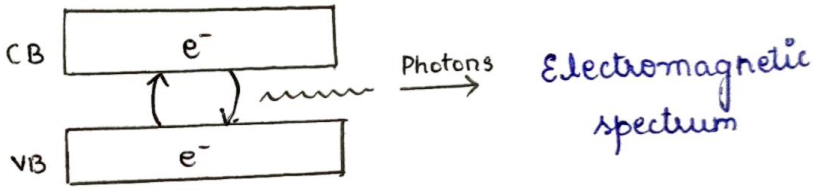
# DIRECT BAND & INDIRECT BAND

The concept is applicable to semiconductor. At 0°K (or) −273°C, All semiconductors are non conducting (i.e) filled V.B and empty C.B

→ However at ampient temperature (or) under applied thermal energy, the $e^-$ of maximum energy level of VB can be promoted / excited to minimum energy level of C.B. Hence it leaves a hole in V.B.

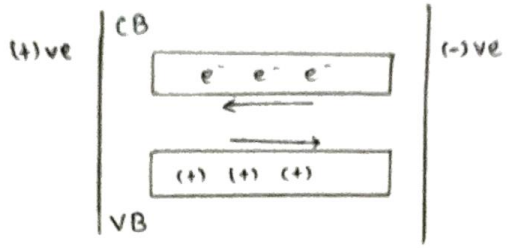



Likewise, the $e^-$ are kept promoted to some extent until a dynamic equilibrium is established

So, at this dynamic equilibrium state, the $e^-$ that are promoted to the lower energy level of the C.B get back to V.B by releasing its energy as radiation (photons)

Two types of emission (2 possibilities of radiation) → photon, phonon

→ Under electric field, the $e^-$ and holes move in opposite direction



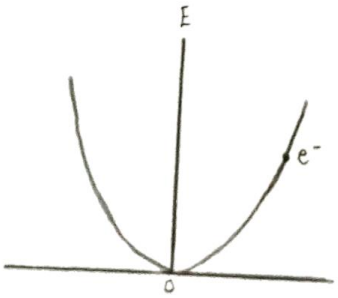

## E - k DIAGRAM:

→ $e^-$ behaves as a wave.

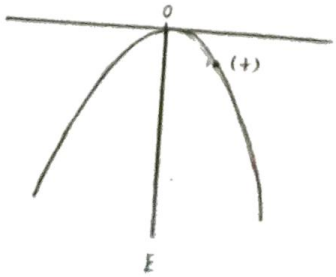
→ The waves can be described by a wave vector (k) whose magnitude is wave number and direction is the direction of propagation of the wave

→ The wave vector 'k' can be equated / considered as momentum of the $e^-$.

## CASE : 1




Lower energy level of CB



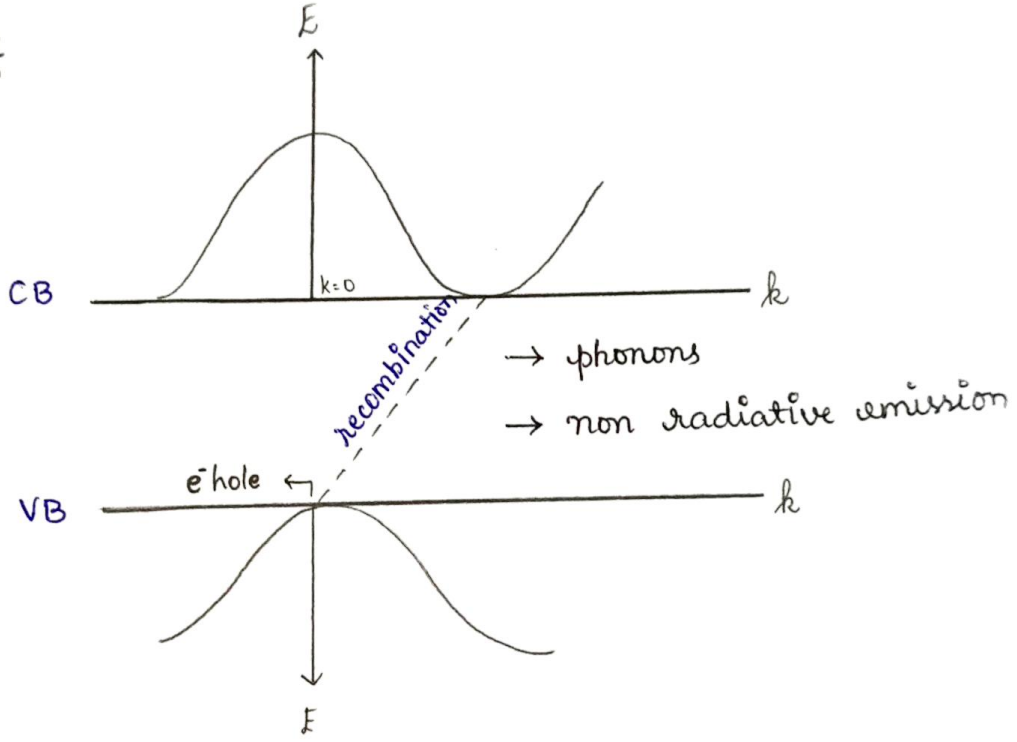

Higher energy level of VB

The lowest point of CB and the top most point of VB are at same k value (k=0)

In this case, $e^-$ of CB can recombine with the VB without change in the momentum directly. The recombination results in the emission of light. Such materials are direct bandgap materials.

Eg: GaAs, GaN, InP, CdS. These are used for LEDs and laser devices

CASE : 2




→ The lowest point of CB and the highest point of VB are not at same k value (MISMATCHING)

→ Therefore $e^-$-hole recombination requires a change in momentum. The recombination is not possible with other process assistance

→ They donot emit light. This is called indirect bandgap

→ The light absorption efficiency is also poor due to same reason

Eg: Si and Ge, not suitable for optical devices - LED & laser device

→ In the direct band semiconductor, the top of VB and bottom of CB lie on top of eachother

→ Hence, $e^-$ can get excited from the VB to CB without change of the wave vector (momentum)

→ It can be achieved by absorption of a photon of appropriate energy.

→ Similarly, the $e^-$ of CB can transit do the VB by emitted photon.

→ On the other hand, In the indirect band sc, VB maximum and the CB minimum, donot line up.