Nishant Jindal

SEMICONDUCTOR

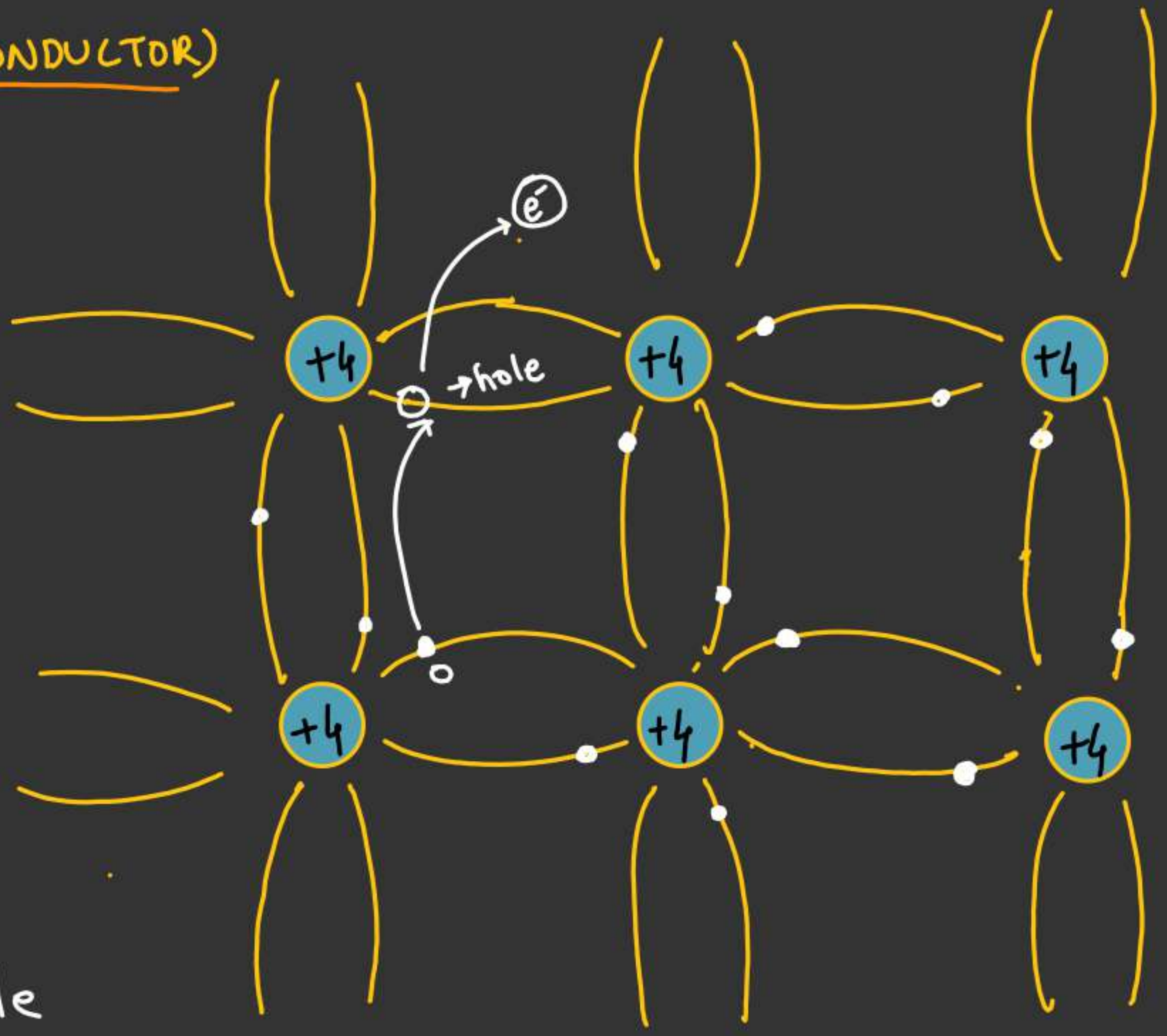
- Much higher resistivity than Metal.
- Temp Coff of resistivity –ve & high
- Charge Carriers lower than Metal.

TYPE

- INTRINSIC (Naturally occuring)
  - Ex:- Ge, Si
- EXTRINSIC (By Doping).
  - n-Type (Majority Charge Carriers electron)
  - P-type (Majority Charge Carriers holes)

Nishant Jindal

INTRINSIC SEMI CONDUCTOR (PURE SEMI CONDUCTOR)



→ Free from impurities ✓

→ At 0K behave as insulators
↳ Temp.

→ At high temp, the thermal energy of valance electron increases.
An electron may break away from the Co-valent bond & become free to conduct

→ To free an electron from Co-valent bond and simultaneously creation of hole requred a kind of ionisation energy E_g.

$$\uparrow n_e = c\, e^{-E_g/2kT\uparrow}$$

⇓
No of electrons set free,

For given E_g, n increases as the temp increases.

Nishant Jindal

→ Each free electron Creates one hole, so in an intrinsic semi conductor no of holes (n_h) and no of electrons n_e are equal.

$$n_e = n_h = n_i$$

→ Total Current in intrinsic Semi Conductor is $I = (I_e + I_h)$ ✓

Nishant Jindal

DOPING :-

Addition of desirable impurity to a pure semi conductor so as to increase it's conductivity.

INTRINSIC SEMICONDUCTOR + impurity ⇒ EXTRINSIC SEMICONDUCTOR

TYPE OF DOPENTS (IMPURITY)

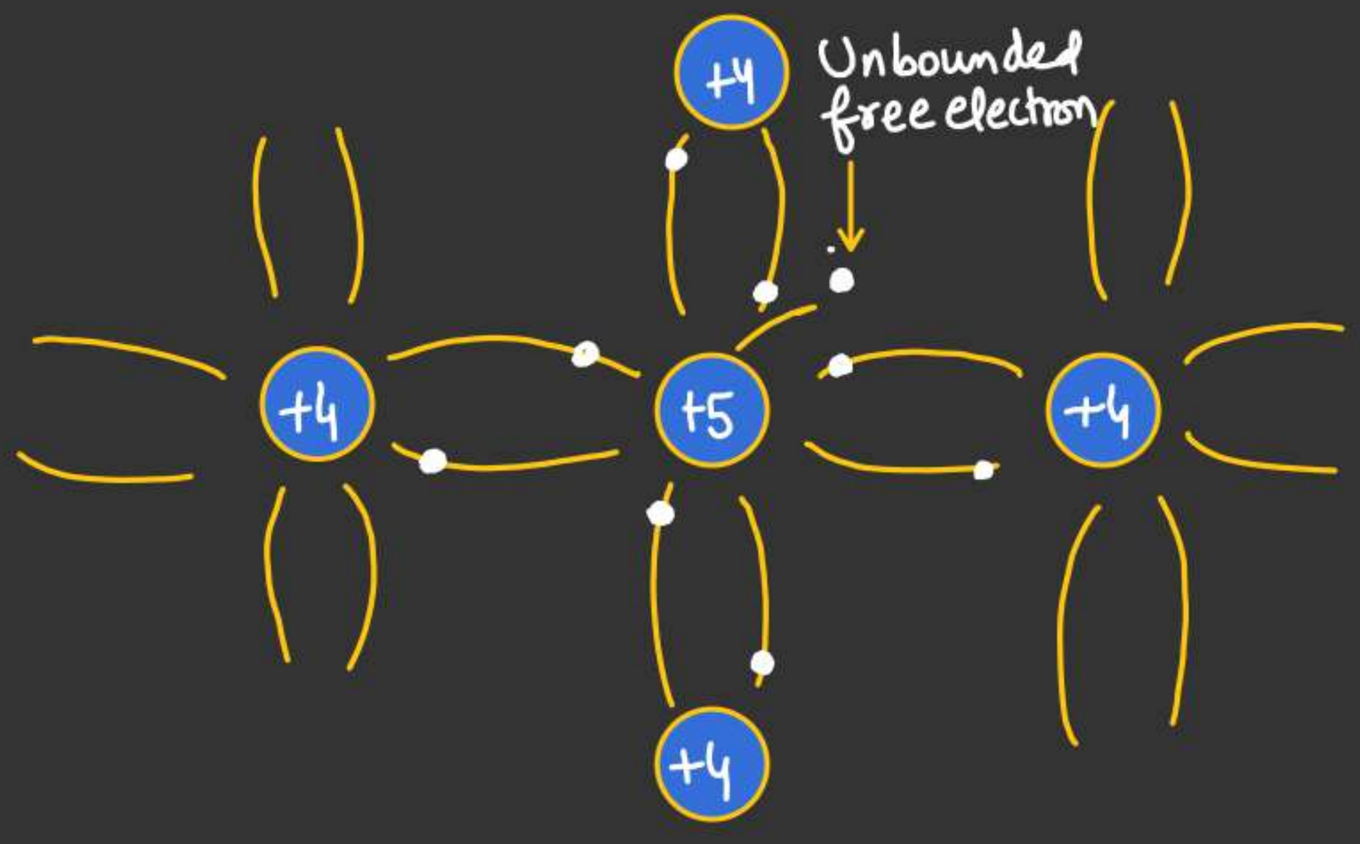
① Pentavalent → 5 Valance electrons.
Arsenic (As), Antimony (Sb), & Phosphorous (P)

② Trivalent → 3 Valance bond
Indium (In), Boron (B) & Aluminium (Al)

Nishant Jindal

EXTRINSIC SEMICONDUCTOR

N-TYPE



→ Doped with pentavalent impurity with Si or Ge.

→ When pentavalent impurity atom substitutes the tetravalent Si atom it uses for of its 5 valance electrons in forming 4- covalent bonds with neighbouring Si atom while the 5^{th} electron is loosely bound to the impurity atom.

A very small amount of ionisation energy $\simeq$ (0.01 e-V) is required to free this e^-

→ N-Type semiconductors electrons are majority charge carriers.

$(n_e >> n_h)$

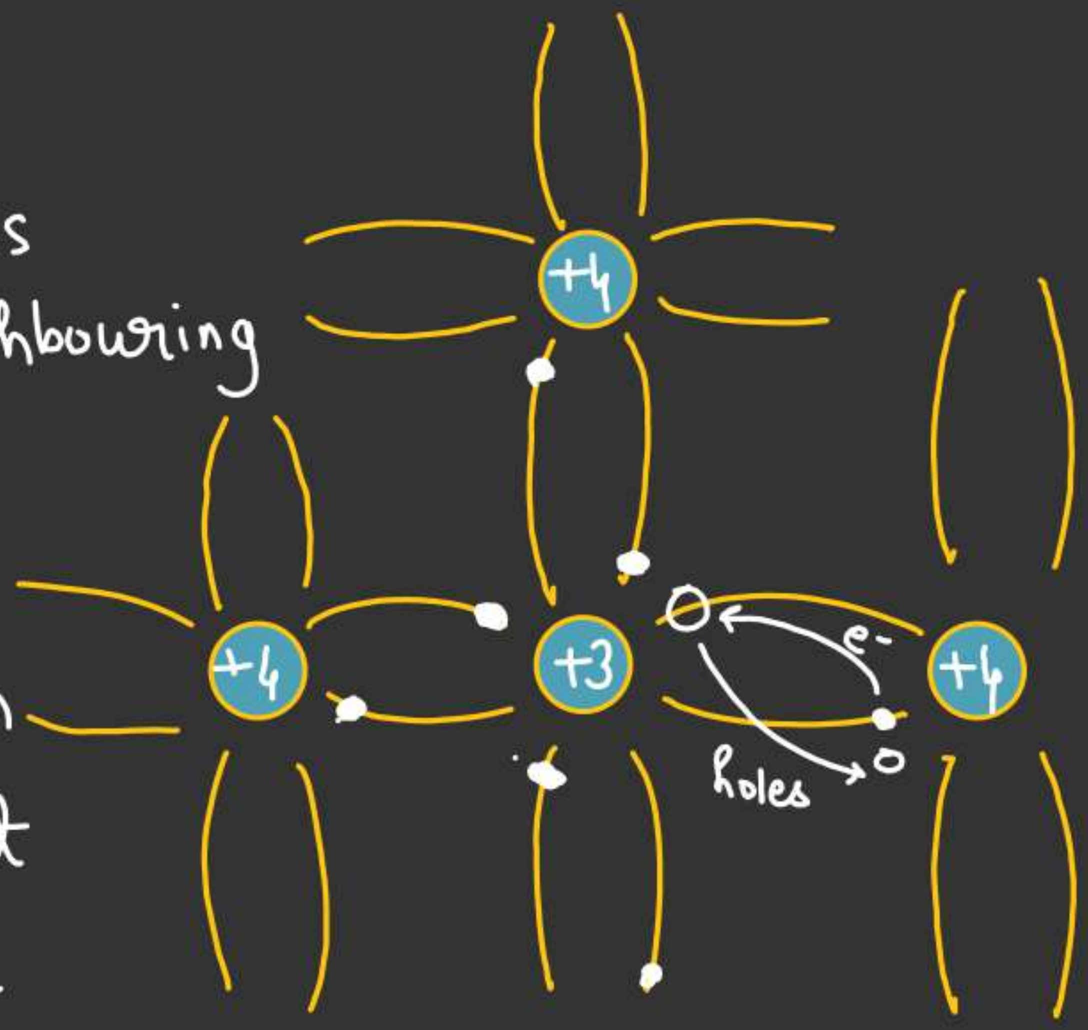
Nishant Jindal

P-TYPE

→ Obtained by doping the trivalent impurity with Si or Ge.

→ Impurity atoms uses its three valance electrons in forming Co-valent bonds with three neighbouring Si atoms.

One Co-valent bond with a neighbouring Si atom is left incomplete due to deficiency of atom. An electron from neighbouring Si-Si Co-valent bond can slide into this vaccant bond creating a vaccancy or hole in that bond.



→ Hole is now available for conduction. Current in P-type due to conduction of hole.

$(n_h >> n_e)$

Nishant Jindal

⇒ For Semiconductor

$$\boxed{n_e n_h = n_i^2}$$

n_e → Concentration of electron

n_h → Concentration of hole

n_i → Intrinsic Charge Concentration

Nishant Jindal

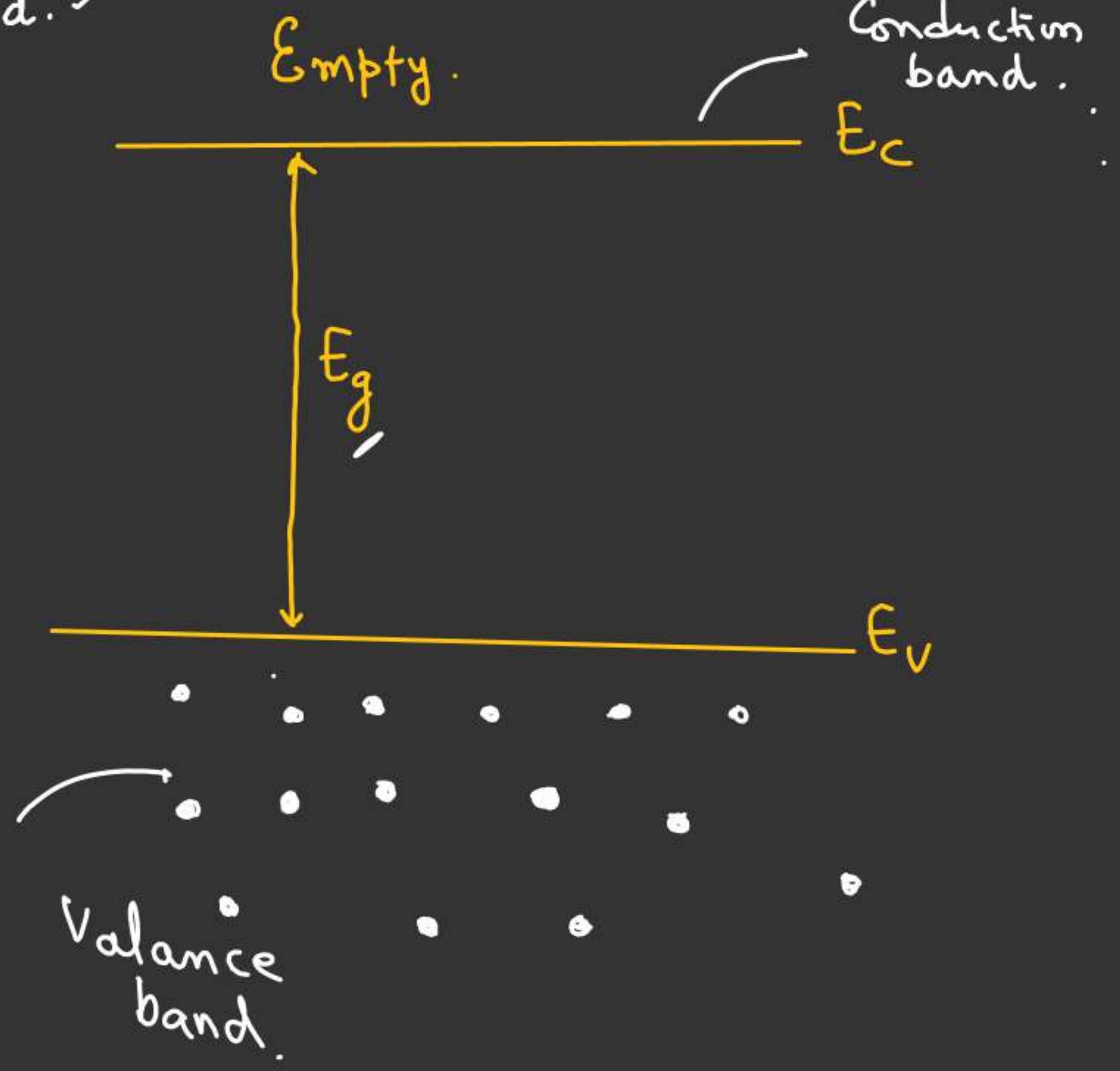
ENERGY BAND THEORY IN SOLIDS

→ Two Energy Bands → Valance Band ✓ / Conduction Band. ✓

→ E_v = Highest valance band energy

E_c = Lowest conduction band energy

$$\boxed{\underline{E_g} = E_c - E_v}$$

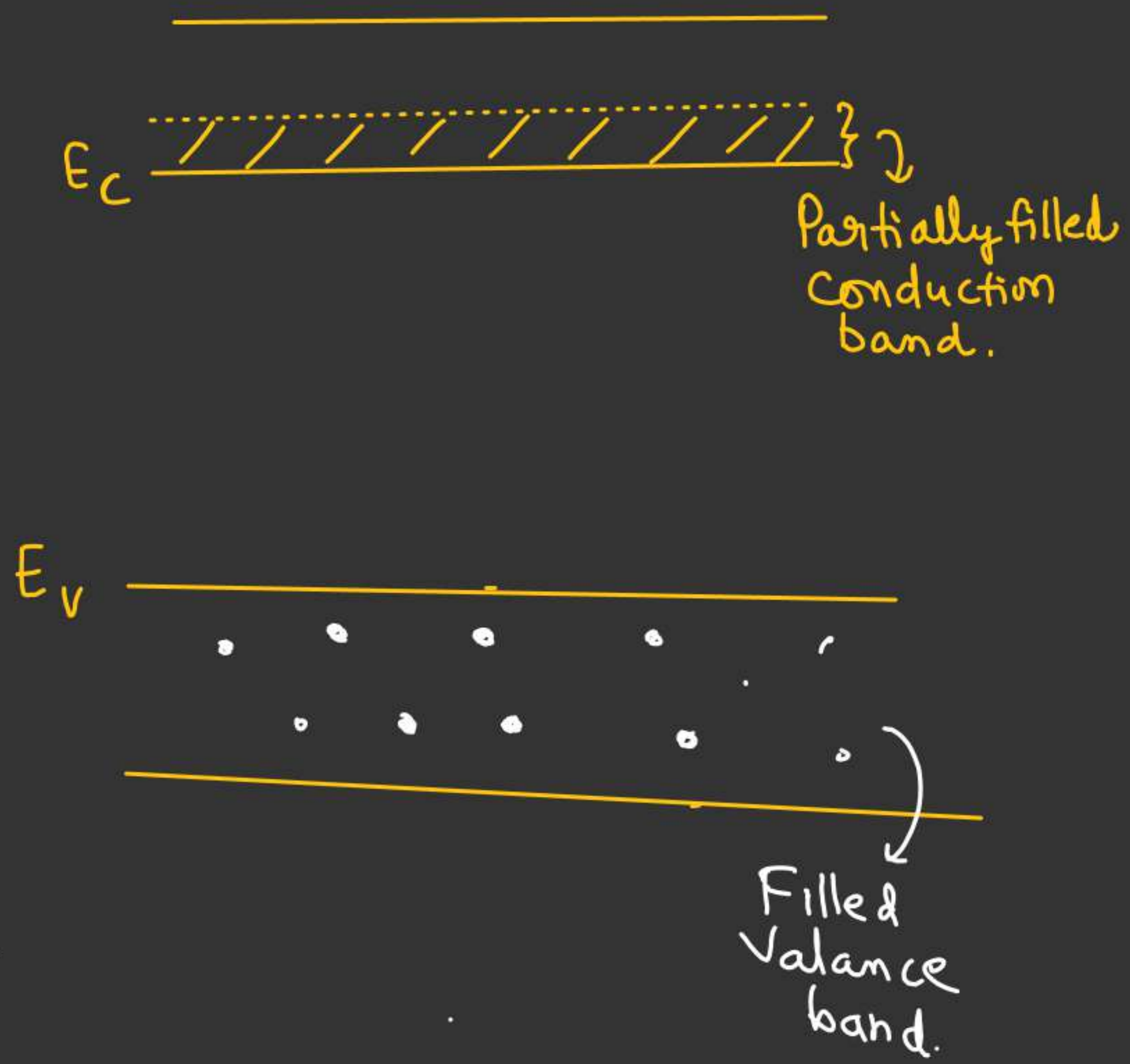


Nishant Jindal

METALS ⇒ (Valance band → Completely filled
Conduction band → Partially filled)

Two type of Energy band structure.

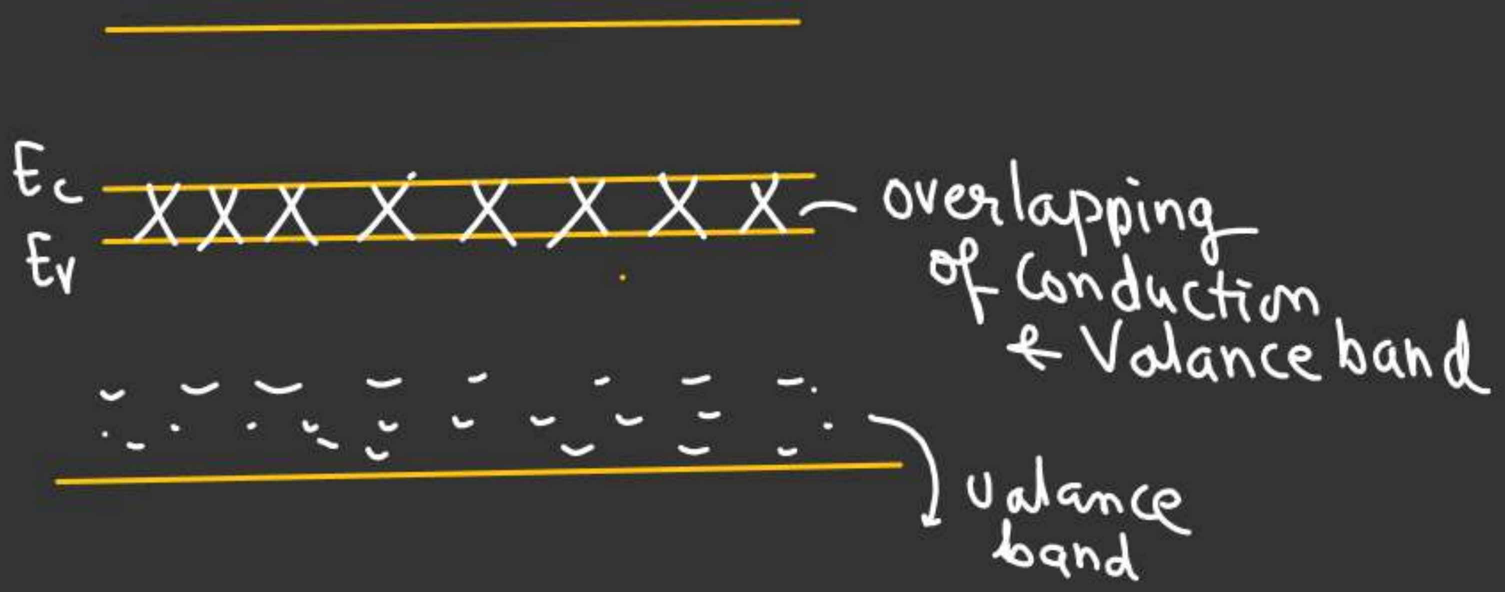
Either there is energy gap b/w the Completely filled Valance band & the partially filled Conduction band.



Ex:- (Alkali Metals, Noble Metals third group Metals)

OR

Conduction and Valance band overlap.



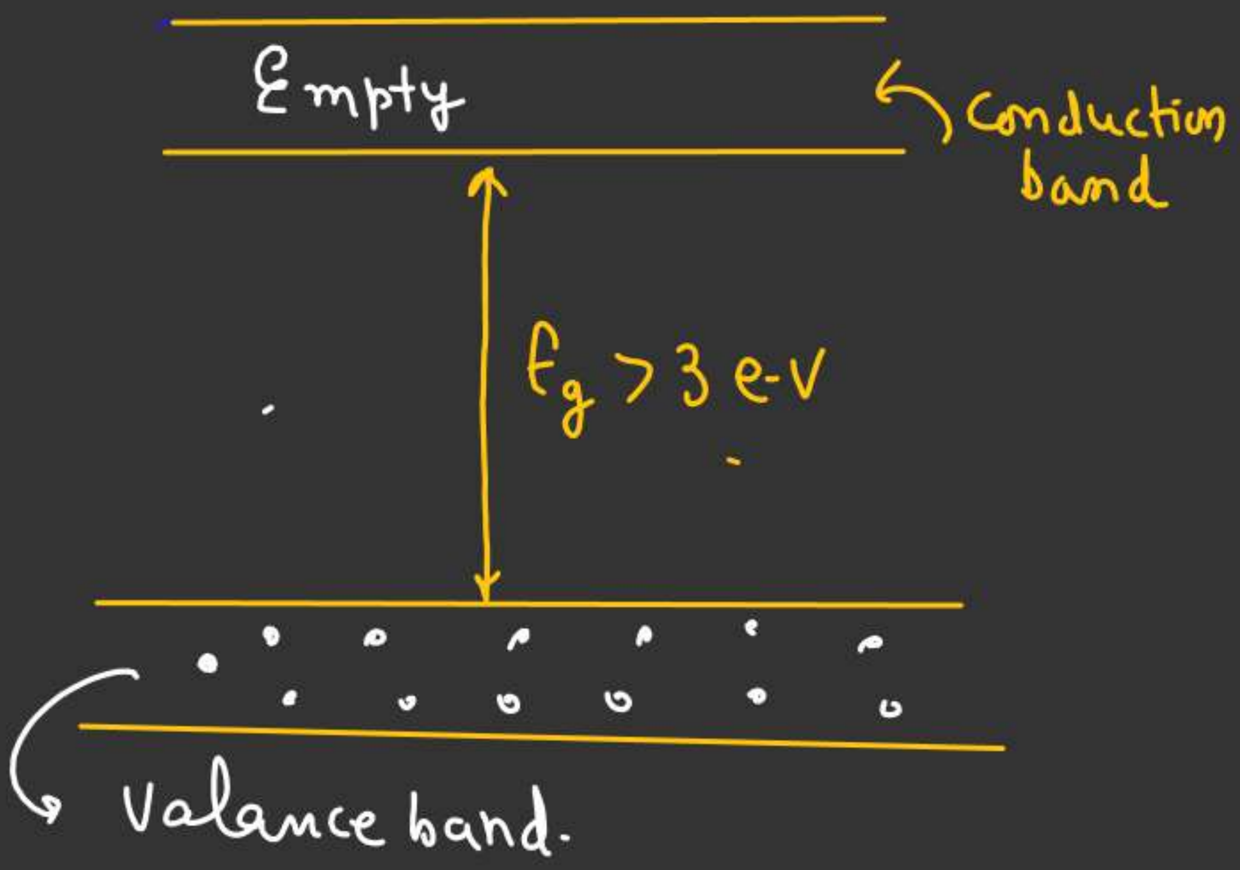
Nishant Jindal

FERMI LEVEL

Highest Energy level in the conduction band at absolute zero is called FERMI LEVEL and energy corresponding to this level is called FERMI Energy level.

INSULATORS

- In insulators, valance band is completely filled while the conduction band is empty.
- Large energy gap b/w the valance band & conduction band ($E_g > 3$ e-V)



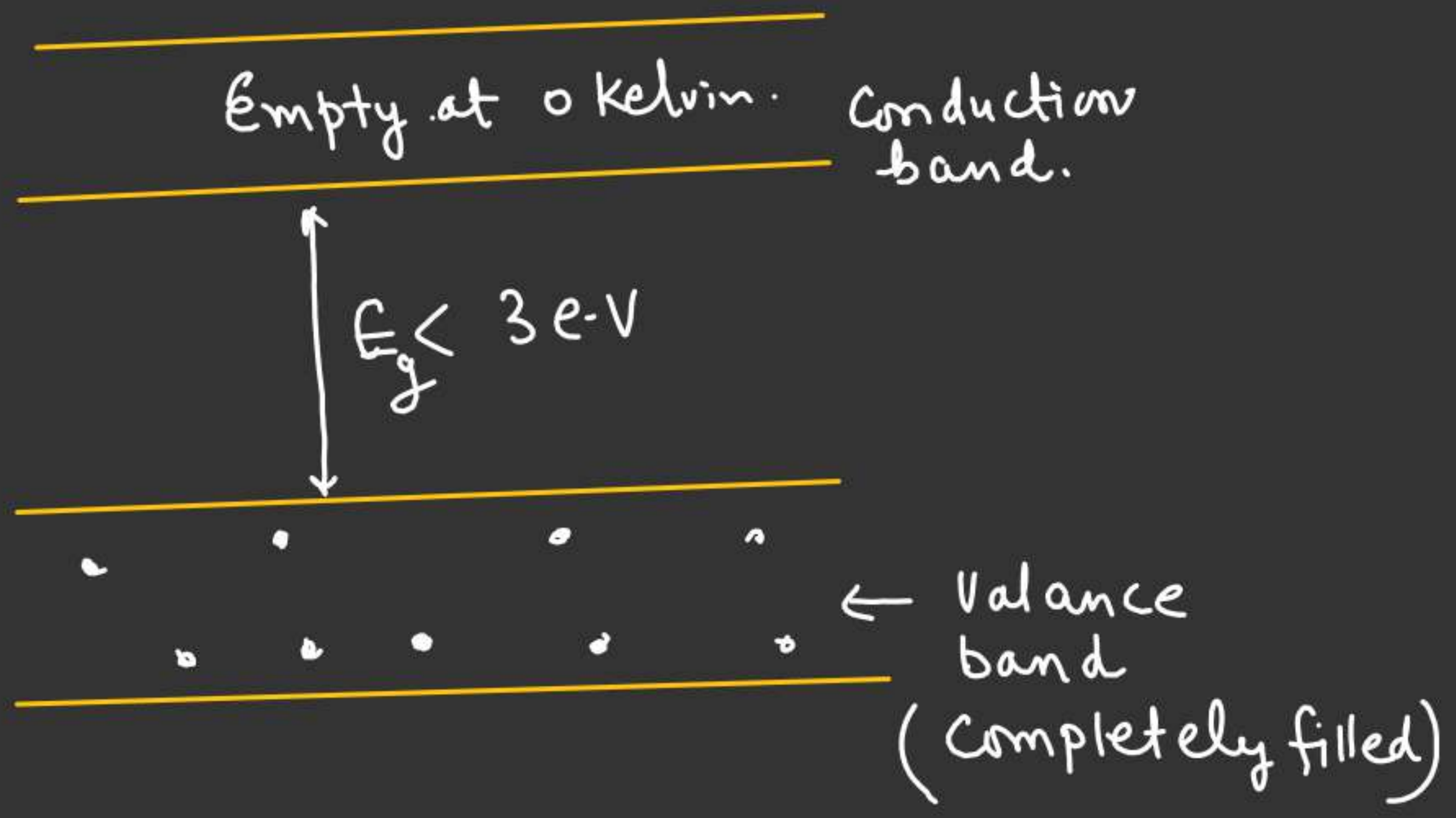
Nishant Jindal

ENERGY BAND IN SEMI CONDUCTOR

INTRINSIC SEMI CONDUCTOR

At 0K, (Temp) Conduction band empty.
Valance band Completely filled

$E_g = 1.17$ e-v for Si
$E_g = 0.74$ e-v for Ge



At higher temp (> 0K) Some Valance electron jump to Conduction band where they are free to conduct.

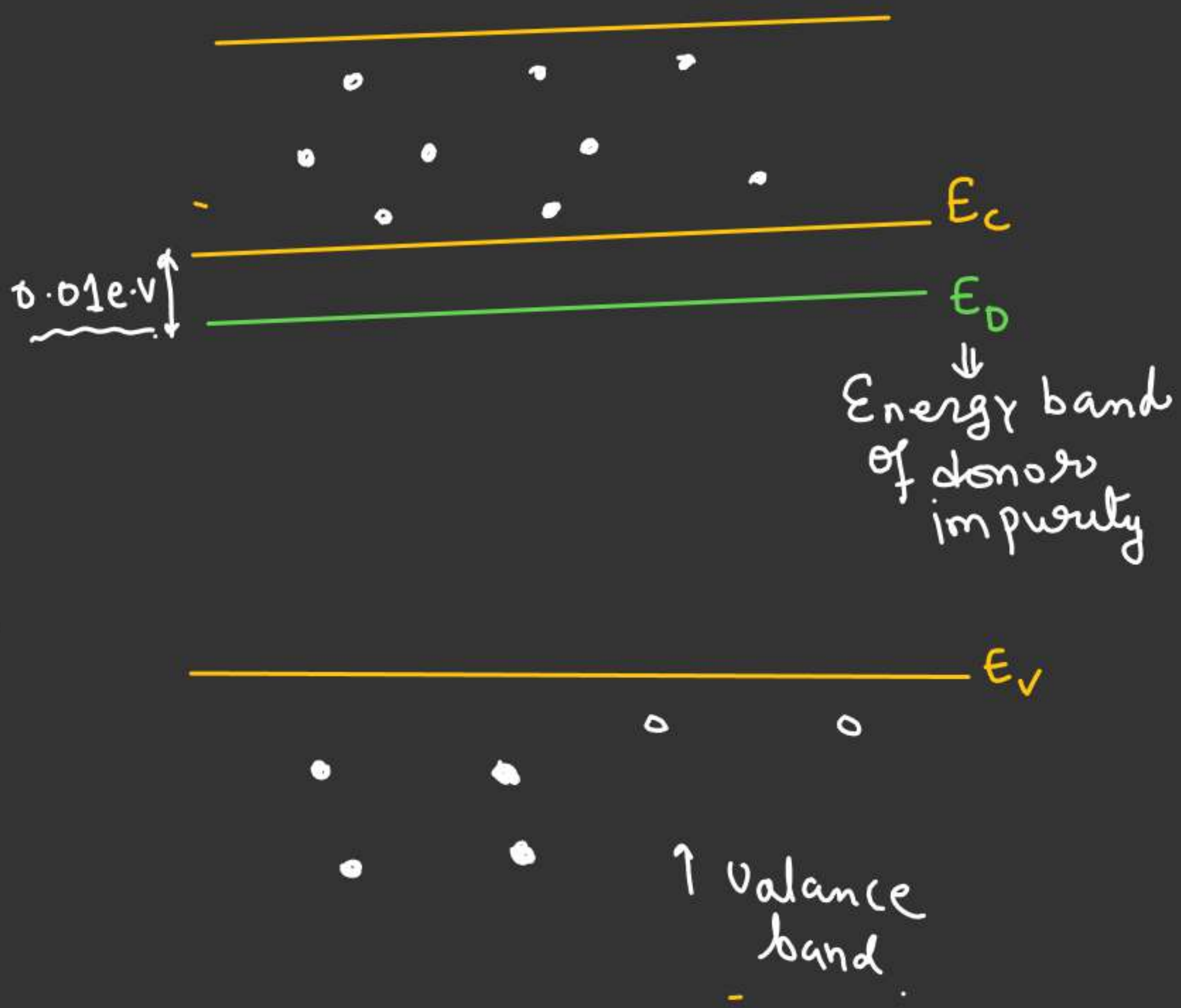
So Intrinsic Semi Conductor acquires Small Conductivity above 0 Kelvin

Nishant Jindal

EXTRINSIC SEMICONDUCTOR

N-Type.

Extra fifth electron is very weakly attracted by the donor impurity. A very small energy is required to free electrons from the donor impurity.



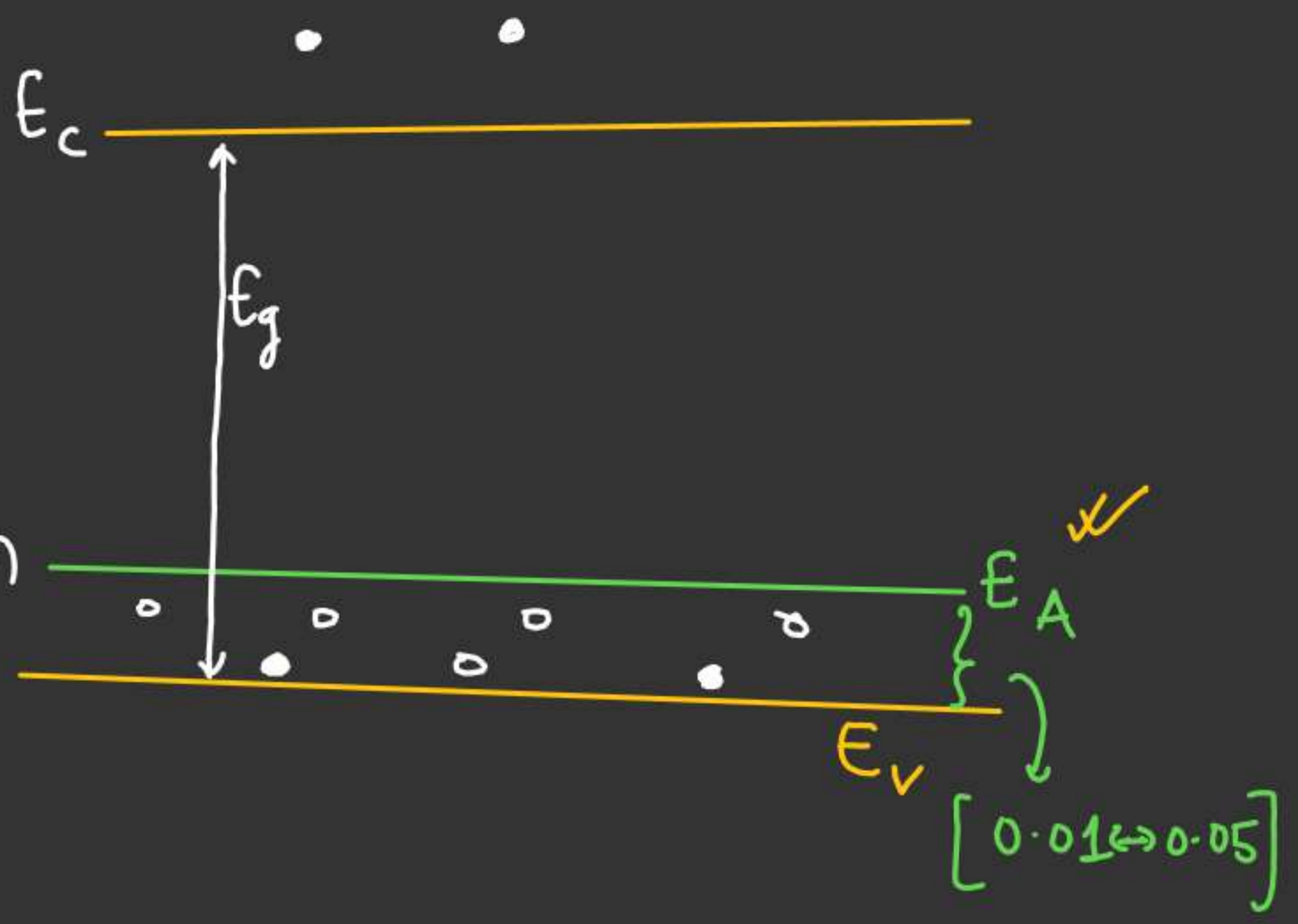
Imp

⇒ Conduction band has more electrons as they have been contributed both in thermal excitation & donor impurity

Nishant Jindal

P- Type

- Each acceptor impurity creates a hole which can be easily filled by an electron of Si – Si Covalent band.



A very Small energy require by an electron of valance band to move into this hole.

Acceptor energy level slightly above the Valance band.