ALPHA COLLEGE OF ENGINEERING & TECHNOLOGY
MOST IMP QUESTION BANK(FAQ)
BRANCH & SEMESTER: 1^{ST} CIVIL, ME, EC

ENGINEERING PHYSICS(2110011)

Q-1 Explain ferrites. (Jan.2013)

Q-2. Derive Clausius – mossotti Equation.(Jan.2013)

Q-3. Explain types of Dielectric material.(Aprl.2013)

Q-4. Explain Electrical polarisation mechanism.

Q-5. Explain hysteresis B - H curve. (March-April 2012)

Q-6. Describe the construction & working of Nd: YAG laser with a suitable energy level diagram.(March 2012)

Q-7. Difference between stimulated emission & spontaneous emission(Jan.2013)

Q-8 What do you mean by acceptance angle & numerical aperture? Derive expression for them.(Jan.2011)

Q-9 List out the difference between single mode fibre & multimode fibre. (Aprl.2013)

Q-10 Explain the mode of propagation of optical fiber & index profile. (Jan.2012)

Q-11 Explain meissner effect & prove that $\chi = -1$ for superconductors. (Jan.2013)

Q-12. Difference between type-I & type-II superconductors.(Jan.2013)

OR

Explain the types of Superconductors on the basis of its behaviour with Applied magnetic field".

Q-13. Discuss the Properties of Supper Conductor. (April.2013)

Q-14 Factor affecting Acoustics of building and their remedies. (Dec.2012)

Q-16. Explain (1) The pulse echo system and (2) ultrasonic flaw detector with advantages & limitations.

Q-17 What is nanoparticle? Explain size dependence effect in nanomaterial. (April. 2014)

Q-18. Discuss in detail (1) the quantum confinement (2) surface to volume ratio.

Q-19 Explain the synthesis method of nano-material (1) Ball Milling (2) Sol-gel .
Explain the properties, application and types of carbon nanotube. (April.2014)

Q-20 The primary advantages of fibre-optics communication compared to metallic cable communication.(Jan.2013)

Physics

(1) Explain ferrites.

Ans: Definition: In some materials, spin alignments are not in a same direction due to this they posses not spin magnetic moments. These materials are known as ferrites.

⇒ The different types of ferrites are:

(1) Spinel: Spinel ferrites are majority Fcc structure carrying AB_2O_4, formula. Here A & B are metal cations.

(2) Hexagonal: They are magnetic iron oxide ceramic with combination of stronium, cobalt and Barium.

(3) Garnet: $Y_3(Fe_5O_{12})$ is a silicate mineral garnet structure. They are hard magnet having antiparallel spin allignment.

(4) Orthoferrites: Ferrous with rare earth materials having formula $RFeO_3$ known as "orthoferrites". They are weak ferromagnetic materials.

⇒ Properties of ferrites:

→ This materials posses net spin magnetic moment and it's allignment is shown in fig.

↑↓↑↓↑↓

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→ They have high resistivity of the order of $10^5 \Omega$.

→ Ferrites exhibits extremelly low di-electric loss.

→ Susceptibility of ferrites is very large and positive.

$$\chi = \frac{C}{T \pm \theta} \quad \text{where, } T > T_n$$

→ They behave like paramagnetic above curie temp and ferromagnetic below curie temp.

⇒ Applications:

→ Ferrites are used for permanent magnet

→ Ferrit rod is used to produce ultrasonic waves through magnetostriction method.

→ Ferrites which have hysteresis loop as rectangular shape is used for data storage.

→ In light frequency transformers, core of transformers in made up of soft ferrites.

→ In television, it's modulation circuit. receivers etc. are made up of soft ferrites are used materials.

→ Soft ferrites are used for high frequency applications.

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(2) Derive Clausius - Mossotti Equation.

Ans:-) The Polarisation for a single atom is given by

$$P = N\alpha_T E_{int}$$

where, α_T = total polarisability,
E_{int} = internal field

we know that, $\alpha_T = \alpha_e + \alpha_i + \alpha_o$

for a cubic structure element, since there are no ions and permanent dipoles $\alpha_i = \alpha_o = 0$

$$\therefore P = N\alpha_e E_{int} \quad [\because \alpha_T = \alpha_e] \text{ --- (1)}$$

Substituting for E_{int}

$$P = N\alpha_e\left(E + \frac{P}{3\varepsilon_0}\right) \text{ --- (2)}$$

we also know that

$$P = \varepsilon_0 E(\varepsilon_r - 1) \text{ --- (3)}$$

Substituting for P in equation (2), we get

$$N\alpha_e \times \left(E + \frac{P}{3\varepsilon_0}\right) = \varepsilon_0 E(\varepsilon_r - 1)$$

$$\therefore N\alpha_e \times \left(E + \frac{\varepsilon_0 E(\varepsilon_r - 1)}{3\varepsilon_0}\right) = \varepsilon_0 E(\varepsilon_r - 1)$$

$$\therefore N\alpha_e E\left(\frac{3 + \varepsilon_r - 1}{3}\right) = \varepsilon_0 E(\varepsilon_r - 1)$$

$$\therefore N\alpha_e(2 + \varepsilon_r) = 3\varepsilon_0(\varepsilon_r - 1)$$

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$$\therefore N\alpha_e = 3\varepsilon_0 \frac{(\varepsilon_r - 1)}{(\varepsilon_r + 2)}$$

$$\therefore \frac{N\alpha_e}{3\varepsilon_0} = \frac{\varepsilon_r - 1}{\varepsilon_r + 2} \quad \text{——— (4)}$$

The above relation is known as clausius-mossotti equation.

(3) Explain types of Dielectric material.

Ans => Dielectric materials can be solied, liquid or gaseous. A high vacuum can be used as a dielectric even though its relative dielectric constant is only unity.

→ Solid dielectric are most commonly used in electrical engineering, these are very good insulators.

E.x Procelain, glass, Plastics, rubber, cotton

→ Liquid dielectric materials are basically of three different types, which include (i) mineral insulating oils (ii) synthetic insulating oils and (iii) miscellaneous insulating oils.

E.x Transformer oil, cable oil, capacitor oil, Vegetable oil, vaseline, silicon liquids.

→ Gaseous dielectric materials are used both as insulators and as cooling agents.

E.x Air, hydrogen, nitrogen, helium, propane, shulphurdioxide, methane, sulphur hexafluoride, ethane, etc.

* Solid dielectrics:

(1) mica: mica is an inorganic mineral material, made of the silicate of aluminium with silicates of soda, potash and magnesia. It is crystalline in nature and can be divided into very thin flat sheets

→ mica is widely used in electric irons, hot plates and toasters for insulation purpose. mica is also used as a dielectric material in high frequency applications.

(2) glass: Glass is an inorganic material made by the fusion of different oxides like SiO_2, ZnO and MgO.

→ It is used as a dielectric in capacitors. It is used in radio and television tubes.

(3) Asbestos: Asbestos is a naturally occurring mineral material of fibrous nature. It generally consists of magnesium silicate.

→ It is used as dielectric or insulating material to prevent current flow in the outer body of electrical appliances like electric iron box, oven etc. It is widely used in the form of paper, tape, cloth and board.

(4) Rubber: Rubber is an organic ploymer, it may be natural or synthetic. synthetic rubbers are produced by copolymerisation of isobutylene and isoprene.

→ Rubber is used in the construction of storage battery housings. It is used as insulating materials for electric wires, tapes, transformers, motor winding etc.

(5) Ceramics: Ceramics are generally non-me inorganic compounds such as silicates, aluminates, oxides, carbides, nitrides and hydroxides.

→ Ceramics are widely used as insulators for switches, plug holders, cathode heaters etc.

* Liquid Dielectrics:

(1) Mineral insulating oils: These oils are obtain from crude petroleum by distillation. These insulating oils possess high oxidation resist and have good thermal stability. These are used in transformers and capacitors.

→ Transformer oil, cable oil and capacitor o belong to the category of mineral insulati oils.

(2) Synthetic insulating oils: Askarels, aroclors, sovol and sovtol are a few synthetic insula oils that are widely used.

→ Synthetic oils are very much resistant to oxidation and to fire hazards.

(3) Miscellaneous insulating oils: Vaseline, vegetable oils and silicon liquids belong t this category. Silicon liquides have thermal stability up to 200°C and are costly. The dielectric strength of these liquids is same as that of mineral oils.

* Gaseous Dielectrics:

(1) Air:→ Air is a naturally available dielectric material. It is the most important insulating material. The dielectric loss is practically zero. It can be used as an insulation only in low voltage application.

(2) Nitrogen: Nitrogen is an important gaseous dielectric. It is chemically inert. It prevents oxidation and reduces the rate of deterioration. It is also used in capacitors and in cables under pressure.

(3) Sulphur hexafloride: Sulphur hexafluoride is formed by burning of sulphur in fluorine atmosphere. It has superior cooling properties than those of air and nitrogen.

(4) Inert gases are used in electronic tubes and discharges tubes as insulators.

4) Explain Electrical Polarisation mechanism.

Ans:→ There are four different types of mechanisms through which electrical polarisation can occur in a dielectric material when it is subjected to an external electric field.

They are:

(1) Electronic polarisation
(2) Ionic polarisation.
(3) Orientation polarisation
(4) Space charge or Interfacial Polarisation.

(1) Electronic Polarisation:

→ The electronic polarisation occurs due to displacement of the positively charged nucleus and the negatively charged electron cloud in opposite directions.

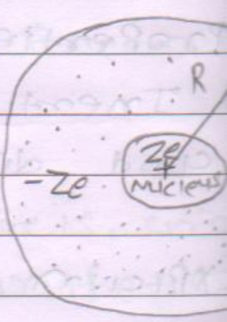
There for, the induced dipole moment, where α_e is electronic polarisability.

The electronic polarisability for a gas atom is given by.

$$\alpha_e = \frac{\epsilon_0(\epsilon_r - 1)}{N}$$ where, N = number of atoms

⇒ Expression for Electronic Polarisability α_e.

Let us consider one of the constituent atoms of a dielectric material in the absence of an electric field E. Let the radius of the atom be R and its atomic number be Z as shown in figure.

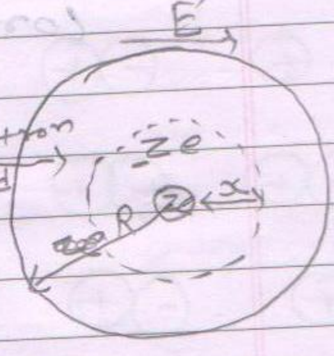


Therfore, the charge density for electron cloud is given by

$$\rho = \frac{-Ze}{\frac{4}{3}\pi R^3} = -\frac{3}{4}\left(\frac{Ze}{\pi R^3}\right)$$

But, when an electric field is applied, the nucleus and the electron cloud experience a Lorentz force of magnitude ZeE.

since the nucleus is much heavier than the electron cloud it is assumed that only the electron cloud is displaced upon applying an electric field. Let the electron cloud displacement be x with respect to the centere of the nucleus.



Hence, the lorentz force acting over the electron cloud is $-ZeE$ — (2)

Thus, the coulomb force $= Ze \times E$ — (3)

Based on coulomb's theorem

$$E = \frac{q}{4\pi\epsilon_0 x^2} \quad \text{— (4)}$$

But the total charge enclosed in sphere of radius x is $q = \rho \times \frac{4}{3}\pi x^3$ — (5)

substituting for ρ from equation (1), we get.

$$q = \frac{-3}{4}\left(\frac{Ze}{\pi R^3}\right) \times \frac{4}{3}\pi x^3$$

$$q = \frac{-Zex^3}{R^3} \quad \text{— (6)}$$

Substituting for q in eqn (4), we get

$$E = \frac{-Zex^3}{R^3} \times \frac{1}{4\pi\epsilon_0 x^2} \quad \text{— (7)}$$

$$\text{coulomb force} = Ze \times \frac{-Zex^3}{R^3} \times \frac{1}{4\pi\epsilon_0 x^2}$$

$$= \frac{-Z^2e^2x}{4\pi\epsilon_0 R^3} \quad \text{— (8)}$$

Lorentz force = coulomb force

$$-zeE = -\frac{z^2e^2x}{4\pi\varepsilon_0R^3}$$

$$E = \frac{zex}{4\pi\varepsilon_0R^3}$$

$$x = \frac{4\pi\varepsilon_0R^3}{ze}.E \quad \text{— (10)}$$

There fore, the induced dipole moment,

$$\mu = ze \times x$$

$$= ze\left(\frac{4\pi\varepsilon_0R^3}{ze}.E\right) \quad \text{— (10)}$$

$$\mu = 4\pi\varepsilon_0R^3.E \quad \text{— (11)}$$

$$\mu = \alpha_eE \quad \text{— (12)}$$

comparing eqn (11) & (12), we have

$$\alpha_e = 4\pi\varepsilon_0R^3$$

$$P = N\mu_0 = N\alpha_eE \quad \text{— (13)}$$

we also know that $P = \varepsilon_0E(\varepsilon_r-1)$ —

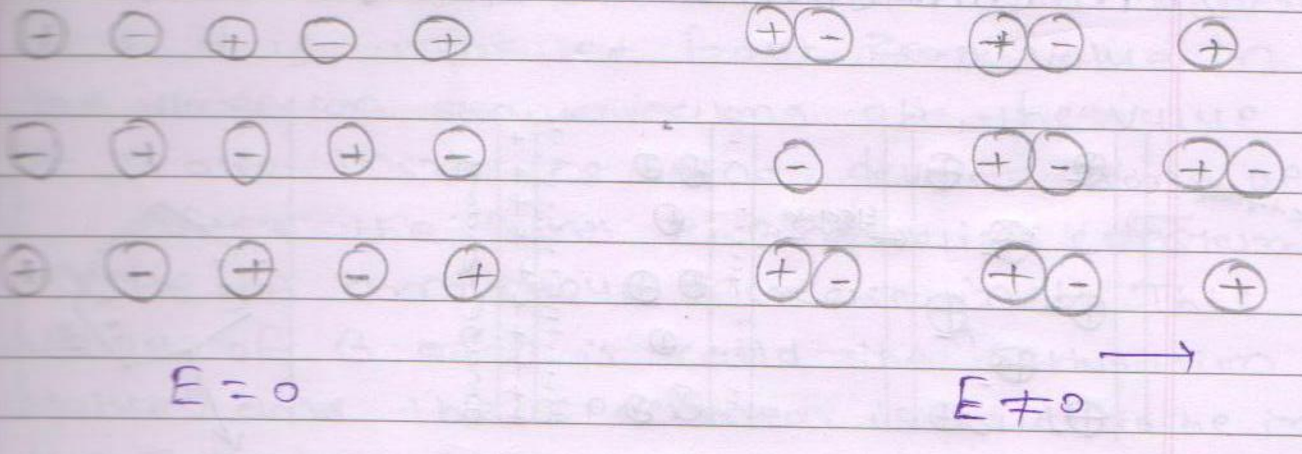
∴ Equating Equation (13) & (14)

$$N\alpha_eE = \varepsilon_0E(\varepsilon_r-1)$$

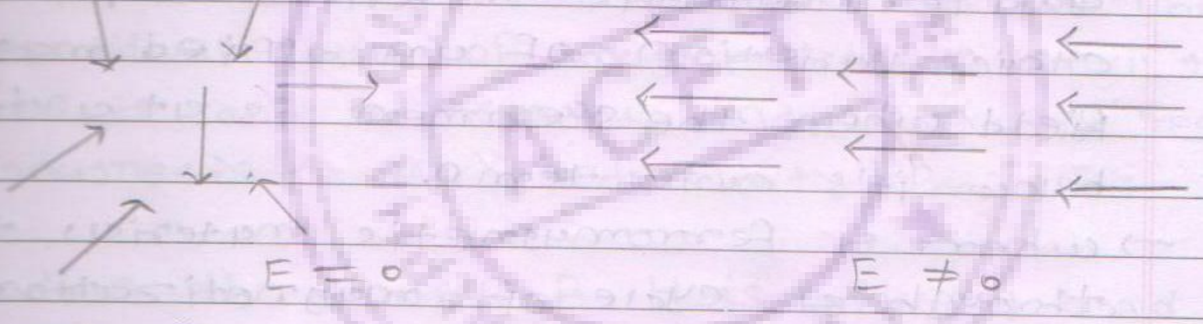
$$\boxed{\alpha_e = \frac{\varepsilon_0(\varepsilon_r-1)}{N}}$$

(2) Ionic polarisation:

→ Ionic polarisation occurs only in ionic s[olids] such as NaCl which possess ionic bonds. [It] does not occur in covalent crystals as diamond, silicon and germanium.



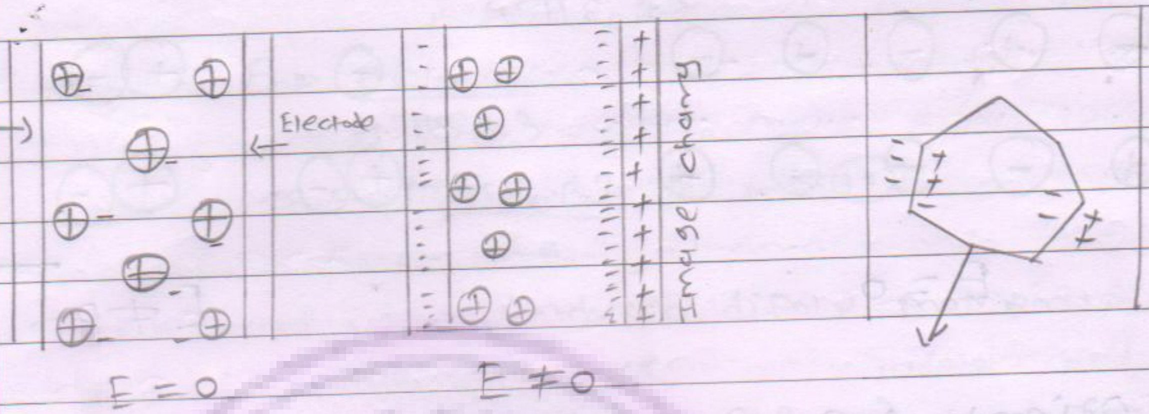
(3) <u>Orientation Polarisation</u>: Orientation Polarisation occurs in dielectric materials which possess molecules with permanent dipole moment.



→ This Polarisation occurs in ferroelectric materials such $BaTiO_3$ and $PbTiO_3$ and produces a very high dielectric constant in these materials.

(4) <u>Space charge</u>: The space charge polarisation occurs in multiphase dielectric materials. When such materials are subjected to an external electric field, especially at high temperature the charges get accumulated at the interface or at the electrodes because of sudden charge

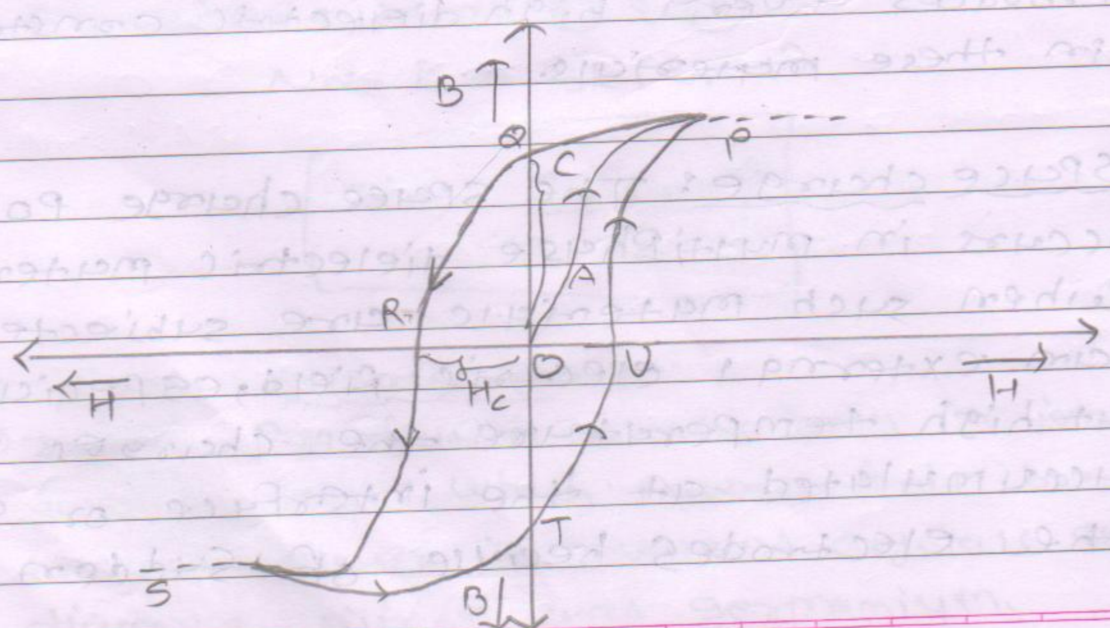
in conductivity as shown in figure.



(5) Explain hysteresis B-H curve.

Ans: Definition: Hysteresis is the lagging of magnetic induction B in ferromagnetic and ferrimagnetic materials w.r.t the cyclic variation of an applied magnetic field when the specimen is at a temp below it's curie temp.

→ when a ferromagnetic material take through a cycle of magnetization, the variation B w.r.t the applied field H is shown in below fig.



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→ we can observe that when the magnetic field H is increased from zero value in the direction shown along OH, the value of B also increases and develops along OP.

After the point P, B remains constant inspite of continuous increase in H. This value of B at P is calld the "saturation value" and the specimen is said to be in the saturated magnetization state.

→ Now value of H is decreased, B start decreasing from the point P, but fail to replace the same path which it had while H was increasing. Thus the new path is PQ. when retain a value equal to OQ. This residual value of magnetization equal to OQ is calld remanent induction or residual magnetism or "retentivity" Br.

→ when the value of H is revesed and increased gradually till the point R is reached, the magnetic induction B becoms zero at the point R. and the specimen get completely demagnetized. This value H = OR is calld coercivefield H_c and the effect is called "coercivity".

→ Further increase in H causes the specimen to get magnetized in the opposite direction. This make B also to increase in opposite direction and reaches a saturation value again at S. when field is decreased the curve traces the path ST insteed of SR.

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→ Again the specimen gets completely demagnetized at U, when the dire^n of H is reversed and increased along OH. The curve traces the path UP as H is increased further.

Thus the variation of B w.r.t H traced along the closed path PQRSTUP in one full cycle of magnetisation and demagnetisation is called "hysteresis loop" or "hysteresis curve".

→ The area enclosed by the curve gives the energy loss per unit volume of material per cycle.

Hysteresis loss:

→ The energy loss in the form of heat that occurs during the full cycle of magnetisation and demagnetisation processes in a ferromagnetic material is called "Hysteriesis loss".

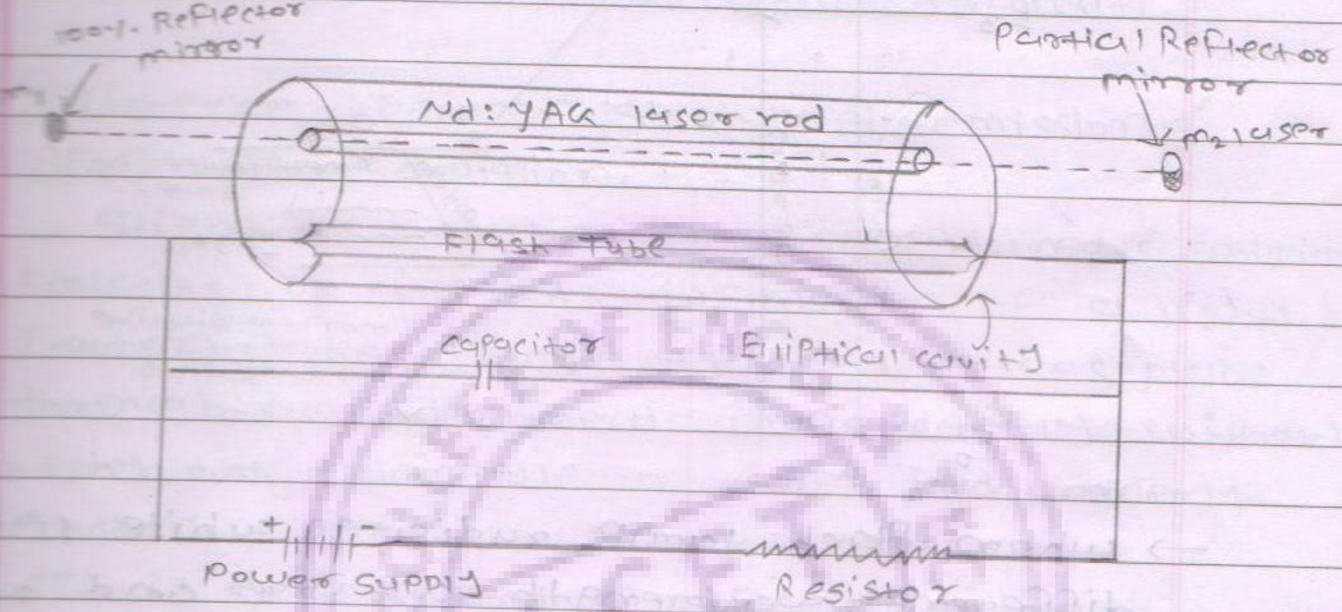
(6) Describe the construction & working of Nd: YAG laser with a suitable energy level diagram.

Ans: ⇒ Active medium Active centere:

Here active medium is YAG - Yttrium aluminium garnet material. In the YAG material 1% doping of Nd^{+3} ion is done. Basically we replaced 1% Al^{+3} ions by Nd^{+3} ions. Nd^{+3} ions are active center for the laser.

→ optical pumping:
A Xenon flash lamp or a Krypton flash lamp is used as a pumping source.

⇒ construction:

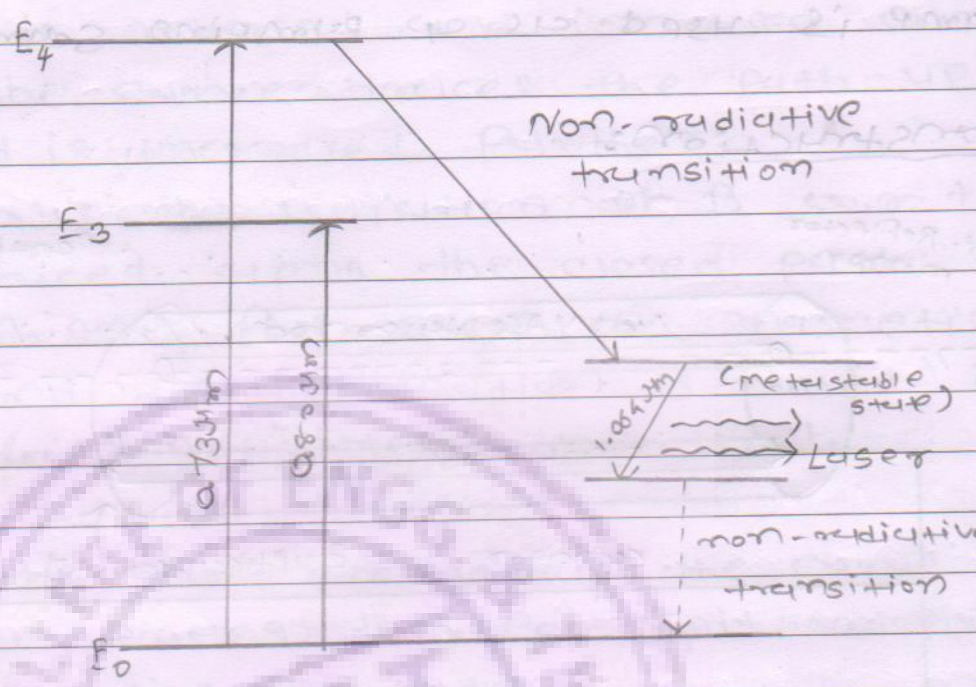


→ As shown in fig Nd: YAG rod is mounted with xenon flash lamp on cavity resonator. The entire system is connected with power supply.

→ Nd: YAG rod is fully silvered at one end to provide 100% reaction that acts as optical cavity. Although 100% reflecting and partially reflecting mirrores are also mounted at the both the sides.

→ Nd: YAG rod is being illuminating by xenon flash lamp which is connected with reqnive power supply.

⟺ Working:



→ when flash lamp radiates white light different wavelength 0.73μm and 0.8 are being absorbed by Nd^{+3} ions and they transit to excited state (E_4→E and ($E_0 \rightarrow E_3$) respectively.

→ Due to solid state excitation, E_3 and are energy bands and then a non radiative transition occurs between $E_4 \rightarrow E_2$ & $E_3 \rightarrow E_1$. Due to this transition energy is released to latt

→ E_2 is a metastable state and move number of Nd^{+3} ions are now in E_2 state compared to lower state E_1. Hence population inversion is achieved.

→ Radiative transition takes place be $E_2 \rightarrow E_1$ and Nd^{+3} ions radiate 1.06

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wavelength. This is infrared region and out put beam is in form of pulse waves.

→ Now, a rapid transition between $E_1 \to E_0$ is achived mostly by colling system. This is again non-radiative transiti.

Difference between stimulated emission & spontaneous emission.

Stimulated emission	Spontaneous emission
1) Emission of a light photon takes place through an inducement i.e by an external photon.	→ Emission of a light photon takes place immediately without any inducement.
2) It is not a random process.	→ It is a random process.
3) The photon get multiplied through chain relation.	→ The photons do not get multiplied through chain reaction.
4) It is a controllable process.	→ It is an uncontrollable process.
5). more intense.	→ Less intense
6) monochromatic radiation.	→ polychromatic radiation.

What do you mean by acceptance angle & numerical aperture? Derive expression for them.

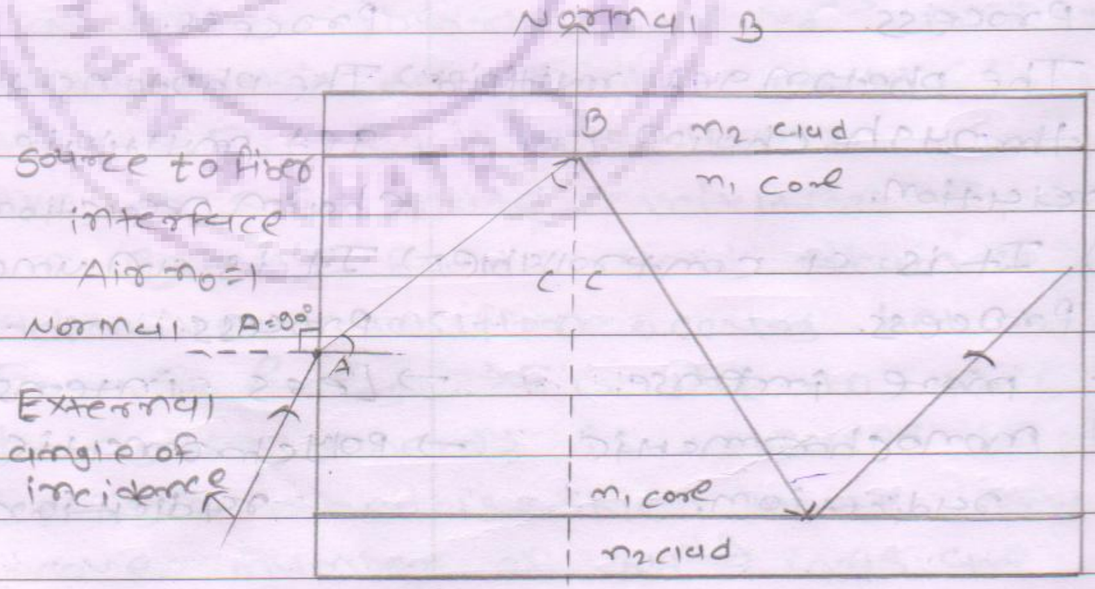
→ Definition - Acceptance Angle: Acceptance angle of the fibre θ_{max} is defined as the maximum value of the angle of incidence at the entrance end of the fibre, at which the angle of incidence at the core-cladding interface is equal to critical angle of the core medium.

mathematically given as

$$\sin \phi_{max} = \sqrt{n_1^2 - n_2^2}$$

Derivation:

The above mathematical relation can be obtained as follows. The core of the fibre has a refractive index n_1 and is surrounded by a cladding of material with a lower refractive index n_2.



Light is launched into the end of the fibre from a launch region with a refractive index n_0. If the launch region is air then $n_0 =$ when light rays enter the fibre, they the air/glass interface at it's axis point A, with an angle of incidence ϕ_{in}.

In order for a ray of light to propagate down the cable, it must strike the internal core interface at an angle that is greater than the critical angle ϕ_c.

Applying Snell's law to the external angle of incidence yields, the following relation

$$n_0 \sin\phi_{in} = n_1 \sin\phi_1 \quad \text{--- (1)}$$

But,

$$\phi_1 = 90° - \phi_c \quad \text{--- (2)}$$

There fore, substituting eqn (2) in (1) we get,

$$n_0 \sin\phi_{in} = n_1 \sin(90° - \phi_c)$$

$$n_0 \sin\phi_{in} = n_1 \cos\phi_c \quad \text{--- (3)}$$

If we consider the point B in fig, the critical angle value for ϕ_c is

$$\sin\phi_c = \frac{n_2}{n_1} \quad \text{--- (4)}$$

ϕ_c in eqn (3), in terms of $\sin\phi_c$,

$$n_0 \sin\phi_{in} = n_1 (1 - \sin^2\phi_c)^{1/2} \quad \text{--- (5)}$$

Substituting for $\sin\phi_c$ from eqn (4)

$$n_0 \sin\phi_{in} = n_1 \left[1 - \left(\frac{n_2}{n_1}\right)^2\right]^{1/2}$$

$$n_0 \sin\phi_{in} = n_1 \left(\frac{n_1^2 - n_2^2}{n_1^2}\right)^{1/2}$$

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

$$\sin \phi_{in(max)} = \sqrt{n_1^2 - n_2^2}$$

$$\boxed{\phi_{in(max)} = \sin^{-1} \sqrt{n_1^2 - n_2^2}} \quad \text{--- (7)}$$

* <u>Numerical Aperture:</u>

→ Numerical aperture (NA) is a figure of merit that is used to describe the light gathering or light collecting ability of optical fibre. The larger the magnitude of NA, the greater the amount of light accepted by the fibre from the external light source.

Thus,

$$NA = \sin \phi_{in(max)}$$

$$NA = \sqrt{n_1^2 - n_2^2} \quad \text{--- (8)}$$

i.e $\Delta = \frac{n_1^2 - n_2^2}{2n_1^2} = \frac{n_1 - n_2}{n_1}$

$$NA = n_1 \sqrt{2\Delta}$$

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

$$= \sqrt{(n_1 + n_2) \Delta n_1}$$

$$= \sqrt{2n_1^2 \Delta} \quad \text{if } n_1 = n_2$$

$$\boxed{NA = n_1 \sqrt{2\Delta}}$$

9) List out the difference between single mode fiber & multimode fibre.

Ans:

single mode fibre	multi mode fibre
1) Light can propagate through the fibre in only one mode.	→ Light can propagate through the fibre with a large number of modes
2) The fibre core diameter is very small and also, the difference between and the refractive indices of the core and cladding is very small.	→ The fibre core diameter is large and also, the difference in refractive indices of the core cladding also large.
3) since light propagates in single mode, no dispersion occurs.	→ Due to multimode propagation and material scattering, there is singl degradation.
4) Launching of light into the fibre and coupling process is not easy.	→ Launching of light into the fibre and coupling process are easy.
5) Used in long haul communication.	→ Used in LAN.
6) since, the fabrication is difficult, the production cost is high.	→ Since, the fabrication is easy, the production cost is low.

10) Explain the mode of propagation of optical fibre & index profile.

Ans: → Light can be propagated down an potical fibre by either reflection or refraction.

→ How the light is propagated depends on the mode of propagation and the index profile of the fibre.

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* Mode of Propagation:-) In fibre optic terminology, the word mode simply path. That is, it defines the number paths being taken by the light to propagate down the cable. These are two modes of propagation.

1. Singlemode fibre.
2. multimode fibre.

* Singlemode fibre: If there is only one for the light to propagate down the cable is called a single mode fibre.

-) singlemode fibres are capable of wide and and are ideally suited for long haul communication. Low cost and high capacity for the transmission of telephone and cable television etc, are the additional features of this fibre.

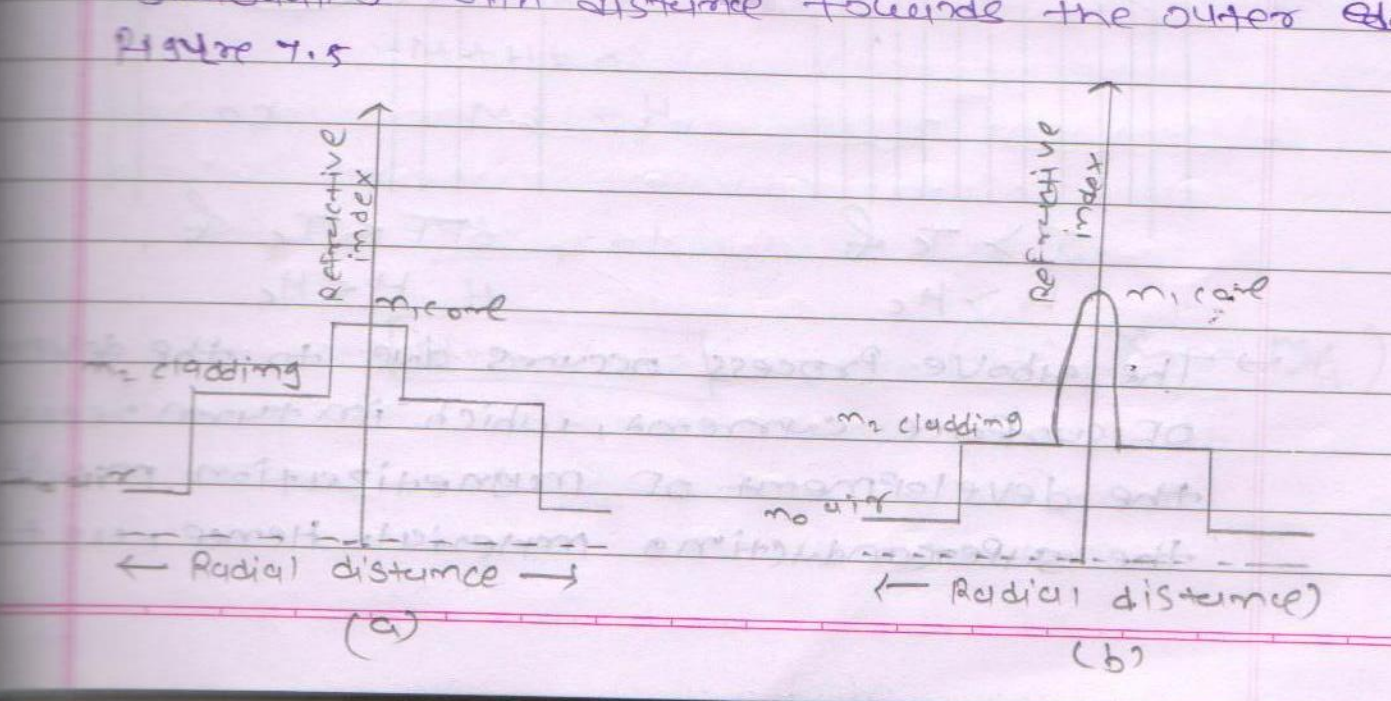
* multimode fibre: If the light takes more one path one path to propagate down cable it is called a multimode fibre.

-) fibres with cores of about 200 to 100 diameter, support many waveguide modes. fibres are ideally suited for high medium haul application. The upper limit of the mode is determind by the core diameter and numerical aperture.

★ INDEX PROFILE: In any optical fibre whole material of the cladding has a uniform refractive index value.

→ The curve which represents the variation of refractive index with respect to the radial distance from the axis of the fibre is called the refractive index profile.
There are two basic types of index profiles:
1) Step-index fibre.
2) Graded-index fibre.

* Step-Index fibre: A step index fibre has a central core with a uniform refractive index. The core is surrounded by an outside cladding with a uniform refractive index less than that of the central core. Below figure(a) shows the index profile for a step-index fibre. From the figure it is seen that, there is an abrupt change in the refractive index at the core/cladding interface and hence the refractive index profile.
* Graded Index Fibre: In a graded index fibre the refractive index of the core is non-uniform. It is highest at the center and decreases gradually with distance towards the outer edge, figure 4.5

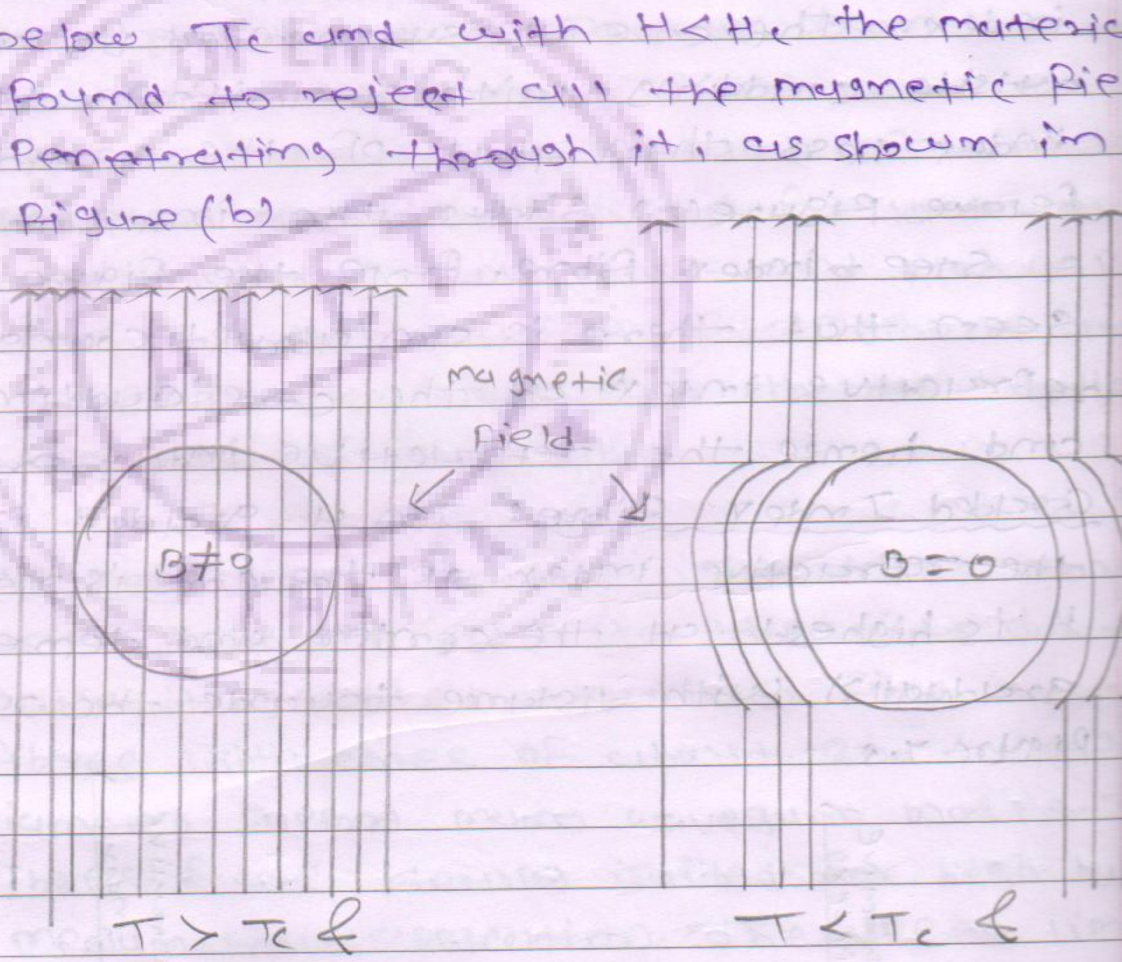


(11) Explain meissner effect & prove that for superconductors.

Ans: ⟹ Meissner effect: The complete expulsio[n of] all the magnetic field by a supercond[ucting] material is called the 'meissner effe[ct]'.

→ When a superconducting material is pl[aced] in a magnetic field (H > H_c) at room temperature the magnetic field is fo[und to] penetrate normally throughout the m[aterial].

→ However, if the temperature is lowere[d] below T_c and with H < H_c the materia[l is] found to reject all the magnetic fie[ld] penetrating through it, as shown in figure (b)



→ The above process occurs due to the de[velopment] of surface currena, which in turn re[sults in] the development of magnetization m[...] the superconducting material. Hence, a[...]

developed magnetisation and the applied field are equal in magnitude but opposite in direction, they cancel each other every-where inside the material.

Thus, below Tc a superconductor from a normal perfect conductor.

* Prove $\chi_m = -1$

We know that for a magnetic material the magnetic induction or magnetic flux density B is given by

$$B = \mu_0 (M + H) \quad \text{--- (1)}$$

where, μ_0 = permeability of free space
M = intensity of magnetisation
H = applied magnetic field.

But, we know that for a superconductor
$B = 0$

There fore eqn (1) can be written as

$$0 = \mu_0 (M + H)$$

$$\therefore \mu_0 \neq 0$$

$$M + H = 0$$

or

$$M = -H$$

$$\frac{M}{H} = -1$$

$$\boxed{\chi_m = -1} \quad \left(\because \chi_m = \frac{M}{H}\right)$$

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(12) ① Difference between type - I & type - II superconductors.

Ans:

Type - I superconductor	Type - II super[conductor]
1) These superconductors are called as soft superconductors.	→ These supercondu[ctors] are called as h[ard] superconductors
2) Only one critical field exists for these superconductors.	→ Two critical fie[lds H_{c1}] and H_{c2} exist [for] these supercondu[ctors]
3). The critical field value is very low.	3) The critical fie[ld] value is very h[igh]
4). These superconductors exhibit perfect and complete meissner effect.	→ These do not exhi[bit] perfect & ~~perfect~~ complet meissner ef[fect]
5) These materials have limited technical applications because of very low field strength value.	→ These materials h[ave] wider technologi[cal] application becau[se of] very high field st[rength]
Examples: Pb, Hg, Zn etc.	E.x: Nb_3Ge, Nb_3Si, ... etc.

(13) Discuss the properties of supper condu[ctors]

Ans:

(1) Electrical resistance: The electrical resis[tance] of a superconducting material is very [low] and is of the order of 10^{-7} Ωm

(2) Effect of impurities: when impurities are [added] to superconducting elements, the supercond[ucting] property is not lost, but the Tc value is lowered.

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(3) Effect of pressure and stress: certain materials are found to exhibit the superconductivity phenomena on increasing the pressure over them. for example, Cesium is found to exhibit superconductivity phenomena at $T_c = 1.5 K$ on applying a pressure of 110k bar

In superconductors, the increase in stress result in increase of the Tc value.

(4) Isotope effects: The critical or transition temperature Tc value of a superconductor is found to vary with its isotopic mass. This variation in Tc with its isotopic mass is called the isotopic effect.

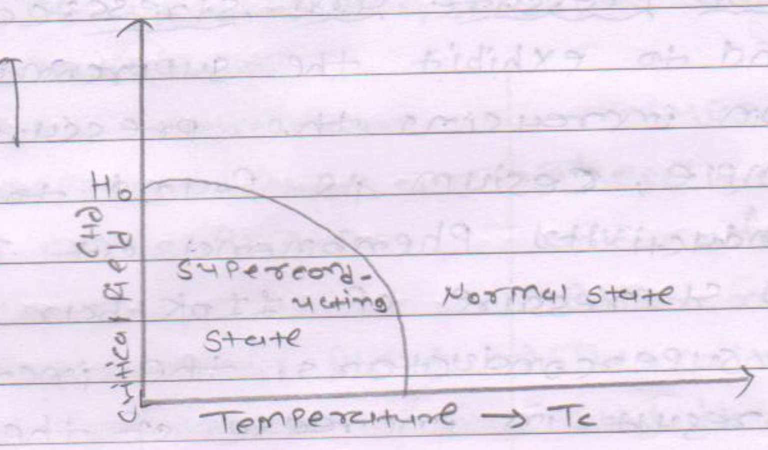
The relation between Tc and the isotopic mass is given by

$$T_c \propto \frac{1}{\sqrt{M}}$$ where, M = isotopic mass

(5) Magnetic field effect: If a sufficiently strong magnetic field is applied to a superconductor at any temperature below its critical temperature Tc, the superconductor is found to undergo a transition from the superconducting state to the normal state.

$$H_c = H_0 \left[1 - \left(\frac{T^2}{T_c} \right)^2 \right]$$

where, H = critical field
T = Tc



→ figure shows the variation of critical field H_c as a function of temperature. The material is said to be in the superconducting state within the curve and is non-superconducting in the region outside the curve.

(6) Critical current density J_c and critical current

→ The critical current density is another important characteristic feature of the superconducting state.

→ Hence, the critical current density can be defined as the maximum current that can be permitted in a superconducting material without destroying its superconductivity state.

$$I_c = 2\pi r H_c$$

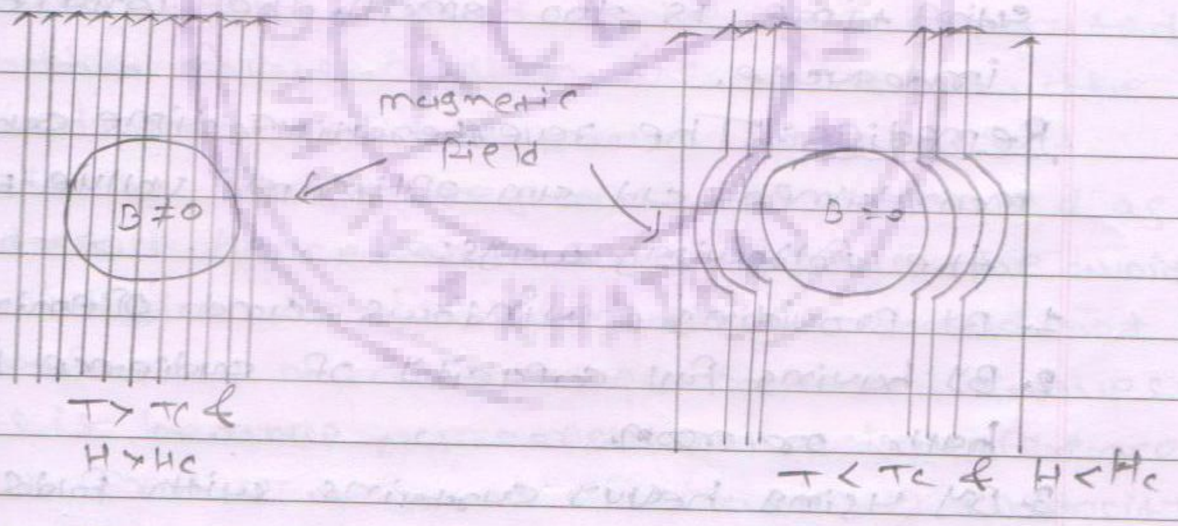
Similarly, the relation between critical current density J_c and critical current I_c is given

$$J_c = \frac{I_c}{A}$$

where, A = superconducting specimen cross sectional area.

(7) <u>Persistent current</u>: when current is made to flow through a superconducting ring, which is at a temperature either equal to its T_c value or less than it's T_c value, it was observed that the current was flowing through the material without any significant loss in it's value.

(8) <u>Meissner effect</u>: The complete expulsion of all the magnetic field by a superconducting material is called the 'meissner effect'.
When a superconducting material is placed in a magnetic field ($H > H_c$) at room temperature, the magnetic field is found to penetrate normally throughout the material.



→ The above process occurs due to development of surface current, which in turn results in the development of magnetization M within the superconducting material. Hence, as the developed magnetization and the applied are equal in magnitude but opposite in direction.

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(14) Factor affecting Acoustics of building & their remedies.

Ans:→ The various factors affecting the ac[oustics] of building such as reverberation time, loudness, focussing, echo, and noise with their remedies are explained in brief i[n] this section.

(i) Reverberation Time: Reverberation is th[e] persistence or prolongation of sound in [a] hall even after the source stopped emitt[ing] sound.

→ In order to have a good acoustic effect, th[e] reverberation time has to be maintained [at] optimum value. The reason is, if the rev[erber]ation time is too small, the loudness be[comes] inadequate.

Remedies: The reverberation time can be maintained at an optimum value by ad[opting] the following ways:

1. By providing windows and openings.
2. By having full capacity of audience in th[e] hall or room.
3. By using heavy curtains with folds.
4. By covering the floor with carpets.
5. By decorating the walls with beautif[ul] picture, maps, etc.

(ii) Loudness: The uniform distribution of lo[udness] in a hall or a room is an important [factor] for satisfactory hearing. Sometimes, the lo[udness] may get reduced due to excess of sound-ab[sorption] materials used inside hall or room.

Remedies:

1) By using suitable absorbents at places where noise in high. As a result, the distribution of loudness may become uniform.

2). By using large sounding boards behind the speaker and facting the audience.

3). By constructing low ceilings for the reflection of sound towards the listener.

4). By using public address system like loudspeakers.

(iii) Focussing and Interference Effects:

→ The presence of any concave surface or any other curved surface in the hall or room may make the sound to be concentrated at this focus region. As a result, the sound may not be heard at all at regions. These regions are referred as dead space. Hence, such surfaces must be avoided.

→ In addition to focussing there should not be interference of direct and reflected waves. This is because, a constructive interference may produce a sound of maximum intensity in some places and a destructive interference may produce a sound.

Remedy: curved surfaces can be avoided. If curved surfaces are present, they should be covered with suitable sound-absorbing materials.

(iv) Echo: An echo is heard due to reflecti
of sound from a distant sound-reflecti
object.
-) If the time interval between the dir
sound and reflected sound is less than
of a second the reflected sound is he
in increasing the loudness.
Remedy: An echo can be avoided by cove
long-distance walls and high ceiling w
suitable sound-absorbing material. Th
prevents reflection of sound.

(v) Echelon Effect: It refers to the gen
of a new separate sound due to multipl
echos. A set of railings or any regu
reflecting surface is said to produce th
echelon effect. This echelon effect aff
the quality of the original sound.
Remedy: The remedy to avoid echelon
to cover such surfaces with sound-
absorbing materials.

(vi) Resonance: Resonance occurs due to the
matching of frequency. If the windo
panels and section of wooden portion
have not been tightly fitted, they ma
start vibrating, thereby creating an
extra which may produce.
Remedy: The resonance may be avoided
fixing the window panels properly. Any o
vibrating object which may produce reso
can be placed over a suitable sound-abso
mate

(vii) Noise: The unwanted sound is called a noise. The hall or room should be properly insulated from external and internal noise. In general, there are three types of noises:
1) Air-borne noise,
2) Structure-borne noise
3) Inside noise.

⟹ Air-borne Noise: Extraneous noises which are coming from outside st through open windows, doors and ventilators are known as air-borne noise.

Remedies:
1). The hall or room can be made air conditioned.
2). By using doors and windows with separate frames with proper sound-insulating material between them.

⟹ Inside Noise: The noise which are produced inside the hall or room is called inside noise. The inside noise may be produced due to machineries like air conditioners.

Remedies:
1). The sound-producing machineries can be placed over sound-absorbing materials like carpet, pads., wood, felt, etc.
2) By using curtains of sound-absorbing materials.
3) By covering the floor, wall and ceiling with sound-absorbing materials.

⟹ Structure - borne noise: The noise which is conveyed through the structure of the building is called structure - borne noise.

Remedies:

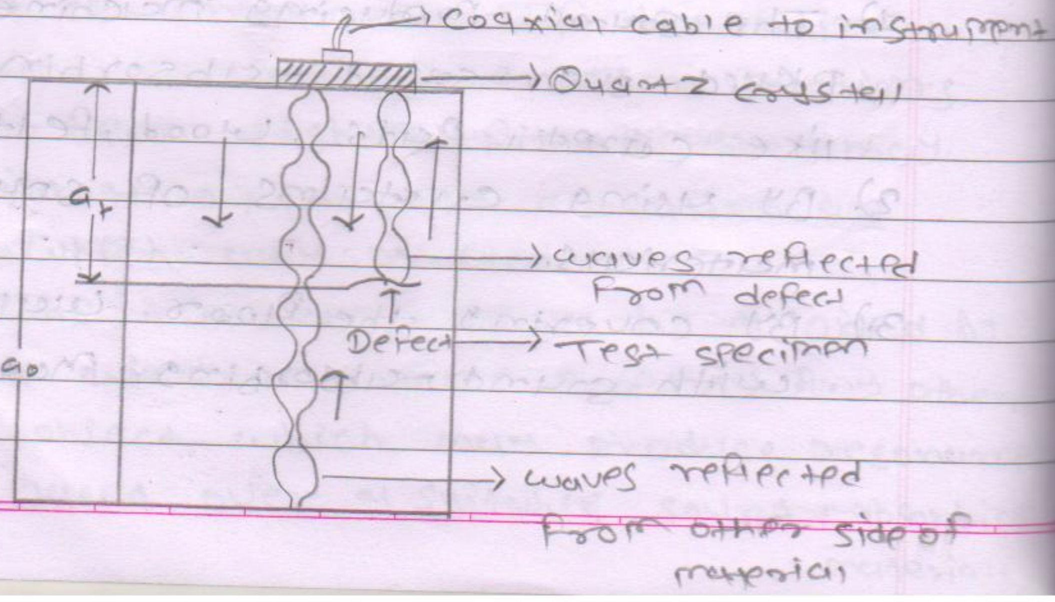
1). This noise can be eliminated by using double walls with air space between them.

2) By using anti-vibration mounts this type of noise can be reduced.

3) By covering the floor and walls with proper sound - absorbing material this noise can be eliminated.

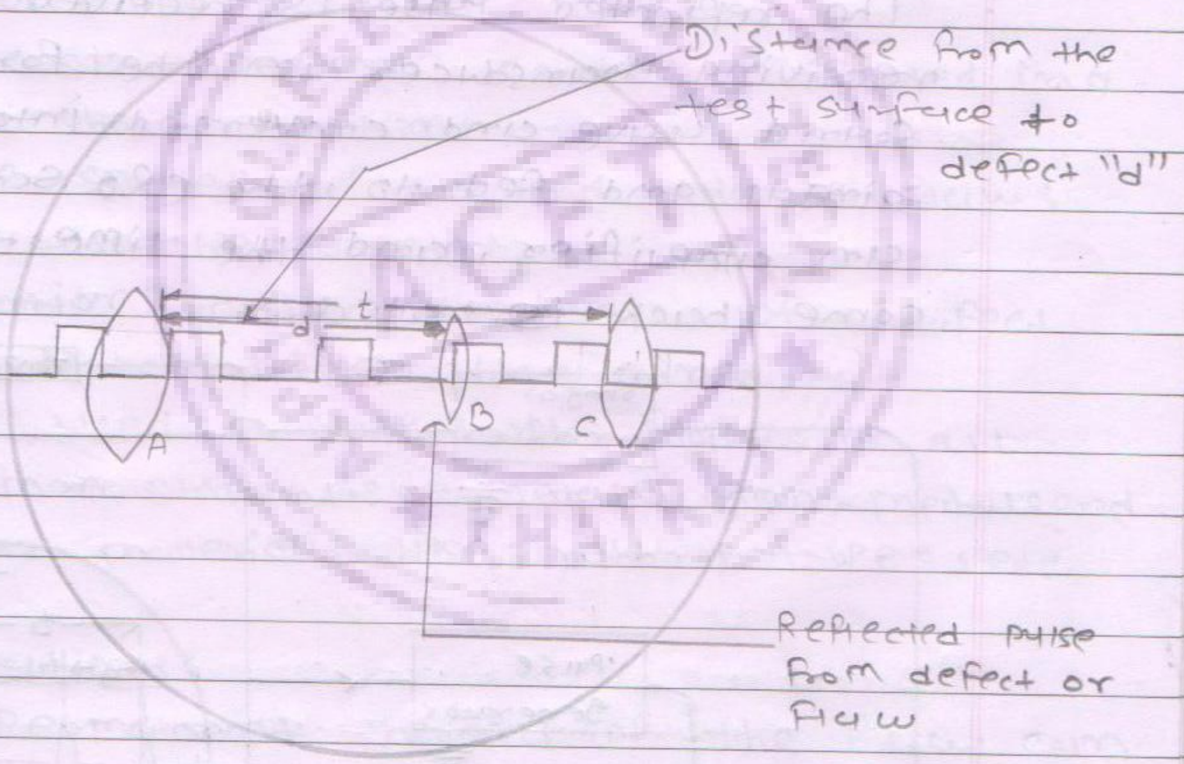
(18) Explain (1) The pulse echo system and (2) ultrasonic flaw detector with advantages & limitations.

Ans: * Pulse Echo System: The pulse echo system is the most widely used ultrasonic test. In this system, a single transducer is used for both sending and receiving the ultrasonic sound waves, as shown in figure. For a better contact of the transducer with the metal surface couplete like thin oil or glycerine is used.



→ In the pulse echo system evenly timed pulses of ultrasonic sound waves are produced from a pulse generator which are transmitted into the material being tested.

→ As the waves pass through the top surface of the material being tested, there will be a pattern or 'pip' on the oscilloscope screen labelled A, and if there is no defect in the specimen the 'pip of reflected pulse will appear at 'c', as shown in figure.



→ The reflected pulse from the flaw will appear as a smaller 'pip' between the other two, i.e. one from top and the other from bottom. Since the distance between the pips on the oscilloscope screen represents elapsed time of the reflected pulse, the distance to a flaw can be accurately measured.

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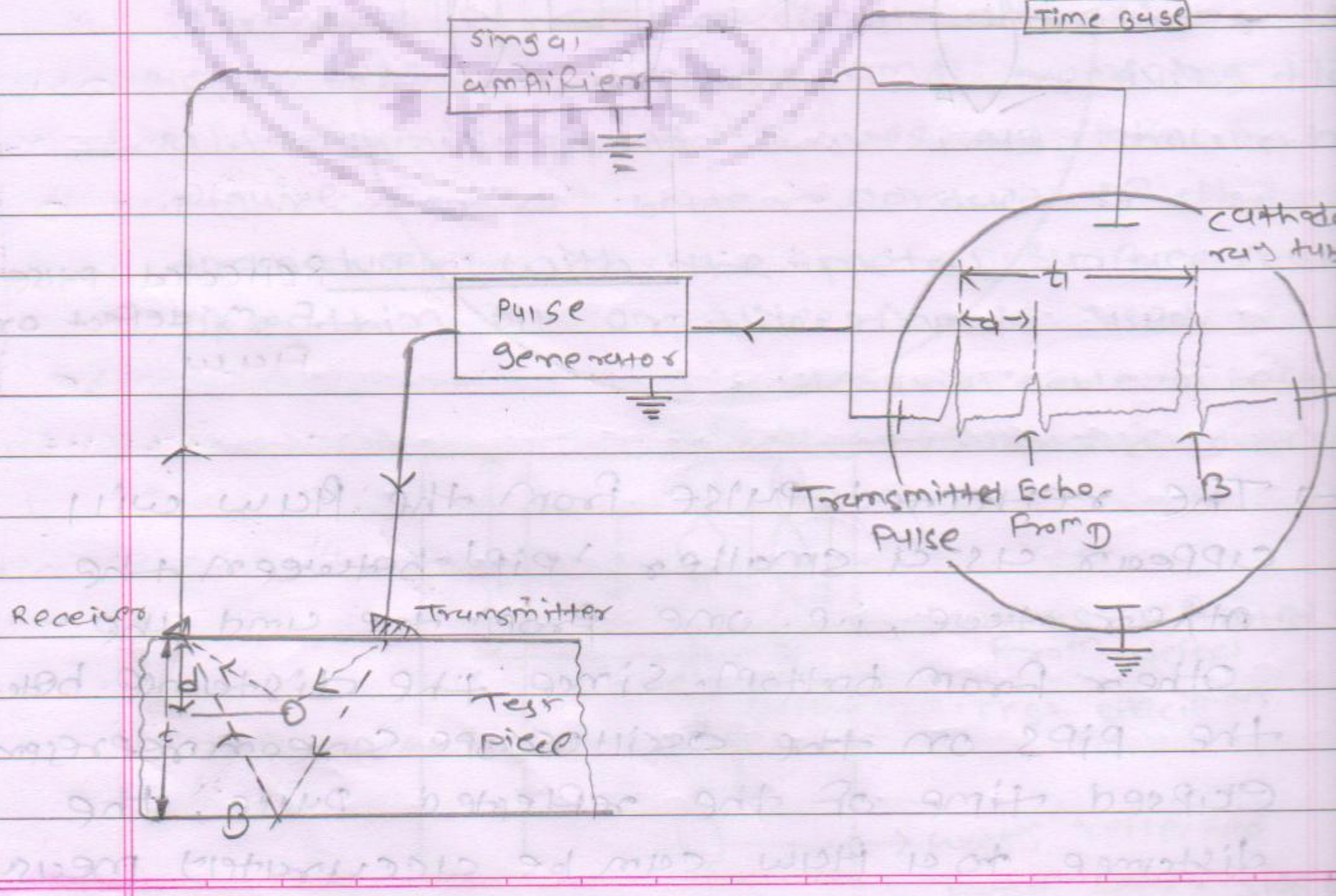
* Ultrasonic Flaw Detector: The through transmission system requires the use of transducers, one for transmitting or sendi[ng] the sound waves, and the other for receiving the sound waves, as shown in figure below.

→ The pulse of ultrasonic waves are transmitted into and through the me[tal]

→ The transmitted ultrasonic waves get reflected when they encounter a crack cavities in the interior of the metal bloc[k]. The reflected pulse is received by the receiving transducer in the form of a sound wave and converted into an ele[ctrical] signal and fed to the CRO screen thr[ough] an amplifier, and the time t taken [to] come back is noted.



→ If the velocity v of the ultrasonic waves in the metal is known, the position of the crack can be located. The exact size and shape of the cavity or crack can be found out by examining the metal specimen from all directions.

⇒ Advantages of Ultrasonic inspection method.

1) It is more accurate than radiography method.
2) It is very cheap and it has a high speed of operation.
3) Large size specimen can be inspected in a very short duration.
4) Deep-seated defects and minute flaws can also be detected.
5) Location, nature and size of a defect can be accurately determined.
6.) It is used to detect the flaws in all common structured metals, non-metals and other materials like rubber types, etc.

⇒ Limitations:

1) No permanent record of the flaw can be obtained and it can be observed only on the screen.
2) only skilled and well-trained technicians can perform this testing.
3). Parts that are rough, irregular in shape, very small or thin or not homogeneous are difficult to inspect.

(17) What is nanoparticle? Explain size dependent effect in nanomaterial.

Ans:→ A particle with size in the range 1-100nm is called a nanoparticle.

→ When the particles are in nanoscale of about 1-100 nm, the material properties change significantly from those at larger scales. This is the size scale where the so called quantum effects rule the behaviour and properties of particles. In this scale range, the properties of particles are size dependent.

→ Thus when the particle is in nanoscale properties such as, melting point, fluorescence, electrical conductivity, chemical reactivity, magnetic permeability etc change as a function of the size of the particle.

⟹ Basically there are two ~~four~~ types of size dependent effects.

(i) Increase in surface area to volume ratio of materials. This effect can make nanomaterials more chemically reactive and affect their strength, melting point or electrical properties.

(ii) Quantum effects which show discontinuous behaviour due to completion of shells in with delocalised electrons. The quantum may affect the optical, electrical and m behaviour of materials.

→ Besides quantum size effect, the nanomaterials behaviour is different due to surface effects which dominate as nanocrystal size decrease.

(14) Discuss in detail (1) the quantum confinement (2) surface to volume ratio.

Ans:

(1) Quantum confinement:

→ Electron confinement or quantum confinement is another process that occur in nanoparticles.

→ Quantum confinement describes how the electronic and optical properties change when the material size is at nanoscale.

→ one of the most direct effect of reducing the size of materials to nano scale is the appearance of quantisation effects due to the confinement of the movement of electrons. This leads to the discrete energy levels depending on the size of the structure.

→ The quantisation confinement can be observed only when the diameter of the material is of the same magnitude as the wavelength of the electron wave function.

→ Quantum confinement effects describe electrons in terms of energy levels, potential well, valence band, conduction band and energy band gap.

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→ However when the material size is decreas towards nanoscale, the confinement dimens also naturally decrease. In other words, the energy spectrum becomes discrete measur as quanta rather than continuous as in bulk materials. This situation of discre energy levels is called quantum confineme

→ Thus to conclude, in nanomaterials, the electrons are cofined in space rather than free to move as in the case of bulk materials.

Nanoscale quantum confinement can be 0D, 1D or 2D.

→ 0D confinement is found in quantum do

→ 1D confinement is found in nanowires. Electron confinement in one direction results in a quantum wire, leaving the electrons free to move only along one direction.

→ 2D confinement is found in quantum well. In quantum well, the electrons are confined within a two dimensional area.

[2] Surface to volume ratio:

→ The surface area to volume ratio, also called the surface to volume ratio is the amount of surface area per unit volume of an object. Surface area to volume ~~to~~ ratio is a great way to measure the efficiency of nanotechnology.

→ Surface area to volume ratio in nanoparticles have a significant effect on the nanoparticles property. Nanoparticles have a larger surface area compared to the same volume of the bulk material.

→ Let us assume that, the nanoparticles are spherical in shape. Let us consider the radius of the atom to be 'r'. Then,

the surface area of spherical atom $= 4\pi r^2$

the volume of the spherical atom $= \frac{4}{3}\pi r^3$

Therefore, the surface area to the volume ratio is $SA : V = \frac{4\pi r^2}{\frac{4}{3}\pi r^3} = \frac{3}{r}$

→ The above value of SA:V ratio shows that, the surface area to volume ratio increases with the decrease in radius of the sphere and vice versa. It can also be concluded that, when a given volume is divided into smaller pieces, the surface area increases. Therefore as particle size decreases, a greater portion of the atoms are found at the surface compared to those inside and thus affecting reactivity.

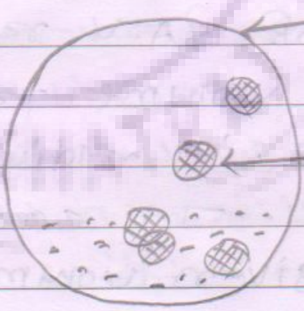
→ Therefore, smaller grains have more surface area with respect to their volume. more surface area to volume ratios are favourable for chemical reactions.

(19) Explain the synthesis method of nano p[articles]
① Ball milling ② Sol-gel.
Explain the properties, application and
of carbon nanotube.

Ans: (1) Ball milling:

→ Ball milling technique produces nano p[articles] by collisions of balls with the fine powde[r] particles. This process is executed in a repeated manner to get nano particles. The grain size in powder sample c[an be] reduced to nanometer range by mecha[nical] deformation.

→ The most industrial important technic in fabricating nanomaterials is high-e[nergy] ball milling also known as mechanical alloying or mechanical attrition.



→ It is a solid state process used for the manufacture of a wide range of nanopowd[ers]. This high energy ball milling process ind[uces] structural changes and chemical reactio[ns] at room temperature.

→ The mechanical crushing of powder material is done by placing the mate[rial] inside a rotating stainless steel dru[m] with hard steel or tungsten carbide balls as shown in figure. Thus on rotating the steel drum, the hard balls crush the powder materials mechanically.

(2) Sol-gel technique:

→ In this technique, nitrates or carbonates are taken as precursore which are dissolved in deionized water. The solution is kept at a suitable temperature and some amount of gelling agents are added to it. Thus, the viscosity, temperature and pH of the solution is controlled in this technique.

→ The sol gel synthesis is most widely used due to the following reasons:

1) In this technique, materials, both ceramic and metals can be produced at ultra low temperature.
2) Any type of material can be synthesised in large quantities very cheaply.
3). Extremely homogeneous alloys and composites can be produced.
4). High purity in synthesised materials can be obtained.
5) Co-synthesise of two or more materials simultaneously is possible.
6). In this technique, the microstructure and physical, chemical and mechanical properties of the final products can be controlled.

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* Properties of carbon nanotubes

1) The carbon nanotubes have extremely low resistance.
2) The conductivity of nanotubes is a function of diameter.
3) CNT's are metallic or semiconducting depending the diameter and chirality of the tube.
4) CNTS have a high thermal conductivity increases with decrease in diameter.
5) CNTS melting temperature is three times higher than the melting point of copper.
6) CNT's have the ability to withstand extreme strain.
7) Nanotubes are highly resistant to chemical attack.

* Application of CNT's:

1) CNTS are used in constructing nanoscale electronic devices.
2) The electron emission concept of CNT are used in developing a flat-panel d
3) Semiconducting CNTS are used as switc devices and display devices.
4) Chiral semiconducting carbon nanotubes c used as a sensitive detector of various
5) CNT's are used in battery technology to design fuel cells.
6) Nanotube tips can be used as nanoprobes.

7) Nanotubes serve as catalyst for some chemical reaction.
8) CNTS are used as interconnects in chip due to their extremely low resistance.

(20) The primary advantages of fibre-optics communication compared to metallic cable communication.

Ans * Extremely large bandwidth:
→ The band width available with single glass fibre is more than 100 GHz.

⇒ Longer life span:
→ A longer life span of 20 to 30 years is predicted for the fibre optic cables as compared to 12 to 15 years for the conventional cables.

⇒ Greater safety:
→ In many wired systems, the potential hazard of short circuits requires precautionary designs. whereas, the dielectric nature of optical fibre eliminates the spark hazard.

⇒ security:
→ Fibre cables are more secure than metal cables. Due to its immunity to electromagnetic coupling and radiation, optical fibre can be used in most secure environments.

Although it can be intercepted or trapped, it is very difficult to because, at the receiving users's end an alarm would be sound

=> Lower cost:

-> The material used in fibre is silicy glass or silicondixide which one of the must abondent material on earth, resulting in lower lost.

=> Smaller size:

-> Fibres are very smaller in size. size redation makes fibres the ideal transmission medium for ships. Aircraft and high rise building where bulky copper cable occupy too much spale.