4x6

Semiconductors & Applications

A solid can be categorised into three main groups based on their current carrying capabilities :-

1. conductors
2. semiconductors
3. Insulators.

It is the energy band structure of a solid determines whether it is a conductor, insulator & semiconductor.

So Cu, which is good conductor has a resistivity $\sim 10^{-8}\ \Omega m$ at room temp, whereas for quartz a good insulator $\rho \approx 1.7 \times 10^{17}\ \Omega m$

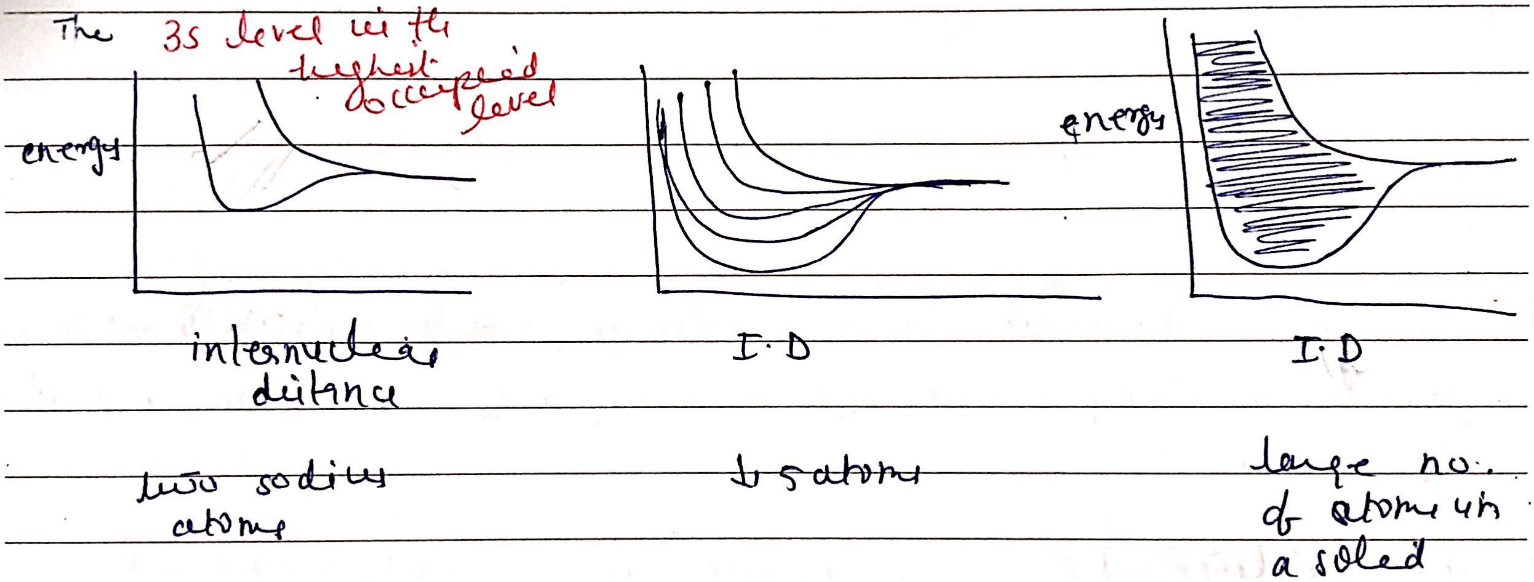
The existence of energy bands in a solid makes it possible to understand this remarkable span.

There are two ways to understand, how the energy band arises. The atoms in every solid, not just in metals, are so near to each other, that their valence e^- wave fn overlap. This overlap results in splitting of energy level in two levels marked as E_A^{total} & E_S^{total}

The greater the no. of interacting atoms, the greater is the no. of levels produced by the mixing of their respective wave fn.

As the solid contains large no. of atoms, ∴ splitting is into as many levels as atoms, which are so closely spaced that they form an energy band that consists of virtually cti spread of energies.

The energy bands of a solid, the gaps b/w them & the extent to which they are filled by e^- not only govern the electrical behaviour of the solid, but also have an important bearing on other Pro.



An e^- in a solid can only have energies that fall within the energy bands.

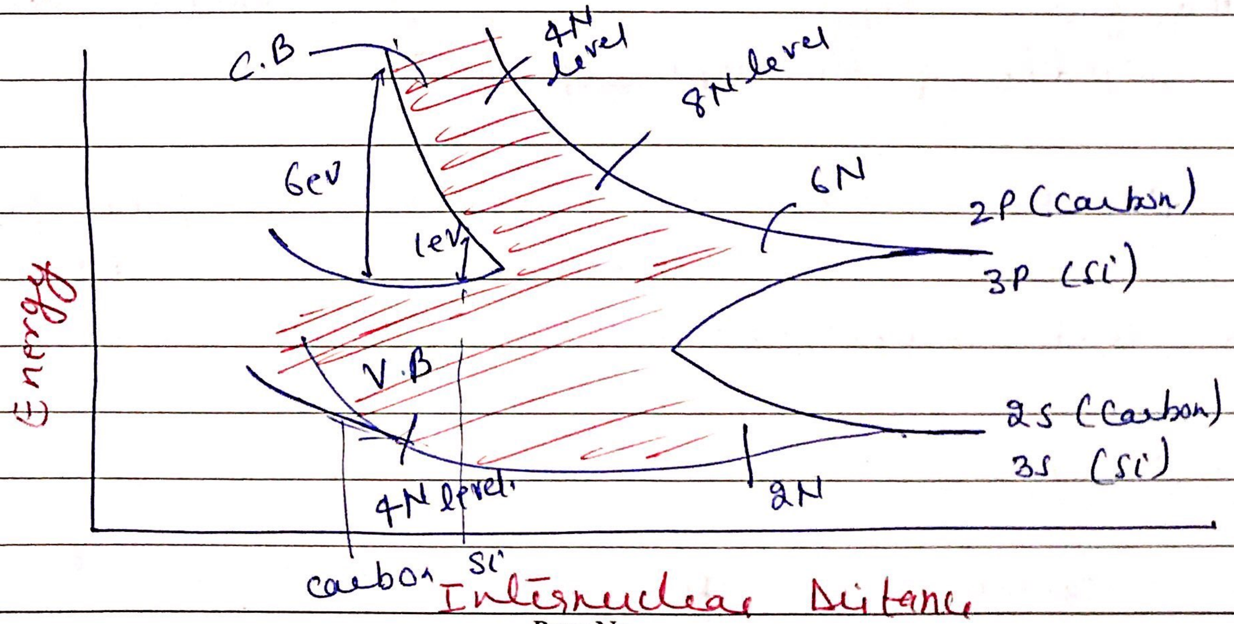
The various outer energy bands in a solid may overlap, in which its valence e^- have available a cti distribution of permitted energies.

In other solid, the band may not overlap & the interval b/w them represents the energies their e^- cannot have.

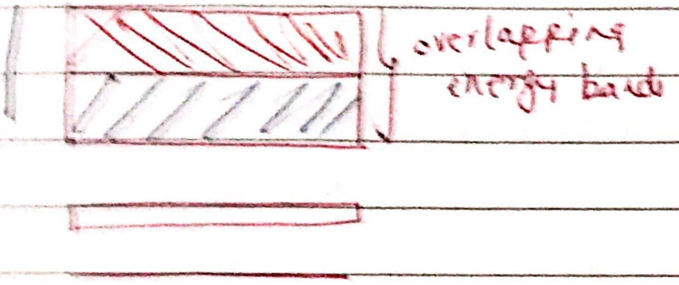
What actually happen is that, although the 2s & 2p bands that form when carbon atoms are brought together overlap at first, at smaller separation the combined band splitting into two bands, each able to contain 4N e⁻. Because a carbon atom has two 2s & two 2p e⁻, in diamond there are 4N valence e⁻ that completely fills the lower or valence band. The empty conduction band is separated from it by a forbidden band of 6 eV.

Here the fermi energy is at the top of the valence band. Atleast 6 eV energy must be provided to an e⁻ in diamond if it is to be climb the conduction band, where it can move freely.

At room temp KT = 0.025 eV, the e⁻ do not have enough energy & ∴ it is an insulator.



such intervals are called the forbidden level or ~~gaps~~ bands. or band gap.



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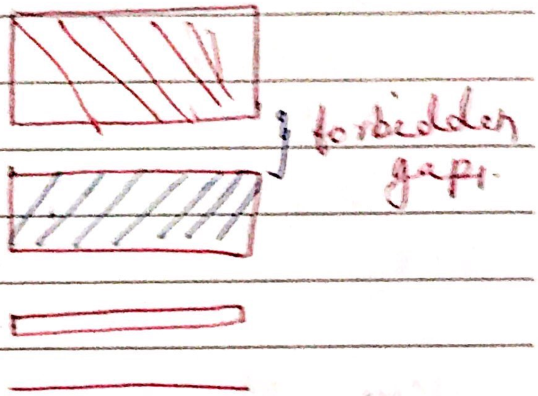


~~for~~ ex A sodium ~~that~~ has a single 3s valence e^-. each atomic level ∴ can hold $2(2l+1)$ e^- = 2 e^-, so that each s band formed by N atoms can hold $2N$ e^-

Thus the 3s band in solid sodium is only half ~~filled~~ filled by e^- & ∴ the fermi energy lies in the middle of the band ~~gap~~

As the P.E voltage is applied across a piece of sodium, 3s e^- can pick additional energy while remaining in their original band ∴ conduct current

Insulators

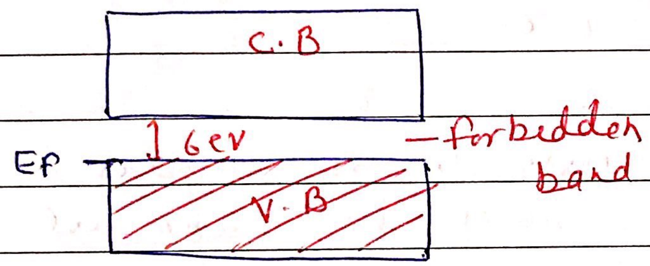
In a carbon atom, the 2P shell contains only 2 e^-. Because a 2P can hold six e^-, we might think that carbon is a conductor, just as sodium is

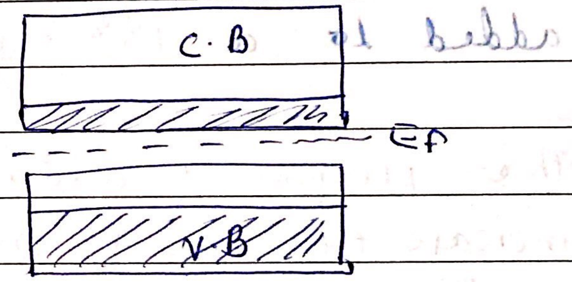
$l(2l+1)$
$= 6$

Semiconductors

Si has a crystal structure like that of diamond & as in diamond, a gap seperate the top of the valence band from an empty conduction band.

In this case the forbidden band is of the order of 1eV wide. At room temp, a small no. of valence e^- have enough thermal energy to jump from the V.B to C.B





These e^-, though few are still enough to have small amount of current to flow when an e.field is applied

Thus Si has ρ intermediate b/w those of conductors & insulator and are termed as semiconductors

Intrinsic & Extrinsic Semiconductor

- Intrinsic SC
- Extrinsic SC.
  - n-type
  - P-type