BASIC ELECTRONICS 01

Energy Band Theory

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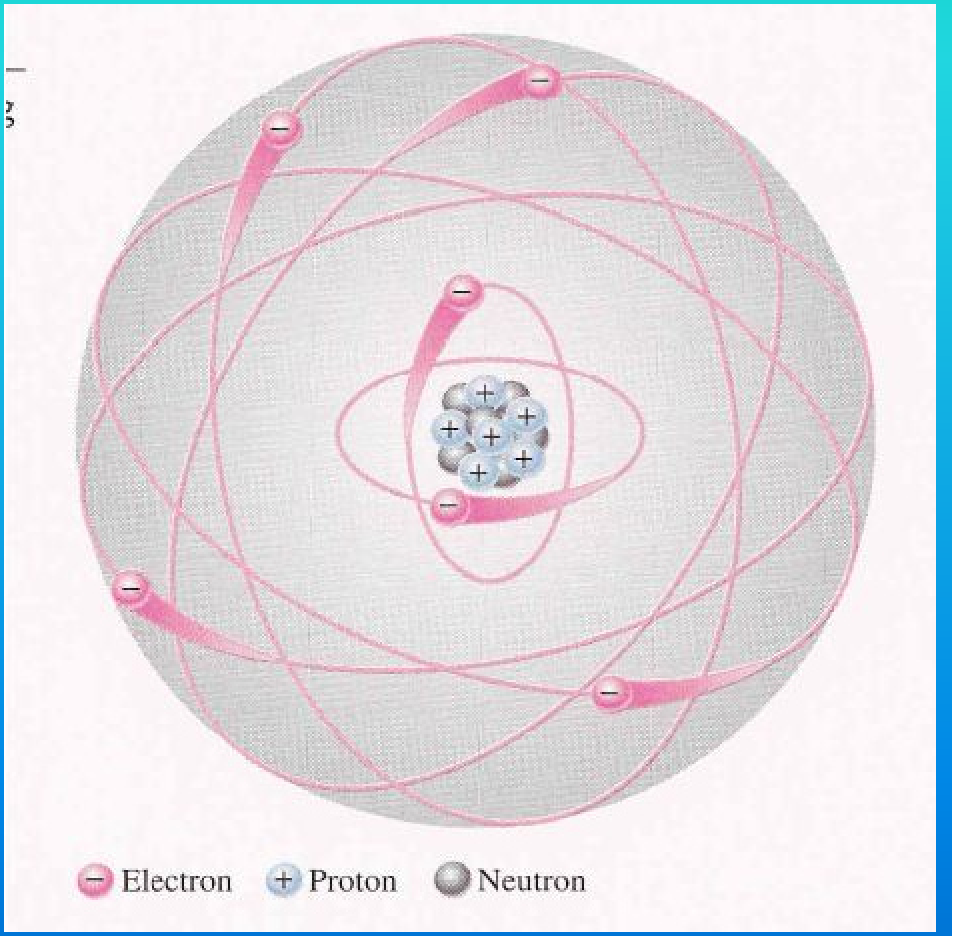
Atomic Structure

- Planetary atomic model (Neil Bohr 1913).
- Nucleus – Central hard core containing almost entire mass of the atom.
  - Proton
  - Neutrons
- Revolving electrons around the nucleus in fixed assigned orbits.
- The centripetal force required to move the electron in an orbit is provided by the attractive force between electrons and nucleus.
- Electrons close to the nucleus are more tightly bound to it as compared to the ones farther away .



Electronic Orbits

- Electrons cannot revolve around the nucleus in any arbitrary orbits.
- Fixed orbits assigned as K,L,M,N etc.
- K-shell corresponds to n=1 quantum number and is closest to the nucleus.
- Maximum number of electrons a shell can have is "$2n^2$"

Electronic Distribution Rules

<u>Rule 1</u>

Maximum number of electrons in the outer most shell of an atom cannot exceed 8.

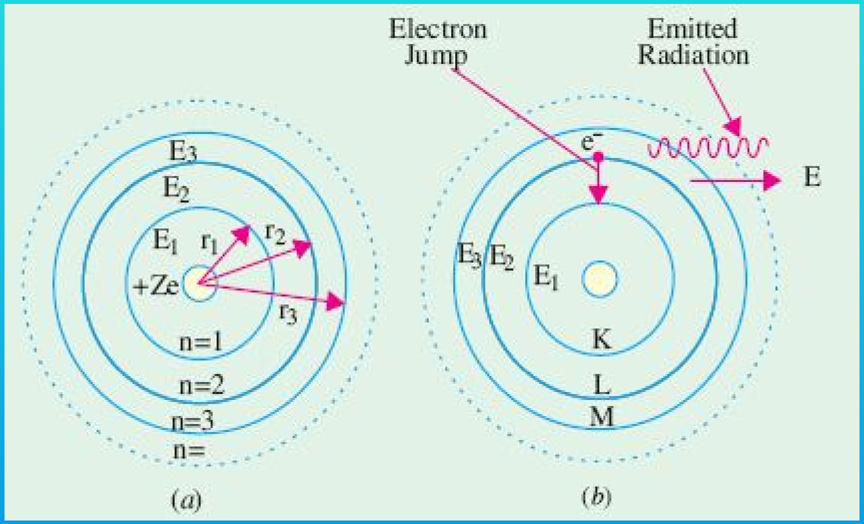
<u>Rule 2</u>

Maximum number of electrons in the shell just prior to the outermost shell cannot exceed 18.

Electronic Energies

- Each electronic orbit is associated with a certain amount of energy.
- While revolving in these permitted orbits an electron does not radiate out any energy.
- It radiate energy only when an electron jumps from one orbit to another.

$$\Delta E = E_2 - E_1 = hf$$

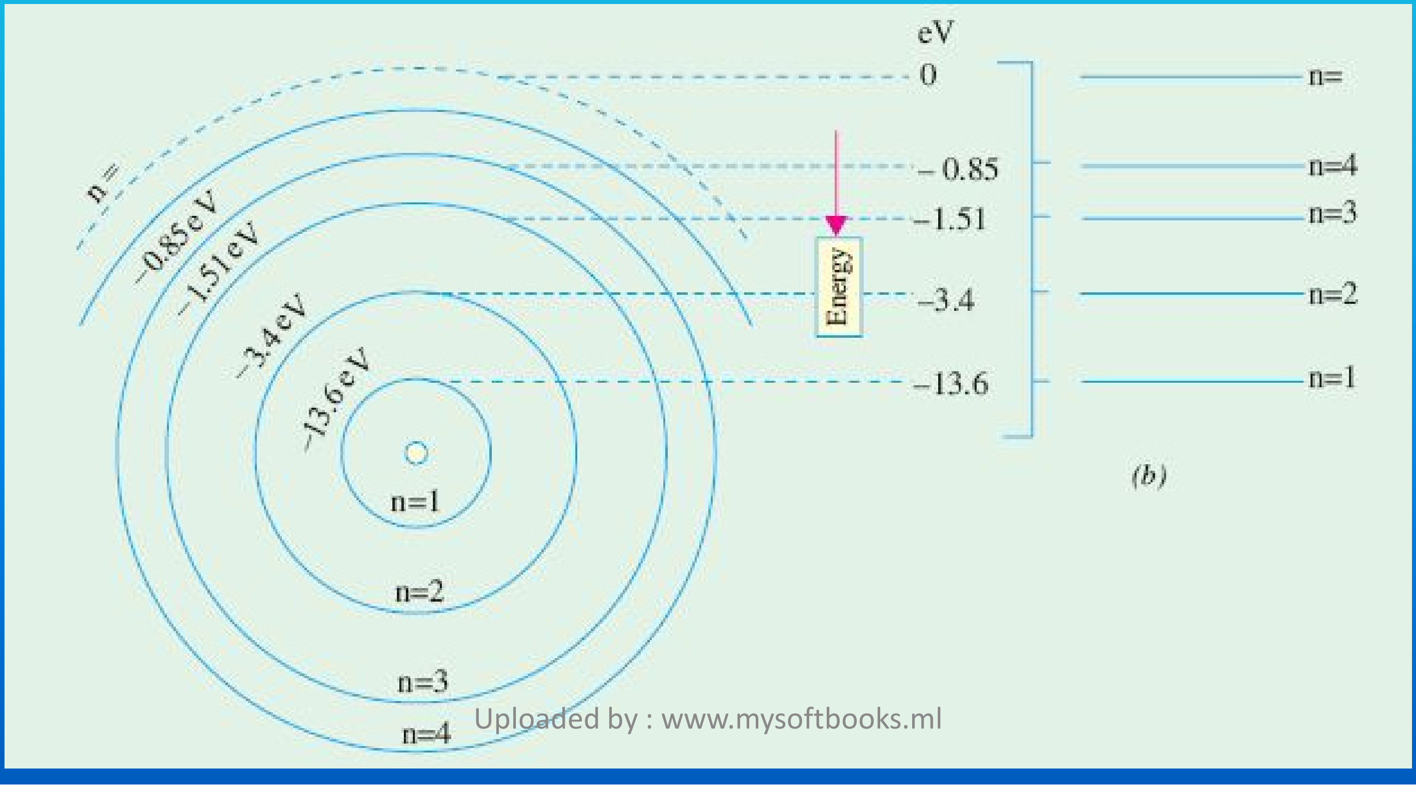


Electron Sub-Orbits

Shell	K	L		M			N			
n	1	2		3			4			
l	0	0	1	0	1	2	0	1	2	3
sub-shell	s	s	p	s	p	d	s	p	d	f
Maximum No. of electrons $= 2(2l + 1)$	2	2	6	2	6	10	2	6	10	14
Total No. of electrons $= 2n^2$	2		8	18						32

Energy Levels of an Isolated Atom

- An isolated atom is the one which is removed from other atoms so that not to be affected at all by their electric fields.
- We draw horizontal lines to an energy scale representing orbital energy level-diagram.



Key Features

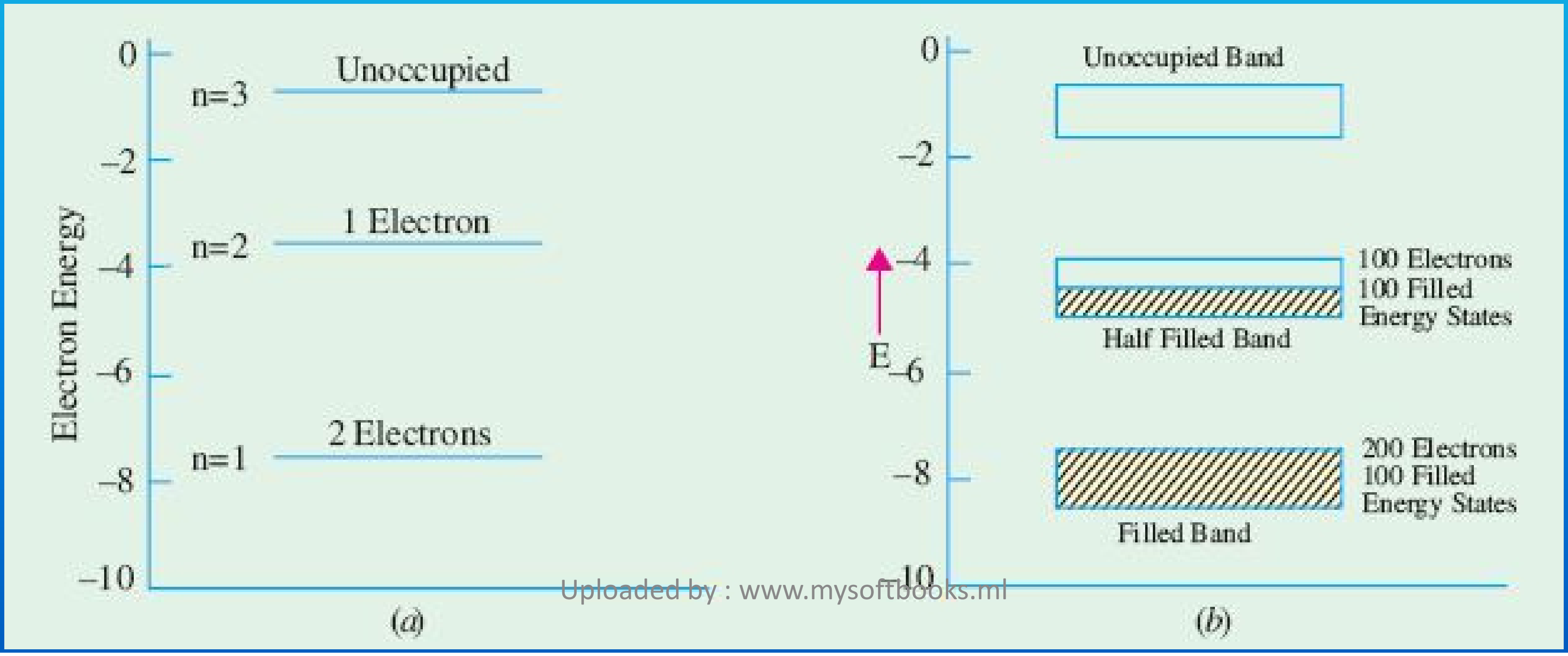
- Less negative energies are at the top where more negative ones are at the bottom.

- It is easier to remove electrons from higher orbits than lower ones.

- Various energy levels are separated by forbidden energy gaps where no electrons can exist.

Energy Bands in Solids

- There is significant change in the energy levels when atoms exist close together as in solids.
- If there are 100 levels of slightly different energies for each n-value then 100 energy level diagrams would be superimposed on each other.
- Hence a single energy level of an isolated atom will become a band of energy in a solid.



Valance & Conduction Bands

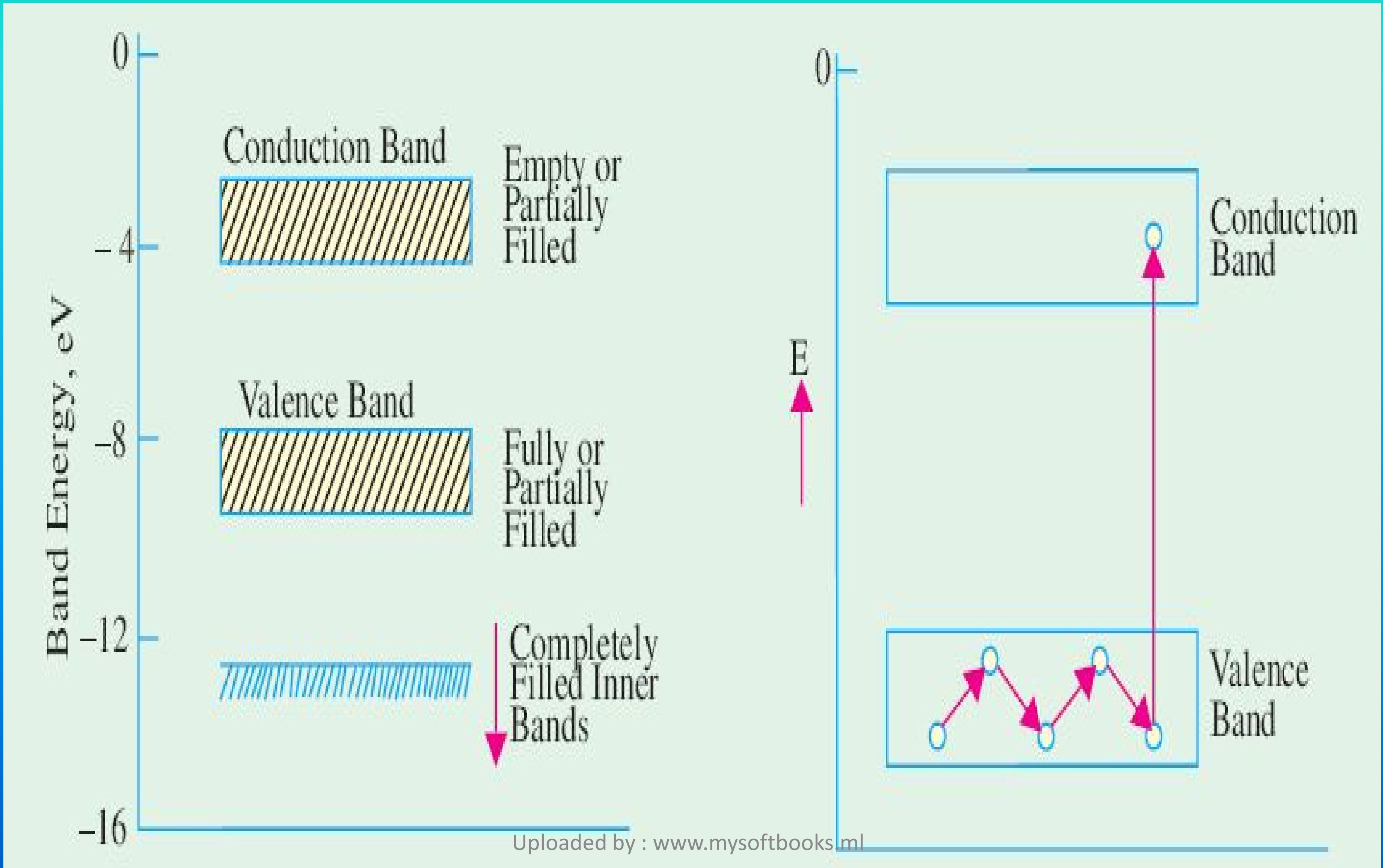
- The band of energy occupied by the valance electrons is called valance band. It may be completely filled or partially filled with electrons but never empty.
- Above the valance band the next permitted energy band is called the conduction band. It may be completely empty or partially filled with electrons.
  - In conduction band electrons can move freely and hence are called conduction or free electrons.

<u>Forbidden Energy Gap</u>

The gap between these two bands is known as forbidden energy gap.

If the valance electrons absorb enough energy , it can jumps across the forbidden energy gap and enters the conduction band.

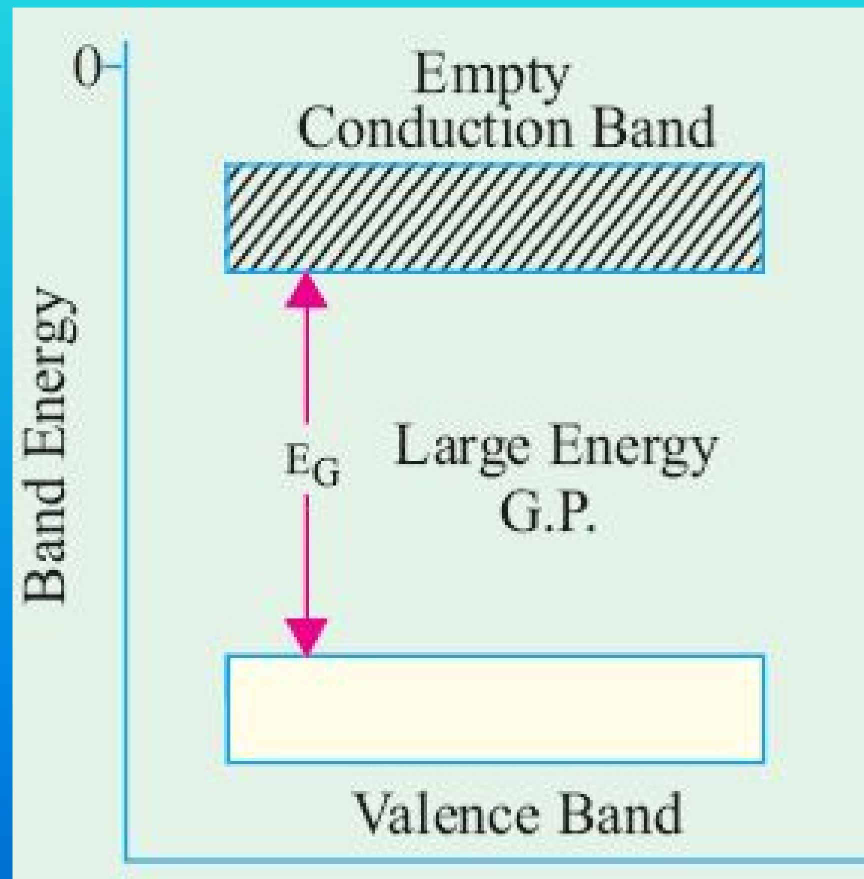
Valance & Conduction Bands



Insulators

Materials in which valance electrons are bound very tightly to their parent atoms, thus requiring very large electric field to remove them from the attraction of their nuclei.

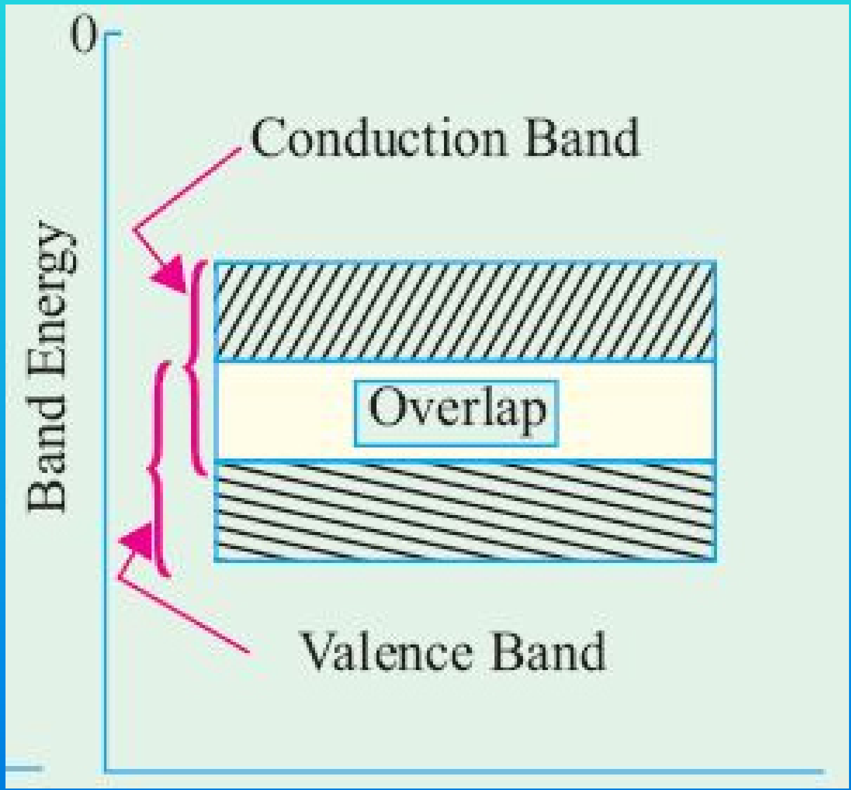
- Have empty conduction band.
- Have a large energy gap between them.
- At ordinary temperatures, have slight probability of electrons from full valance band to gain energy to overcome energy gap.



Conductors

Materials in which plenty of free electrons are available for conduction.

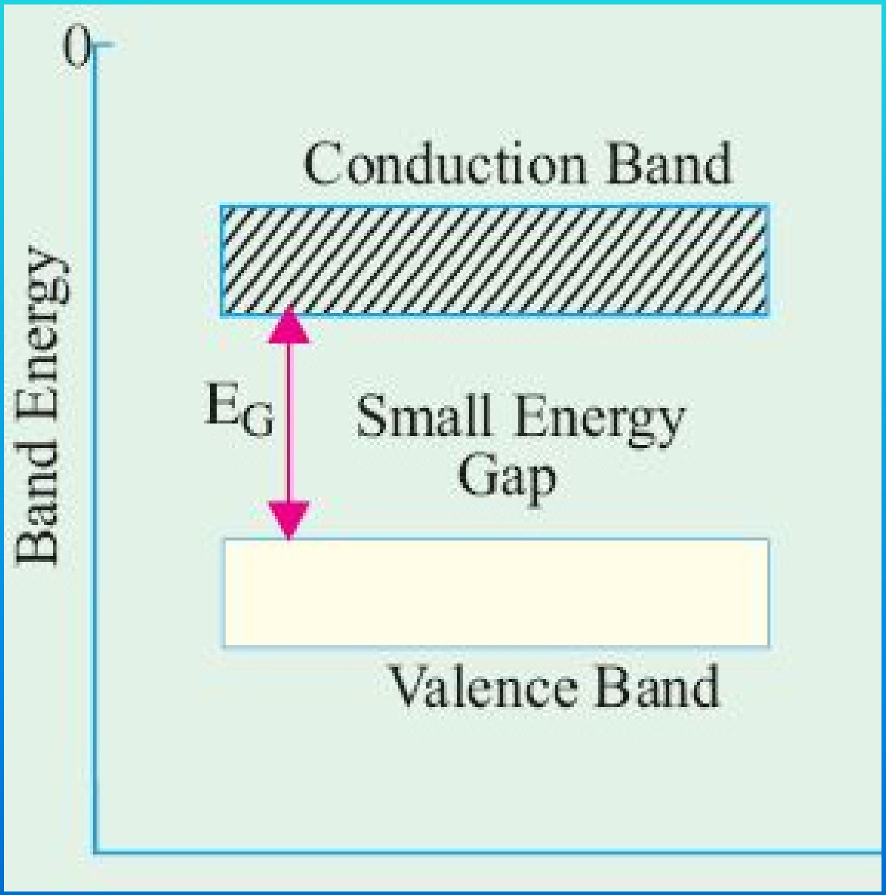
- Have overlapping valance and conduction bands.
- Have large number of conduction electrons are available for conduction.
- Absence of forbidden energy gap.



Semiconductors

Materials whose electrical properties lies between those of insulators and conductors.

- Have an almost empty conduction band and almost filled valance band with a narrow energy gap.
- At 0^0K there are no electrons in the conduction band and the valance band is completely filled. However with increase in temperature, width of forbidden energy band is decreased so that some electrons are liberated into the conduction band.



Self Assessment

SECTION 1-2 REVIEW

1. What is the basic difference between conductors and insulators?
2. How do semiconductors differ from conductors and insulators?
3. How many valence electrons does a conductor such as copper have?
4. How many valence electrons does a semiconductor have?
5. Name three of the best conductive materials.
6. What is the most widely used semiconductive material?
7. Why does a semiconductor have fewer free electrons than a conductor?