Handwritten Notes
On
Semi Conductors

Excess S ⇒ upto 0.15 Error
5 Que Jeemain

Semi-Conductors

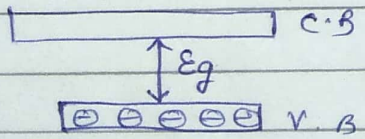
4) **Energy Band Theory of Solid :-** In a solid Every atom Consist of central nucleus and e$^{\ominus}$s revolved around the nucleus in different orbits Called Energy levels.
Energy levels are represented on a diagram by discreat energy lines Called energy level diagram

In a crystall of solid atoms are very closely packed such that their energy levels overlapped. due to overlapping energy levels split up and form an energy region instead of discreat energy lines. This energy region is called energy band. in a solid e$^{\ominus}$s are found in energy band instead of energy levels.

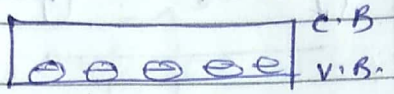
All the energy level are not splited. Outermost energy levels are more splited. Innermost energy levels remains unsplited due to interaction of Nucleus

Energy difference b/w two energy band called forbidden energy gap.

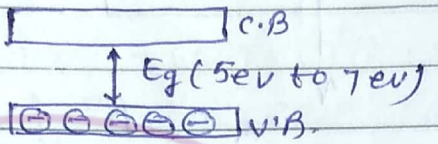
Energy band corresponding to valence electron Called valence band
An empty band above valence band called Condection band.



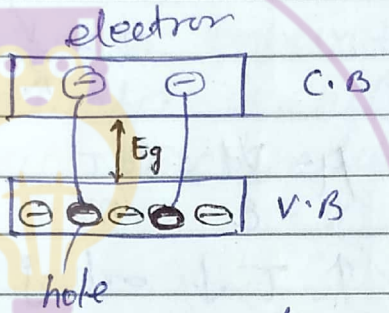
* Conductors: these are the substances having unpaired $e^{\ominus}$'s valence band and conduction band overlap in conductors. valency $e^{\ominus}$ are free electrons hence their conductivity is high



* Insulators: They have large energy gap b/w valence band and conduction band



* Semi conductors:



Energy band b/w valence band and conduction band is small some electrons reach to conduction band from valence band due to thermal energy at room temp. hence a vacancy is created in the valence band known as hole. In pure semiconductor holes and $e^{\ominus}$ concentration are equal

$$n_h = n_e = n_i$$

Pure semiconductor

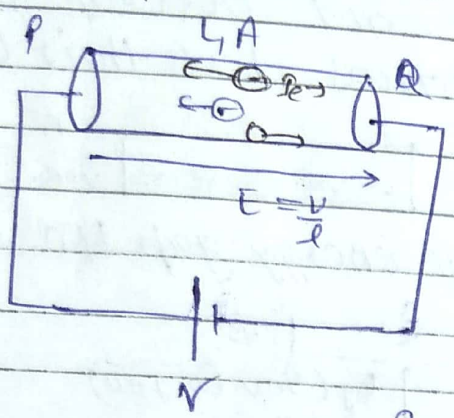
Intrinsic semiconductor

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

n_h = no. of hole/vol.

n_e = No. of $e^{\ominus}$/volu.

* Conduction in Semiconductors :



$$V_d = \frac{eE\tau}{m}$$

$$\sigma = \frac{ne^2\tau}{m} = ne\mu$$

$$\rho = \frac{m}{ne^2\tau}$$

$$R = \rho \frac{l}{A}$$

$$I = \frac{V}{R} = neAV_d$$

mobility $\mu = \frac{V_d}{E} = \frac{e\tau}{m}$

Temp. ↑ τ ↓ σ ↓ ρ ↑ R ↑

$$R = R_0(1 + \alpha \Delta t)$$

In a Semiconductor e^- moves in Conduction band and holes in valence band Producing electron current and hole current hence net current is the sum of electron current and hole current

$$I = I_e + I_h$$

Pure Semi-conductor

$$n_h = n_e = n$$

Conductivity

$$\sigma_e = n e \mu_e \qquad \sigma_h = n e \mu_h$$

$$\sigma = ne(\mu_e + \mu_h)$$

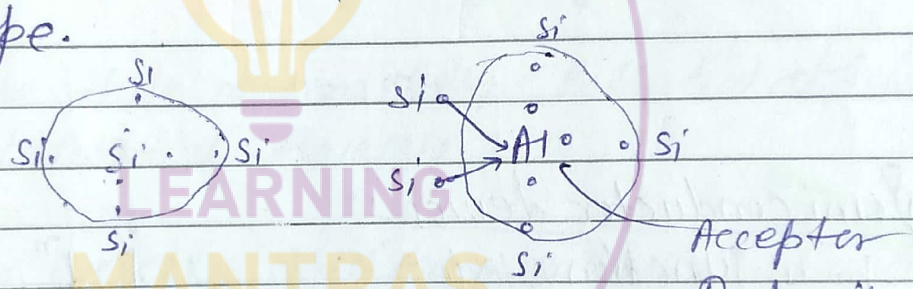
$\rho = \frac{1}{\sigma}$ $R = \rho \frac{l}{A}$ S.C. $\sigma \uparrow$ $T \uparrow$

$I = \frac{V}{R} = I_e + I_h$ $R \downarrow$

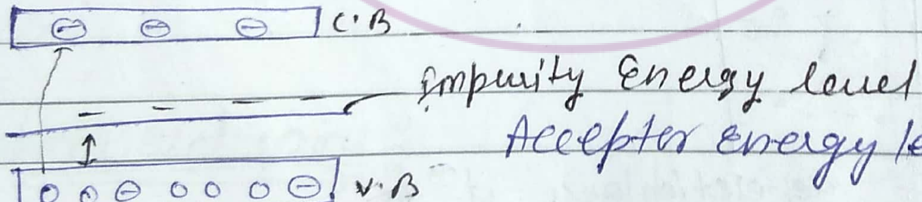
Conductivity of Pure semiconductor increases with increase in temp and resistance decreases.

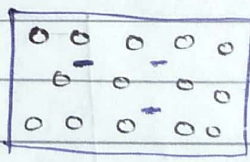
Conductivity of pure Semi-conductor is very small and of no Practicle use. To increase conductivity an impurity as to be added in Pure semiconductor the Process of adding in Impurity is called doping. and semiconductor is called impure or dopped or extrinsic semiconductor. and it is of two type.

i) P-types:



Bend theory





P type

$n_h >>> n_e$

majority charge carrier — minorty charge carrier

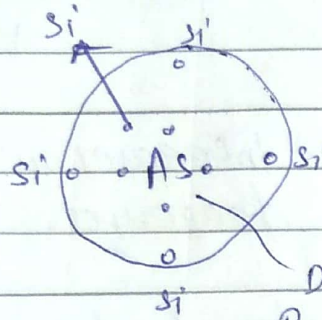
if N_A - Accepter concn.

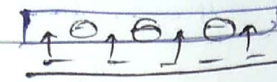
$n_h \simeq N_A$

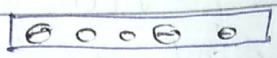
$n_h n_e = n_i^2$

or $N_A n_e = n_i^2$

(ii) n-type : Penta valent impurity







$n_h < < < < n_e$

minority majority

N_D : Donor Conc.

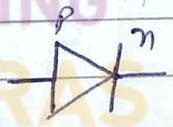
$n_e \simeq N_D$

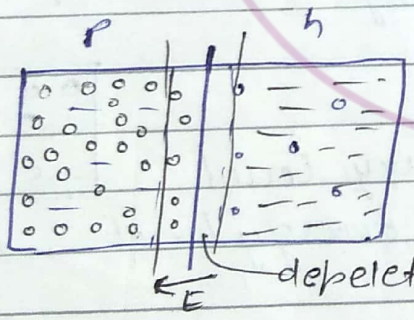
$n_e n_h = n_i^2$

$N_D n_h = n_i^2$

* Semiconductor device :

(1) p-n junction diode :





depeletion layer = $d \simeq 10^{-6}$

$E = \frac{\Delta V}{\Delta x}$

Si — 0.7V

Ge — 0.3V

$E = \frac{0.3}{10^{-6}}$

$= 3 \times 10^5$ V/m

P–n junction is formed by adding donor impurity at one side and Acceptor impurity on another side of a Semi Conductor

As the junction is formed e and holes moves towards each other and Combined near the junction to neutralised each other

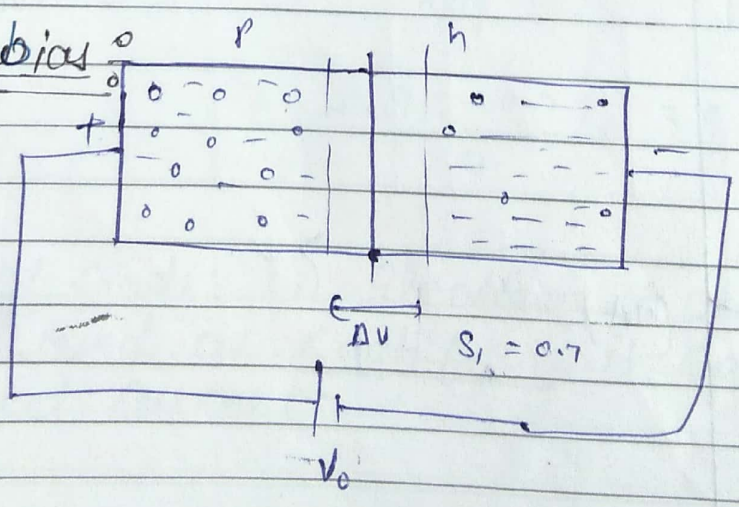
Hence n side become positively charge and P side Negatively charge

A Potential difference is developed across the junction which opposes the motion of majority charge careers.

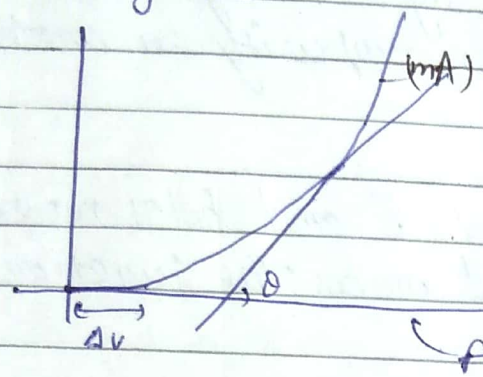
after some time their motion stops Potential at this moment called Potential Barrier

Minority charge careers still move across the junction Hence a very small current flow across the junction from n type to p type called Reverse Saturation Current

① forward bias



R - very small

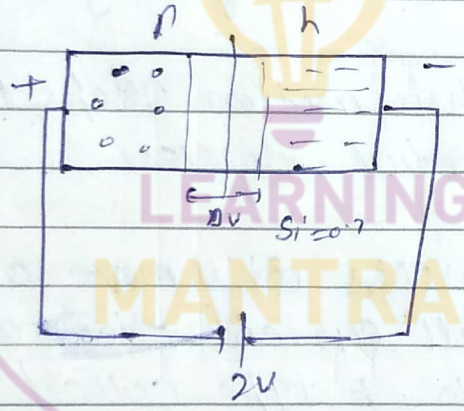


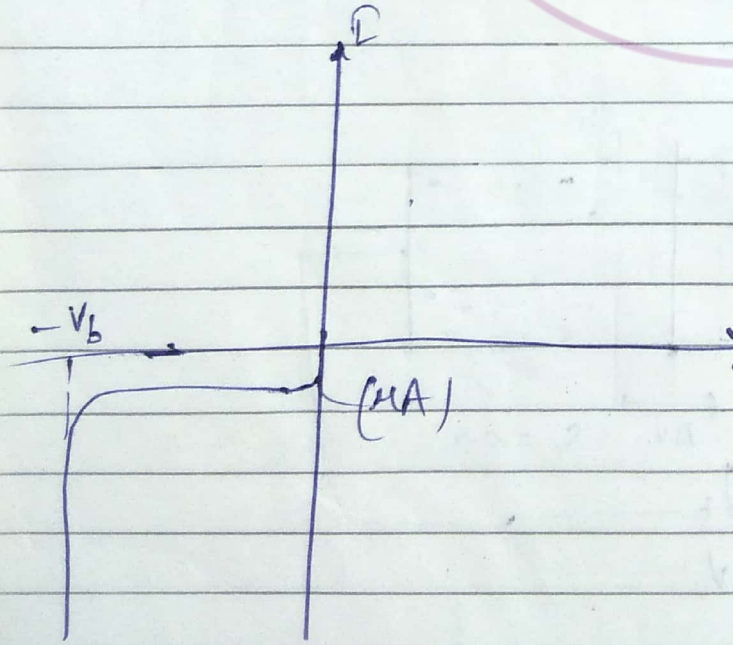
forward characteristic

$$\tan\theta = \frac{dI}{dV}$$

$$R_f = \frac{dV}{dI} = \frac{1}{\tan\theta}$$

* Reverse Bias:





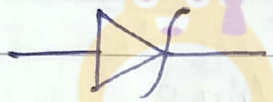
V_b = Break down Voltage

p → n.

n → p

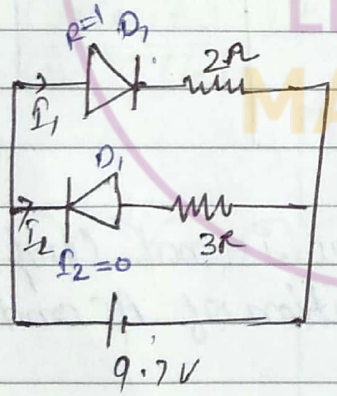
In Reverse Bias Potential Barrier and width of diplation layer increases. a very small Current flow from n-type to p-type which Remains constant with increase in Reverse Bias voltage at a Perticular Voltage Current Suddenly increases even when Potential is kept this Phenomina is called Avalanche Breakdown.

At Break down Covalent Bonds are Broken near the junction and a no. of electrons becomes free this Phenomina is used in Voltage Stabilisation.

* Zener Diode :- 

It is havily doped diode. It works in Reverse Bias Break down occurs before avalanche Breakdown called Zener Break down.

Que :



~~R=2.~~

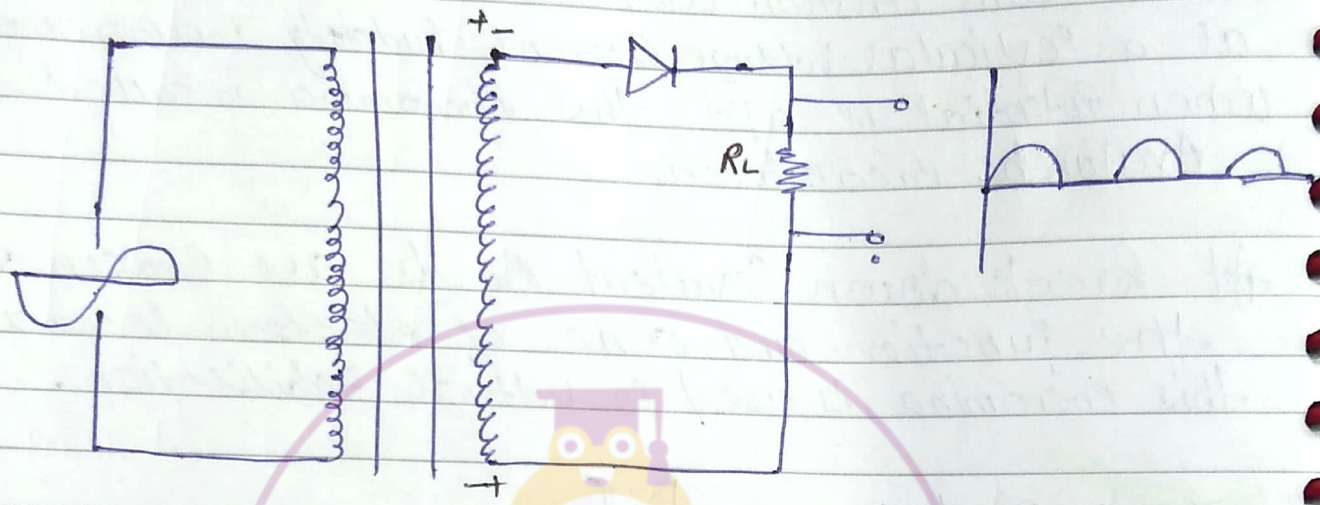
find current I_1 and I_2

$$I = \frac{V - \Delta V}{Req.}$$

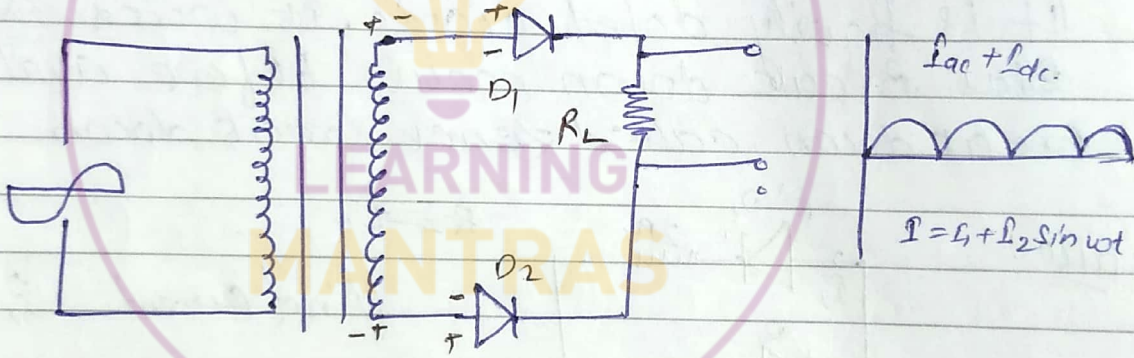
$$= \frac{9.7 - 0.7}{3} = 3A.$$

* Applications of Diode : In Electronic circuit diode is used as Rectifier it converts AC to Direct Current.

① As half wave Rectifier:



② As full wave Rectifier:



Output current from the Rectifier is not completely direct current it is a combination of AC and DC

* form factor: $f = \frac{I_{rms}}{I_{dc}}$

$H \cdot \omega \cdot R = F \omega R$

$F = \frac{\pi}{2\sqrt{2}}$ $\quad f = \frac{\pi}{2}$

* Ripple factor: $\gamma = \frac{I_{ac}}{I_{dc}}$

$$I_{rms} = \sqrt{I_{ac}^2 + I_{dc}^2}$$

$$I_{rms}^2 = I_{ac}^2 + I_{dc}^2$$

$$\left(\frac{I_{rms}}{I_{dc}}\right)^2 = \left(\frac{I_{ac}}{I_{dc}}\right)^2 + 1$$

$$\boxed{f^2 = r^2 + 1}$$

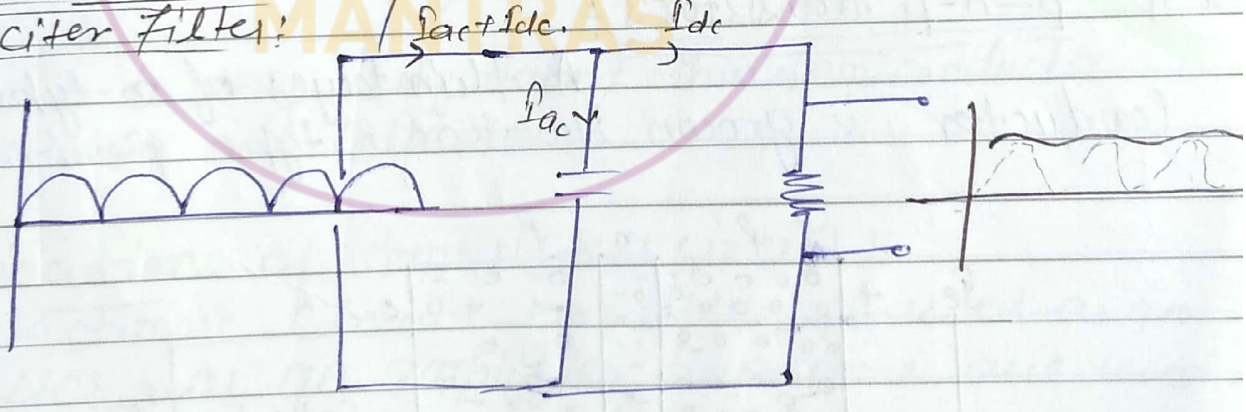
* **Efficiency:** $\eta = \frac{P_{out}}{P_{input}}$

H.W.R
$\eta = 40.6\%$

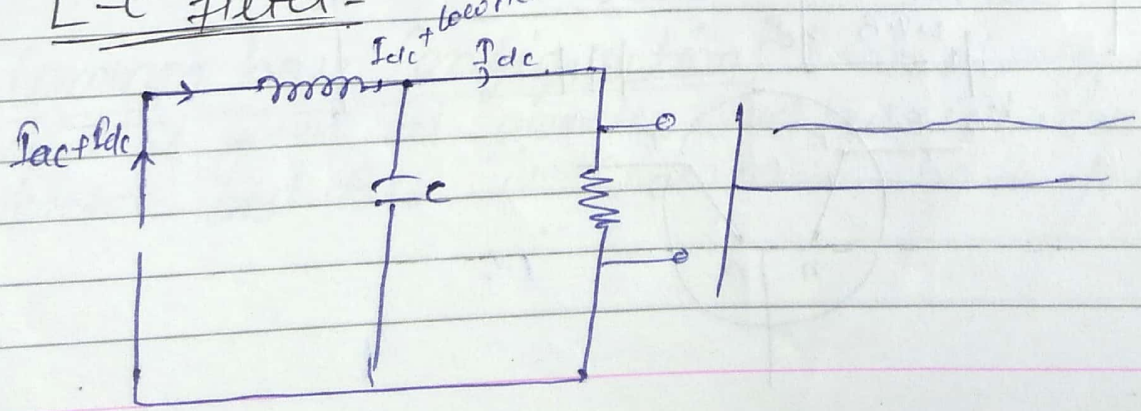
F.W.R
$\eta = 81.2\%$

* **Filter Circuit:** It seperate AC component from DC.

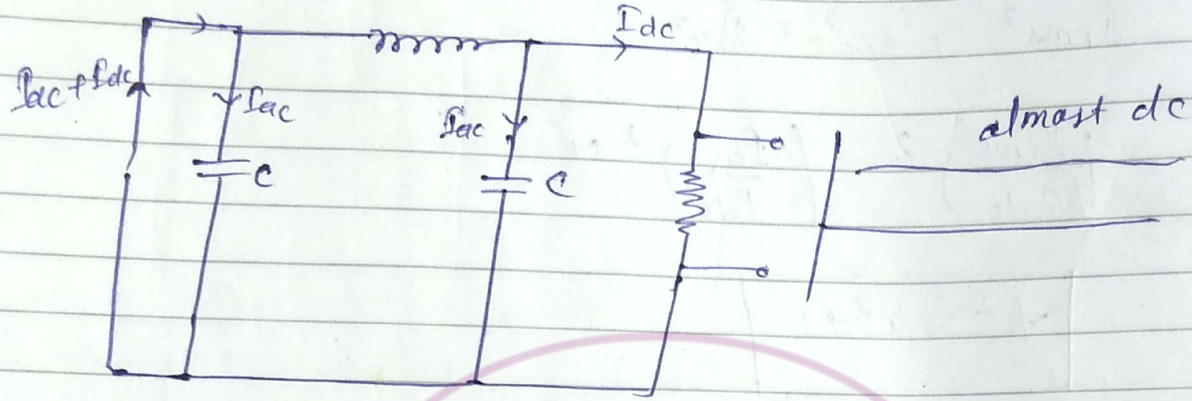
① **Capacitor Filter:**



② **L-C filter:**



(3) π - filter:

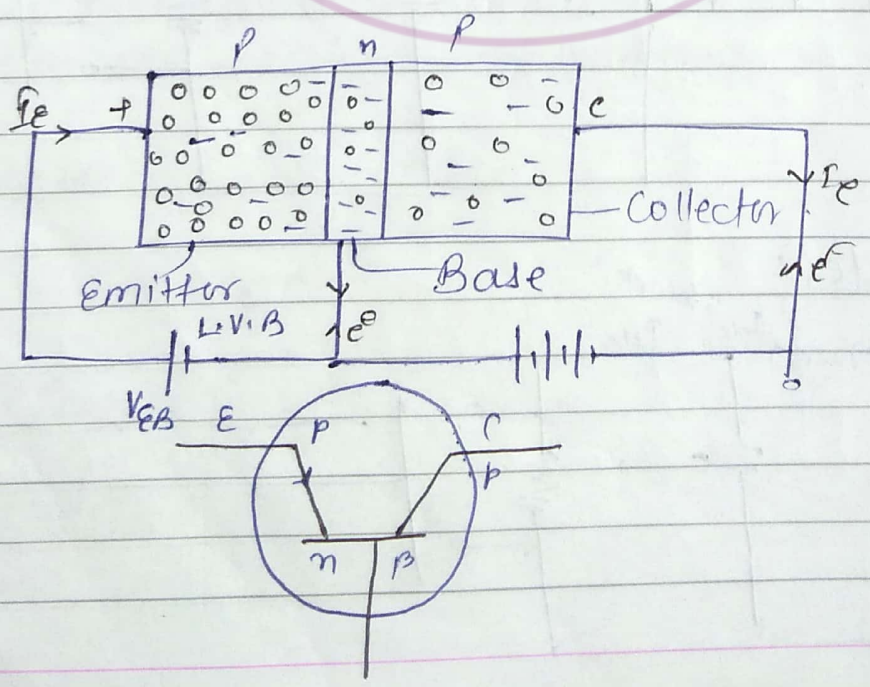


* Transistors :-

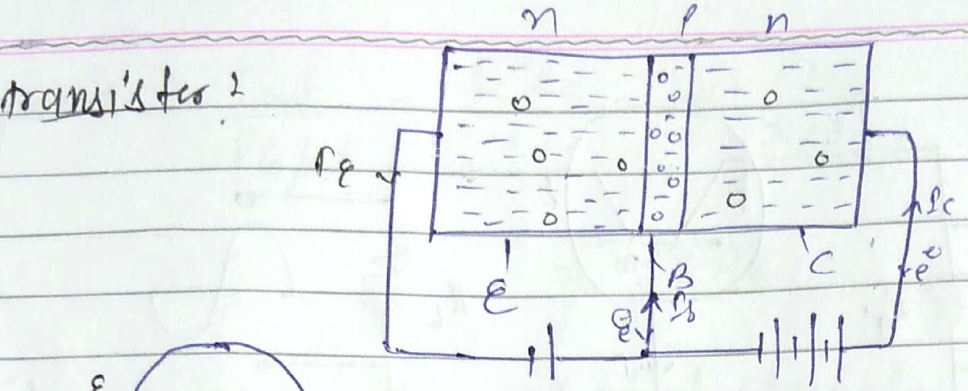
These are the semiconductors device which transfer a signal from low resistance region to high resistance region which results in the amplification of signal. hence transistors are also used as an amplifier

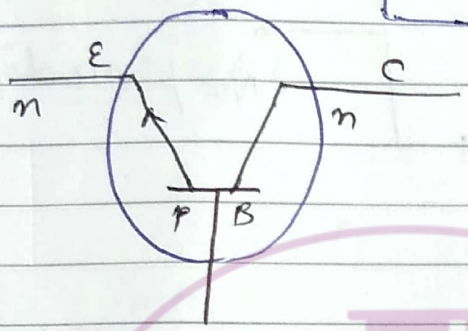
⇒ 1) p-n-p transistors :-

A thin layer of n-type semi-conducter is grocon b/w two p type semi-conducters.



n-p-n transistor:





$$I_E = I_b + I_c$$

$$I_b = 0.2\, I_E$$

$$I_c = 0.98\, I_E$$

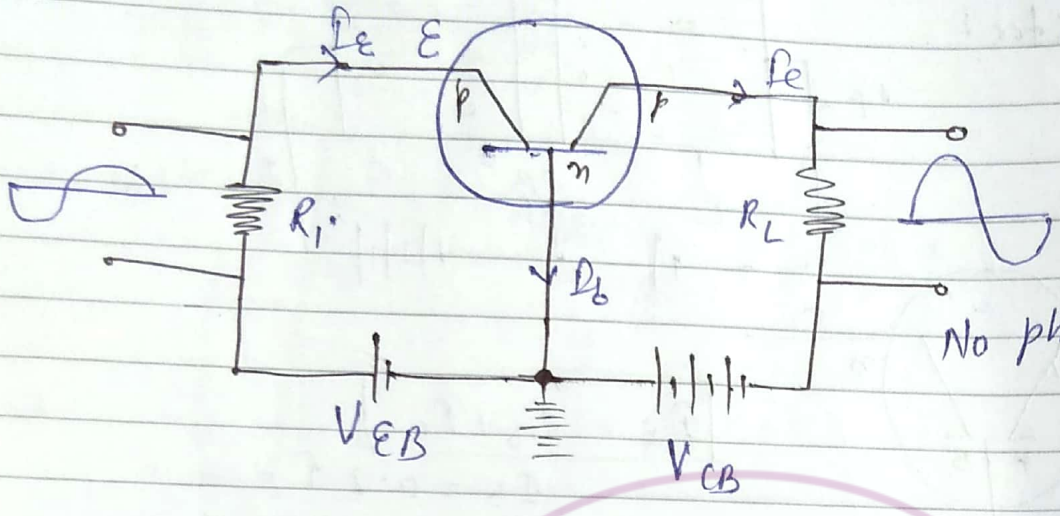
* Emitter: It provide charge carriers to Base and Collector. Hence it is heavily doped and always caped in ferword bias.

* Collecter: It recieve charge carrier coming from emitter through base. It is caped in reverse bias. It is moderatly doped ~~base~~.

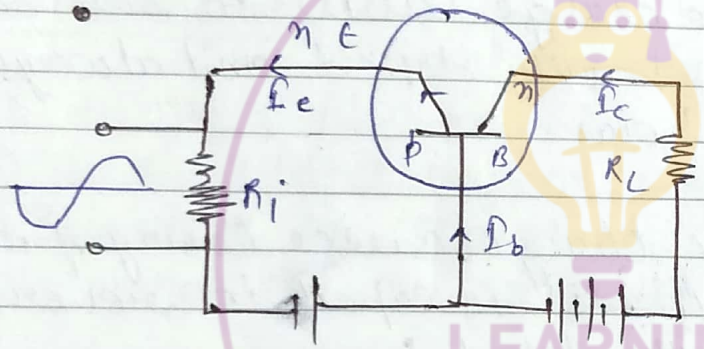
* Base: It is very likely doped thin semiconducter b/w emitter and collecter

* Applications of transisters circuit:
In electronic circuit transister is used as an amplifier. as an amplifier transistors are used in three configuations

① Common base Configuation: In this configuation input is given at ammeter. Output is taken at collector and Base is common in both the circuits



No phase diff.



npn

$$I_E = I_b + I_C$$

(i) Current gain (α) :

$$\alpha = \frac{\text{Out put Current}}{\text{Input Current}}$$

$$\alpha = \frac{I_C}{I_E} < 1$$

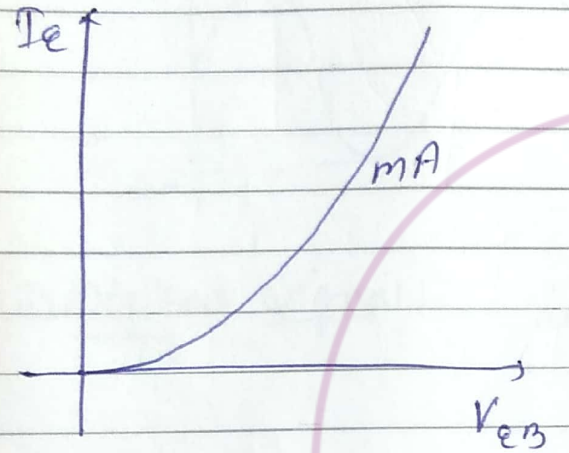
(ii) Voltage gain (Av) : $A_V = \frac{V_{out}}{V_{input}}$

$$A_V = \frac{I_C R_L}{I_E R_i} = \alpha \frac{R_L}{R_i}$$

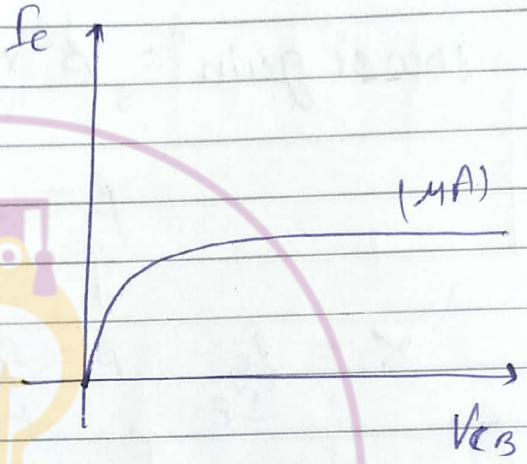
* Power gain: $\frac{P_{out}}{P_{input}} = \frac{I_c^2 R_L}{I_e^2 R_i} = \alpha^2 \frac{R_L}{R_i}$

$= \alpha \times A_v$.

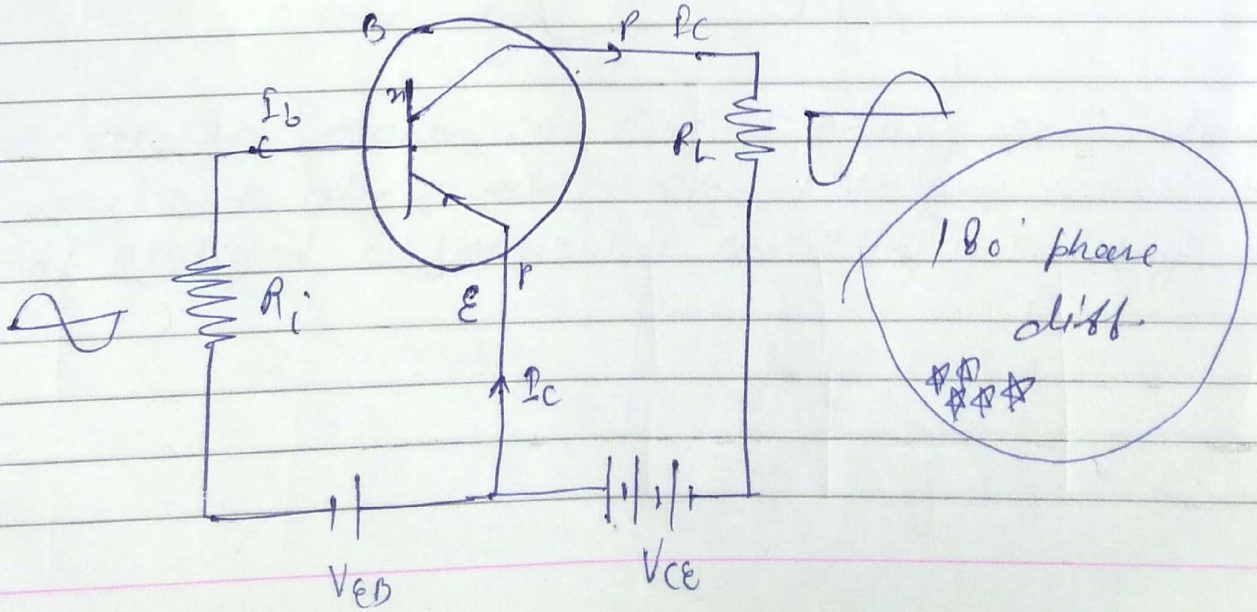
* Input characteristic



Output characteristic



(ii) Common Emitter Configuration:



α =

Current gain $\beta = \frac{I_c}{I_b} \approx 49$

Voltage gain $A_V = \frac{I_c R_L}{I_b R_i} = \beta \times \frac{R_L}{R_i}$

Power gain $= \beta^2 \times \frac{R_L}{R_i}$

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

$$\alpha = \frac{I_c}{I_E} \qquad \beta = \frac{I_c}{I_b}$$

$$\frac{1}{\alpha} = \frac{I_E}{I_c} = \frac{I_c + I_b}{I_c} = 1 + \frac{I_b}{I_c}$$

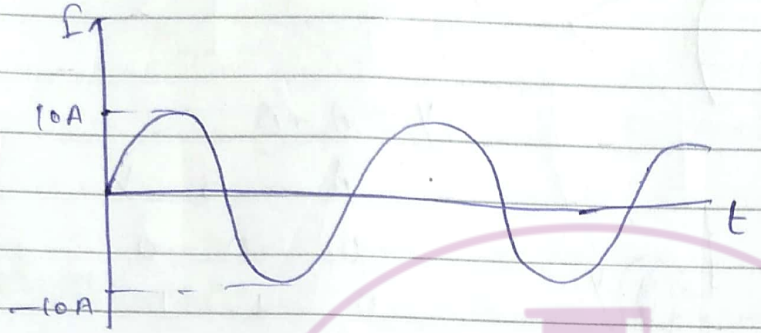
$$\frac{1}{\alpha} - 1 = \frac{I_b}{I_c} \qquad \frac{I_b}{I_c} = 1 - \frac{\alpha}{\alpha}$$

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

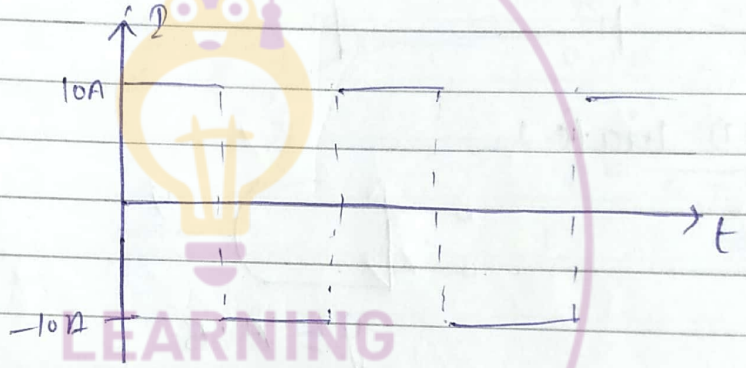
* Logic Gate:

(1) Signal :- It is a function of time carrying Information

(i) Analog signal :- It is continuous function of time



(ii) Digital Signal :



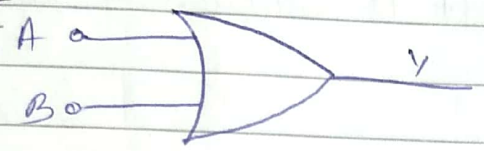
Boolean Algebra :

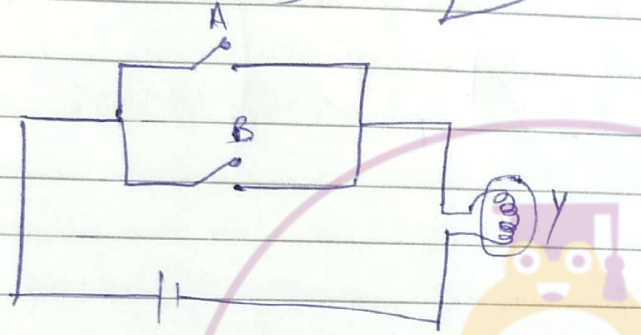
0	1
min	max
NO	Yes
false	true.

These are the electronics Circuit adding semiconducts devices which allow ~~the~~ a signal to pass when signal satified a perticular condition called logic

* Truth table: It is a combination of all the possible input and output

(i) OR Gate:

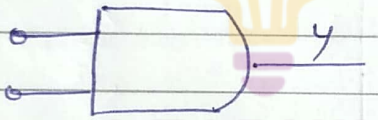




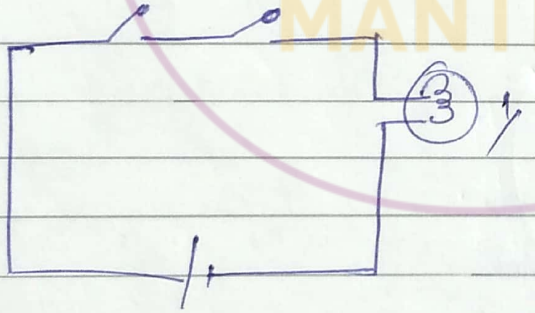
$Y = A + B$

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

(ii) AND Gate:

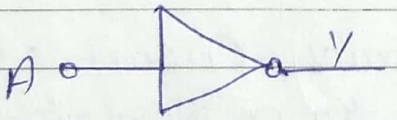


$Y = A \cdot B$

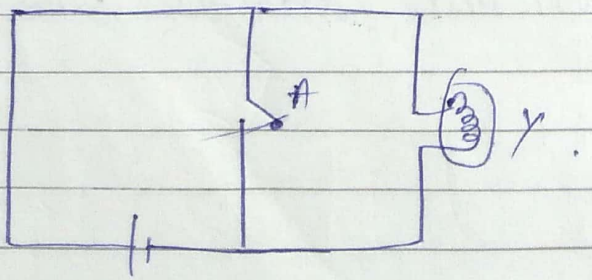


A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

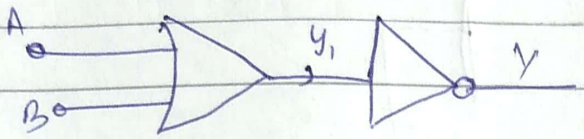
(iii) NOT Gate:



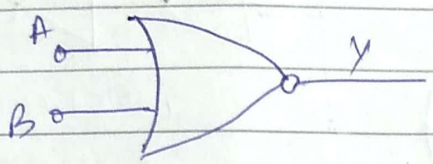
A	Y
0	1
1	0



NOR Gate:



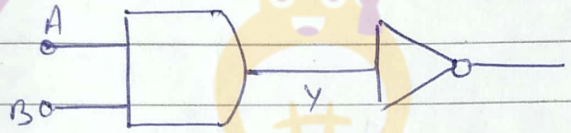
A	B	y_1	y
0	0	0	1
0	1	1	0
1	0	1	0
1	1	1	0



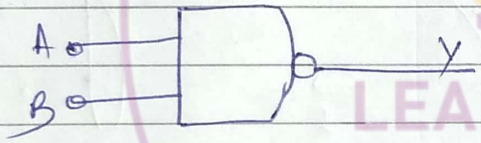
$y = \bar{y_1}$

$y = \overline{A+B}$

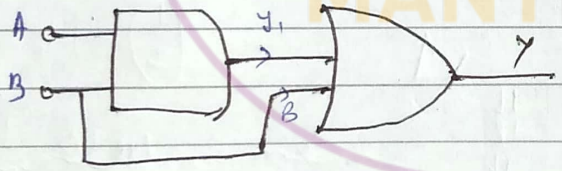
NAND Gate:



A	B	y_1	y
0	0	0	1
0	1	0	1
1	0	0	1
1	1	1	0



Ex!



write Boolean exp & truth table

$y = \frac{A \cdot B}{2} + \frac{A+B}{2}$

$y = y_1 + B = A \cdot B + B$

A	B	y_1	y
0	0	0	0
0	1	0	1
1	0	0	0
1	1	1	1

Redundant