Energy Bands Description

In gaseous substances, the arrangement of molecules is spread apart and are not so close to each other. In liquids, the molecules are closer to each other. But, in solids, the molecules are closely arranged together, due to this atom of molecules tend to move into the orbitals of neighbouring atoms. Hence, the electron orbitals overlap when atoms come together.

In solids, several bands of energy levels are formed due to the intermixing of atoms in solids. We call these set of energy levels as **energy bands**.

Formation of Energy Bands

In an isolated atom, the electrons in each orbit possess definite energy. But, in the case of solids, the energy level of the outermost orbit electrons is affected by the neighbouring atoms.

When two isolated charges are brought close to each other, the electrons in the outermost orbit experience an attractive force from the nearest or neighbouring atomic nucleus. Due to this reason, the energies of the electrons will not be at the same level, the energy levels of electrons are changed to a value which is higher or lower than that of the original energy level of the electron.

The electrons in the same orbit exhibit different energy levels. The grouping of these different energy levels is known as the energy band.

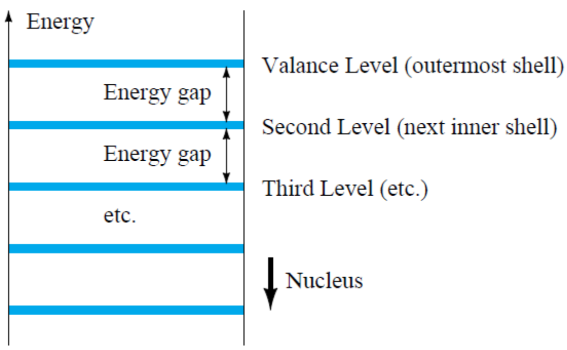
However, the energy of the inner orbit electrons is not much affected by the presence of neighbouring atoms.

Classification of Energy Bands

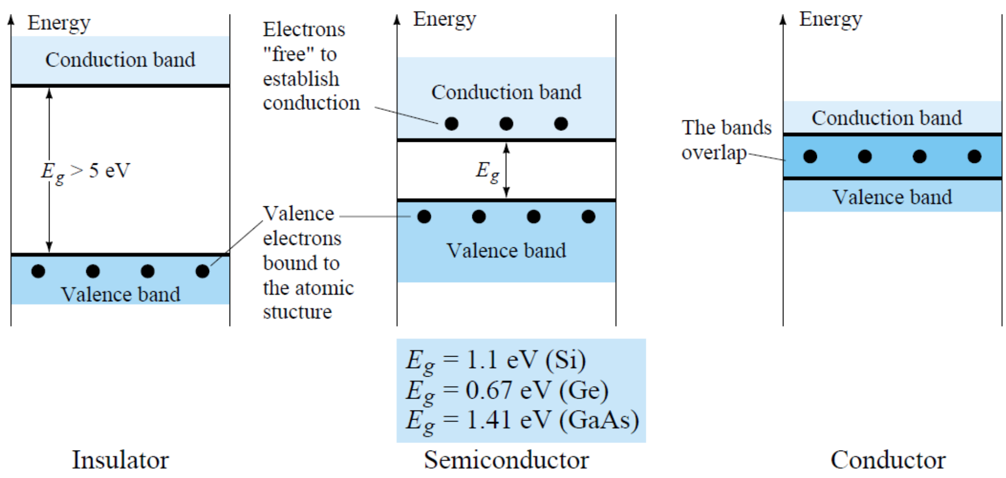
Energy Levels

In the isolated atomic structure, there are discrete (individual) energy levels associated with each orbiting electron, as shown in Fig. (a). Each material will, in fact, have its own set of permissible energy levels for the electrons in its atomic structure.

The more distant the electron from the nucleus, the higher the energy state, and any electron that has left its parent atom has a higher energy state than any electron in the atomic structure.



Energy levels: (a) discrete levels in isolated atomic structures.



(b) conduction and valence bands of an insulator, semiconductor, and conductor.

Between the discrete energy levels are gaps in which no electrons in the isolated atomic structure can appear. As the atoms of a material are brought closer together to form the crystal lattice structure, there is an interaction between atoms that will result in the electrons in a particular orbit of one atom having slightly different energy levels from electrons in the same orbit of an adjoining atom. The net result is an expansion of the discrete levels of possible energy states for the valence electrons to that of bands as shown in Fig. (b).

Valence Band

The electrons in the outermost shell are known as valence electrons. These valence electrons contain a series of energy levels and form an energy band known as the valence band. The valence band has the highest occupied energy.

Conduction Band

The valence electrons are not tightly held to the nucleus due to which a few of these valence electrons leave the outermost orbit even at room temperature and become free electrons. The free electrons conduct current in conductors and are therefore known as conduction electrons. The conduction band is one that contains conduction electrons and has the lowest occupied energy levels.

Forbidden Energy Gap

The gap between the valence band and the conduction band is referred to as the forbidden gap. As the name suggests, the forbidden gap doesn't have any energy and no electrons stay in this band. If the forbidden energy gap is greater, then the valence band electrons are tightly bound or firmly attached to the nucleus. We require some amount of external energy that is equal to the forbidden energy gap.

Conductors

Gold, Aluminium, Silver, Copper, all these metals allow an electric current to flow through them.

There is no forbidden gap between the valence band and conduction band which results in the overlapping of both the bands. The number of free electrons available at room temperature is large.

Insulators

Glass and wood are examples of the insulator. These substances do not allow electricity to pass through them. They have high resistivity and very low conductivity.

The energy gap in the insulator is very high up to 7eV. The material cannot conduct because the movement of the electrons from the valence band to the conduction band is not possible.

Semiconductors

Germanium and Silicon are the most preferable material whose electrical properties lie in between semiconductors and insulators. The energy band diagram of semiconductors is shown where the conduction band is empty, and the valence band is completely filled but the forbidden gap between the two bands is very small that is about 1eV. For Germanium, the forbidden gap is 0.72eV and for Silicon, it is 1.1eV. Thus, semiconductor requires small conductivity.