Unit - II

1 Mark Questions

Marks	BL	CO
1	L_1	C112.1

① What is Fermi level ?

A:- In metal, there is one partially filled band which is a result of conduction band overlapping with valence band. In this band lowest energy levels are filled first. The highest occupied energy level at absolute zero temperature (0K) is called as Fermi level. Energy corresponding to it is called as Fermi energy denoted by E_F.

Marks	BL	CO
1	L_1	C112.1

② What is Hall effect ?

A:- If a metal or Semiconductor carrying a current (I) is placed in a transverse magnetic field (B), an electric field (E) is induced in the direction perpendicular to both the direction of current and magnetic field. This phenomenon is called as Hall effect.

Marks	BL	CO
1	L_1	C112.1

③ What are the Examples of Extrinsic Semiconductor ?

A:- Depending on the type of doping material used, Extrinsic Semiconductor can be classified as:

1) N-type Semiconductors :- A pentavalent impurities are doped with Pure Semiconductor.

2) P-type Semiconductors:- A trivalent impurity such as Boran is mixed with the pure Semiconductor

④ What are the applications of photodiodes?

A: photodiodes are used as,

→ High voltage rectifier
→ RF Switch
→ photodetectors
→ distance measurement,
→ data transmission and range finding.

Name	CL	CD
1	L	CD2.1

⑤ Can you list three applications of BJT?

A:- → The Bipolar Junction Transistors (BJT) is used in

→ logic circuits
→ It is used as a amplifier.
→ It is used as a multivibrator
→ It is used in electronic Switches
→ It is used in Switching Circuits.

3-Marks Questions

1) Explain the working principle of a Solar cell ?

Marks	BL	CO
3	L2	C112.1

A:- A Solar cell, or photovoltaic cell, is an electrical device that converts the energy of light directly into electricity by the photovoltaic effect, which is a physical and chemical phenomenon.

Working of Solar Cell:

→ Solar cell works under the principle of photovoltaic effect – when light is incident on P–N junction a potential gets developed across the junction, this potential is capable of driving a current through the circuit.

→ Hence light energy is getting converted to electrical energy.

→ Here electron absorbs photon having energy greater than the band gap energy hence they can make transition from valance band to the conduction band and hence contributes current.

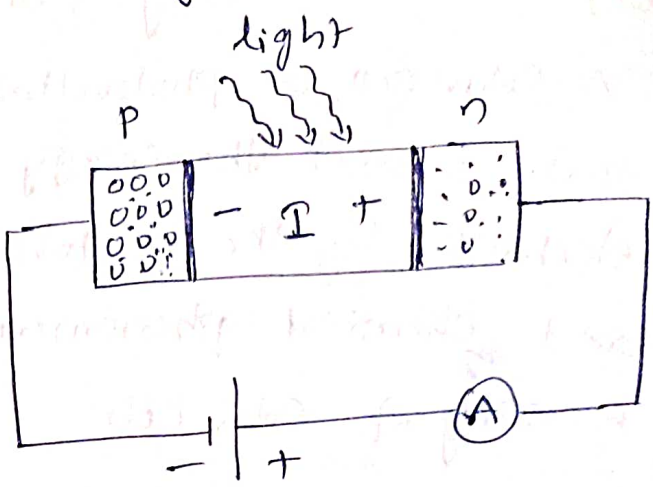
2) Illustrate working of a PIN diode ?

Marks	BL	CO
3	L2	C112.1

A:- A PIN diode is made up of three semiconductor materials. the intrinsic semiconductor seperated by two heavily dopped p and n type semiconductor material.

→ When the reverse bias is applied to PIN diode the width of depletion region starts ~~increasing~~ increasing in the intrinsic region and it increases till it reach

to the thickness of the intrinsic layer with increase of applied reverse voltage.



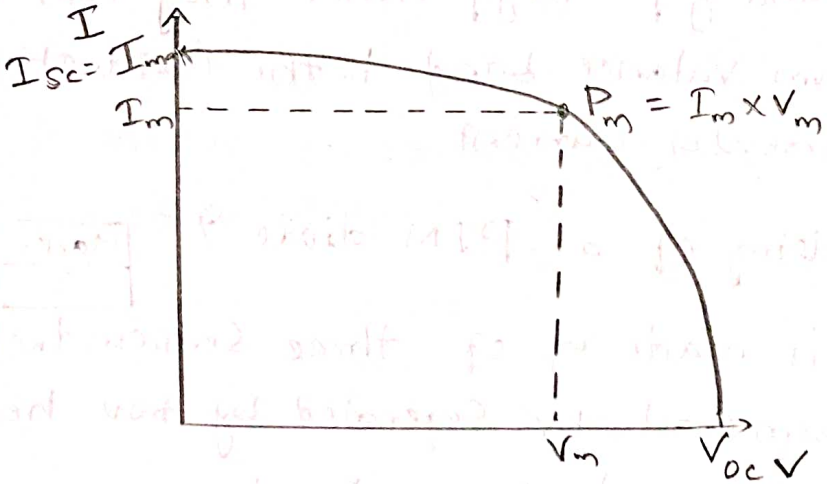
→ In this point, the intrinsic layer is swept free of mobile charge carriers.

→ In this condition, there is no electron-hole recombination take place within the depletion region because it is completely free of mobile charge carriers. And each photon absorbed generates one electron-hole pair.

(3) Explain V-I characteristics of a Solar cell ?

Marks	BL	CO
3	L2	CO1,1

A:- A solar cell, that converts the energy of light directly into electricity.



The above graph shows the Current-Voltage (I-V) characteristics of a typical Silicon PV cell operating under normal condition. The power delivered by a Solar cell is the product of current and voltage (I x V).

→ With the Solar cell Open-circuited that is not connected to any load the current will be at its minimum (Zero) and the voltage across the cell is at its maximum, known as the Solar cells Open Circuit Voltage (V_{oc}).

→ When the Solar cell is short circuited, that is the positive and negative leads connected together, the voltage across the cell is at its minimum (Zero) but the current flowing out of the cell reaches its maximum, known as the Solar Cells Short Circuit Current (I_{SL})

(4) How would you describe intrinsic and Extrinsic Semi-Conductors?

marks	BL	CO
3	L2	C112.1

A:- The Semiconductor material which does not have any impurities is known as intrinsic Semiconductor or pure Semiconductor. Silicon and Germinium, which belong to the fourth group element, behave like a intrinsic Semiconductor.

By adding some impurities to the pure Semiconductor the Conductivity can be improved, this process is called dopping.

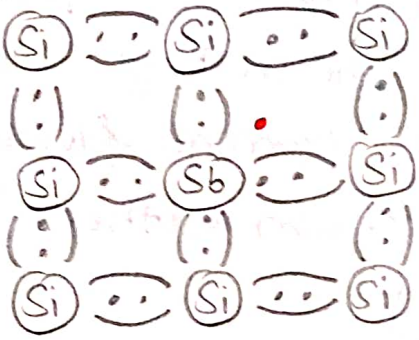
Depending on the type of doping material used, Extrinsic Semiconductors can be classified as,

1. N-type Semiconductor
2. P-type Semiconductor

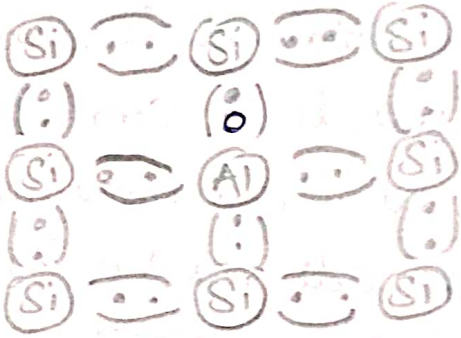
A pentavalent impurity such as phosphorus or arsenic is added to the Silicon Crystal, we get N-type Semiconductor.

A trivalent impurity such as Boron is mixed with the Silicon atoms, we get p-type Superconductors.

n-type



p-type



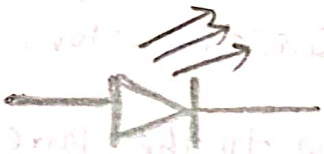
(5) What is the working principle of LED ?

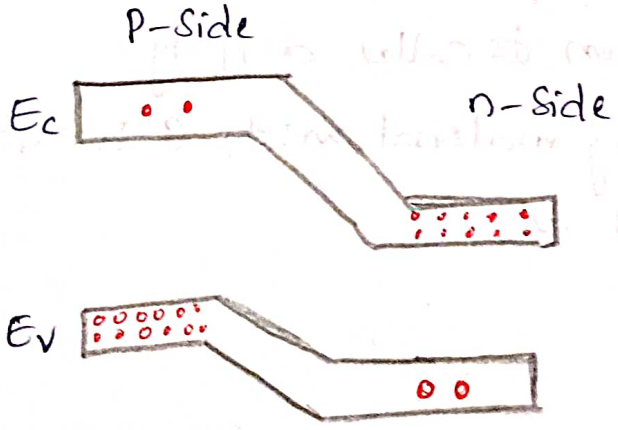
Marks	BL	CO
3	L2	C112.1

→ LED is a diode which emits visible light when forward biased.

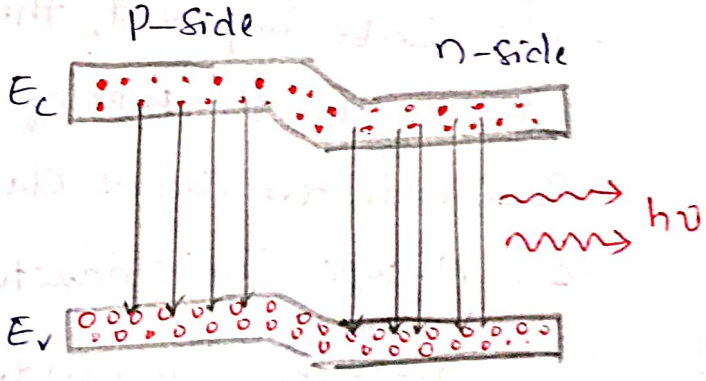
→ LED works on the basic principle called 'recombination'.

→ Symbol :-



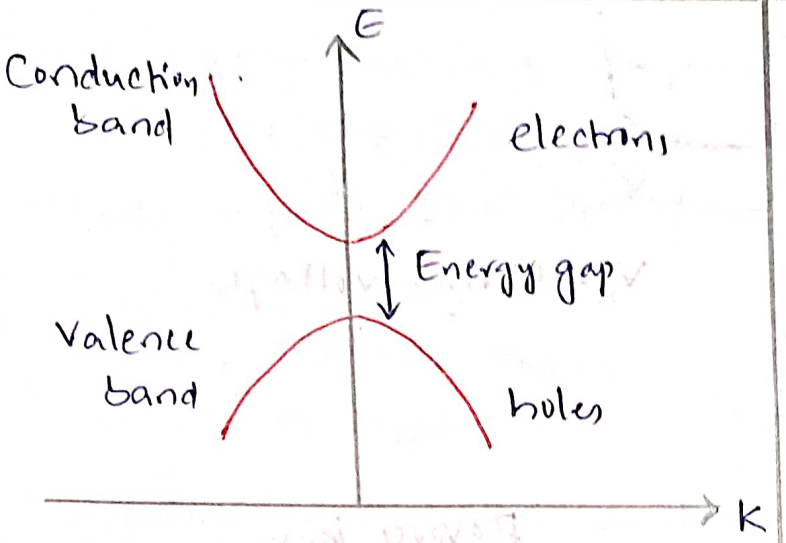
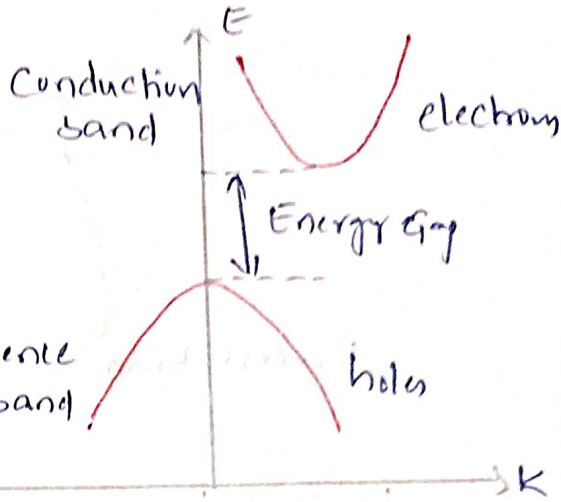


Energy Bands of Unbiased LED



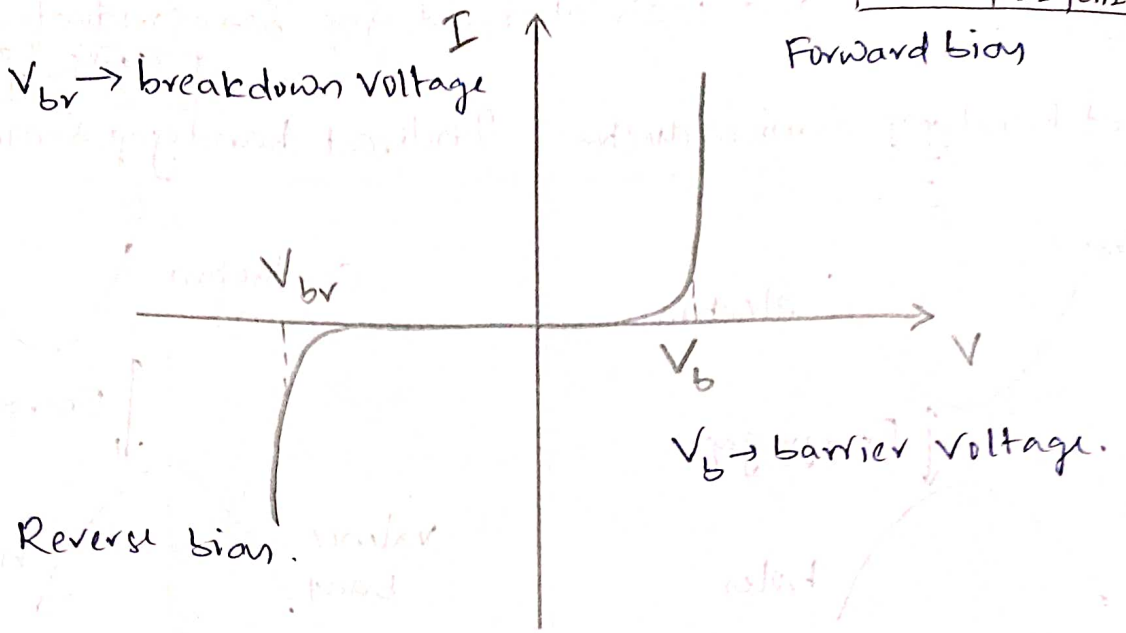
Energy bands aligned when forward biased

(1) Distinguish direct and indirect band gap Semiconductors?

Direct bandgap Semiconductor	Indirect bandgap Semiconductor
	
Maximum of Valence band and minimum of Conduction band occur at Same momentum Values	Maximum of valence band and minimum of Conduction band occur at two different momentum values
Electron making a transition from velence band to Conduction band need not undergo any change in its momentum	In order to make a transition from maximum point in Valence band to minimum point in Conduction band, the electron requires energy for the change in momentum in addition to the energy gap E_g.
The Compound Semiconductor Such as GaAs, are direct gap Semiconductor	All elemental Semiconductors as Si, Ge, are indirect gap Semiconductor
Then direct gap Semiconductors are used in LED and Semiconductor Laser.	Not useful for LED and Semiconductor Laser.

② Explain V-I characteristics of P-n junction diode ?

Marks	BL	CO
5	L2	CO2-1



Forward bias

→ As forward bias voltage is increased, depletion layer width reduces.

→ When forward bias voltage is equal to barrier voltage, the depletion layer vanishes and majority carriers can cross the junction.

Reverse bias

→ As reverse bias voltage is increased, depletion layer width increases.

→ Majority carriers cannot cross the junction as repulsive force increases.

→ Current due to minority carriers can be obtained which is negligible.

→ If the reverse bias voltage is very high, then the minority charge carriers get accelarated and gain kinetic energy.

→ the number of electrons in the depletion layer suddenly gets multip which leads to breakdown voltage.

Discuss about the Avalanche photodiode ? (9)

Marks	BL	CO
5	L_2	CO2

Ans:-

→ Avalanche photodiodes are high Sensitivity, high Speed Semiconductor "Light" detector.

→ Avalanche photodiode structural Configuration is similar to the PIN photodiode. Avalanche diode also Consist of three regions like PIN diode.

- p-region
- intrinsic region
- n-region

→ Avalanche photodiode Operates under a high reverse bias condition (avalanche breakdown Cond.)

→ The electron-hole pairs that are generated by incident photons are accelavated by high electric field to kick new electrons from the VB (valence band) to CB (Conduction band)

→ These are Swept Out of the depletion region quickly due to the low transit time.

→ the Current Sensitivity is increases from 30 to 100 times due to its avalanche Operation.

Applications :-

- Distance measurement,
- data transmission (Over fiber or through free space)
- range finding
- high Speed industrial inspection (including Colour measurement)
- in various other medical and Scientific instrumentation.

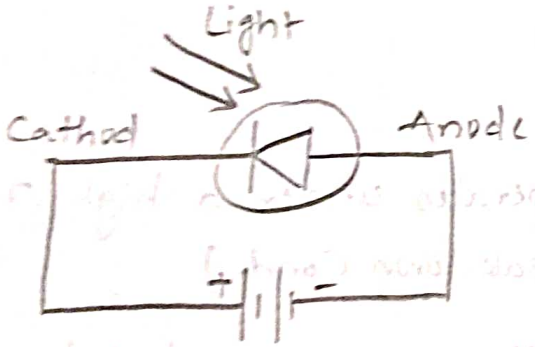
Marks	BL	CO
5	L2	CO1-4

(+) What do you know about the photodiodes?

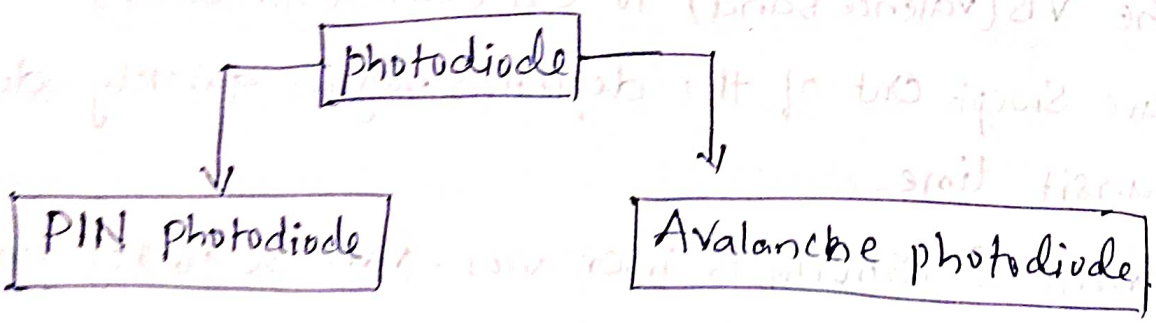
→ photodiode is one kind of detector, that can able to convert the optical signals into electrical signals.

Symbol :-

→ photodiode is a P-N junction diode operated in Reverse bias.



→ Different kinds of photodiodes are developed to reach the specific applications.

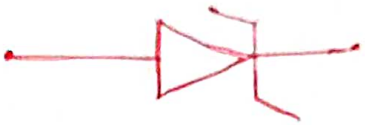
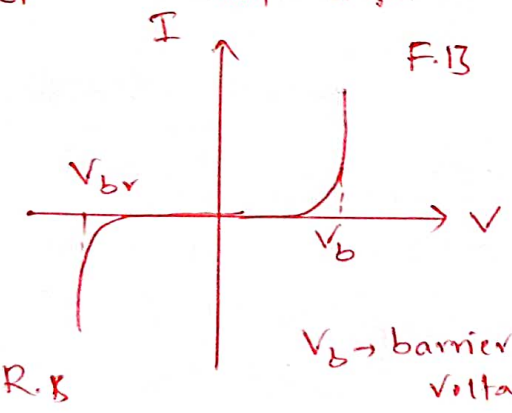
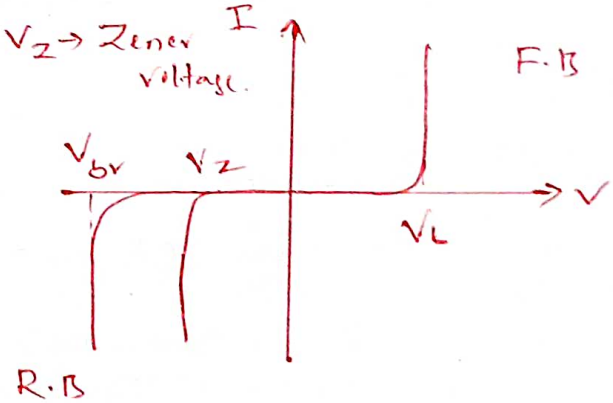


ne working operation of both type of photodiodes are same.
N photodiodes are developed to increase the response speed.
valanche photodiodes are used where high level
nsitivity needed.

Explain advantages of Zener diode over p-n junction diode (11)

Marks	BL	CO
5	L1	CO2.1

A:-

	PN junction Diode	Zener Diode
Definition	It is a Semiconductor diode which Conducts only in one direction, i.e., in forward direction	The diode which allows the current to flow in both the direction i.e., forward and reverse, Such type of diode is known as the Zener diode.
Symbol		
Reverse Current Effect	→ Damage the junction	Donot damage the junction
Dopping level	→ Low	High
Breakdown	→ Occures in high voltage	occur in lower voltage.
Ohms law	→ Obey	Donot obey.
Application	→ For rectification	Voltage stabilizer, motor Protection and wave shapping.
V-I Characteristics	V_{br} → breakdown voltage. 	V_z → Zener voltage. 

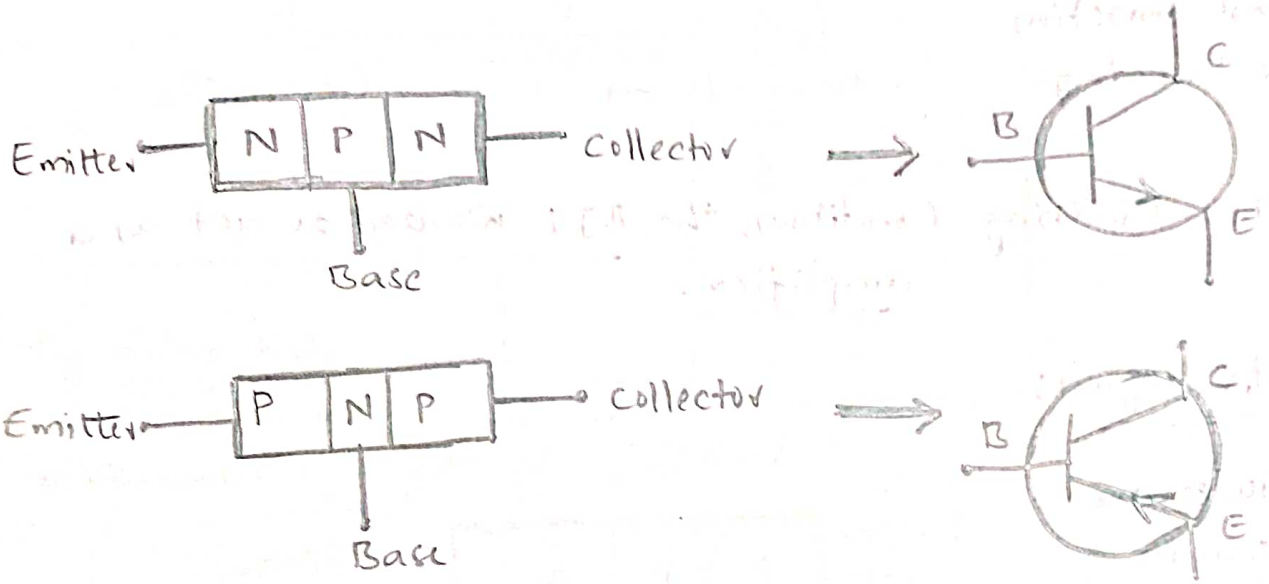
10-Marks Questions.

(12)

With the help of schematic diagrams, Explain the principle of operation of BJT ?

Marks	BL	CO
10	L3	CH2.1

A:- A bipolar junction transistor (BJT) consists of three different doped regions. these can have the configuration of npn or pnp



1. Emitter region – this is usually a heavily dopped region. The emitter 'emits' the carriers into the base.
2. Base region – this is lightly dopped region. the base region is also physically thin so that carriers can pass through with minimal recombination.
3. Collector region – The collector region has a larger width that the other two regions since charge is accumalated here from the base.

BJT Operation modes:

The transistor can be operated in three modes:

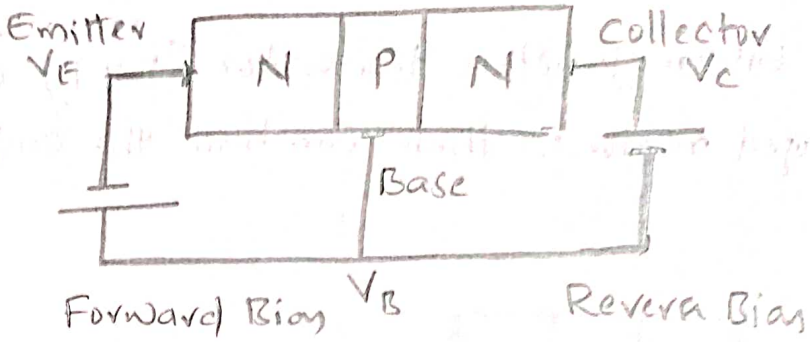
- Active region — In this region BJT worked as a amplifier
- Cut-off region
- Saturation region } → BJT worked as a Switching circuit

① Active region:

$V_B > V_E \quad V_C > V_B$

$V_C > V_B > V_E$

In Active region, Emitter-Base junction in forward biasing and collector-Base junction in reverse biasing condition.



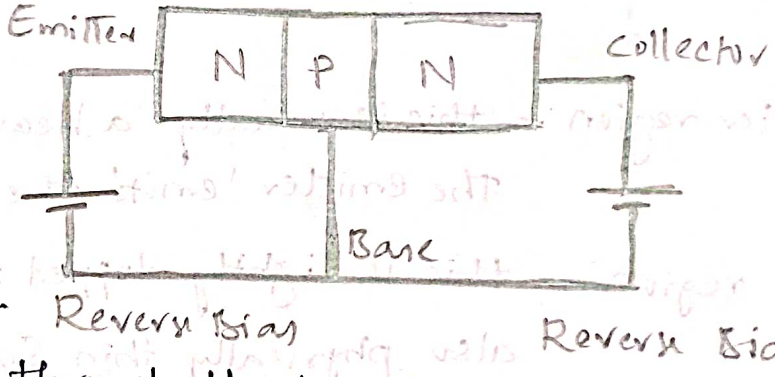
In this biasing Condition, the BJT worked or act as a amplifier.

② Cut-off region:

$V_E > V_B, \quad V_C > V_B$

Both the diodes are reverse biased in cutoff mode.

We know that in reverse bias condition, no current flows through the device. Hence, no current flows through the transistor. Therefore, the transistor is in offstate and act like an open switch.

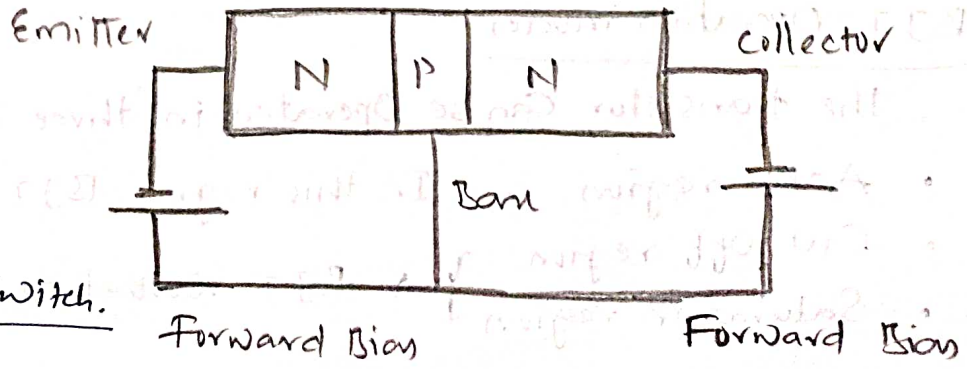


③ Saturation region:

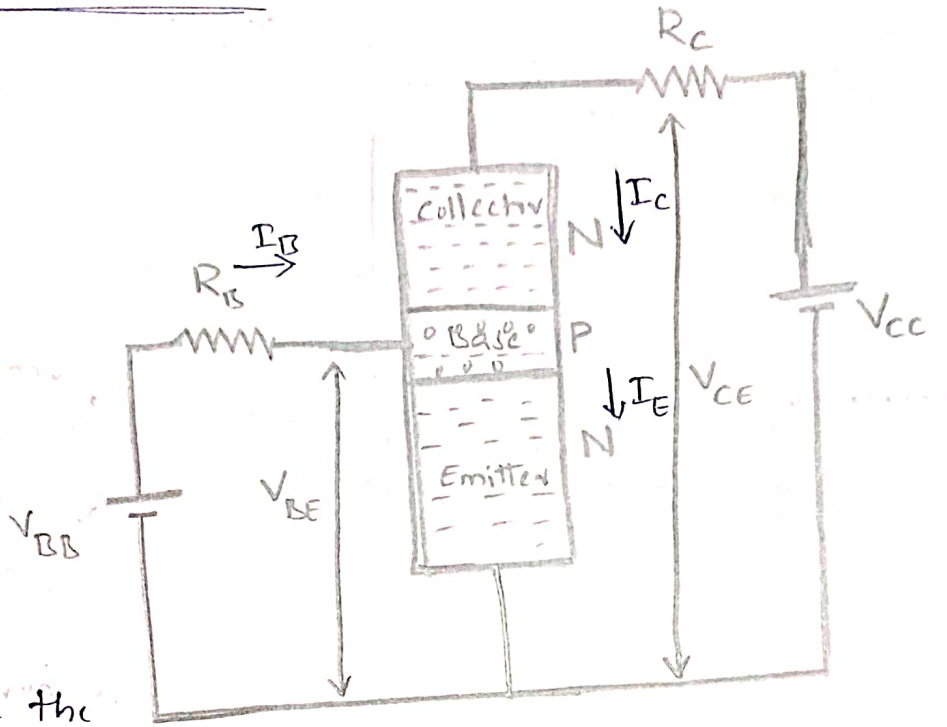
$V_B > V_E \quad V_B > V_C$

Both the diodes are forward biased.

The transistor in saturation mode will be in on state and acts like a closed switch.



Working principle of BJT :-



By using KCL we can observe the mathematical equation,

$$\boxed{I_B + I_C = I_E} \quad \text{——(1)}$$

The base current is very less as compared to emitter and collector current.

$$I_E \approx I_C$$

$$\Rightarrow \boxed{I_C = \alpha I_E} \quad \text{——(2)}$$

α - defines, what fraction of the emitter current is flowing through the collector terminal.

Put (2) in (1) $\Rightarrow I_B + \alpha I_E = I_E$

$$\Rightarrow I_B = (1-\alpha) I_E$$

$$\Rightarrow I_B = (1-\alpha) \frac{I_C}{\alpha}$$

$$\Rightarrow I_C = \frac{\alpha}{(1-\alpha)} I_B$$

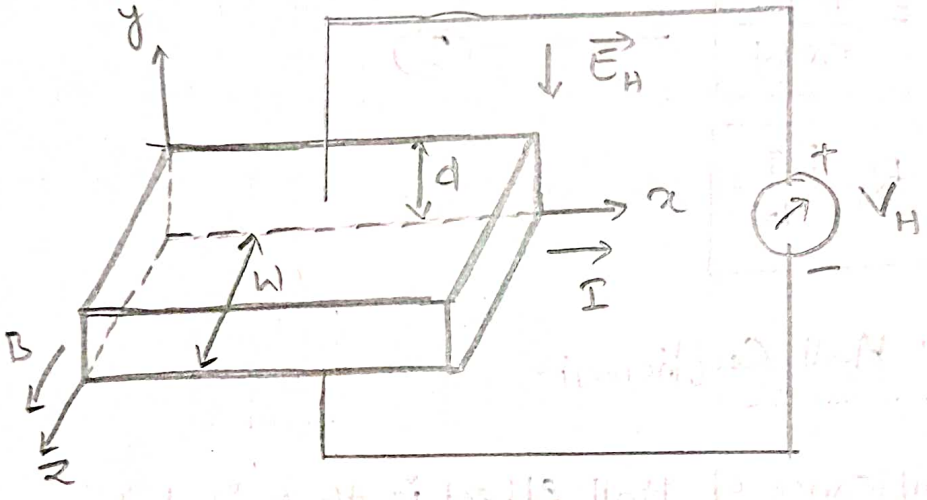
$$\Rightarrow \boxed{I_C = \beta I_B} \quad \text{where } \beta = \frac{\alpha}{1-\alpha}$$

Where $\beta \rightarrow$ is the amplification factor.

Describe the Hall effect and derive the Hall Coefficient and Hall voltage ?

Marks	BL	CO
10	L3	C112.1

If a metal or Semiconductor Carrying a Current (I) is placed in a transverse magnetic field (B), an electric field (E) or voltage is induced in the direction perpendicular to both the direction of current and magnetic field. This phenomenon is Called as Hall effect. The electric field produced is called Hall field (E_H).



The Current through the metal (or) Semiconductor is given by

$$I = nevA \quad \text{——— (1)}$$

where n is a Concentration of electrons
A is area of cross section of the plate.
e is charge of the electron,
v is average drift velocity of electrons.

At equilibrium,

electric force on electrons = magnetic force on electrons

$$\boxed{eE_H = evB} \quad \text{---(2)}$$

$E_H = \frac{V_H}{d}$ is the Hall field

V_H is Hall voltage

$$\therefore \quad \frac{V_H}{d} = vB \quad \text{As } E_H = \frac{V_H}{d}$$

$$\therefore \quad V_H = vBd$$

$$\therefore \quad V_H = \frac{nevBd}{ne}$$

from (1) $$V_H = \frac{IBd}{neA} = \frac{IBdw}{neAw}$$

$$\therefore \quad \boxed{V_H = \frac{BI}{neW}} \quad \text{---(3)}$$

$$\therefore \quad \boxed{V_H = R_H \frac{BI}{W}}$$

$\boxed{R_H = \frac{1}{ne}}$ is Hall Coefficient.

Importance / Significance of Hall effect is that it helps :-

→ To determine Carrier Concentration (n)

→ To determine type of the Superconductor

→ To determine mobility (μ) of the charge Carriers if Conductivity of the Semiconductor is known. $\boxed{\sigma = ne\mu}$

Discuss about working, I-V characteristics of Zener diode?

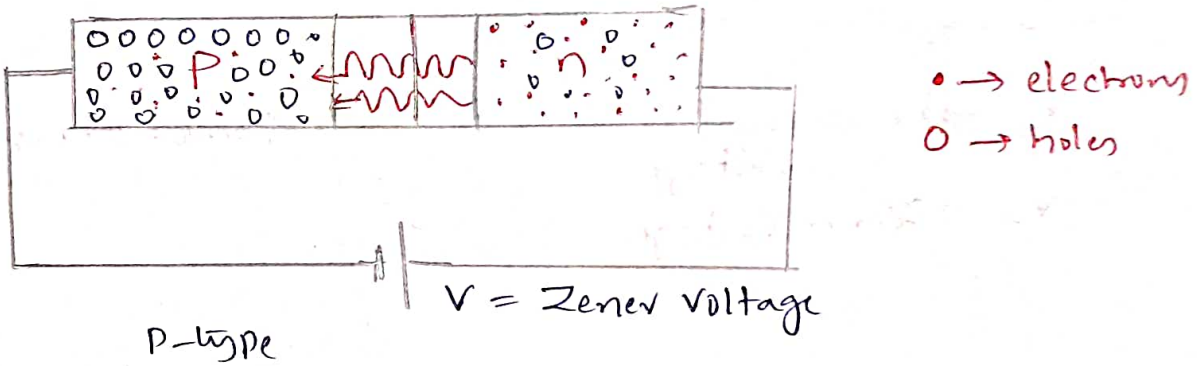
Marks	BL	CO
10	L2	CO12.

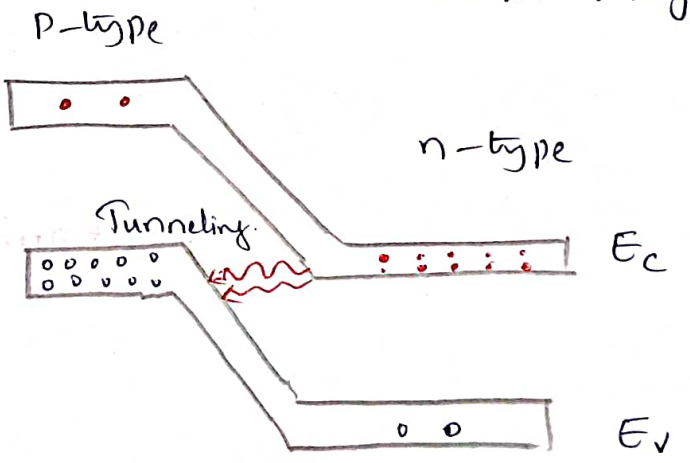
→ Zener diode is also called as "Breakdown Diode"

Symbol:

→ Same as the Standard PN junction diode but are specially designed to have a low pre-determined Reverse breakdown voltage achieved by Extremely high level of doping.

→ The Zener diode used in breakdown mode is the simplest type of Voltage regulator and the point at which a Zener diode breaks down or conducts is called the "Zener Voltage" (V_Z).





→ the electric field becomes extremely strong, but at the same time, it is extremely narrow, hence many charge carriers can't get accelarated.

→ Instead a quantum mechanical effect takes place. this is called as quantum tunneling.

→ So there is no impact ionization, the electrons just tunnel through. (like digging a hole, instead of overcoming the mountain).

→ Zener breakdown, only happens, when the dopping concentration is extremely high. So that depletion region becomes very narrow.

V-I Characteristics: