STEP MATERIAL

UNIT I

1) What is interference?what are the conditions for interference?

Definition: Interference is based on the principle of superposition of waves. When two or more waves superimpose, the resultant amplitude in the region of superposition is different than the amplitude of individual waves. This modification in the distribution of intensity in the region of superposition is called interference of light.

Def: Superimposing of two or more waves is interference.

Conditions for Interference of light:

(1) Conditions for sustained interference.

(2) Conditions for observation of fringes.

(3) Conditions for good contrast between maxima and minima.

Conditions for sustained interference: The two sources should be coherent, i.e they should vibrate in the same phase or there should be a constant phase difference between the two sources must emit continuous waves of same wavelength and time period.

2)What is coherence? Explain types of coherence?

Two waves are said to be coherent if they have

1.Same wave wavelength

2.same amplitude

3.constant phase diffrerence

Coherence is a property of a wave. A predictable correlation of the amplitude and phase at any point with other point is called as coherence.

There are two types of coherence.they are

1) Temporal coherence
2) spatial coherence

Temporal coherence(longitudinal coherence):
It is possible to predict the amplitude and the phase at a one point on the wave with respect to another point on the same wave is called as Temporal coherence.

Spatial coherence: It is possible to predict the amplitude and the phase at a one point on the wave with respect to another point on the second wave then it is called as spatial coherence.

3) **Explain division of amplitude and division of wavefront**.

Division of wavefront :

The incident wavefront is divided into two parts by utilizing the phenomenon of reflection,refraction or diffraction .these two parts of the same wavefront travel unequal distances and reunite at some angle to produce interference bands

The fresnel biprism, Lloyd’s mirror are the examples.

Division of amplitude:

The amplitude of the incoming beam is divided into two parts either by parallel reflection or refraction.these divided parts reunite after traversing different parts and produce interference.

Newtons rings ,michelsons interferometer coimes under this class.

4) Explain the concept of Newton rings

When a plano-convex lens with its convex surface is placed on a plane glass sheet, an air film of gradually increasing thickness outward is formed between the lens and the sheet. The thickness of film at the point of contact is zero. If monochromatic light is allowed to fall normally on the lens, and the film is viewed in reflected light, alternate bright and dark concentric rings are seen around the point of contact. These rings were first discovered by Newton, that's why they are called **NEWTON'S RINGS.**

5) **What are the differences between fresnel and fraunhoffer diffraction?**

sno	Fresnel diffraction	Fraunhoffer diffraction
1	Either a point source or an illuminated narrow slit is used.	Extended source at infinite distance is used.

2	The wavefront undergoing diffraction is either spherical or cylindrical.	The wavefront undergoing diffraction is plane wavefront.
3	The source and the screen are finite distances from the obstacles producing diffraction	The source and the screen are infinite distances from the obstacles producing diffraction
4	No lens is used to focus the rays	Converging lens is used to focus the rays

5) **Define diffraction grating?**

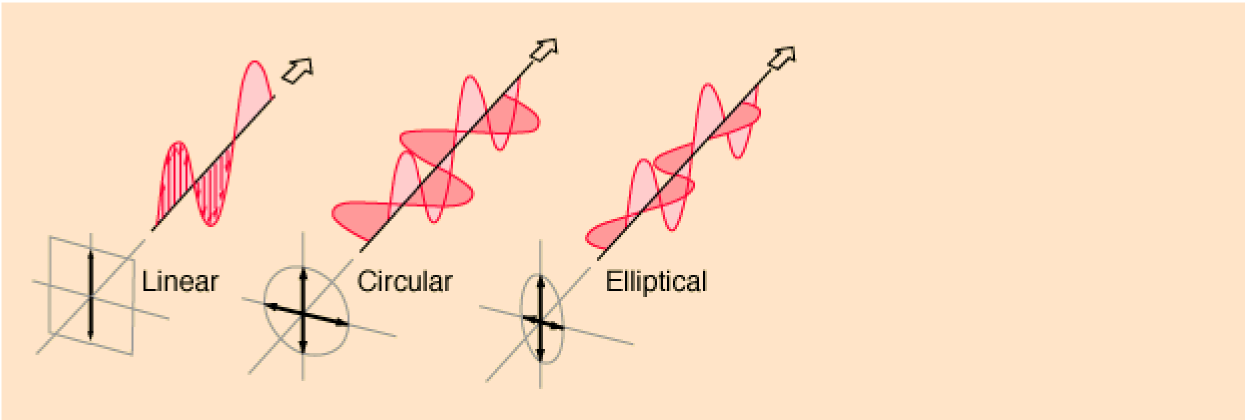
Diffraction grating is nothing but close placed multiple slits. It consists of very large numberof multiple slits sise by side separated by opaque spaces. The incideny light is transmitted through the slits and blocked by opaque spaces. Such a grating is called transmission grating. When light passs through the grating ,each one of the slit diffracts the waves. All the diffracted waves reinforce one another producing sharper and intense maxima on the screen. A plane transmission grating is nothing but a plane sheet of transparent material on which opaque rulings are made. The spaces between the rulings are equal and transparent and constitute the parallel slits. The rulings and slits are of equal width.

UNIT II

1) **Define polarization? What are the types of polarization?**

The process of converting unpolarized light to polarized light is called as polarization.

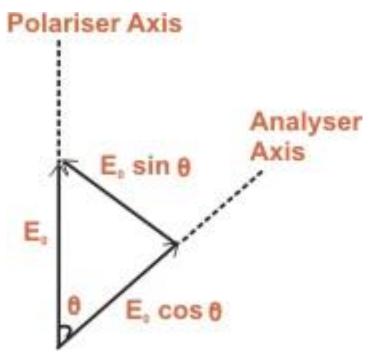
Light in the form of a plane wave in space is said to be linearly polarized. Light is a transverse electromagnetic wave, but natural light is generally unpolarized, all planes of propagation being equally probable. If light is composed of two plane waves of equal amplitude by differing in phase by 90°, then the light is said to be circularly polarized. If two plane waves of differing amplitude are related in phase by 90°, or if the relative phase is other than 90° then the light is said to be elliptically polarized



2)**State malus law?**

According to malus, when completely plane polarized light is incident on the analyzer, the intensity I of the light transmitted by the analyzer is directly proportional to the square of the cosine of angle between the transmission axes of the analyzer and the polarizer.

i.e $I \propto \cos^2\theta$



2) What is double refraction?

Unpolarized light has two components –one vertical and another horizontal. When unpolarized light passes through certain anisotropic crystals such as calcite or quartz, velocity of propagation of these two components vary. This means that the material exhibits two different refractive indices.

Since $\mu = \sin I / \sin r$, though both the components have the same angle of incidence, they have different angles of refraction. Hence when unpolarized light passes through such crystals, we get two refracted beams and this phenomenon is called <u>double refraction or birefringence.</u>

3) **Explain the principle of Nicol's Prism.**

It is a device for producing and analyzing a plane polarized light. When an ordinary light is transmitted through a calcite crystal, it splits in o-ray and e-ray which is completely plane polarized with vibrations in two mutually perpendicular planes. If one beam is eliminated then the emergent beam from the crystal will be plane polarized light. Nicol eliminated the o-ray by utilizing the phenomenon of total reflection at thin film of Canada balsam separating the two pieces of calcite. The device is known as Nicol prism.

4) **Define quarter wave plate ?**

A calcite plate cut with optical axis parallel to the surface.when a plane polarized light falls normally on a thin plate of uniaxial crystal(here calcite plate) cut parallel to its optic axis,the light splits into ordinary and extraordinary plane polarized lights.they travel along the same path but with different velocities.the velocity of extra ordinary ray is greater than the velocity of ordinary ray. As a result a phase difference is introduced between them.

If the thickness of the crystal plate is such that it introduces a phase difference of π/2 radians or a path difference of λ/4 then it is called a quarter wave plate.

5) Define half wave plate ?

IF the thickness of the calcite crystal plate,cut with its faces parallel to optical axis,is such that it introduces a phase difference of π or a path difference of λ/2 between ordinary and extra ordinary wave then it is called as half wave plate. For a half wave plate

$(\mu_o - \mu_e) t = \lambda/2$

6) **What is LASER? Explain the characteristics of LASER's**?

Laser is an acronym for light amplification by stimulated emission of radiation.

Characteristics of laser **:**

(1)Laser is highly monochromatic
(2)Laser is highly directional
(3)Laser is highly coherent
(4)The intensity of laser is very high

7)Write the differences between spontaneous emission and stimulated emission of radiation?

SPONTANEOUS EMISSION	**STIMULATED EMISSION**
1) Incoherent radiation	1) coherent radiation
2) Less Intensity	2) high intensity
3) Poly chromatic	3) mono chromatic
4) One photon released	4) two photons released
5) Less directionality	5) high directionality

6) More angular spread during propagation	6) less angular spread during Propagation
Ex:-Light fromsodium Mercury vapour lamp	ex: - light froma laser source ruby laser, He-Ne Laser

8) **What is population inversion?**

The number of atoms in higher energy level is less than the no of atoms in lowest energy level.The process of making of higher population in higher energy level than the population in lower energy level is known as population inversion.

Population inversion is achieved by pumping the atoms fromt he ground level to the higher energy level through optical (or) electrical pumping

9) What are Einstein's coefficients?

Based on Einstein’s theory ofradiation one can get the expression for probability for stimulated emission of radiation to the probability for spontaneous emission of radiation under thermal equilibrium.

E_1,E_2be the energy states

N_1,N_2be the no of atoms per unit volume

ABSORPTION: If ρ(υ)dυ is the radiation energy per unit volume between the frequency range of ν andν +d ν

The number of atoms undergoing absorption per unit volume per second fromlevel

$E_1$to E_2= $N_1\rho(\upsilon)B_{12}$

B_{12}represents probability of absorption per unit time

STIMILATED EMISSION: When an atommakes transitionE_2toE_1in the presence of external photon whose energy equal to (E_2-E_1)stimulated emission takes place thusthe number of stimulated emission per unit volume per second from levels.

$E_2$to E_1= N2 ρ(ν) B_{21}

$B_{21}$is represents probability ofstimulated emission per unit time.

SPONSTANEOUS EMISSION: An atomin the level E_2can also make a spontaneous emission by jumping in to lower energy level E_1.

$E_2$to E_1=N_2A_{21}

10)**What are the applications of lasers in different fields?**

in scientific research

1)Lasers are used to clean delicate pieces of art, develop hidden finger prints

2)Laser are used in the fields of3D photography called holography

3) Using lasers the internal structure of microorganism sand cells are studied very accurately

4) Lasers are used to produce certain chemical reactions.

Laser in Medicine:

1) The heating action of a laser beamused to remove diseased body tissue

2)Lasers are used for elimination of moles and tumours,which are developing in the skin tissue.

3) Argon and CO_2 lasers are used in the treatment liver and lungs

4) Laser beam is used to correct the retinal detachment by eye specialist

Lasers in Communication:

1) More amounts of data can be sent due to the large band with ofsemiconductor lasers

2) More channels can be simultaneously transmitted

3) Signals cannot tapped

4)Atmospheric pollutants concentration, ozone concentration and watervapour concentration can be measured

Lasers in Industry: Lasers are used

1) To blast holes in diamonds and hard steel

2) To cut, drill,welding and remove metal fromsurfaces

3) To measure distance to making maps by surveyors

4) For cutting and drilling of metals and non- metals such a ceramics plastics glass

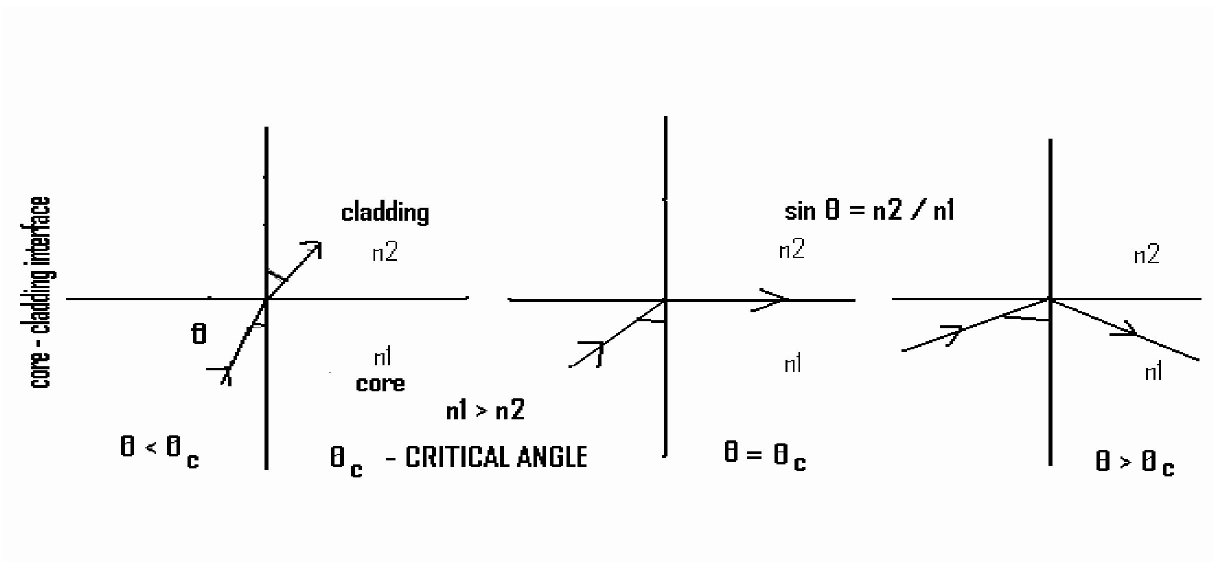
Unit III

1. **What is optical fiber? Explain the principle of optical fibers.**

The optical fiber mainly consists of the following parts.

i .Core ii .Cladding iii . Outer jacket

The mechanismof light propagation along fibers can be understood using the principle of geometrical optics. The transmission of light in opticalfiber is based on the phenomenon of total internal reflection.



2)**Define Acceptance angle of optical fiber?**

When the light beamis launched into a fiber, the entire light may not pass through the core and propagate. Only the rays which makes the angle of incidence greater than critical angle at the core –cladding interface undergoes total internal reflection. The other rays are refracted to the cladding and are lost. Hencethe angle we have to launch the beam at its end is essential to enable the entire lightto pass through the core .This maximum angle of launch is called acceptance angle.

$$\alpha\ (max)=\sin^{-1}\sqrt{(n_1^2-n_2^2)}/n_o$$

3)**Define Numerical aperture?**

Light collecting capacity of the fiber is expressed in terms of acceptance angle using numerical aperture. Sine of the maximum acceptance angle is called the numerical aperture of the fiber.

Numerical aperture = $\sin\alpha$ (max)

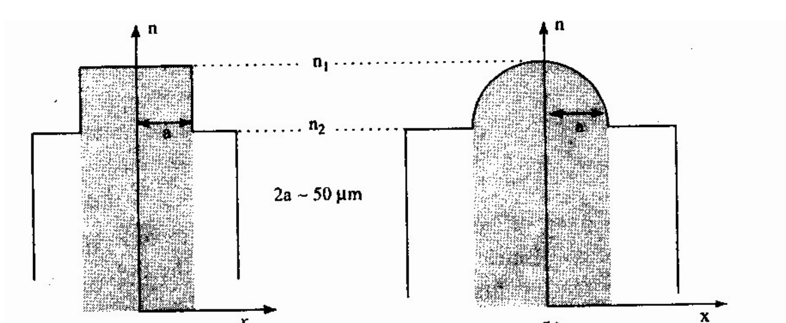
$\sin\alpha$ (max) $=\sqrt{(n_1^2-n_2^2)}/n_o$

4)**What are step index optical fibers?**

In step index fibers the refractive index of the core is uniform through out the medium and undergoes an abrupt change at the interface of core and cladding.The diameter of the core is about 50-200μm and in case of multimode fiber.And 10μm in the case of single mode fiber.Thetransmittedopticalsignalstravel through core medium in the form of meridonal rays, which will cross the fiber axis during every reflection at the core-cladding interface. The shape of the propagation appears in a zig-zac manner.

What are graded index fibres?

In these fibers the



Refractive index profile for (a) multimode step index and (b) multimode graded index fibers refractive index of the core varies radially.As the radius increasesin the core medium the refractive index decreases. The diameter of the core is about 50μm.The transmitted optical signals travel through core mediumin the formof helical rays, which will not cross the fiber axis at any time.

5)**What are the Applications of optical Fibers?**

1. Optical fibers are used assensors
2. These are used in Endoscopy
3. These are used in communication system
4. For decorative peaces inhome needs.
5. These are used in defence areas for the sake of high security.
6. These are used in electrical engineering.

6)What are the advantages of optical fibers?

- Enormous Bandwidth
- Immunity to interference and cross talk
- Signal security
- Small size and weight
- Low transmission loss
- Low cost

7)What are losses in optical fibres

While transmitting the signals through optical fiber some energy is lost due to few reasons. The major losses in fibers are 1.Distotrion losses 2.Transmission losses 3.Bending losses.

1. Distortion losses:-

When a pulse is launched at one end of the fiber and collected at the other end of the fiber, the shape and size of the pulse should not be changed. Distortion of signals in optical fiber is an undesired feature.If the output pulse is not same as the input pulse,then it is said that the pulse is distorted.If the refractive index of thecore is not uniform most of the rays will travel through the medium of lower refractive index region. Due to this the rays which are travel in fiber will become broadened. Because of this the output pulses will no longer matches with the input pulses.

The distortion takes place due to the presence of imperfections, impurities and doping concentrations in fiber crystals.Disperion is large in multi mode than in single mode fiber.

2. Transmission losses (attenuation):-

The attenuation or transmission losses may be classified into two categories i) Absorptionlosses ii) scattering losses

i) Absorption losses:-

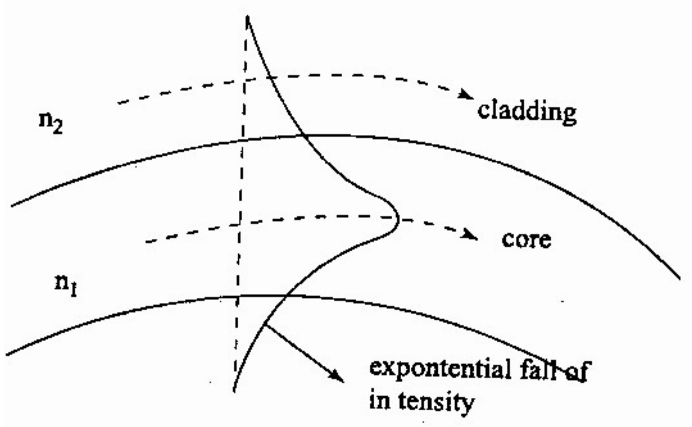
Absorption is a characteristic possessed by all materials every material inuniverse absorb suitable wavelengths as they incident orpassed through the material. In the same wayCore material of the fiber absorbs wavelengths as the optical pulses or wavelengths pass through it.

ii) Scattering losses:-

The core medium of the fiber is made of glass or silica .In the passage of optical signals in the core medium if crystal efects are encountered, they deviate from the path and total internal reflection is discontinued, hence such signals will be destroyed by entering into the cladding however attenuation is minimum in optical fibers compared to other cables.

ii) Bending losses:-

The distortion of the fiber from the ideal strait line configuration may also result in fiber.Let us consider away front that travels perpendicular to the direction of propagation.In order to maintain this, the part of the mode which is on the outside of the bend has to travel faster than that on the inside.As per the theory each mode extends an infinite distance into the cladding though the intensity falls exponentially.Since the refractive index of cladding is less than that of the core(n_1>n_2),the part of the mode traveling in the cladding will attempt to travel faster. As per Einistein'stheory of relativity since the part of the mode cannot travel faster the energy associated with this particular part of the mode is lost by radiation.



Attenuation loss is generally measured interms of decibels(dB), which is a logarithmic unit.Loss of optical power = -10 log (P_{out}/ P_{in}) dB Where $P_{out}$is the power emerging out of the fiber

P_{in} is the power launched into the fiber.

Unit IV

1)What are the differences between crystalline solids and amorphous solids?

Crystalline solids	**Amorphous solids**
. The atoms or molecules of the crystalline solids are periodic in space. 2. Some crystalline solids are anisotropic i.e The magnitude of physical properties such as refractive index, electrical conductivity. Thermal conductivity etc., are different along different directions of the crystal. 3. When it is broken, all broken pieces are same in shape. Because the atomic arrangement is regular manner. 4. They have sharp melting points. 5. They posses plane faces.	1. The atoms or molecules of the amorphous solids are not periodic in space. 2. Amorphous solids are isotropic i.e The magnitude of the physical properties are same along all directions of the solid. 3. When it is broken, all broken pieces are random in shape. Because: the atomic arrangement is random manner. 4. They do not posses sharp melting point. (wide range of melting points) 5. They do not possess plane faces.

2) Explain the following terms.

- **i) Crystal structure**
- **ii) Space lattice**
- **iii) Basis**

Crystal structure:

Atomic arrangement in a crystal is called crystal structure.

(Or)

Crystal is 3Dimensional body. These are made up of regular and periodic 3D Pattern's of atoms of molecules in space is called the crystal structure.

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Space lattice:

The atomic arrangement in a crystal is called crystal structure. It is very convenient to imagine periodic arrangement of points in space about which these atoms are located. This leads to the concept of space lattice.

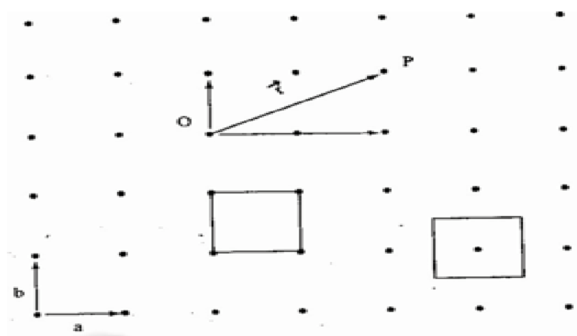


Fig. A two-dimensional square array of points.

A space lattice is defined as an infinite array of points in 3-dimensions in which every point has surroundings identical to that of every other point in the array.

Let us consider the 2D square array of points as shown in figure.

Let us choose any arbitrary point `o` as origin and a, b are two fundamental translational vectors along x and y directions the angle b/w these two vectors is 90^0. The magnitudes of 'a' and 'b' are equal and can be taken to be unity.

Let l, m are two integers along x and y direction and T_1 is the translational vector along x-axis and T_2 is the translational vector along y-axis.

$T_1 = la$ ---------------- (1)

$T_2 = mb$ --------------- (2)

L = 1+1 = 2 Units

M = 1 Units

Then the resultant translational vector T is

$T = T_1 + T_2$

$$T = la + mb$$

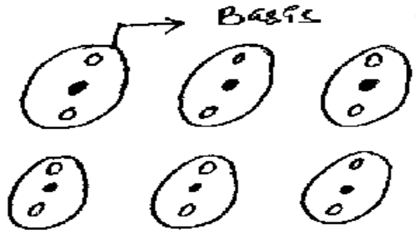
For 3Dimensions,

The resultant translational vector $T = la + mb + nc$

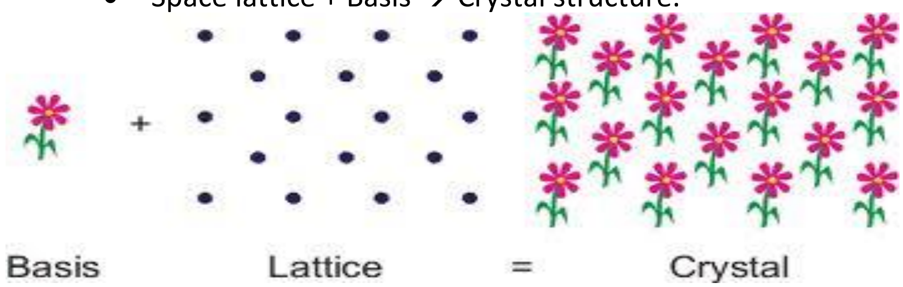
Where n, c is fundamental translational vector and integer along Z- axis.

Basis: A Group of identical in composition is called basis. It provides the no. of atoms per lattice point.

FIG:



- Space lattice + Basis → Crystal structure.



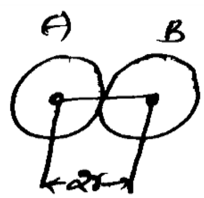
3)Explain the terms:
i) Nearest neighbour distance
ii) Coordination number
iii)Atomic radius

Nearest neighboring distance (2r):

The distance b/w the centers of two nearest neighboring atoms are called nearest neighboring distance.

If 'r 'is the radius of the atom.

FIG:



Nearest neighboring distance = r + r = 2r

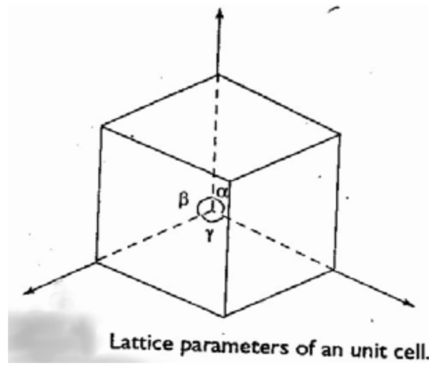
2. Atomic radius (r): It is defined as half the distance b/w the nearest neighboring distance or atoms in a crystal.

Atomic radius = 2r/2 = r

3. Coordination Number [CN]: It is defined as the no. of equidistant nearest neighboring atoms. How many nearest neighboring atoms are surrounded by the atom is called as co-ordination number [CN].

Coordination number for Simple cubic structure is 6
Coordination number for Body centered structure is 8 and
Coordination number for Face centered structure is 12.

4) What are the lattice parameters? Explain it.



Lattice parameters of an unit cell.

The lines drawn parallel to the lines of intersection of any three faces of the unit cell. Which do not lie in the same plane are called crystallographic axes (x, y and z). Let a, b, c are three translational vectors along x, y and z- directions. Unit cell shown with three crystallographic axes (x, y and z) and the intercepts a, b, c, are define the dimensions of a unit cell and are known as its primitives.

The angles b/w the three crystallographic axes are known as interfacial angles.

The angle between b and c is α

The angle between c and a is β and

The angle between a and b is γ.

The primitives a, b and c and interfacial angles α,β and γ are the Basis lattice parameters. Because they are used to determine the **size** and **dimension** of the unit cell. The unit cell formed by the primitives a, b, c is called `primitive cell`.

5)Derive an expression for Inter planer spacing of orthogonal crystal system?

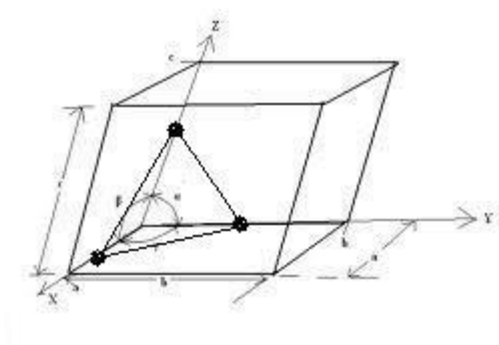


Fig:1

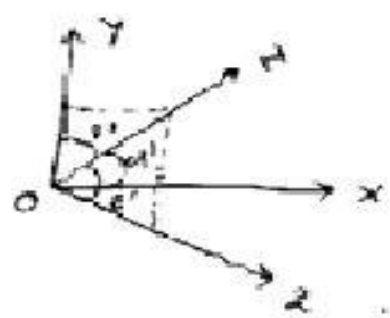


Fig: 2

The distance `d` b/w a series of planar in a crystal is known as inter planar spacing (d).

Let us consider a plane ABC with miller indices (h,k,l) has intercepts OA, OB,OC and three axes X, Y and Z – directions respectively.

The intercepts of the plane on three axes are OA = a/h , OB = b/k and OC = c/l

Let ON = d perpendicular distance from the origin to the plane. Let the direction cosines of ` ON` be $\cos\alpha^1$, $\cos\beta^1$, $\cos\gamma^1$.

$$\cos\alpha^1 = ON/OA = d/(a/h) = dh/a$$

similarly

$$\cos\beta^1 = ON/OB = d/(b/k) = dk/b$$

$$\cos\gamma^1 = ON/OC = d/(c/l) = dl/c$$

But we know that $\cos^2\alpha^1 + \cos^2\beta^1 + \cos^2\gamma^1 = 1$

$$(dh/a)^2 + (dk/b)^2 + (dl/c)^2 = 1$$

$$d^2\left[\frac{h^2}{a^2}+\frac{k^2}{b^r}+\frac{l^2}{c^2}\right] = 1$$

$$d^2 = \frac{1}{\frac{h^2}{a^2}+\frac{k^2}{b^r}+\frac{l^2}{c^2}}$$

$$d = \frac{1}{\sqrt{\frac{h^2}{a^2}+\frac{k^2}{b^2}+\frac{l^2}{c^2}}} \quad \text{-------- (1)}$$

OM be the $\perp^{lar}$ distance pf the next parallel plane from the origin. Its intercepts are $\frac{2a}{h}, \frac{2b}{k}, \frac{2c}{l}$.

$$OM = d = \frac{2}{\sqrt{\frac{h^2}{a^2}+\frac{k^2}{b^2}+\frac{l^2}{c^2}}} \quad \text{----------- (2)}$$

The spacing b/w two adjacent planes OM-ON = MN is called the inter planer spacing `d`.

$$d = OM - ON = \frac{2}{\sqrt{\frac{h^2}{a^2}+\frac{k^2}{b^2}+\frac{l^2}{c^2}}} - \frac{1}{\sqrt{\frac{h^2}{a^2}+\frac{k^2}{b^2}+\frac{l^2}{c^2}}}$$

$$d = \frac{1}{\sqrt{\frac{h^2}{a^2}+\frac{k^2}{b^2}+\frac{l^2}{c^2}}} \quad \text{--------- (3)}$$

In case of SC structure a=b=c

Than the inter planar spacing for SC structure is

$$d = \frac{1}{\sqrt{\frac{h^2}{a^2}+\frac{k^2}{a^2}+\frac{l^2}{a^2}}}$$

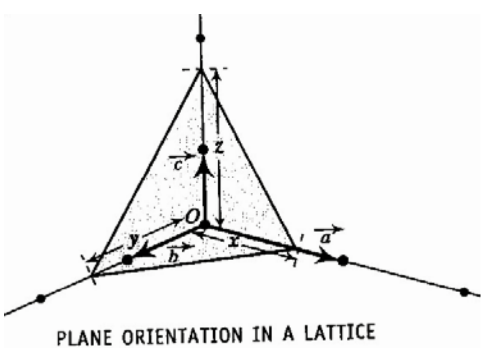
$$d = \frac{a}{(h^2+k^2+l^2)^{1/2}} \quad \text{---------- (4)}$$

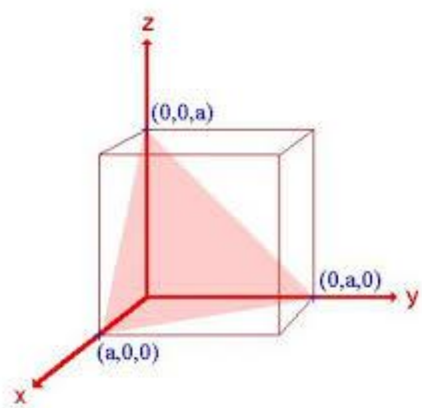
6)What are miller indices? Explain the procedure for finding miller indices?

The smallest whole numbers which are used to represent a set of parallel planes.

Procedure for the finding of miller indices:

(i) Find the intercepts of the desired plane on the 3-coordinate axis. Let these be (pa, qb, rc).





(ii) Express the intercepts as multiples of the unit cell dimensions or lattice parameters.

i.e (p,q,r)

(ii) Take the ratio of reciprocal of these numbers.

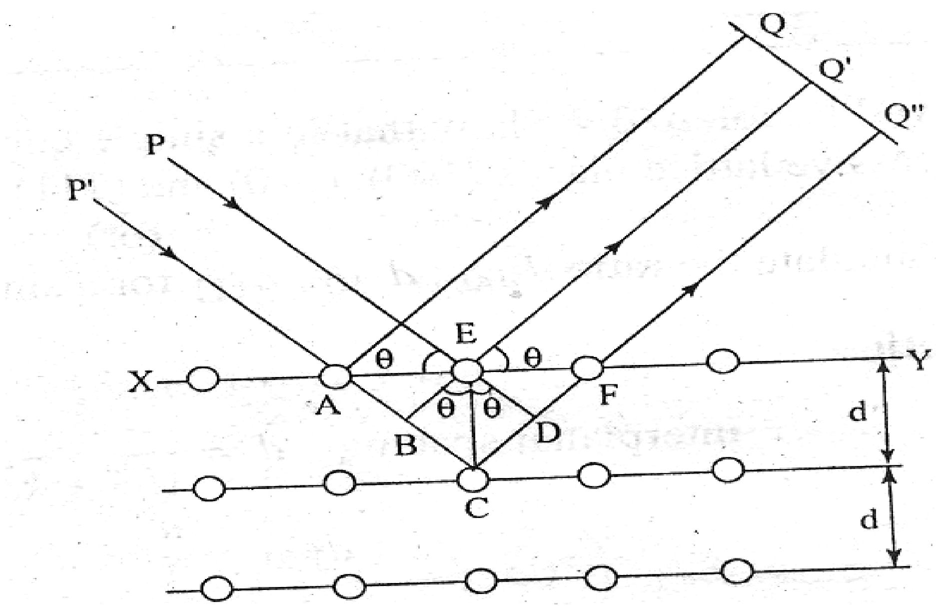
i.e (1/p, 1/q, 1/r)

(iv) Convert these reciprocals into whole numbers by multiplying each with their LCM to get the smallest whole number this gives the miller indices (h, k, l) of the plane.

UNIT V

1) State Bragg's law ? Derive the condition for bragg's law

"Bragg's law states that the X-rays reflected from different parallel planes of a crystal interfere constructively when the path difference is integral multiple of the wavelength of X-rays.



Let us consider a crystal made up of equidistant parallel planes of atoms with the inter-planar spacing 'd' as shown in fig. Let wave front of a mono-chromatic X-ray beam of wavelength 'λ' fall at an angle 'θ' on these atomic planes. Each atom scatters the X-rays in all directions. In certain directions these scattered radiations are in phase.

i.e., they interfere constructively while in all other directions, there is destructive interference.

Let us consider the rays PE and P'A inclined at an angle 'θ' with the top of the crystal plane XY. They are scattered along AQ and EQ' at an angle 'θ' with respect to the plane XY. Let us consider another incoming beam P'C and scattered along CQ''. Let us draw EB normal to AC and ED normal to CF as shown in fig. If 'EB' and 'ED' are parallel to the incident and reflected wave fronts.

Then the path difference between the incident and reflected waves is given by

$$\Delta = BC + CD \text{ --------------- } (1)$$

$$\text{In } \Delta\ BEC, \sin\theta = BC / EC = BC / d$$

$$\text{i.e., } BC = d \sin\theta \text{ ------------------- } (2)$$

$$\text{Similarly, in } \Delta\ DEC,\ CD = d \sin\theta \text{ ----------------- } (3)$$

$$\text{Hence, path difference } \Delta = BC + CD$$
$$= d\sin\theta + d\sin\theta$$
$$\Delta = 2d\sin\theta \text{ ---------------- } (4)$$

If two consecutive planes scatter waves in phase with each other, then the path difference must be an integral multiple of wavelength.

$$\text{i.e., } \Delta = n\lambda$$

Where n = 0, 1, 2, 3,……. is the order of reflection

From (4) and (5)

$$\mathbf{2d \sin\theta = n\lambda}$$

The above equation represents Bragg's equation or Bragg's law.

2)Explain Point defects?

A point defect or imperfection is much localized interruption in the regularity of the crystal. It produces strain in small volume of the crystal surrounding the defect, but does not affects the perfection of more distant parts of the crystal. Such defects may be in the form of vacancy Interstitial and impurity. When the vacancy is trapped (filled) by electron or holes constitute new types of point defects called as color centres.

<u>Vacancy or vacancies</u>:

These are the lattice sites from which the atoms are missing from their regular positions. It is shown in Fig 1. A vacancy is called Schottky defect. In ionic crystals, a Schottky defect is one anion vacancy together with cation vacancy. This is because the interior of ionic crystal is electrically neutral. It is shown in Fig. 2.

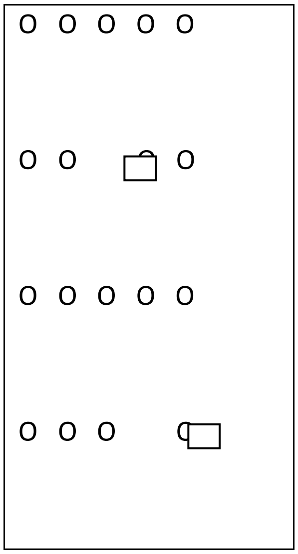


Fig 1: Crystal

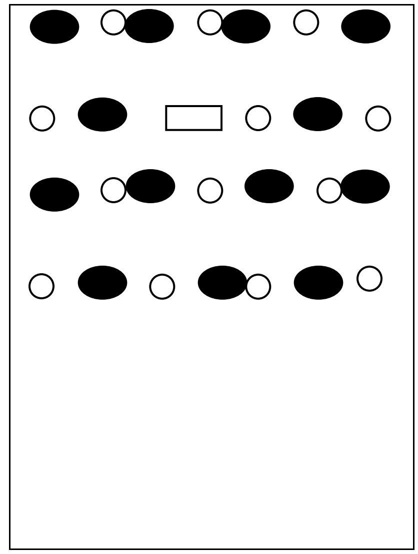


Fig 2 : Ionic Crystal

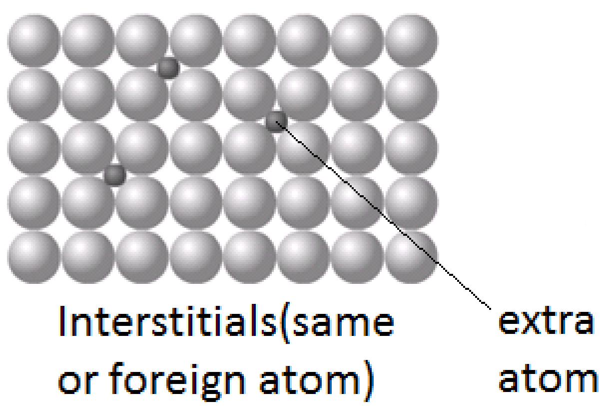
They are usually referred as the intrinsic defects as the associated vacancies are the intrinsic vacancies. It is clear that these clear defects preserve the stoichiometry of the crystal.

For most of the crystals, the thermal energy required to create a vacancy is about 1ev.

Interstitial atoms:

This is an extra atom inserted into the voids called intertice of the lattice between the regularity occupied sites as shown in figure. Thus such an atom does into occupy regular lattice sites. This extra atom may be in an impurity atom are an atom of the same type as on the regular lattice sites.

An atom can enter the interstitial void or space between the regular positioned atoms only when it is substantially smaller or equal to the parent atoms, otherwise it will produce atom distortion.



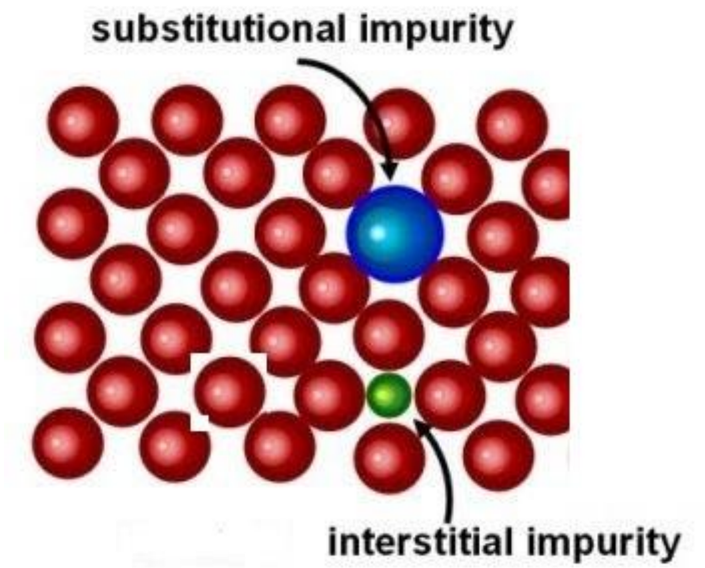
Impurity Defects:

Impurity defects are foreign atoms introduced into a crystal lattice. The most obvious point defect is the presence of a impurity atom in a perfect crystal. It may fit into the structure in two ways.

1.It may occupy a position normally occupied by the crystal atom .i.e. host atom in which case it will be called as “ substitutional impurity “ .

2.It may lodge normally unfilled volume, termed as void interstice between the atoms of the host crystal and called as interstitial impurity.

These are shown in figure



If the impurity atoms has roughly the same size and vacancy as the host atom, then the substitutional impurity created on the other hand, if the host crystal has relatively large interstices, then the interstitial impurity is accommodated in the crystal. Obviously, the interstitial impurity can exist only in ionic and covalent crystals and not in close packed crystal. In closed pack crystal substitutional impurity can take place. Impurities are usually deliberately added to pure crystals in order to modify their properties. The electrical conductivity of pure Ge, Se is enormously increased by adding trivalent or pentavalent which are well known in semi conductor devices.

<u>Electronic Defects</u>:

Errors in change distribution in solids are called electronic defects. These defects are produced when the composition of an ionic crystal does not correspond to the exact stoichiometric formula. Ex: ZnO, FeO etc.,

<u>Schottky Defects</u>:

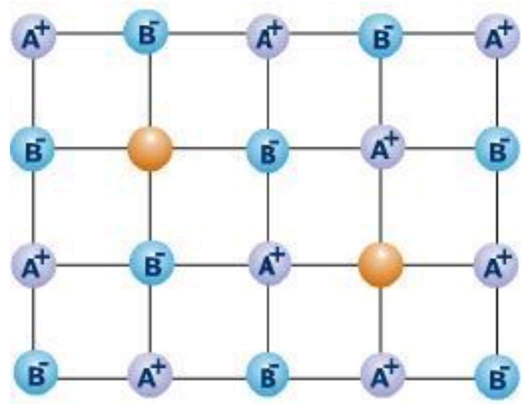
1. Ion vacancies are called Schottky defects.
2. A pair of one cation and one anion can be missing from an ionic crystal as shown in figure. The valance of the missing pair of ions should be equal to maintain neutrality. So these are normally generated in equal number of anion and cation vacancies in a crystal.

3. A Schottky defect is the combination of one cation vacancy and one anion vacancy.

4. When vacancies are created by movements of an anion and one cation from positions inside the crystal to positions on the surface of the crystal. A Schottky defect is said to have been formed.

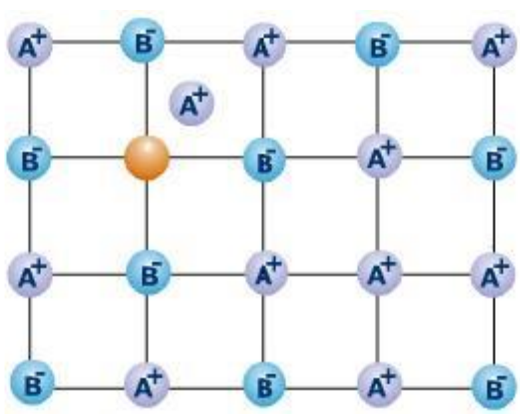
5. The concentration of Schottky defects decreased the density of the crystal.

6. This type of point defect is dominant in alkali halides



Frenkel Defect:

1. In the case of ionic crystals an ion displaced from the lattice in to an interstitial site is called a Frenkel defect.
2. As cations are generally the smaller ions, it is possible for then to get displaced into the void space present in the lattice. Anions do not get displaced like this as the void space is just too small for their size.
3. A Frenkel defect s the combination of one cation vacancy and one cation interstitial defect.
4. The concentration of Frankel defects does not change the density of the crystal.
5. A Frankel imperfection does not change the overall electrical neutrality of the crystal.
6. The point imperfections in silver halides and calcium floride are of the Frenkel type.
7. Frenkel and Schottky defects together are called “Intrinsic defects”.



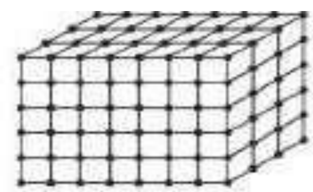
3) Explain Line Defects?

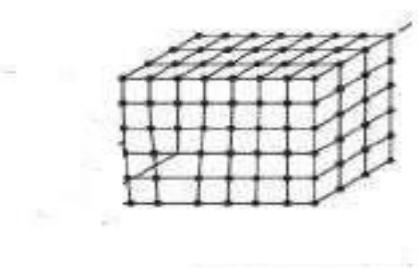
Line defects are one dimensional imperfection in the geometrical sense. Line imperfections are called dislocations. Dislocations are best understood by referring to tow limiting straight line type.

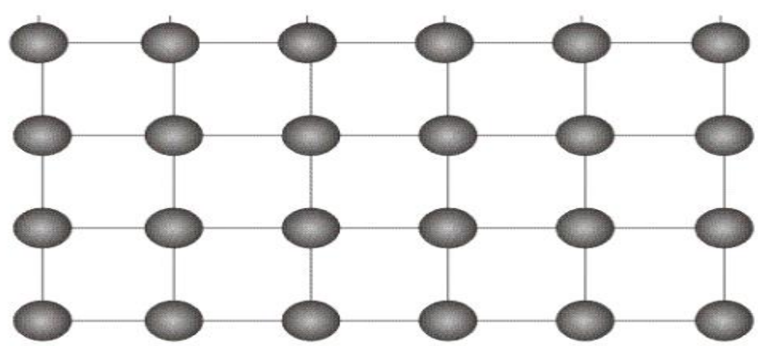
(i) The edge dislocation
(ii) Screw dislocation

Edge dislocation:

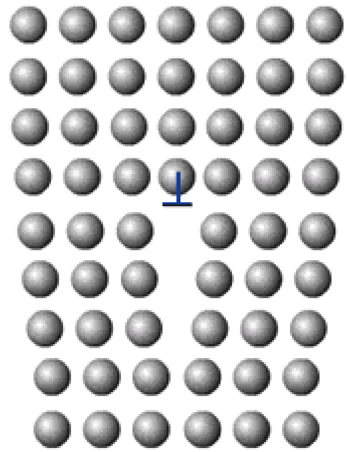
In perfect crystal, atoms are arranged in both vertical and horizontal planes parallel to the side faces as shown in Fig (a). If one of these vertical planes does not extend to the full length but ends in b/w. within the crystal as shown in Fig (b). It is called edge dislocation.







Perfect Crystal



Crystal with edge dislocation.

Edge dislocations are symbolically represented by T or ⊥ depending on whether the incomplete plane starts from the top or from the bottom of the crystal. These two configurations are referred to as positive and negative edge dislocations

Screw dislocation:

Screw dislocation results from a displacement of the atoms in one part of a crystal relative to the rest of the crystal. Forming a spiral ramp around the dislocation line as illustrated in figure. It shows a method of determining the burgers vector applied to an edge dislocation. Arbitrary a positive direction is chosen for the dislocation and then the vector which closes the circuit is found. In the figure one such burgers vector circuit is shown. Burgers vector 'b' is required to close the circuit, which is parallel to the dislocation line.

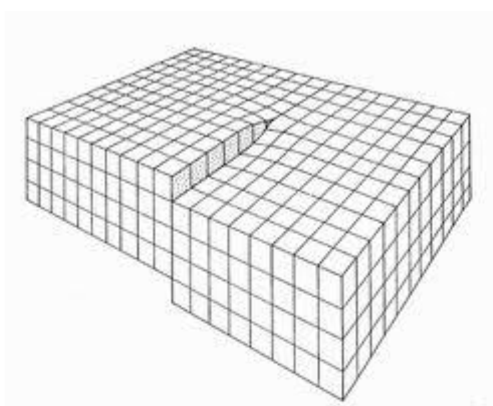


Fig Screw dislocation.

<u>4)</u> Explain Burgers vector?

The magnitude and direction of the displacement are defined by a vector is called the "Burgers vector".

We understand the burgers vector concept. Let us consider two crystals, one perfect and another with edge dislocation as shown in figure (a) and (b) respectively. In fig (a), starting from the point 'P' we go up by 6 steps, then move towards right by 5 steps and move down by 6 steps and finally move towards left by 5 steps to reach the starting point 'P'. The burgers vector circuit gets closed, when the same operation is performed on the crystal shown in fig (b). We end up at Q instead of the starting point P. Now we have to move an extra step QP to return to "P" in order to close the burgers circuit. The magnitude and the direction of the step defines the burgers vector (BV).

BV=QP=B