* Introduction to Electronics :-

Electronics is composed of physics, engineering, technology and applications. The field of electronics deals with the emission, flow and control of electrons in vacum and matter. Electronic use active devices to control electron flow by amplification and rectification. Electronics distinguish itself from classical electrical engineering that uses passive effects like resistance, capacitance and inductance to control current flow. The ability of electronic devices to act as switches makes digital information processing happen. The term electronic deals with electrical circuits that have electrical components are vacum tubes, transistors, diodes, integrated circuits, optoelectronics, and designs of electronic circuits to solve different types of problems come under electronics engineering. All of them are associated with passive electrical components and interconnection technologies.

	Electrical device	Electronics device
Operating principle	Primarily converts mains electrical energy to other forms of energy.	Primarily controls the flow of electrons to perform a particular task at low voltages.
Materials	Metals & semi-conductor.	Metals & semiconductor
Current	Primarily Alternating current (AC)	Primarily Direct current
Voltage	High voltage	Low voltage
Power consumption	More	Less
Manipulation.	Not generally used for information flow	Manipulates data
Required space	More	Less
safe	Less	More

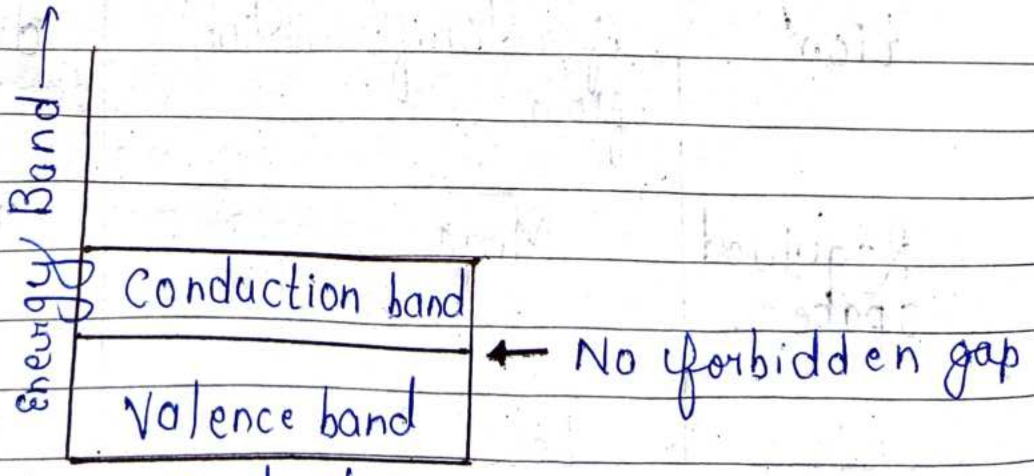
→ Examples :- Transformer, heater torch, hair dryer etc.

Transistor, diode, microprocessor etc.

* Different between conductors, semi-conductors and Insulator.

- Conductor :-

A conductor is a type of material that allows the electric current to flow through it i.e it possesses least resistance in the path of free electrons In case of conductor, the valence and conduction band overlap. Due to this overlapping, a small potential difference across a conductor causes the free electrons to constitute electric current.

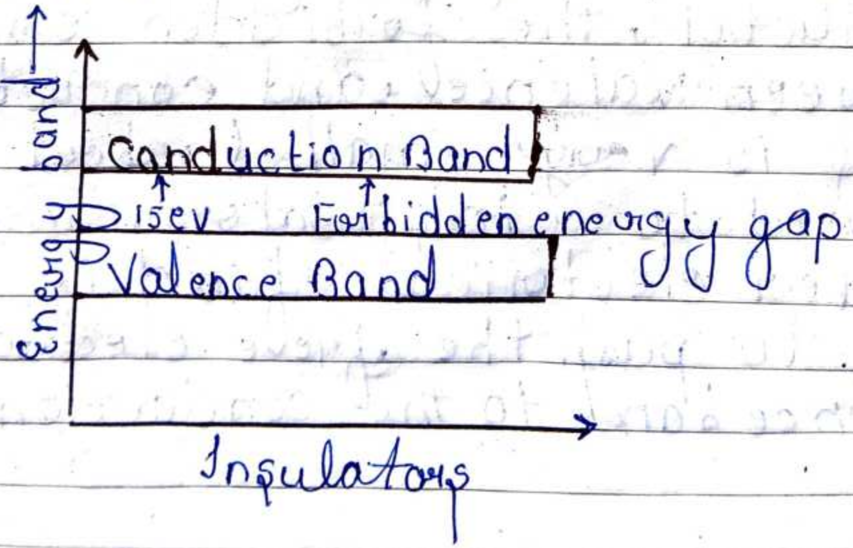


Conductors

All the metals are conductors. The resistance of the conductors increases with the increase in the temp. Hence, the conductor have positive temp co-efficient of resistance.

* Insulator :—

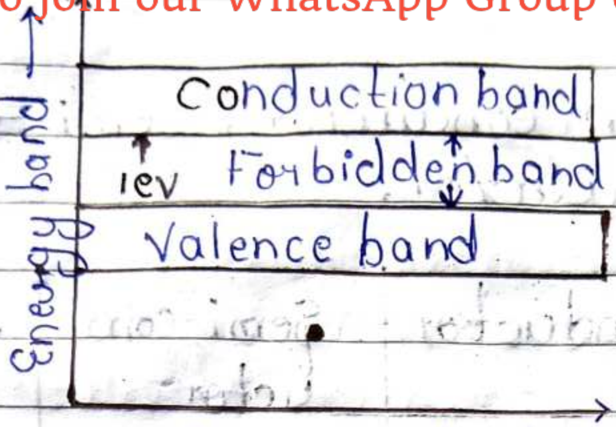
An insulator is type of material that does not allow the electric current to pass through it, due to its high electrical resistance. In the insulators, the energy gap between valence and conduction Bands is very large (about 15 ev). Therefore, a very high electric field is required to push the valence electrons to the conduction band.



At room temp, the valence electrons of insulator do not have enough energy to cross over to the forbidden energy gap. But, if the temp is raised, some of the electrons may acquire enough energy to cross over to the forbidden energy gap. Hence, the resistance of the insulator decreases with the rise in temp. Therefore, the insulators have negative temp co-efficient of resistance.

* Semi - Conductor :-

The semiconductors are the materials having conductivity in between conductors and insulators. In a semiconductor, the forbidden energy gap between valence and conduction bands is very small (about 1 ev) as compared to insulators. Therefore, a smaller electrical field is required to push the free electrons from valence band to the conduction band.



Semi Conductor

At low temp. the valence band of semi-conductor is completely full and the conduction band is completely empty. Thus, a semiconductor behaves as an insulator at low temp. However, at room temp, some electrons can cross the forbidden gap, imparting a little conductivity to the semiconductor. As temp is increased, more valence electrons across over to the energy gap to reach to the conduction band and the conductivity increases. This shows that electrical conductivity of semi-conductors increases with the rise in temp. Hence, a semiconductor has negative temp cofficient of resistance.

The semi-conductors are commonly used in manufacturing of solid state electronic devices.

* Difference between conductor, semi-conductor and Insulator.

→ Parameter	Conductor	Semi-conductor	Insulator
Definition	A material that allows electric current to pass through it very easily.	A material that has conductivity in between conductors and insulators.	Materials that do not allow the electric current to pass through them.
Forbidden energy gap	No energy gap i.e the conduction band overlap the valance band.	Small energy gap (approx 1ev).	Very large energy gap (approx 15 ev)
Conductivity	High conductivity of the order of 10^{-7} mho/m)	Intermediate conductivity (ranging from 10^{4} mho/m to 10^{-13} mho/m	Very large conductivity of the order of 10^{-13} mho/m

Conduction	Due to free electrons.	Due to movement of both electrons & holes (positive change carrier)	No Conduction
Resistivity	Low (of the order of 10^{-5} Ω/m).	Intermediate (from 10^{-5} Ω/m to 10^{5}	Very high (of the order of 10^{5} Ω/m)
Temp cofficient of resistivity.	Positive	Negative	Negative
Valence electrons in outer most shell	Less than 4	4	More than 4.
Examples	Metals like silver, gold, copper aluminium etc.	Silicon, Galium, Germonium, Arsenic etc.	Air, Mica Glass, wood, etc.

* Important Energy Bands in solids :-

(i) Valence Band :- The range of energies possessed by vallence electrons is known as valence band.

(ii) Conduction Band :- The range of energies possessed by conduction band electrons is known as conduction band.

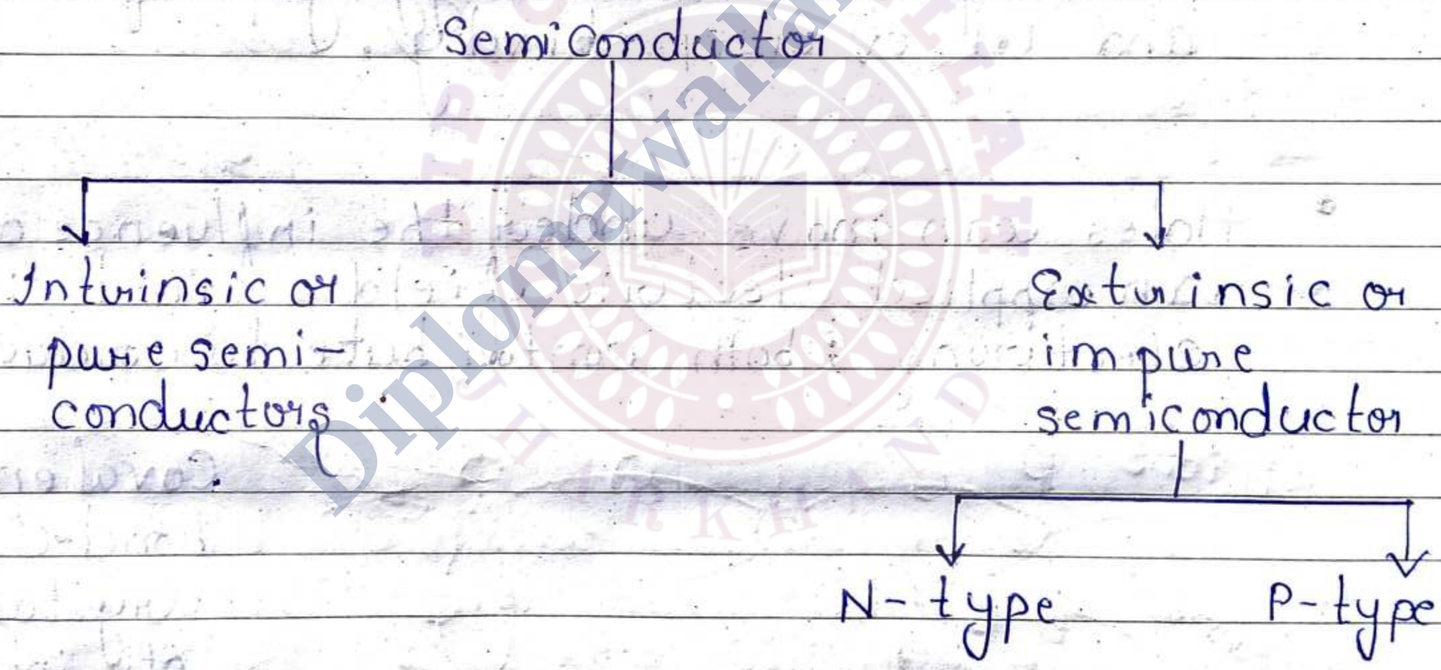
(iii) Forbidden energy gap :- The seperation between conduction band and valence band on the energy level diagram is known as forbidden energy gap.

* Commonly used Semiconductors :-

There are mainly semiconductors available but very few of them have a practical application in electronics.

The two most frequently used materials are germanium (Ge) and silicon(si). It is because the energy required to break their co-valent bonds is very small; being about 0.7 eV for germanium and about 1.1 eV for silicon.

* Types of Semiconductors :—



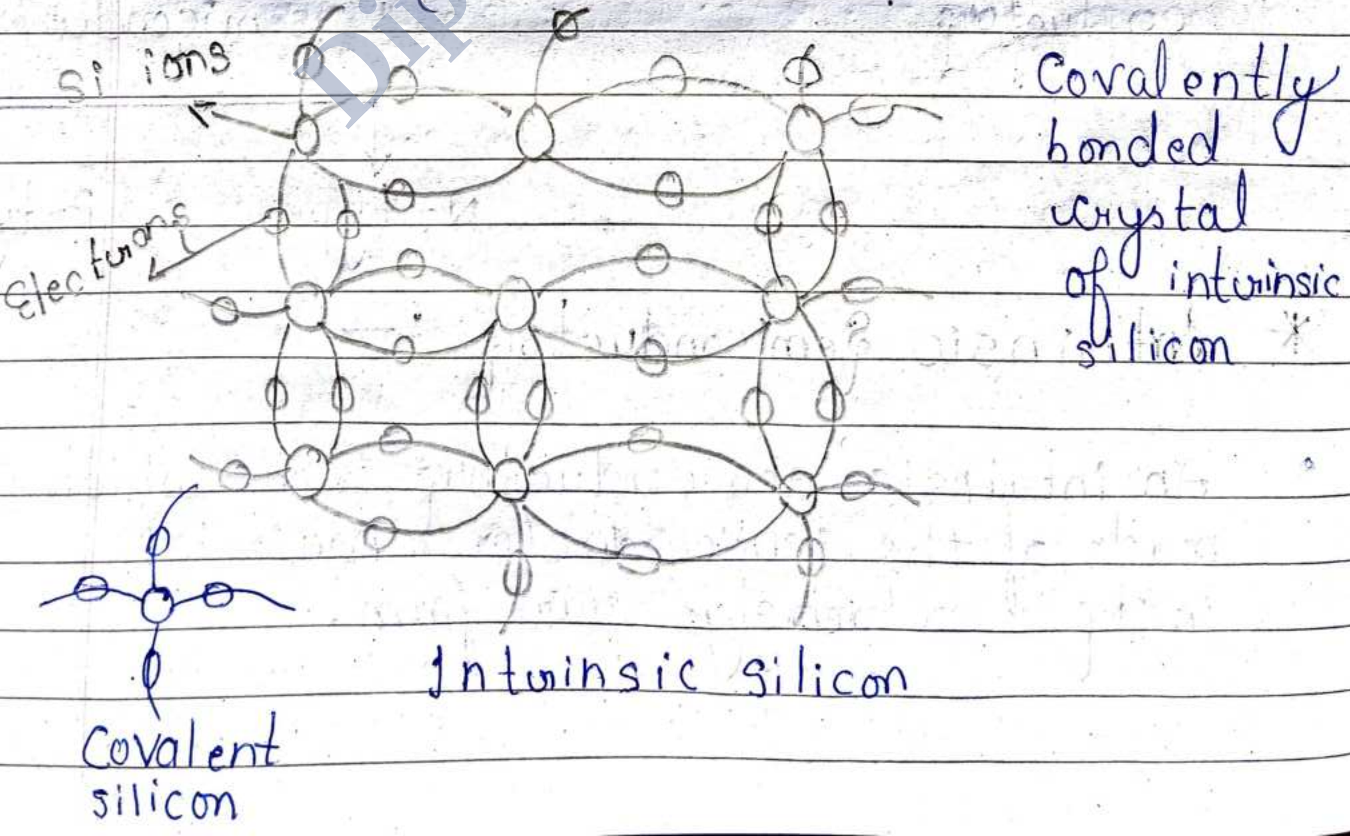
* Intrinsic Semiconductors :—

- An intrinsic semiconductors is one which is made of the semiconductor material in its extremely pure form.

- Alternatively, an intrinsic semiconductor may be defined as one in which the number of conduction electrons is equal to the number of holes.

- Examples of such semiconductors are: pure germanium and silicon which have forbidden energy gaps of 0.72eV and 1.1 eV respectively.

- Holes can move under the influence of an applied electric field, just like electrons; both contribute to conduction.

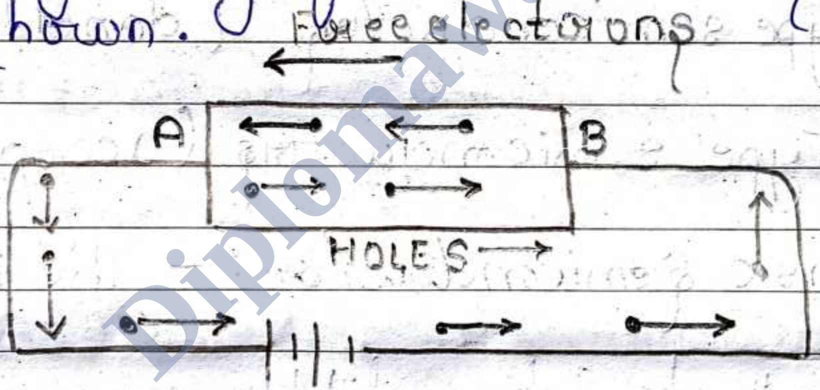


Intrinsic silicon

- Intrinsic Semiconductors :—

→ A semiconductor is an extremely pure form is known as an intrinsic semiconductors.

In an intrinsic semiconductor, even at room temp, hole - electron pairs are created When electric field is applied across an intrinsic semiconductor the current conduction takes place by two processes namely; by free electrons and holes as shown.



* Extrinsic semiconductors ("doped semi-conductor)

- Semiconductor with small admixture of trivalent or pentavalent atoms.

- Those intrinsic semiconductors to which some suitable impurity or doping agent or doping has been added in extremely small amounts (about 1 part in 108) are called "extrinsic or impurity semiconductors".

* Types of extrinsic semiconductor :—

Depending on the type of doping material used, extrinsic semiconductors can be sub-divided into two classes :

- N - Type semiconductors (donor).
- P - Type semiconductors (acceptor)

* Extrinsic semiconductor :— The intrinsic semiconductor has little current conduction capability at room temp. To be useful in electronic devices, the pure semiconductor must be altered so as to significantly increase its conducting properties. This is achieved by adding a small amount of suitable impurity to a semiconductor. Depending upon the type of impurity added, extrinsic semiconductors are classified into :—

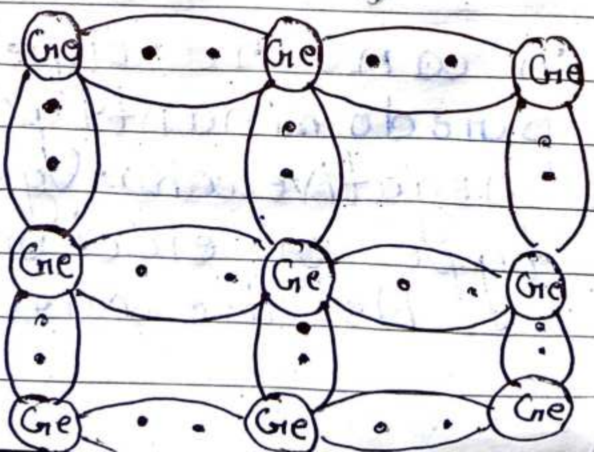
(i) n-type semi conductor

(ii) P-type semiconductor

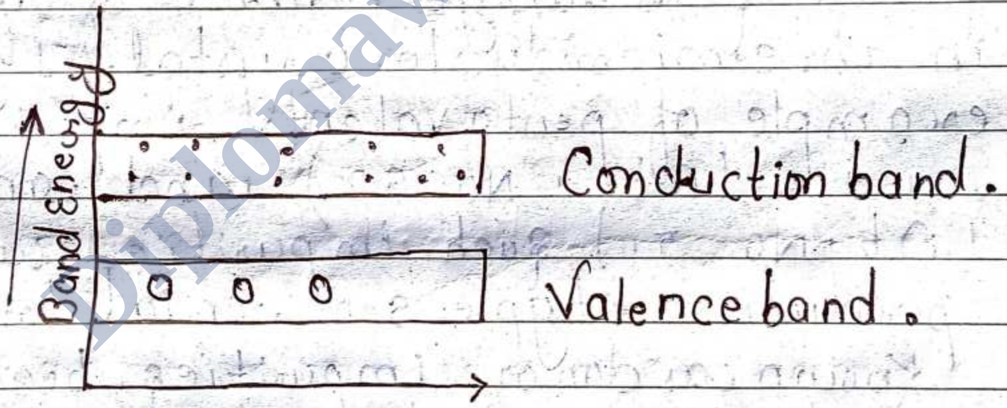
- n-type semiconductor :—

When a small amount of pentavalent impurity is ~~called~~ added to a pure semiconductor, it is known as n-type semiconductor.

The addition of pentavalent impurity provides a large number of free electrons in the semiconductor crystal. Typical example of pentavalent impurities are arsenic (At. No 33) and antimony (At. No. 51) such impurities which produce n-type semiconductors are known as donor impurities because they donate or provide free electrons to the semi conductor crystal.



The energy band description of n-type semiconductor. The addition of pentavalent impurity has produced a number of conduction band electrons i.e free electrons. The four valence electrons of pentavalent atom from covalent bonds with four neighbouring germanium atoms. The fifth left over valence electron of the pentavalent atom can not be accomodated in the valence bond and travels to the conduction band.



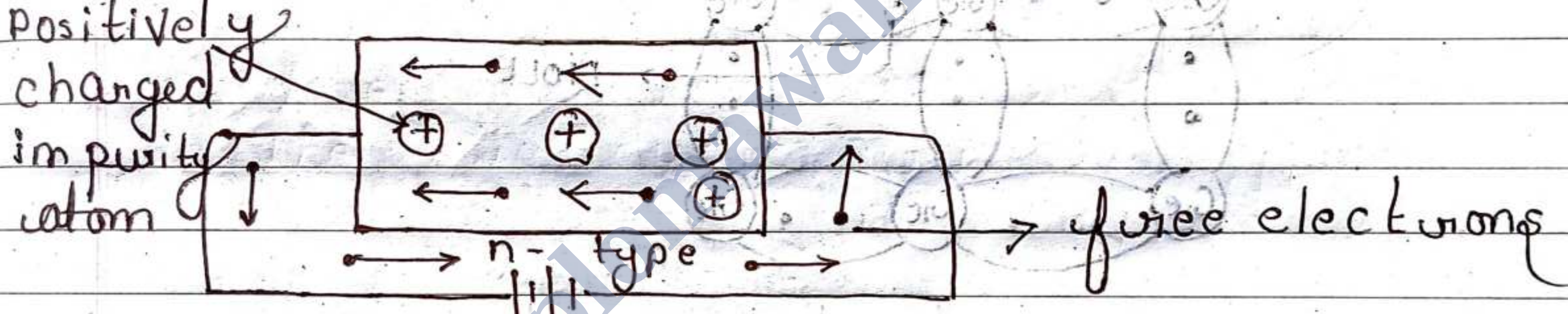
n-type conductivity :— The current

semiconductor in an n-type semiconductor is predominantly by free electrons i.e negative charges and is called n-type or electron type conductivity. As the current flow

~~free electrons which~~

through the crystal is by free electrons which are carriers by negative charge. therefore, this type of conductivity is called negative or n- type conductivity.

Principle of Electronics :-

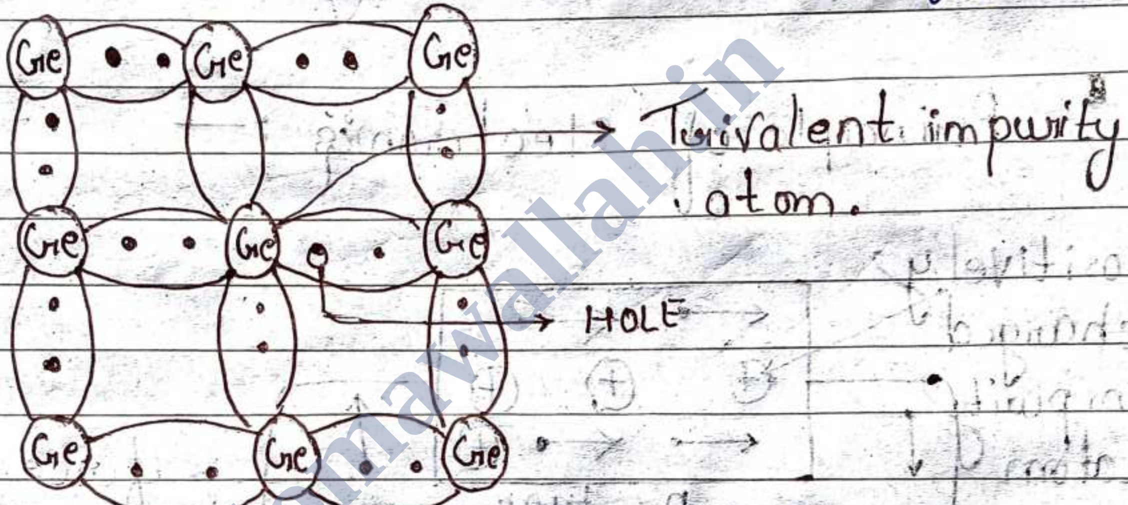


* P – type semiconductor :-

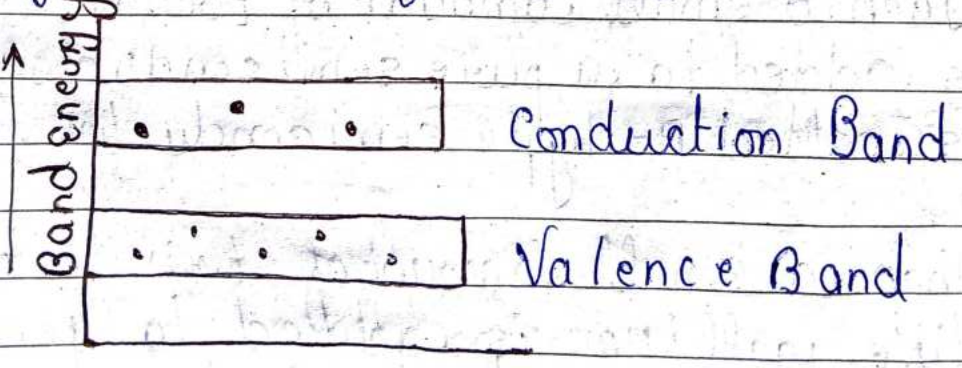
→ When a small amount of trivalent impurity is added to a pure semiconductor, it is called P- type semiconductor.

When a small amount of trivalent impurity like gallium is added to germanium crystal, there exists a large number of holes in the crystal.

Each atom of gallium fits into the germanium crystal but now only three covalent bonds can be formed. It is because three valence electrons of gallium atom can form only three single covalent bonds with three germanium atoms as shown in fig.

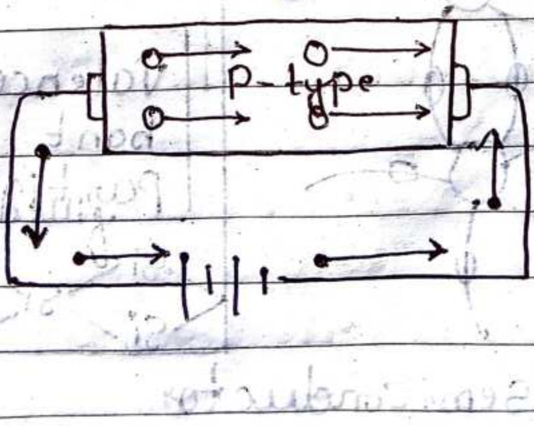


The energy band description of the P-type semiconductor. The addition of trivalent impurity has produced a large number of holes.

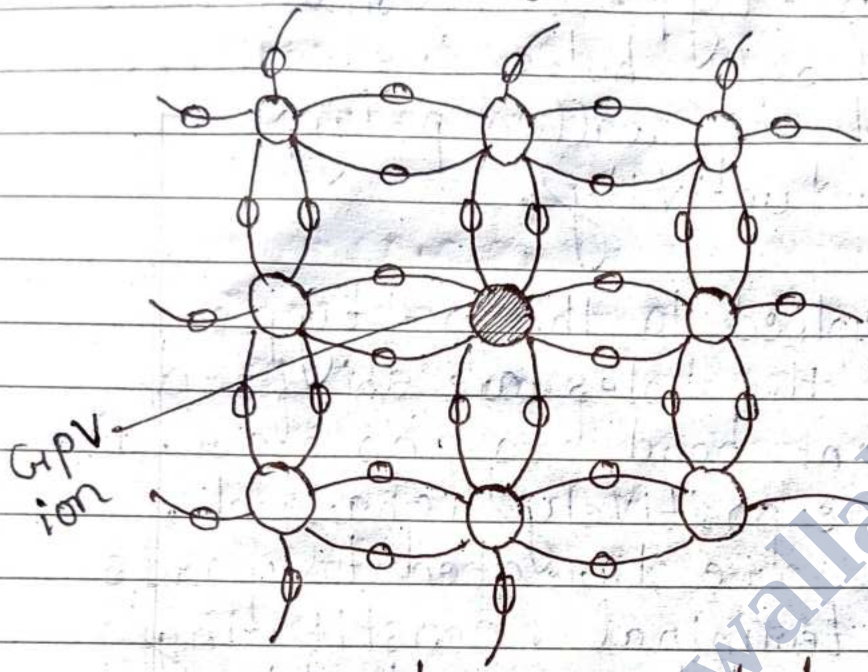


p-type conductivity :- The current conduction in p-type semiconductor is predominantly by holes i.e positive charges and is called p-type or hole type conductivity.

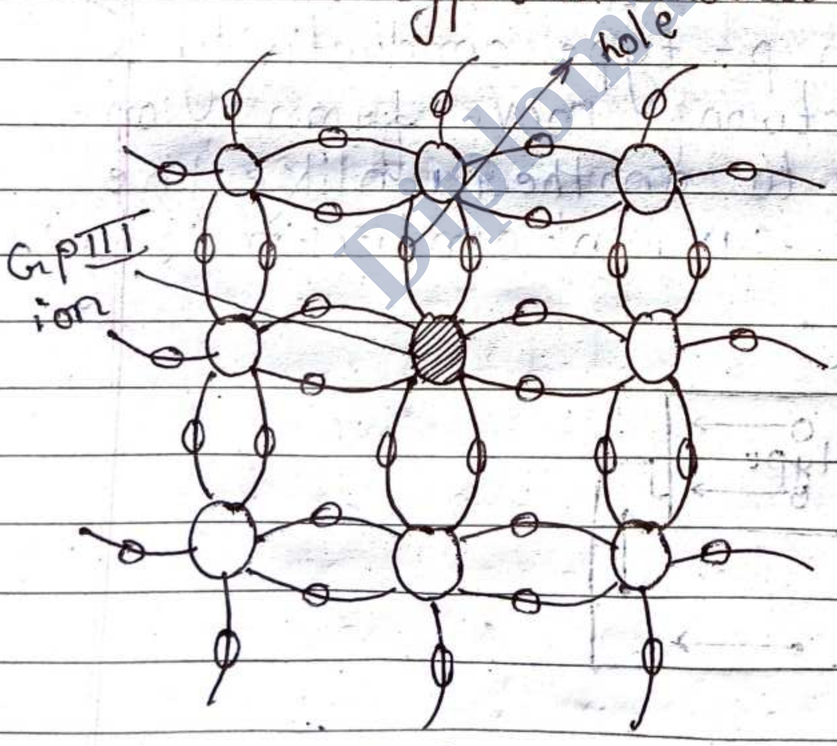
When p.d is applied to the p-type semiconductor the holes are shifted from one covalent bond to another. As the holes are positively charged, therefore they are directed towards the negative terminal, constituting what is known as hole current. It may be noted that in p-type conductivity, the valence electrons move from one co-valent bond to another unlike the n-type where current conduction is by free electrons.

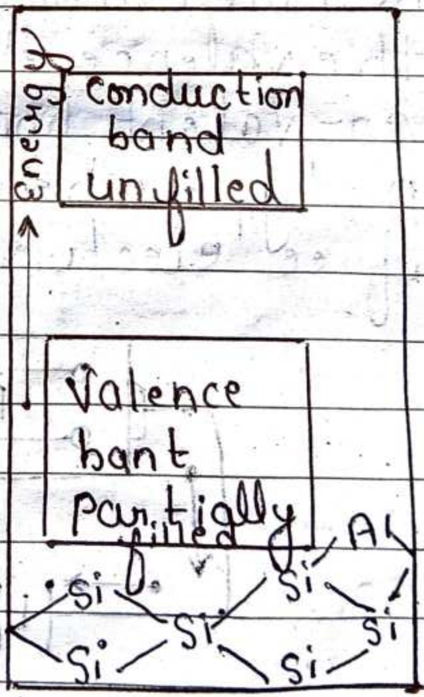


* P and N- type Extrinsic Semiconductor



n-type semiconductor

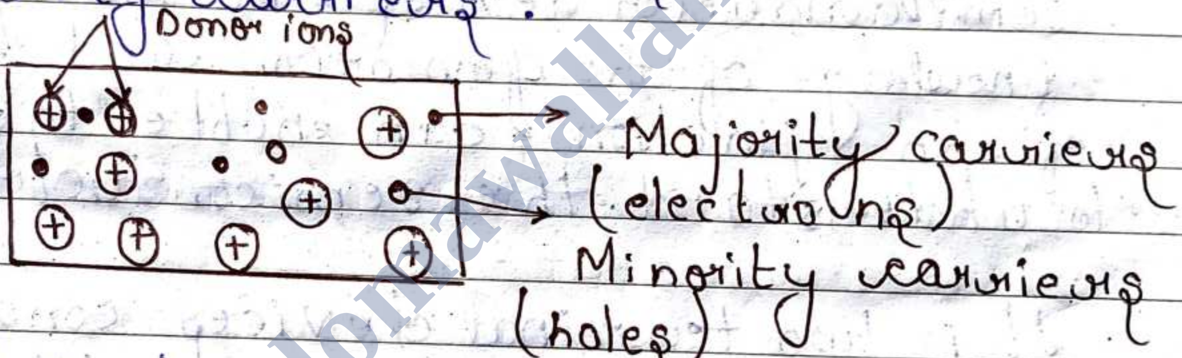




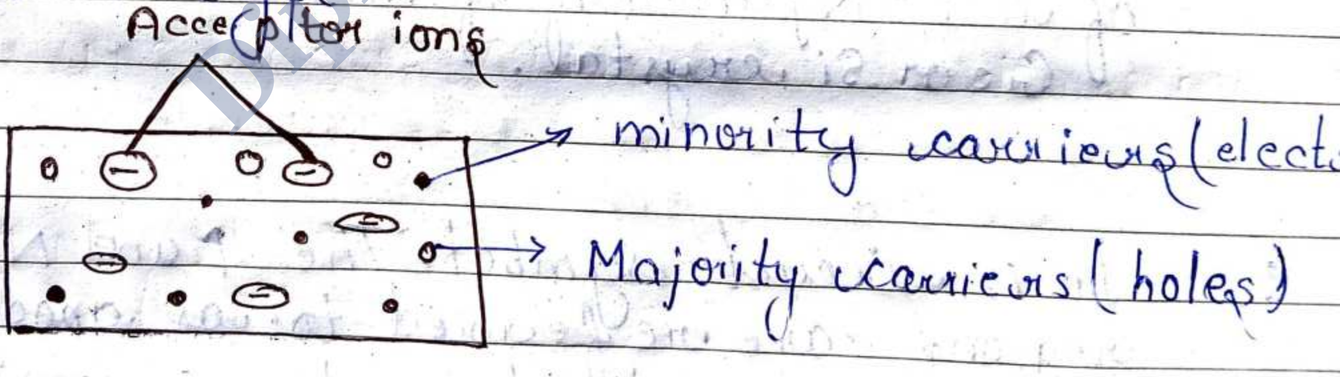
P- type semiconductor

* Majority and Minority carriers :-

The p-n junction, on the p-side, the holes constitute the dominant carriers and so are called majority carriers. A few thermally generated electrons will also exist in the p-side; these are termed as minority carriers. On the n-side, the electrons are the majority carriers, while the holes are the minority carriers.



(i) n-type



(ii) P- type

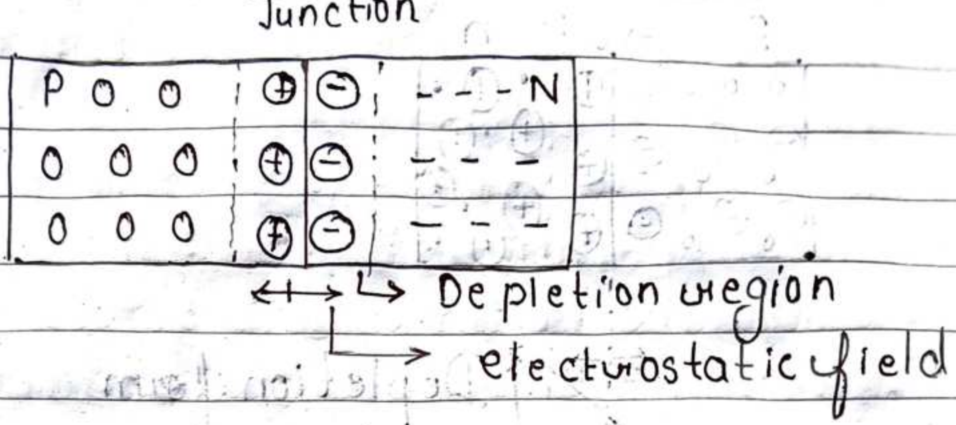
* Pn junction :— *

When a p-type semiconductor is suitably joined to n-type semiconductor the contact surface is called Pn junction.

Most semiconductor devices contain one or more pn junction. The pn junction is of great importance because it is in effect, the control element for semiconductor devices. A through knowledge of the formation and properties of pn junction can enable the reader to understand the semiconductor devices.

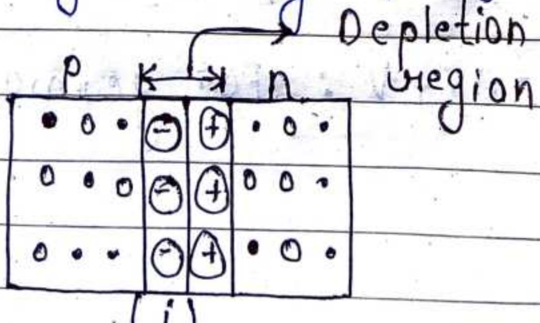
- It is two terminal devices consisting of a P-N junction formed either in Ge or Si crystal.

- It is circuit symbol: The P and N type regions are referred to as anode and cathode respectively. In arrowhead indicates the conventional direction of current flow when forward biased. It is the same direction in which hole flow take place.

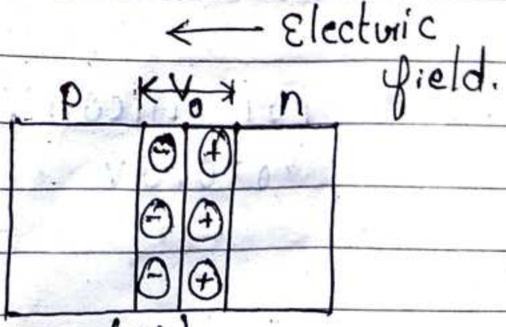


* Properties of P-N Junction :-

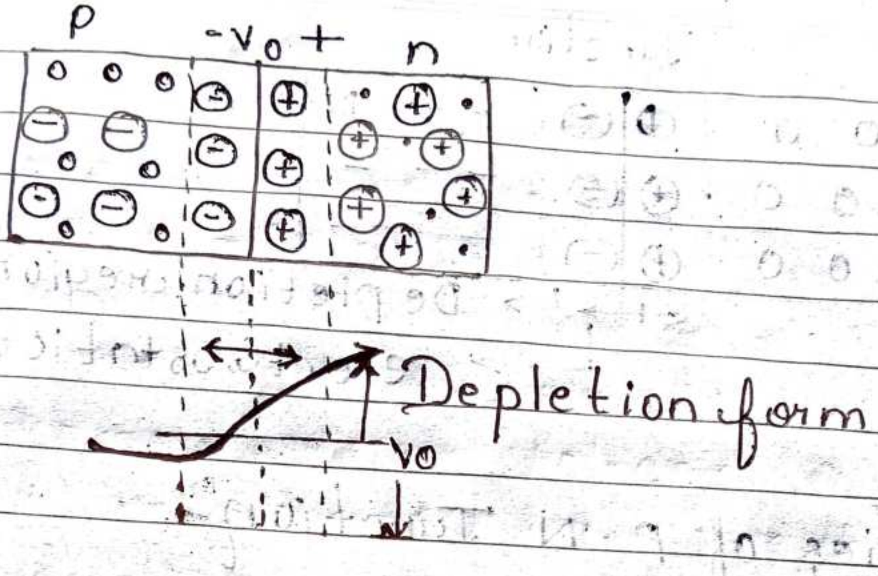
The Pn junction is the semiconductor can fulfil very diversified functions. It can rectify electric current, inject minority carriers, create a potential barrier, make use of its capacitance properties, accumulate space charge, create various non-linear current-voltage characteristics, transform light energy into electrical react to various kinds of irradiation, emit light radiation when a current flows through it, and respond to the function of a close or neighbouring pn junction.



(i)



(ii)



Once Pn junction is formed and depletion layer created, the diffusion of free electrons stops. In other words, the depletion region acts as a barrier to the further movement of free electrons across the junction. The positive and negative charges set up an electric field.

The electric field is a barrier to the free electrons in the n-region. There exists a potential difference across the depletion layer and is called barrier potential.

For silicon, $V_0 = 0.7\,V$; For germanium, $V_0 = 0.3\,V$

* Principle of electronics

In relation to pn junction, there are following two bias condition :

(i) Forward biasing (ii) Reverse biasing

* **Forward biasing** :- When external d.c voltage applied to the junction is in such a direction that it cancels the potential barrier, thus permitting current flow. it is called forward biasing.

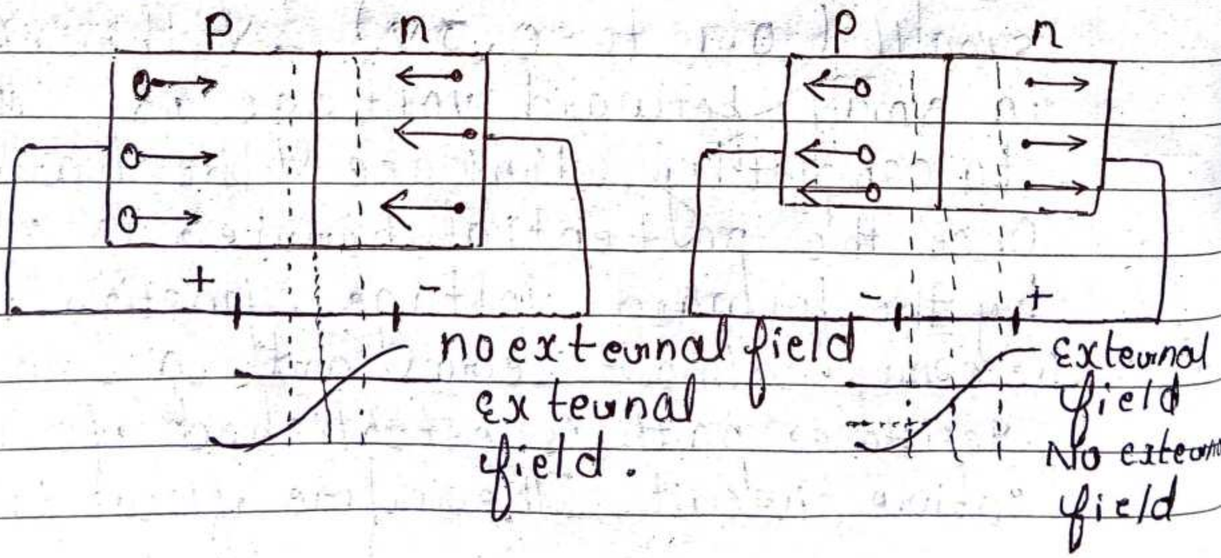
To apply forward bias, connect positive terminal of the battery to p - type and negative terminal to n - type.

As potential barrier voltage is very small (0.1 to 0.3V), therefore, a small forward voltage is sufficient to completly eliminate the barrier. Once the potential barrier is eliminated by the forward voltage, junction resistance becomes almost zero and a low resistance path is established for the entire circuit. Therefore flows in the circuit. This is called forward current. With forward bias to pn junction, the following points are worth noting:

(i) The potential barrier is reduced and at some forward voltage (0.1 to 0.3V) it is eliminated altogether.

(ii) The junction offers low resistance to current flow.

(iii) Current flows in the circuit due to establishment of low resistance path. The magnitude of current depends upon the applied forward voltage.



(ii) Reversed biasing :- When the external d.c voltage applied to the junction is in such direction that potential barrier is increased, it is called reversed biasing.

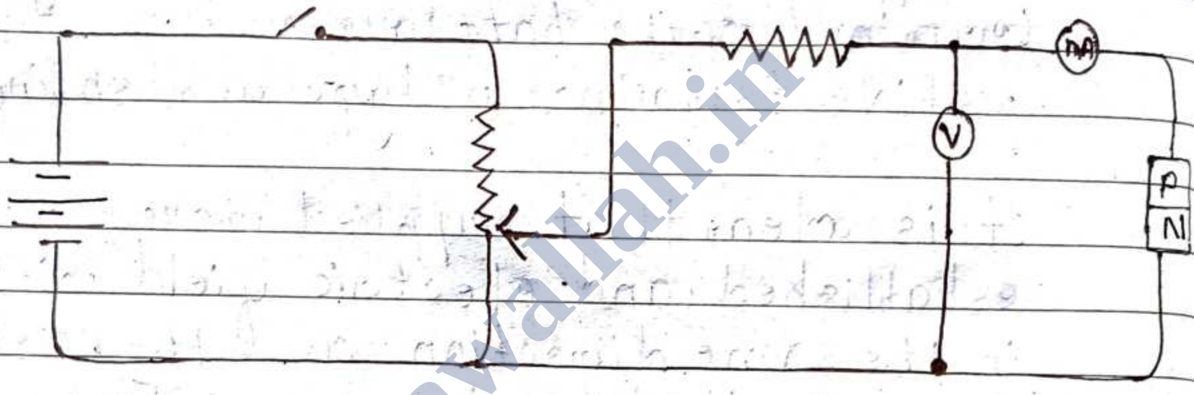
To apply reverse bias, connect negative terminal of the battery p-type and positive terminal n-type as shown.

It is clear that applied reverse voltage established and electric field with acts in the same direction as the field due to potential barrier. Therefore, the resultant field at the junction is strengthened and the barrier height is increased. The increased potential barrier prevents the flow of charge carriers across the junction. Thus, a high resistance path is established for the entire circuit and hence the current does not flow.

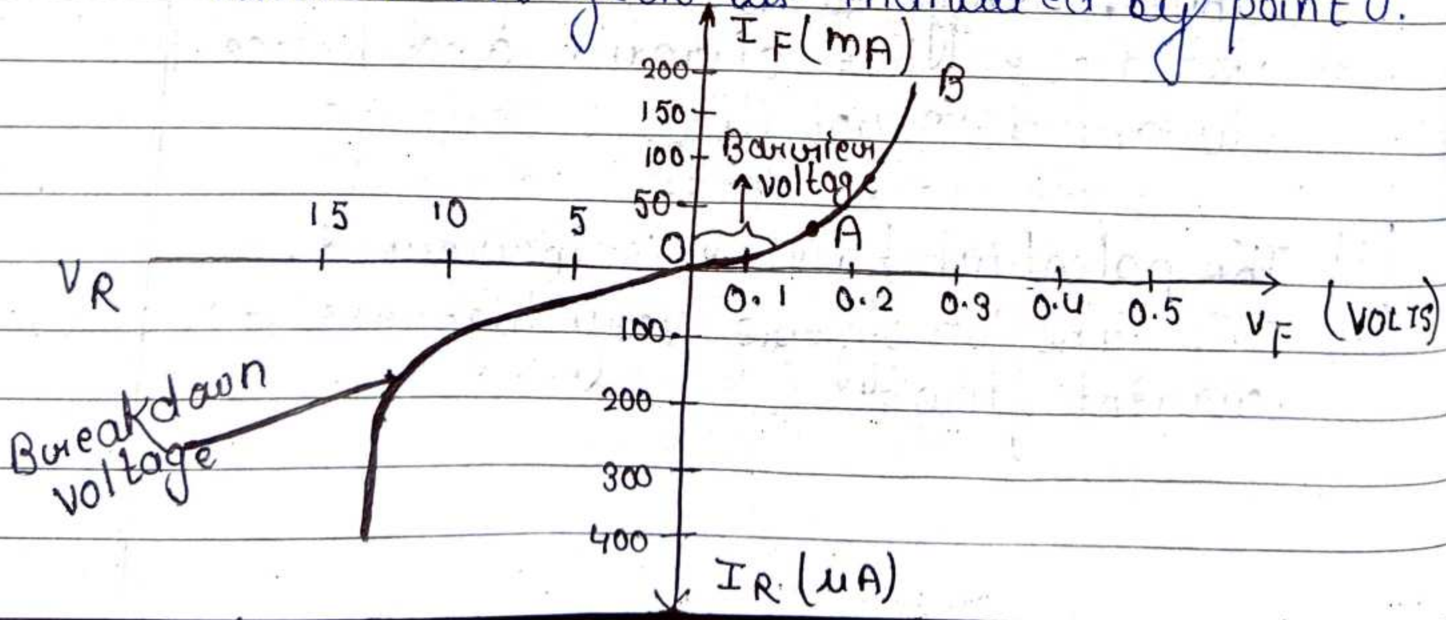
(i) The potential barrier is increased.
(ii) The junction offers very high resistance to current flow.

* Volt - Ampere characteristics of pn Junction :-

Volt Ampere or V- I characteristics of a pn junction is the curve between voltage across the junction and the circuit current.



- **Zero external voltage :-** When the external voltage is zero, i.e circuit is open at K, the potential barrier at the junction does not permit current flow. Therefore, the circuit current is zero as indicated by point O.

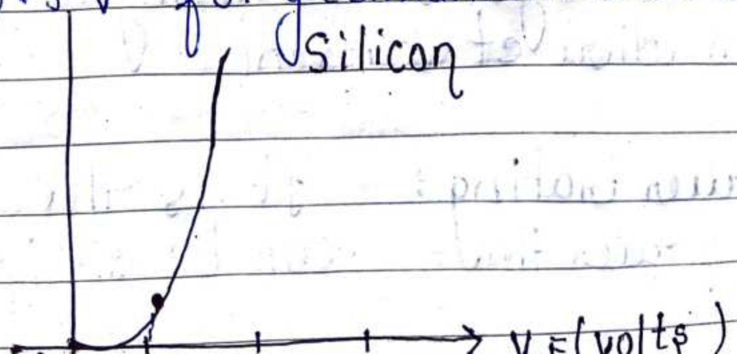


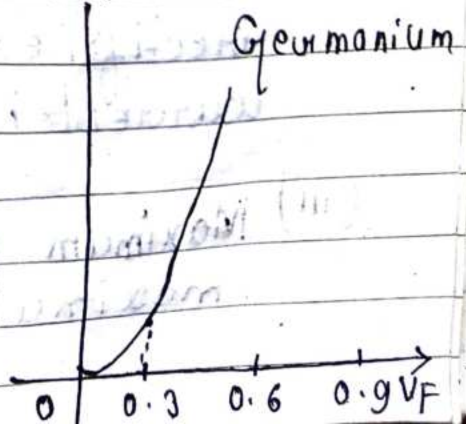
* Important terms :—

- **Breakdown voltage :—** It is the minimum reverse voltage at which pn junction breaks down with sudden rise in reverse current.

- **Knee voltage :—** It is the forward voltage at which the current through the junction starts to increase rapidly.

When a diode is forward biased, it conducts current very slowly until we overcome the potential barrier. For silicon pn junction, potential barrier is 0.7 V where as it is 0.3 V for germanium junction. It is clear from that Knee voltage for silicon diode is 0.7 V and 0.3 V for germanium diode.





* Limitation in the operating conditions of pn junction

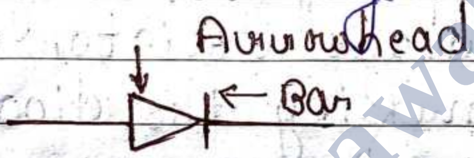
(i) Maximum forward current :- It is the highest instantaneous forward current that a pn junction can conduct without damage to the junction.

(ii) Peak inverse voltage :- It is the maximum reverse voltage that can be applied to the pn junction without damage to the junction. If the reverse voltage across the junction exceeds its PIV, the junction may be destroyed due to excessive heat. The peak inverse voltage is of particular importance in rectifier service. A pn junction i.e a crystal diode is used as a rectifier to change alternating current into direct current.

(iii) Maximum power rating :- It is the maximum power that can be dissipated at the junction without damaging it. The power dissipated at the junction is equal to the product of junction current and the voltage across the junction.

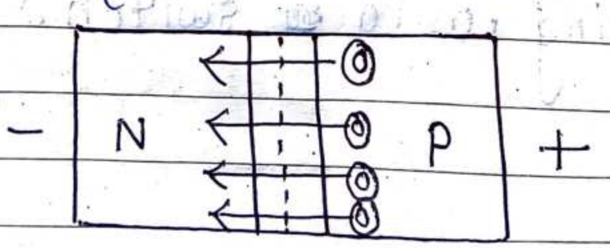
* Semiconductor :—

A pn junction is known as a semiconductor or crystal diode.



(i) If arrowhead of diode symbol is positive with respect to bar of the symbol, the diode is forward biased.

(ii) If the arrowhead of diode symbol is negative with respect to bar, the diode is reverse biased.

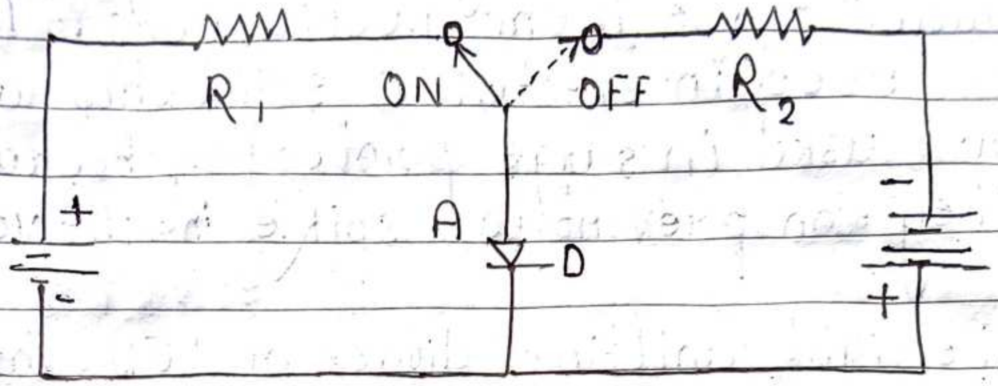


1. A diode is two terminal PN junctions, the PN junction when forward biased acts as closed - circuited and when reversed biased acts as on open circuited. Hence change in state from forward biased to reverse biased makes the diode work as a switch, the forward being ON and the reverse being OFF.

2. Whenever a specified voltage is exceeded the diode resistance gets increased, making the diode reverse biased and it acts as an open switch.

3. Whenever the voltage applied is below the reference voltage, the diode resistance gets decreased, making the diode forward biased, and it acts as a closed switch.

The following circuit explains the diode acting as a switch.



Switching circuit using Diode

A switching diode has a PN junction in which P-region is lightly doped and N-region is heavily doped. The above circuit symbolize that the diode that gets ON when positive voltage forward biases the diode and it gets OFF when negative voltage reverse biases the diode.

* Application and uses of diodes :-

There are various types of diodes and these diodes are used in numerous ways.

- The most basic function would be changing AC current to DC current by removing some part of the signal. This functionality would make them rectifiers. They are used in electrical switches and are used in surge protectors because they can prevent a spike in the voltage.

- The light emitting diodes or LEDs are used in sensors and also in laser devices any many other light illumination devices.

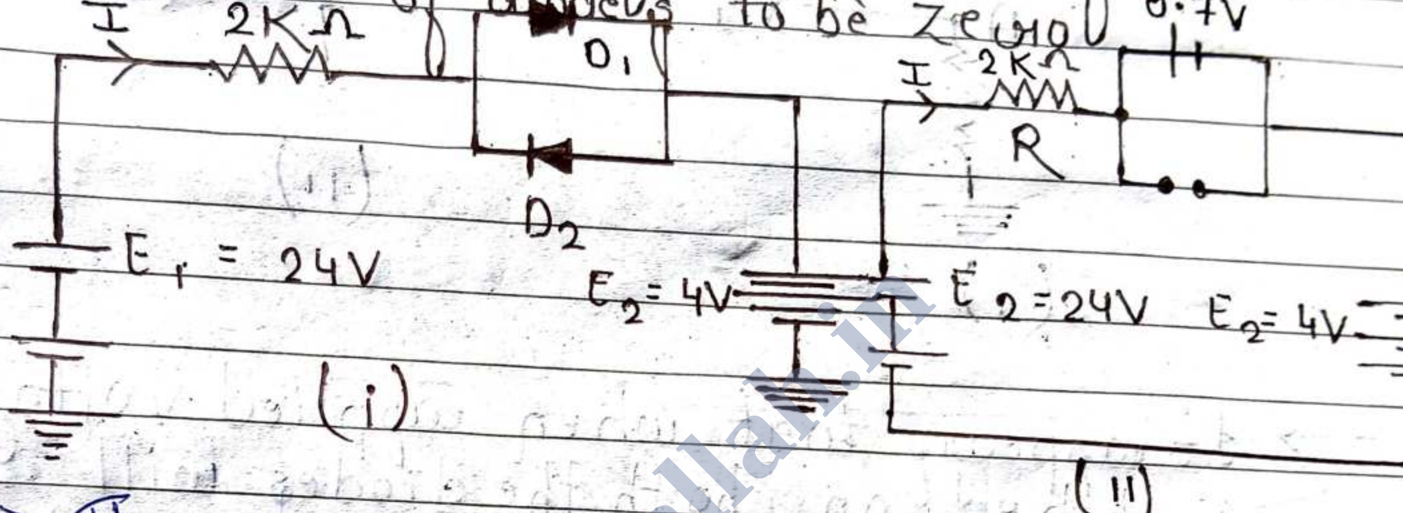
- Zener diodes are used as voltage regulations and varactors are used in electronic tunning and varistors are used in suppressing AC lines.

- Diodes are the basic of op-amps and transistors.

- They are used for isolating signals from a supply.

- Numericals on diode :-

1. (1) Determine the current I in the circuit shown in fig 6.12 (i) Assume the diodes to be of silicon and forward resistance of diodes to be zero



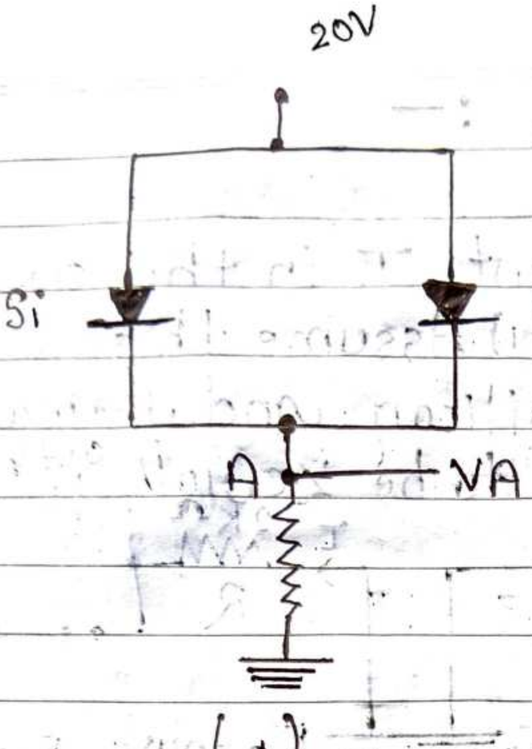
→ The condition of the problem suggest that diode D₁ is forward biased and diode D₂ is reverse biased.

$$\therefore I = \frac{E_1 - E_2 - V_0}{R}$$

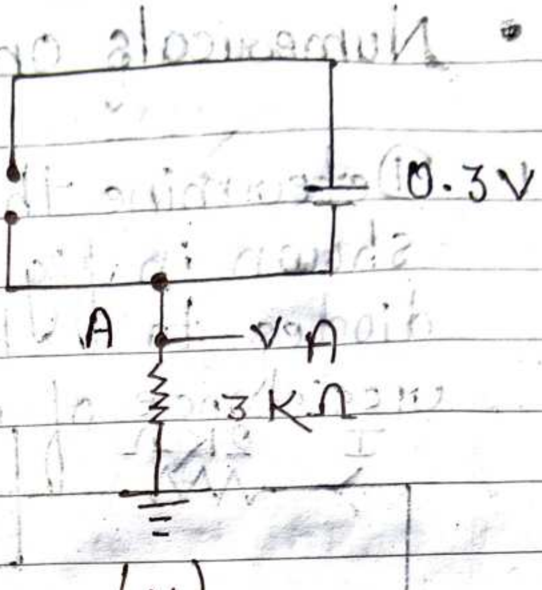
$$= \frac{24 - 4 - 0.7}{2K\Omega}$$

$$= \frac{19.3V}{2K\Omega} = 9.65mA$$

2. find the voltage VA in the circuit shown in fig. Use simplified model.



(i)

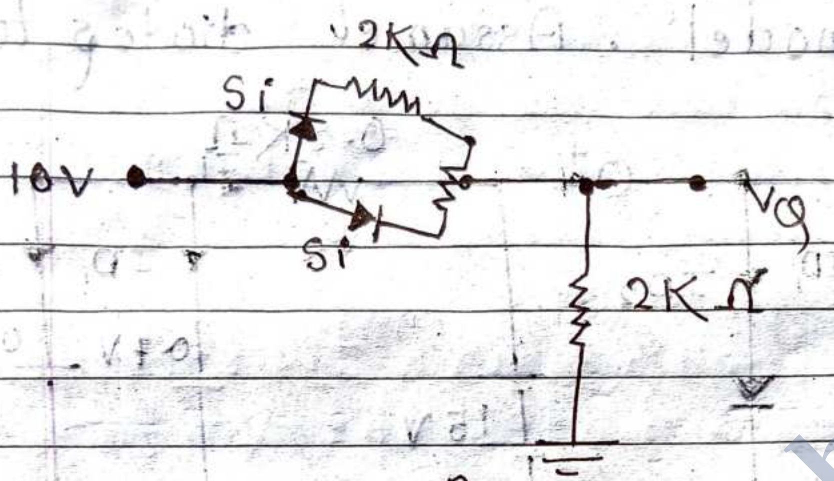


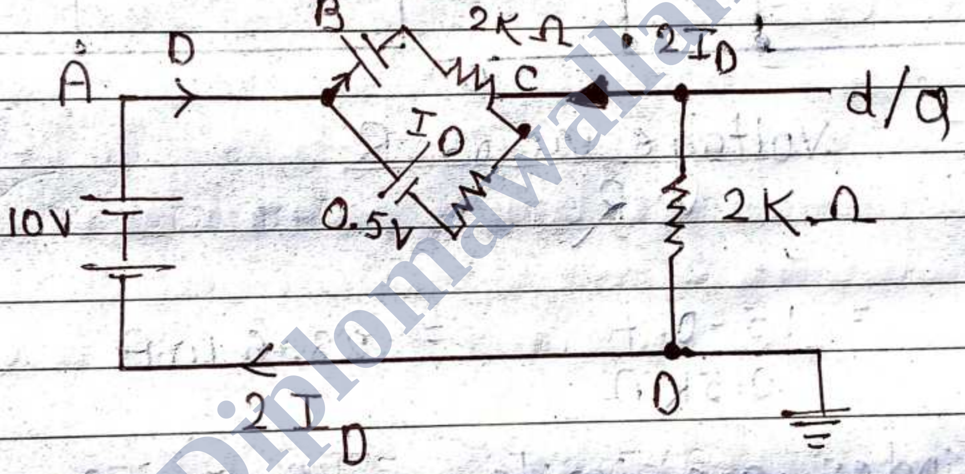
(ii)

→ It appears that when applied voltage is switched on, both the diodes will turn "on". But that is not so. when voltage applied, germanium diode ($V_0 = 0.3V$) will turn on first and a level of 0.3V is maintained across the parallel circuit. The silicon diode never gets the opportunity to have 0.7V across it and, therefore, remains in open-circuit state.

$V_A = 20 - 0.3$
$= 19.7V$

3. Find V and I_D in the network shown in fig. Use simplified model.





→ Applying Kirchhoff's voltage law to the closed circuit ABCDA, we have

$$-0.7 - I_D \times 2 - 2I_D \times 2 + 10 = 0$$

$$6 I_D = 9.3$$

$$I_D = \frac{9.3}{6} = 1.55 \text{ mA}$$

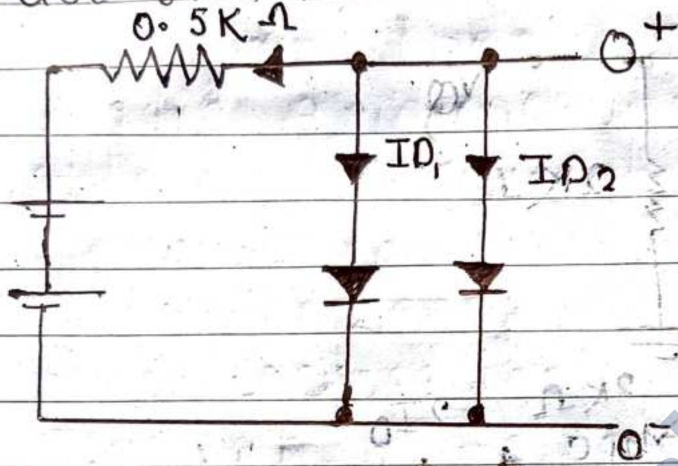
Also,

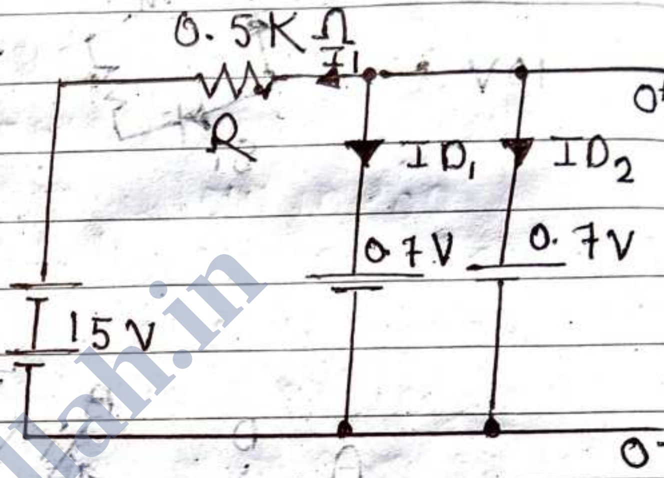
$$V_o = (2 I_D) \times 2K\Omega$$

$$= 2 \times 1.55 \times 2K\Omega$$

$$= 6.2V$$

4. Determine current through each diode in the circuit shown in figure. Use simplified model. Assume diodes to use similar.





→ $I_1 = \dfrac{\text{Voltage across R}}{R}$

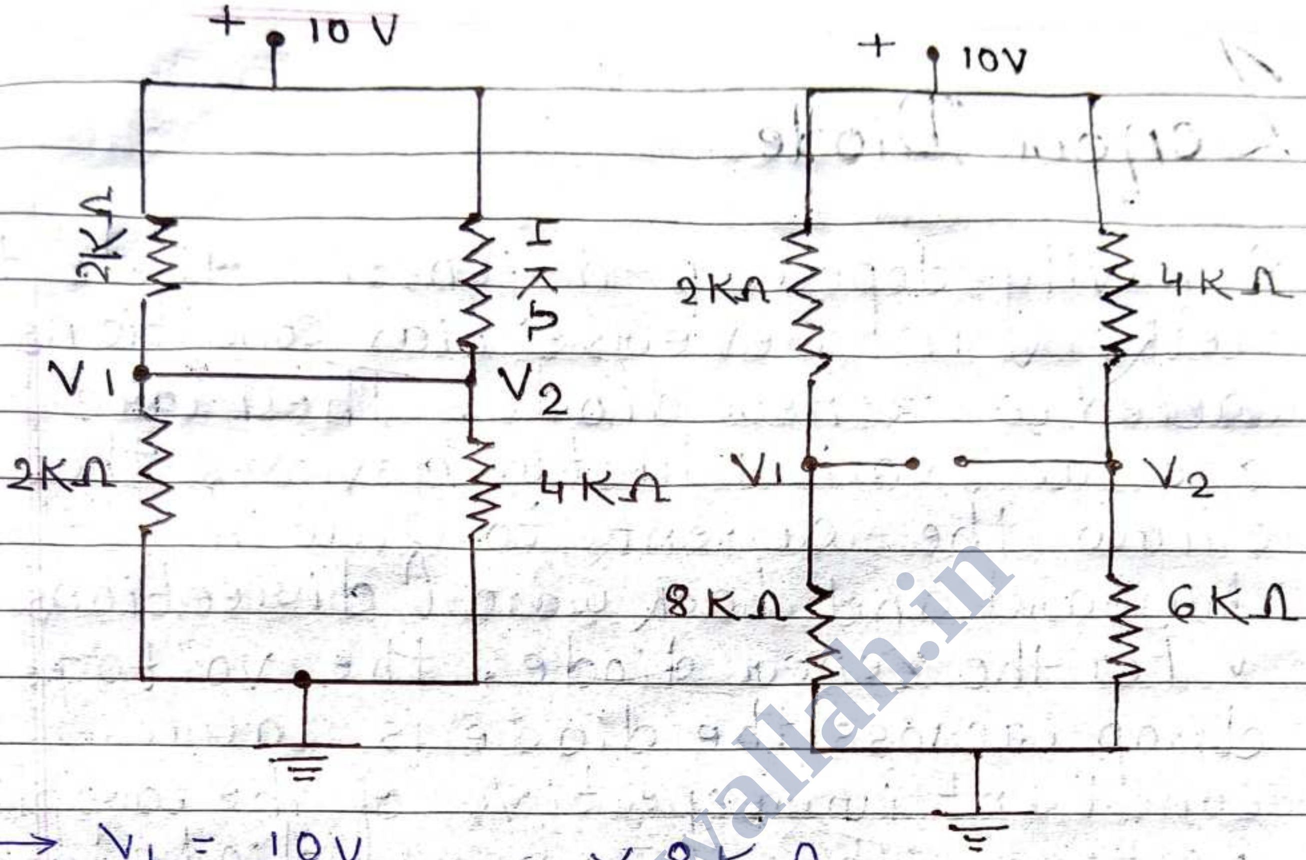
$= \dfrac{15 - 0.7}{0.5 K\Omega} = 28.6\ mA$

Diodes are similar, $ID_1 = ID_2 = \dfrac{I_1}{2}$

$= \dfrac{28.6}{2}$

$= 14.3\ mA$

5. Determine if the diode (ideal) in figure is forward biased or reverse biased.



$$\rightarrow V_1 = \frac{10V}{2K\Omega + 8K\Omega} \times 8K\Omega$$

$$= \frac{\cancel{10}V}{\cancel{10K\Omega}} \times 8\,\cancel{K\Omega}$$

$$= 8V$$

$$V_2 = \frac{10V}{4K\Omega + 6K\Omega} \times 6K\Omega$$

$$= \frac{\cancel{10}V}{\cancel{10K\Omega}} \times 6\,\cancel{K\Omega}$$

$$= 6V$$

∴ Voltage across diode = 8V − 6V
= 2V

* Zener Diode

A havily doped p-n junction diode that works in reverse bias conditions is called a zener diode. They are special semiconductor devices that allow the current to flow in both forward and backward directions. For the zener diode, the voltage drop across the diode is always constant irrespective of the applied voltage. Thus, zener diode are used as a voltage regulator.

* What is zenerdiode?

A zener diode can be considered as a highly doped p-n junction diode which is made such that it works in reverse bias condition.

A zener diode which is also called a Breakdown diode works in reverse bias conditions. An electrical breakdown occuring in the reverse biased condition of the PN Junction diode is called the

Zener effect. In this condition when the electric field increases to a high value it enables the tunnelling of electrons from the valence band to the conduction band of a semiconductor, which suddenly increases the reverse current.

* History of Zener diodes :-

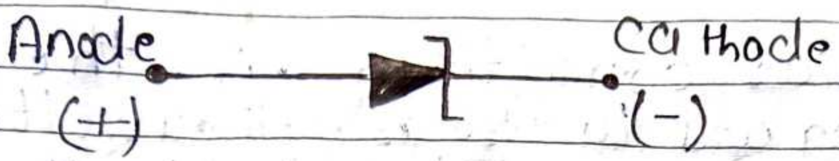
A theoretical physicit working at Bell Labs was the first man to describe the electrical properties of zener diode. His name was Clarence Melvin Zener, he was the first to tell about this special diode that works on reverse bias conditions so the diode is name after him zener Diode. He first postulated the breakdown effect in a paper published in 1934.

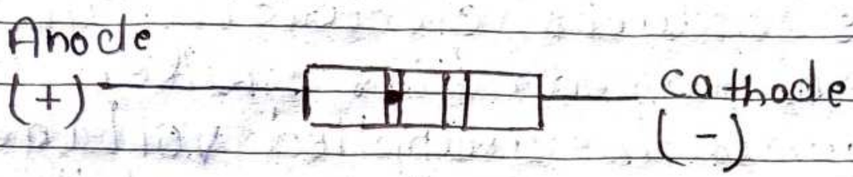
* Zener diode Explanation :-

Zener diode that is also known as a breakdown diode is a heavily doped semiconductor device that has been specially designed to operate in the reverse direction. When the potential reaches the Zener voltage which is also known as Knee voltage and the voltage across the terminal of the Zener Diode is reversed, at that point time the junction breaks down and the current starts flowing in the reverse direction. This effect is known as the Zener effect.

* Zener diode circuit Diagram :-

→ The figure given below is the circuit diagram of the zener Diode. The Zener diode has applications in various electronic devices and applications in various electronic devices and it works in reverse biasing condition. In reverse biasing, the P-type material of the diode is connected with the negative terminal of the power supply and the n-type material is connected with the positive terminal of the power supply. The diode consists of a very thin depletion region as it is mode up of heavily doped semiconductor material.





There are two tags at the end of the bar in the circuit symbol of the Zener diode, one in the upward direction of the other in the lower direction. In this way, we can easily distinguish between the Zener diode and other diodes.

* Zener diode working :-

High level impurities are added to a zener diode to make it more conductive and thus the zener diodes can easily conduct electricity. Compared to other p-n junction diodes. These impurities reduce the depletion layer of the Zener diode and make it very thin. Thus, this diode also works even if the voltage applied is very small.

In reverse bias conditions, if the Zener voltage is equal to the supplied voltage, the diode conducts electricity in the direction of reverse bias. When the Zener voltage equals the supplied voltage the depletion layer vanishes completlly.

* Zener diode working in reverse biased:-

→ In forward biased conditions, the Zener Diode works like any normal diode but in the reverse bias condition, a small leak current flows through the diode. As we keep increasing the reverse voltage it reaches a point where the reverse voltage equals the breakdown voltage. The breakdown voltage is represented as Vz and in this condition the current start flowing in the diode. After the breakdown voltage the current increase drastically until it reaches a stable value.

In reverse bias condition, two kinds of breakdown occur for Zener diode which are :-

- Avalanch Breakdown
- Zener Breakdown

* Avalanche Breakdown :-

The phenomenon of Avalanche breakdown occurs both ~~path~~ in the ordinary diode and zener diode at high reverse voltage. For a high value of reverse voltage, the free electron in the PN junction diode gains energy and acquires high velocity and these high velocity electrons collides with other atoms and knock electrons from that atoms. This collision continues and new electrons are available for conductivity current thus the current increase rapidly in the diode.

If the reverse voltage is greater than 6V the avalanche breakdown happens in the Zener diode.

* Zener Breakdown :-

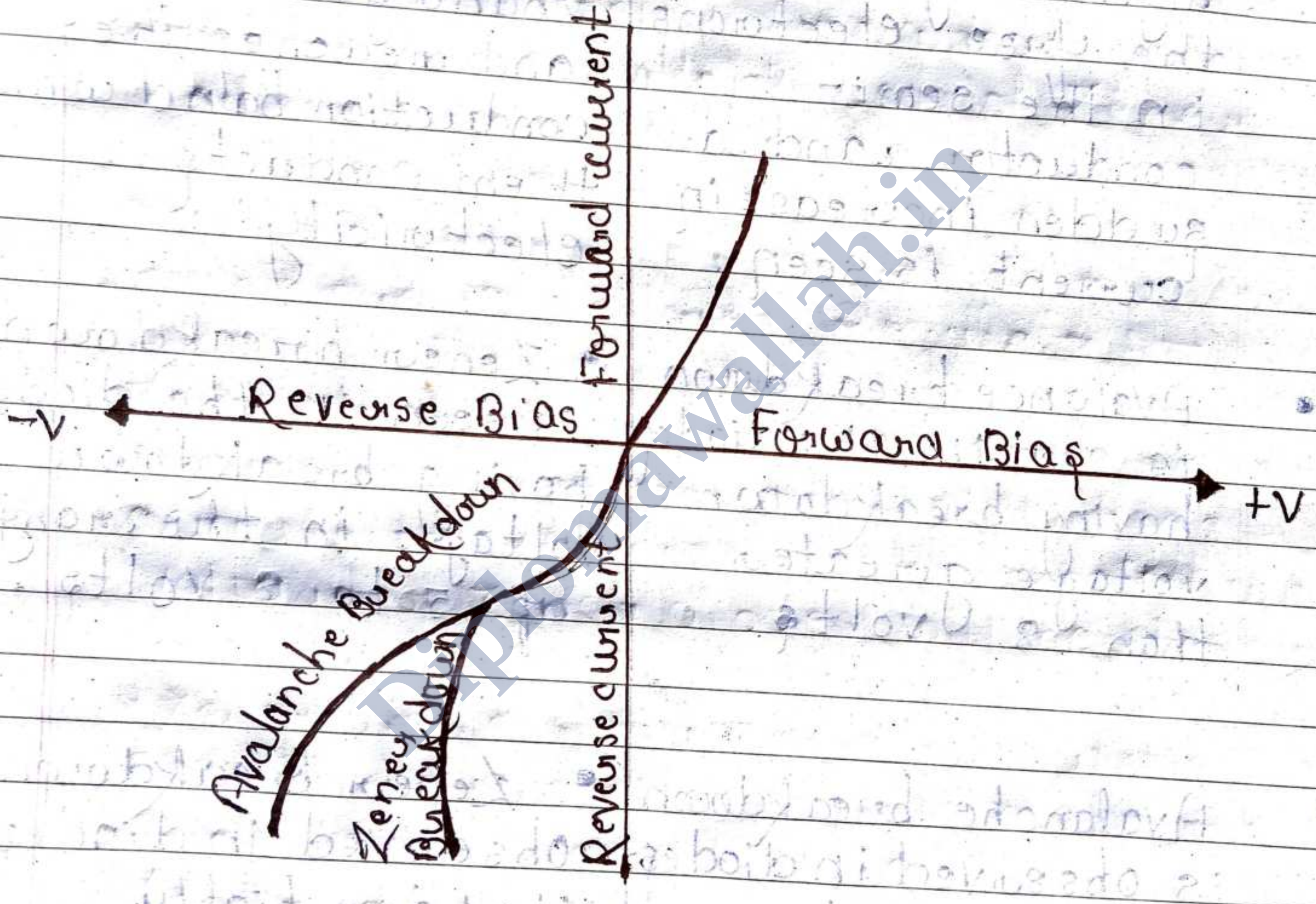
→ Zener breakdown happens in heavily doped PN junction diodes. In these diodes, if the reverse bias voltage reach closer to Zener voltage, the electric field gets stronger and is sufficient enough to pull electrons from the valance band. These electrons then gain energy from the electric field and break free from the atom.

Thus, for these diodes in the Zener breakdown region, a slight increase in the voltage causes a sudden increase in the current.

Avalanche Breakdown	Zener Breakdown
• Avalanche breakdown occurs when the high voltage increase the free electrons in the semi-conductor and a sudden increase in current is seen.	• Zener breakdown happens when electrons from the valance band gain energy and reaches the conduction band which them conducts electricity.
• Avalance breakdown is seen in the diodes having breakdown voltage greater than 8 volts.	• Zener breakdown is seen in the diodes having breakdown voltage in the range of 5 to 8 volts.
• Avalanche breakdown is observed in diodes that are lightly doped.	• Zener breakdown is observed in diodes that are highly doped.
• For Avalanche breakdown increase in temp increases the breakdown voltage.	• For Zener breakdown increase in temp decreases the breakdown voltage.

* VI characteristics of Zener diode :-

The graph given underneath shows the V-I characteristics of the Zener diode.



V-I characteristics of a Zener Diode can be studied under the following two headings,

* Forward characteristics of Zener diode :-

→ Forward characteristic of the Zener diode are similar to the forward characteristics of any normal diode. It is clearly evident from the above diagram in the first quadrant that the VI forward characteristics are similar to other P-N junction diodes.

* Reverse characteristics of Zener diode :-

→ In reverse voltage conditions a small amount of current flow through the Zener diode. This current is because of the electrons which are thermally generated in the Zener diode. As we keep increasing the reverse voltage at any particular value of reverse voltage the reverse current increases suddenly at the breakdown point this voltage is called Zener voltage and is represented as Vz.

* Application of Zener diode :—

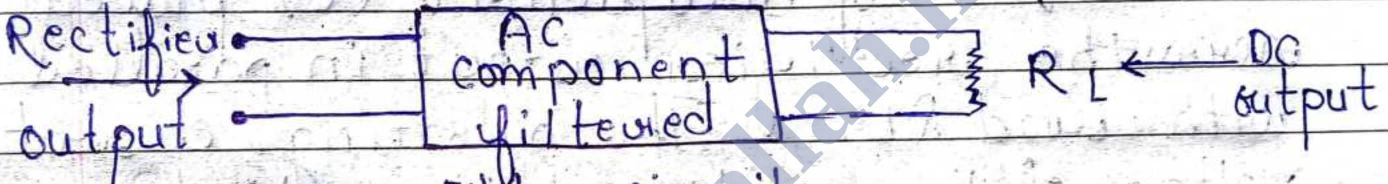
→ Zener diode is a Very useful diode. Due to its ability to allow current to flow in reverse bias conditions, it is used widely for various purposes. Some of the common uses of Zener diode are discussed below.

* Zener diode as voltage Regulator :—

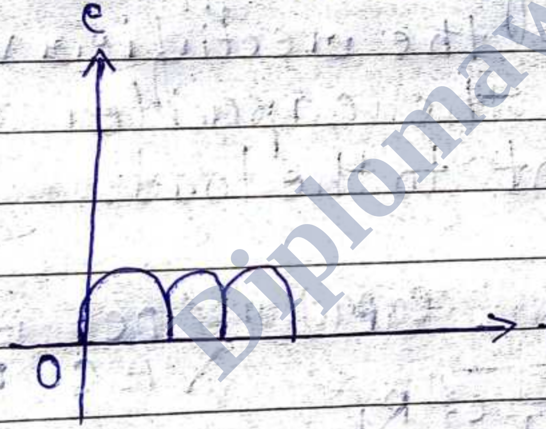
→ Zener diode is utilized as a shunt voltage controller for managing voltage across little loads. The breakdown voltage of Zener diodes will be steady for a wide scope of current. The Zener diode is associated with corresponding to the head to make it switch predisposition and when the Zener diode surpasses knee voltage, the voltage across the heap will become consistent.

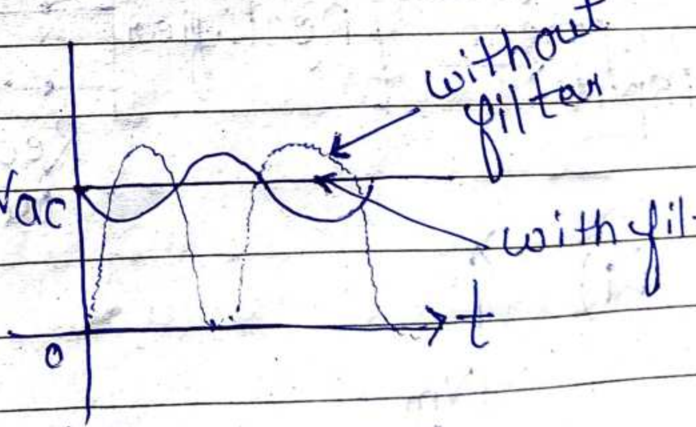
* Filter component and their role in reducing ripple.

- **Filter Circuit :—** A filter circuit is a device which removes the AC component of the rectifier output but allows the DC component to reach the load.



Filter circuit





* types of filter circuit :—

The most commonly used filter circuits are :—

(i) Capacitor filter

(ii) Inductor filter

(iii) choke Input filter

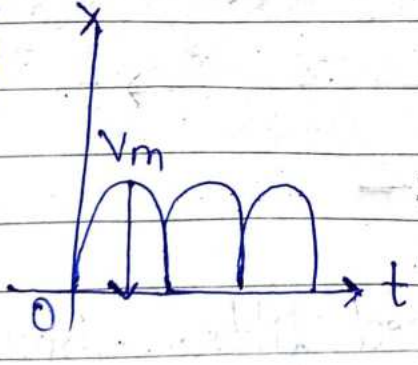
(iv) Pie (π) filter or capacitor Input filter

- Capacitor filter :— Capaciter filter is consist of a capacitor (c) placed across the rectifier output in parallel with load RL. The pulsating direct voltage of the rectifier is applied across the capacitor. As the rectifier voltage increases it charges the capacitor and also supply current to the load.

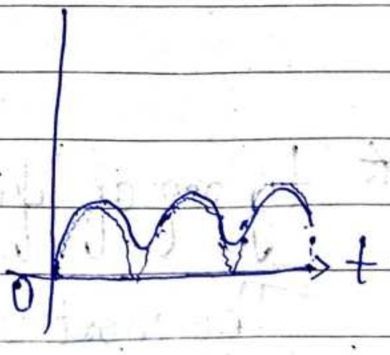
Capacitor < DC Block / A C Pass >

reverse inductor

(i)



(ii)



$\text{Reactant}\,(X_c) = \frac{1}{\omega C}$

Omega ← ωC → Capacitance

$= \frac{1}{2\pi f C}$

$= \frac{1}{0}$ [frequency = 0]

$\boxed{X_c = \infty}$

∴ Capacitor acts as DC as an open circuit.

(ii) At the end of quarter cycle, the capacitor is charge to the peak value V_m of the rectifier voltage.

(iii) The voltage across load will decrease only slightly because immediately the next voltage peak comes and recharge the capacitor.

(iv) This process is repeated again and again and the output voltage wave form becomes as shown in the fig. It may be seen very little ripple is left in the output.

* Brief idea about capacitor :-

→ The capacitor offers opposition that is called capacitive reactance. It is represented by X_C and is given as

$$X_C = \frac{1}{\omega C} \quad \begin{bmatrix} \omega = \text{frequency} \\ C = \text{capacitance} \end{bmatrix}$$

$$= \frac{1}{2\pi f C}$$

for DC we know that, frequency $(F) = 0$

$$= \frac{1}{2\pi \times 0 \times C}$$

$$= \frac{1}{0}$$

$$\boxed{X_C = \infty}$$

$X_C = \infty$ means that a capacitor for a DC acts as an circuit and blocks the DC on the other hand for AC f = large so, X_C = small.

Half wave rectifier efficiency = 40.6

* HALF WAVE RECTIFIER :-

efficiency (η) = $\frac{\text{dc power output}}{\text{AC power output}}$

dc power (Pdc) = $I^2_{dc} \times R_L$

$\left(\frac{I_m}{\pi}\right)^2 \times R_L$ $\left[I_m = \frac{V_m}{R_f + R_L} \right]$

R_L = load resistance.

R_F = Forward resistance

AC power input (Pac) = $I^2_{rms}(\gamma_f + \eta)$
for Half wave Rectifier

$$\left[I_{rms} = \frac{I_m}{2} \right]$$

$$P_{ac} = \left(\frac{I_m}{2}\right)^2 \times (\gamma_f + R_L)$$

Now,

efficiency (η) = $\frac{P_{dc}}{P_{ac}}$

$$= \frac{I^2_{dc} \times R_L}{I^2_{\gamma m} \times (R_L \times R_F)}$$

$$= \frac{\left(\frac{I_m}{\pi}\right)^2 \times R_L}{(I_m)^2 \times (R_L \times R_P)}$$

$$= \frac{\frac{R_L}{\pi^2}}{\frac{R_L \times R_F}{4}}$$

$$= \frac{\overset{4}{\cancel{R_L}}}{\pi^2} \times \frac{4}{\cancel{R_L} \times R_F} \quad \left[\because r_F \text{ is negligible as compared to } R_L\right]$$

$$= \frac{4}{\pi^2}$$

$$= \frac{4}{9.8596} = 0.4056$$

$$= 40.6\ \%$$

Therefore maximum rectifier efficency is equal to 40.6%.

* Efficiency of full wave rectifier :-

$$\text{effeciency of FWR } (\eta) = \frac{\text{DC output power}}{\text{Ac input power}}$$

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

$$\text{DC output power} = I^2_{dc} \times R_L$$

$$= \left(\frac{2Im}{\pi}\right)^2 \times R_L \quad \left[\begin{array}{l}\text{For FWR} \\ Idc = \frac{2Im}{\pi}\end{array}\right]$$

AC input power (Pac) $= \underline{I^2 rms} \times (R_L + R_F)$

$$\left[\begin{array}{l}\text{for FWR} \\ Irms = \frac{Im}{\sqrt{2}}\end{array}\right] = \left(\frac{Im}{\sqrt{2}}\right)^2 \times (R_L + R_F)$$

Now, $\eta = \frac{Pdc}{Pac}$

$$\eta = \frac{\left(\frac{2Im}{\pi}\right)^2 \times R_L}{\left(\frac{Im}{\sqrt{2}}\right)^2 \times (R_L + R_F)}$$

$$= \frac{\frac{4\cancel{Im^2}}{\pi^2} \times R_L}{\frac{\cancel{Im^2}}{2} \times (R_L + R_F)}$$

$$= \frac{\frac{4R_L}{\pi^2}}{\frac{R_L + R_F}{2}}$$

$$= \frac{4R_L}{\pi^2} \times \frac{2}{R_L + R_F}$$

$$= \frac{8}{\pi^2} = \frac{8}{9.8596}$$

Since, r_f is negligible as composed to R_L $8 / 9.8596 = 0.811$

$= 81.2\ \%$

∴ Maximum efficiency of FWR is equal to 81.2%.

* Riple factors :—

The output of a rectifier consist of a dc component and an ac component. The AC component is undesirable and accounts for the pulsation in the rectifier output.

The effectiveness of a rectifier depends upon the magnitude of AC component in the output, the smaller this component the more effectictive is the rectifier.

The ratio of Rms value of AC component is the DC component in the rectifier output is known as ripple factor.

$$\text{Ripple factor} = \frac{\text{RMs value of AC component}}{\text{value of DC component}}$$

$$= \frac{I_{ac}}{I_{dc}}$$

I_{rms} = (rms value of load current)

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

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

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

$$\text{Ripple factor} = \frac{I_{ac}}{I_{dc}}$$

$$= \sqrt{I_{rms}^2 - I_{dc}^2}$$

$$= \sqrt{I_{rms}^2 - I_{ac}^2}$$

$$= \frac{\sqrt{I_{rms}^2 - I_{dc}^2}}{I_{dc}}$$

$$= \frac{1}{I_{dc}} \sqrt{I_{rms}^2 - I_{dc}^2}$$

$$= \sqrt{\left(\frac{I_{rms}}{I_{dc}}\right)^2 - \frac{I_{dc}^2}{I_{dc}^2}}$$

$$= \sqrt{\left(\frac{I_{rm}}{I_{dc}}\right)^2 - 1}$$

For HWR

$$I_{rms} = \frac{I_m}{2} \quad \& \quad I_{dc} = \frac{I_m}{\pi}$$

$$\text{Ripple factor} = \sqrt{\left(\frac{I_{rm}}{I_{dc}}\right)^2 - 1}$$

$$= \sqrt{\left(\frac{I_m/2}{I_m/\pi}\right)^2 - 1}$$

$$= \sqrt{\frac{\pi^2}{4} - 1}$$

$$= \sqrt{\frac{9.8596}{4} - 1}$$

$$= \sqrt{2.4649 - 1}$$

$$= \sqrt{1.4649}$$

$$= 1.21$$

For FWR,

$$I_{rms} = \frac{I_m}{\sqrt{2}}, \quad I_{dc} = \frac{2I_m}{\pi}$$

$$\text{Ripple factor} = \sqrt{\left(\frac{I_{rms}}{I_{dc}}\right)^2 - 1}$$

$= \sqrt{\left(\frac{Im/\sqrt{2}}{2Im/\pi}\right) - 1}$

$= \sqrt{\frac{1/2}{4/2} - 1}$

$= \sqrt{\frac{\pi^2}{8} - 1}$

$= \sqrt{1.2206 - 1}$

$= \sqrt{0.2206}$

$= 0.469$

$= 0.48$

Q. A full wave rectifier uses two diodes, the internal resistance of each diode may be assumed constant at 20Ω. The transformer Rms secondary voltage from center tap to each and of secondary is 50V and load resistance is 980Ω. find out :-

(i) The mean load current
(ii) The rms value of load current

→ Given.

(diode resistance) $r_f = 20\Omega$ (each diode)

r_{ms} value (secondary) = 50V

$V_{rms} = 50V$

$R_L = 980\Omega$

(i) Maximum AC voltage $(V_m) = V_{rms} \times \sqrt{2}$

$= 50V \times \sqrt{2}$

$= 50\sqrt{2}V$

$= 70.7V$

Max^m load current $(I_m) = \frac{V_m}{R}$

$= \frac{70.7}{980+20} = \frac{70.7}{10000}$

$= 0.0707 A$

$= 70.7 mA$

Mean load current $(I_{dc}) = \frac{2 I_m}{\pi}$

$= \frac{2 \times 70.7 \times 10\cancel{0}}{3.14 \times 1\cancel{0}}$

$= \frac{\cancel{2} \times 707 \times 10}{\cancel{314}}$

157

$$= \frac{7070}{157}$$

$$= 45.03 \, mA$$

(ii) Rms value of load current $(I_{rms}) = \frac{I_m}{\sqrt{2}}$

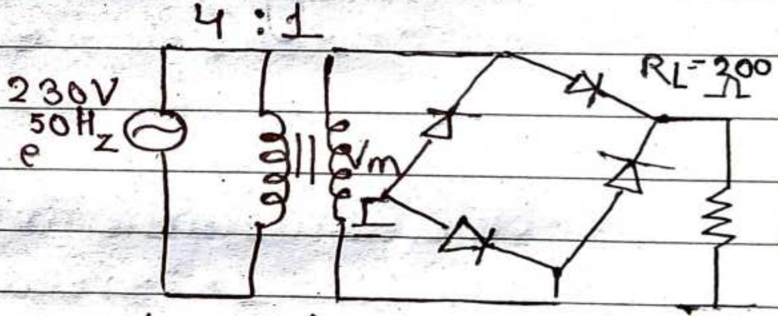
$$= \frac{70.7}{\sqrt{2}}$$

$$= 49.99$$

$$= 50 \, mA$$

Q. In the bridge type circuit as shown below, the diodes are assumed to be ideal. Find out

(i) DC output voltage.
(ii) Peak inverse voltage
(iii) output frequency



Assume primary to secondary turns to be 4.

→ Primary / Secondary $= \frac{N_1}{N_2} = \frac{4}{1}$

$$= 4$$

Voltage across primary winding $= 230V$
" " secondary " $= 230V \times \frac{N_2}{N_1}$

Rms Voltage $= \cancel{230}^{115} \times \frac{1}{\cancel{4}\,2} = \frac{115}{2}$

$= 57.5\ V$

Rms primary voltage $= 230V$

" secondary voltage $= 57.5\ V$

Maximum voltage across secondary is (V_m)

$V_m = V_{rms}(\text{secondary}) \times \sqrt{2}$

$= 57.5 \times \sqrt{2}$

$= 81.3\ V$

Average current $(I_{dc}) = \frac{2V_m}{\pi R_L}$

$= \frac{2 \times 81.3}{3.14 \times 200}$

$= \frac{162.6}{628} = 0.258$

$= 0.26\ Amp.$

(i) output dc voltage $(V_{dc}) = I_{dc} \times R_L$

$= 0.26 \times 200$

$= 52V$

(ii) Peak inverse voltage is equal to the max secondary voltage.

$\therefore$ PIV = V_m

$$\boxed{PIV = 81.3}$$

(iii) In full wave rectifier, their are two output pulses for each complete cycle of the input AC voltage Therefore the output frequency is twice that of AC supply frequency

i.e. $F_{out} = 2 \times f_{in}$

$= 2 \times 50 Hz$

$= 100 Hz$