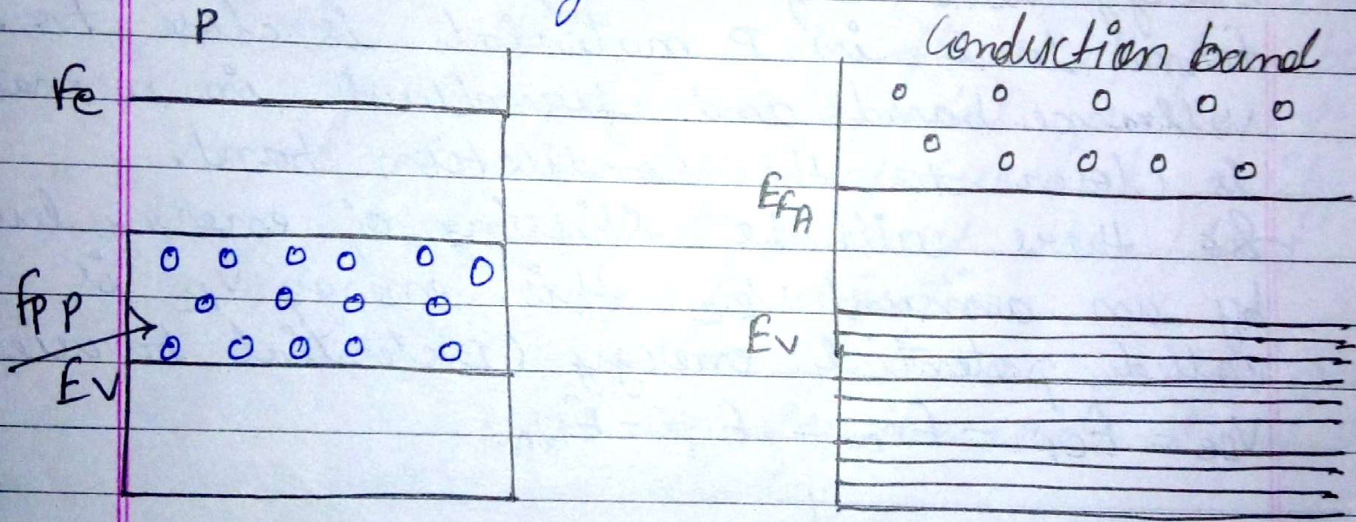
# Unit - IV th

## ✱ P-N Junction →

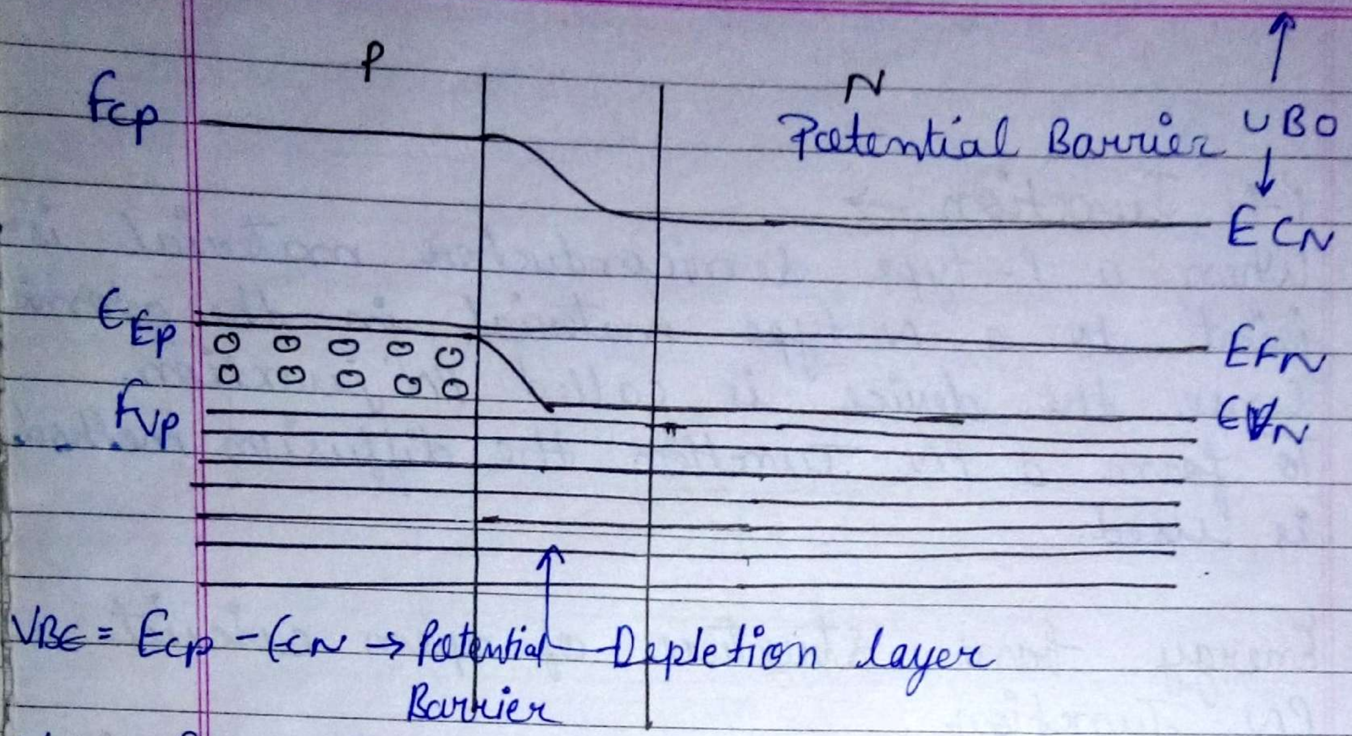
When a P-type semiconductor material is joint to a N-type material in the atomic sense the device is called PN junction. To form a PN Junction the diffusion method is used.

## ✱ Energy band structure of open circuit PN Junction.

Energy level digram for P and N semi-conductors before junction formation as shown in digram

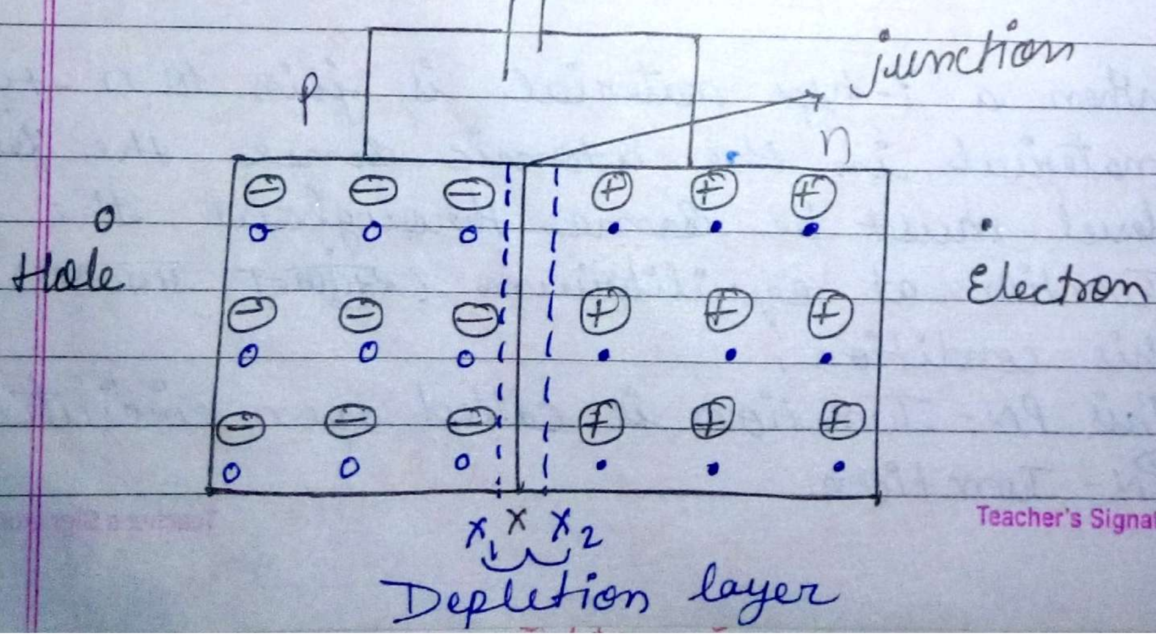



When a P-type material is join to n-type material in the atomic sense the fermi level must be same throughout the PN Junction at equilibrium (संतुलन अवस्था) under this condition.
This PN-Junction is called open circuited PN-Junction.




$V_{BE} = E_{VP} - E_{VN}$

Energy band digram of PN Junction →
fermi level in P material is close to the vallance band and fermilevel in n materia is closer to the conduction band.
So there will be shifting of energy levels by an amount $V_{Be}$ this energy $V_{Be}$ is called potential energy (potential barrier)
$V_{Be} = E_{CF} - E_{CN} = E_{VP} - E_{VN}$



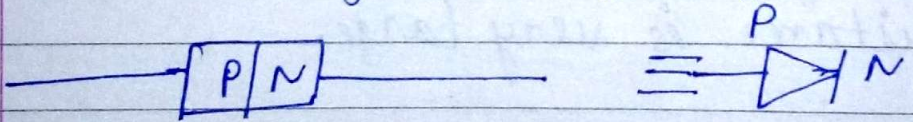
- Holes diffuse from the P side to N side while electrons diffuse the N side to P side.
- This process of diffusion thin layer at the junction formed. In this layer at the holes capture the electrons and no charge remain fill.
- This region of the junction is depleted of the free charge carriers and the layer so formed is called depletion layer.

## PN-Junction as a rectifier →

- (During the formation of a PN junction a potential barrier is developed at the junction which the flow of free charge. This structure has a special feature that it allows the flow of current easily in one direction but abstruct the flow of current in opposite direction.

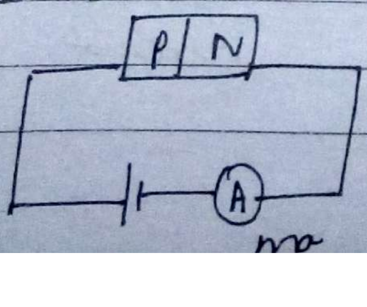
Thus, a PN-Junction acts as a rectifier diode, So called is PN junction diode or Semiconductor diode.

Circuit diagram of PN junction diode is



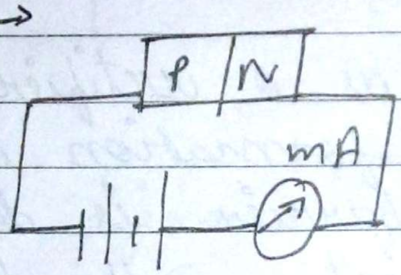

## Biasing of a P-N junction Diode →

(a) forward bias →



if a PN junction diode is connected to a battery in such a way that P- terminal of diode is connected to positive terminal or battery and N-terminal.
~~Then~~ Then the diode is said to be forward bia
In forward bias the weight of the potential barrier is reduced large amount of curre of the order of mA exist and the resistance is very low (~100 Ω).

(b.) Reverse bias→




- If the P terminal of diode is connected to negative terminal of battery and negative terminal of ~~battery~~ diode is connected to +ve terminal of battery than the diode is said to be reversed bias.
- In this bias height of the potential barrier is increased i.e a small current of the order of few micro ampere does exist and the resistance is very large.

EMF → open circu

Terminal Potential diff. → closed circuit

# P-N junction diode as a rectifier –

## Rectification →

- There are two types of current
(i) Direct Current (D.C.)
(ii) Alternating Current (A.C.)

Direct current →
In which the magnitude and direction of flow of current remains constant.

Alternate Current →
Alternate current have direction and magnitude both depends on time and change with time.

* Rectification is the process by alternating voltage is converted in direct voltage.
- The device used for rectification is called Rectifier

* Rectifiers are of mainly two types –
(i) half wave rectifier →
- In which only half of the cycle of input alternating voltage is used the other half remains unused.
(ii) full wave rectifier →
- In which the full wave of the input alternating voltage is used.

## Half wave rectifier —

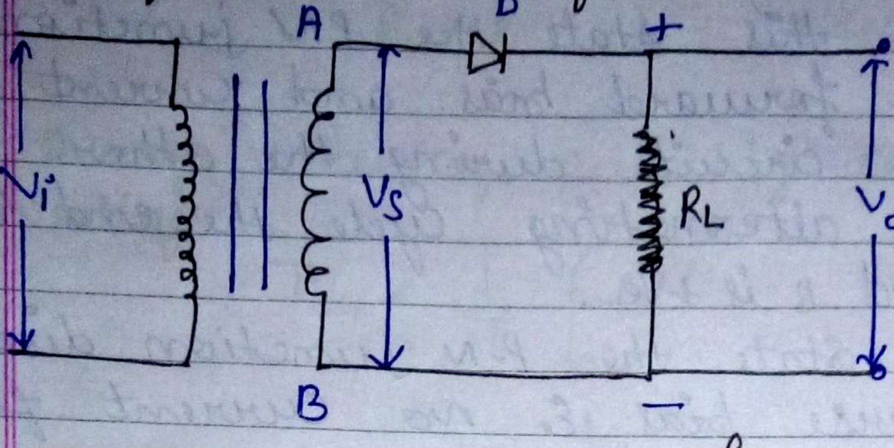



fig —(i)

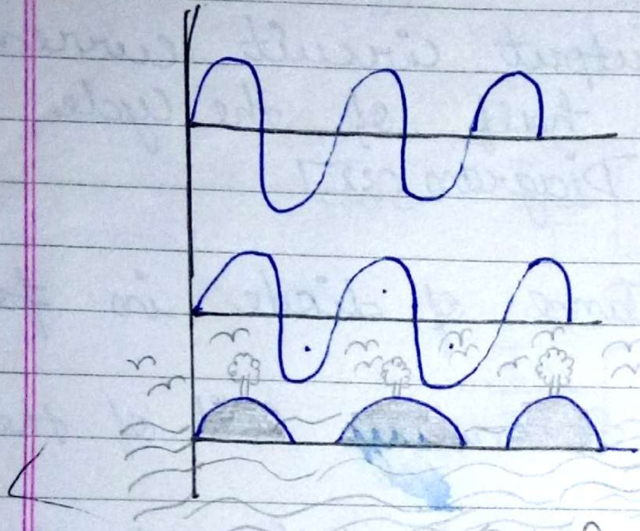


fig- (ii)

The circuit diagram of half wave rectifier is given in diagram(i). The source of alternating voltage is connected to the primary coil of the transformer and the secondary coil is connected to a diode & resistance in series.

- When the input voltage on the primary coil of the transformer is $V_i = E_p \sin\omega t$
- The secondary voltage is $V_S = n E_p \sin\omega t$

n → Ratio of No. of turns in secondary and in primary coils

For the +ve half cycle of the alternating voltage $V_i$ the end A of secondary coil is at a +ve voltage & B at -ve voltage!

- During this state the PN junction diode is in forward bias and current flows in the circuit during the other half of the alternating cycle the end A is -ve and B is +ve.
- In this state the P-N junction diode is in reverse bias & no current flows in the circuit.
- Thus, in the output circuit current flows only for half of the cycle of input voltage [Diagram (2)]

Suppose the resistance of diode in forward bias is $R_f$.
The resistance of secondary coil of the transformer is $R_s$.
Then, the current flowing through the resistance $R_L$ is $i = \frac{V_s}{R_s + R_f + R_L}$

$$i = \frac{V_s}{R_L + R} \quad (\because R_s + R_f = R)$$

$$i = \frac{nE_P \sin \omega t}{R_L + R} \quad (\because V_s = nE_P \sin \omega t)$$

$$i_m = \frac{E_m \sin \omega t}{R_L + R} \quad (\because E_m = nE_P)$$

$$i = i_m \sin \omega t \quad 0 < t < T/2$$

$$i = 0 \quad T/2 < t < T$$

$$I_m = \frac{E_m}{R_L + R}$$

a) Average value of pulsating current and voltage

$$I_{dc} = \frac{1}{T}\int_0^T i\,dt$$

$$I_{dc} = \frac{1}{T}\int_0^{T/2} I_m \sin\omega t\, dt$$

$$I_{dc} = \frac{I_m}{T}\left[-\frac{\cos\omega t}{\omega}\right]_0^{T/2}$$

$$= \frac{I_m}{T\omega}\left[-\cos\omega t\right]_0^{T/2}$$

$$= \frac{I_m}{2\pi}(1+1) \Rightarrow \frac{I_m}{\pi}$$

$$I_{dc} = \frac{E_m}{(R_L+R)\pi}$$

☆ RMS value of Pulsative current →

$$I_{rms} = \left[\frac{1}{T}\int_0^T i^2\,dt\right]^{1/2}$$

$$I_{rms} = \left[\frac{1}{T}\int_0^{T/2} i_m^2 \sin^2\omega t\right]^{1/2}$$

$$I_{rms} = \left[\frac{I_m^2}{2T}\int_0^{T/2}(1-\cos 2\omega t)\,dt\right]^{1/2}$$

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$$= \frac{I_m}{2} \Rightarrow \frac{E_m}{2(R+R_L)}$$

(c) Efficiency of Rectifier →

$$\eta = \frac{\text{output dc Power}}{\text{Input dc power}}$$

$$\eta = \frac{P_{dc}}{P_{ac}}$$

$$P_{dc} = I^2_{dc} R_L = \frac{I^2_m}{\pi^2} R_L$$

$$P_{ac} = I^2_{rms}(R+R_L)$$

$$P_{ac} = \frac{I^2_m}{4}(R+R_L)$$

$$\eta = \frac{P_{dc}}{P_{ac}} = \frac{I^2_m}{\pi^2} \frac{R_L \times 4}{I^2_m (R+R_L)}$$

$$\eta = \frac{4 R_L}{\pi^2 (R+R_L)}$$

$$\eta = \frac{4R_L}{\pi^2 R_L \left(\frac{R}{R_L}+1\right)}$$

$$\eta = \frac{4}{\pi^2\left(1+\frac{R}{R_L}\right)}$$



$$\eta = \frac{0.406}{(1+R/R_L)} \%$$

(d) Ripple factor →

- The output voltage and current are uni-directional but not constant and vary with time.
- The alternating variation present in the output is called Ripple.
- It is measured by a constant called ripple factor.

$$\text{Ripple factor} = \frac{\text{The effective value of ac component in output}}{\text{The dc component in output}}$$