

BAND THEORY OF SOLIDS

The energy band structure of a solid determines whether it is a conductor, an insulator or a semiconductor.

A solid contains an enormous number of atoms packed closely together. Each atom, when isolated, has a discrete set of electron energy levels $1s, 2s, 2p, \dots$. If we imagine all the N atoms of the solid to be isolated from one another, they would have completely coinciding schemes of their energy levels.

Let us study what happens to the energy levels of an isolated atom, as they are brought closer and closer together to form a solid. If the atoms are brought in close proximity, the valence electrons of adjacent atoms interact. Hence the valence electrons constitute a single system of electrons common to the entire crystal with overlapping of their outermost electronic orbits. Therefore, the N electrons will now have to occupy different energy levels. This is brought about by the electric forces exerted in each electron by all the N nuclei. As a result of these forces, each atomic energy level is split up into a large number of closely spaced energy levels. A set of such closely spaced energy levels is called an energy band.

For example, the 11 electrons in a neutral sodium atom, each occupy a specific energy level as indicated in fig.10.

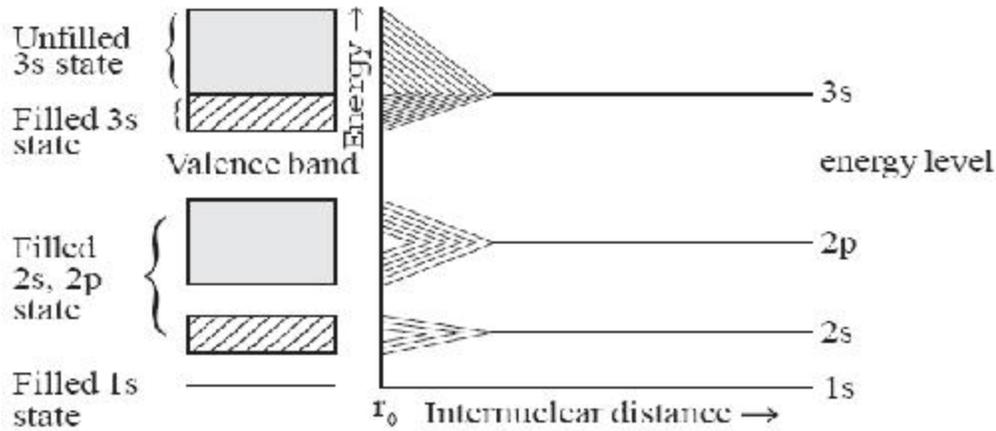


Fig. 10 Energy level of sodium

The energy levels of sodium become bands when the atoms are close together. In figure r_0 is the distance between the atoms in solid sodium. When the atoms are in solid, they interact with each other and the electrons have slightly different energies.

In the energy band, the allowed energies are almost continuous. These energy bands are in general, separated by regions, which have no allowed energy levels. These regions are known as "forbidden bands" or 'energy gaps'.

The amount of splitting is not the same for different levels. The levels filled by the valence electrons in an atom are disturbed to a greater extent, while those filled by inner electrons are disturbed only slightly fig.10.

If there are N atoms in a solid, there will be N allowed quantum states in each band. Each quantum state can be occupied by a maximum of two electrons with opposite spins. Thus each energy band can be occupied by $2N$ electrons. The band formed from the atomic energy levels

containing valence electrons is called valence band. These electrons have the highest energy. Above the valence band, there is the band of next higher permitted energies called the 'conduction band'. The conduction band corresponds to the first excited states; electrons can move freely in this band and are called 'conduction electrons'. The interval between conduction band and valence band in which electrons cannot occupy is called 'Forbidden gap'.

Source : <http://mediatoget.blogspot.in/2011/07/band-theory-of-solids.html>