Temp ↑, Conductors, Resistivity ↑. {Cu, Ag} → free electrons.

→ Resistivity = 10^{-2} to 10^{-8} Ω m

conductivity = $\frac{1}{\text{resistivity}}$ ← $\Omega^{-1} m^{-1}$

→ Siemens m^{-1}

Semi-conductors, Resistivity ↑↑ → 10^{-5} – 10^{6} Ω-m. [Group 14, 15).

T ↓ → no. of free e^- ↑

Insulators, $T \uparrow$, $R \downarrow$ ∴ ⟶ e^- ↑

Resistivity = $10^{11} - 10^{19}\ \Omega - m$.

Conductivity = $\frac{1}{\rho}$

Energy Band gap: Valence Band & Conduction Band.

Outermost orbitals of e^- / of any material.

e^- helps in conduction.

Forbidden Energy gap:

→ Energy required to move an e^- from valence band to conduction band

Si, Ge → $E_g \Rightarrow$ < 3eV. [for semi-conductors].

$3 \times 1.6 \times 10^{-19}$ J.

Insulator / non-metals.
$E_g > 3eV$.

Mobility:

→ How fast is the charge carrier travels.

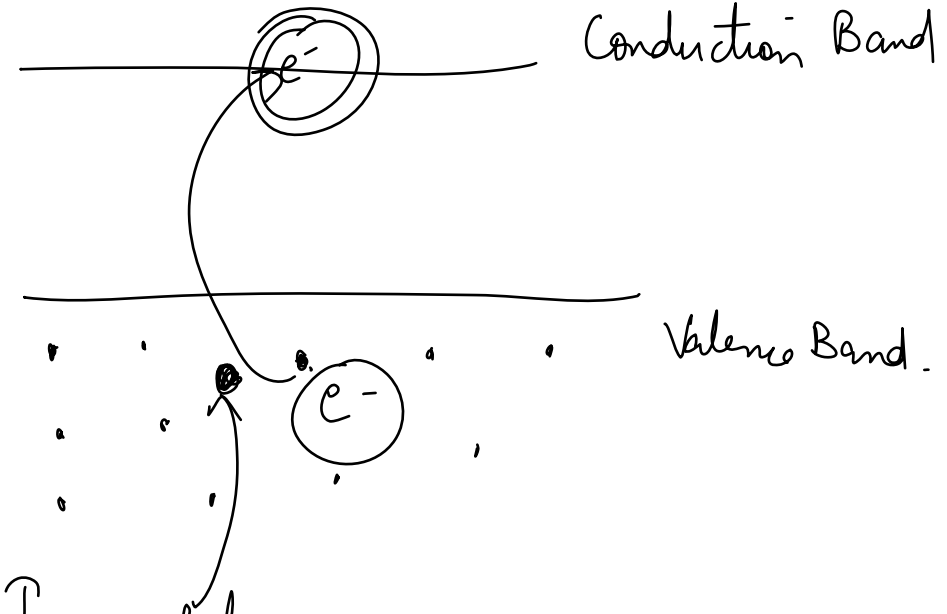
In semiconductors [holes, free electron]

$\mu_e > \mu_h$ → Electrons are lighter than hole.

Intrinsic Semi-Conductors:

Impurity = 0

Doping $\neq 0$

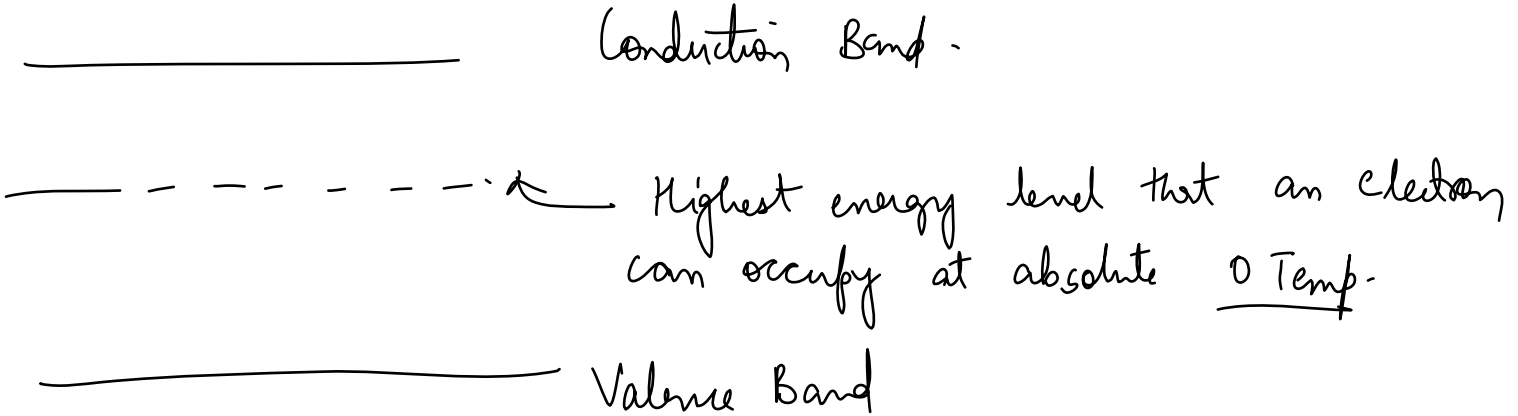


e^- transferred to the conduction Band.

$n_e = n_h$ - free electrons.

$I = I_e + I_h$ - holes.

Fermi level :


Conduction Band.
Highest energy level that an electron can occupy at absolute 0 Temp.
Valence Band

Extrinsic Semiconductors:

When a small amount of a suitable impurity is added to the pure semiconductor, to the pure semi-conductivity, the conductivity of semiconductors and those semiconductors are called extrinsic semiconductors.

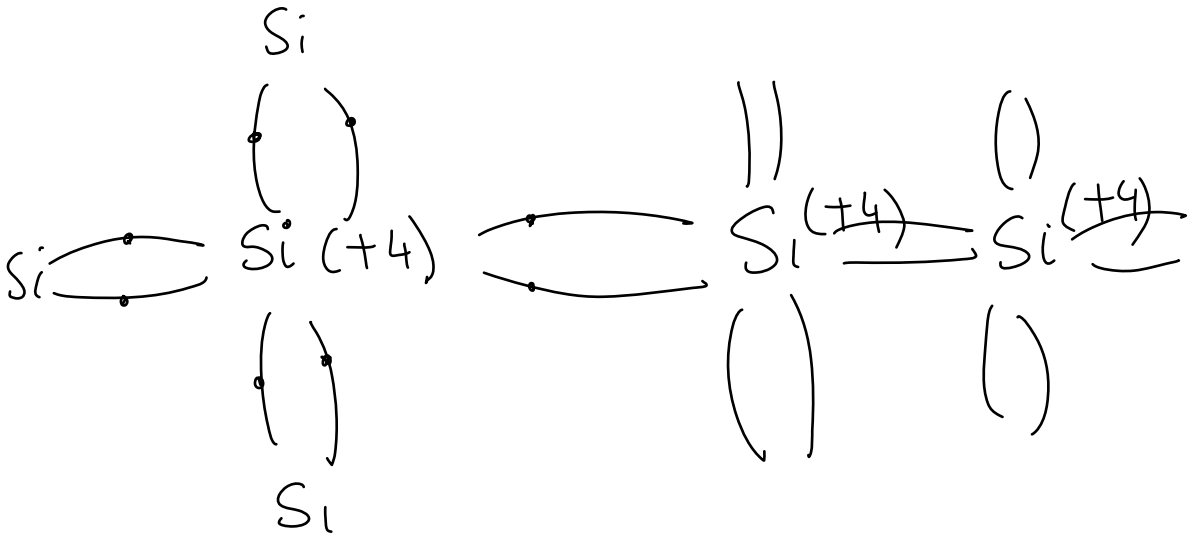
Impurity added = dopants.

Pentavalent (5 valency)

As, Antimony, Phosphorous

Trivalent (3 valency):

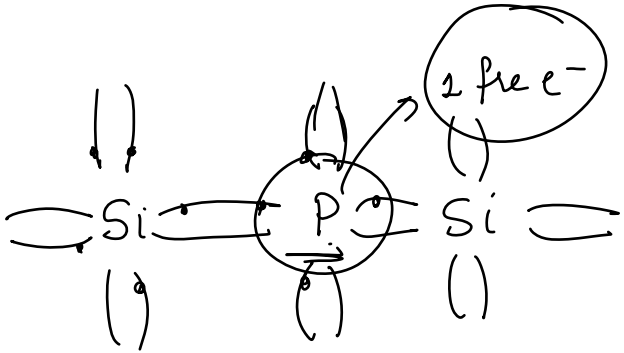
Al, B, In.



Pentavalent (n type semiconductors).

No. of e^- = 5

4 e^- covalent bonding, remains 1 e^-



Conductivity ↑.

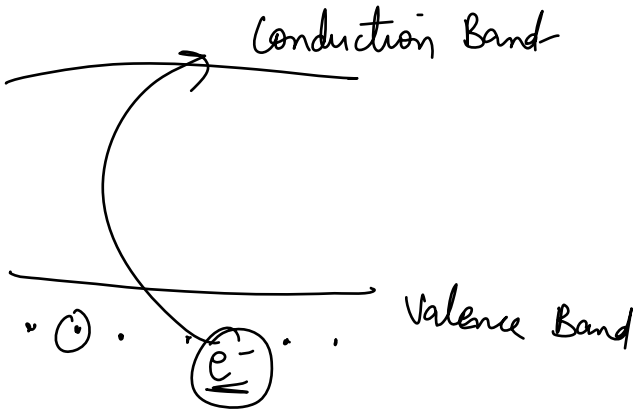
Extra no. of atoms of P = no. of free e^-

In n-type semi-conductor: (Group 15).

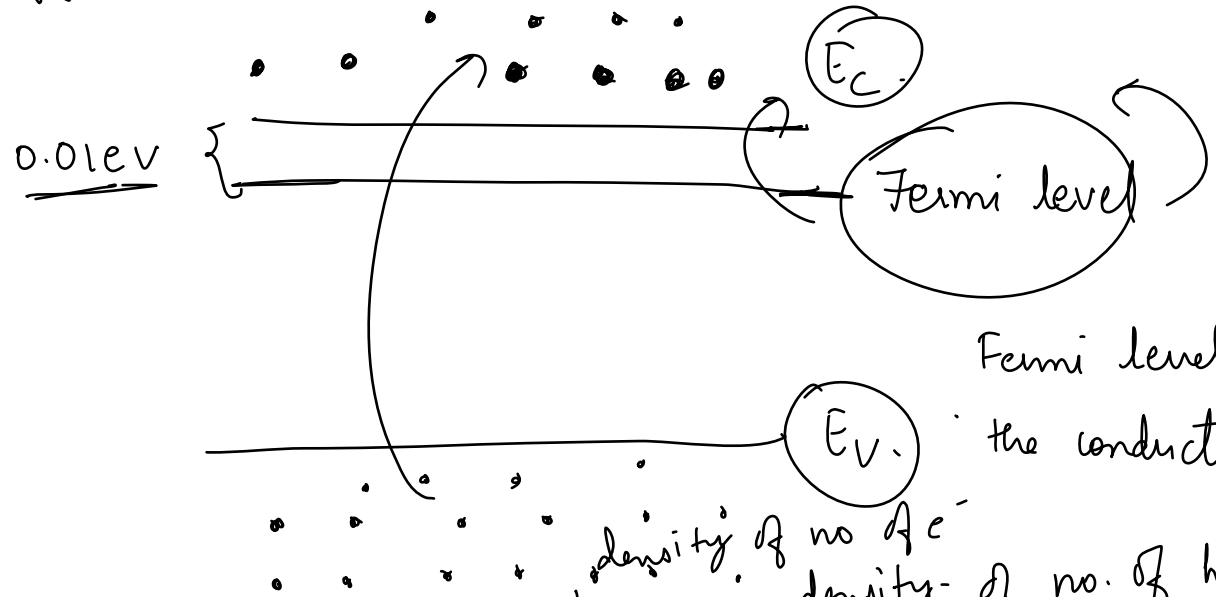
$n_e >>> n_h$ → (minority carriers)

n_e: no. of free e^- (Majority carriers)

n_h: no. of holes.



Energy Band graph:



Fermi level gets shifted towards the conduction Band.

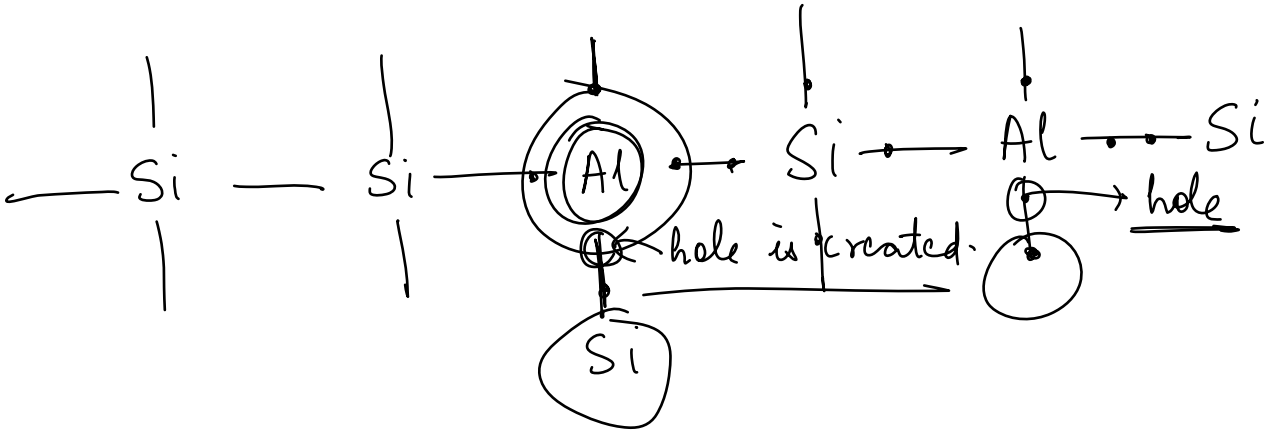
$T > 0$

density of no of e^-

density of no. of holes

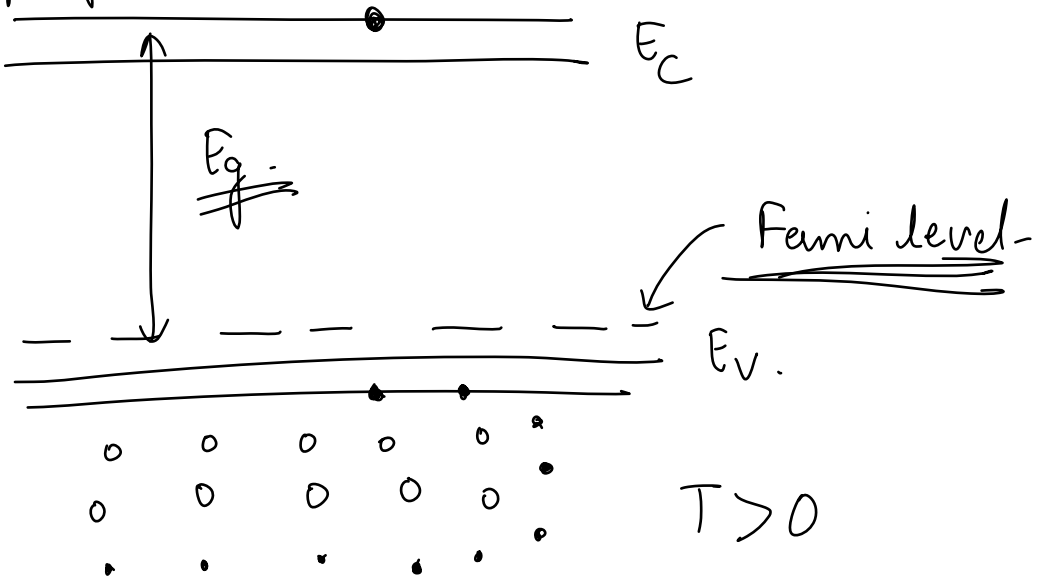
In thermal equilibrium, extrinsic semiconductor $n_e \times n_h = n_i^2$ → density of ~~ex~~ intrinsic charge carriers

P-type Semi-Conductor (Trivalent Element doping) (Group 13).



$n_h >>>> n_e$.

Energy Band gap (p-type semi-conductor)



P-N Junction :

Energy gap :

Si → 1.1 eV

Ge → 0.7 eV