UNIT 05 CHAPTER 25

Solids:-

Date
Page

Energy band:-

↳ The range of energy of an electron in an atom is called energy band. There are three energy band in solid. They are:-

(i) Valence band
(ii) Conduction band
(iii) Forbidden band (Band gap)

(i) Valence band:-

↳ The range of energy occupied by valance electrons is known as valence band. It may be partially or completely filled but never be empty. In case of inert gas, the valance band is full where as for other materials, it is partially filled. In this band, electrons cannot gain energy from external electric field.

(ii) Conduction band:-

↳ The electrons which have left the valence band are called conductions electrons and the range of energy occupied by conduction electrons is known as conduction band. It lies above the valence band. It is empty for insulator and partially filled for conductor. In this band, electrons can gain energy from external electric field.

(iii) Forbidden band (Band gap):-

→ The conduction band is separated from valence band by a certain gap is known as forbidden ~~gap~~ band or gap↔band. There are no electrons in band gap. In order to jump a electron from valence band to

Conduction band it requires some energy which is called band gap energy.

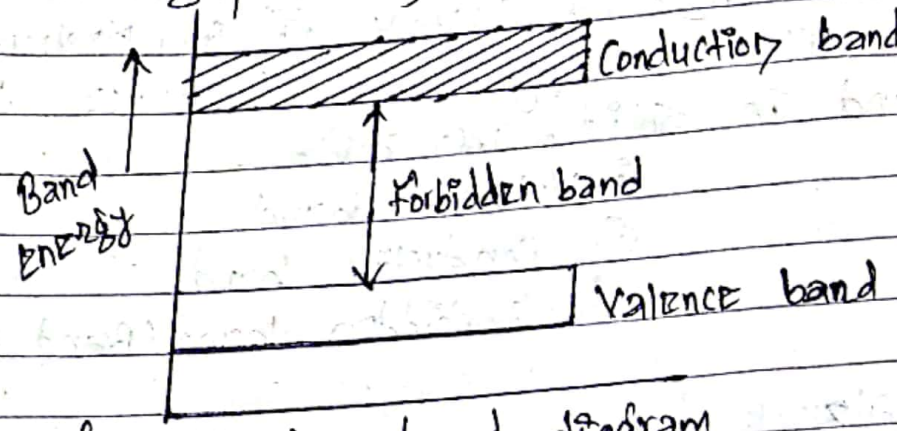


fig:- Energy band diagram

Imp ## Classification of Solid on the basis of band theory of Solid (Difference between conductor, insulator & Semi-conductor based on band theory):-

↳ on the basis of the width of the energy band in solids the solids are classified into conductor, insulators and Semi-conductors.

[1] Conductor:-

↳ The material having no forbidden energy gap is called conductor. The valence and conduction bands overlap in a conductor so valence electron easily passed into conduction band, Thus conductor will conduct electricity.

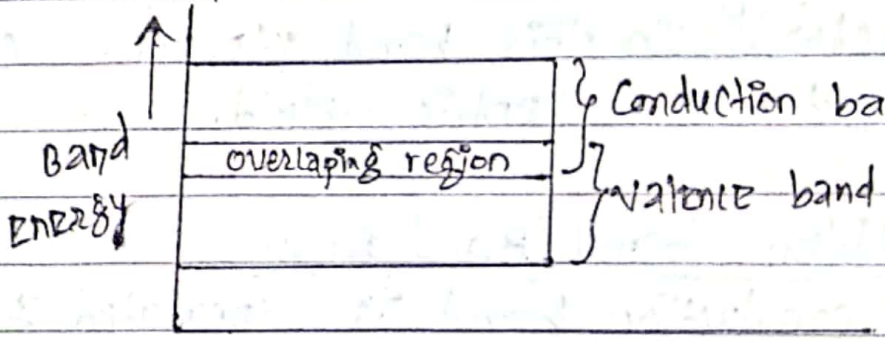
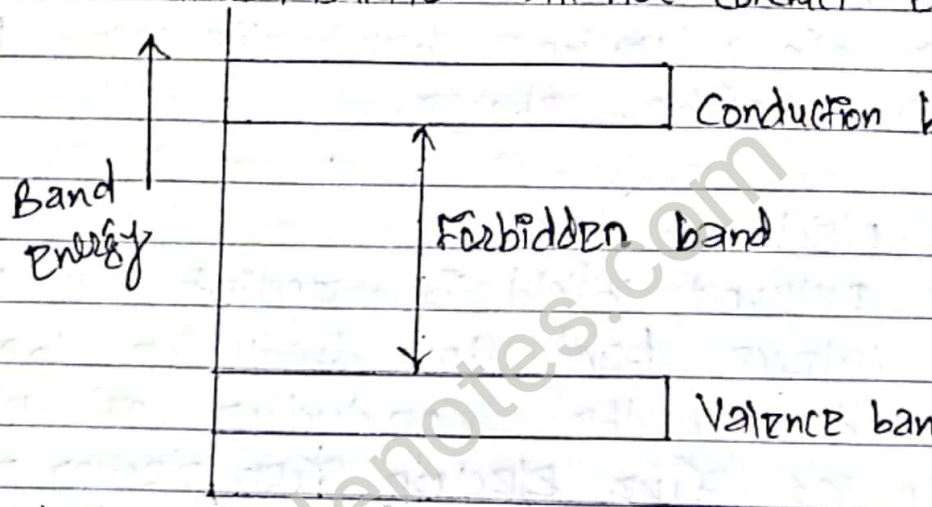


fig:- Energy band diagram in a conductor.

[2] Insulator:-

↳ A material having large forbidden energy gap (more than 3eV) is called insulator. In case of insulator valence band is filled but conduction band is empty. Due to large energy gap between valence band and conduction band (forbidden gap), insulator require large energy to jump valence band to conduction band. Thus, isulator will not conduct electricity.



[3] Semi-Conductor:-

↳ A material having a small forbidden energy gap(≈1 e
is called semiconductor. In case of semiconductor
valence bond is almost filled and conduction ban
is almost empty. Due to small forbidden gap, semicon-
ductor require small energy to jump. Valence band
to Conduction band. Thus at low temperature a pure
Semiductor do not conduct electricity so behaves as
insulator but at high temperature a pure semiconducto
conduct electricity so behaves as conductor.

Fig:- Energy band diagram in semi-conductor

Imp

HOLE:-

↳ At absolute zero (0 K or -273°C), in a pure semiconductor all the electrons lies in a valence band. As a result, the valence band is completely filled by electrons but conduction band is empty. When temperature of semiconductor increases the valence electrons gets thermal energy and jump to the conduction band creating a vacant space in a valance band. This vacant space in a valence band is called **hole**. The hole acts as positive charge.

Free electron:-

↳ When external field is applied, the electron move from valence band to conduction band and is responsible for the conduction of electricity is known as **free electron**. Free electron acts as -ve charge.

Types of semi-conductor:-

↳ On the basis of electrical conductivity and impurity concentrations, semiconductor are classified into two groups. They are:-

(i) Intrinsic Semiconductor [Pure semiconductor]

(ii) Extrinsic Semiconductor [Impure semiconductor]

Date
Page

Difference between intrinsic & Extrinsic Semiconductor :-

Intrinsic Semiconductor	Extrinsic Semiconductor
(i) The extremely pure form of Semiconductor is called intrinsic Semiconductor.	(i) The impure form of semi-conductor is called extrinsic semiconductor.
(ii) Example:- pure silicon(Si), and Germanium (Ge)	(ii) Example:- Silicon(Si), and Germanium (Ge) with impure Boron(B) & phosphorus(P)
(iii) It's Conductivity is Low	(iii) It's Conductivity is high.
(iv) It's conductivity is the function of temperature only.	(iv) It's Conductivity is the function of temperature as well as number of impurity atoms.
(v) The no. of free electrons present in conduction band is equal to the no. of holes present in Valence band.	(v) The no. of free electrons present in Conduction band is not equal to the no. of holes present in Valence band.

Q. What is doping? Discuss it's significance in Semiconductor Studies.

↳ Doping is the process of adding impurity atoms to pure Semiconductor. The impurity atoms are either pentavalent atoms or trivalent atoms.

When, pentavalent atoms are added to pure Semiconductor the no. of free electron increases while the addition of trivalent impurity atoms increases the no. of holes. Hence addition of impurity atoms to the pure Semiconductor (i.e. doping) increases the conductivity of Semiconductor.

Date
Page

* Pentavalent atoms:-

↳ The atoms which have 5-valence electrons are called pentavalent atoms. For example:- antimony (Sb-51), arsenic (AS-33), nitrogen (N-7), phosphorous (P-15) etc. Pentavalent impurity donates free electrons for the conduction to the semiconductor crystal, so it is called Donor.

* Trivalent atoms:-

↳ The atoms which have 3-valence electrons are called trivalent atoms. For example:- Indium (In-49), Boron (B-5), Gallium (Ga-31), Aluminium (Al-13) etc. Trivalent impurity donates holes for the conduction in the semiconductor and these holes accept electrons. So, it is called acceptor.

Types of Extrinsic Semiconductor:-

(i) N-Types Semiconductors:-

↳ A pure semiconductor doped with pentavalent impurity is called N-type semiconductor. In this semiconductor, the number of free electrons is much more than holes. So electrons are majority charge carries and holes are minorly charge carries. Clearly, the current conductor is predominantly by free electron (Negative charge) and due to this it is called N-type Semi conductor.

(ii) P-types Semiconductors:-

↳ A pure semiconductor doped with trivalent impurity is called P-types semiconductor. In this semiconductor, the number of hole is mouch more than free electrons. So holes are majority charge carries.

and free electrons are minority charge carriers. Clearly, the current conduction is predominantly by hole (positive charge) and due to this it is called P-types semiconductor.

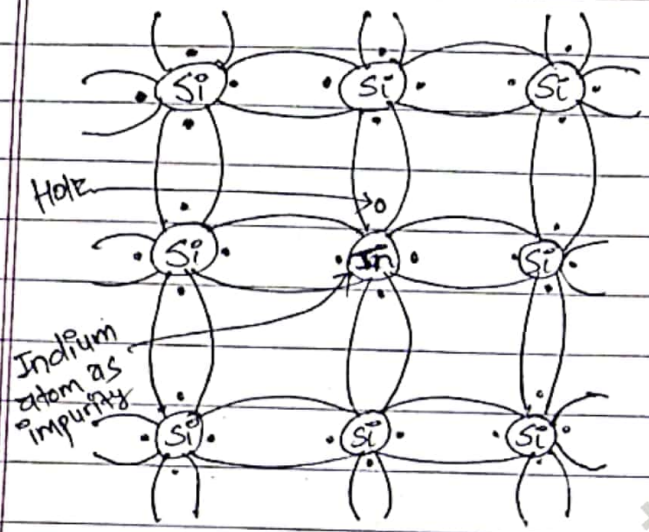


Fig:- Crystal Lattice of P-type Semi-Conductor.

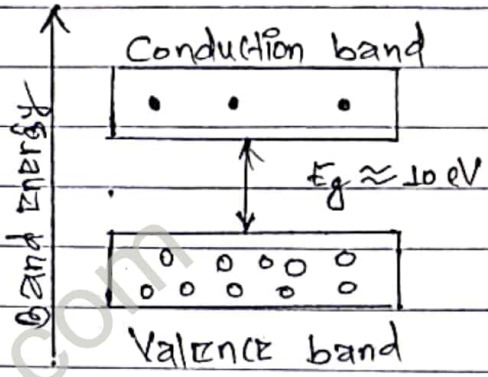


Fig:- Energy diagram of P-type semiconductor.

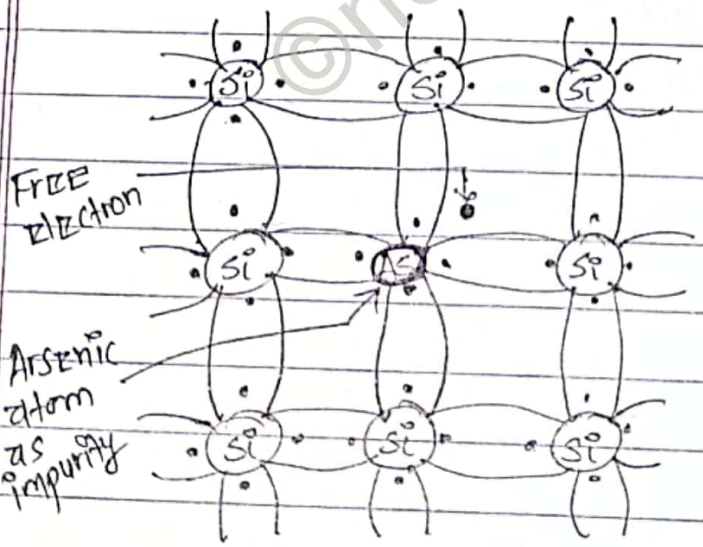


Fig:- Crystal Lattice of N-type Semiconductor.

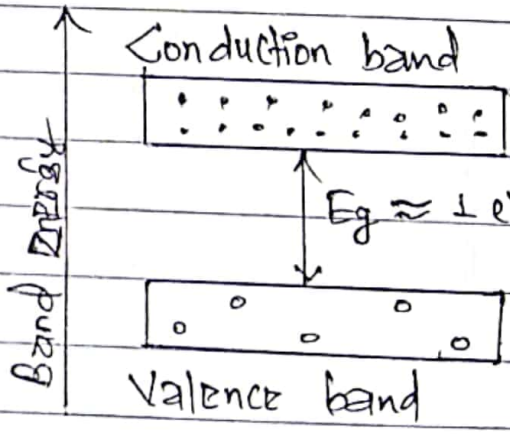


Fig:- Energy band diagram of N-type Semiconductor.