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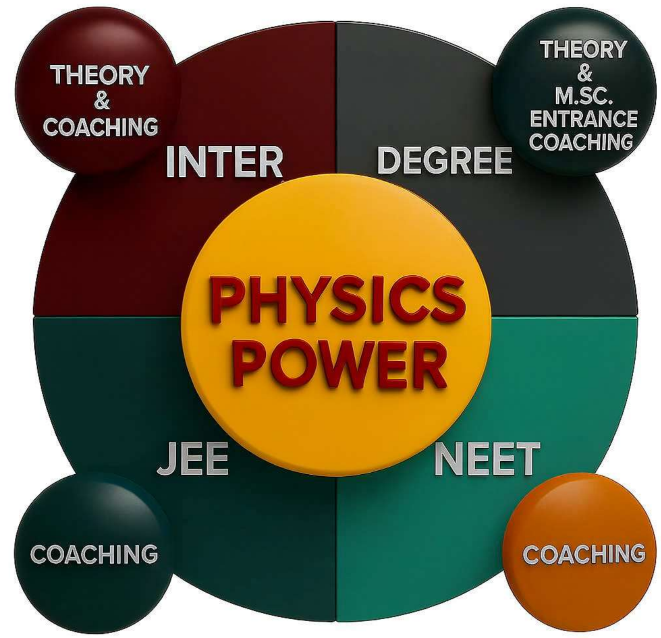
PHYSICS POWER



CHAPTER - 15

SEMICONDUCTORELECTRONICS: MATERIALS,DEVICES AND SIMPLE CIRCUITS

INTRODUCTION
Classification of Metals, Conductors and Semiconductors
Intrinsic Semiconductor
Extrinsic Semiconductor
p-n Junction
Semiconductor diode
Application of Junction Diode as a Rectifier
Special Purpose p-n Junction Diodes
Junction Transistor
Digital Electronics and Logic Gates
Integrated Circuits

Removed Topics

Purpose of P-N junction diode

1. Zener diode and their characteristics
2. Zener diode as a voltage regulators.

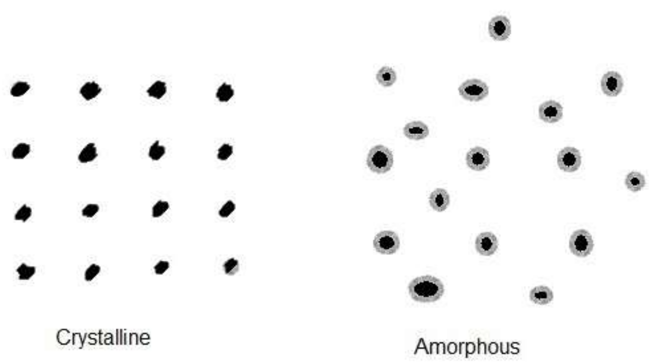
INTRODUCTION

CRYSTAL STRUCTURE

Crystalline nature of matter:

If the atoms or molecules in a solid are arranged in some regular fashion then it is known as **crystalline**.

When the atoms or molecules in a solid are arranged in a irregular fashion then it is known as **amorphous**.



Crystal:

A crystal is a solid composed of a periodic array of atoms i.e. a representative unit is repeated at regular intervals along array and all directions.

Differences between crystalline and amorphous solids:

Crystalline solids	Amorphous solids
1. These have a regular arrangement of particles in the solid.	1. These have a completely random arrangement.
2. These have different physical properties (thermal conductivity, refractive index, etc) in different directions i.e. These are anisotropic substances.	2. These have same physical properties in all directions
3. All bonds in crystalline solids are equally strong due to their symmetry.	3. All bonds in amorphous solid are not equally strong.
4. These have very sharp melting point.	4. These do not have sharp melting point.

Classification of solids – On the basis of electrical properties

Conductors:

The substances which easily allow the electric current through them are called conductors

Eg: Au, Ag, Cu, Al, etc.,

Insulators:

The substances which do not allow the electric current through them are called insulators.

Eg: Glass, Wood, Mica, etc.,

Semiconductors

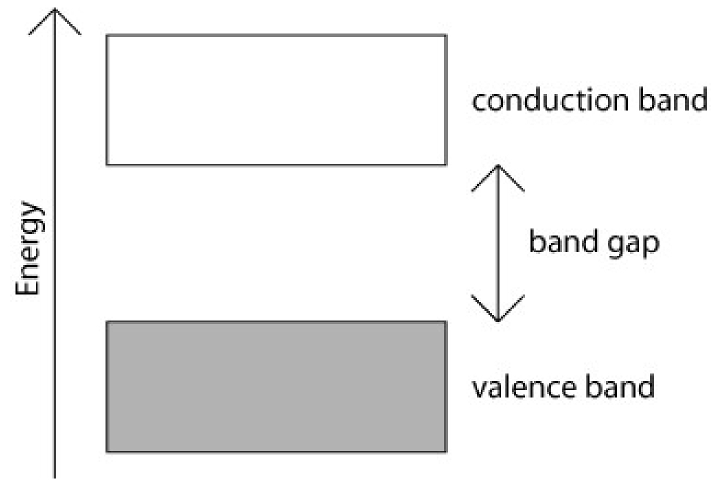
The substance whose electrical properties lie in between conductors and insulators are called semiconductors

Eg: Si, Ge, etc.,

BAND THEORY

BAND THEORY

Energy bands consisting of a large number of closely spaced energy levels exist in crystalline materials.
The bands can be thought of as the collection of the individual energy levels of electrons surrounding each atom.



VALANCY BAND

The energy band occupied by the valancy electrons of all the atoms of a solid, is known as Valancy Band.

CONDUCTION BAND

The energy band occupied by the free electrons in a solid is known as Conduction Band

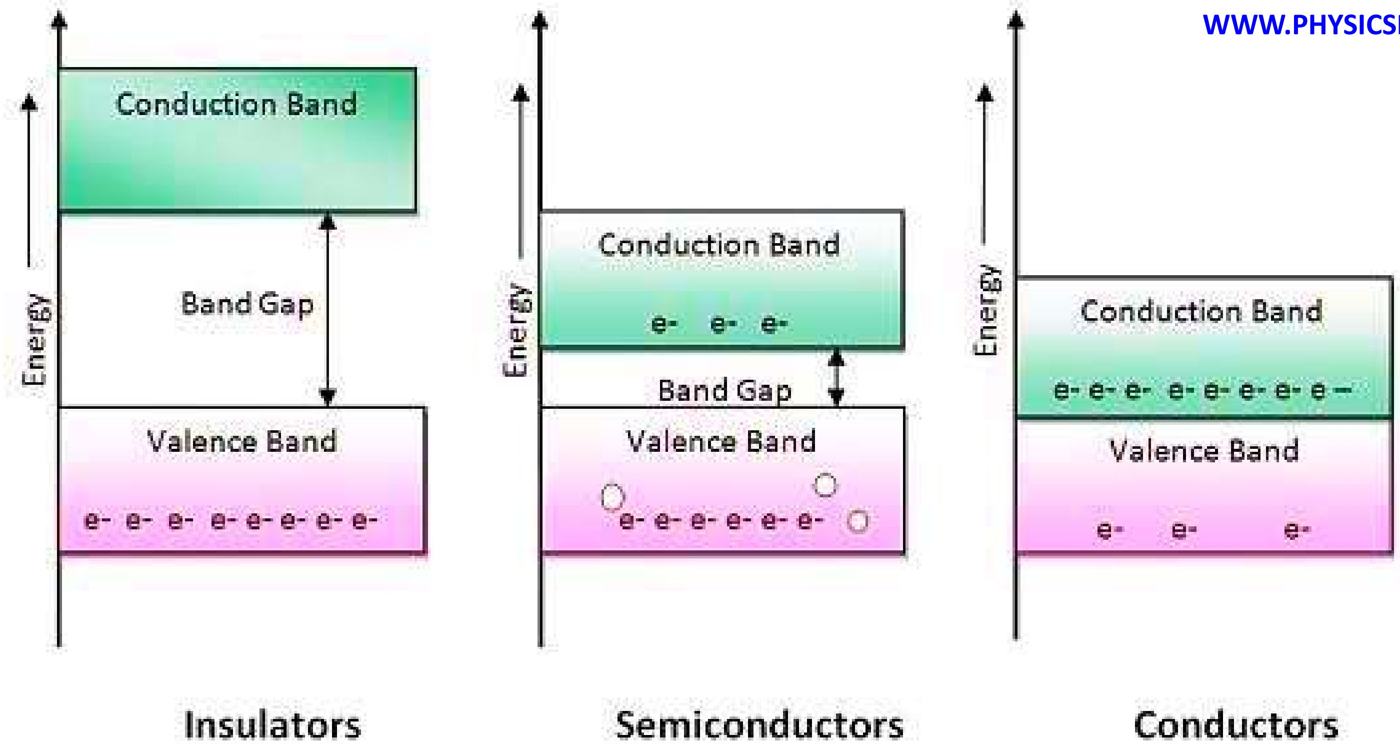


Image source: https://electricalvoice.com/

TEMPERATURE EFFECT ON THE RESISTANCE OF THE SEMICONDUCTORS:

When the temperature is increased the forbidden gap between the two bands becomes very less and the electrons move from the valence band to the conduction band.

Thus, when the temperature is increased in a semiconductor, the density of the charge carriers also increases and the resistance / resistivity decreases.

TEMPERATURE EFFECT ON THE RESISTANCE OF THE INSULATORS:

When the temperature is increased the forbidden gap between the two bands becomes very less and the electrons move from the valence band to the conduction band.

Thus when the temperature is increased in a insulator, the density of the charge carriers also increases and the resistance / resistivity decreases.

TEMPERATURE EFFECT ON THE RESISTANCE OF THE CONDUCTORS:

When the temperature is increased in a conductor, the density of the charge carriers increases much more in conduction band and collision between the electrons in the conduction band increases, which stops the flow of electrons. Hence the resistance / resistivity increases.

DIFFERENCES BETWEEN CONDUCTORS, SEMI CONDUCTORS AND INSULATORS

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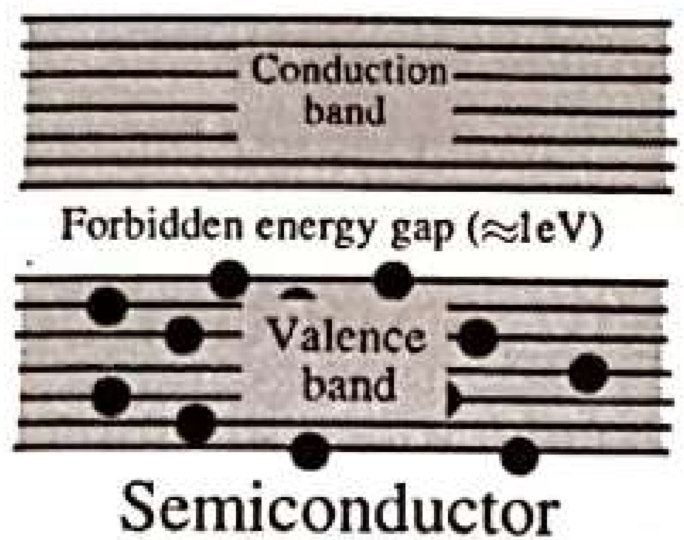
S.No	Conductors	SemiConductors	Insulators
1.	In this, valence band and conduction band overlap each other	In this, valence band and conduction band are separated by small forbidden gap.	In this, valence band and conduction band are largely separated.
2.	Forbidden Energy gap = 0 eV	Forbidden energy gap is in the order of 1 eV.	Forbidden energy gap is in the order of 6 eV
3.	At room temperature conductivity is high	At room temperature conductivity is intermediate.	At room temperature conductivity is nil.
4.	They possess very low resistivity (or high conductivity). $\rho \sim 10^{-2} - 10^{-8}\ \Omega m$ $\sigma \sim 10^{2} - 10^{8}\ Sm^{-1}$	They have resistivity or conductivity intermediate to metals and insulators. $\rho \sim 10^{-5} - 10^{6}\ \Omega m$ $\sigma \sim 10^{5} - 10^{-6}\ Sm^{-1}$	They have high resistivity (or low conductivity). $\rho \sim 10^{11} - 10^{19}\ \Omega m$ $\sigma \sim 10^{-11} - 10^{-19}\ Sm^{-1}$
5.	V.B & C.B over lap	V.B is almost full C.B. is almost empty	V.B. is completely filled C.B. is completely empty
6.	Ex :- All metals	Ex :- Ge, Si	Ex :- Rubber, Glass, Mica.

SEMICONDUCTORS

CLASSIFICATION OF SEMICONDUCTORS

Intrinsic semiconductors

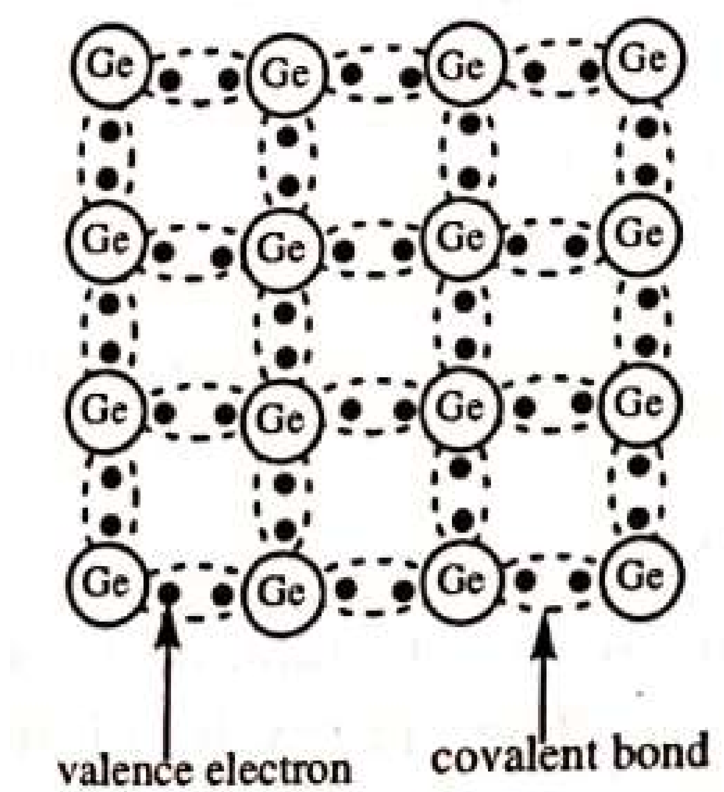
Extrinsic semiconductors

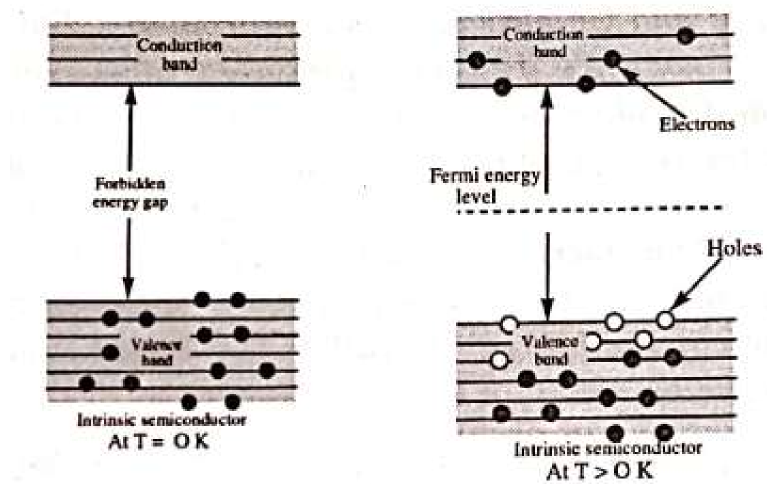


Intrinsic semiconductor

Eg: Si, Ge

$$n_e = n_h = n_i$$





Fermi Energy Level:

The highest energy that an electron can have at 0K is called fermi energy. The level corresponding to fermi energy is called fermi energy level.

Or

The average of energies of holes in the valancy band and electrons in the conduction band is called fermi energy.

Extrinsic semiconductors

P – type semiconductor

N – type semiconductor

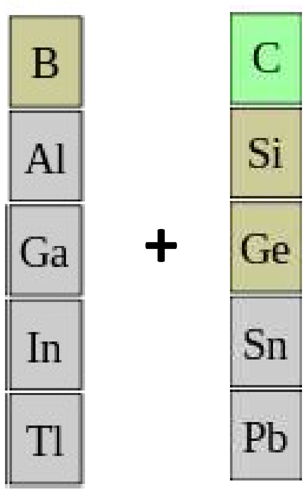
Dopping:

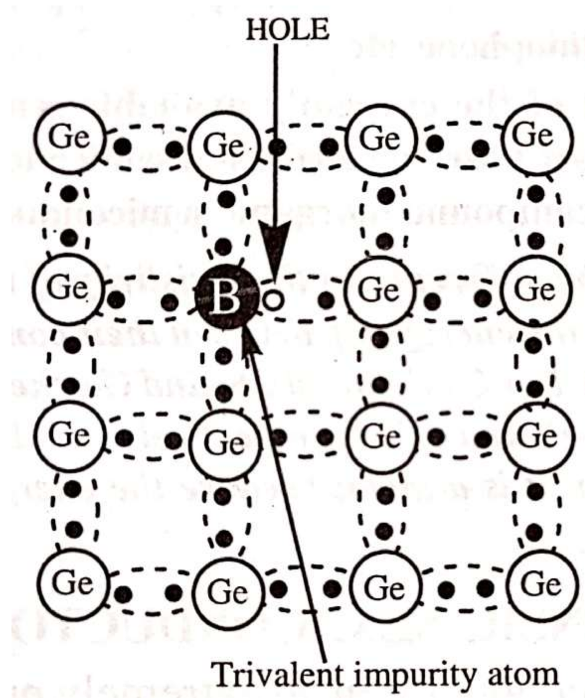
The process of adding impurity to a pure semiconductor crystal so as to increase its conductivity is called doping.

P – type SEMICONDUCTORS

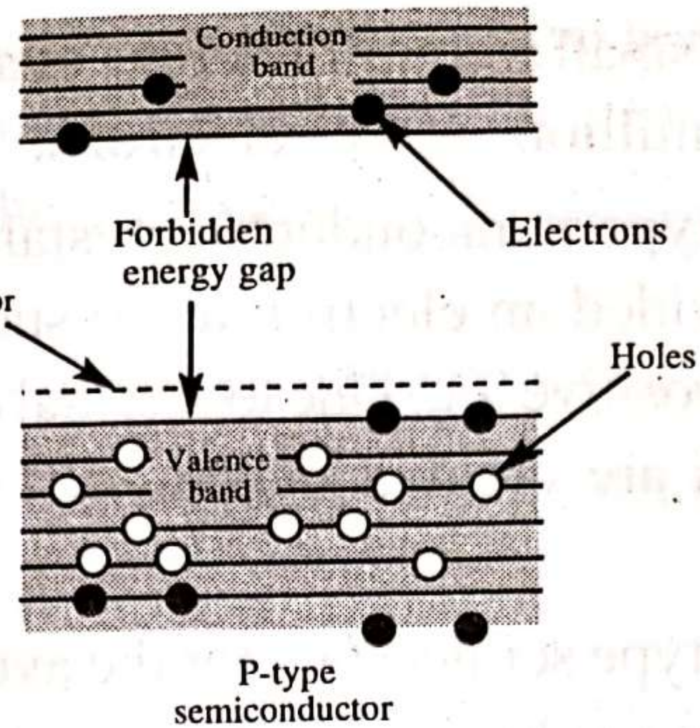
When few semiconductor atoms of pure crystal are replaced with atoms of III group element, the resulting crystal is called P-type semiconductor.

III A GROUP + IV A GROUP





$$n_e n_h = n_i^2$$

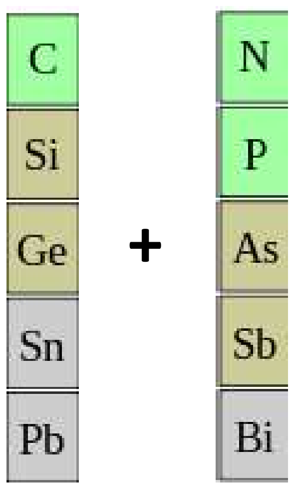


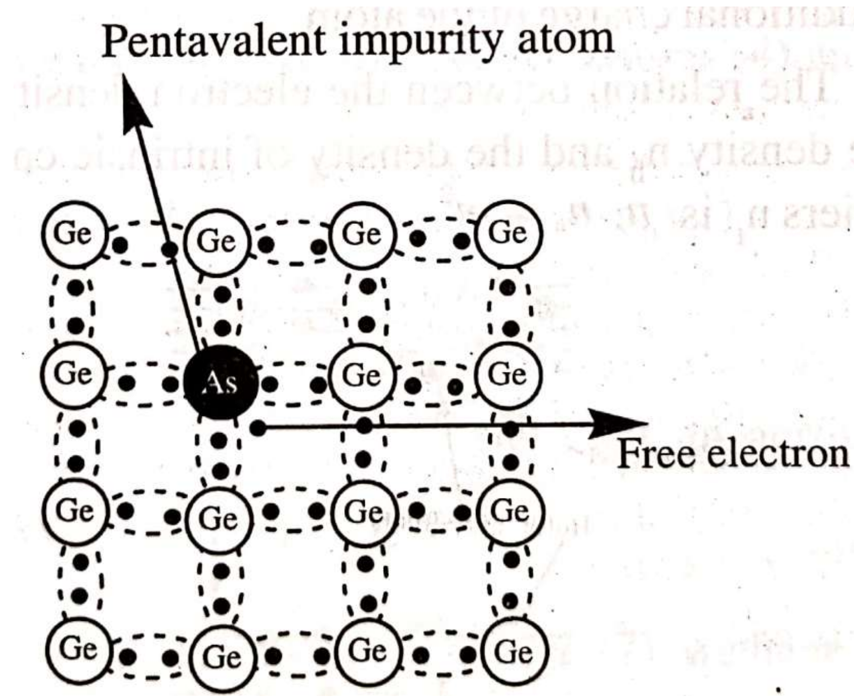
Conduction band
Forbidden energy gap
Electrons
acceptor level
Holes
Valence band
P-type semiconductor

N – TYPE SEMICONDUCTORS

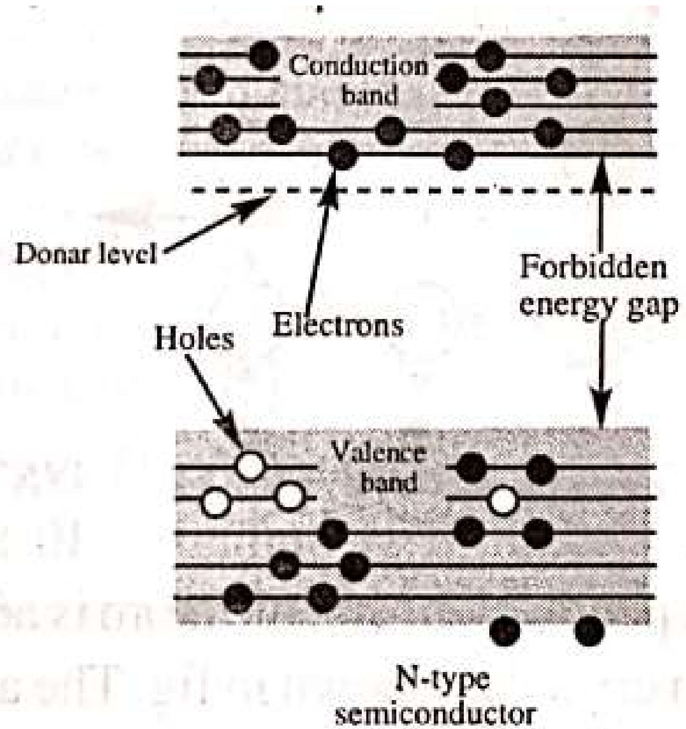
When few semiconductor atoms of pure crystal are replaced with atoms of V group element, the resulting crystal is called N-type semiconductor.

IV A GROUP + V A GROUP





$$n_e n_h = n_i^2$$



Conduction band
Donar level
Electrons
Forbidden energy gap
Holes
Valence band
N-type semiconductor

Pure Si at 300 K has equal electron (n_e) and hole (n_h) concentration of $1.5 \times 10^{16} m^{-3}$. Doping by indium increases into $4.5 \times 10^{22} m^{-3}$. Calculate n_e in the doped silicon.

$$n_i = 1.5\times10^{16}\,m^{-3}; n_h = 4.5\times10^{22}\,m^{-3}$$

$$n_e n_h = n_i^2$$

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

$$= \frac{\left(1.5\times10^{16}\right)^2}{4.5\times10^{22}} \quad = 5\times10^{9}\,m^{-3}$$

The energy of a photon of sodium light of wavelength 589 nm equal to the band gap of a semiconducting material. Find the minimum energy E required to create a hole-electron pair.

Energy in electron volt E $= \frac{12400}{\lambda}$

Wavelength of photon = 589 nm = 5890 A^0

$$= \frac{12400}{5890}$$

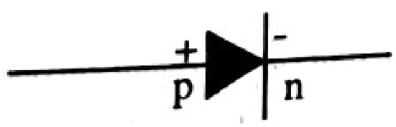
$$= 2.1 eV$$

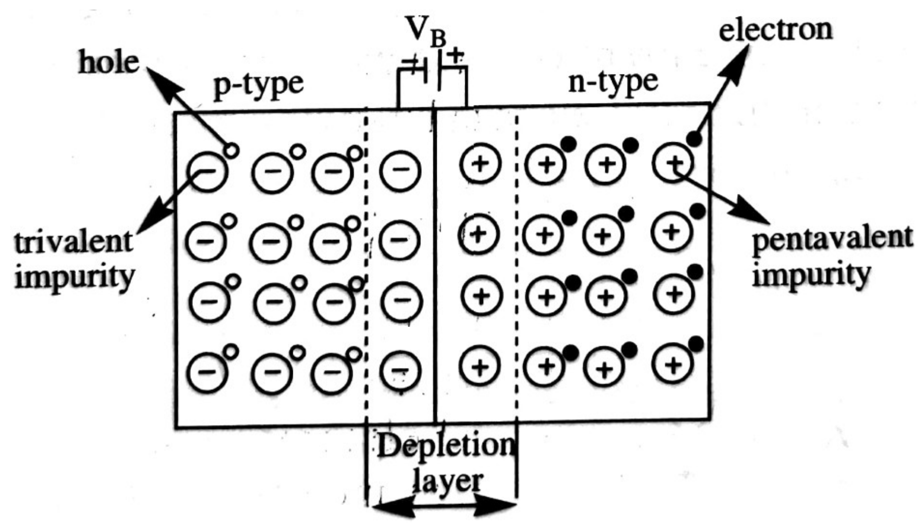
PN – JUNCTION DIODE

PN JUCTION DIODE

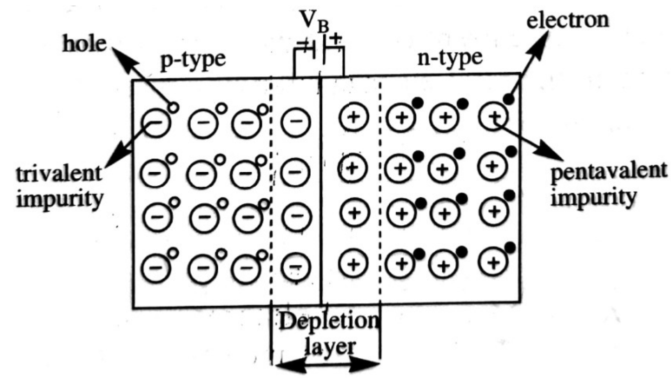
When a single semiconductor crystal is doped with P-type impurities from one side and that of N-type from the other side, a layer in the crystal separating P-type from N-type, is known as P-N junction.

PN Junction Diode Symbol:





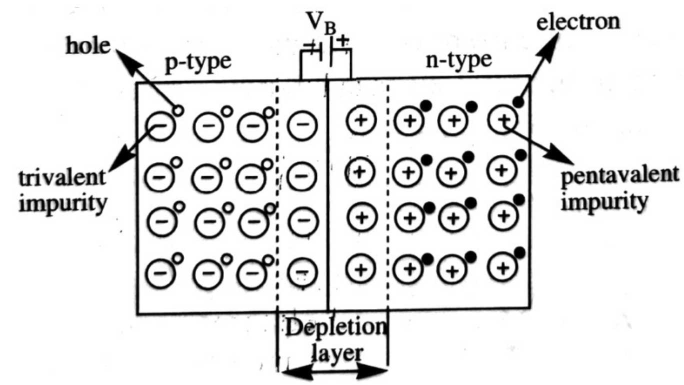
Near the junction, the free electrons from n-region migrate towards p-region and the holes in p-region migrate towards n-region. This process is known as diffusion.



A region of no charge carriers that is formed at p-n junction due to the combination of electrons and holes is called depletion layer.

The thickness of the depletion layer is of the order of 10^{-6} m.

The potential difference across the barrier is called potential barrier. It behaves as a pseudo battery.



The potential barrier for silicon is around 0.7 volt and for Germanium it is around 0.3 volt.

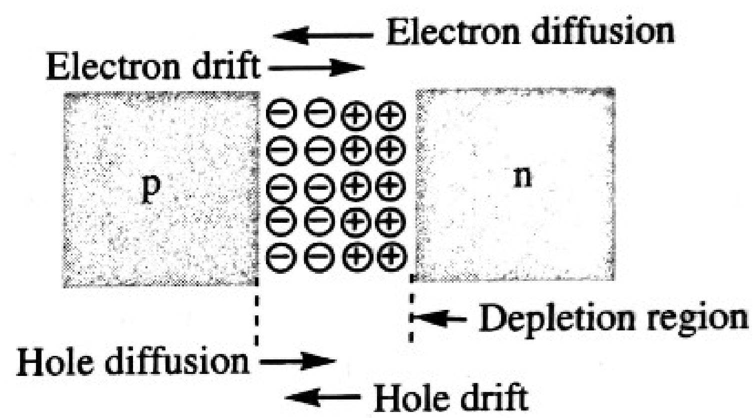
Barrier potential depends upon

1)The nature of the semiconductor

2)Doping concentration

3)Temperature of the junction

Diffusion Current:

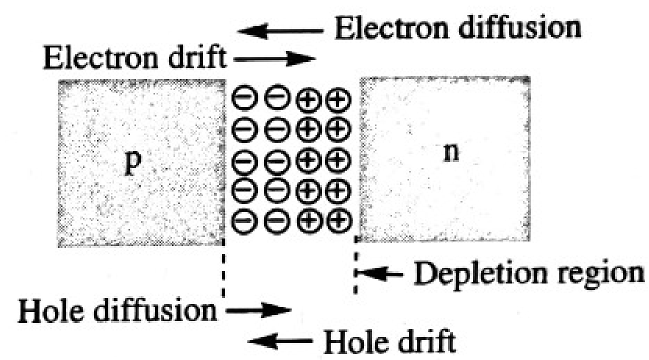


Due to the difference in concentration of charge carriers, hole from p-side diffuse towards n-side and electrons from n-side diffuse towards p-side. This movement of charge carriers across the junction causes a current called diffusion current.

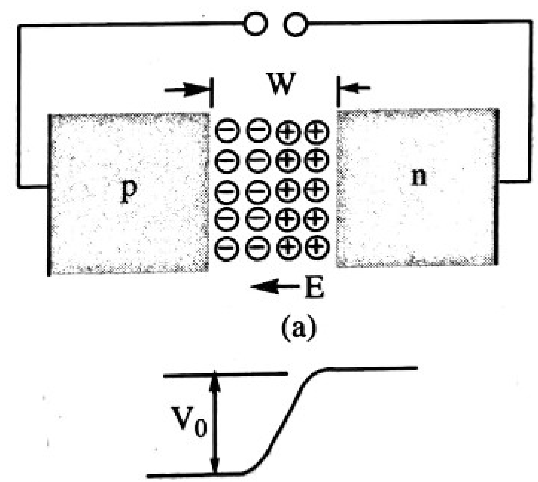
Diffusion current from p-side to n-side.

Drift current:

Drift current is the electric current caused by particles getting pulled by an electric field.

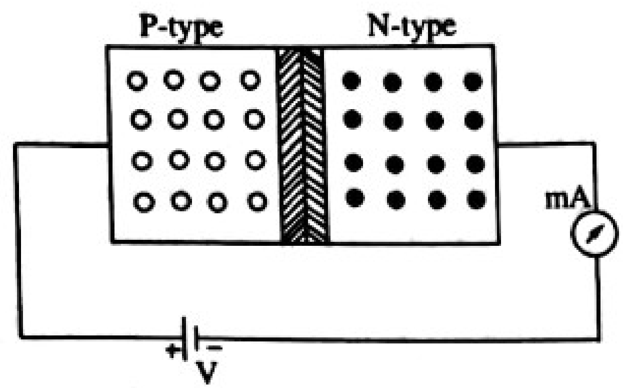


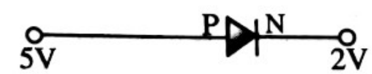
Drift current from the n- side to the p-side.

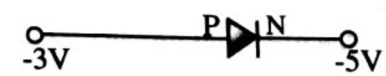


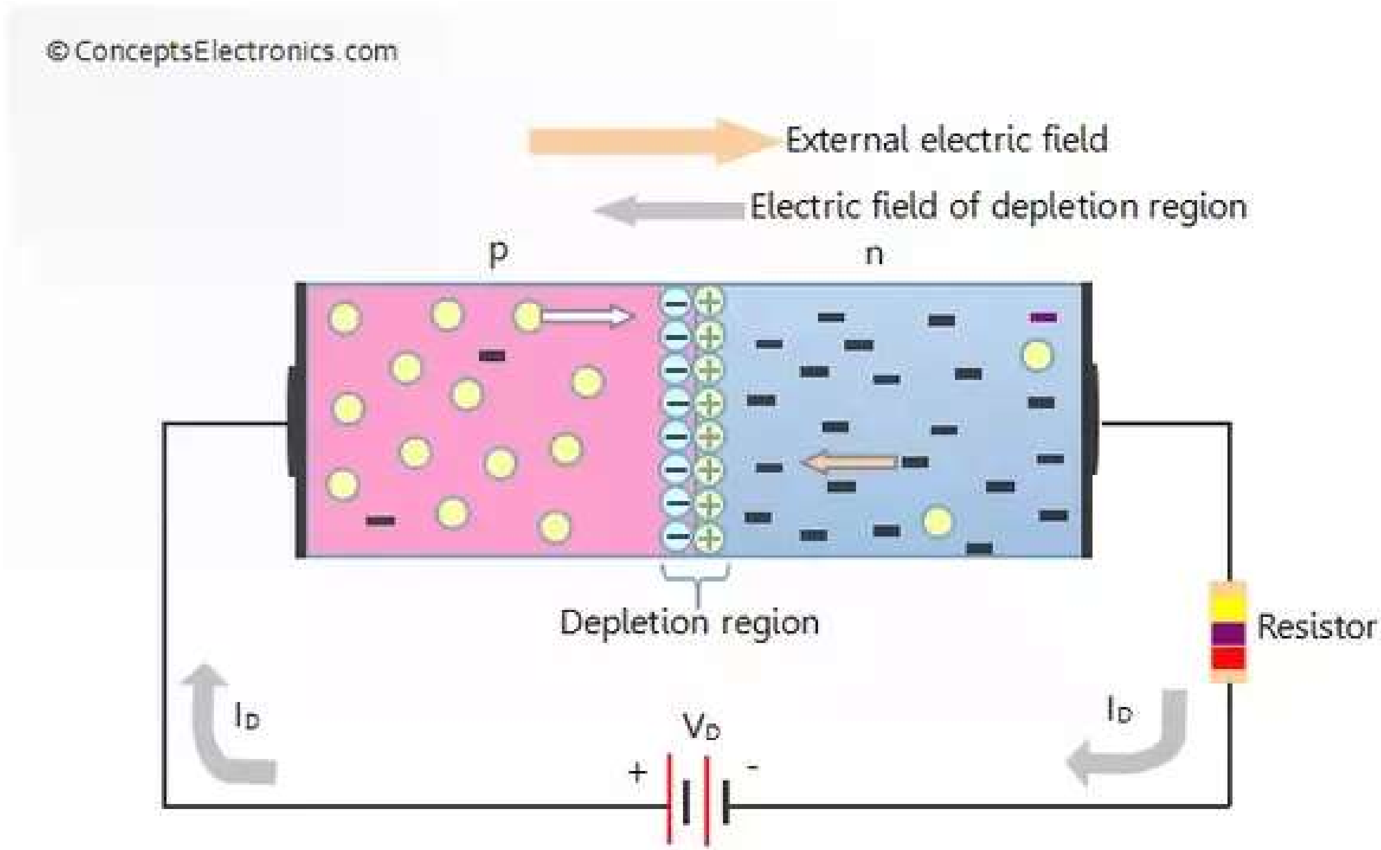
FORWARD BIAS

When the positive terminal of a battery is connected to P-type semiconductor and the negative terminal of the battery is connected to N-type semiconductor, then the junction diode is said to be in forward bias.





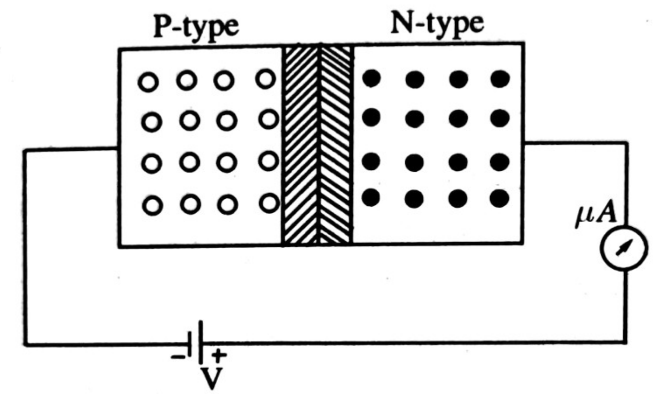


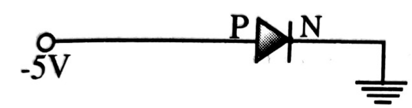


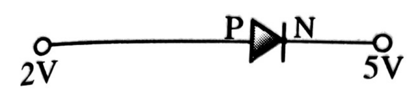
Forward biased p-n junction

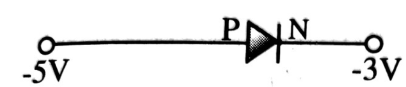
REVERSE BIAS

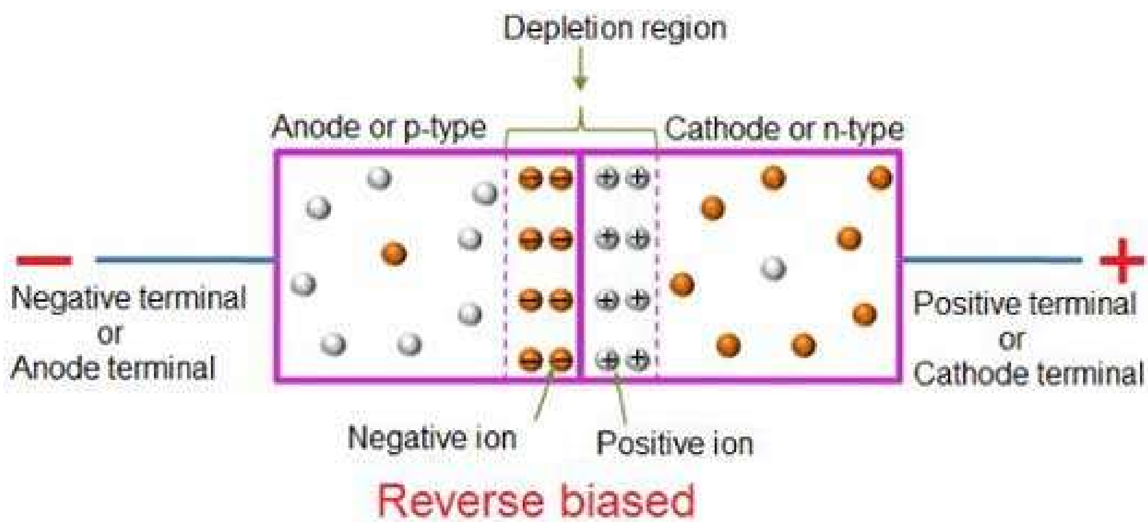
When the positive terminal of a battery is connected to N-type semiconductor and the negative terminal of the battery is connected to P-type semiconductor, then the junction diode is said to be in reverse bias.







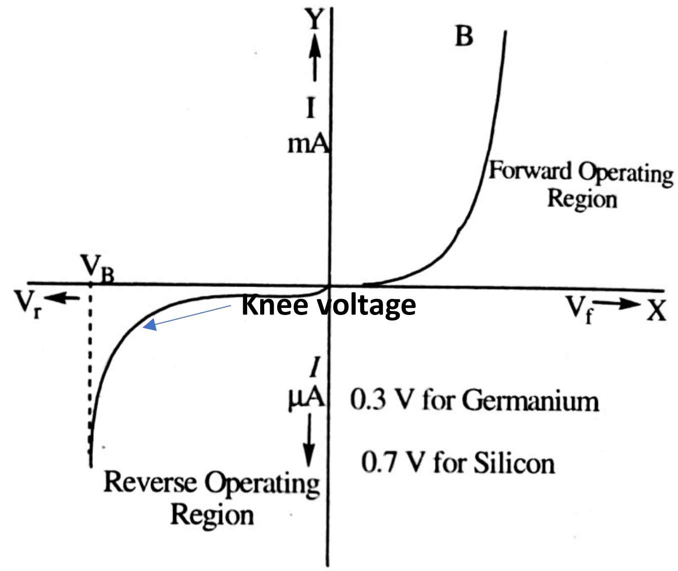



Depletion region
Anode or p-type
Cathode or n-type
Negative terminal
or
Anode terminal
Positive terminal
or
Cathode terminal
Negative ion
Positive ion
Reverse biased

V-I characteristics of a PN junction diode:

Knee voltage:

The forward voltage at which the flow of current during the PN Junction begins increasing quickly is known as knee voltage.



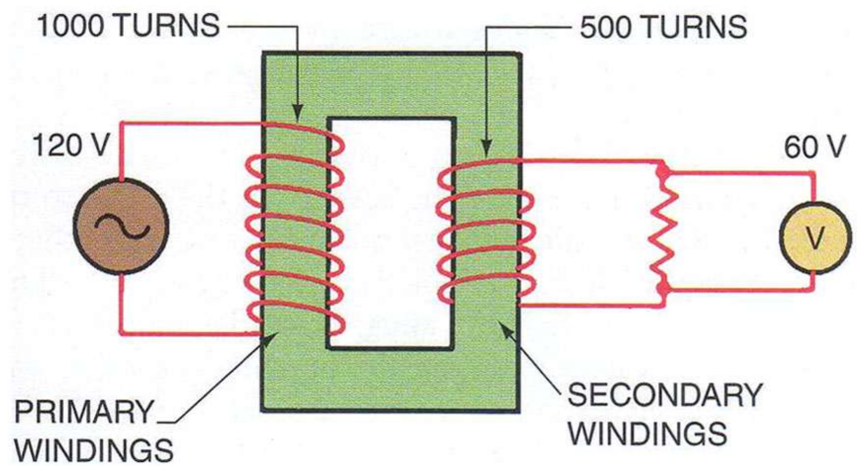
Breakdown voltage:

The breakdown voltage is the minimum reverse voltage that makes the diode conduct appreciably in reverse.

$$\frac{N_S}{N_P} = \frac{V_S}{V_P}$$

For 100% efficient transformer,
Input power = Output power
$\Rightarrow \quad V_P I_P = V_S I_S$

$$\frac{N_S}{N_P} = \frac{V_S}{V_P} = \frac{I_P}{I_S}$$




USB Charger
For Samsung
For iPhone
Dual USB Port
Input: 100V~240V
Output: DC5V=2.1A


AC-DC ADAPTOR
MODEL:SY-002-5-12
INPUT:100-240VAC
50/60Hz,0.8A
OUTPUT:12V ═══ 2A
5V ═══ 2A
CAUTION! HAZARDOUSAREA
Do Not Remore This Cover
Tiained Service Personal Ony
No Serviceabe Compcnents Inside
ATTENTION! ZONEDANGEREUSE
115°C
MADE IN CHINA

APPLICATIONS OF PN - JUNCTION DIODE

APPLICATIONS OF PN JUNCTION DIODE

- **As a voltage rectifier, such as turning the AC into DC**
- **As a voltage regulator**
- **As a photo diode to detect the signals**
- **As a LEDs – lighting systems**
- **As a solar cell**

JUNCTION DIODE AS RECTIFIER

Rectification: The process of converting an alternating current into a direct current is called rectification.

Rectifier: The device used to covert an alternating current into a direct current is called rectifier.

A PN junction diode can be used as a rectifier because it permits current in on direction only.

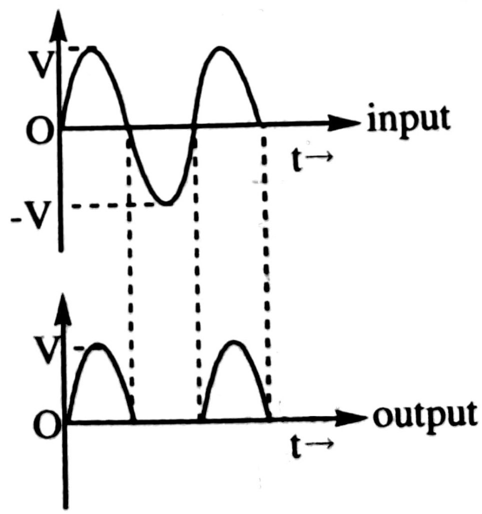
RECTIFIER

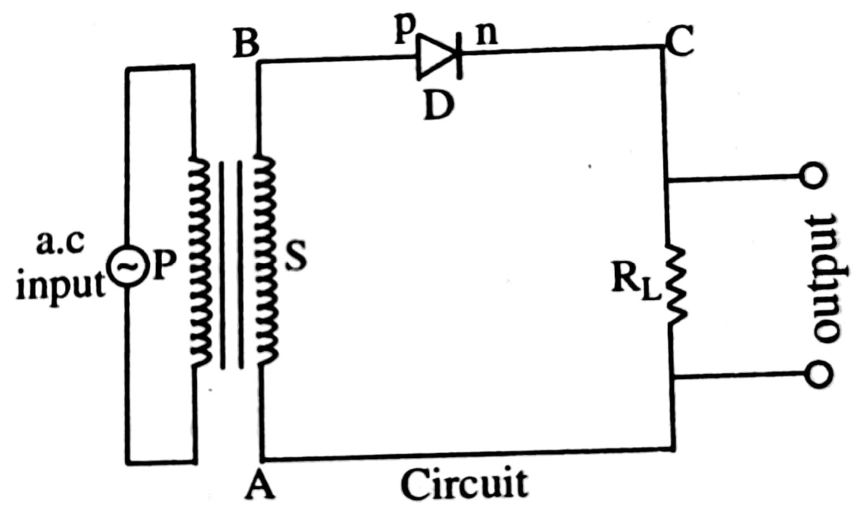
Half wave rectifier

Full wave rectifier

Half wave rectifier:

A half wave rectifier can be constructed with a single diode

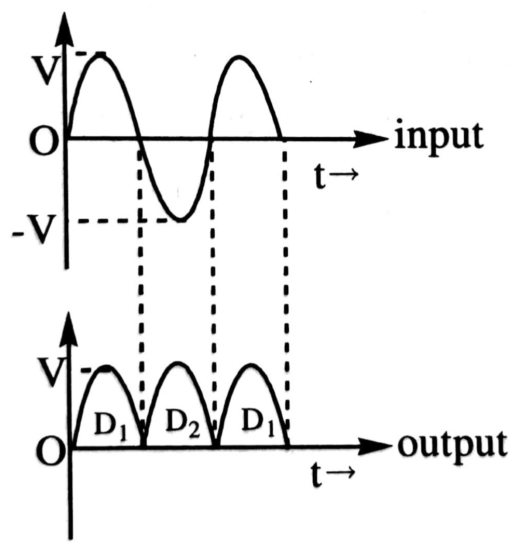


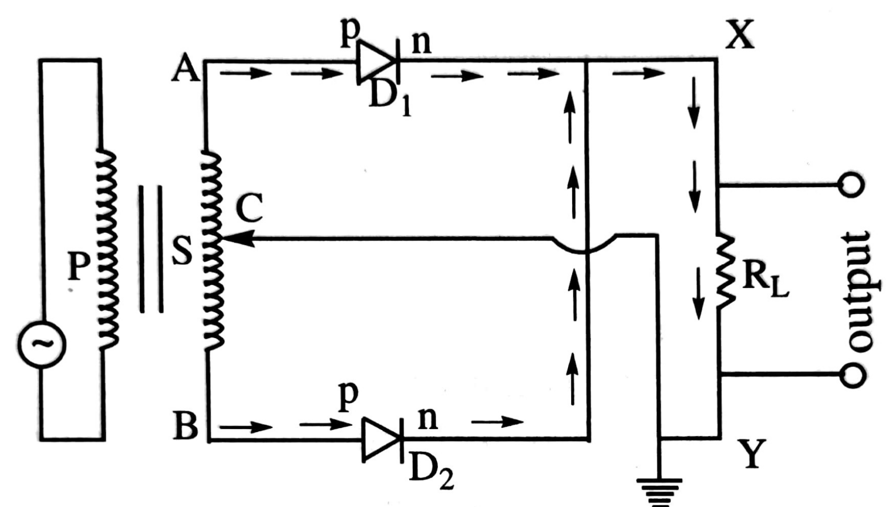


Full wave rectifier:

A rectifier which rectifies both halves of the ac input is called full wave rectifier.

A full wave rectification can be achieved by using two diodes.

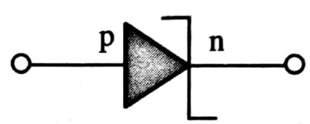


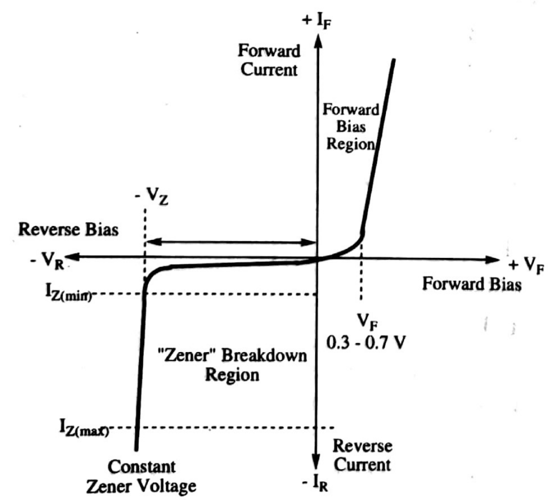


ZENER DIODE:

A Zener diode is a silicon semiconductor device which allows current to flow in either a forward or reverse direction. It is a heavily doped p-n junction diode, designed to conduct in the reverse direction when a certain specified voltage is reached.

Symbol

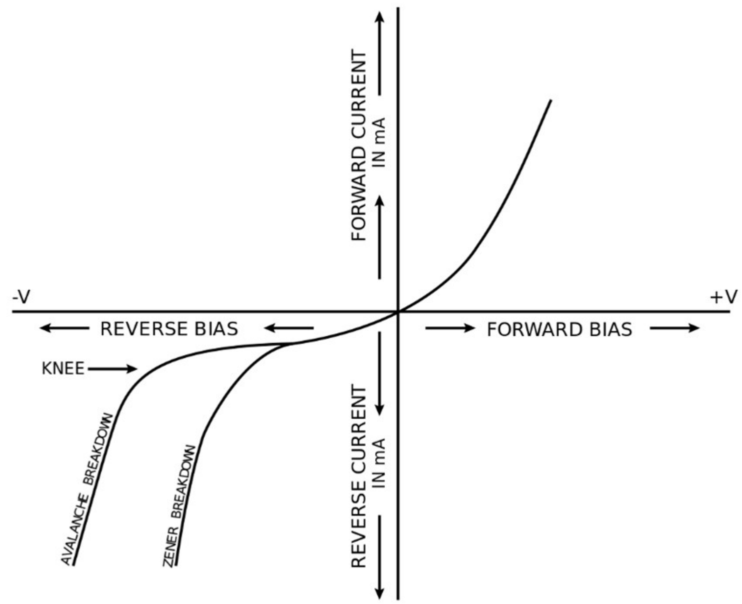


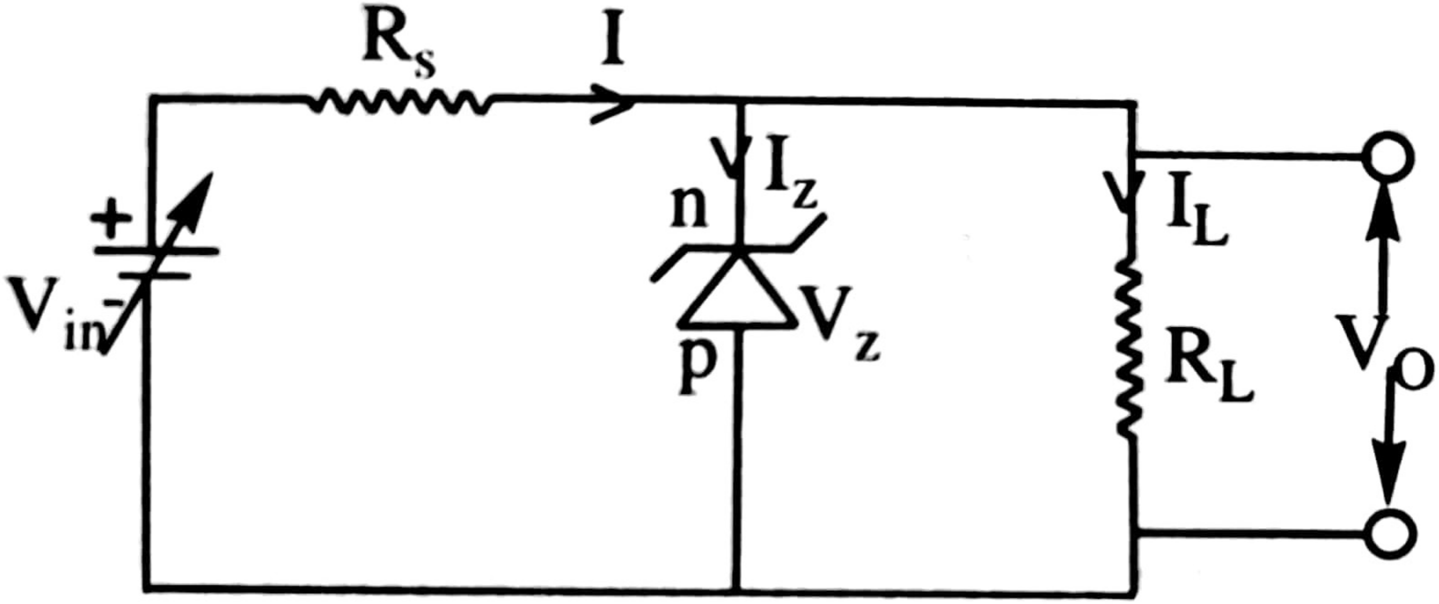


Avalanche breakdown:

Avalanche breakdown occurs in a PN junction **diode** which is moderately doped and has a thick depletion layer.

Avalanche breakdown occurs when a high reverse voltage apply across the highly doped PN junction **diode.**





R_s
I
I_z
n
V_z
p
I_L
R_L
V_in
V_O
+
-

Differences between Zener Breakdown and Avalanche Breakdown:

Zener Breakdown	Avalanche Breakdown
The process in which the electrons move across the barrier from the valence band of p-type material to the conduction band of n-type material is known as Zener breakdown.	The process of applying high voltage and increasing the free electrons or electric current in semiconductors and insulating materials is called an avalanche breakdown.
This is observed in Zener diodes having a Zener breakdown voltage V_Z of 5 to 8 volts.	This is observed in Zener diode having a Zener breakdown voltage V_Z greater than 8 volts.
The valence electrons are pulled into conduction due to the high electric field in the narrow depletion region.	The valence electrons are pushed to conduction due to the energy imparted by accelerated electrons, which gain their velocity due to their collision with other atoms.
The increase in temperature decreases the breakdown voltage.	The increase in temperature increases the breakdown voltage.
The VI characteristics of a Zener breakdown has a sharp curve.	The VI characteristic curve of the avalanche breakdown is not as sharp as the Zener breakdown.
It occurs in diodes that are highly doped.	It occurs in diodes that are lightly doped.

OPTO ELECTRONIC JUNCTION DEVICES

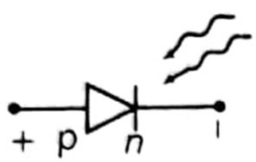
Optoelectronic Junction devices

Semiconductor diodes in which carriers are generated by photons i.e. photo excitation, such devices are known as optoelectronic devices.

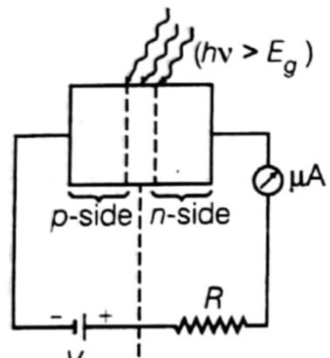
Photodiode:

It is a special type of junction diode used for detecting optical signals. It is a reverse biased PN junction made from a photosensitive material.

Symbol:

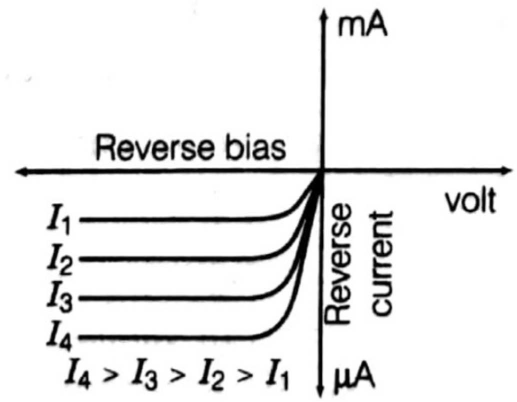


Working:



A reverse biased photodiode illuminated with light

V-I characteristics graph



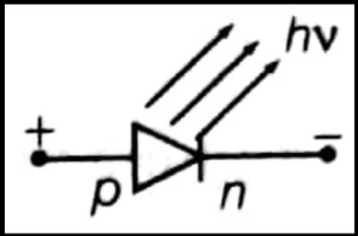
KEY POINTS:

- It is operated under reverse bias
- Current will flow when it is illuminated with light of photon energy greater than the energy gap of the semiconductor

Light Emitting Diode (LED):

It is a heavily doped PN junction diode which converts electrical energy into light energy. This diode emits spontaneous radiation, under forward biasing.

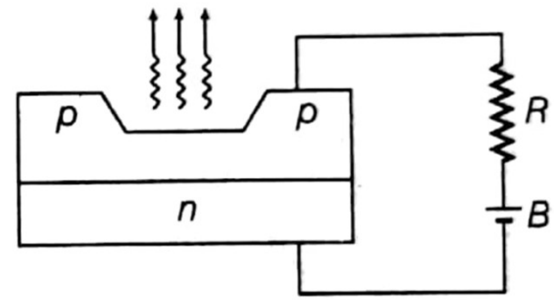
Symbol:



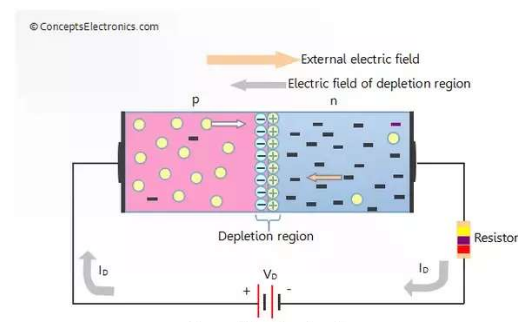
Working:

When PN junction is forward biased, electrons and holes move towards opposite sides of junction through it.

Hence there exists excess minority charge carriers on the either side of the junction boundary which recombines with majority carriers near the junction



Forward biased LED



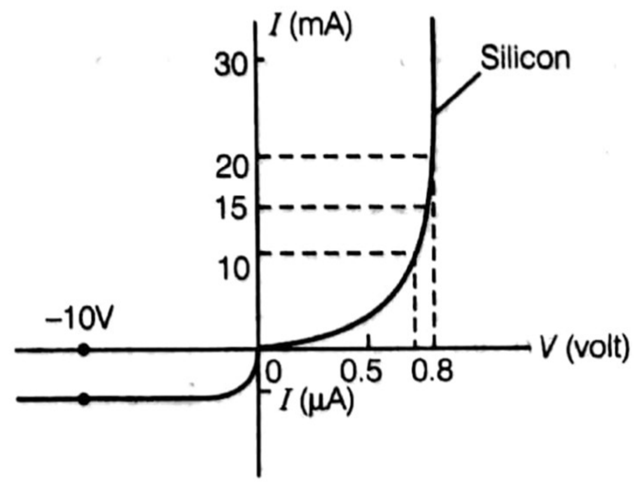
Forward biased p-n junction

V-I characteristics:

Advantages:

A low voltage DC supply is required to operated an LED.

Current drawn by LED's is of the order of milliampere



V-I Characteristics of LED

KEY POINTS:

- It converts electrical energy to light energy
- It is a heavily doped PN junction which will be in forward bias emits light of certain radiation
- The semiconductor used should have a band gap of 1.8 eV to give light in visible region
- Gallium arsenide phosphide (GaAsP) is used for making LEDs of different colours

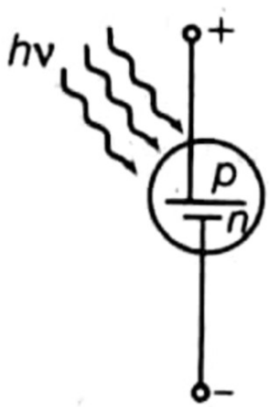
LED's Advantages over Lamps with filament (Incandescent low power lamps)

- Fast action and no warm up time required
- Low bandwidth (nearly monochromatic)
- Long life and ruggedness
- Low operational voltage and less power consumed

Solar Cell:

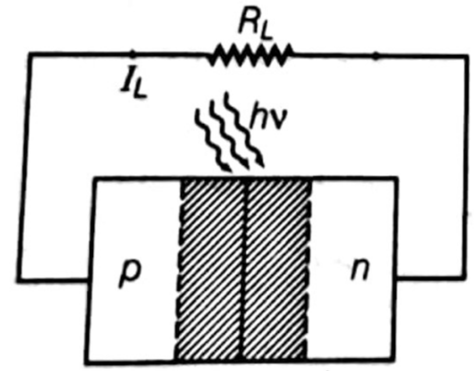
It is a PN junction diode, which converts solar energy into electrical energy.

Symbol:



Construction:

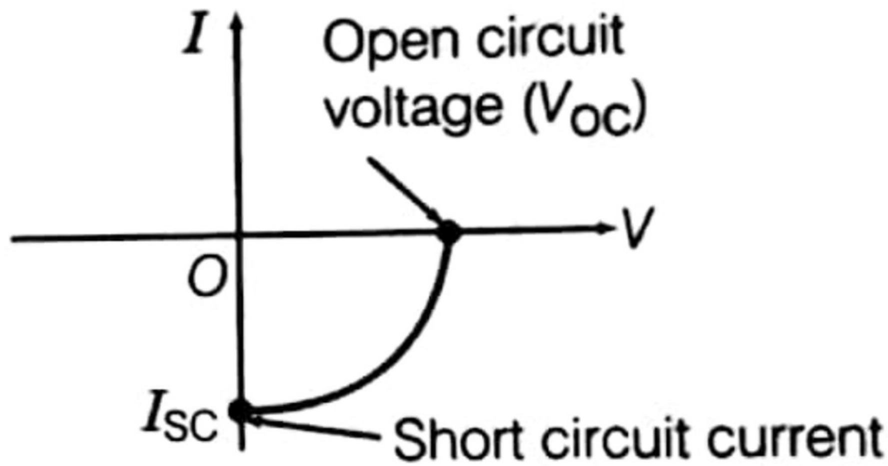
It consists of a silicon or gallium arsenide PN junction diode



Working:

When photons of light (more than energy gap) falls at the junction, electron hole pairs are generated near the junction and they move in opposite directions due to junction field.

V-I characteristics:



I-V characteristics of a solar cell

Key points:

- It converts solar energy into electrical energy
- It is basically a PN junction which generates emf when solar radiation falls on the PN junction
- It works on the sample principle as the photoelectric effect

Logic Gates

LOGIC GATES

A digital circuit with one or more inputs but only one output is known as logic gate.

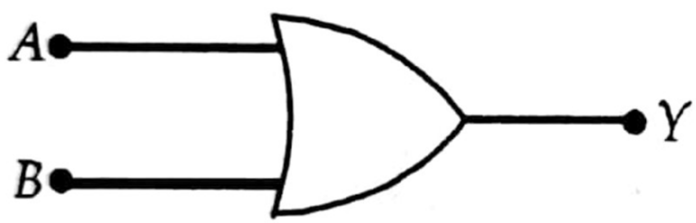
Basic logic gates:

- OR gate
- AND gate
- NOT gate

OR gate:

OR gate has two or more inputs but only one output. It is called OR gate because the output is high if any or all the inputs are high.

Symbol:



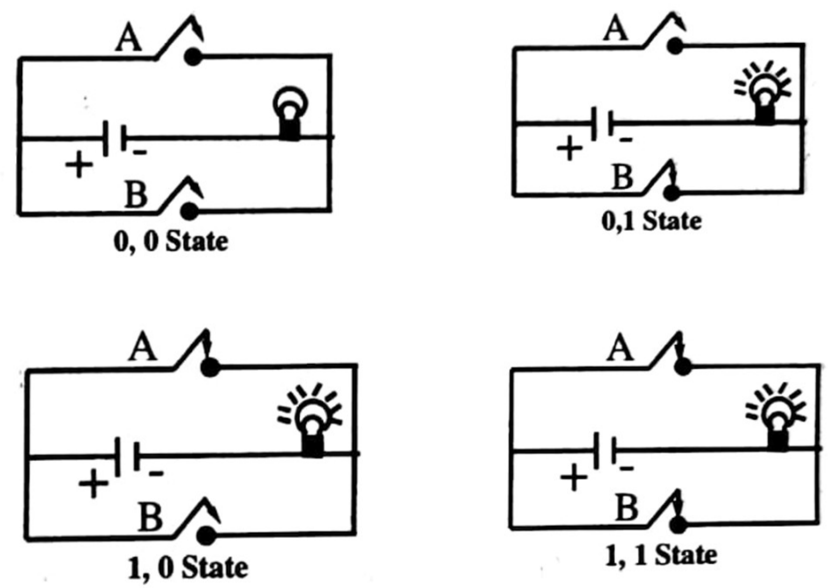
Truth Table:

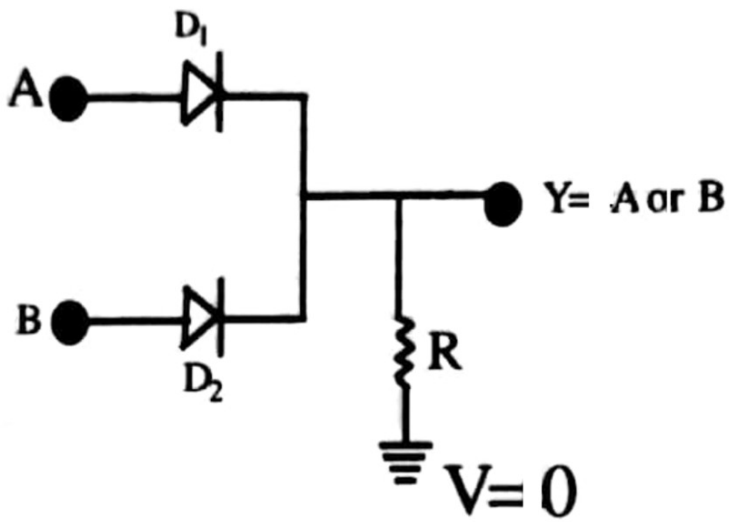
It is a table that shows all possible input combinations and the corresponding output combinations for a logic gate.

The Boolean expression for OR gate is
$Y = A + B$

The truth table for OR gate is

Input		Output
A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1





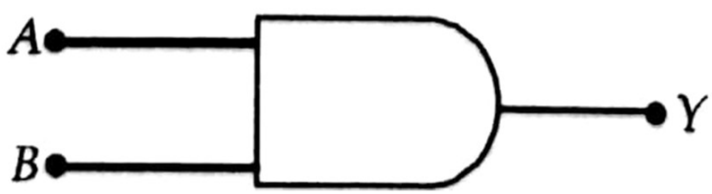
Input		Output
A	B	Y
Low	Low	Low
High	Low	High
Low	High	High
High	High	High

Input		Output
A	B	Y
0	0	0
1	0	1
0	1	1
1	1	1

AND gate:

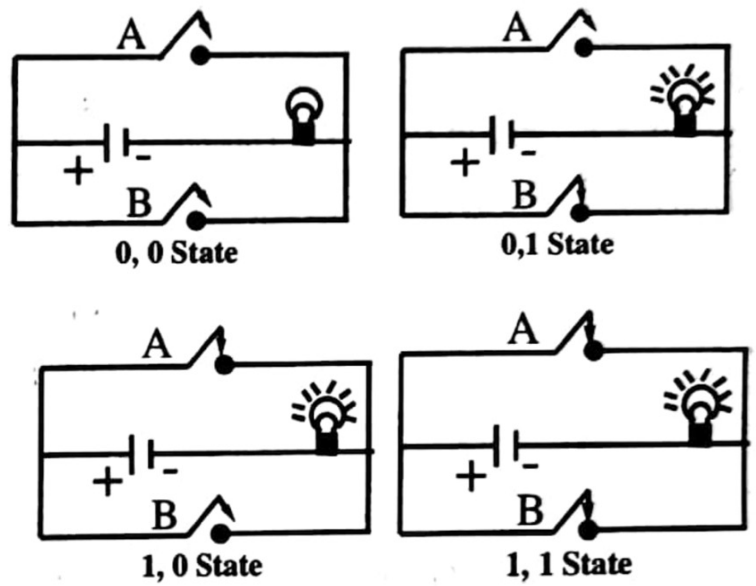
An AND gate has two or more inputs but only one output. It is called AND gate because output is high only when all the inputs are high.

Symbol:



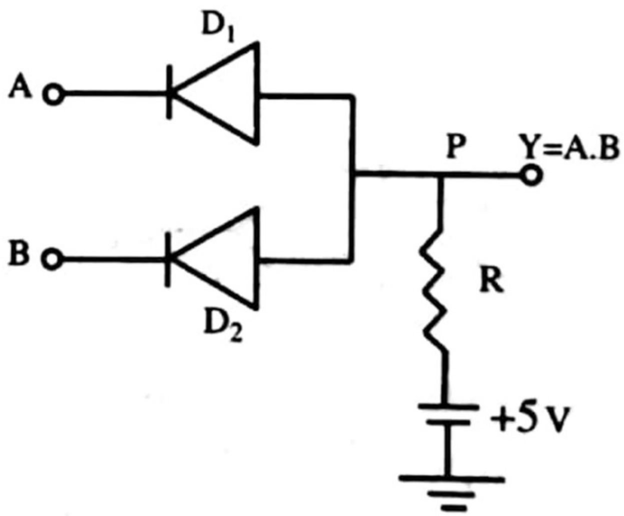
The truth table for AND gate is

Input		Output
A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1



The Boolean expression for AND gate is

$$Y = A \cdot B$$



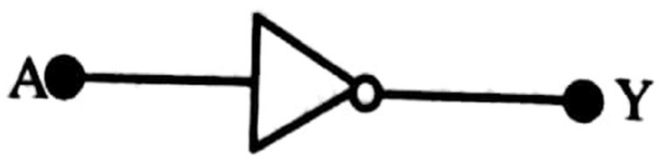
Input		Output
A	B	Y
Low	Low	Low
High	Low	Low
Low	High	Low
High	High	High

Input		Output
A	B	Y
0	0	0
1	0	0
0	1	0
1	1	1

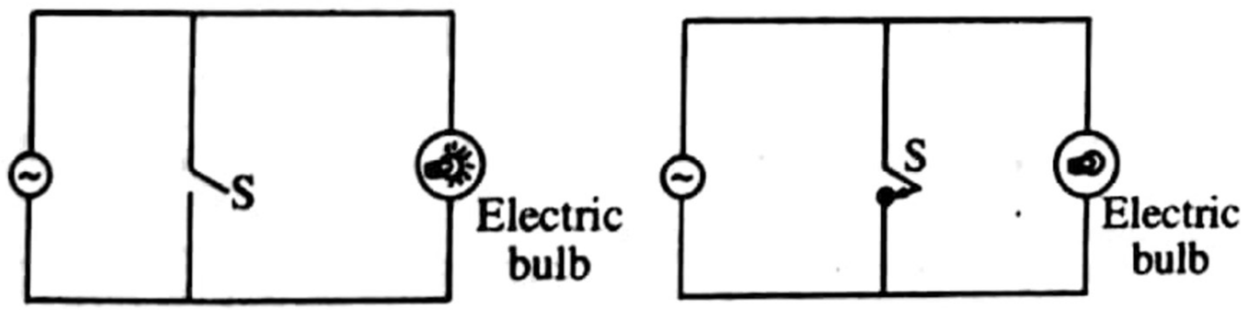
NOT gate:

NOT gate has one input and one output. It is called as NOT gate because output is not the same as its input.

Symbol:



$$Y = \bar{A}$$



Truth table for NOT gate

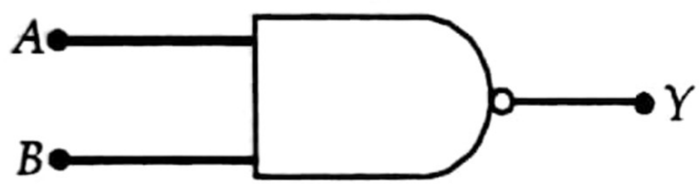
Input A	Output Q
Low	High
High	Low

Input A	Output Q
0	1
1	0

NAND GATE:

It is an AND gate followed by a NOT gate.

The logic symbol for NAND gate is



The Boolean expression for NAND gate is

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

Truth table of NAND gate

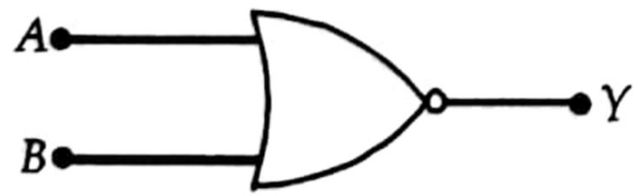
Input		Output
A	B	$Y=\overline{A.B}$
Low	Low	High
High	Low	High
Low	High	High
High	High	Low

Input		Output
A	B	$Y=\overline{A.B}$
0	0	1
1	0	1
0	1	1
1	1	0

NOR GATE:

It is an OR gate followed by a NOT gate.

The logic symbol of NOR gate is



The Boolean expression for NOR gate is

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

Truth table for NOR gate

Input		Output
A	B	$Y=\overline{A+B}$
Low	Low	High
High	Low	Low
Low	High	Low
High	High	Low

Input		Output
A	B	$Y=\overline{A+B}$
0	0	1
1	0	0
0	1	0
1	1	0

De-morgan's Theorems:

$$\overline{A+B} = \overline{A} \cdot \overline{B} \qquad \overline{A.B} = \overline{A} + \overline{B}$$

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

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

De-morgon's first law proof: $\overline{A+B} = \overline{A}\cdot\overline{B}$

(i) *When* $A = 0, \quad B = 0,$

$\overline{A+B} = \overline{0+0} = \bar{0} = 1$

and $\bar{A}.\bar{B} = \bar{0}.\bar{0} = 1.1 = 1$

Hence $\overline{A+B} = \bar{A}.\bar{B}$

(ii) *When* $A = 0, \quad B = 1,$

$\overline{A+B} = \overline{0+1} = \bar{1} = 0$

and $\bar{A}.\bar{B} = \bar{0}.\bar{1} = 1.0 = 0$

Hence $\overline{A+B} = \bar{A}.\bar{B}$

(iii) *When* $A = 1, \quad B = 0,$

$\overline{A+B} = \overline{1+0} = \bar{1} = 0$

and $\bar{A}.\bar{B} = \bar{1}.\bar{0} = 0.1 = 0$

Hence $\overline{A+B} = \bar{A}.\bar{B}$

(iv) *When* $A = 1, \quad B = 1,$

$\overline{A+B} = \overline{1+1} = \bar{1} = 0$

and $\bar{A}.\bar{B} = \bar{1}.\bar{1} = 0.0 = 0$

Hence $\overline{A+B} = \bar{A}.\bar{B}$

De-morgon's second law proof: $\overline{A.B} = \overline{A} + \overline{B}$

(i) When $A = 0, \quad B = 0,$

$$\overline{A\,.\,B} = \overline{0\,.\,0} = \bar{0} = 1$$

and $\bar{A} + \bar{B} = \bar{0} + \bar{0} = 1 + 1 = 1$

Hence $\overline{A\,.\,B} = \bar{A} + \bar{B}$

(ii) When $A = 0, \quad B = 1,$

$$\overline{A\,.\,B} = \overline{0\,.\,1} = \bar{0} = 1$$

and $\bar{A} + \bar{B} = \bar{0} + \bar{1} = 1 + 0 = 1$

Hence $\overline{A\,.\,B} = \bar{A} + \bar{B}$

(iii) When $A = 1, \quad B = 0,$

$$\overline{A\,.\,B} = \overline{1\,.\,0} = \bar{0} = 1$$

and $\bar{A} + \bar{B} = \bar{1} + \bar{0} = 0 + 1 = 1$

Hence $\overline{A\,.\,B} = \bar{A} + \bar{B}$

(iv) When $A = 1, \quad B = 1,$

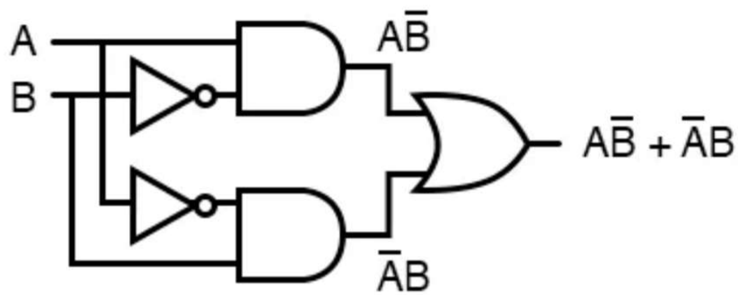
$$\overline{A\,.\,B} = \overline{1\,.\,1} = \bar{1} = 0$$

and $\bar{A} + \bar{B} = \bar{1} + \bar{1} = 0 + 0 = 0$

Hence $\overline{A\,.\,B} = \bar{A} + \bar{B}$

XOR GATE: $A \cdot \overline{B} + \overline{A} \cdot B$

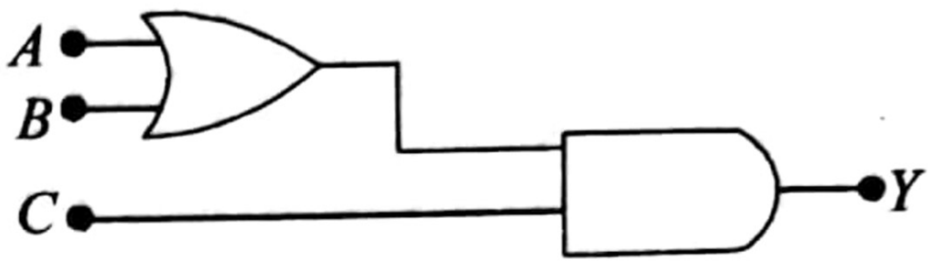
Symbol:



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

Truth Table		
A	*B*	*Y*
0	0	0
0	1	1
1	0	1
1	1	0

What must be the input to get an output $Y = 1$ from the circuit shown in figure?

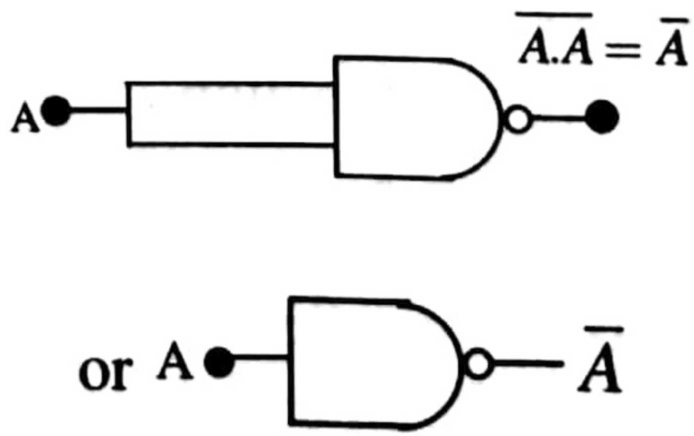


	A	B	C
(i)	1	0	1
(ii)	0	1	1
(iii)	1	1	1

Soln.: It is a combination of OR and AND gate.

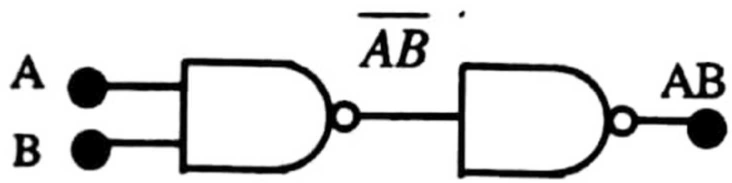
There can be three schemes for getting output = 1.

Construction of NOT gate using NAND gate:



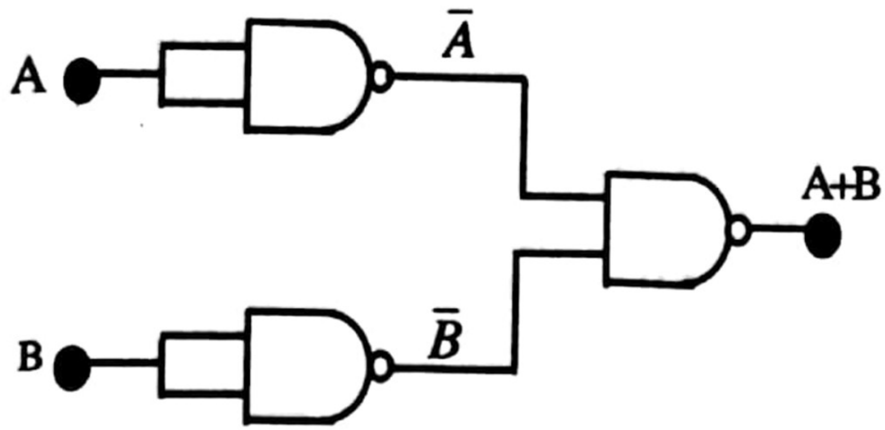
$$Y = \overline{A.A} = \bar{A}$$

Construction of AND gate using NAND gate:



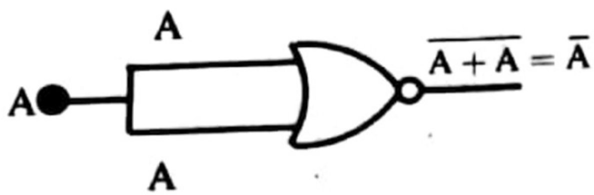
In terms of Boolen equation $Y = \overline{\overline{A.B}} = A.B$

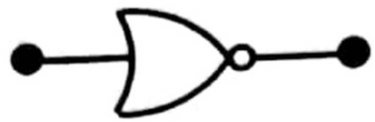
Construction of OR gate using NAND gate:



In terms of Boolen equation $Y = \overline{\overline{A}.\overline{B}} = A + B$

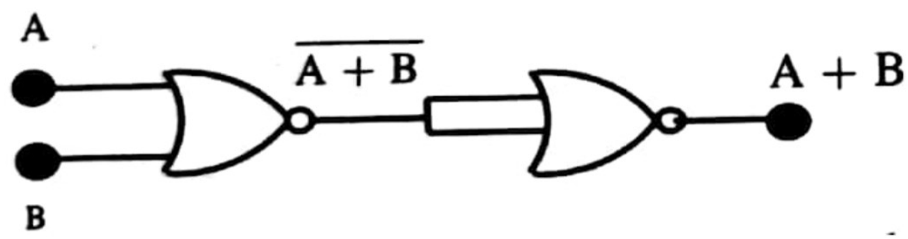
Construction of NOT gate using NOR gate:





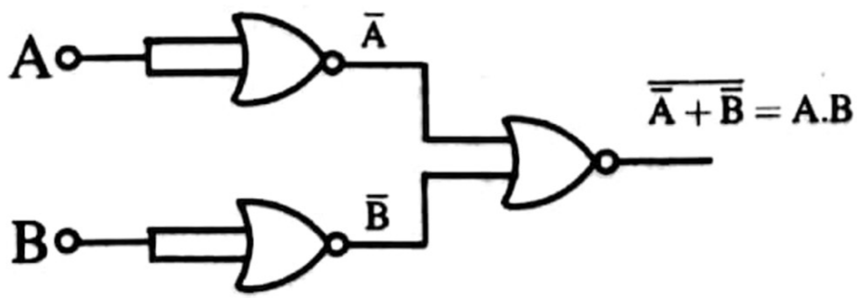
$$Y = \overline{A+A} = \bar{A}$$

Construction of OR gate using NOR gate:



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

Construction of AND gate using NOR gate:



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

Binary numbers:

Decimal number	Binary number
0	0
1	1
2	10
3	11
4	100

Decimal number	Binary number
5	101
6	110
7	111
8	1000
9	1001

$$1325 = 1000 + 300 + 20 + 5$$
$$= 1 \times 10^3 + 3 \times 10^2 + 2 \times 10^1 + 5 \times 10^0$$

$$1001 = 1 \times 2^3 + 0 \times 2^2 + 0 \times 2^1 + 1 \times 2^0$$
$$= 9$$

Binary System:

The binary weights in a mixed binary number may be listed below :

$$\ldots \quad 2^3 \quad 2^2 \quad 2^1 \quad 2^0 \quad \bullet \quad 2^{-1} \quad 2^{-2} \quad 2^{-3} \quad \ldots$$

↑

Binary point

Let us consider the binary number 11011.1011. This can be written as

Binary number	1	1	0	1	1	.	1	0	1	1
Weight	2^4	2^3	2^2	2^1	2^0	.	2^{-1}	2^{-2}	2^{-3}	2^{-4}

Convert 13 into binary system.

Divisor	Number	Remainder
2	13	
2	6	1
2	3	0
2	1	1
2	0	1

$$(13)_{10} = (1101)_2$$

Convert $(100)_{10}$ into binary

2	100	Remainder
2	50	0
2	25	0
2	12	1
2	6	0
2	3	0
2	1	1
2	0	1

$$(100)_{10} = (1100100)_2$$

Binary to Decimal conversion:

$$1101 = 1\times2^3 + 1\times2^2 + 0\times2^1 + 1\times2^0$$

$$= 8 + 4 + 0 + 1$$

$$= 13$$

Convert $(0.1011)_2$ to decimal

$$0.1011 = 1\times2^{-1} + 0\times2^{-2} + 1\times2^{-3} + 1\times2^{-4}$$

$$= \frac{1}{2} + 0 + \frac{1}{8} + \frac{1}{16}$$

$$= \frac{8+0+2+1}{16} = \frac{11}{16}$$

$$= 0.6875$$

Convert $(110111)_2$ to decimal

$$(110111)_2 = (1 \times 2^5) + (1 \times 2^4) + (0 \times 2^3) + (1 \times 2^2) + (1 \times 2^1) + (1 \times 2^0)$$

$$= 32 + 16 + 0 + 4 + 2 + 1$$

$$= (55)_{10}$$

Convert binary number 0.101 to a decimal number.

$$(0.101)_2 = 1\times2^{-1} + 0\times2^{-2} + 1\times10^{-3}$$

$$= \frac{1}{2} + 0 + \frac{1}{8}$$

$$= 0.5 + 0 + 0.125$$

$$= (0.625)_{10}$$

THANK YOU

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