right]$$

Comparing these expressions, we get

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

$$\therefore U_\gamma = \frac{A}{B}\left[\frac{1}{e^{\frac{h\gamma}{kT}}-1}\right] \qquad [3]$$

3b.

Industrial Applications

1) Laser Welding: [1]

Lasers are used for welding metals, by virtue of its ability to focus large power in a small region.

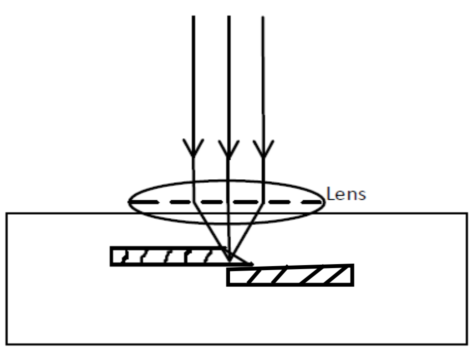
In laser welding, the laser beam is focussed to the spot to be welded by means of a lens and a very high temperature is generated at this spot by virtue of its high intensity.

Due to the heat, the metal used for welding is melted and a strong, homogeneous joint is formed.

Advantages:

a) It is a contactless process. Therefore, unwanted materials like oxides can be eliminated.
b) Only the focussed region is heated and so it can be used in micro-electronics, where heat-sensitive components are involved.
c) There is no mechanical stress on the components involved, thus there is no deformation.
d) It can be used to weld joints where man cannot physically be present, for example, in nuclear power plants.

Carbon di-oxide lasers are the most popular one in this particular application



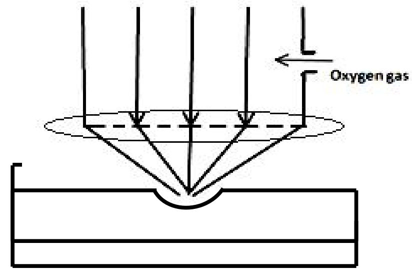
2) Laser Cutting: [2]

A laser beam, assisted by a jet of gas is used for cutting materials. The laser beam is surrounded by a nozzle into which oxygen gas is fed. The gas helps in combustion and also assists by blowing out the molten metal. The blowing action increases the depth and also the speed of cutting. The cutting accuracy is well controlled.

Laser cutting is used in the tailoring industry where large number of layers of cloth is stockpiled. In this case the laser beam is focussed on the pile and moved along the path, along which the cut is to be made.

Advantages:

a) There is no thermal damage and chemical change in the material
b) There is no wear and tear and no mechanical stress induced
c) There is no need for a coolant while cutting the material
d) The cutting is clean, fast, accurate, and of a high quality
e) Saves manpower and time



3) Laser Drilling: [1]

High power laser pulses are used to drill holes in metals. In this process, the metal is heated to its boiling point and then the laser pulses are allowed to evaporate the material in the given region, so that a hole is formed.

Advantages:

a) No wear and tear of tools
b) Drilling can be done at any oblique angle
c) Fine holes of diameter 0.2 to 0.5 mm can also be drilled adjacent to each other
d) Even hard or brittle materials can be drilled as there are no mechanical stresses induced in the material.

Nd – YAG laser is used to drill holes in metals. Where as CO2 laser is used in case of nonmetallic materials.

4a.

CO2 LASER

It belongs to the category of gas lasers with four level lasing systems which operates in the far IR region.

Energy levels of CO2 molecule.

CO2 molecule is a linear molecule. It has two oxygen atoms between which there is a carbon atom. It has three different vibrational oscillation called vibrational modes. The energy associated with each of these vibrations is quantized. Its three fundamental vibration modes are symmetric stretching, asymmetric stretching and bending mode.

Symmetric stretching mode-

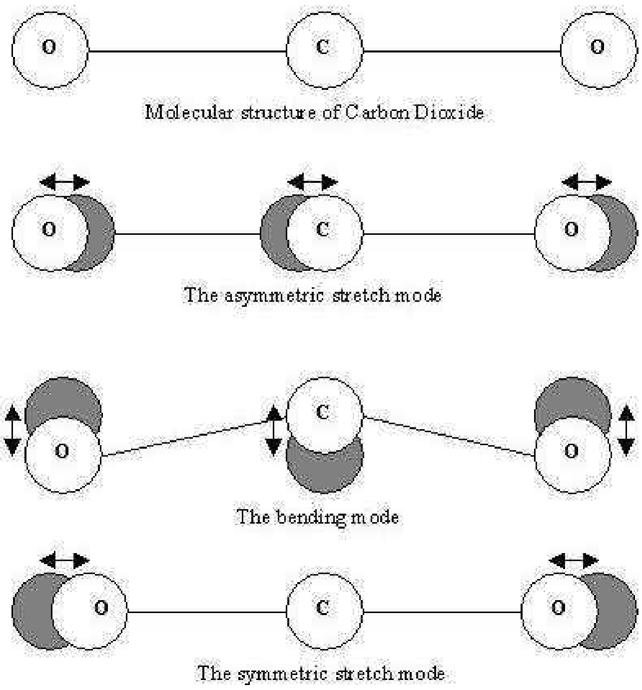
In this mode, the oxygen atoms oscillate along the molecular axis either approaching towards or departing from the carbon atom simultaneously along the molecular axis and Carbon atom is stationary. The CO2 molecule in this state has intermediate energy and referred as 100 state.

Asymmetric stretching mode-

During the vibration in this mode, all three atoms oscillate along the molecular axis but two Oxygen atoms move in on direction while the carbon atom moves in the opposite direction and vice versa. The CO2 molecule in this state has highest energy and referred as 001 state.

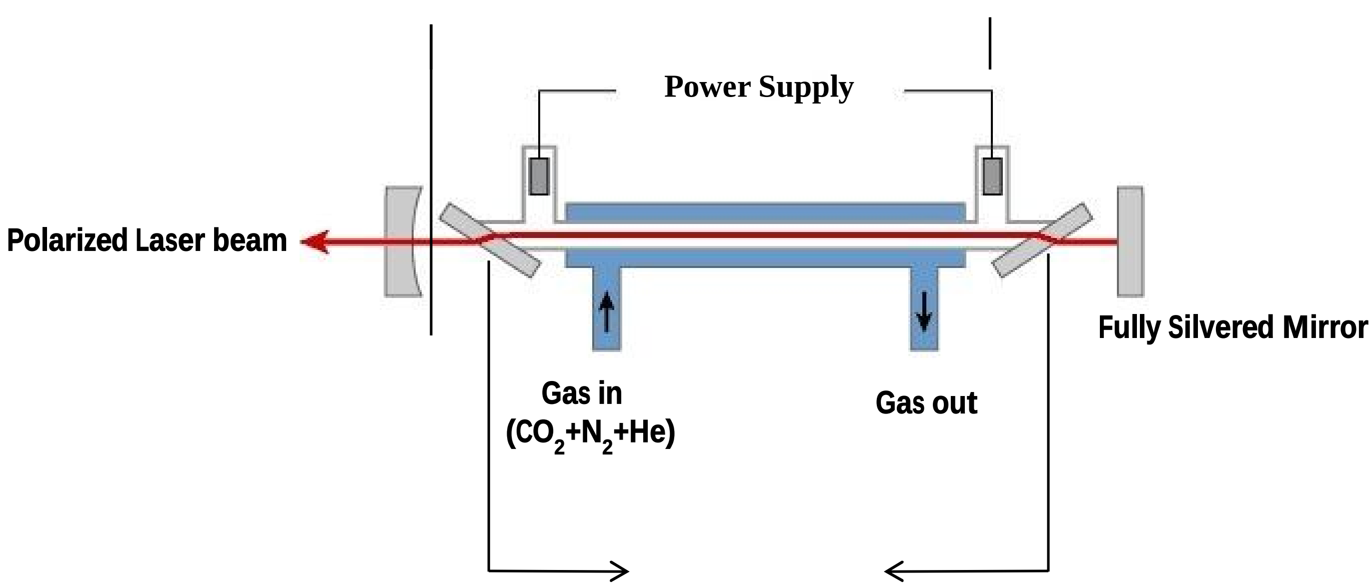
Bending mode-

In this mode all three atoms oscillate normal to molecular axis. While vibrating, the two Oxygen atoms pull together in one direction as carbon atom is displaced in opposite direction. This is lowest energy state of CO2 molecule referred as 010. Next highest energy is this mode is 020 which is close to 100 state of symmetric stretching mode. [2]



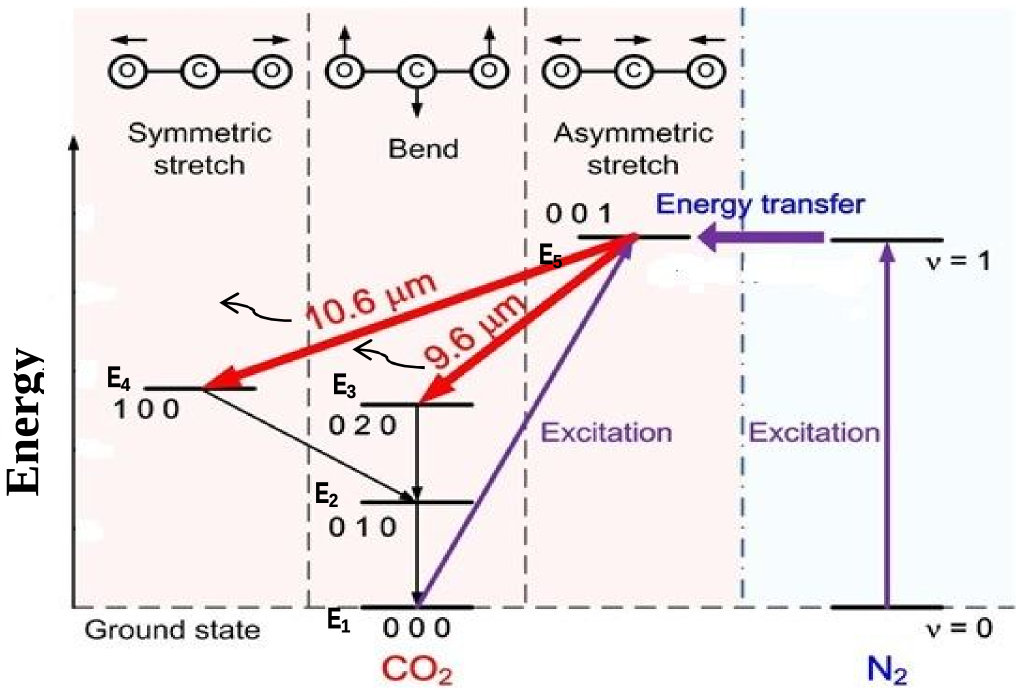
Construction-

A typical CO2 laser consists of discharge tube of 2.5 cm in diameter and 5 m in length. The ends of the tube is closed with alkali halide Brewster windows. Outside the ends of the tube, confocal silicon mirrors, one of which is fully silvered can reflect all the incident light whereas the other is partially reflecting are arranged which forms the laser cavity. The active medium consists of Mixture of CO2, N2 and He gases in the ratio of 1:2:3. The pressure inside the tube is 6-17 Torr. The actual size, pressure and proportion of gases vary with the particular application of the laser. Also either ac or dc voltage is applied depending on the use of laser unit. When voltage is applied to the mixture, pumping mechanism based on electric discharge is used to create population inversion. During discharge, some CO2 molecules break into CO and O. So, sometimes Hydrogen and water vapour are added which help to reoxidise CO to CO2.The mirrors act as optical feedback resonators providing necessary feedback for the emitted photons. The Brewster angle windows are provided to give polarized output. [2]



Working

Fig. shows the lowest vibrational levels of ground electron energy state of CO2 molecule and N2 molecule. The excited state of N2 molecule is metastable and is identical in energy to (001) vibrational level of CO2 molecule.



1. When suitable voltage is applied across the two electrodes, glow discharge of the gases is initiated and many electrons are rendered free from the gas during discharge. These free electrons while accelerating towards the positive electrode collide with N2 and CO2 molecules in their path, wherein the N2 molecule get excited to the metastable state and Some of CO2 molecules are also excited to upper energy level E5.

   The excited N2 molecules undergo inelastic collisions with ground state CO2 molecules and excite them to (001 state) E5 level.
2. As the population of CO2 molecules builds up at E5 levels population inversion is achieved between E5 level and at (100) and (020) states marked as E4 and E3 levels. Random photons are emitted spontaneously by few of the atoms at energy level E5. The spontaneous photon travelling through gas mixture prompts stimulated emission of photons. The photons bounce back and forth between end mirrors, causing more and more stimulated emission during each passage and the strength of photons travelling along axis of laser cavity builds up rapidly.
3. The laser transition between E5 → E4 levels produces far IR radiation at wavelength 10.6µm and laser transition between E5 → E3 levels produces far IR radiation at wavelength 9.6 µm.
4. CO2 molecules at E4 and E3 levels fall to lower level E2 (010 state) through inelastic collisions with unexcited CO2 molecules. This process leads to accumulation of population at E2 level, which is close to ground state, also tends to be populated through thermal excitations. Thus, the de-excitation of CO2 molecules at the lower lasing level poses a problem and inhibits laser action.
5. The He atoms de-excite CO2 molecules through inelastic collisions and decrease the population density of CO2 at E2 level. Due to high thermal conductivity of helium, it also aids in cooling the gas mixture through heat conduction and thus brings down the thermal excitations of CO2 from ground level E1 to E2 level.
6. The CO2 molecules are once again available for excitation to higher state and participate in laser action [3]

4b.

$$\frac{N_1}{N_2} = e^{\frac{hc}{\lambda kT}}$$ [1]

T= 27^{0}C = 300 K [1]

$$\frac{N_1}{N_2} = 1.309 \times 10^{30}$$

$$\frac{N_2}{N_1} = 7.93 \times 10^{-31}$$

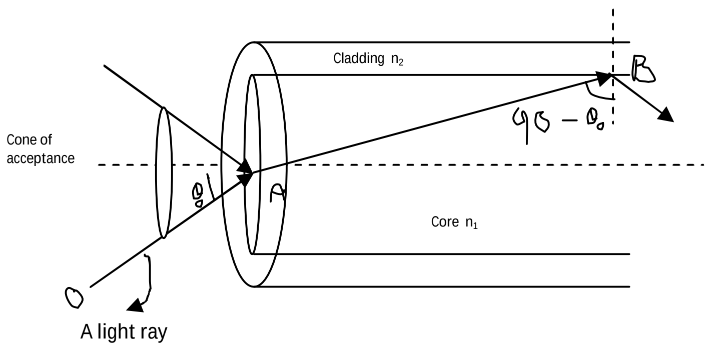
5a.

Numerical aperture is a measure of light carrying capacity of an optical fiber.It is given by Sine of angle of acceptance. [1]

Expression for condition for propagation :

Consider a light ray falling in to the optical fibre at an angle of incidence θ_0 equal to acceptance angle. Let n_0 be the refractive index of the surrounding medium .
Let n_1 be the refractive index of the core.
Let n_2 be the refractive index of the cladding.
From Snell's Law:
For the ray OA $n_0 \sin\theta_0 = n_1 \sin\theta_1$

$$= n_1(1-\cos^2\theta_1)^{\frac{1}{2}} \quad \text{.....................(1)}$$



[2]

For the ray AB

$$n_1 \sin(90 - \theta_1) = n_2 \sin 90$$

[here the angle of incidence is $(90 - \theta_1)$ for which angle of refraction is 90^0].

$$n_1 \cos\theta_1 = n_2$$

Substituting for $\cos\theta_1$ in equation (1)

$$n_0 \sin\theta_0 = n_1\sqrt{1-\frac{n_2^2}{n_1^2}}$$

$$\sin\theta_0 = \frac{\sqrt{n_1^2 - n_2^2}}{n_0}$$

If the medium surrounding the fibre is air then $n_0 = 1$,

Numerical aperture = $\sin\theta_0 = \sqrt{n_1^2 - n_2^2}$ [2]

The total internal reflection will take place only if the angle of incidence $\theta_i < \theta_0$

$\therefore \sin\theta_i < \sin\theta_0$

$$\mathbf{\sin\theta_i < \sqrt{n_1^2 - n_2^2}}$$ **[1]**

5b.

Attenuation constant $\alpha = -\frac{10}{L}\log\left(\frac{P_{out}}{P_{in}}\right) dB/Km$ [1]

On substitution, $5.6 = -\frac{10}{8}\log\left(\frac{P_{out}}{P_{in}}\right)$ [1]

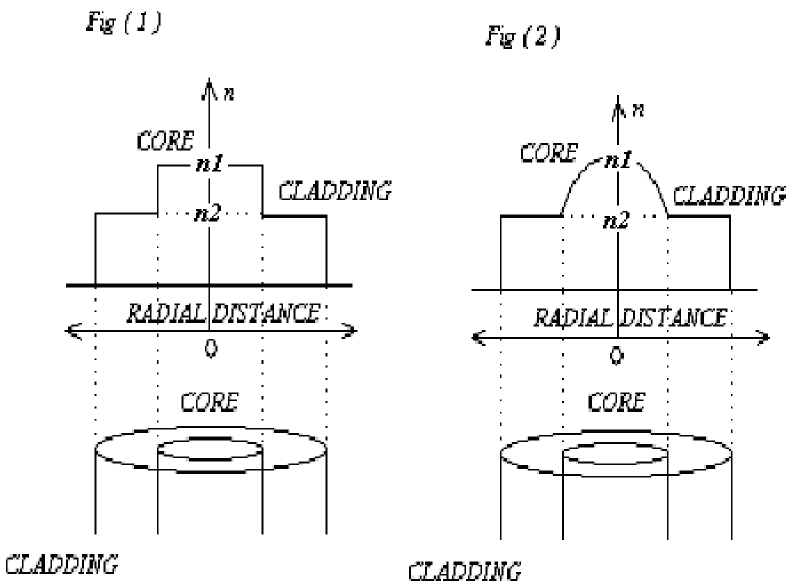
$$\left(\frac{P_{out}}{P_{in}}\right) = 3.311\times10^{-5}$$ [2]

6a.

Based on refractive index profiles: Optical fibers mainly have been classified according to their refractive index profile as

1. Step index single mode fiber. [2]
2. Step index multimode fiber. [2]
3. Graded index multimode fibers. [2]

Refractive index profile is a graph which shows variation of refractive index along the diameter of the optical fiber. i.e. graph plotted between the refractive index and radial distance



Step index fibers

Fig (1) shows R.I. profile of step d cladding vary like a step and so it called as step index fiber. It has constant higher value of refractive index of core and constant lower value of refractive index of cladding. The light rays propagating through it are in the form of meridional rays which will cross the fiber axis during every reflection at the core-cladding boundary and are propagating in a zig-zag manner. Step index fibers can be divided as Step index single mode fiber and Step index multi-mode fiber.

Step index single mode fiber

These fibers will have the core diameter of the order of 8 to 10 μm and cladding diameter of the order of 60 to 70 μm. Because of narrow core they can guide only a single mode as shown in fig. (a).

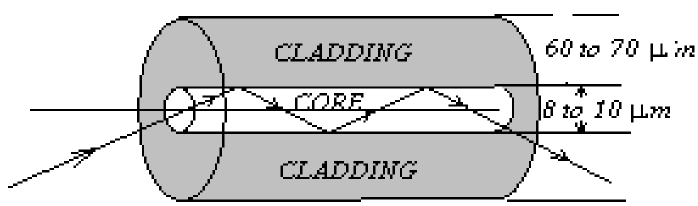


Fig. (a)

Characteristics of single mode step index fiber

It has small core diameter.

It has high bandwidth.

It has small numerical aperture.

It has less attenuation.

Advantages

It has very high capacity. Nearly 80% of the fibers are of step index single mode.

Fabrication of fibers, Launching of light into single mode fibers and joining of two fibers are very difficult.

They need lasers as a source and are used in long distance communications. They find application in submarine cable systems.

Step index multi-mode fiber

These fibers will have core diameter of the order 50 to 200 μm and cladding diameter of 100 to 250 μm. Due to large core diameter it can support large number of modes as shown in fig. (b).

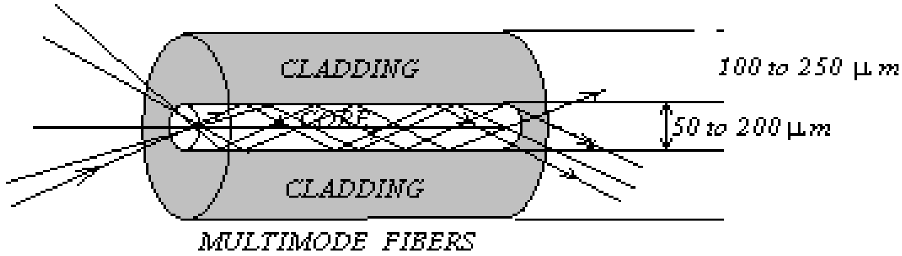


Fig. (b)

Characteristics of Multimode step index fiber

It has high core diameter.
It has low band width.
It has high numerical aperture.
They suffer from intermodal dispersion so attenuation is more.
Advantages
They are easier to manufacture.
They have simple circuitry.

LED or Laser can be used as a source. Fabrication, Launching of light into fiber and joining of two fibers are easy in these fibers so they are cheap. They are used as data links for communication purposes which has lower bandwidth requirements.
Light propagation in step index fibers is by multiple total internal reflections. In multimode step index fibers, there is a time delay between different pulses of lower order modes and high order modes travelling along different paths as shown in fig.(3). Hence the pulse received at the other end is broadened. This is known as intermodal dispersion. This imposes limitation on the separation between pulses and reduces the transmission rate and capacity. To overcome this problem, graded index fibers are used.

Graded Index fibers

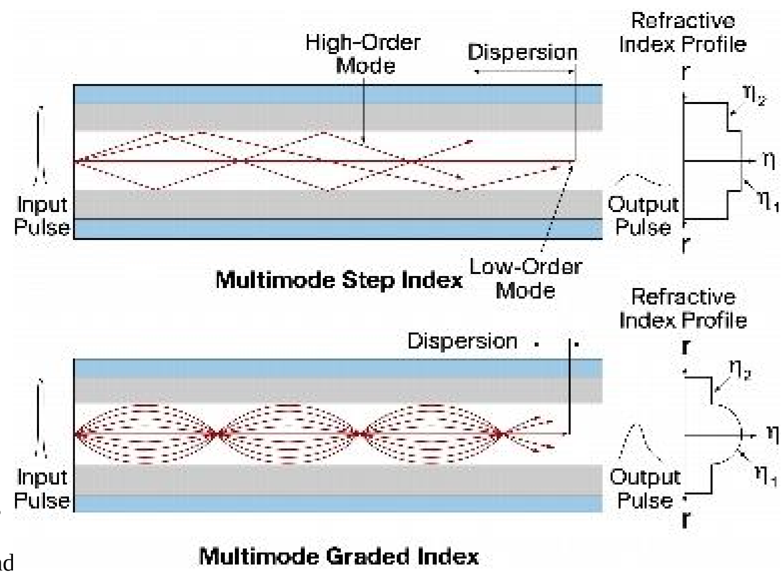


Fig (2) shows R.I. profile of graded ind e away from the axis of the core. But refractive index of cladding remains constant and its value is less than the core's refractive index. As there is continuous variation in the refractive index of the core, light propagates through refraction of light following a curved path as shown in figure below. The light rays travel along the region of lower refractive index faster as compared to light travelling in the region of high refractive index, hence all the pulses of signals will reach at the other end of fiber simultaneously. Thus the problem of intermodal dispersion can be reduced to a large extent and attenuation is less in graded index fiber. Light rays propagating through it are in the form of skew rays (or) helical rays which will not cross the fiber axis at any time and are propagating around the fiber axis in a helical (or) spiral manner as shown in fig. (3).

Characteristics of graded index multimode fibers
It is a high quality fiber.
It has moderate bandwidth and capacity.
It has small numerical aperture.
It has low attenuation.
Advantages

LED or Laser can be used as a source for GRIN multimode fibers. It is most expensive of all. It is easier to splice and interconnect. But these fibers are free from intermodal dispersion. Its typical application is in telephone trunk between central offices.

6b.

Optical fiber communication is the transmission of information by propagation of optical signal through optical fibers over the required distance. Block diagram for point to point communication using optical fibers is shown in the fig. given below.

Explanation: [2]

Information in the form of sound signals are fed to microphone (transducer), which converts this into electrical signals. These electrical signals are fed to encoder which converts electrical signals into 0 and 1 bits and are fed to photo transmitter which consists of LED or laser like light sources and out put will be in the form of light signals.

These light signals are fed to optical fibers where light signal propagates through it by means of total internal reflection and reaches the other end. This output light is fed to photo detector which consists of photo cathodes where light energy will be converted into electrical signals, and these electrical signals are decoded by means of decoders. Output of decoders will be again in the form of electrical pulses are fed to speakers which converts electrical signals back into original information in the form of sound.

Block diagram for point to point communication using optical fibers is shown in the fig. given below. [2]

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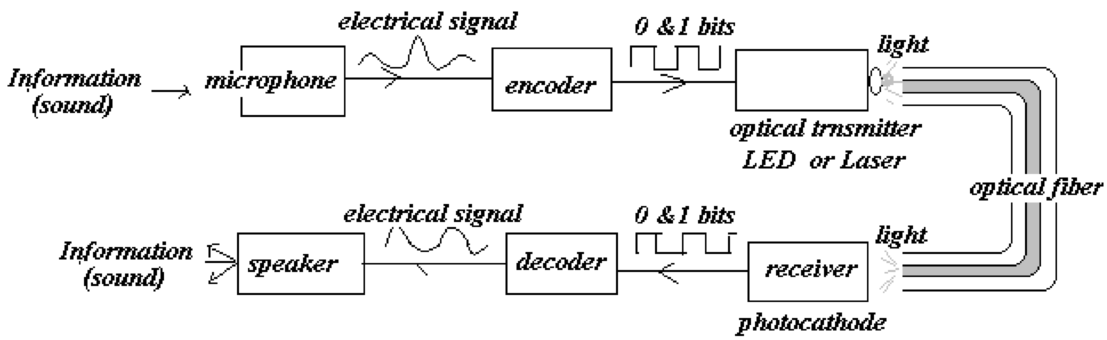
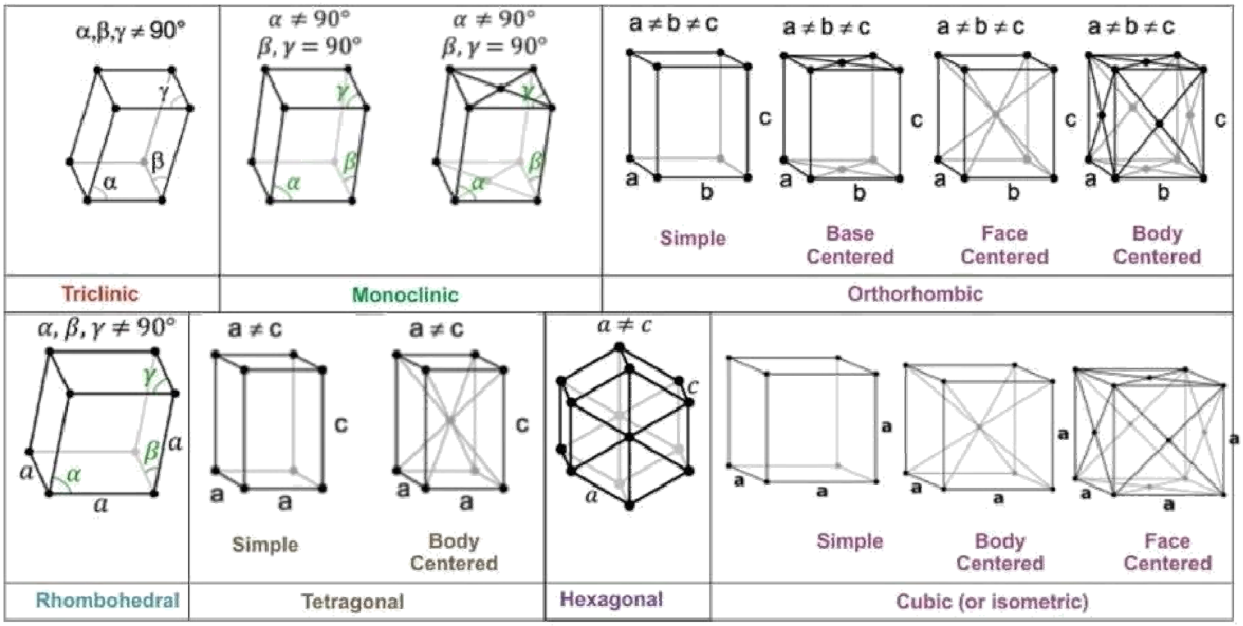
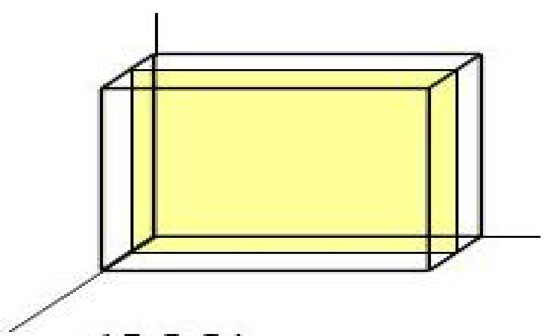


7a.

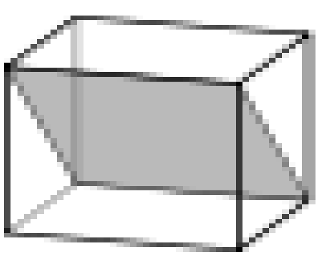
Crystal systems	Type and No. of Bravais lattices	Unit cell axes	Interfacial angles	Example
Cubic [1]	Simple Body centered Face centered **3**	a=b=c	$\alpha=\beta=\gamma=90^0$	Au,Cu, NaCl
Tetragonal [1]	Simple Body centered **2**	a=b≠c	$\alpha=\beta=\gamma=90^0$	SnO_2, TiO_2
Orthorhombic [1]	Simple Body centered Face centered Base ceneterd **4**	a≠b≠c	$\alpha=\beta=\gamma=90^0$	K_2SO_4, $BaSO_4$
Monoclinic [1]	Simple Base centered **2**	a≠b≠c	$\alpha=\gamma=90^0\neq\beta$	Na_3AlF_6, $CaSO_4.2H_2O$
Triclinic [1]	Simple **1**	a≠b≠c	$\alpha\neq\beta\neq\gamma\neq90^0$	$K_2Cr_2O_7$, $CuSO_4.5H_2O$
Trigonal or Rhombohedral [1]	Simple **1**	a=b=c	$\alpha=\beta=\gamma\neq90^0$	As, Sb, Bi
Hexagonal [1]	Simple **1**	a=b≠c	$\alpha=\beta=90^0,\gamma=120^0$	Zn, Mg, Graphite



7b. [1+1+1]



(200)



(011)

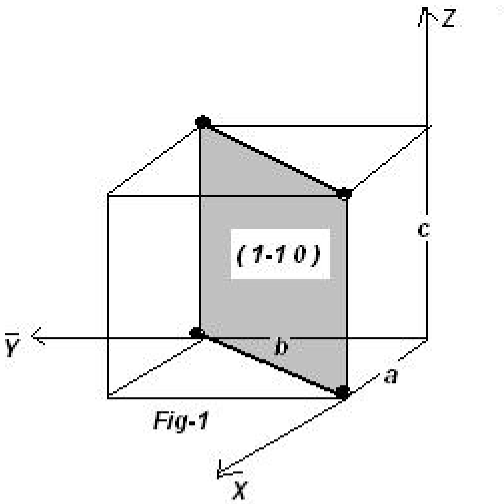


Fig-1

8a.

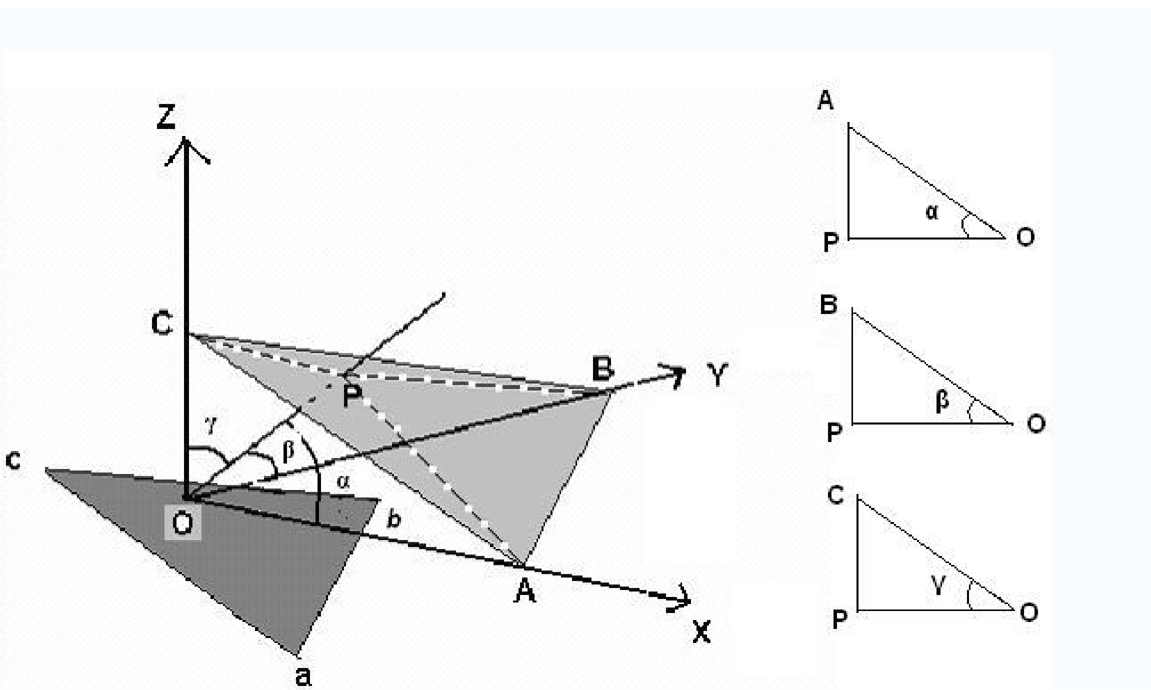
Miller indices are the set of 3 smallest whole numbers which determines the position and direction of set of parallel and equidistant planes in a crystal. It is generally written as (h k l). [1]

Expression for interplanar spacing

Let ABC be one of the parallel planes represented by Miller indices (hkl). Plane ABC is intersecting coordinate axes X,Y,Z at x,y & z respectively. Let OA = x, OB = y and OC = z which are the intercepts made by ABC w.r.to X,Y & Z axis respectively.

Let another plane abc parallel to this plane passes through the origin of the coordinate system O.

Draw a perpendicular OP to the plane ABC from O,here OP= interplanar distance=d(hkl). Let α β and γ be the angle made by OP w.r.to X,Y& Z axis respectively. [1+fig 1mark]



From right angled triangle OPA, cosα = OP/ OA= d(hkl). / x,

From right angled triangle OPB, cosβ = OP/ OB= d(hkl). /y From right angled triangle OPC, cos γ = OP/ OC= d(hkl)./z. Here cosα, cosβ & cos γ are direction cosines of line OP, therefore cos2α + cos2β + cos2 γ = 1,

i.e (d(hkl). / x,)2 +(d(hkl). / y) 2 + (d(hkl). / z)2 = 1 or

$$d_{hkl} = \frac{1}{\sqrt{\frac{1}{x^2} + \frac{1}{y^2} + \frac{1}{z^2}}}$$

using (h= a/x, k= b/y, l= c/z) , and substituting 1/x= h/a, 1/y = k/b, 1/z= l / c in above relation we get [2]

$$d_{hkl} = \frac{1}{\sqrt{\frac{h^2}{a^2} + \frac{k^2}{b^2} + \frac{l^2}{c^2}}}$$

for cubic system a = b = c, so $d_{hkl} = \frac{a}{\sqrt{h^2 + k^2 + l^2}}$ [1]

8b.

$2d \sin\theta = n\lambda$ [1]

λ =1.774Å [1]

$E = \frac{hc}{\lambda}$ = 1.121 X 10^{-15} J= 7007.5 eV [2]