SUPERCONDUCTIVITY

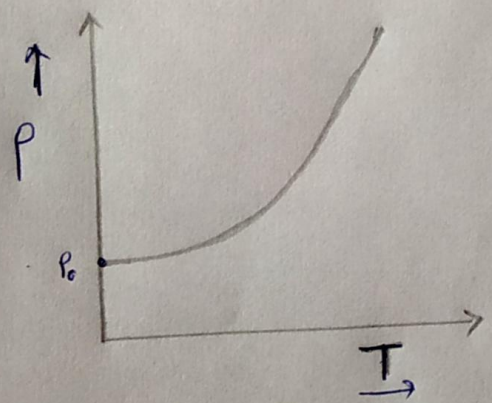
The superconducting material shows some extra-ordinary properties which make them very important for modern tech-nology. Superconductivity is a phenomenon in which electric resistivity of a substance drops suddenly to zero, when it is cooled below a certain temperature. The substances which show this property are called superconductor.

This phenomenon was firstly observed by Kamerligh Onnes while he was measuring the resistivity of mercury at low temperature. The electric resistivity of mercury drops to zero at temperature about 4.2 K. He observed that mercury has gone into new state and is named as superconducting state.

Properties of Superconductor :—

1) Zero electric resistance (Infinite conductivity):

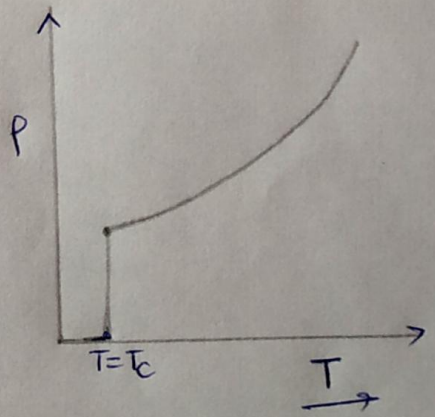
The super conductors show zero resistance when cooled down to a certain temperature.



at $T \to 0$, $\rho = \rho_0$ (fixed value)

(Metal)

Fig. 1



$\rho = 0$ at $T = T_c$

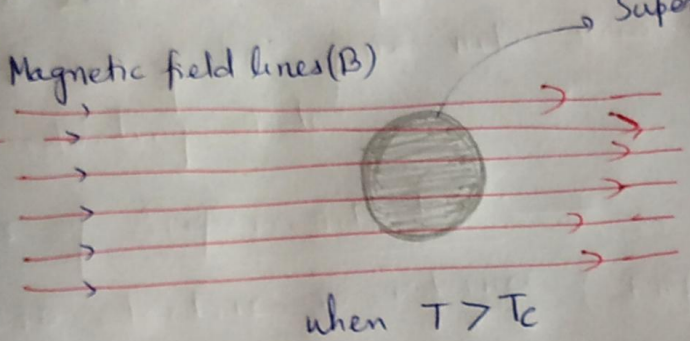
(Superconductor)

Fig. 2

As it is evident from fig 1 is that even at $T \to 0$, we have fixed amount of resistivity in case of metal but in super-conductors resistivity gets zero value at a particular temperature as shown in fig (2).

2) Meissner Effect (Expulsion of magnetic field):—

A superconductor, when it is cooled below the critical temperature T_c, expels the magnetic field and does not allow to magnetic field to penetrate inside it. This phenomenon is called ~~magn~~ Meissner Effect. The Meissner effect is shown below.



when $T > T_c$

when $T < T_c$

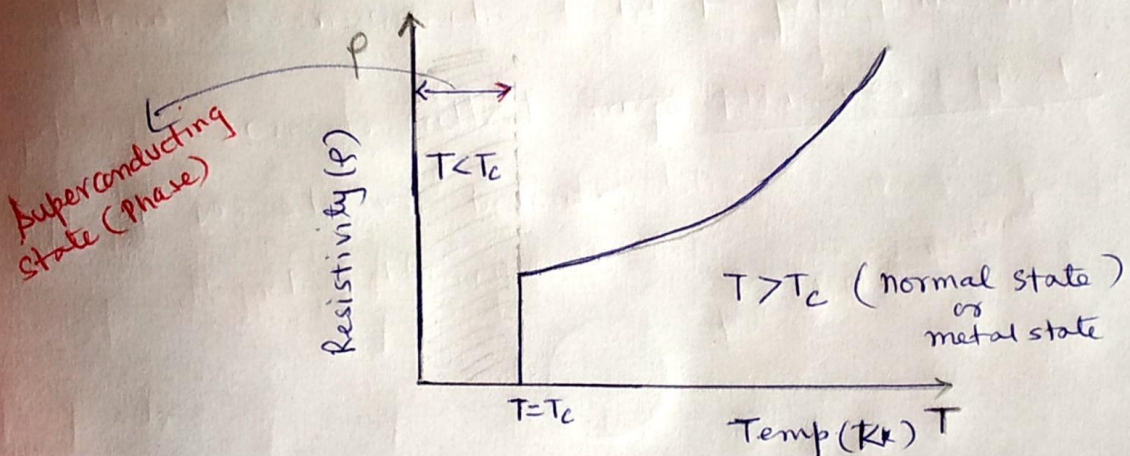
(Meissner Effect)

where T_c is the critical or transition temperature

3) Critical temperature / Transition temperature :-

Critical temperature of a superconducting material is the temperature at which the material changes from normal conducting state to superconducting state. This transition from normal conducting state (phase) to superconducting phase is sudden and sharp.

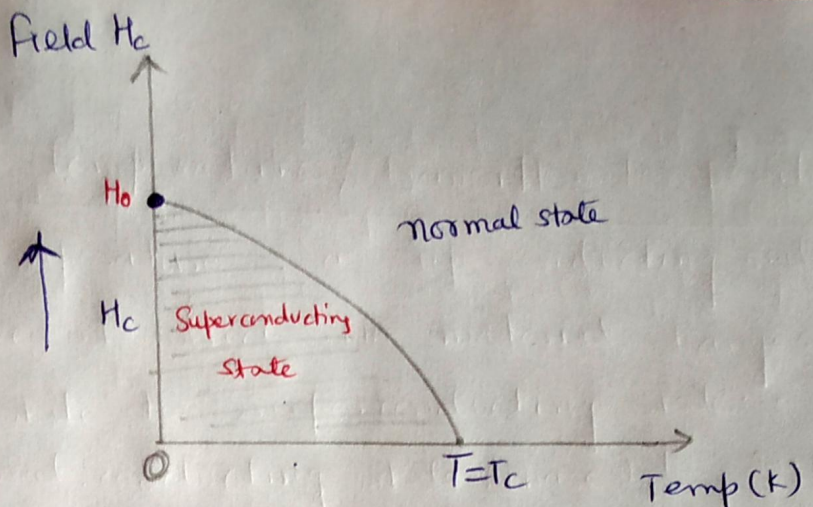
The transition of mercury from normal to superconducting state is shown in figure below.



Where $T = T_c$ is critical temp. [$T < T_c$ - superconducting state; $T > T_c \rightarrow$ normal state]

(4) Critical Magnetic field :-

The superconducting state / phase of a superconducting material breaks when the magnetic field is applied beyond a certain value and material starts behaving like an ordinary conductor. This certain values of magnetic field beyond which superconductor returns back to ordinary state is called CRITICAL FIELD. It also depends on temperature.



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

where H_0 is the field at '0' K. superconductivity disappears when $T = T_c$. and $H_c = 0$.