

SEMICONDUCTORS AND JUNCTION DIODES

Analog Electronics
Pujianto

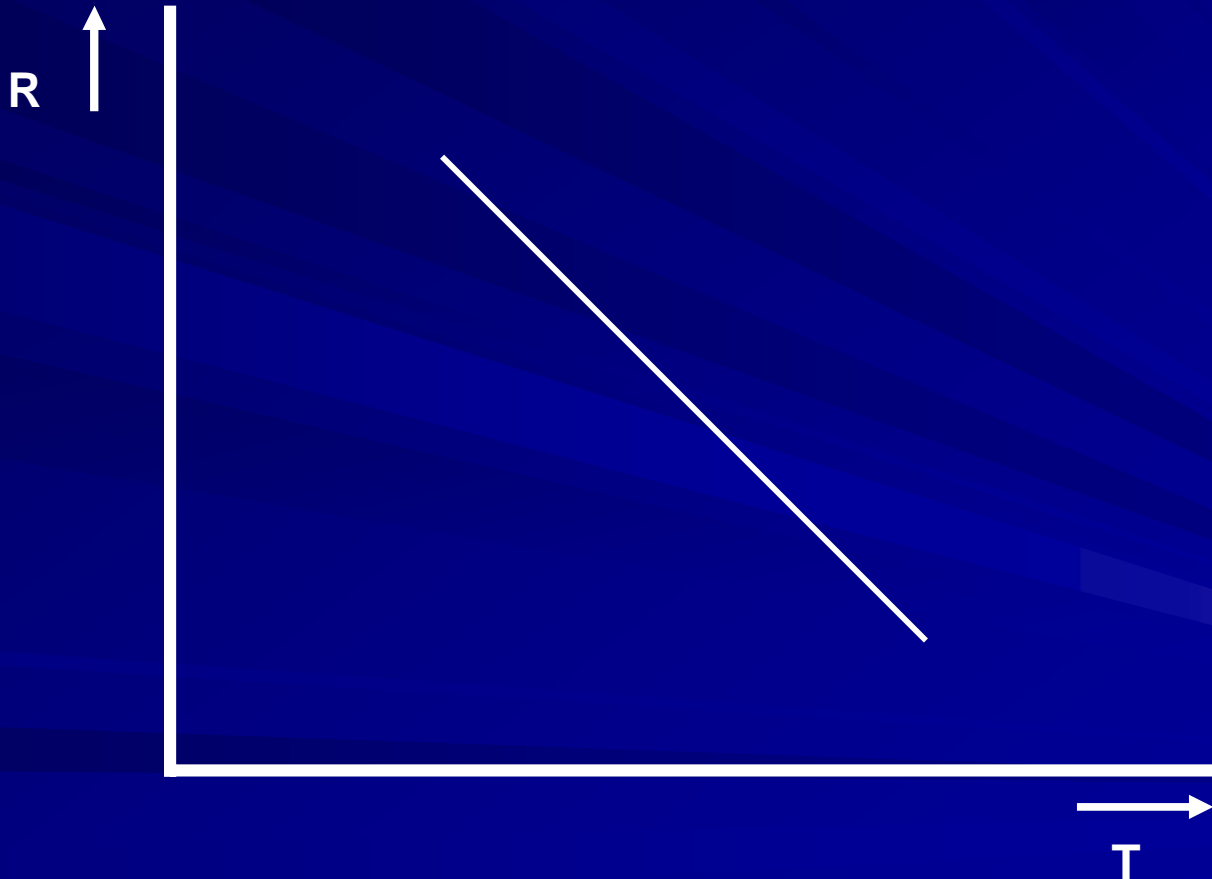
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Semiconductors

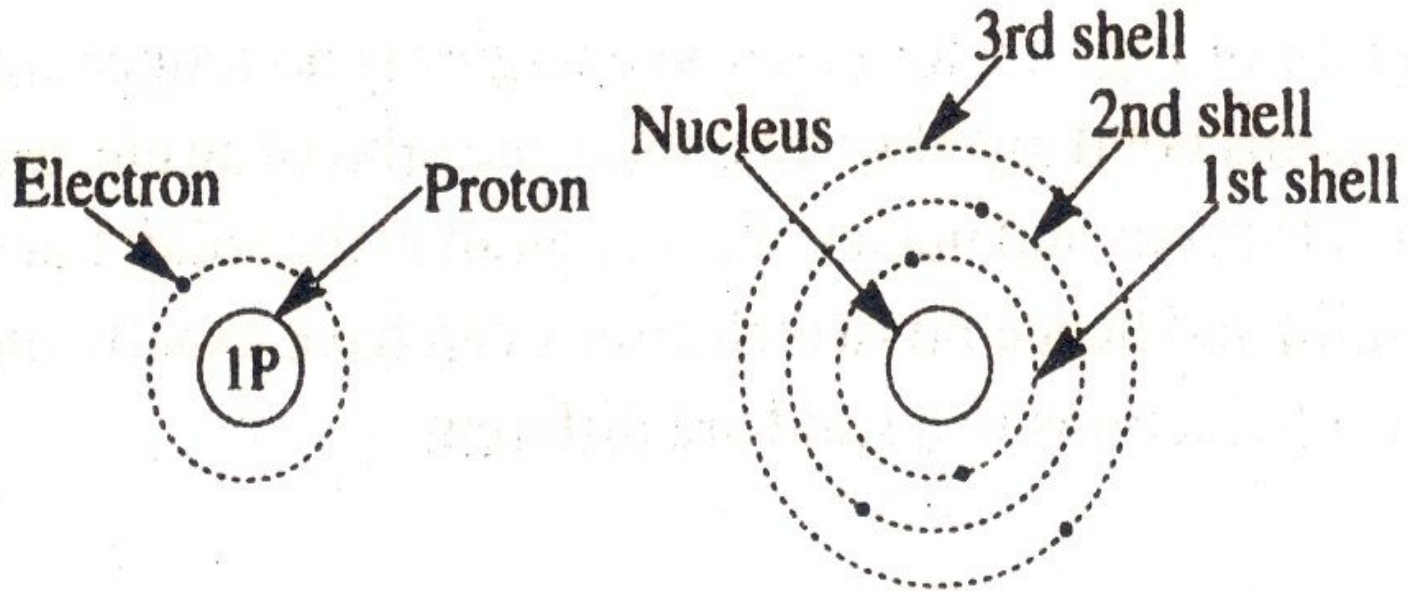
A large class of substances which have resistivities lying between those of insulator and conductors.

The resistivity of semiconductors varies within wide limits, i.e., 10^{-4} to $10^4 \Omega \cdot m$ and is reduced to a very great extent with an increase in temperature (according to an exponential law)

The Temperature Dependence of the Resistance in Semiconductors

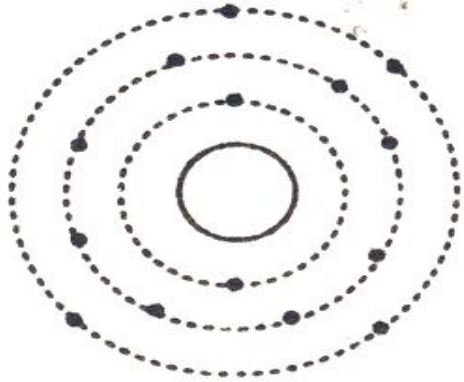


Atomic Structure and Energy Level

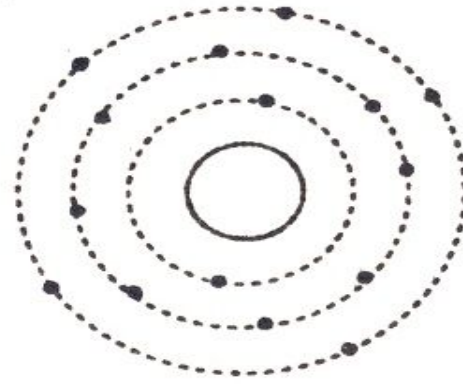


(a) Hydrogen atom
(1H)

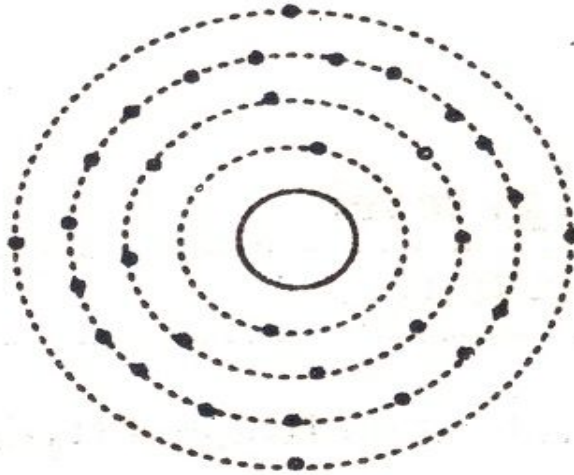
(b) Boron atom
(5B)



(c) Silicon atom
(14Si)



(d) Phosphorus atom
(15P)

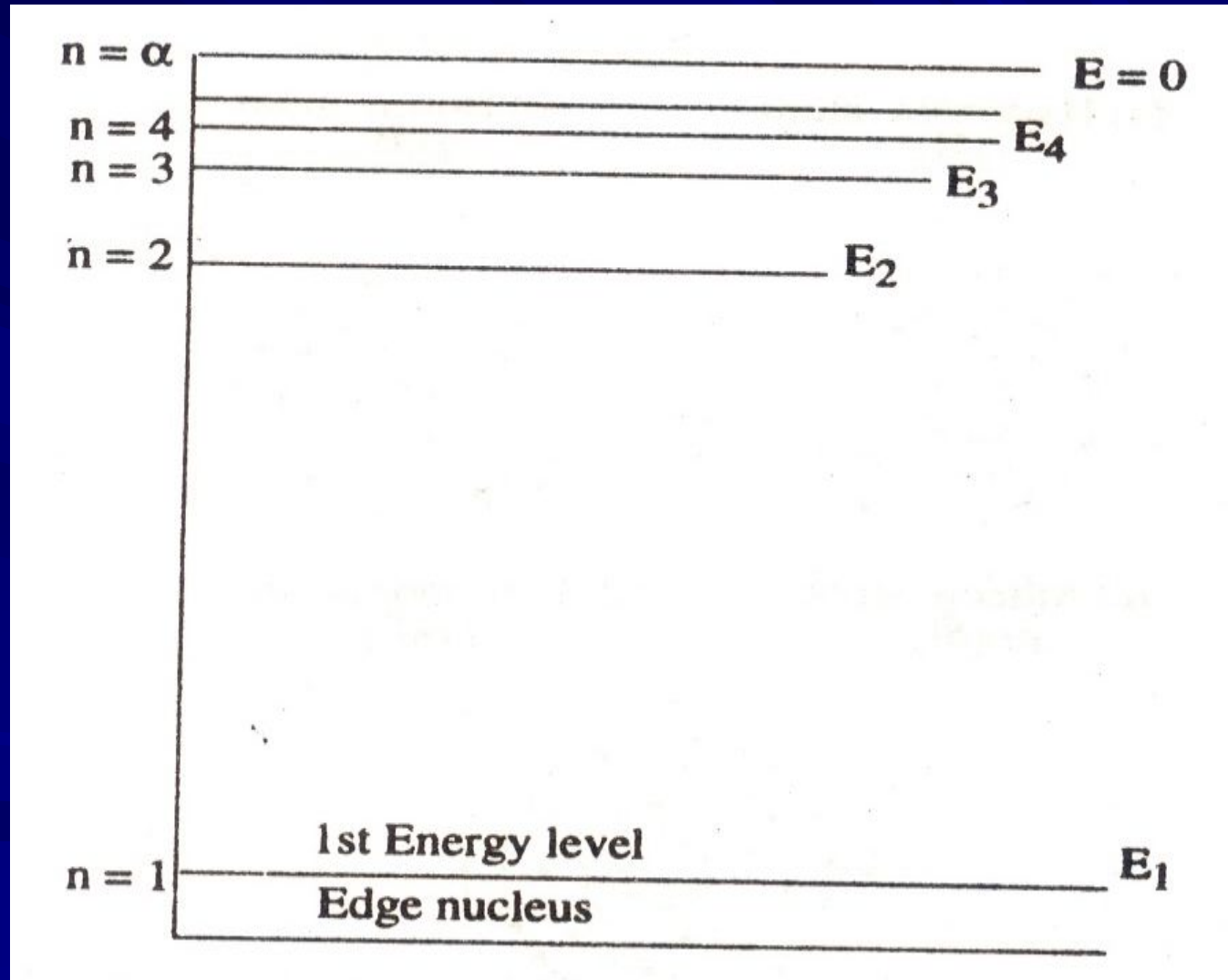


(e) Germanium atom
(32Ge)

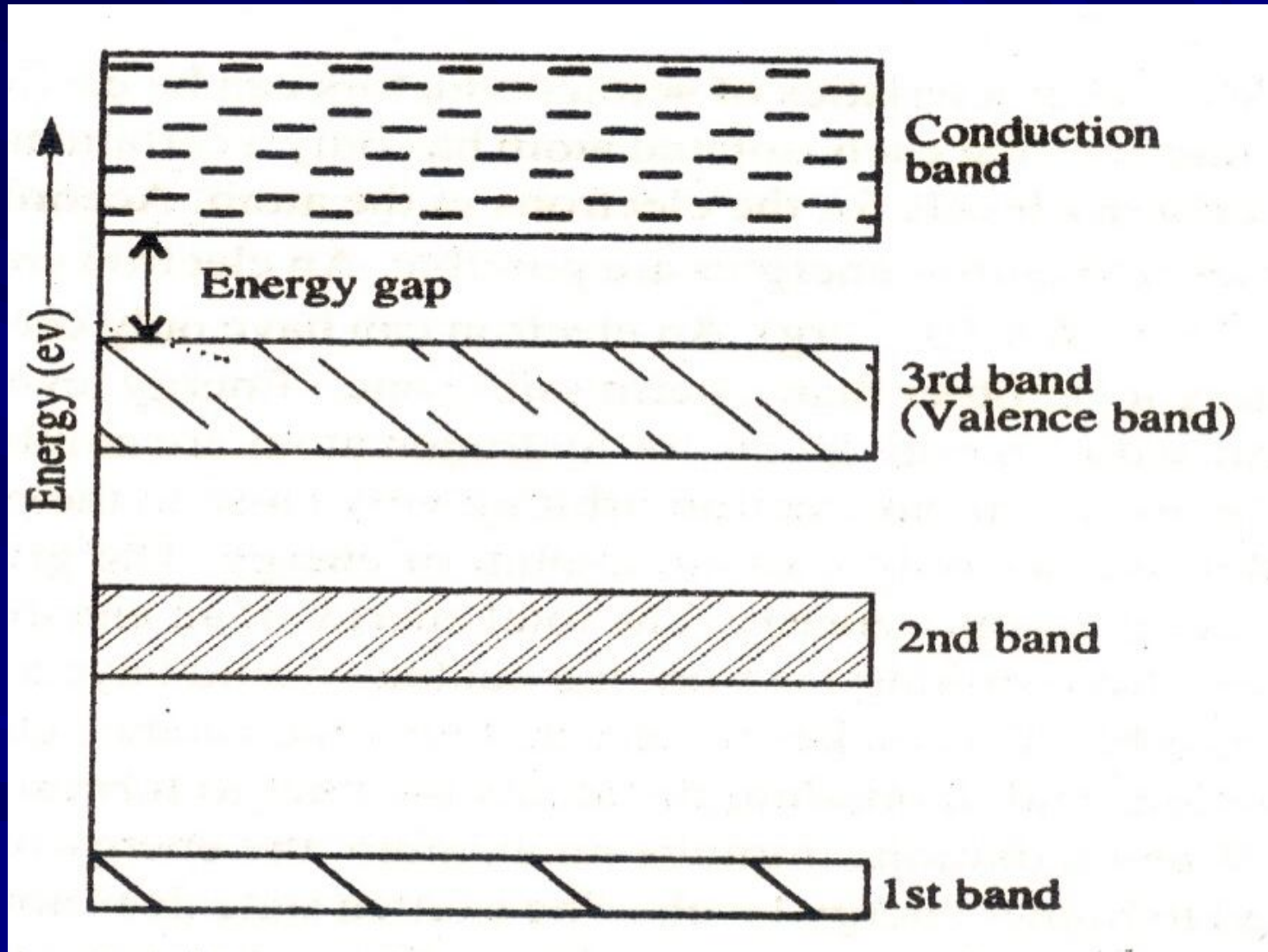
Energy Band Diagram in Solids

- ✓ A solid is formed when atoms bond together.
- ✓ In a solid, the orbit of an electron is influenced not only by the charges in its own atom but by electrons and nuclei of every atom in the solid.
- ✓ Each electron in a solid occupies a different position inside the solid and hence no two electrons can have exactly the same pattern of surrounding charges.
- ✓ The orbits of electrons in a solid are different.

Energy Levels of an Isolated Hydrogen Atom



Energy Bands of Silicon at Absolute Zero



Insulators, Conductors and Semiconductors

The band structure in a solid determines whether the solid is an insulator or a conductor or a semiconductor.

Insulators

If the energy gap between the valence band and the conduction band is too large, then the electron will not be able to make a jump. It is called an insulator.

The band theory of solid tells us that an insulator is a material in which the valence bands are filled and the forbidden energy gap between valence band and conduction band is too great for the valence electrons cannot jump at normal temperatures from VB to the CB.

An insulator does not conduct at room temperature because there are no conduction electrons in it.

Conductors

There are actually two possibilities for a substance to be a conductor.

One is that the valence band is not completely filled. Then an electron in the valence band can get free of its atom by simply jumping to a higher energy level within the same band. This jump requires a small amount of energy, and many electrons can, therefore, make that jump.

The band theory tells us that we have a conductor when

- (i) The valence band is not filled, so electrons can move to higher states in the valence band and be free
- (ii) When there is no energy gap between the valence band and the conduction band, so electron can easily make the transitions from the valence to the conduction band

Semiconductors

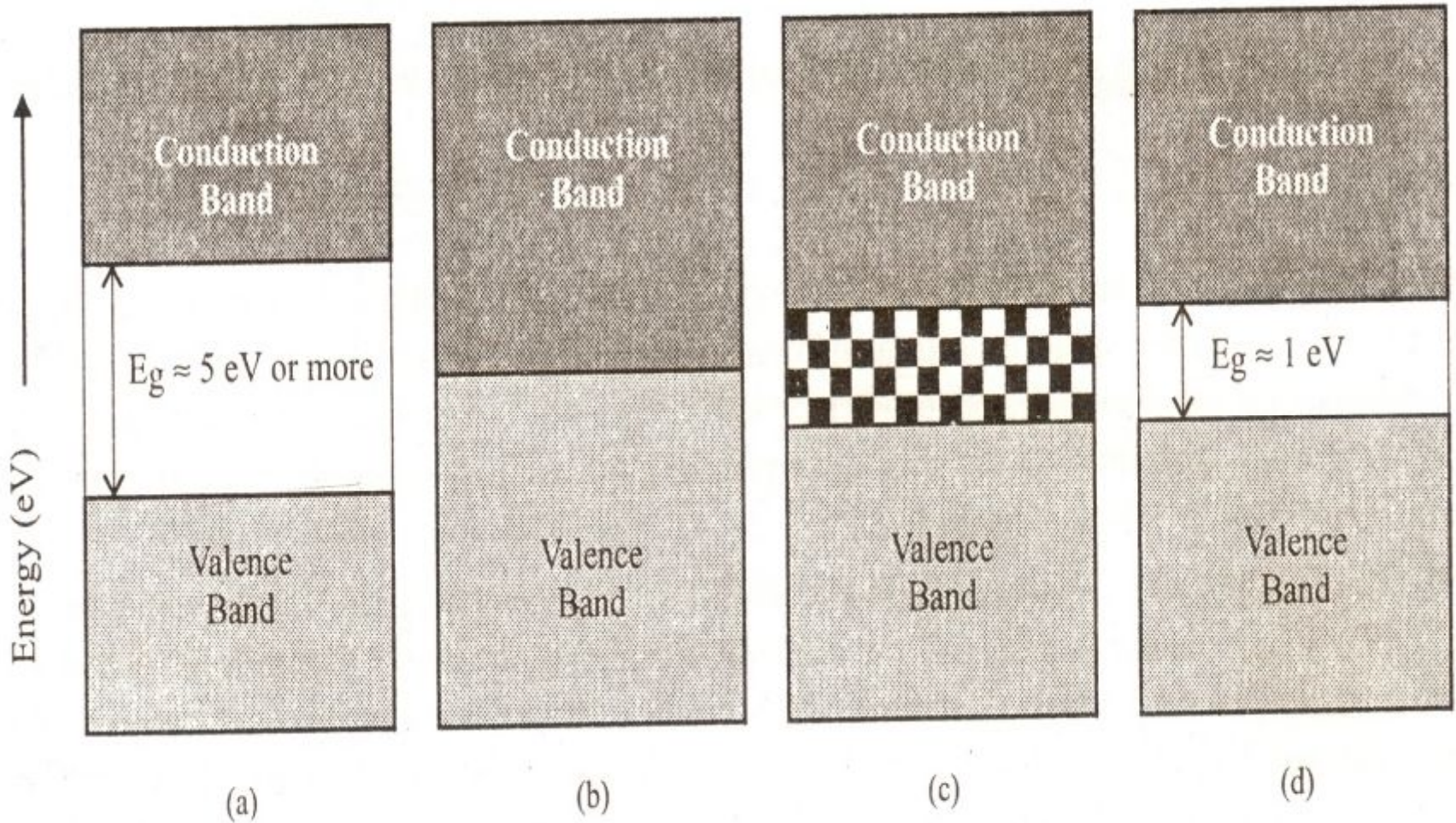
There is a case in between 'conductor' and 'insulator'.

A material with intermediate properties is called a semiconductor

In a semiconductor,

- (i) The valence band is filled, and
- (ii) Although there is an energy gap between the valence band and the conduction band yet the energy gap is not very large.

Energy Band Diagram for (a) Insulators, (b) Conductors, (c) Semiconductor



To be Continued ...