Unit-III

Applied physics.

Question Bank
with
Answers.

Submitted by

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Mark

1)(a) Define Piezoelectricity with example?

The material which gets polarized when subjected to mechanical stress is known as piezoelectric material and the property is known as piezo electric effect

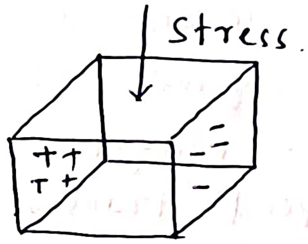
$$P = d \cdot \sigma$$

where P = polarization

d = piezoelectric coefficient

σ = stress applied.

Quartz, Barium Titanate ($BaTiO_3$) are the example of piezo electric material. When stress is applied on these material, they get polarized.



(1)(b) Define ferroelectricity with examples?

The dielectric materials which are having spontaneous polarization in the absence of electric field are called ferroelectric materials. The phenomenon of possessing spontaneous polarization in the absence of electric field is called ferroelectricity.

Barium titanate, Lithium niobate and Lithium tantalate are some ferroelectric material.

(3)(c) Interprete the classification of polarization?

Polarization in dielectrics occur due to several mechanism. When the dielectric is placed inside a dc field, four kinds of polarization occurs.

(I) Electronic polarization.

(II) Ionic polarization.

(III) Orientational polarization

(IV) Space charge polarization.

(4)(d) Summerize any three application of superconductor.?

There are several applications of superconductors which are given as follows

(I) Magnetic Levitation :-

It means a superconducting material can be suspended in air against the repulsive force from a permanent - magnet. Magnetic Levitation effect can be used for high speed transportation.

(II) Superconductors are used to generate very high magnetic field of order 50 Tesla.

(III) Superconductors are used as fast electrical switching applications

(IV) Superconductors are also used to form SQUID (Super-conducting quantum interference device) sensor.

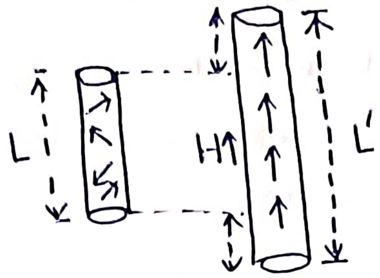
(V) Superconductors are also used to perform logic and storage func in computer.

(Any three write)

rk

(e) What is magnetostriction?

When a magnetic field is applied to a material, it experiences a change in shape or size. The property of changing the dimension of material due to presence of magnetic field is known as magnetostriction.



H = applied field.

L' > L.

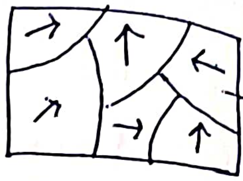
3 Marks

(2) (a) Distinguish betⁿ soft and Hard magnetic materials.

Soft magnetic materials	Hard magnetic materials.
(i) Soft magnetic materials are those which can be easily - magnetized demagnetized.	(i) Hard magnetic materials are those which are difficult to magnetize and demagnetize.
(ii) Soft magnetic materials - posses low hysteresis loop area. Hence these are having low hysteresis loss.	(ii) Hard magnetic materials are having high/wide hysteresis loop area. Thus, they have higher ~~hystere~~ hysteresis loss.
(iii) These materials are having low ~~high~~ value of coercivity and retaintivity	(iii) These materials are having high values of coercivity and retaintivity.
(iv) These materials are having large values of permeability and susceptibility.	(iv) These materials are having small values of permeability and susceptibility.
(v) Eg ÷ Fe-Si Alloy	(v) Eg ÷ Fe-Ni-Al alloy with Co doping.

(2) (b) Define domain ~~and~~ in ferromagne... basis of domain
Explain ferromagnetism on the
Or explain domain theory of ferromagnetism ?

According to Weiss, a virgin specimen of ferromagnetic material consists of a number of spontaneously magnetized regions known as domains.



ferromagnetic material.

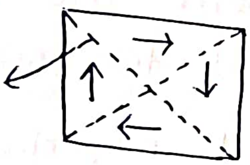
(i) In each domain spontaneous magnetization is due to parallel alignment of magnetic dipoles. The dirn of spontaneous magnetization varies from domain to domain. Thus, the resultant magnetization is zero.

(ii) When an external magnetic field is applied, there are two possible ways of ~~possible~~ alignment of domain

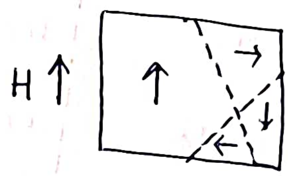
(a) By motion of domain walls :-

The volm of the domain that are favourably oriented w.r.t. magnetizing field increases at cost of those unfavoured orientation.

domain wall or Bloch wall



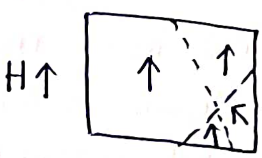
ferromagnetic domain.



domain magnetization by domain wall movement

(b) By rotation of domains :-

When applied field is strong, rotation of dirn of magnetization occurs along the applied field dirn



strong field.
rotation of magnetization in domain

Q.) Explain piezoelectric materials and mention their application ?

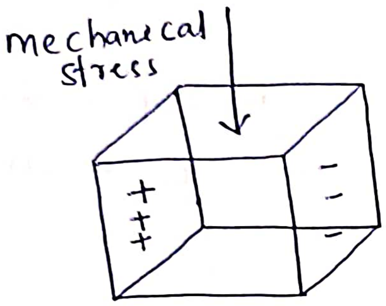
The materials which can be polarized when subjected to mechanical stress are known as piezoelectric materials. The polarization occurred in the material is directly proportional to the applied mechanical stress

$$\vec{P} = d\vec{\sigma}$$

P = polarization

d = piezoelectric coefficient

σ = applied mechanical stress



⇒ Electric field is generated in the piezoelectric material ⊥er to the applied field.

Eg ÷ Quartz, Barium titanate are good examples of piezo electric materials.

Applications ÷

(I) These materials are used to convert mechanical energy into electrical energy by means of Piezo electric effect

(II) Piezoelectric materials are used in filter, resonator circuit

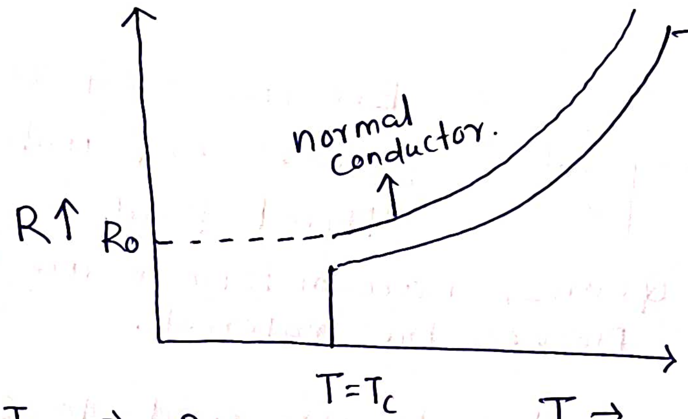
(III) These materials are used for transducer applications

3 Marks

(2) (d) Define superconductivity. Graphically represent how resistance of superconductor varies from normal cond. and explain the dependance of superconductivity on app. magnetic field. ?

When certain metal and alloys are cooled to a very low tempr, their electrical resistance decreases. But on reaching a certain tempr, their resistance falls sharply and becomes zero.

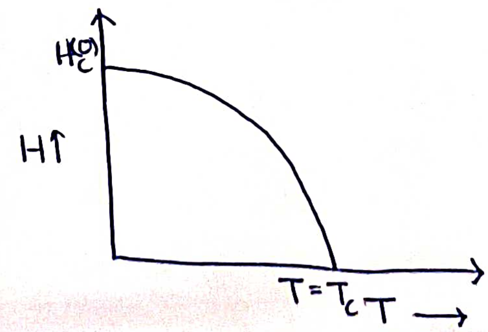
The disappearance of electrical resistance at or below finite ~~exterme~~ extremely low tempr is known as superconductivity and tempr at which resistance becomes zero is known as critical tempr (T_c)



For SC $T < T_c \Rightarrow R = 0$.

For normal conductor, $T < T_c \Rightarrow R \neq 0$.

* The superconducting behaviour depends on the intensity of applied magnetic field. If the magnetic field intensity increases to a critical value, the superconducting behaviour is lost and material makes transition to normal state. The value of critical magnetic field decreases with tempr.



Define ... types ... Mult... m...

e) Define Multiferroic materials and classify the different types of multiferroic materials with examples? [3]

Multiferroic materials are those materials which exhibit more than one ferroic properties in the same phase. The ferroic properties may be followings

(I) Ferromagnetic
(II) Antiferromagnetic
(III) Ferrimagnetic
(IV) Ferroelectric
(V) Ferroelasticity

Depending on the origin of ferroic behaviour of materials, Multiferroic are classified into two categories.

(i) Type - I Multiferroic
(ii) Type - II Multiferroic

(i) Type-I Multiferroic :-

Type-I multiferroic are those materials whose both the ferroic behaviour are having different origin.

$BiFeO_3$ is a type - I multiferroic, where ferroelectricity occurs due to loan pair in Bi atom and unpaired electron in Fe gives rise to antiferromagnetism.

(ii) Type - II Multiferroic :-

Type - II multiferroic are those, where ferroelectricity is generated in specific magnetic ordering and also called as magnetism - driven multiferroic

Ex :- $TbMnO_3$ and $TbMnO_5$ are examples of Type - II Multiferroic.

1)(a) Define Polarization? Explain different types of Polarization

Polarization vector is defined as electric dipole moment per unit vol^m.

$$\vec{P} = \frac{\vec{\mu_e}}{V}$$

$\vec{\mu_e}$ = dipole moment
$\vec{P}$ = Polarization
V = vol^m.

There are four kinds of polarization

(I) Electronic polarization
(II) Ionic polarization.
(III) Orientational polarization.
(IV) Space charge polarization.

(I) Electronic polarization :-

When an atom is placed in an electric field, the +vely charged nucleus and -vely charged ~~nucleus~~ electrons are shifted in opposite dir^n to the applied field and the atom is polarized. It is called ionic polarization.

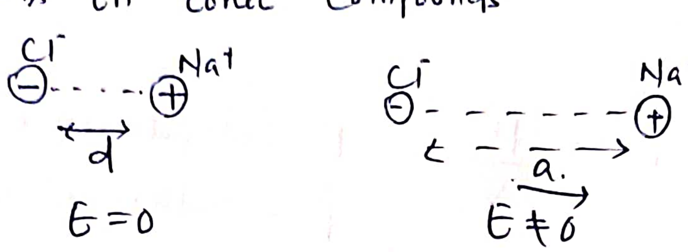
Here $\vec{\mu_e} = \alpha_e \vec{E}$

$\vec{\mu_e}$ = induced dipole moment
α_e = electronic polarizability
$\vec{E}$ = applied electric field.

* α_e is independent of temp^r.

(II) Ionic Polarization :-

The ionic polarization occurs due to displace of cation and anion in opposite dir^n when field is appl
It occurs in ionic compounds



a > d.

$$\alpha_i = \frac{\mu}{E} = \frac{e^2}{\omega_0^2}\left(\frac{1}{M} + \frac{1}{m}\right).$$

ω_0 = natural frequency of vibration.

M, m = masses of atoms.

(III) Orientational Polarization :-

It occurs in molecules having permanent dipolemoment. Kllhen electric field is applied, dipoles align ltheir selves along applied field dir^n and polarization occurs.

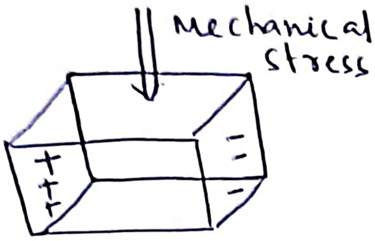
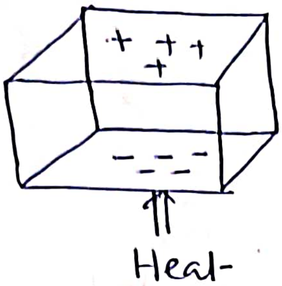
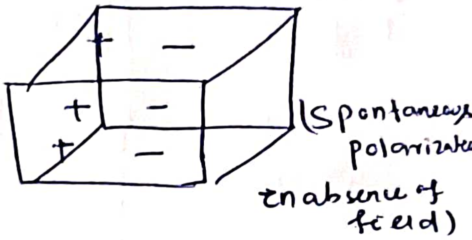
$$\alpha_0 = \frac{P}{NE} = \frac{\mu^2}{3KT}$$

* Orientational polarizability depends on temp^r. i.e. inversely proportional.

(IV) Space charge Polarization :-

It occurs due to accumulation of charges at electrodes or at the interface of multiphase material. Space charge polarization is very small as compared to other polarization

(b) Differentiate betn ferro, piezo and pyro electric properties.

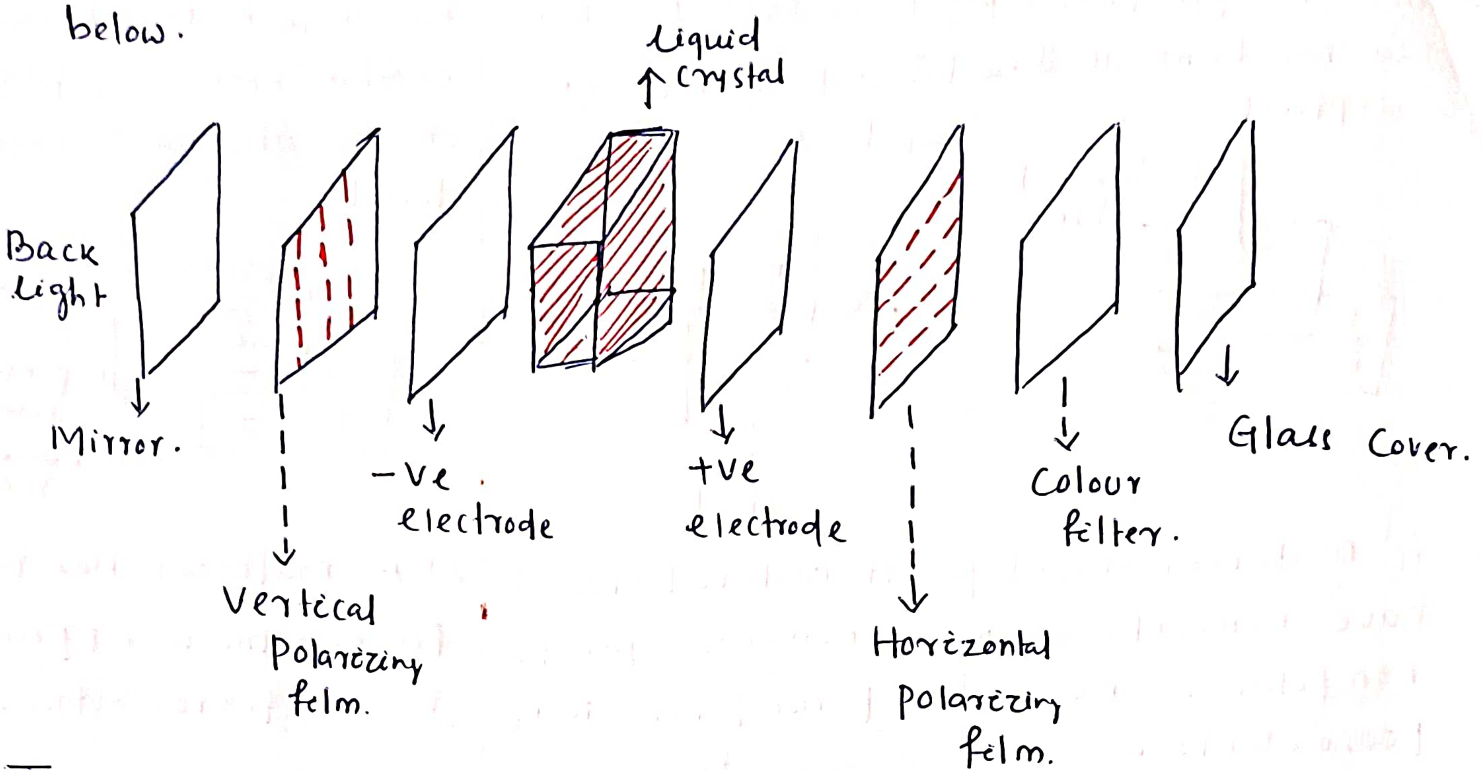
Piezoelectric	Pyroelectric	Ferroelectric
(1) Piezoelectric materials get polarized when mechanical stress is applied.	(1) Pyroelectric materials get polarized when thermal stress is applied.	(1) Ferroelectric materials are those material which exhibit spontaneous polarization in the absence of electric field.
		
(2) A material should have noncentrosymmetric non polar to be piezoelectric	(2) A material should be noncentrosymmetric and non polar to be pyro electric	(2) A material has to be piezoelectric and pyroelectric to be ferroelectric.
(3) Eg ÷ Quartz crystal, ADP.	(3) Eg ÷ Quartz crystal ADP.	(3) Eg ÷ Lithium niobate, Barium titanate.
(4) Acts like transducers, generates ultrasonic waves	(4) Used in IR detectors, Image tubes.	(4) Used in ultrasonic - transducers, pressure transducers.
(5) Presence of piezoelectric effect $P = d\sigma$ d = Piezoelectric coefficient	(5) Presence of pyroelectric effect $\lambda = \frac{dP}{dT}$ λ = Pyro electric coefficient	(5) Presence of ferroelectric effect $\varepsilon = \frac{C}{T-T_c}$ ε = dielectric const

(3)(c) How does liquid crystal ~~works?~~ display works?

Explain the working principle of LCD?

What

Liquid crystal display is a combination of two state of matter, the solid and liquid. LCD uses liquid crystal, material to produce visible image. The schematic of LCD is given below.



(I) The LCD works on the principle of blocking of light. LCD needs external fluroscent lamp or CRT to produce backlight which is unpolarized.

(II) The unpolarized light pass through vertical polarizer and ~~vertially~~ becomes vertically polarized.

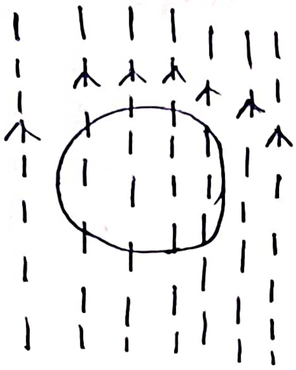
(III) Liquid crystal generally twist the light by 90°, But when electric current is applied across the electrode, the molecule of liquid crystal tends to untwisted and can't able to rotate the light

(IV) The particular portion of vertically polarized light which passes through the liquid crystal is blocked by horizontal filter and particular portion appears ~~to~~ dark in the screen. In this way the image is produced in the screen.

What is Meissner's effect. Show that a superconducting material exhibits diamagnetic behaviour using this effect and state any three applications of superconductors?

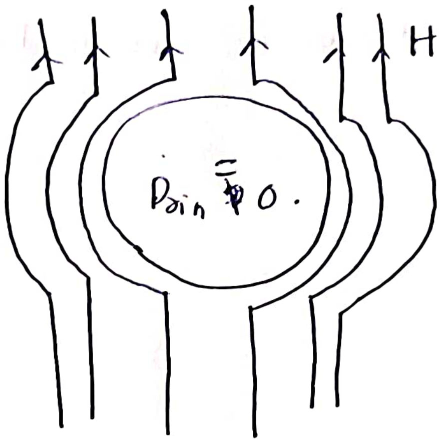
When a material makes transition from normal state to superconducting state, it actively ~~exple~~ expells the magnetic lines of force from its interior below critical tempr (T_c). This phenomenon is called Meissner's effect.

Normal state.



$B_{in} \neq 0$.

$T > T_c$



$B_{in} = 0$.

$T < T_c$

As for superconductor $B = 0$. (By Meissner's effect)

$$\Rightarrow \mu(M + H) = 0.$$

$$\Rightarrow M + H = 0$$

$$\Rightarrow M = -H$$

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

$$\Rightarrow \boxed{\chi_m = \frac{M}{H} = -1.}$$

(M = magnetization.
H = applied field.
χ_m = magnetic susceptibility
B = magnetic flux density.)

As $\chi_m = -1$ for superconductor, it behaves as diamagnetic.

Applications :-

(1) A superconducting material can be suspended in air against the repulsive force from a permanent magnet. This effect is called magnetic levitation. This effect is used for high speed transportation.

Marks (b)(e)

(ii) Superconductors are used to generate very high magnetic field of order 50 T.

(iii) Super-conductors are used as fast electrecal switch elements and electric generator.

(iv) Superconducting wires can be used in transformer to ~~avoi~~ avoid power loss due to heating.

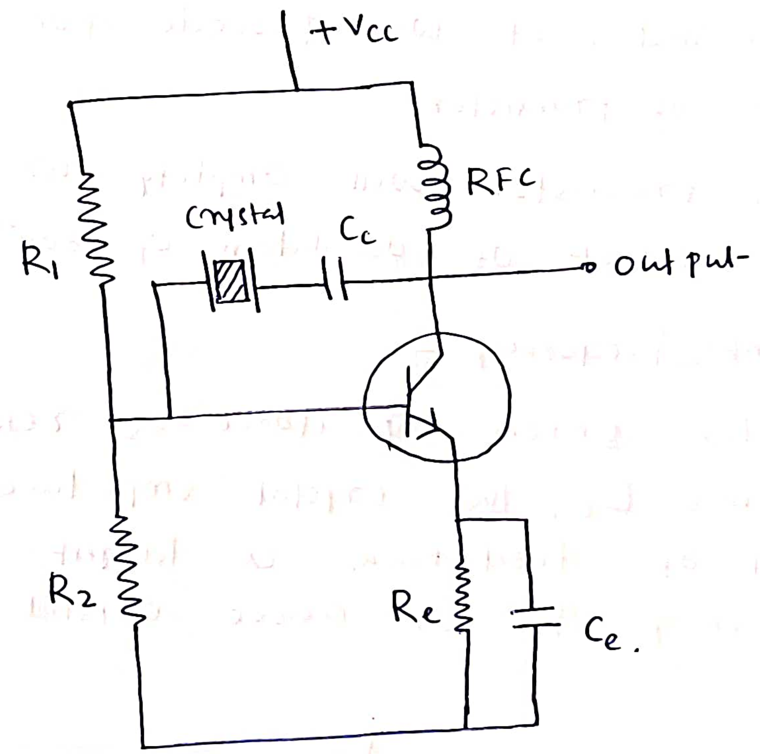
(B)(e) Explain the working of crystal oscillator and interpret the expression for resonant frequency along with necessary circuit diagram.

Crystal oscillator is one of the oscillators in which the electrical tune circuit is replaced by properly cut quartz crystal.

In crystal oscillator, the primary frequency determining element is a quartz crystal whereas in normal oscillator it is electrical oscillatory circuit. Because of the inherent properties of quartz crystal, crystal oscillator gives accuracy of frequency stability.

Crystal oscillator works on the principle of inverse piezoelectric effect, in which an ac voltage is applied across the crystal causes it to vibrate at its natural frequency

Circuit diagram and working :-



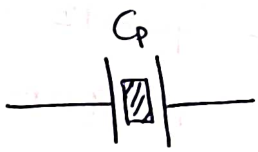
(I) The resistances R_1, R_2, and R_e provides biasing Stabilization to the circuit

(II) Capacitor C_e bypasses ac component and isolate R_e, avoid voltage drop.

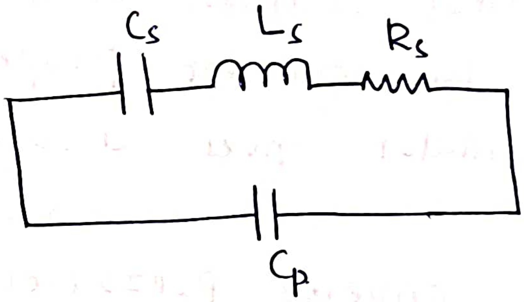
(III) Radio Frequency choke (RFC) provides dc collector load and prevents any ac signal from entering the power supply, when V_{cc} is switched on.

(IV) The crystal in the circuit acts as LCR tank circuit which generate oscillation wave form at 180° phase.

(V) ~~The crys~~



Crystal



(V) The crystal is connected in series with transistor such that, it will provide +ve feedback at the base of transistor.

(VI) The transistor will amplify the signal and produce an output of oscillation of 360° phase.

Resonant Frequency ÷

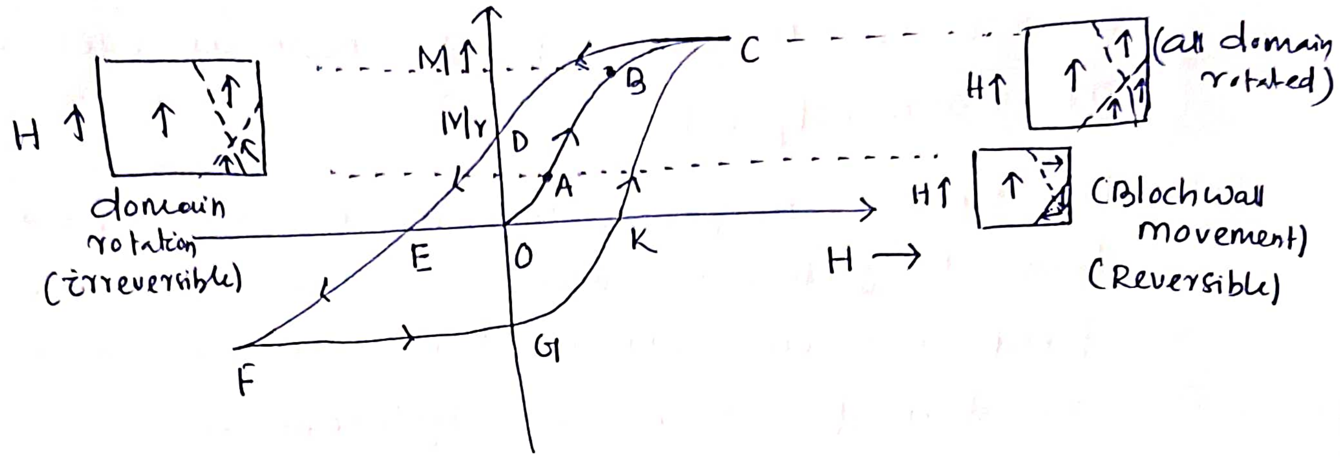
When the series capacitance C_s resonant with series - inductance L_s, the crystal impedance will be least and amount of feed-back is largest. The series resonant frequency for the above crystal oscillator is given by

$$f_r = \frac{1}{2\pi\sqrt{L_s C_s}}.$$

Q (a) Explain the hysteresis curve of ferromagnetic material on the basis of domain theory of ferromagnetism. [10]

The hysteresis of ferromagnetic materials refers to the lagging of magnetization behind the applied magnetic field.

The hysteresis loop (M vs H) for ferromagnetic material is given in the figure.



(I) When a weak magnetic field is applied to the ferromagnetic material, the domains those are aligned parallel to the applied field grows at the expense of domain having opposite orientation. ~~To~~ Thus resulting in small magnetization as indicated by initial portion OA. Such displacement of domain boundary are reversible by the removal of field.

(II) When the field becomes stronger, the Bloch wall movement continues and the dipole in the domains rotates to align itself along applied magnetic field. This process is represented by AB in the M-H curve. It is irreversible in nature.

(III) If further the magnetic field is increased, all the magnetic dipoles in the domains will ~~all~~ align themselves along the applied magnetic field and magnetization becomes maximum. This is called saturation magnetization.

(IV) On decreasing the field, the magnetization doesn't follow the same path because the aligned domains do not reg their random state of orientation.

(V) There exist some nonzero magnetization even after removal of magnetic field. This magnetization is called remanant magnetization or remanance (M_r)

(VI) The magnetization can be reduced to zero by applying a reverse magnetic field known as coercive field or coercivity (H_c)

(VII) If further ~~magnetic~~ reverse magnetic field is increased then magnetization occurs similar to the +ve magnetic field but in reverse dirn. In this way a loop is formed known as Hysteresis loop.

(VIII) ~~They~~ The hysteresis loss is represented by the area of loop which is defined as the energy loss during complete cycle of magnetization for ferro magnetic material.

(IX) Based on area of hysteresis loop, magnetic material is divided into soft and hard magnetic material.

b) Classify the different magnetic properties of materials.?

The magnetic properties of materials are classified into five categories.

(i) Diamagnetism. (IV) Antiferromagnetism

(II) Ferromagnetism. (V) Ferrimagnetism.

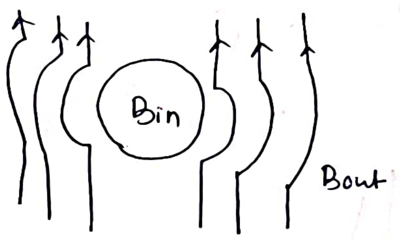
(III) Paramagnetism.

(1) Diamagnetism :-

(a) Diamagnetism is a very weak effect and is observed in solids which do not contain any permanent magnetic moment.

(b) An electron moving around the nucleus results in magnetic moment. Due to different orientation of various orbit of atoms, the net magnetization is zero in diamagnetic materials.

(c) When diamagnetic material is placed in the magnetic field, it repells the magnetic lines of force.



Bin < Bout

(d) Magnetic susceptibility is independent of tempr and applied magnetic field.

(e) Relative permeability is slightly less than '1'

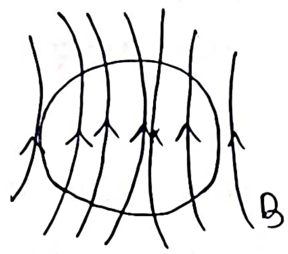
(II) Paramagnetism :

(a) Each electron in an orbit has magnetic moment. In absence of magnetic field, the moments are randomly oriented and no magnetization.

When external magnetic field is applied, the dipoles align themselves along applied field and dipole ~~Momem~~ moment is induced. The induced dipole moment is proportional to the applied field and is source of paramagnetism.

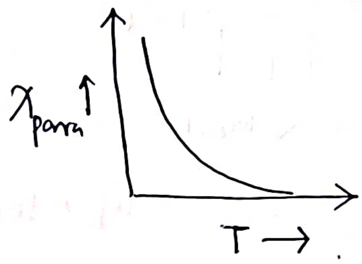
(b) Paramagnetic material possess permanent magnetic dipole moment.

(c) When placed in the magnetic field, it attracts the magnetic lines of force and allow them to pass through it.



(d) Paramagnetic susceptibility is +ve and inversely proportional to tempr

$$\chi_{para} = \frac{C}{T} \qquad C = \text{Curie's const}$$



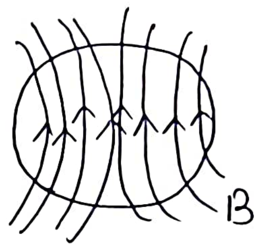
Ferromagnetism :-

(a) Ferromagnetism is associated with ferromagnetic material. Ferromagnetic materials exhibit magnetic moment in the absence of applied magnetic field below curie tempr (T_c) The magnetization existing in ferromagnetic material in the absence of magnetic field is called spontaneous magnetization.

(b) ferromagnetic materials acquire large magnetization in presence of weak magnetic field.

(c) When placed in magnetic field, it allow the lines of force to pass through it.

(d) Magnetic susceptibility (χ_{ferro}) is large and inversely proportional to tempr



$$\chi_{ferro} = \frac{C}{T - T_c}$$ (T_c = critical tempr
C = curie const)

(e) Spin alignment are parallel.

↑ ↑ ↑ ↑.

(IV) Antiferromagnetism :-

When the distance betn interacting atoms is small, the exchange forces produce antiparallel alignment of electron spin in neighbouring atom. If the spins are equal in magnitude and have opposite alignment then it is called anti ferro-magnetism.

↑↓↑↓↑

* The susceptibility is +ve and ~~va~~ vary with tempr as follows

$$\chi_{Anti} = \frac{C}{T + T_N}$$ (T_N = neel tempr)

* Antiferromagnetism occurs below ~~nett~~ Neel tempr.

Ferrimagnetism :-

It is a special kind of antiferromagnetesm. If the neigh spins are opposite and unequal then it is called ferrimagnetism

↑↓↑↓↑↓

* The susceptibility is +ve and ferrimagnetism occurs below currie tempr.

$$\chi_{ferri} = \frac{C}{T \pm T_c}.$$

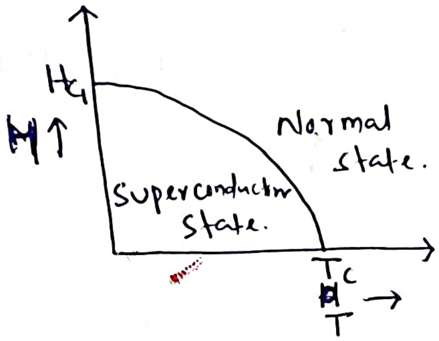
Describe the difference betⁿ Type-I and Type-II superconductor?

Based on the diamagnetic response, superconductor can be classified as type-I and type-II. The difference betⁿ these type-I and type-II superconductors are given as follows.

Type-I superconductor

(I) Superconductors those obey ~~Complete~~ Meissner's effect completely i.e. perfect diamagnetism are known as type-II superconductors.

(II)

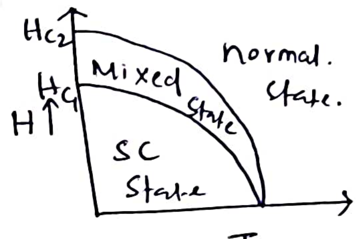


The transition from a superconducting state to normal state due to the external magnetic field is sharp and abrupt for type-I. It is shown in the above figure.

Type-II superconductor

(I) These are superconductors which obey Meissner's effect partially i.e. allow the penetration of magnetic lines of force through it is known as type-II superconductor.

(II)

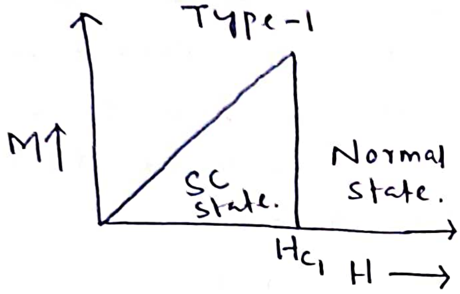


SC→ superconducting. T →

The transition from superconducting state to normal state due to external magnetic field is gradual but not sharp and abrupt. At lower critical magnetic field (H_{c1}), type-II superconductor starts losing its superconductivity. At upper critical field (H_{c2}) type-II superconductor completely loses its superconductivity. The state betⁿ H_{c1} and H_{c2} is known as intermediate state or Mixed state or vertex state.

(III) When the applied magnetic field strength is gradually increased from the initial value to $H < H_c$ for type-I superconductor, ~~diamag~~ diamagnetic behaviour increases. But when applied field is equal to critical field H_{c_1}, the diamagnetic behaviour disappear and superconductor becomes normal conductor.

Type-I



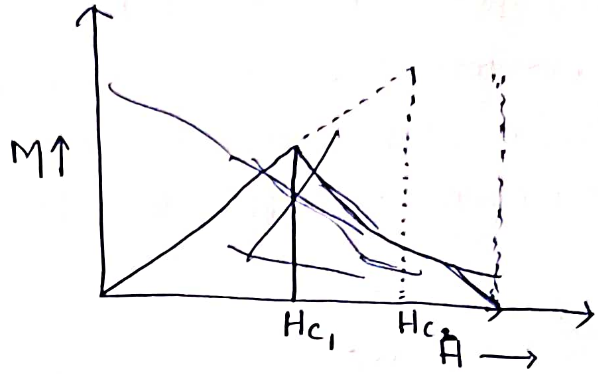
(IV) Type-I superconductor possesses lower critical temperature

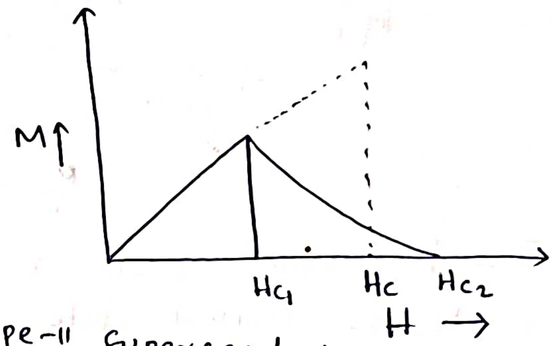
(V) Type-I superconductors have lower critical magnetic field

(VI) It can easily lose superconducting behaviour by the application of low intensity magnetic field. Hence type-I superconductors are known as soft superconductor.

(VII) Due to low critical field these superconductors can't be used for manufacturing electromagnets

(III) When applied magnetic field increases upto lower critical magnetic field H_{c_1}, type-II behave perfect diamagnetic and in pure superconducting state. When the field is increased beyond H_{c_1}, magnetic lines of force starts penetrating. The specimen is in mixed state betn H_{c_1} and H_{c_2}





(IV) Type-II superconductors have higher critical tempr.

(V) These superconductors have higher critical magnetic field

(VI) It does n't lose its superconducting nature easily with the application of external magnetic field and hence known as hard superconductor.

(VII) Due to high critical field these are used to manufacture electromagnet to produce high intense field.

Type-I Superconductor	Type-II superconductor
BCS theory can be used to explain Super Conductivity in these materials.	(VIII) BCS theory can't be used to explain superconductivity for these super conductors.
(IX) They are completely diamagnetic	(IX) They are not completely diamagnetic.
(X) These are called low-temperature superconductor.	(X) These are called high temp^r superconductor.
(XI) No mixed state exist for these super conductor.	(XI) Mixed state exist for these superconductor.
(XII) Due to low critical magnetic field, type-I superconductor have limited technical application.	(XII) Due to high critical field these super conductors have wide technical applications.
(XIII) Eg ÷ Hg, Pb, Zn. etc.	(XIII) Ex ÷ NbTi, Nb_3Sn, etc.