Semiconductors

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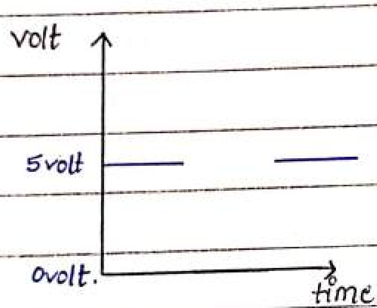
SEMICONDUCTORS.

BOOLEAN ALGEBRA

Digital signal
- 0 → 0volt → low → off → no
- 1 → 5volt → high → on → yes.



A = 0, 1
B = 1,0
↓
variable

Addition	Multiplication	Inverse
$0+0=0$	$0.0=0$	$\bar{0}=1$
$0+1=1$	$1.0=0$	$\bar{1}=0$
$1+1=1$	$1.1=1$	$\bar{\bar{1}}=1$
$1+1+1+0=1$	$A.0=0$	$\bar{\bar{0}}=0$
$A+0=A$	$A.1=A$	$\overline{\overline{A+B}}=A+B$
$A+1=1$	$A.\bar{A}=0$	
$A+\bar{A}=1$	$A.A=A$	
$A+A=A$	MR* = Takat ya to '0' ke paas hogi ya A ke pass majorly	

Takat ya to '1' ke paas hogi ya variable ke paas majorly

$1 > A > 0$

$1 < A < 0$

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Q $AB + \bar{A} + 1 = ??$

Ans $\underbrace{AB+\bar{A}}_{0 \text{ or } 1} + 1 = 1$

De-Morgans law

$\overline{A+B} = \bar{A}\cdot\bar{B}$

$\overline{A\cdot B} = \bar{A}+\bar{B}$

$\bar{A}+\bar{B} = \overline{A\cdot B}$

Commutative law

$A+B = B+A$

$A\cdot B = B\cdot A$

Associative law

$A+(B+C) = (A+B)+C$

Distributive law

$A\cdot(B+C) = A\cdot B + A\cdot C$

Q Simplify

$\overline{\bar{A}B + \bar{B}A} = \overline{\bar{A}\cdot B}\cdot\overline{\bar{B}A}$

$= (\bar{\bar{A}}+\bar{B})\cdot(\bar{\bar{B}}+\bar{A})$

$= (A+\bar{B})\cdot(B+\bar{A})$

$= AB + \cancel{A\bar{A}}^{0} + \cancel{\bar{B}B}^{0} + \bar{A}\bar{B}$

$= \boxed{AB+\bar{A}\bar{B}}$

Q $AB+\bar{A}\bar{B}$

→ $\overline{\overline{AB+\bar{A}\bar{B}}}$

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$$\overline{AB + \bar{A}\bar{B}} = \overline{\overline{AB} \cdot \overline{\bar{A}\bar{B}}}$$

$$= \overline{(\bar{A}+\bar{B}) \cdot (\bar{\bar{A}}+\bar{\bar{B}})}$$

$$= \overline{(\bar{A}+\bar{B}) \cdot (A+B)}$$

$$= \overline{\cancel{\bar{A}A}^{0} + \bar{A}B + A\bar{B} + \cancel{\bar{B}B}^{0}}$$

$$\therefore \overline{\bar{A}B + \bar{B}A} \quad \text{ANS}$$

Q Find $y = A + AB$

$\Rightarrow$ $Y = A + AB$

$= A[1+B]$

$= A.1 = A$

Q Find $y = B\bar{A} + \bar{B}\bar{A} = ?$

$\Rightarrow$ $\bar{A}[B+\bar{B}]$

$\bar{A}.1 = \bar{A}$

Q Find $y = A\bar{B} + AB =$

ANS $y = A[\bar{B}+B]$

$A.1 = A$

Fundamental gate

Based on fundamental operations

Inverse	Addition	multiplication.
NOT	OR	AND

Universal gate

Gate by which any gate can be formed

eg NOR / NAND

Special gate

X-OR

X-NOR

NOT GATE

Based on inverse operation

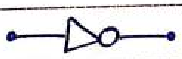
Single input gate

Fundamental gate

Formed using Common emitter transistor

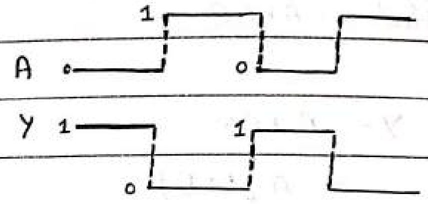
Boolean expression $Y = \bar{A}$

Circuit symbol



$Y = \bar{A}$

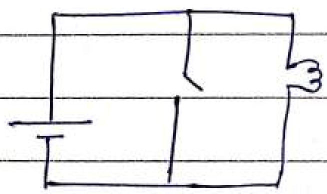
Time scale



Truth table

A	$Y = \bar{A}$
0	1
1	0

Electric equivalent → Electrical realisation



AND GATE

Two input circuit

Based on multiplication operation.

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Page ____

Fundamental Gate

Formed using two diode

Circuit symbol 

Y=A·B

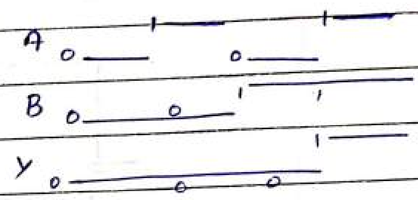
Output is only high when both the input is high

Output is low when any one input is low.

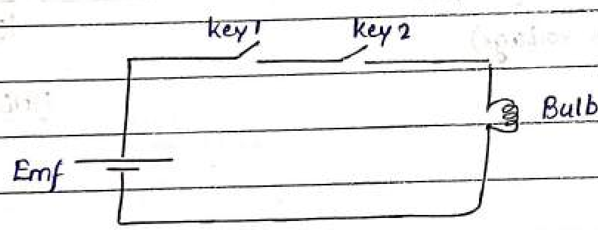
Truth table

A	B	Y=AB
0	0	0
0	1	0
1	0	0
1	1	1

Time scale



Electric equivalent circuit for AND GATE



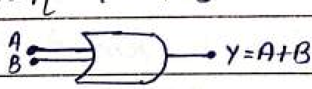
OR- GATE Two input device

Based on Addition operation

Fundamental gate

Formed using two diode

Boolean expression $Y = A+B$

Circuit symbol 

Output is high when any one of the input is high.

Output is only low when both the input is low.

Truth table

A	B	Y = A+B
0	0	0
0	1	1
1	0	1
1	1	1

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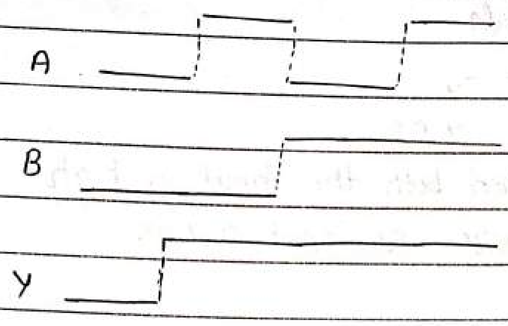
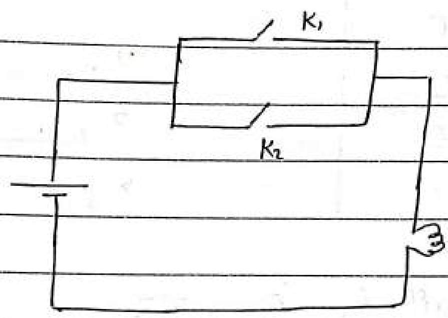
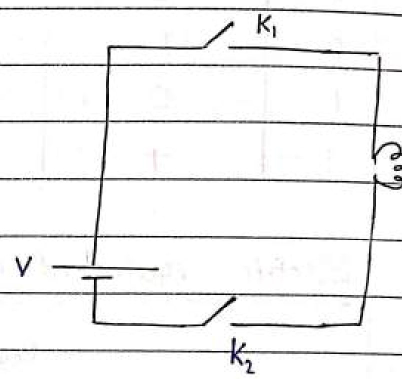
Time scale



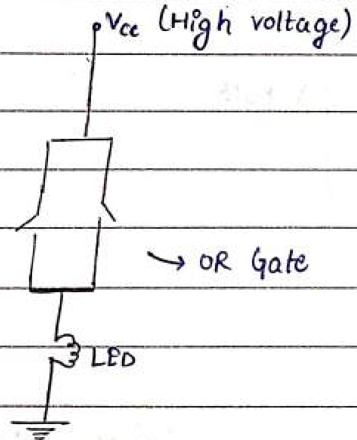
Electrical equivalent circuit for OR Gate



OR Gate



AND Gate



NOR GATE (opposite of OR gate)

Universal gate :- Any gate can be formed using this gate

Boolean expression ⇒ $Y = \overline{A+B}$

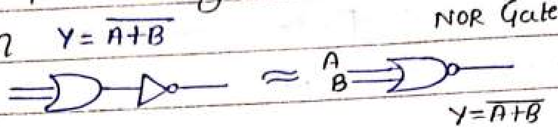
NOR GATE ⟶ OR + NOT

Universal gate

All Gate can be formed using this

Boolean expression $Y = \overline{A+B}$

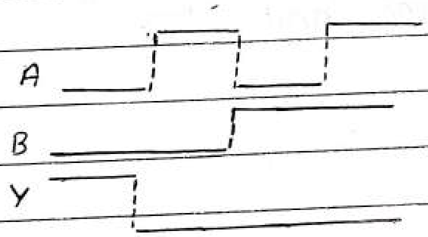
Circuit symbol



Truth table

A	B	Y
0	0	1
0	1	0
1	0	0
1	1	0

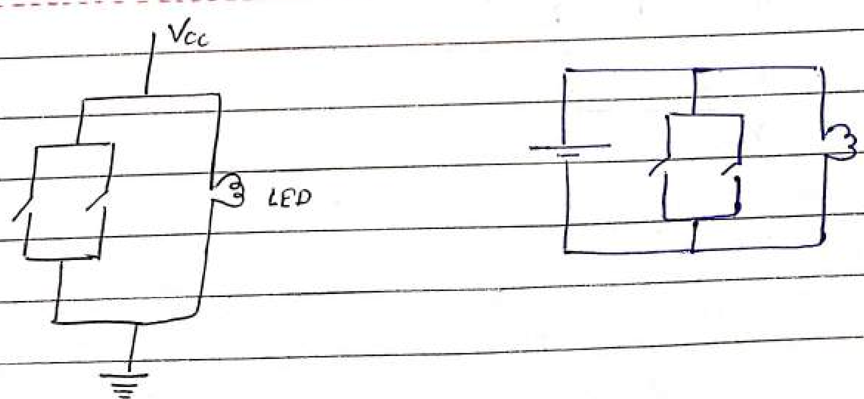
Time scale



Output is only high when both the input is low.

Output is low when any one input is high

Electrical equivalent circuit



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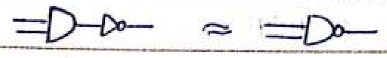
NAND GATE

↓

AND + NOT

Universal gate

All Gate can be formed using this

Circuit symbol 

Boolean expression $Y = \overline{AB}$

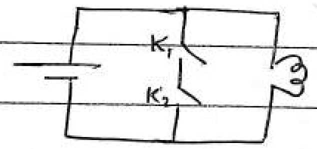
Truth table

A	B	AB	$\overline{AB}$
1	0	0	1
0	0	0	1
1	1	1	0
0	1	0	1

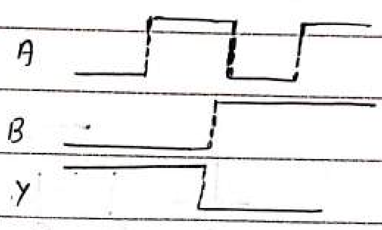
Output is only low when both the input is high

Output is high when any one input is low.

Electrical circuit



Time scale



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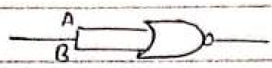
Single Input NOR Gate and NAND Gate

Single input nor gate



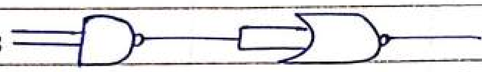
If $(A=B)$ then $\quad Y = \overline{A+B}$

$Y = \overline{A}$ Not gate

$\therefore$ single input NOR Gate → Not Gate

Single input NAND Gate → NOT GATE

Q Find name of Gate ?



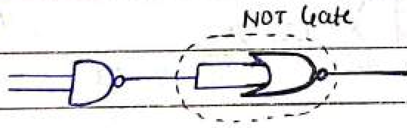
$Y = \overline{A \cdot B}$ $\qquad$ $Y' = \overline{\overline{A \cdot B}} = A \cdot B$

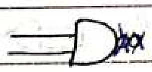
Net result $\quad A, B \rightarrow A \cdot B$

AND Gate

MR*

NOT Gate





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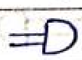
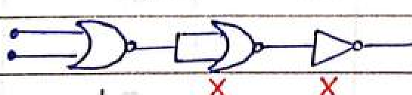
 AND Gate

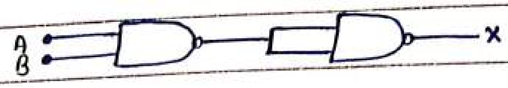
Q The given electrical network is equivalent to.



↓

NOR GATE

Q The output (x) of the logic circuit as shown in figure will be.

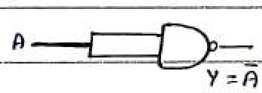


⇒ $X = A \cdot B$

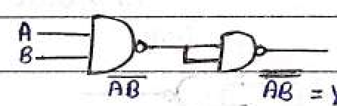
FORMATION OF DIFFERENT GATE USING NAND GATE

GATE	NOT	AND	OR	NOR
No. of NAND Gate required for different gate	1	2	3	4

For NOT GATE



For AND GATE

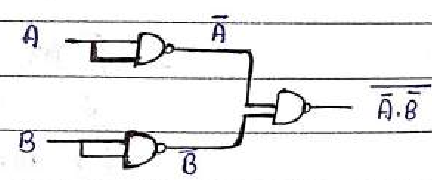


$\overline{\overline{AB}} = Y = AB$

For OR Gate

$Y = A+B = \overline{\overline{A+B}}$

$= \overline{\bar{A} \cdot \bar{B}}$



FORMATION OF DIFFERENT GATE USING NOR

	NOT	OR	AND	NAND
No. of NOR Gate	1	2	3	4

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X-OR GATE

Special purpose gate

Boolean expression $Y = \bar{A}B + \bar{B}A$

Circuit symbol $Y = A \oplus B = \bar{A}B + \bar{B}A$

$Y = A \oplus B$

Truth table

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	0

* Oputput is high when both the input is different
* Output is low when both the input is same

X-NOR Gate

X-OR + NOT ⇒ Boolean expression

$Y = \overline{A \oplus B}$

$Y = \overline{A\bar{B} + \bar{A}B}$

A	B	Y
0	0	1
0	1	0
1	0	0
1	1	1

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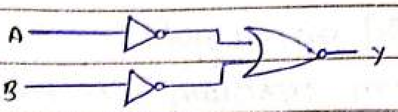
Q For the logic circuit shown, the truth table is.

ans

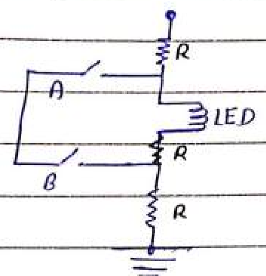
A	B	Y
1	0	0
0	0	0
1	1	1
0	1	0



$\Rightarrow \quad Y = \overline{\overline{A} + \overline{B}} = \overline{\overline{A \cdot B}} = AB$

behave as AND Gate

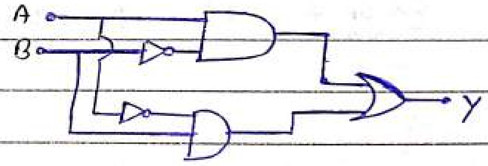
Q The correct Boolean operation represented by the circuit diagram drawn is.



a) NOR (b) AND

(c) OR (d) NAND

Q In the combination of the following gates the output Y can be written in terms of inputs A and B as.

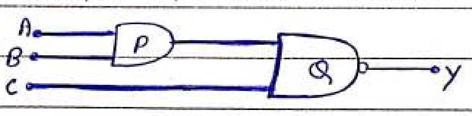


a) $\overline{A \cdot B}$ (b) $A \cdot \overline{B} + \overline{A} \cdot B$

c) $\overline{A \cdot B} + A \cdot B$ (d) $\overline{A + B}$

$\Rightarrow \quad A \cdot \overline{B} + \overline{A} \cdot B$

Q What is the output Y in the following circuit, when all three inputs A, B, C are first 0, then



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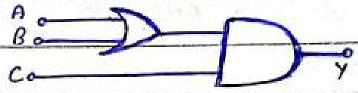
a) 0, 1 (b) 0, 0
(c) 1, 0 (d) 1, 1

ANS 1, 0

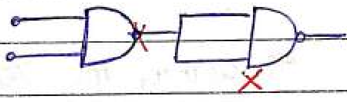
Q To get output 1 for the following circuit, the correct choice for the output is.

a) A = 1, B = 1, C = 0
b) A = 1, B = 0, C = 1
c) A = 0, B = 1, C = 0
d) A = 1, B = 0, C = 0

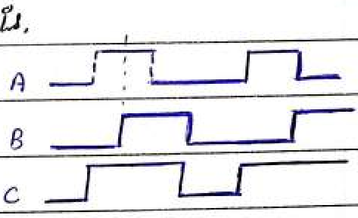


Q The output form of a NAND Gate is divided into two in parallel and fed to another NAND gate. The resulting gate is a

a) AND gate
b) NOR gate
c) OR gate
d) NOT gate



Q The given figure shows a logic circuit with two inputs A and B and the output C. The voltage wave forms across A, B and C are as given. The logic circuit gate is.



a) OR gate
b) NOR gate
c) AND gate
d) NAND gate.

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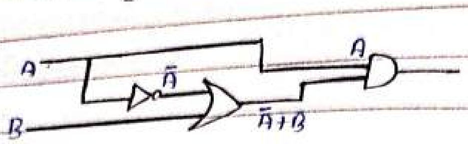
Q Name the gate



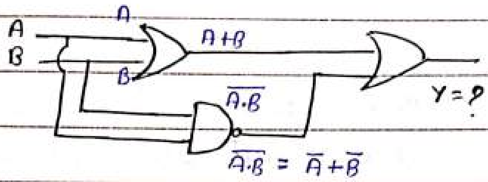
$Y = A\cdot(\bar{A}+B)$

$= \cancel{A\bar{A}} + AB$

$= AB$

$\therefore$ it is an AND gate.

Q What is output



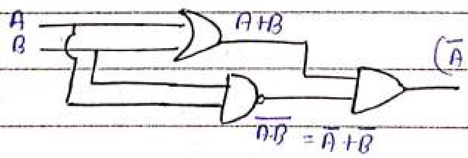
$\overline{A\cdot B} = \bar{A}+\bar{B}$

$Y = A+B + \bar{A}+\bar{B}$

$= 1+1 = 1$

Whatever the input output is also high

Q Name the gate



$(\bar{A}+\bar{B}).(A+B)$

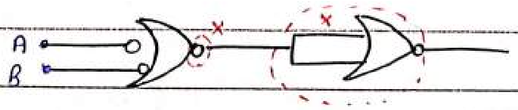
$\overline{A\cdot B} = \bar{A}+\bar{B}$

$Y = \cancel{\bar{A}A} + \bar{A}B + \bar{B}A + \cancel{\bar{B}B}$

$\Rightarrow \bar{A}B + \bar{B}A$

X-OR Gate

Q Name the gate

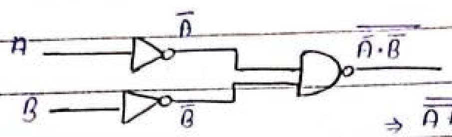


Resulting gate  $\Rightarrow \bar{A}+\bar{B}$

$= \overline{A \cdot B}$

$\therefore$ it is a NAND Gate

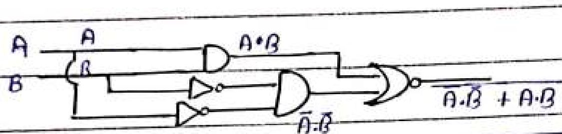
Q Name of gate



$\Rightarrow \overline{\overline{A+B}} = A+B$

it is an OR gate

Q



$\overline{\bar{A}\cdot\bar{B} + A\cdot B}$

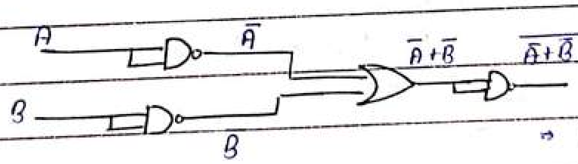
$\Rightarrow \overline{\bar{A}\cdot\bar{B} + A B}$

$\Rightarrow$ X-OR ANS

OR + NOT = NOR

NOR + NOT = OR

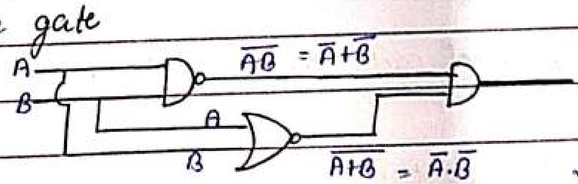
Q Name the gate



$\Rightarrow \bar{\bar{A}}\cdot\bar{\bar{B}} = AB$

it is a NAND gate

Q Name the gate



$Y = (\bar{A}+\bar{B}).(\bar{A}\cdot\bar{B})$

$\Rightarrow \bar{A}\bar{A}\bar{B} + \bar{B}\bar{B}\bar{A}$

$\Rightarrow \bar{A}\bar{B} + \bar{A}\bar{B} = \bar{A}\bar{B} = \overline{A+B}$ = NOR Gate

Semiconductor

Conductor is conductor, insulator is insulator but semiconductor have dual nature.

Q Why semiconductor is important?

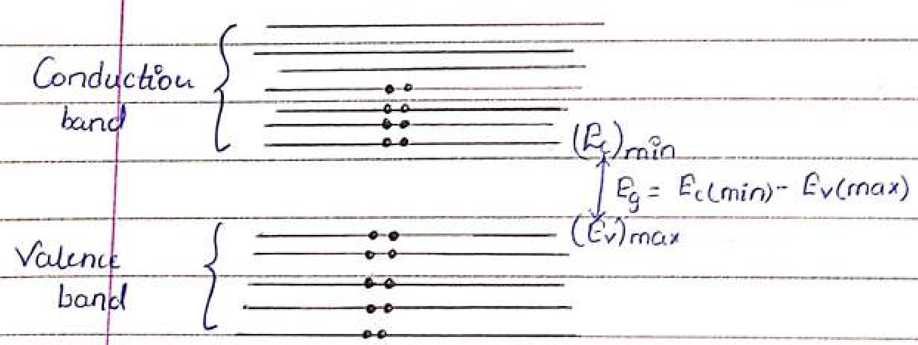
⇒ . Conductivity and resistivity can be controlled

no. of charge carriers can be controlled.

Unidirectional current flows.

	Resistivity
Conductor	$10^{-2}\,\Omega m$ to $10^{-8}\,\Omega m$
Semi cond.	$10^{-5}\,\Omega m$ to $10^{+6}\,\Omega m$
Insulator	$10^{11}\,\Omega m$ to $10^{19}\,\Omega m$

Energy band diagram for a crystal



Conduction band

Infinite energy level each fixed with two electron

There are free $e^{\ominus}$s

Current flows due to these $e^{\ominus}$

Valence band

Infinite energy level always filled with $e^{\ominus}$, these are bonded $e^{\ominus}$. Current do not flow due to these $e^{\ominus}$.

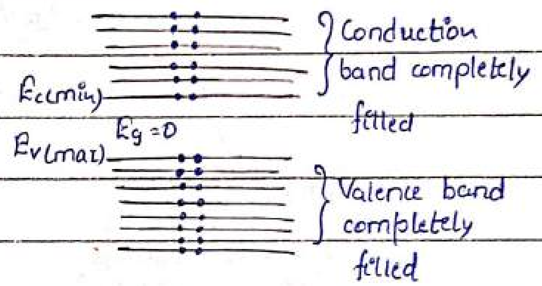
E_g = Egap energy is provided by heat, light, electric field.

Metal

$E_g = 0$, zero or very small

$E_g = E_c(min) - E_v(max)$

Band diagram for metal



Q Hole is formed or not?

→ Yes hole will be formed but its life time is very small

bonded $e^{\ominus}$ ka tootna   Temp ↑ { Randomness of $e^{\ominus}$ ↑ }

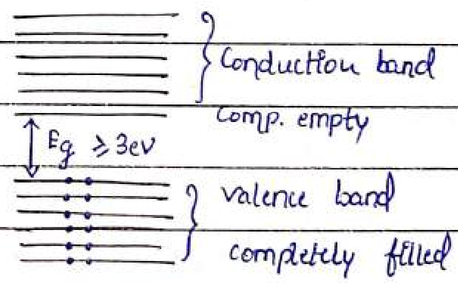
At 0 K current can flow in conductor.

Insulator

$E_g \geq 3eV$

⇒ very large

⇒ no current



Temp ↑ ⇒ Conductivity is increased in very small amount.

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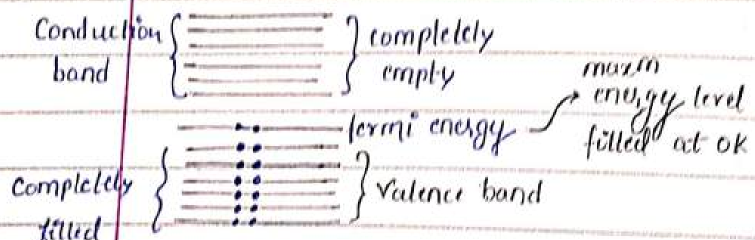
$E_g = 0.7eV$ → $E_g = 1.5 / 1.4eV$

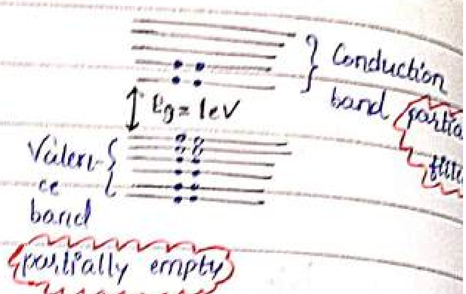
Semiconductor Ex = Si, Ge, GaAs, etc

$E_g = 1.1eV$

At T = 0K

At 300K (Room temp)





$n_i = [n_e] = [n_h]$ → intrinsic charge carriers

$n_i = n_e = n_h$

n_i → no. of intrinsic charge carriers per unit volume

n_e → no of free e⁻ per unit volume

n_h → no of holes per unit volume

Hole ⇒ Defficiency of e⁻, charge = +e

effective mass of hole > effective mass of electron. ($\because M_e >>> M_h$)

as temp ↑ no. of e⁻ hole pair also increased hence conductivity increases.

Recombination When free e⁻ collide with hole the free e⁻ recombine with the hole that decreases the conductivity

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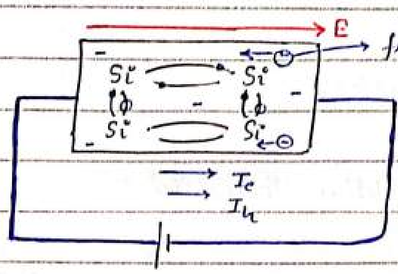
$T = 27°C$



$I_{net} = I_e + I_h$

but here $I_e >>> I_h$

$\downarrow \because$

mobility of $e^\ominus$ >>>> mobility of hole

Q Is this intrinsic semiconductor usefull?

⇒ No because its conductivity depends only on temperature and also conductivity is varies.

$$I_{net} = I_e + I_h$$

$$I_{net} = n_e A e V_{de} + n_h e A V_{dh}$$

$$= n_i e A [V_{de} + V_{dh}]$$

$$= n_i e A E [\mu_e + \mu_h] \quad (\because \mu E = V_d)$$

$$= \frac{n_i e A V}{l} [\mu_e + \mu_h]$$

α = +ve coefficient of resistivity

α = -ve

Temperature	Conductor	Semiconductor	Insulator
Increases			
Randomness	↑	↑ (but in less amt)	
$e^\ominus$ hole pair	constant	↑	↑ (very less amount)
conductivity	↓	↑	↑
resistivity	↑	↓	
drift velocity ★	↓	↓	
Decreases			
Randomness	↓	↓ (but in less amt)	
$e^\ominus$ hole pair	constt	↓	↓ (but in small amt)
conductivity	↑	↓	↓
resistivity	↓	↑	
Drift velocity ★	↑	↑	

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Extrinsic semiconductor.

at room temp ← Doping :- process of adding impurity

N-type Pentavalent impurity

Eg: P, As, Sb

$n_e >>> n_h$

n_e = majority charge carrier

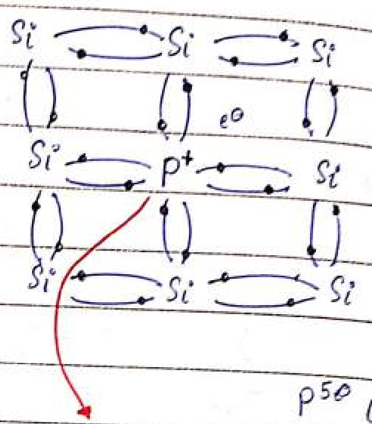
n_h = minority charge carrier

$I_e >>> I_h$

$Q_{net} = 0$

$N_D \approx n_e$ [$N_D \leq n_e$]

↳ some $e^{\ominus}$s due to thermal excitation



fixed +ve donor ion

$P^{5\ominus}$ (Neutral)

$1e^{\ominus}$ will be donated by P

↓

$P^+ \Rightarrow$ +ve P ion

P-type Trivalent impurity

Eg:- B, In, Al

$n_e <<< n_h$

I_h = hole current majority

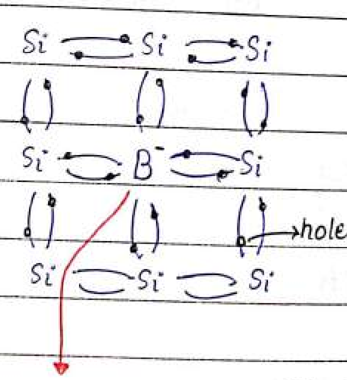
I_e = minority current

$Q_{net} = 0$

$N_A \approx n_h$ ($\because n_h > N_A$)

↓ $\because$

at room temp some holes will be created due to thermal excitation



fixed -ve acceptor ion

$n_h \approx N_A$

B^{3e} (Neutral)

Boron will accept one extra $e^{\ominus}$

$B^- \Rightarrow$ -ve ion

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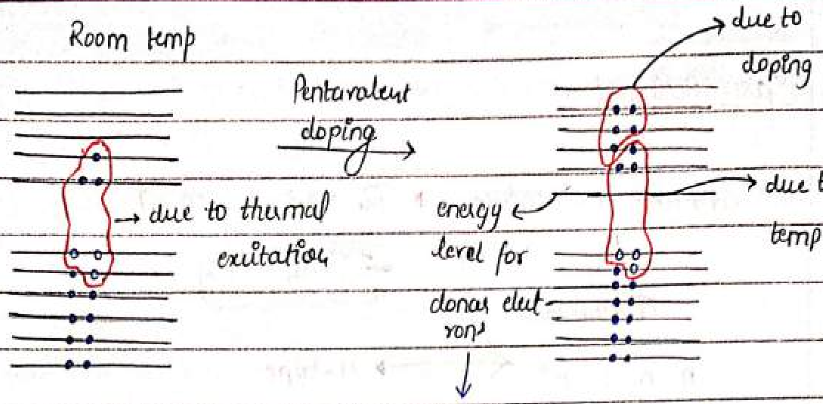
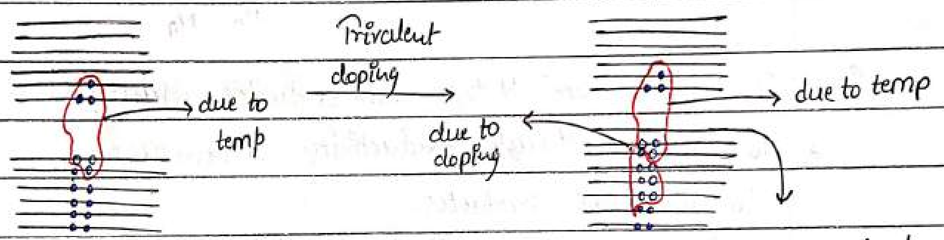
N type



since they are free from covalent bond they have very high energy than Bonded electron but low energy than e^-s in conduction band.

P type



energy level of acceptor ion

this energy level belongs to holes which in turns means the electrons which move from one hole to another.

Here the electron has to break the covalent bonding to get into the conduction band. Therefore are its energy level is closest to the valence energy level.

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Mass-Action law

At constant temperature → for intrinsic [Pure]

↓

Isothermal

$\boxed{n_e = n_h = n_i}$

$n_e \cdot n_h = n_i^2$

→ N-type

$n_e \approx N_D$

$n_h = \frac{n_i^2}{n_e} = \frac{n_i^2}{N_D}$

→ P-type

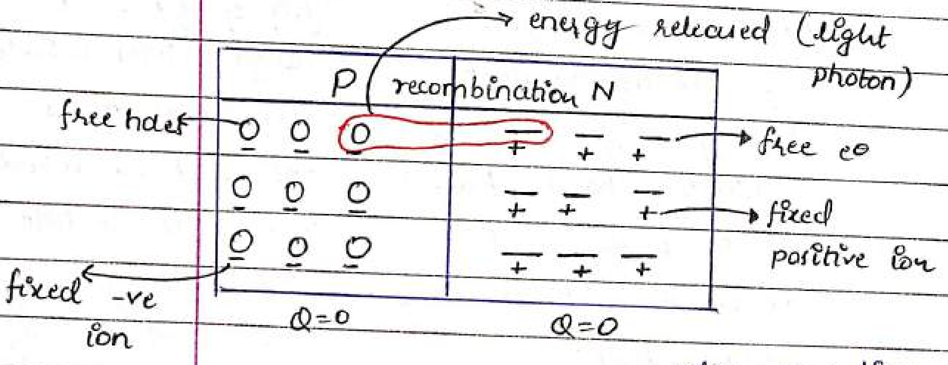
$n_h = N_A \qquad n_h \approx N_A$

$n_e = \frac{n_i^2}{n_h} = \frac{n_i^2}{N_A}$

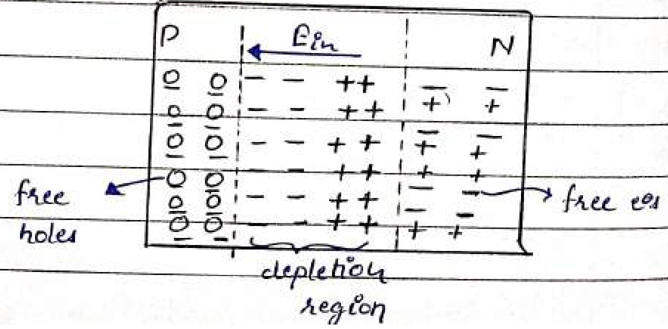
Q Is P-type and N type semiconductor useful?

⇒ No, because though conductivity is increased but we have conductor.

P-N JUNCTION DIODE



after some time



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Electric field → from N → P

Width of depletion region ⇒ μm

Potential barrier $= E_g \approx 0.7$ volt ≈ 0.5 volt

Electron will diffuse from N → P

hole will diffuse from P → N

Diffusion current → due to concentration difference.

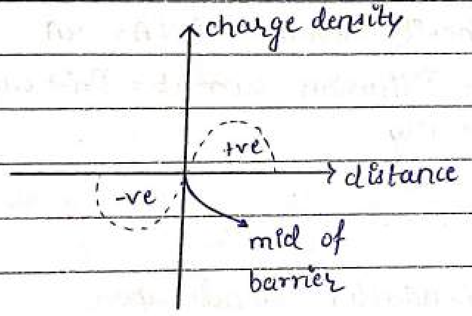
$I_D \rightarrow$ [P to N]

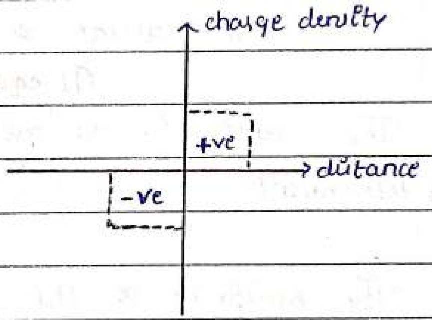
$$E = \frac{\Delta V}{\Delta r} = \frac{0.5}{1\,\mu m} = 5 \times 10^5 \text{ V/m} = \text{constant}$$

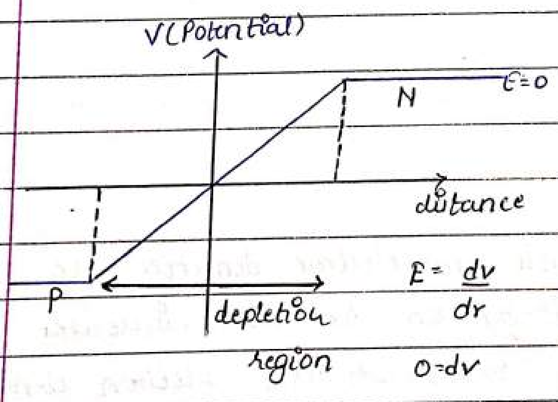
$$|E| = \frac{dV}{dr} \rightarrow E\int dr = \int dV$$

$$Er = V \Rightarrow V \propto r$$

Very high electric field



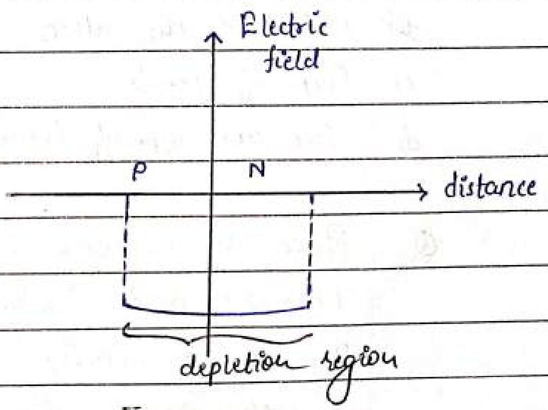




$$E = \frac{dV}{dr}$$

$$0 = dV$$

$$V = \text{constant}$$



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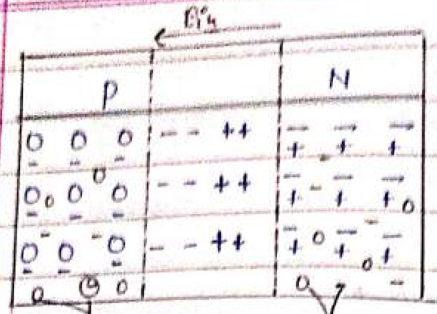

↗ due to electric field

$e^{\ominus}$ will drift from P to N

hole will drift from N to P

I_{drift} [from N to P]

Diffusion current ⇒ Majority current = 10^{-3} Amp ⇒ mA

Drift current ⇒ minority current = 10^{-6} A = μA

At equi ⇒ Diffusion current = Drift current.

Q The semiconductors are generally

⇒ tetravalent

Q The resistivity of the semiconductor depends upon.

a) Size of the atom

~~b)~~ nature of the atom

c) Type of bonds

d) Size and type of bonds.

Q Pure Si at 300K has hole and electron densities are $1.5 \times 10^{16}\ m^{-3}$. Doping it by an impurity increases the hole density (n_h) to $4.5 \times 10^{22}\ m^{-3}$. Electron density in the doped silicon is.

⇒ $n_i = 1.5 \times 10^{16}$

$n_h = 4.5 \times 10^{22}$

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$n_i^2 = n_h n_e$

$$\frac{1.5 \times 1.5 \times 10^{32}}{4.5 \times 10^{22}} = n_e$$

$n_e = 5 \times 10^9\ m^{-3}$

Q In an intrinsic (pure) semiconductors the number of conduction electrons is 7×10^{19} per cubic metre. Find the total number of current carriers (electrons and holes) in a same semiconductor of size 1cm x 1cm x 1mm.

⇒ $n_i = 7 \times 10^{19}\ m^{-3}$

$n_i = 7 \times 10^{19} \times 10^{-2} \times 10^{-2} \times 10^{-3}\ m^3$

$= 7 \times 10^{12} = n_e = n_h$

total $= n_e + n_h$

$= 14 \times 10^{12}$ Ans

Q When n-type semiconductor is heated

⇒ No. of electrons and holes increases equally.

Q The rate of recombination or generation are governed by laws of

⇒ Thermodynamics

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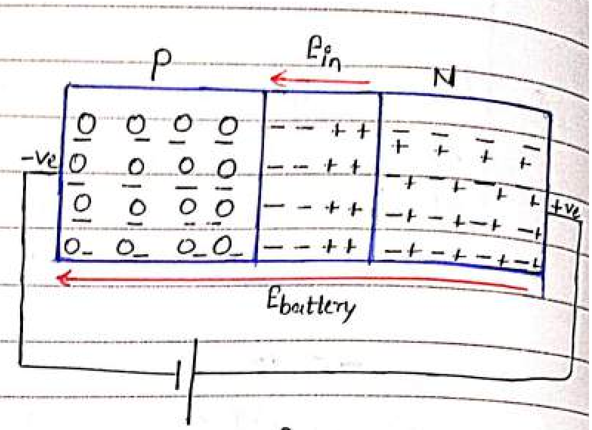
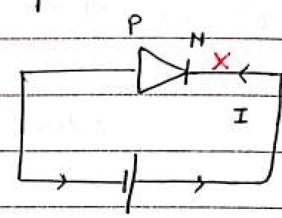
REVERSE BIAS

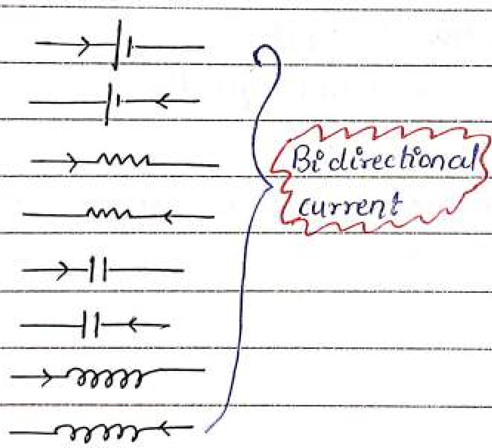
+ve, terminal connected to N side
-ve terminal connected to P side

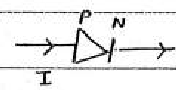
E_{net} ↑
ΔV (Potential barrier) ↑
Width ↑
Diffusion current ↓(mA) = 0
Drift current ↑(μA)
Resistance = infinite



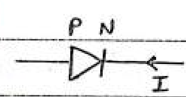
In Reverse biasing diode will behave as open wire.







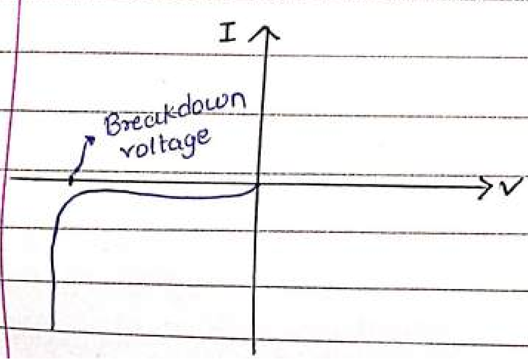
$R_{ideal} = 0$
Simple wire



does not allow this current

$R = \infty$
open wire

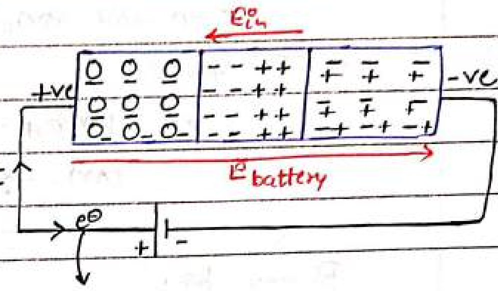
I-V Graph for reverse bias.



Breakdown voltage ⇒ Voltage at which covalent bond will break in depletion region.

FORWARD BIAS

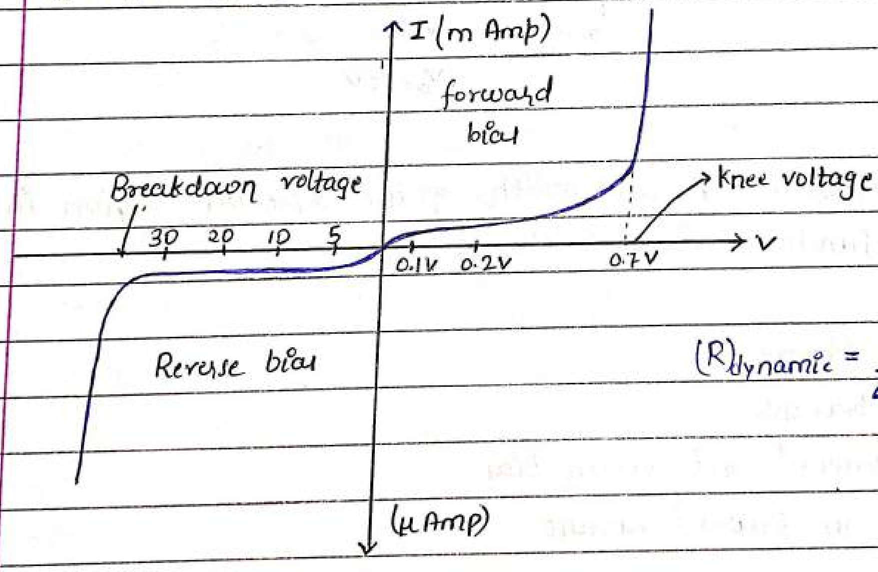
+ve terminal connected to P side
-ve terminal connected to NP side
E_{net} ↓
ΔV (Potential barrier) ↓
Width ↓
Diffusion current ↑



$R_{ideal} = 0$	$R_{practical} \approx$ small resistance
Simple wire	$(\Delta V)_{diode}$ = small voltage
$(\Delta V)_{diode} = 0$	

bonded electron toot gaya

I-V characteristic



Slope = $\frac{\Delta I}{\Delta V} = \frac{1}{\text{Resistance}}$

Resistance $\propto \frac{1}{\text{slope}}$

$(R)_{dynamic} = \frac{\Delta V}{\Delta I}$

Forward bias

Ideal	Practical
$R_{diode} = 0$	R_{diode} = small
simple wire	$(\Delta V)_{diode} \approx$ Band gap in forward bias
$(\Delta V)_{diode} = 0$	

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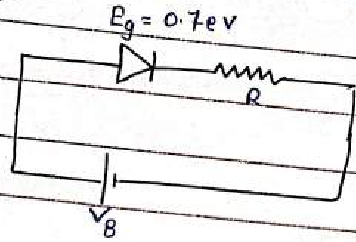
Practical diode



1) For $V_B = 0.5eV$

$I = 0$ and $(\Delta V)_{diode} = 0.5eV$

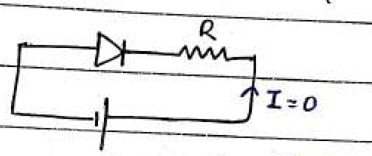
2) For $V_B = 2eV$

$I \neq 0$ $(\Delta V)_{diode} = 0.7eV$

$(\Delta V)_R = 1.3\,eV$

Reverse bias

No matter whether it is ideal/ Practical



$V_R = 0$

$V_D = 20V$

Q The increase in the width of the depletion region in a p-n junction diode is due to

a) Forward bias only

~~b)~~ Reverse bias only

c) Both forward and Reverse bias

d) Increase in forward current

Q Depletion layer consists of

a) mobile ions ~~(d)~~ immobile ions

b) protons

c) electrons

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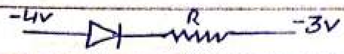
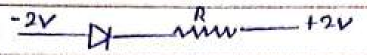
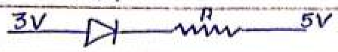
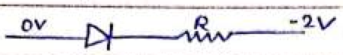
Q Which one of the following represents forward bias diode?

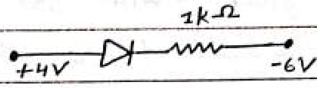
a) 

b) 

c) 

d) 

Q Consider the junction diode as ideal. The value of current flowing through AB is



a) 10^{-1} A

b) 10^{-3} A

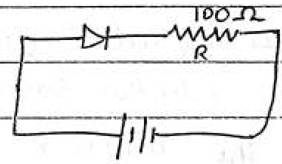
c) 0A

d) 10^{-2} A

Ans $(\Delta V)_R = 4-(-6) = +10V$

$I = \frac{V}{R} = \frac{10}{10^3} = 10^{-2}A$ Ans

Q In the given figure, a diode D is connected to an external resistance R = 100 Ω and an emf of 3.5V. If the barrier potential developed across the diode is 0.5 V the current in the circuit will be.



3.5V

a) 20mA

b) 35mA

c) 30 mA

d) 40mA

Ans $(\Delta V)_R = 3.5 - 0.5 = 3V$

$I = \frac{V}{R} = \frac{3}{10^2} = 30mA$ Ans

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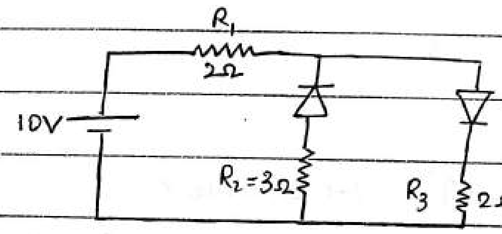
Q In a p-n junction diode, change in temperature due to heating.

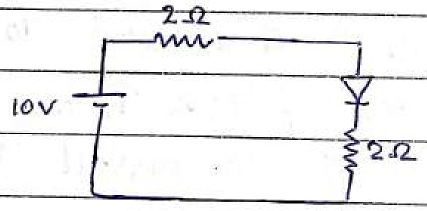
a) Affects only reverse resistance
b) Affects only forward resistance
c) Does not affect resistance of p-n junction.
d) Affects the overall V-I characteristics of p-n junction.

Q In the given circuit has two ideal diodes connected as shown in the figure. The current flowing through the resistance R_1 will be



a) 2.5 A
b) 10.0 A
c) 1.43 A
d) 3.13 A

⇒

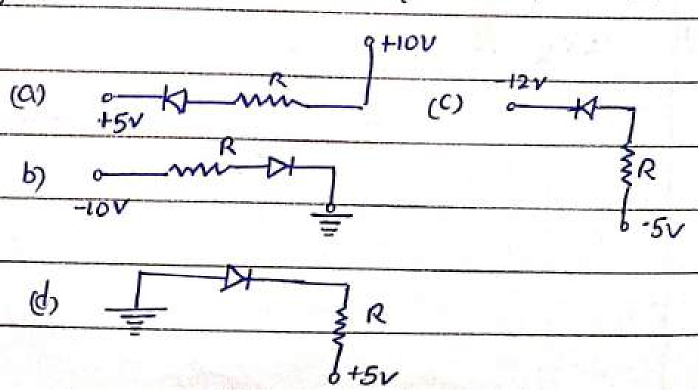


$I = \frac{V}{R} = \frac{10}{4} = 2.5\,A$

Q Reverse bias applied to junction diode
a) ⇒ Raises the potential barrier.
b) Increases the minority carrier current

Q In the following figure, the diodes which are forward biased are

a) a, b. and d
b) c only
c) c and a
d) b and d



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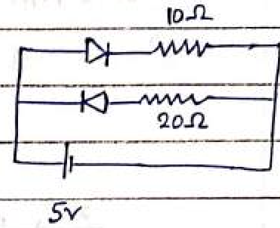
Q Two ideal diodes are connected to a battery as shown in the circuit. The current supplied by the battery is



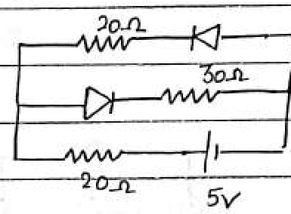
a) 0.75A

b) zero

c) 0.25A

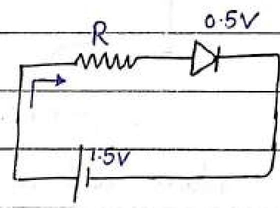
d) 0.5A

Q The current in the circuit will be



$\Rightarrow I = \frac{V}{R} = \frac{5}{50}$

Q The diode used in the circuit shown in the figure has a constant voltage drop at 0.5 v at all currents and a maximum power rating of 100 milli watts. What should be the value of the resistor R, connected in series with diode for obtaining maximum current



Ans Maximum power $\Rightarrow$ at maximum current

$P = VI$

$100 \times 10^{-3} = 0.5\, I$

$I = 0.2A$

$V_R' = 1V$

$V = IR$

$R = \frac{1}{0.2} = 5\,\Omega$ Ans

Q An LED is constructed from a p-n junction diode using GaAsP. The energy gap is 1.9eV. The wavelength of the light emitted will be equal to.

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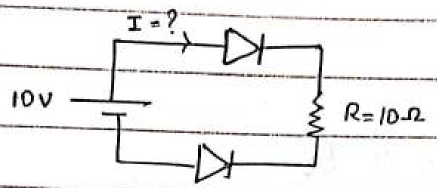
⇒ $E = \frac{hc}{\lambda}$

$\frac{12400}{1.9} = \lambda(Å)$

⇒ $6540\ Å$

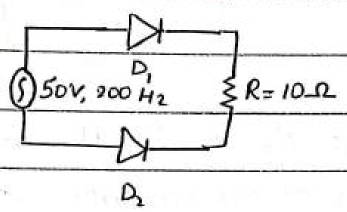
⇒ $654\ nm$ Ans

Q



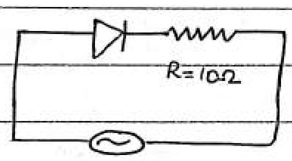
$I = 0$

Q



$I = 0$

Q



20V, 100 Hz

Power drop in resistance?

⇒ Power $= \frac{V_{rms}^2}{R} = \frac{20 \times 20}{10} = 40W$

But ans ⇒ $\frac{40}{2} = 20W$ Ans

OR it is half way rectifier

$I'_{rms} = \frac{I_0}{2} = \frac{I_{rms}}{\sqrt{2}} = \frac{20}{10} = \frac{2}{\sqrt{2}} = \sqrt{2}A$

Power $= I_{rms}^2 R$

$= 2 \times 10 = 20W$ Ans

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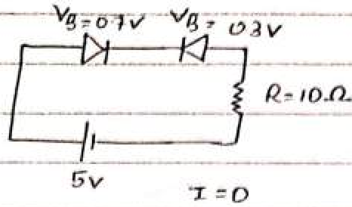
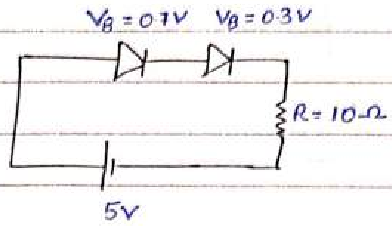
Q



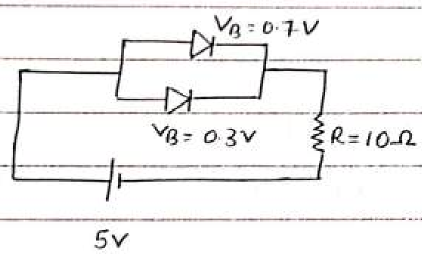
$I = 0$

Q



$I = \frac{5-1}{10} = \frac{4}{10} = 0.4$ A

Q ★



$I = ?$

$5 - 0.3 = 4.7$

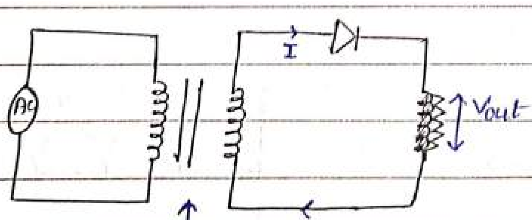
$\Rightarrow I = \frac{4.7}{10} = 0.47$ A Ans

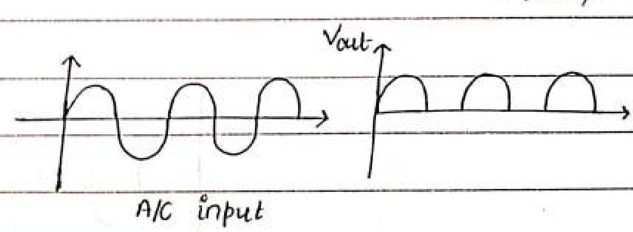
Half wave Rectifier

↓

convert A/C to DC

(Ripple frequency) output frequency = f_{input} frequency





↑

Transformer

↳ step up and step down

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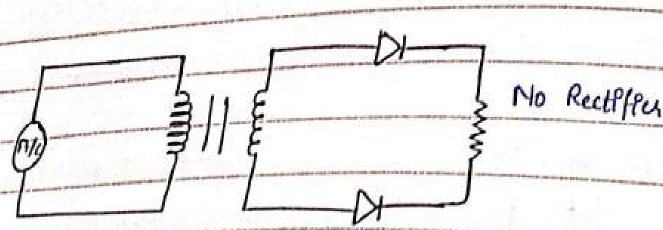
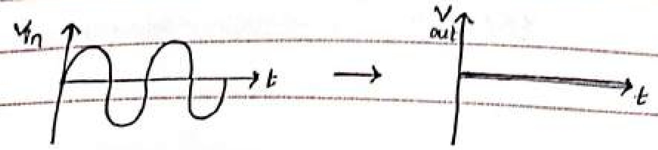
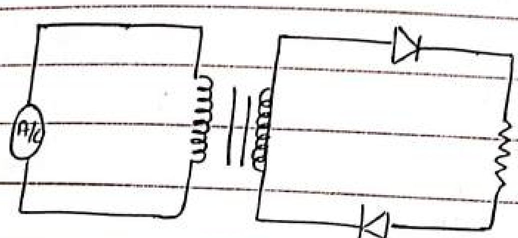
Full Wave Rectifier



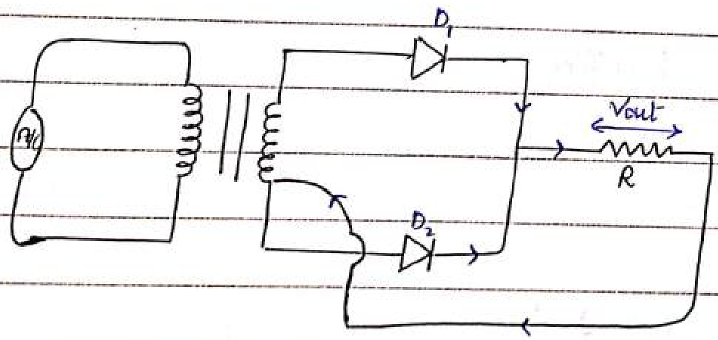


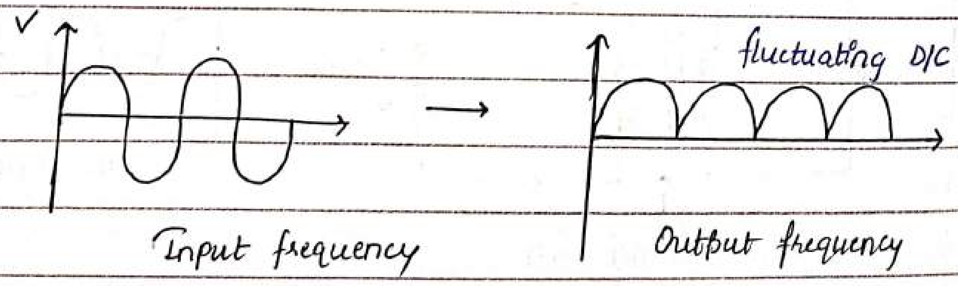


↳ Half wave rectifier

Full wave rectifier.

Converts Alternating current to variable direct current.





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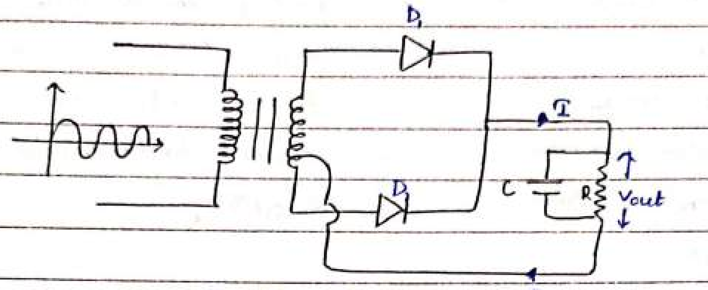
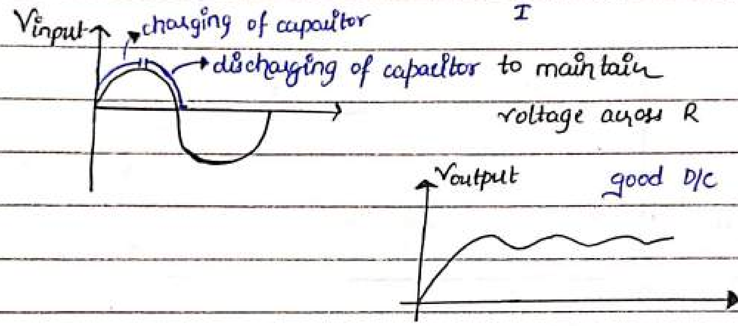
Output frequency = 2 × input frequency

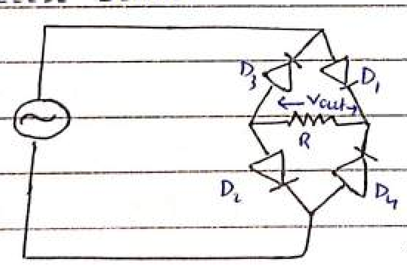
Capacitor filter circuit (full wave rectifier)

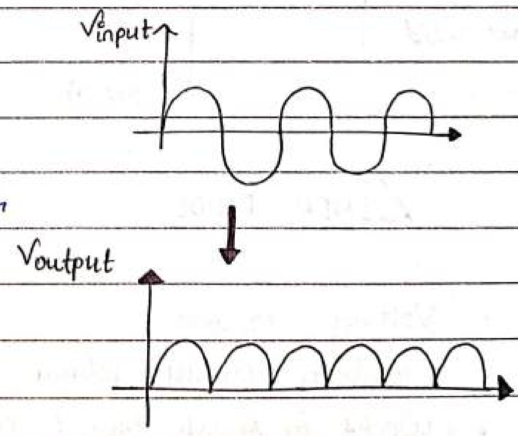




Full wave rectifier

Bridge rectifier





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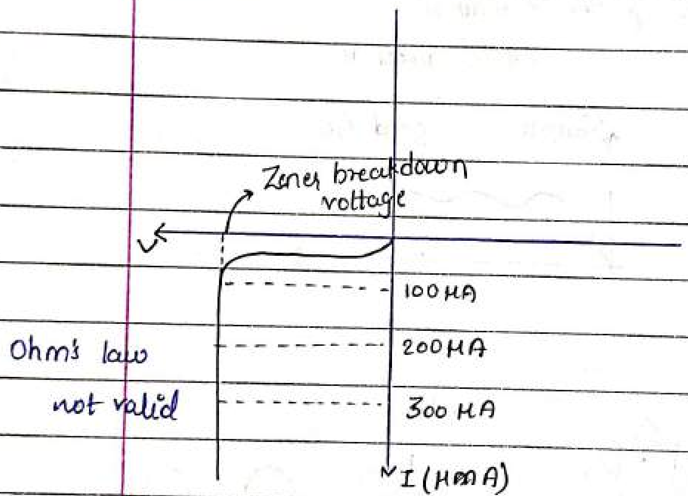
width of depletion region $\propto \frac{1}{\text{doping level}}$

Breakdown

Avalanche breakdown	Zener Breakdown
• Low doped semiconductor	• High doped semiconductor
• Depletion width thick	• Depletion width thin
• Not reversible	• Covalent bond will break due to electric field in reverse biased condition
• Covalent bond will break due to collision between minority e⁻ and covalent bonded electrons.	• Reversible.



ZENER DIODE

- Voltage regulator
- Maintain constant voltage
- Works in reverse biased condition at Zener breakdown voltage.
- Resistance of zener diode is not defined.

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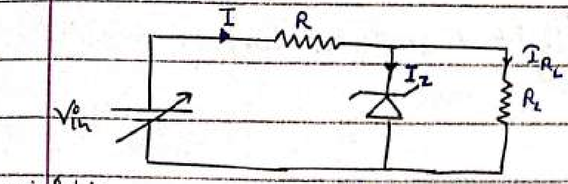


variable voltage

$I = I_Z + I_{R_L} \rightarrow$ constant

$V_{out} \geq V_Z$ (diode will on)

$V_{out} = V_Z$

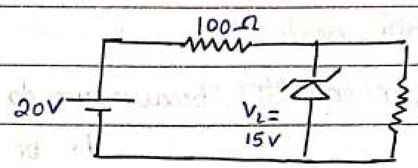
$I_{R_L} R_L = V_Z = V_{out}$

const^n const^n const^n

$V_Z > V_{out}$ diode will off does not work

$I_Z = 0$

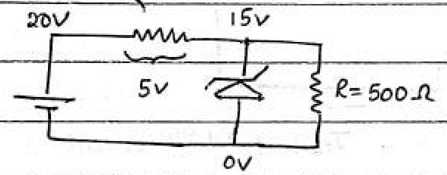
Q Find current in Zener



ANS $V_{R_L} = V_Z = 15v$

$I_{R_L} = \frac{\cancel{15}\,3}{\cancel{500}\,100} = 0.03$ Amp

$I = \frac{5}{100}$ Amp

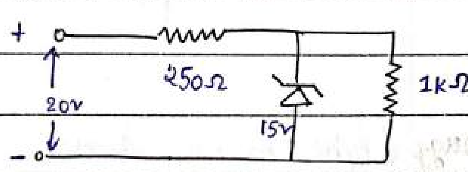


$I = I_Z + I_{R_L}$

$0.05A - 0.03A = I_Z = 0.02\ A$

Since Resistance of Zener diode is not defined therefore we cannot find current by the formula ⇒ $\frac{\text{Total emf}}{\text{Total Resistance}}$

Q A Zener diode, having breakdown voltage equal to 15, is used in a voltage regulator circuit shown in figure. The current through the diode is.



ANS $I = \frac{\cancel{5}}{\cancel{250}\,50} = \frac{1}{50}\ A = 20mA$

$I_{R_L} = \frac{15}{1000} = 15mA$

$I_Z = 5mA$ Ans

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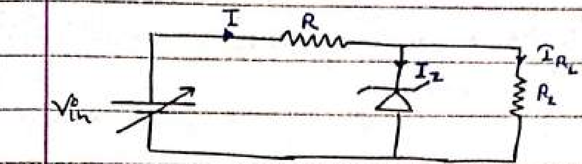


variable voltage

$V_{out} \geq V_z$ (diode will on)

$V_{out} = V_z$

$I = I_z + I_{R_L} \rightarrow$ constant

$\underset{\text{const}^n}{I_{R_L}} \underset{\text{const}^n}{R_L} = \underset{\text{const}^n}{V_z} = V_{out}$

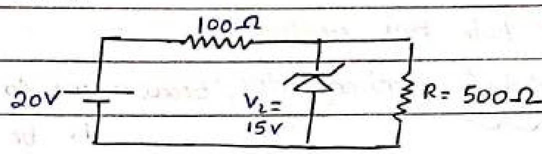
$V_z > V_{out}$

diode will off

does not work

$I_z = 0$

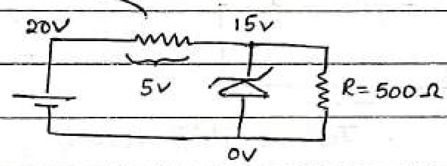
Q Find current in Zener



ANS $V_{R_L} = V_z = 15v$

$I_{R_L} = \frac{\cancel{15}\,3}{\cancel{500}\,100} = 0.03$ Amp

$I = \frac{5}{100}$ Amp

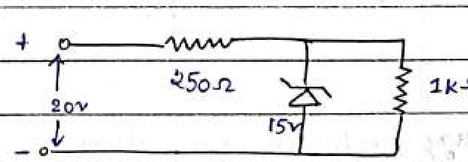


Since Resistance of Zener diode is not defined therefore we cannot find current by the formula ⇒ $\frac{\text{Total emf}}{\text{Total Resistan}}$

$I = I_z + I_{R_L}$

$0.05A - 0.03A = I_z = 0.02$ A

Q A Zener diode, having breakdown voltage equal to 15, is used in a voltage regulator circuit shown in figure. The current through the diode is.



ANS $I = \frac{\cancel{5}}{\cancel{250}\,50} = \frac{1}{50}$ A $= 20$mA

$I_{R_L} = \frac{15}{1000} = 15$mA

$I_z = 5$mA Ans

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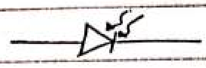
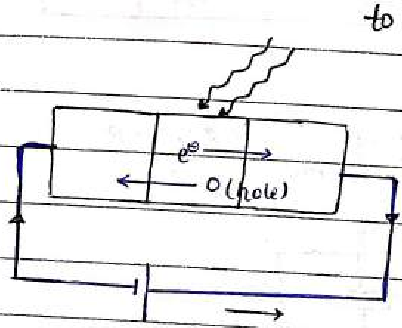
light energy
to
electrical energy

Photo-electronic circuit (light + semiconductor)

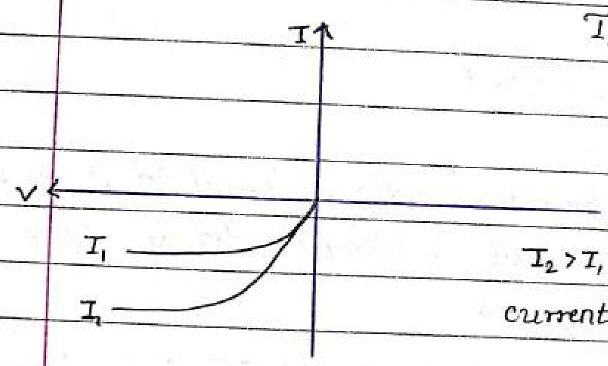
Symbol 

- Used to detect signal (optical signal)
- Reverse biased
- It measures intensity of signal
- $e^{\ominus}$ does not comes out of diode due to falling of light but $e^{\ominus}$ hole pair created
- Low doped semiconductor, because we do not want covalent bonds to be broken down



Current (drift current)

$I_{Diffusion} = 0$



$I_2 > I_1$

current $\propto$ Intensity $\propto$ no. of photons

Electrical energy
to
light energy

Light emitting diode

Formed using GaAs semiconductor
Used in forward condition
Photon emitted due to $e^{\ominus}$ hole pair recombination
Cannot be formed using Si & Ge

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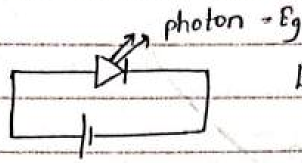
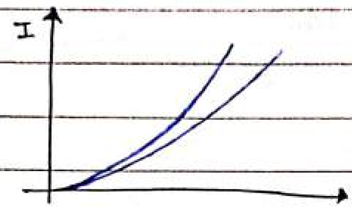
→ High doped



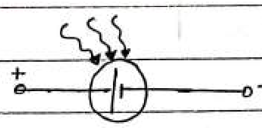
Energy of visible light = 1.4eV



Solar energy to light energy

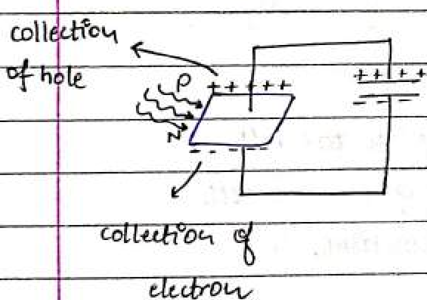
Solar cell

Symbol



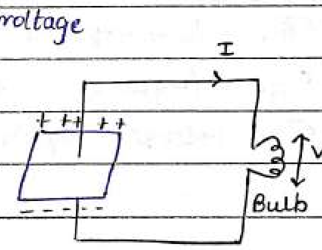
Series and parallel combination of large number of photodiode.

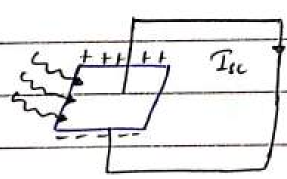
* No baising



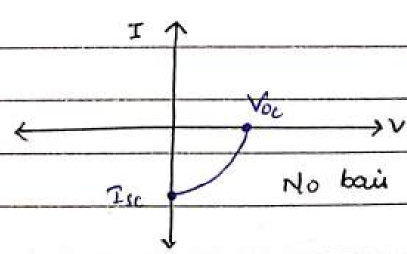
Capacitor

V_{oc} = open circuit voltage





Short circuit



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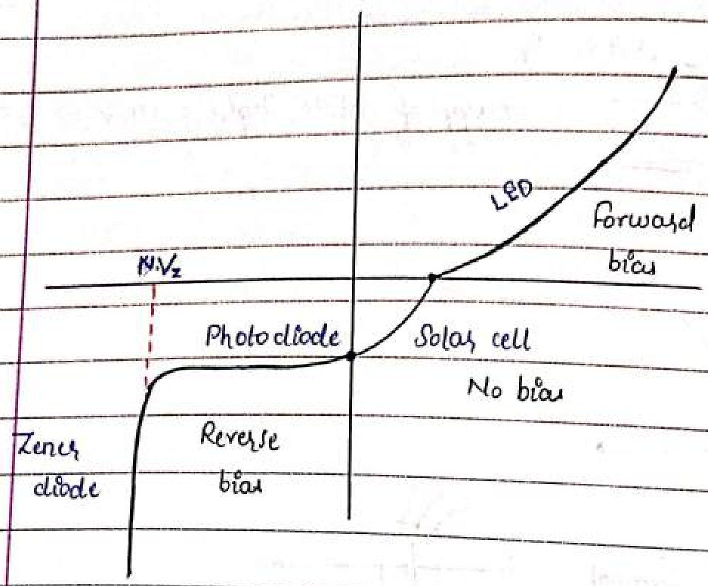

Q In a p-n junction photo cell, the value of the photo-electromotive force produced by monochromatic light is proportional to

a) The barrier voltage at the p-n junction
b) The intensity of the light falling on the cell
c) The frequency of the light falling on the cell.
d) The voltage applied at the p-n junction.

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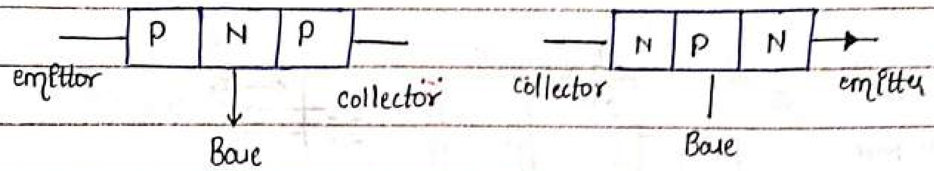
Triode ⇒ Transistor → Junction transistor

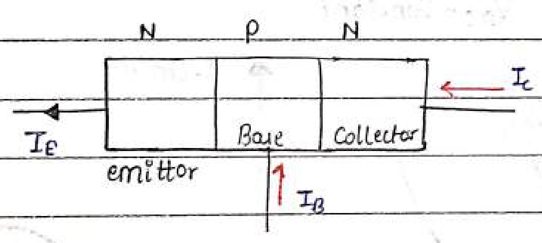


- Arrow is always present at emittor
- I_E along arrow
- $I_C + I_B = I_E$
- NPN transistor ↓ Agar current bahar nikalta hai

PNP transistor ↓ current ja raha hai

NPN is more useful than PNP ∵ $M_e > M_h$ [And NPN has large no of electron]

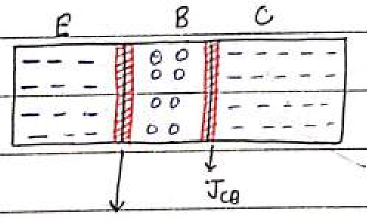
Transistor



Doping level ⇒ E > C > B ↑ minimum doping

Length of crystal (not depletion width) $L_C > L_E > L_B$

$$I_B + I_C = I_E$$

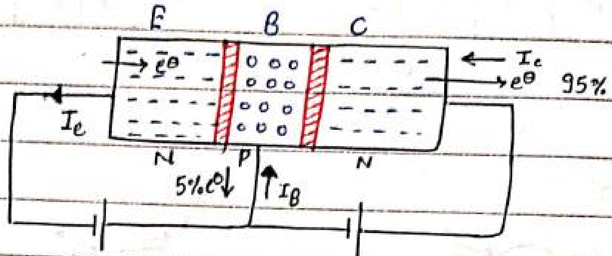


Barrier potential = Junctional potential

J_{EB}

Working of NPN Transistor

- Let 100 $e^{\ominus}$ injected from emitter to base
- Almost 5% $e^{\ominus}$ hole pair will recombine in base
- these 5% $e^{\ominus}$ hole pair will new formed and come out as I_B
- 95% will be collected by collector

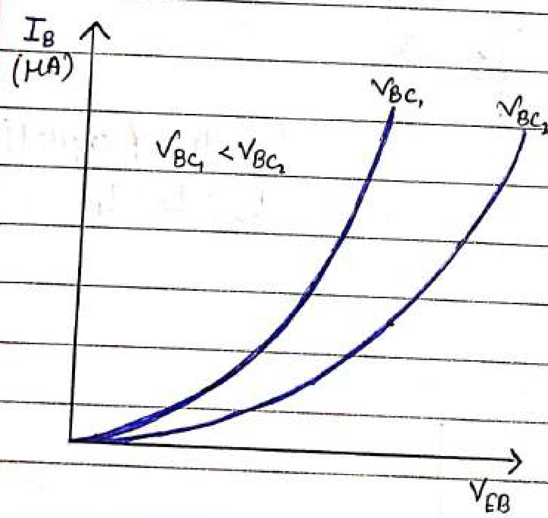


$V_{in} = E_{BE}$ → Input junction → Base emitter junction → forward bias

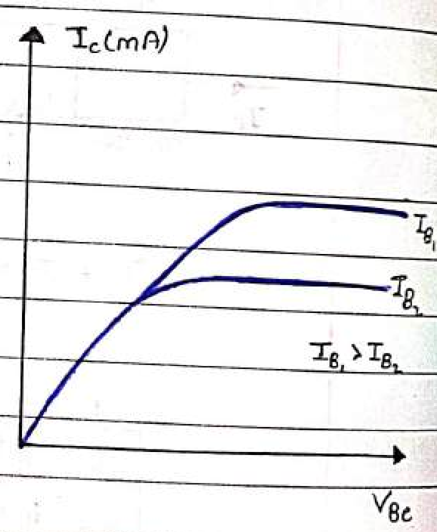
V_{BC} → Base-collector junction → reverse bias

Input characteristic

V_{BC} = Constant



Output characteristic



If V_{BC_2} ↑ then force on coming electron increases

electrons coming out of B ↓

∴ I_B will decrease

and also due to increase in reverse bias the knee voltage will increase.

$$\beta \text{ (Current gain)} = \frac{I_c}{I_B}$$

Here V_{BC} should remain constant

∴ as I_B ↑ I_c also increases

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Q A n-p-n transistor conducts when.

→ Collector is positive and emitter is negative with respect to the base.

Q One way in which the operation of n-p-n transistor differ from that of p-n-p?

a) The emitter injects hole into the base of the p-n-p and electrons into the base region of n-p-n.

	J_{BE}	J_{BC}	Working
1>	R.B.	R.B.	cut off region
2>	F.B.	R.B	Active region
3>	F.B.	F.B.	saturation region
4>	R.B.	F.B.	Reverse active region

Common base → Not in syllabus ✗
Common collector

Common Emitter

Input ⇒ Base

I_B = Base current
= Input current

R_B = Base resistance
Input resistance

V_{BE} = Input voltage

Output ⇒ collector

I_C = Output current
= collector current

R_C = Output resistance
Collector resistance
Load resistance

V_{CE} = Output voltage

I_E Bekar hai
R_E nahin hoga
Emitter directly grounded.

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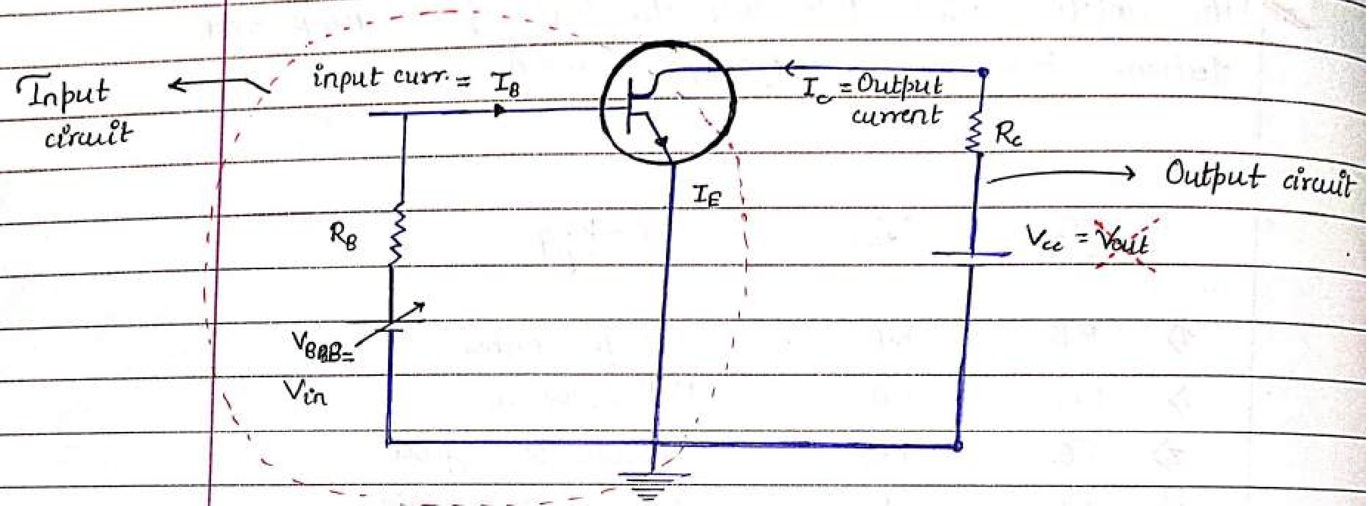
Common emitter transistor as a amplifier

amplifier → a piece of electrical equipment for making sounds louder or signals stronger.



KVL in input circuit

$V_{BB} - I_B R_B - V_{BE} = 0$

$V_{BB} = V_{in} = V_{BE} + I_B R_B$

$\boxed{V_{in} = V_{BE} + I_B R_B}$

Differentiation

$\Delta V_{in} = \cancel{\Delta V_{BE}}^{0} + R_B \Delta I_B$

[In case of
Forward biasing
V_{BE} = constant]

$\Delta V_{in} = R_B \Delta I_B$

KVL in output circuit

$V_{cc} - I_C R_C - \underbrace{V_{CE}}_{V_{output}} = 0$

$\cancel{V_{cc}} = V_{out} = \cancel{-V_{CE} + I_C R_C}$

$\cancel{\boxed{V_{out} = -V_{CE} + I_C R_C}}$

$\boxed{V_{CE} = V_{out} = V_{cc} - I_C R_C}$

$\Delta V_{out} = \cancel{\Delta V_{cc}}^{0} - R_C \Delta I_C$

$\Delta V_{out} = -R_C \Delta I_C$

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Current gain $(\beta) = \dfrac{\text{Output current}}{\text{Input current}} = \left(\dfrac{I_c}{I_B}\right)_{D/C} = \left(\dfrac{\Delta I_c}{\Delta I_B}\right)_{A/C}$

unit and dimensionless.

$\beta > 1$

$R_L = \text{Load}$

Voltage gain $(A_v) = \dfrac{\text{Output voltage}}{\text{Input voltage}} = \dfrac{-R_c \Delta I_c}{R_B \Delta I_B} = \dfrac{-R_c}{R_B}\beta = \dfrac{-R_L}{R_{in}}\beta$

Power gain $(A_p) = \dfrac{\Delta I_c \, \Delta V_{out}}{\Delta I_B \, \Delta V_{in}} = \dfrac{R_L}{R_{in}}\beta^2 = \dfrac{V_{out}}{V_{in}}\beta$

$$A_p = A_v \beta$$

Transconductance $(g_m) = \dfrac{\text{Output}}{\text{Input}}$

unit : mho $\left(\dfrac{1}{\Omega}\right)$ $\Rightarrow \dfrac{\text{collector current}}{\text{Base voltage}} = \dfrac{I_c}{V_{in}} = g_m$

constant for a transistor

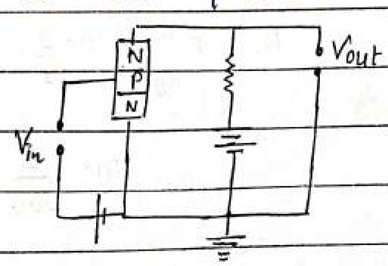
$$g_m = \frac{I_c}{V_{in}} \times \frac{I_B}{I_B} = \frac{\beta}{R_{in}}$$

$$g_m = \frac{I_c}{V_{in}} \times \frac{V_{out}}{V_{out}} = \frac{A_v}{R_c}$$

Q An n-p-n transistor circuit is arranged as shown in the figure. It is a common

a) Base amplifier circuit (b) Collectedtor amplifier circuit

(c) Emitter amplifier circuit (d) None of these



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Q In a common emitter transistor amplifier the audio signal voltage across the collector is 3V. The resistance of collector is 3kΩ. If current gain is 100 and the base resistance is 2kΩ, the voltage and power gain of the amplifier is.

a) 15 and 200 (b) 150 and 15000
c) 20 and 2000 (d) 200 and 1000

ANS $V_{out} = 3V$ $A_V = \beta \frac{R_C}{R_B} = 100 \times \frac{3}{2} = 150$

$R_C = 3k\Omega$

$\beta = 100$ $A_P = \beta^2 \frac{R_C}{R_B} = 100 \times 100 \times \frac{3}{2}$

$R_B = 2k\Omega$

$\Rightarrow 15000$

Q In a CE transmitter amplifier, the audio signal voltage across the collector resistance of 2kΩ is 2V. If the base resistance 1kΩ and the current amplification of the transistor is 100, the input signal voltage is.

a) 0.1V (b) 1.0V
c) 1mV (d) 10mV

ANS $V_{out} = 2V$

$R_C = 2k\Omega$

$R_B = 1k\Omega$

$\beta = 100$

$A_V = \beta \frac{R_C}{R_B} = 100 \times \frac{2}{1} = 200 = \frac{V_{out}}{V_{in}}$

$V_{in} = \frac{2}{200} = 10mV$

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Q For a CE transmitter amplifier, the audio signal voltage across the collector resistance of $2k\Omega$ is 4V. If the current amplification factor of the transistor is 100 and the base resistance is $1k\Omega$, then the input signal voltage is.

a) 10mV (b) 20mV
c) 30mV (d) 15mV

$V_{out} = 4V$

$R_c = 2k\Omega$ $A_v = \beta \frac{R_c}{R_B} = 100 \times 2 = 200$

$\beta = 100$

$R_B = 1k\Omega$ $V_{in} = \frac{V_{out}}{A_v} = \frac{4}{200} = 20mV$ Ans

Q A npn transistor is connected in common emitter configuration in a given amplifier. A load resistance of 800Ω is connected in the collector circuit and the voltage drop across it is 0.8V. If the current amplification factor is 0.96 and the input resistance of the circuit is 192Ω, the voltage gain and the power gain of the amplifier will respectively be.

a) 4, 4 (b) 4, 3.69
(c) 4, 3.84 (d) 3.69, 3.84

Ans $R_L = 800\Omega$

$\beta = 0.96$

$R_B = 192\Omega$

$A_v = \beta \frac{R_L}{R_B} = 0.96 \times \frac{800}{192} = 4$

$A_p = \beta^2 \frac{R_L}{R_B} = 0.96 \times 0.96 \times \frac{800}{192} = \frac{96}{24} \times 0.96 = 3.84$ Ans

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Q The input resistance of a silicon transistor is 100 Ω. Base current is changed by 40 μA which results in a change in collector current by 2mA. This transistor is used as a common emitter amplifier with a load resistance of 4kΩ. The voltage gain of the amplifier is.

→ (a) 2000 (b) 3000

(c) 4000 (d) 1000

Ans

$R_B = 100\Omega$

$\Delta I_B = 40\mu A$

$\Delta I_c = 2mA$

$R_L = 4k\Omega$

$$A_v = \frac{\Delta I_c R_L}{R_B \Delta I_B} = \frac{\cancel{2}mA \times 4k}{_{20}\cancel{40}\mu \times 100\Omega}$$

$$\frac{10^{\cancel{3}} \times 10\cancel{0}\cancel{0}}{500\mu}$$

$$\Rightarrow \frac{10^4}{5} = 2\times10^3.$$

Q A transistor is operated in common emitter configuration at $V_c = 2V$ such that a change in the base current from 100 μA to 300 μA produces a change in the collector current from 10mA to 20mA. The current gain is....

(a) 50 (b) 75

(c) 100 (d) 25

Ans

$\Delta I_B = 200\mu A$

$\Delta I_c = 10mA$

$$\beta = \frac{\Delta I_c}{\Delta I_B} = \frac{1\cancel{0}\times10^{-3}}{20\cancel{0}\times10^{-6}} = \frac{100\cancel{0}}{2\cancel{0}} = 50$$

Q A common emitter amplifier has a voltage gain of 50 an input impedence of 100Ω and an output impedence of 200Ω. The power gain of the amplifier is.

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⇒ $A_v = 50$ $\qquad A_p = \beta^2 \times \frac{R_c}{R_B} = 25 \times 25 \times \frac{200}{100}$

$R_B = 100\Omega$

$R_c = 200\Omega$ $\qquad = 1250$ Ans

$A_v = \beta \frac{R_c}{R_B}$

$\frac{50 \times 100}{200} = 25$

Q A transistor is operated in CE configuration at $V_{cc} = 2V$, such that a change in base current from $100\mu A$ to $200\mu A$ produces a change in the collector current from $9mA$ to $16.5\ mA$. The value of current gain is......

Ans $V_{cc} = 2V$

$\Delta I_B = 100\mu A$

$\Delta I_c = 7.5mA$

$\beta = \frac{7.5 \times 10^{-3}}{10^{-4}} = 75$ Ans

Q The input resistance of a silicon transistor is $1k\Omega$. If base current is changed by $100\mu A$, it causes the change in collector current by $2mA$. This transistor is used as a CE amplifier with a load resistance of $5k\Omega$ What is the AC voltage gain of amplifier?

Ans $R_B = 1K\Omega$

$\Delta I_B = 100\mu A$

$\Delta I_C = 2mA$

$R_L = 5K\Omega$

$A_V = \frac{R_L \Delta I_C}{R_B \Delta I_B} = \frac{5 \times 2mA}{1 \times 100\mu} = \frac{10^{-3} \times 10^{6}}{10} = 100$ ANS

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Q What is the voltage gain in a common emitter amplifier, where input resistance is 3Ω and load resistance is 24Ω ($\beta = 0.6$)?

⇒ $R_B = 3\Omega$ $\quad A_v = \beta \frac{R_L}{R_B} = 0.6 \times \frac{24}{3} = 4.8$ Ans

$R_L = 24$

$\beta = 0.6$

Q A transistor cannot be used as.

a) Amplifier (b) Oscillator

c) Modulator (d) Rectifier.

★ Q The relationship between α and β is given by

a) $\alpha = \beta$ (b) $\alpha = \frac{1}{\beta}$

c) $\beta = \frac{\alpha}{1-\alpha}$

d) $\beta = \frac{\alpha}{1+\alpha}$

Ans Common emitter Common base

$\beta = \frac{I_c}{I_B}$ $\beta > 1$ [Current gain] $\quad \alpha = \frac{I_c}{I_E}$ $\alpha < 1$

⇒ $I_E = I_c + I_B$

Divide by collector both side

$$\frac{I_E}{I_c} = 1 + \frac{I_B}{I_c}$$

$$\frac{1}{\alpha} = 1 + \frac{1}{\beta}$$

$$\frac{1-\alpha}{\alpha} = \frac{1}{\beta}$$

$$\beta = \frac{\alpha}{1-\alpha}$$

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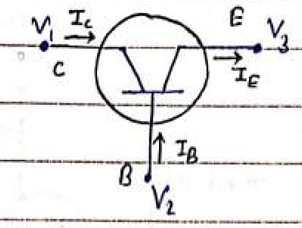


Relation b/w V_1 & V_3

$V_1 - V_{CE} = V_3$

$V_1 - V_3 = V_{CE}$

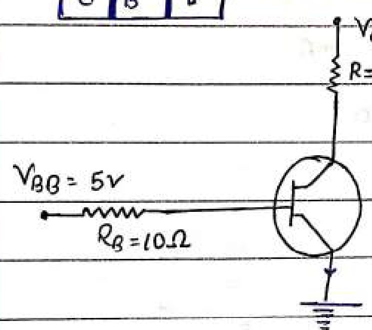
$\boxed{V_2 - V_{BE} = V_3}$

$V_{BE} = V_2 - V_3$

$V_{CB} + V_{BE} = V_{CE}$

C	B	E

Q



Find I_B, I_c and β if $V_{CB} = 0$ & $V_{CE} = 0$

→ $V_{BB} - \cancel{V_{EB} = 0}$ $\quad V_{BB} - I_B R_B - V_{EB} = 0$

$\cancel{V_{EB} = 5V}$ $\quad 5 - I_B R_B = V_{EB}$ → $5 = I_B \times 10$

$I_B = 0.5\ A$

$V_{cc} - I_c R_c - V_{CE} = 0$

$20 - I_c \times 5 - V_{CE} = 0$

$I_c = \frac{20}{5} = 4\ A$ Ans

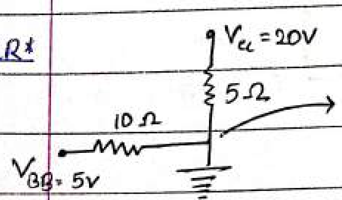
$\beta = \frac{I_c}{I_B} = \frac{4}{0.5} = 8$ Ans

$V_{CB} + V_{BE} = V_{CE}$

$0 + V_{BE} = V_{CE} = 0$

$\therefore V_{BE} = 0$

MR*



→ Because $V_{CB} = 0$

$V_{CE} = 0$

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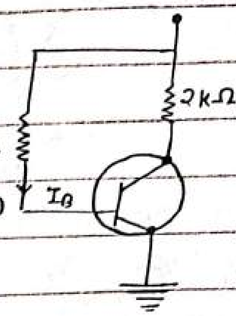
Q In the following transistor amplifier circuit $\beta = 50$. V_{CE} of the transistor is.



a) 4V ~~b)~~ 6V

c) 10V (d) 8V

Ans $10 - 245 \times 10^3 \times 40 \times 10^{-6} - V_{BE} = 0$

$10 - 2.45 \times 4 = V_{BE}$ No need to find V_{BE}

$0.2 = V_{BE}$

$\beta = \frac{I_C}{I_B} = \frac{I_C}{40\mu} = 50$

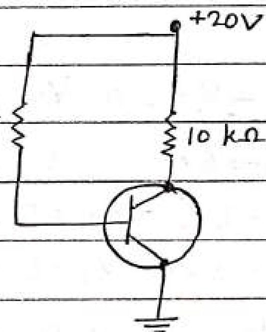
$I_C = 2 \times 10^{-3}\ A = 2mA$

$10 - 2 \times 10^3 \times 2mA - V_{CE} = 0$

$10 - 4 = V_{CE}$

$V_{CE} = \cancel{8}\ 6$

Q The given transistor amplifier connection is



a) Common base connection

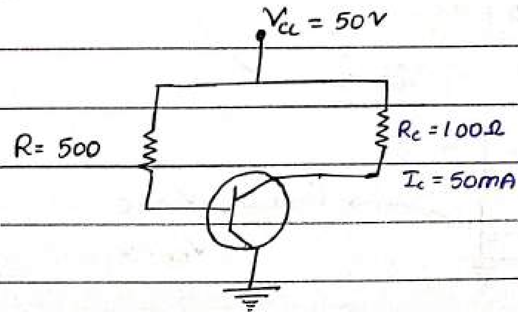
~~b)~~ Common emitter connection

c) Common collector connection

d) All of these

⇒ Imp point There is a phase difference of π between input and output voltage

Q Find V_{BE} if $\beta = 50$



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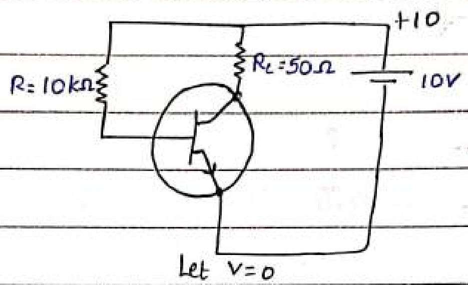
$\Rightarrow$ $\beta = \frac{I_c}{I_B}$ $\boxed{I_B = \frac{I_c}{\beta}}$

$I_B = \frac{50m}{50} = 1mA$

$50 - 10^{-3} \times 500 - V_{BE} = 0$

$V_{BE} = 50 - 0.5 = 49.5\ V$ Ans

Q If $V_{BE} = 0$ then find V_{CE} = ____, if $\beta = 100$



Ans $\beta = 100 = \frac{I_c}{I_B}$

$10 - I_B \times 10k\Omega - V_{BE} = 0$

$10 - I_c \times 50\Omega - V_{CE} = 0$

Given $V_{BE} = 0$

$10 = I_B \times 10 \times 10^3$

$I_B = 10^{-3} A$

$\beta = 100 = \frac{I_c}{I_B}$

$I_C = 100 \times I_B = 100 \times 10^{-3} = 0.1 A$

Now

$10 - 0.1 \times 50 = V_{CE}$

$V_{CE} = 5V$ Ans

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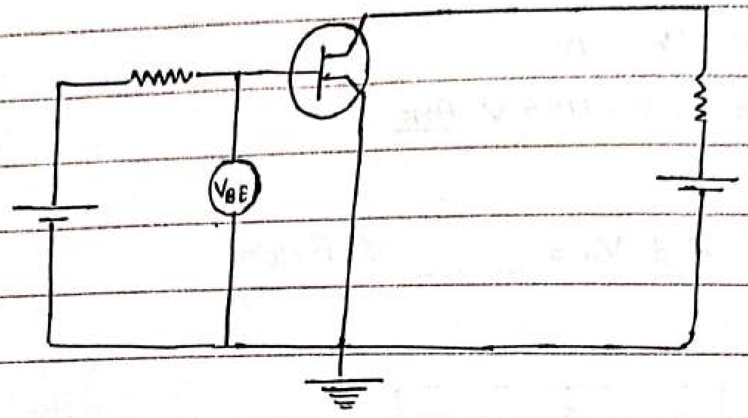
Transistor as a switch (NPN)



$V_{in} = V_{BE} + I_B R_B$ ------- (i)

$V_{out} = V_{cc} - I_c R_c$ ------ (ii)

Case-1

If $V_{in} \cong 0.1$ volt

cut off region

$I_B = 0$; $I_c = \beta I_B = 0$

$|V_{out}|_{max} = V_{cc} - I_c R_c = V_{cc}$

$V_{out} = V_{cc}$

Case-2

$V_{In} = 0.4$ volt

$I_B \uparrow$

$I_c \uparrow = \beta I_B$

$V_{out} = V_{cc} - (I_c R_c) \uparrow$ = decrease

Case-3

If V_{in} = knee voltage = 0.5 volt or 0.7 volt

I_B = sharp increase

I_c = sharp increase

V_{out} = decrease fast (sharp)

Case-4

V_{in} > knee voltage

I_B = maximum

I_c = maximum

$V_{out} = V_{cc} - I_c R \approx 0$

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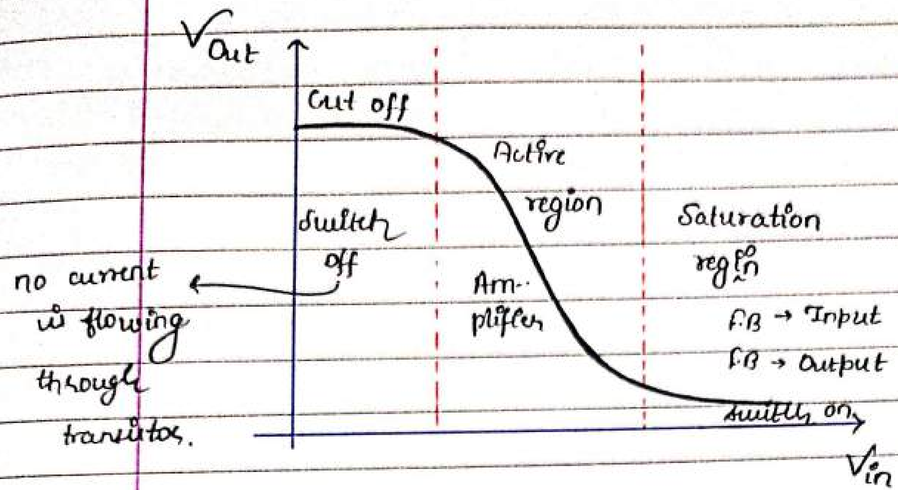


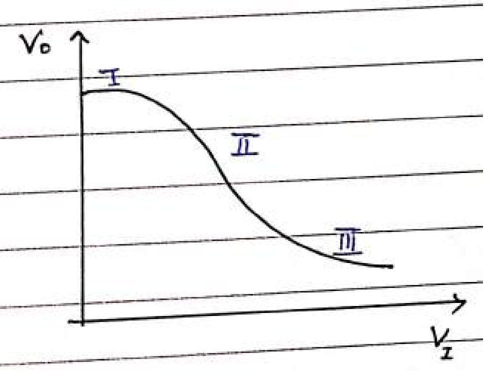
Jab input '0' output high

Jab input high output zero

Q. Transfer characteristic [output voltage (V_o) vs input voltage (V_i)] for a base biased transistor in CE confrigaration is as shown in the figure. For using transistor as a switch, it is used

a) In region II (b) In region I

c) In region III (d) Both in region (I) & (III)



An oscillator is an amplifier with positive feedbauk

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