FREE NOTES · NCERT + JEE/NEET LEVEL

Semiconductor Electronics

Energy bands, intrinsic aur extrinsic semiconductors, p-n junction, forward aur reverse bias, diode ke graphs, rectifier, special diodes aur logic gates.

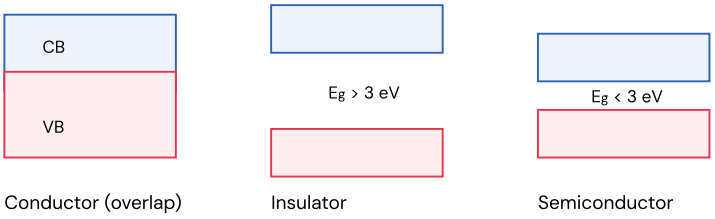
01 Energy bands
02 Conductor, insulator, semiconductor
03 Intrinsic semiconductor
04 Extrinsic: n-type & p-type (doping)
05 p-n junction
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07 Diode ka V-I graph
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01 Energy bands

Solid me atoms paas-paas hote hain, isliye electron ki energy levels milke **bands** ban jaati hain.

- **Valence band (VB):** bandhe hue (valence) electrons.
- **Conduction band (CB):** free electrons jo current chala sakte.
- **Energy gap (E_g):** dono ke beech ki khaali jagah (forbidden gap).

02 Conductor, insulator, semiconductor



Band gap se pehchaan

	E_g	Example
Conductor	0 (overlap)	Copper, aluminium
Semiconductor	Chhota (Si 1.1 eV, Ge 0.7 eV)	Si, Ge, GaAs
Insulator	Bada (> 3 eV, diamond ≈ 5.4)	Diamond, kaanch

0 K pe semiconductor insulator jaisa. Garam karo ⇒ electrons CB me ⇒ conductivity badhti (resistance ghatta, metals ke ulta).

03 Intrinsic semiconductor

Pure Si ya Ge. Garmi se ek electron CB me jaata toh VB me ek khaali jagah bachti: **hole** (positive charge jaisa).

$$n_e = n_h = n_i$$

Electrons aur holes barabar. Current dono se: $I = I_e + I_h$. Electrons ki mobility holes se zyada.

04 Extrinsic: n-type & p-type (doping)

Pure semiconductor me thodi si impurity (~1 in 10^6) milaana = **doping**. Conductivity bahut badh jaati.

	n-type	p-type
Dopant	Pentavalent (P, As, Sb)	Trivalent (B, Al, Ga, In)
Naam	Donor	Acceptor
Majority carriers	Electrons	Holes
Minority carriers	Holes	Electrons
Extra level	CB ke thoda neeche (donor level)	VB ke thoda upar (acceptor level)

$$n_e \times n_h = n_i^2$$

(Mass action law, thermal equilibrium me.)

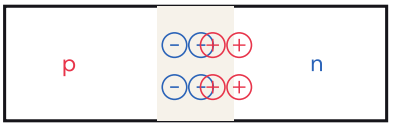
DHYAN DO

n-type aur p-type dono **electrically neutral** hote hain. n-type ka matlab "negative charge" nahi, sirf "electrons majority".

05 p-n junction

p aur n ko jodo: n se electrons p ki taraf, p se holes n ki taraf **diffuse** hote (concentration difference). Junction ke paas mobile charges khatam ⇒ **depletion layer** (sirf fixed ions bache).

- n side pe + ions, p side pe − ions ⇒ andar electric field ⇒ **barrier potential** (Si ≈ 0.7 V, Ge ≈ 0.3 V).
- Ye field minority carriers ko **drift** karata. Equilibrium: diffusion current = drift current.

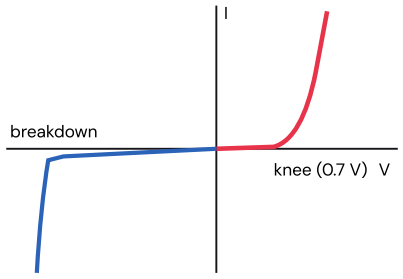


Junction pe fixed ions ki patli parat

06 Forward & reverse bias

	Forward bias	Reverse bias
Connection	p → battery +, n → battery −	p → −, n → +
Barrier	Ghatta	Badhta
Depletion layer	Patli	Moti
Current	Zyada (mA), majority carriers	Bahut kam (µA), minority carriers
Resistance	Kam	Bahut zyada

07 Diode ka V-I graph



Forward (laal) aur reverse (neela)

- Forward: knee/threshold voltage ke baad current tezi se badhta.
- Reverse: bahut chhota current jab tak **breakdown voltage**, phir achanak bahut zyada.
- Ohm's law follow nahi karta (non-ohmic).

DYNAMIC RESISTANCE

$$r_d = \Delta V / \Delta I$$

08 Rectifier (AC → DC)

Diode current sirf ek direction me jaane deta ⇒ AC ko DC me badalta.

	Half-wave	Full-wave
Diodes	1	2 (centre-tap) ya 4 (bridge)
Output	Sirf aadhe cycle	Dono aadhe cycle (ek direction me)
Output frequency	f (50 Hz)	2f (100 Hz)
Efficiency	40.6% (max)	81.2% (max)



Half-wave Full-wave

Output "pulsating DC" hota. Isse smooth karne ke liye **filter**: load ke parallel capacitor (ya inductor series me).

09 Special diodes (JEE)

Diode	Bias	Use
Zener diode	Reverse (breakdown pe)	Voltage regulator: output voltage constant rakhna
LED	Forward	Electron-hole milne pe light; $E_g \geq 1.8$ eV (visible). Kam power, lambi life
Photodiode	Reverse	Light detect karna; light se current badhta
Solar cell	Bina bias	Light se EMF; Si, GaAs ($E_g \approx 1$–1.8 eV ideal)

10 Logic gates (JEE)

Gate	Boolean	Output 1 kab
OR	$Y = A + B$	Koi bhi ek input 1
AND	$Y = A \cdot B$	Dono input 1
NOT	$Y = \bar{A}$	Input 0
NAND	$Y = \overline{(A \cdot B)}$	Dono 1 na hon
NOR	$Y = \overline{(A + B)}$	Dono 0
XOR	$Y = A \oplus B$	Inputs alag

UNIVERSAL GATES

NAND aur NOR se koi bhi gate bana sakte. NAND ke dono input jodo ⇒ NOT. De Morgan: $\overline{(A \cdot B)} = \bar{A} + \bar{B}$, $\overline{(A + B)} = \bar{A} \cdot \bar{B}$.

11 JEE Extra + Tricks

JEE LEVEL

- NAND aur NOR **universal gates** (inse koi bhi gate ban sakta). NAND = AND ka NOT; NOR = OR ka NOT.
- De Morgan: $(A + B)' = A' \cdot B'$; $(A \cdot B)' = A' + B'$.
- Full-wave rectifier ki output frequency = 2f (50 Hz mains pe 100 Hz); half-wave = f.
- Zener diode reverse breakdown me voltage regulator; series resistor extra voltage leta.
- Circuit me diode: forward bias ⇒ short (ideal) ya 0.7 V (Si); reverse ⇒ open.
- Doping: pentavalent (P, As) ⇒ n-type; trivalent (B, Al, In) ⇒ p-type. $n_e n_h = n_i^2$.

12 Solved numericals

Q1. Si me $n_i = 1.5 \times 10^{16}$ m^{-3}. Doping se $n_e = 4.5 \times 10^{22}$ m^{-3}. n_h? Kaun sa type?
$n_h = n_i^2/n_e = 2.25 \times 10^{32}/4.5 \times 10^{22} = 5 \times 10^9$ m^{-3}. Electrons majority ⇒ n-type. **Ans: 5×10^9 m^{-3}, n-type**

Q2. 50 Hz AC ko full-wave rectifier se. Output ripple frequency?
2f = 100 Hz. **Ans: 100 Hz**

Q3. Diode me V 0.7 se 0.8 V hua, I 10 se 30 mA. Dynamic resistance?
$r_d = 0.1/0.02 = 5\ \Omega$. **Ans: 5 Ω**

Q4. LED se 620 nm ki light. Band gap?
E = 1240/620 = 2 eV. **Ans: 2 eV**

Q5. A = 1, B = 0. NAND aur NOR ka output?
AND = 0 ⇒ NAND = 1. OR = 1 ⇒ NOR = 0. **Ans: 1, 0**

13 Common mistakes

- n-type ko negative charged samajhna (neutral hai).
- Semiconductor garam karne pe resistance badhta maan lena (ghatta).
- Forward bias me p ko - se jodna (p → +).
- Zener ko forward bias me regulator maan lena (reverse breakdown me kaam).
- Full-wave ki output frequency f likhna (2f hai).

14 Formula sheet

Intrinsic	$n_e = n_h = n_i$
Mass action	$n_e n_h = n_i^2$
Conductivity	$\sigma = e(n_e\mu_e + n_h\mu_h)$
Dynamic resistance	$r_d = \Delta V/\Delta I$
Rectifier frequency	half f, full 2f
Photon / band gap	$E_g = 1240/\lambda(\text{nm})$ eV
Gates	$A + B$, $A{\cdot}B$, $\bar{A}$, De Morgan

15 Practice questions

1. Si me Boron milaaya. Kaun sa type aur majority carrier?
2. Reverse bias me depletion layer?
3. Photodiode kaun se bias me?
4. NOR gate ke dono input 0. Output?

ANSWERS

1) p-type, holes · 2) Moti hoti · 3) Reverse · 4) 1

16 Quick revision: exam se pehle 5 minute

BANDS

- Si 1.1 eV, Ge 0.7 eV; insulator > 3 eV.
- Garmi ⇒ semiconductor ka R ghatta.
- $n_e n_h = n_i^2$.

DOPING

- n: P, As (donor), electrons majority.
- p: B, Al (acceptor), holes majority.
- Dono neutral.

JUNCTION

- Forward: p → +, barrier ghatta.
- Reverse: barrier badhta, µA current.
- Full-wave 2f, half-wave f.

SPECIAL

- Zener: reverse, regulator.
- LED forward; photodiode reverse.
- NAND, NOR universal.

Doubt hai? padhaiadda.netlify.app pe AI Doubt Solver se poocho, ya is chapter ka mock test do.