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SUPER CONDUCTIVITY

What do we Mean by Superconductivity?

When certain materials are cooled below a particular temperature their electrical resistivity drops to zero & it expels the magnetic flux from its interior, then this material is known as superconductor and phenomenon is known as superconductivity.

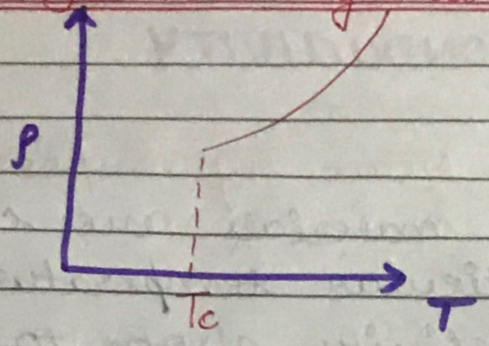
History:

The discovery of superconductivity owes itself to Dutch Scientist Heike Kamerlingh Onnes. He successfully cooled down mercury to extremely low temperatures, within the range of those of liquid helium and revealed that below temp. of 4.2 K, the resistivity fell drastically and became ZERO!

Critical Temperature:

The temperature at which the resistance of a specimen vanishes completely and it enters a superconducting state, is known as superconducting transition temp. or "critical temperature (T_c)".

why are they known as "super conductors"?



Acc to ohm's law

$$J = \sigma E$$

$$\Rightarrow E = \frac{J}{\sigma} = J\rho$$

so $E = 0$ if $\rho = 0$ (case of super conductors)

In an Ideal conductors also $E=0$ But here it's called superconductors, because it possess one more effect & that effect is Meissner Effect.

MEISSNER- EFFECT:-

It was discovered by Meissner & Ochsenfield in 1933 that if a long superconductor is allowed to cool in a longitudinal magnetic field upto a temperature below its critical temperature, then the magnetic field lines are pushed out of the body of superconductor at this transition. This is known as flux exclusion or popularly known as " Meissner Effect".

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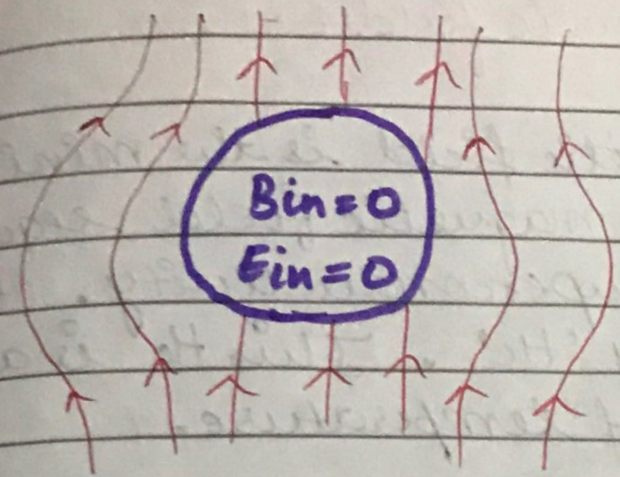


$\vec{B}in = 0 = \mu_0(\vec{H} + \vec{M})$

$\Rightarrow \vec{M} = -\vec{H}$

magnetic susceptibility $= \chi = \boxed{\frac{M}{H} = -1}$

$\boxed{\chi = -1}$ This is the condition forperfect diamagnetism.

After flux ejection, superconductor becomes a perfect diamagnet.

Range of Normal diamagnetic:

$\boxed{-1 < \chi < 0}$

Please Note:-

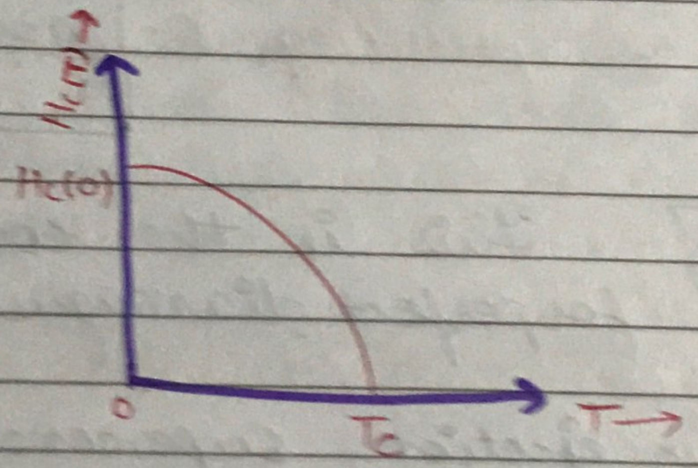
So Magnetic susceptibility of super conductors is negative and independent of temp and its Value is -1.

Critical magnetic field:

Critical Magnetic field is the minimum amount of magnetic field required to destroy superconductivity. It is denoted by 'Hc'. This Hc is a function of temperature.

$$H_c(T) = H_c(0)\left[1-\left(\frac{T}{T_c}\right)^2\right]$$

If we increase the temp., Hc will decrease.



AT $T=T_c$, temp. have destroyed the superconductivity, so the field must be zero.

AT $T=T_c$

$H_c(T_c)=0$

Critical Current :

Critical magnetic field which we have stated need not always be an externally applied field.
when the current induced in a superconductor from an external source arouses another magnetic field, then also the transition from superconducting to normal state occurs.
The maximum value of electric current which can be passed through a substance without destroying its superconductivity is called Critical Current (I_c)[4].

Isotope Effect:

It was discovered by Maxwell & Reynolds.

If M is average Mass of Isotopes, then for series of Isotopes:

$$M^{\alpha} T_c = \text{constant}$$

where $\boxed{\alpha = 0.5}$

and $\boxed{M^{1/2} T_c = \text{constant}}$