Vision

To be the centre of excellence in the field of technical education.

Program Code:- First Semester – All Program

Course Name:- Basic Science (PHYSICS)

Course Code : - BSC (22102)

Course coordinator: Mr. S. K. Rawat

Course Name:- Basic Science (PHYSICS)

Unit No:2

Unit Name: Electricity, Magnetism & Semiconductors.

Unit Outcomes (UO2e): Distinguish the given conductors, semiconductors and insulators on the basis of energy bands.

Learning Outcomes (LOs):

LO8: Student will be able to distinguish between conductors, semiconductors and insulators on the basis of energy bands.

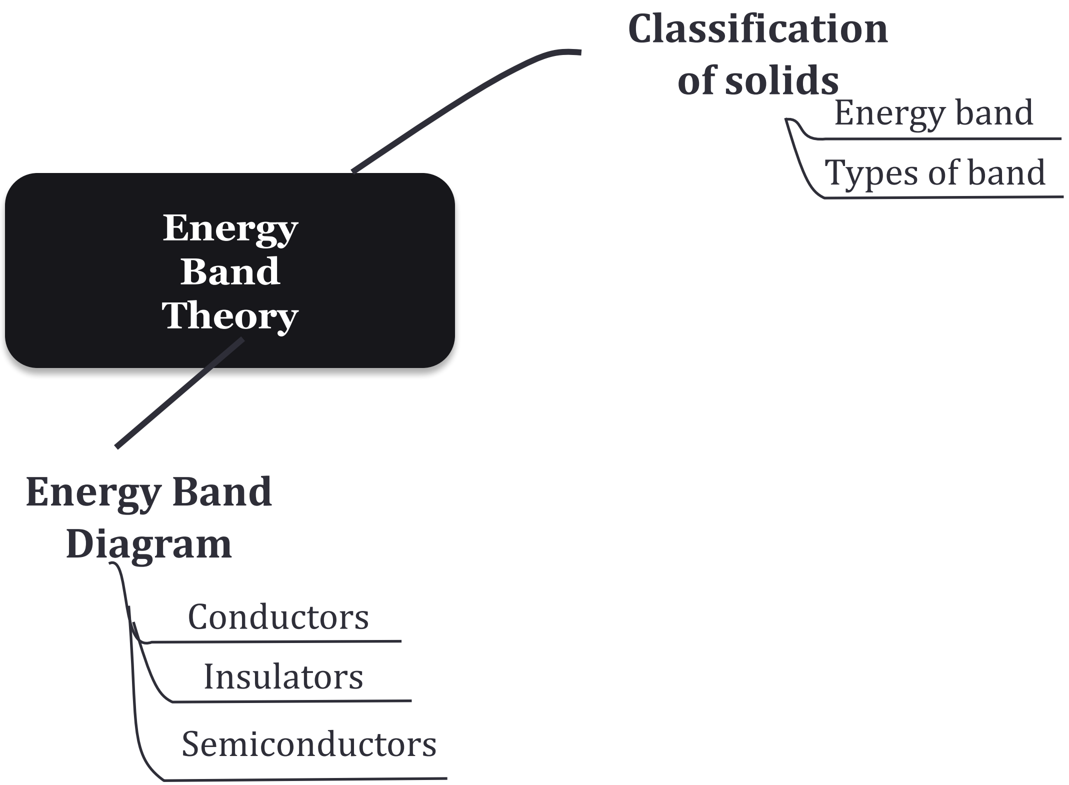
CONTENT

- Classification of solids on the basis of band theory
- Energy band diagram
  - Conductors
  - Insulators
  - Semiconductors

LEARNING OBJECTIVES

- Student will be able to distinguish between conductors, semiconductors and insulators on the basis of energy bands.

Concept Map

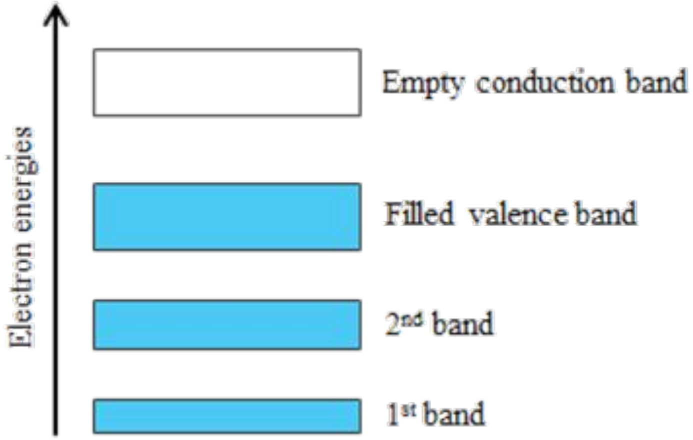

Classification of solids
Energy band
Types of band
Energy Band Theory
Energy Band Diagram
Conductors
Insulators
Semiconductors

Introduction

- Before the discovery of diodes and transistor, devices which were used were mostly vacuum tubes (also called valves) like the vacuum diode, triode, tetrode and pentode.
- Discovery of semiconductors and invention of transistor and IC’s has greatest impact on field of Electronics, Telecommunication, Computer Technology and Artificial Intelligence and so on.
- We know that materials are classified as conductors, insulators and semiconductors on the basis of conductivity.
- In the following session, you will learn classification of solids on the basis of the band theory.

Classification of solids on the basis of band theory

- The atoms come together to form a solid, they are close to each other.
- So the outer orbits of electrons from neighbouring atoms would come very close or could even overlap.
- Inside the crystal each electron has a unique position and no two electrons see exactly the same pattern of surrounding charges. Because of this, each electron will have a different energy level. Thus for a given solid, closely spaced energy levels of all electrons in a particular orbit is called energy band.
- As seen in Fig.1, the energy band for typical solid illustrates the different energy band. Shaded band indicates filled band, whereas the unshaded band indicates some orbits are empty or some energy levels are vacant.



TYPES OF BAND

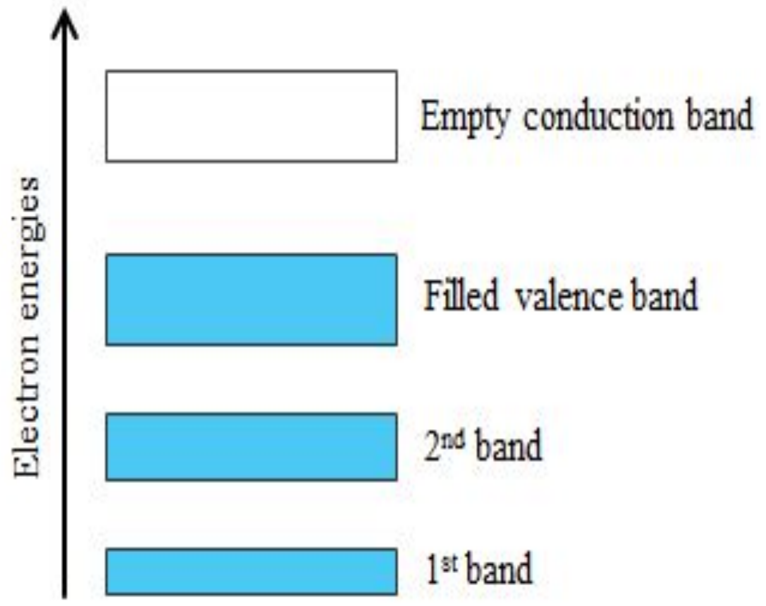
Energy band: The different closely spaced energy levels of all electrons in a particular orbit with continuous energy variation are called energy bands.

Valence band: The energy band which occupies valence electrons is called valence band. or The energy band which includes the energy levels of the valence electrons is called the valence band.

The valence band may be partially or completely filled up depending on the nature of the crystal.

Conduction band: The energy band which occupies free electrons is called conduction band. Or The energy band above the valence band is called the conduction band.

Conduction band may be empty or partially filled. In conduction band the electrons can freely move.

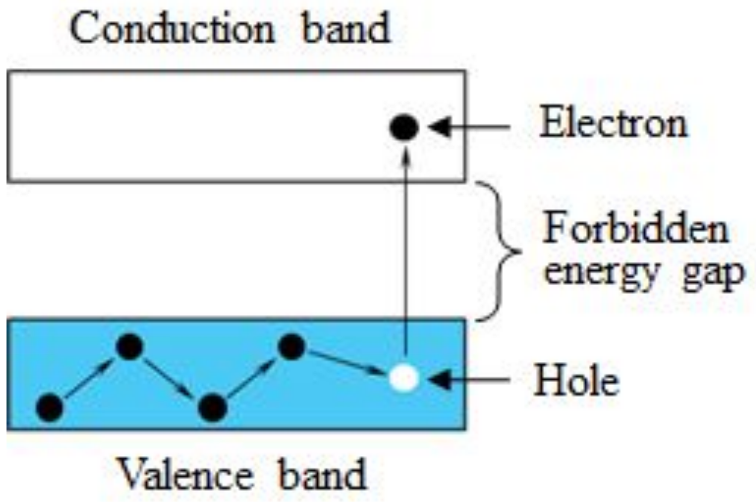


TYPES OF BAND

Forbidden energy gap: The separation between conduction band and valence band in energy band diagram is called forbidden energy gap or band gap. or The gap between the top of the valence band and bottom of the conduction band is called the energy band gap (Energy gap Eg).

Forbidden gap or energy gap may be large, small, or zero, depending upon the material.

When the electrons from the valence band gains external energy it cross the forbidden gap and enters the conduction band. Then these electrons will move into the conduction band, thereby creating holes or vacant energy levels in the valence band where other valence electrons can move as shown in Fig.2. Thus the process creates the possibility of conduction due to electrons in conduction band as well as due to holes in the valence band.



Attempt Set 1 MCQs

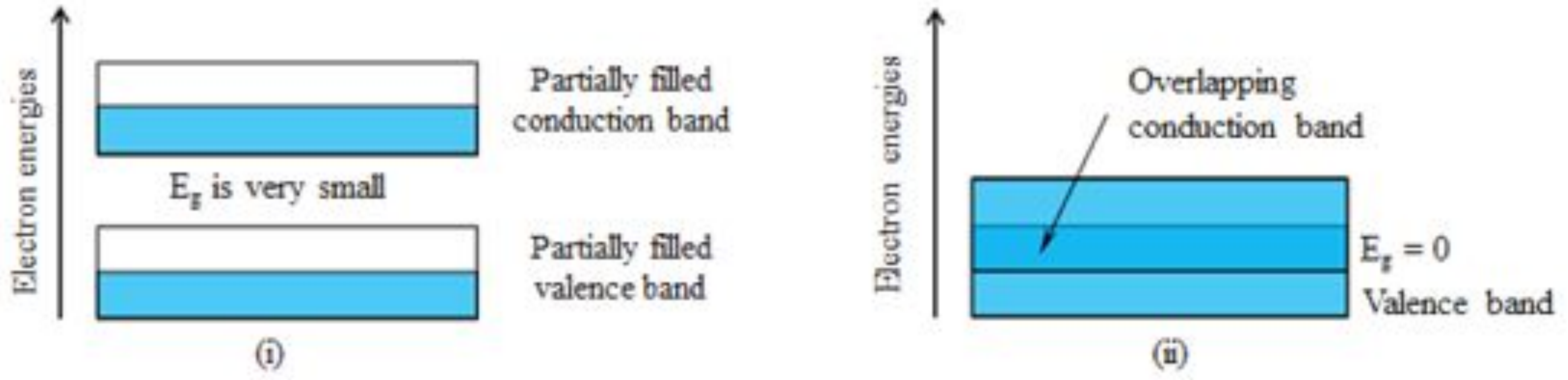
Question No	Question No. 1	Question No. 2	Question No. 3
Statement of Question	Electron is a Greek word for ____________	Which material has more free electrons?	An insulating element or material has capability of __________________
Level of Question	Remembering	Understanding	Applications
Option (a)	a) amber	a) Conductors	a) conducting large current
Option (b)	b) fire	b) Insulators	b) storing voltage
Option (c)	c) Stone	c) Mica	c) storing high current
Option (d)	d) heat	d) Dielectric	d) preventing short circuit
Correct Option	**amber**	**Conductors**	**preventing short circuit**

START

Energy band diagram

Conductors

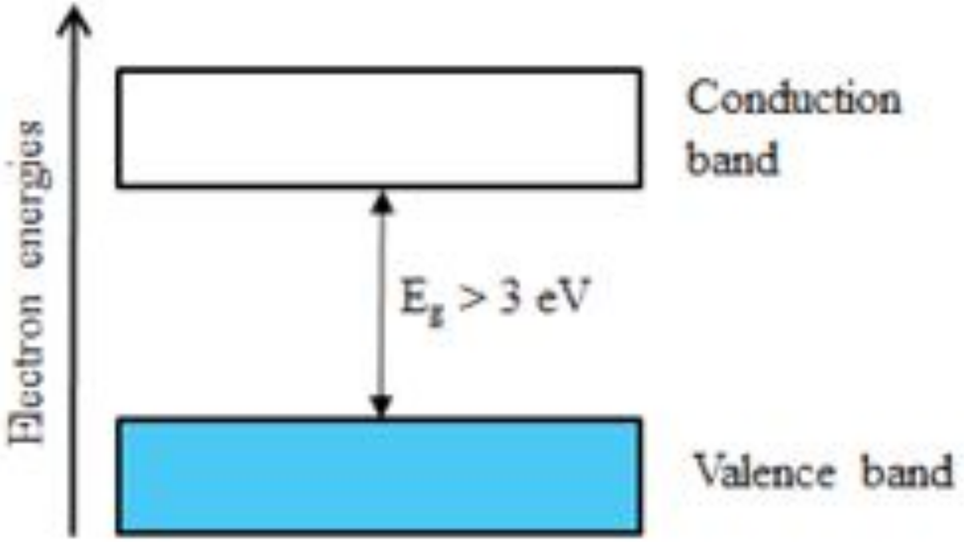
- In conductors, either when the conduction band is partially filled and the valance band is partially empty or when the conduction and valence bands overlap; the electrons from valence band can easily move into the conduction band.
- Thus there is no energy band gap (Eg = 0) as shown in Fig and a large number of electrons are available for electrical conduction. The electrons from valence band freely enter in the conduction band due to absence of forbidden band. Therefore, the resistance of such materials is low and the conductivity is high.



Energy band diagram

Insulators

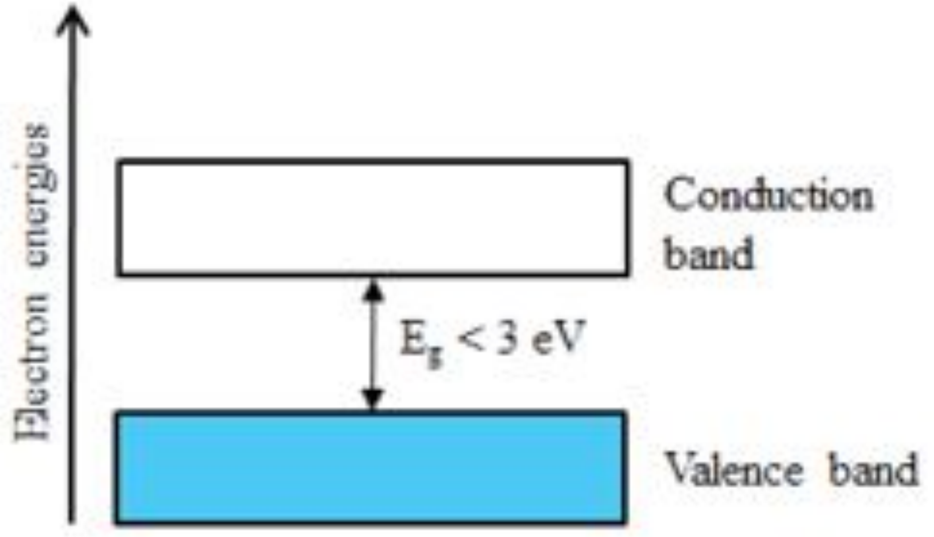
- In case of insulators, a large energy band gap exists (Eg > 3 eV) and conduction band is empty as shown in Fig.
- The energy gap is so large that at room temperature, due to thermal excitation the electrons cannot be excited from valence band to conduction band and hence no electrons are available for conduction. Therefore the resistance of such materials is high and the conductivity is low.



Energy band diagram

Semiconductors

- In semiconductors, a finite but small band gap (E_g < 3 eV) exists. Because of the small band gap, at room temperature some electrons from valence band can acquire enough energy to jump through the energy gap and enter the conduction band. These electrons (though small in numbers) can move in the conduction band. Hence, the resistance of semiconductors is not as high as that of the insulators.
- Germanium (Ge) and Silicon (Si) are the examples of semiconductors. In Germanium the forbidden energy gap is of order of 0.72 eV while in Silicon, the forbidden energy gap is of the order of 1.1 eV.



Attempt Set 2 MCQs

Question No	Question No. 1	Question No. 2	Question No. 3
Statement of Question	In materials, which is the region that separates the valence and conduction bands?	In semiconductors, energy band gap is of the order of	Ge and Si are the examples of ________________
Level of Question	Remembering	Understanding	Remembering
Option (a)	a) barrier potential	a) 0 eV	a) conductors
Option (b)	b) forbidden level	b) < 1.1 eV	b) semiconductors
Option (c)	c) insulation band	c) > 5.5 eV	c) Insulators
Option (d)	d) energy forbidden gap	d) 6 eV	d) metalloids
Correct Option	**energy forbidden gap**	**< 1.1 eV**	**semiconductors**

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