DRGP Institute

Chapter 14

Semiconductor Electronics

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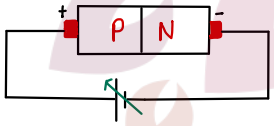
Semiconductor Electronics

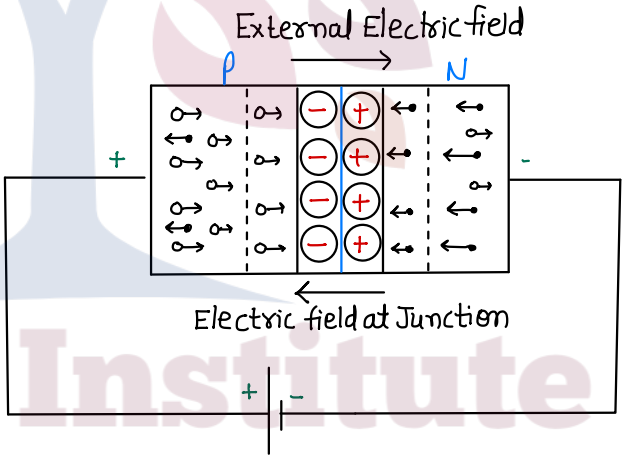
- Metal, Conductor & Semiconductor (Band theory)
- Intrinsic & Extrinsic semiconductor
- P-N Junction
- Diode
- Rectifier

BOARD - 2013

1. Explain the working to obtain *V-I* characteristic curve in forward biasing of *P-N* junction diode. Draw circuit diagram of experimental arrangement. $\frac{1}{2} + 1\frac{1}{2} = 2$

⇒ Forward Bias - Process of connecting battery with diode is called Biasing of diode. When we connect +ve terminal of Battery with P-type & -ve terminal of battery with N-type of diode then biasing known as forward Bias.

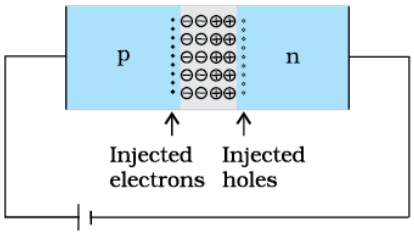




Working - In this bias the direction of the external electric field is just opposite to electric field at junction (Barrier electric field).

→ Due to this, the value of potential barrier present at the junction decreases.

→ Due to the applied voltage, e^- from n-sides cross the depletion region and reach p-side (where they are minority carrier) and similarly holes from p-side cross the junction and reach n-side (where they are minority carrier). This process under forward bias known as Minority carrier injection.



→ Due to this at junction boundry, on each side, the minority carrier conc. increases significantly compared to the location far from the junction.

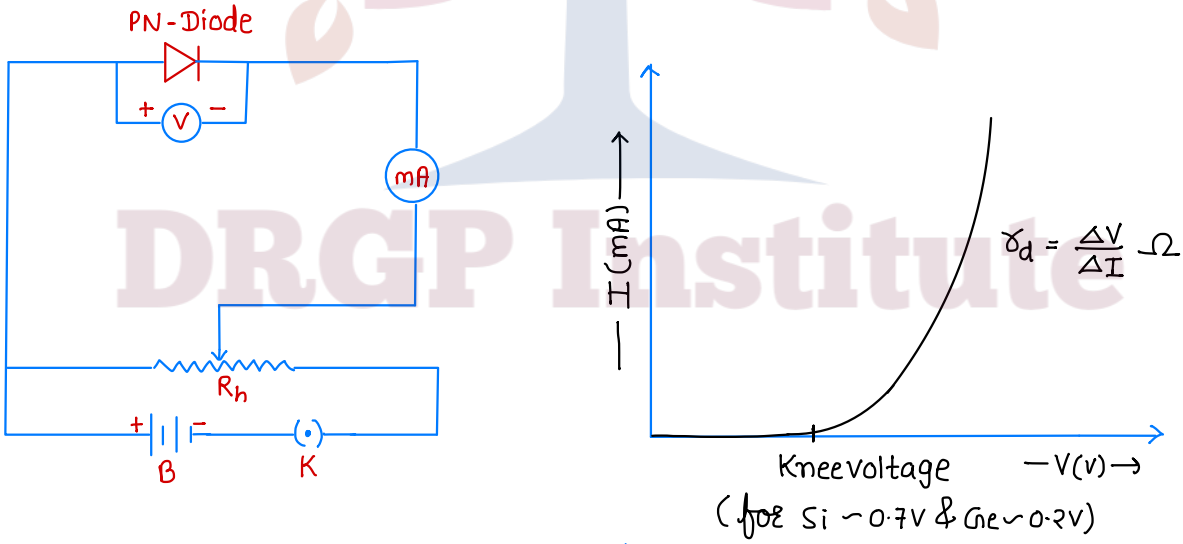
→ Due to this conc. gradient injected e on p-side diffuse towards +ve terminal and injected hole on n-side diffuse towards -ve terminal. This motion of charge carrier gives rise to current.

→ If applied voltage is small
↓
Reduction in barrier potential is very slightly
↓
current will be small.

If we increase applied voltage
↓
Reduction in barrier potential increase
↓
Current will be high.

So, in forward bias - (i) Applied field is opposite to junction electric field.
(ii) Depletion layer decrease
(iii) Current through majority charge carrier
(iv) Magnitude of current is in mA.

V-I Characterstics Curve - Graph b/w potential difference and current flowing in diode is called as characterstic curve of diode.



→ As we increase voltage then current initially doesn't increases because of potential barrier. when we increase voltage more than potential barrier then current increase exponentially due to flow of majority charge carrier.

Cut in voltage / Knee voltage -
Voltage applied across P-N Junction diode in F.B above which current increases exponentially is called Knee voltage / Cut in voltage / threshold voltage.

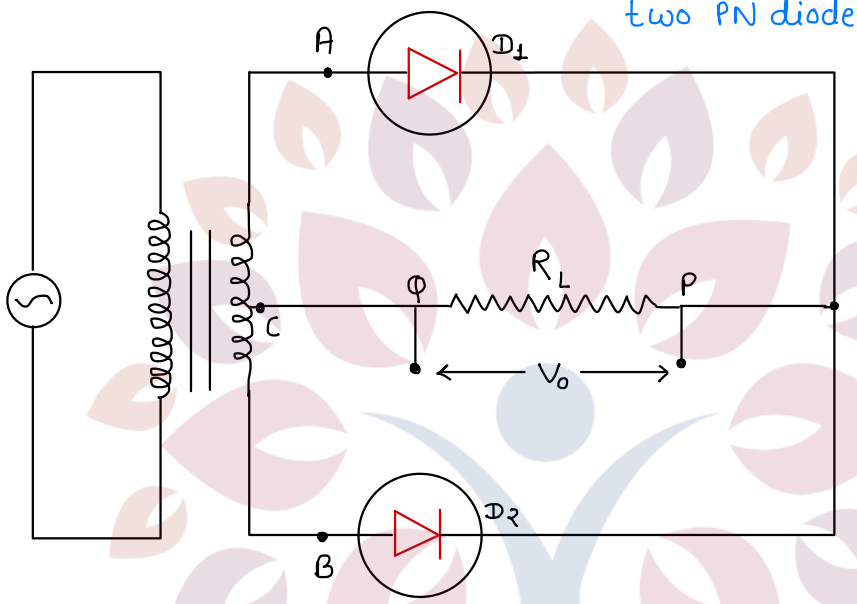
2. What is rectification ? Explain the working of a fullwave rectifier. Draw necessary circuit diagram. $\frac{1}{2} + \frac{1}{2} + 2 = 3$

⇒

Rectification- An electronic circuit which convert AC into DC is known as Rectifier and this process is known as Rectification.

full wave rectifier- An electronic circuit or rectifier which convert complete wave of AC into DC is known as full wave rectifier.

→ In full wave rectifier we use centre tap transformer and two PN diode.



working-

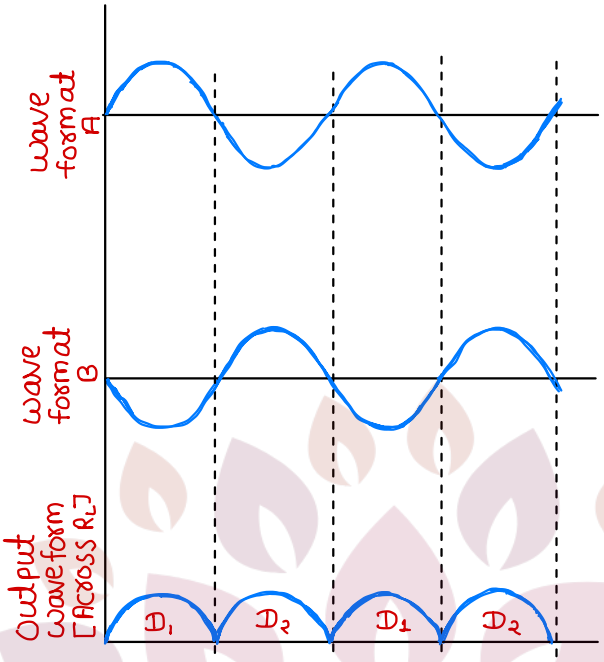
(i) when 1st 1/2 cycle of AC is applied-

Terminal A become +ve
and B become -ve
↓
Diode D_1 in F.B
Diode D_2 in R.B
↓
A at high voltage
C at low voltage
↓
So charge flow from
A to C
Direction of current
is AD_1PR_LQC
↓
Direction of current
in Load resistance
is P to Q

(2) when 1st 1/2 cycle of AC is applied-

Terminal A become -ve
and B become +ve
↓
Diode D_1 in R.B
Diode D_2 in f.B
↓
B at high voltage
C at low voltage
↓
So charge flow from
B to C
Direction of current
is BD_2PR_LQC
↓
Direction of current
in Load resistance
is P to Q

→ So, in both case current in Load resistance is same P to Q. Hence it is DC.



BOARD:- 2013 (Supp.)

3. What is rectification ? Explain the working of a fullwave rectifier. Draw necessary circuit diagram. $\frac{1}{2} + \frac{1}{2} + 2 = 3$

BOARD:- 2014

4. Write the names of two important processes which occur on formation of *p-n* junction. Define the 'depletion region' and 'potential barrier' in it. $\frac{1}{2} + \frac{1}{2} + \frac{1}{2} + \frac{1}{2} = 2$

⇒ A. Two important processes occur during the formation of a P-n junction - (i) Diffusion
(ii) Drift

B. (i) Depletion region - Due to concentration gradient holes diffuses from P→n and e^- from n→P. due to it only immobile ions remains in very small region. Region in which no free e^- or halls are found and only immobile ions are present known as Depletion region.

(ii) Potential barrier - A potential difference present on the depletion layer which opposes the flow of charge is called barrier potential.

BOARD:- 2015

5. Select one donor impurity among the following :

Boron (B), Aluminium (Al), and Arsenic (As). 1

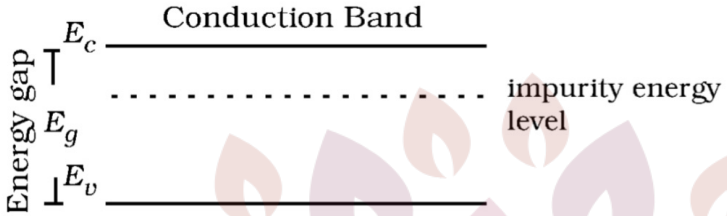
⇒ Donor impurity - Pentavalent impurity ⇒ As {P, As, Sb} - n type
Acceptor impurity - Trivalent impurity ⇒ B, Al {B, Al, Ga, In} - p type

6. Define rectification.

Draw circuit diagram of a full-wave rectifier.

Semi-conductor related to given energy band diagram is :

n-type semi-conductor, *p*-type semi-conductor or intrinsic semi-conductor.



1 + 1 + 1 = 3

⇒ (i) Rectification ✓
(ii) Full wave rectifier ✓
(iii) n-type

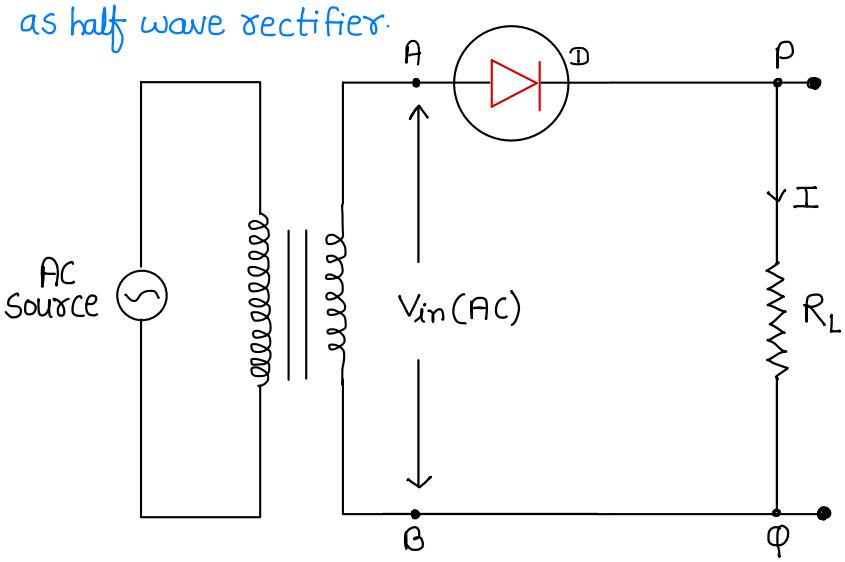
BOARD - 2016

7. Write the two examples of acceptor impurities. [1]

⇒ B, Al, Ga, In

8. What is rectification? Draw the circuit diagram of half wave rectifier and explain its working. Show the input ac voltage and output voltage waveforms from the rectifier circuit. [1 + 2 + 1 = 4]

⇒ (i) Rectification
(ii) Half-wave rectifier - An electronic circuit or rectifier which convert 1/2 portion of AC wave into DC is known as half wave rectifier.



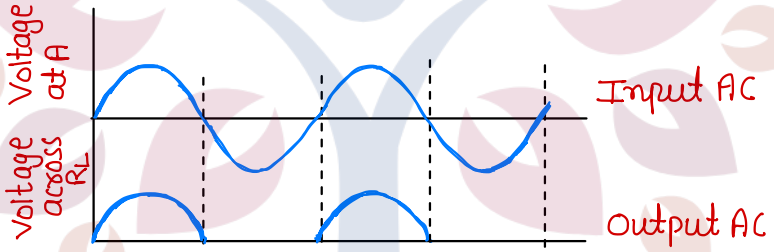
Working-

(1) When 1st 1/2 cycle of AC is applied-

Terminal A become +ve
and B become -ve
⇓
Diode D in F.B
⇓
A at high voltage
B at low voltage
⇓
So charge flow from
A to B
Direction of current
is APR$_L$QB
⇓
Direction of current
in Load resistance
is PtoQ

(2) When 1st 1/2 cycle of AC is applied-

Terminal A become -ve
and B become +ve
⇓
Diode D in R.B
⇓
No current in Load
resistance
(R.B act open circuit)



9. What is extrinsic semiconductor? How many types of these are? Write their names. Explain the processes which are occured during the formation of a P-N junction.

Determine the electric field produced at a P-N junction when width of depletion layer is 1 micrometer and barrier potential is 0.7 volt.

[1 + 1 + 1 + 1 = 4]

⇒ Extrinsic Semiconductor- when impurity is added to a pure semiconductor, it is called an extrinsic semiconductor.

→ It is done to improve conductivity.

Types of Extrinsic Semiconductor → There are two types of extrinsic semiconductor.

1. P-type semiconductor
2. n-type semiconductor

Process of formation of Pn Junction -

Consider a thin p-type semiconductor wafer and add a small quantity of pentavalent impurity. So, due to it some part of p convert into n. There is metallurgical junction b/w these two region.

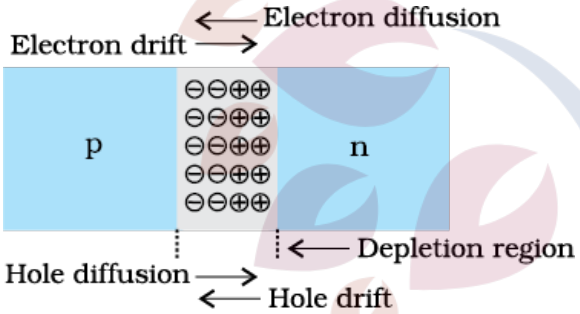
→ There are two important process - (i) Diffusion (ii) Drift.

→ (i) Due to conc. gradient holes diffuse from p → n side and electrons diffuse from n → p side. Due to this motion diffusion current form across junction. Due to this diffusion depletion region form. Region in which no free e^- or hole are found and only immobile ions are present known as Depletion region.

(ii) Due to immobile ions now minority charge carrier moves. electrons from p → n & holes from n → p under electric field of depletion region. This motion known as drift current. Its direction is just opposite to diffusion current.

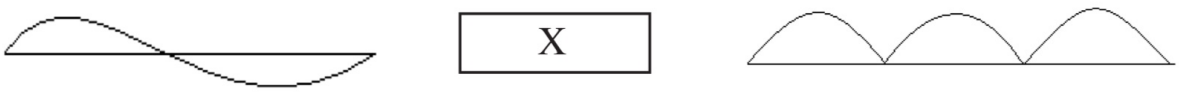
→ Initially diffusion current > drift current

→ After some times both current become equal equilibrium is established. Now Pn junction is formed. The potential at junction which prevent flow of majority charge carrier, known as Barrier potential.



BOARD - 2017

9. Write the name of device 'X' in the following given diagram. Explain its working making its circuit diagram.



Input signal Output signal

⇒ X = full wave rectifier
Circuit diagram - ✓

BOARD - 2018

10. Reverse Bias.

BOARD:- 2019

No question from current syllabus

BOARD:- 2020

11. What is intrinsic semiconductor and extrinsic semiconductor ? Write an example of each semiconductor. **1 + 1 = 2**

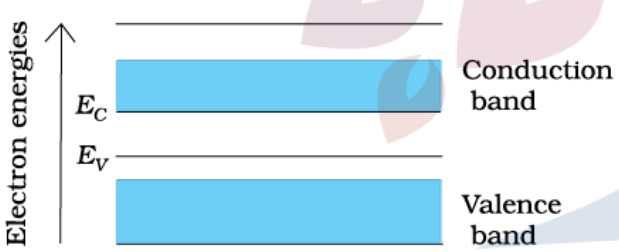
⇒

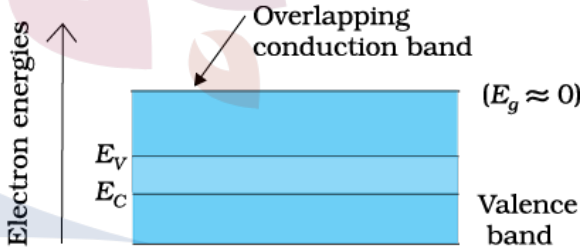
Intrinsic Semiconductor	Extrinsic Semiconductor
1. Semiconductor in its pure state is called pure / Intrinsic Semiconductor.	1. When an impurity is added to a pure semiconductor it is called an extrinsic semiconductor.
2. $n_e = n_h$	2. Either $n_e > n_h$ or $n_h > n_e$
3. Conductivity is low	3. Conductivity is high
Eg:- Si & Ge	Eg:- Si & Ge with pentavalent & trivalent impurity.

BOARD:- 2021

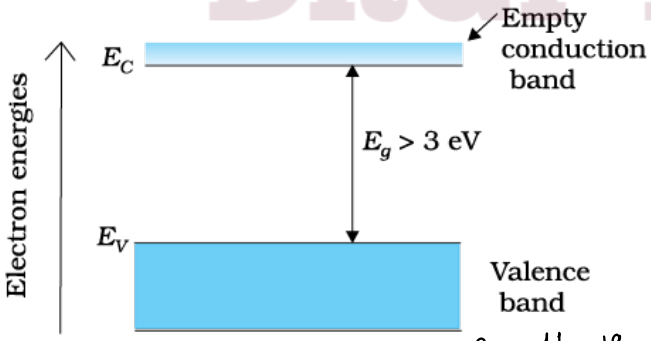
12. A. Distinguish clearly between conductor, insulator and semiconductor on the basis of energy band theory.
B. Draw characteristic curve for pn junction diode.

⇒

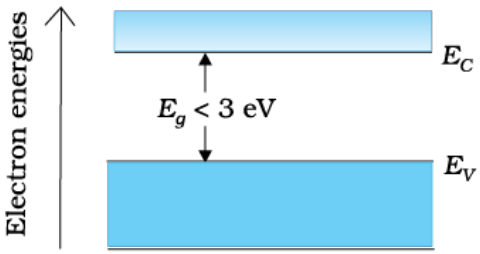




A. Conductor ⇝ $\rho = 10^{-2} - 10^{-8}\ \Omega m$, $\sigma = 10^{2} - 10^{8}\ Sm^{-1}$



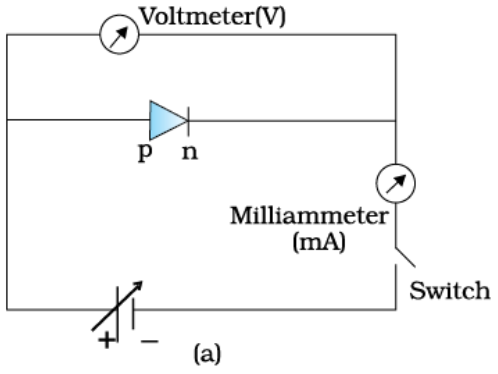
B. Insulator ⇝ $\rho = 10^{11} - 10^{19}\ \Omega m$, $\sigma = 10^{-11} - 10^{-19}\ Sm^{-1}$



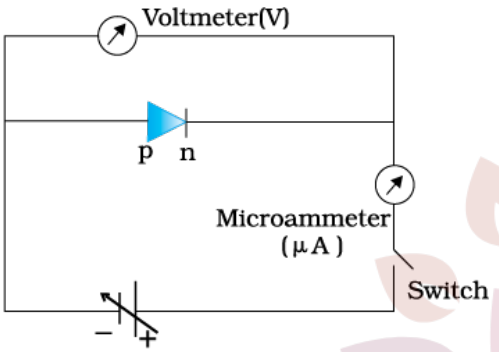
C. Semiconductor
($\rho = 10^{-5} - 10^{6}\ \Omega m$, $\sigma = 10^{5} - 10^{-6}\ Sm^{-1}$)

B. Characteristic curve for Pn junction diode -

Graph b/w potential difference and current flowing in diode is called as characterstic curve of diode.



(a)

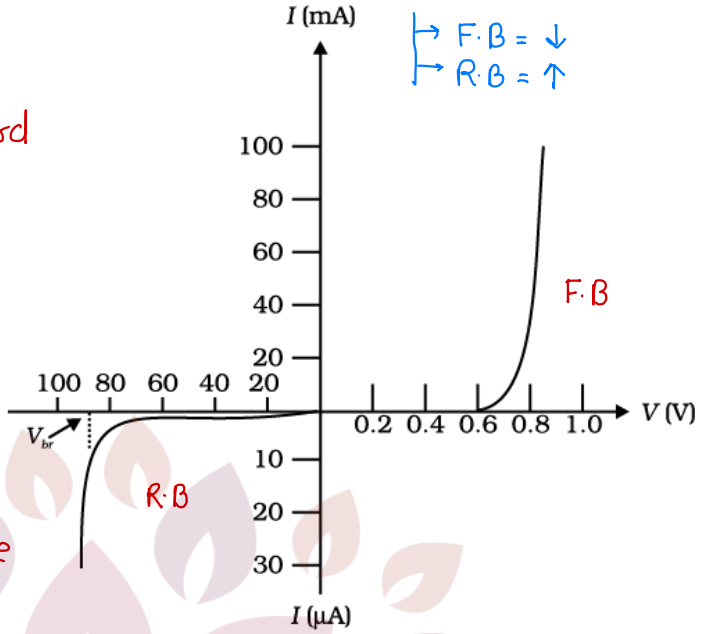


(b)

Dynamic Resistance - $r_d = \frac{\Delta V}{\Delta I}\ \Omega$

Forward Bias

Reverse Bias



(c)

BOARD:- 2022

13. The .....are majority charge carriers and ..... are minority charge carriers in p-type semiconductor.

⇒ Holes are majority charge carriers
electrons are minority charge carriers

BOARD:- 2023

14. Write name of majority charge carriers and minority charge carries in p-type semiconductor.

15. What is rectification? Draw the circuit diagram of full wave rectifier and explain its working. Show the input ac voltage and output voltage waveforms from the rectifier circuit.

BOARD:- 2024

16. Example of inorganic semiconductor is -

A) Ge B) CdS
C) anthracene D) polyaniline

⇒

Semiconductor-

(i) Elemental - Si & Ge
(ii) Compound -
A. Inorganic - CdS, GaAs, CdSe, InP
B. Organic - Anthracene, doped pthalocyanines
C. Organic polymer - polypyrrole, polyaniline
polythiophene etc.

17. _____ types of extrinsic semiconductors are found.

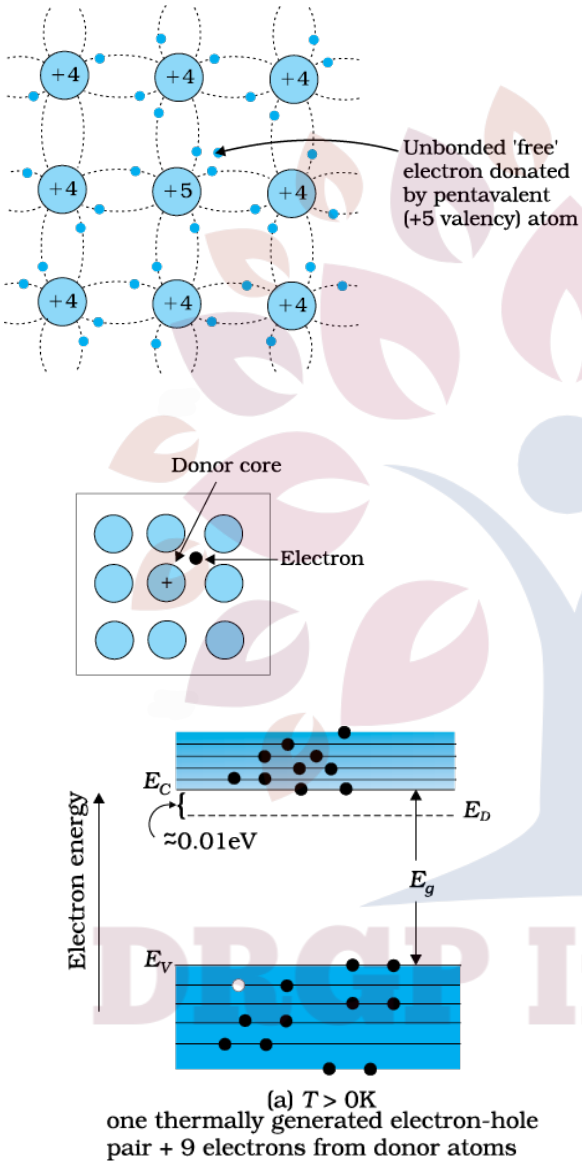
⇒ Two types - (i) p-type (ii) n-type

18. a) On the basis of energy band theory, write the difference between conductor, insulator and semiconductor.

b) Draw energy band diagram of *n*-types semiconductor.

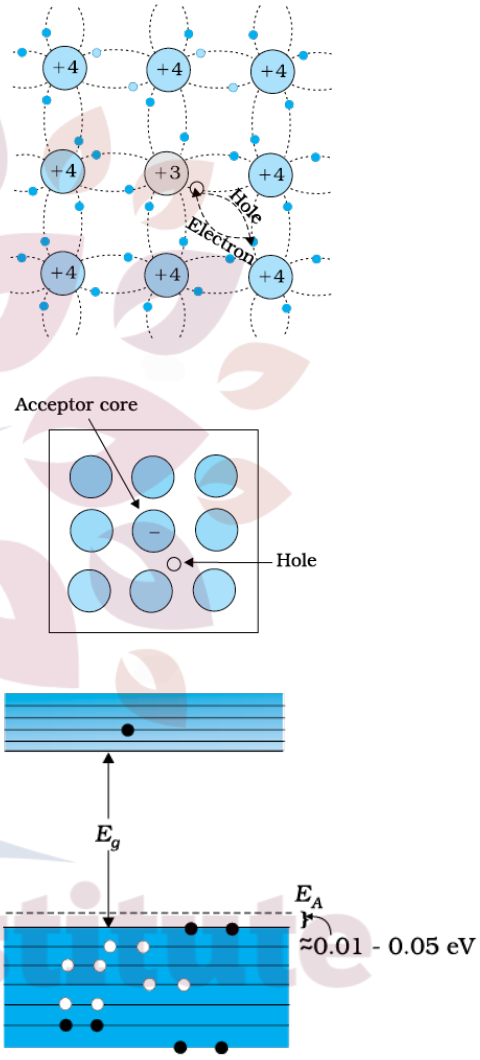
⇒ a) ✓

b) 'n' type semiconductor-



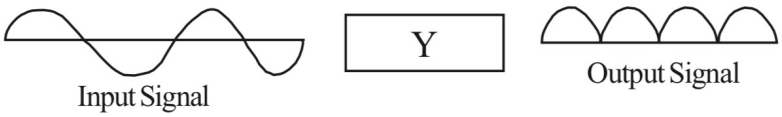
(a) $T > 0K$ one thermally generated electron-hole pair + 9 electrons from donor atoms

'p' type semiconductor-



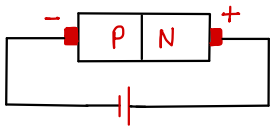
(b) $T > 0K$

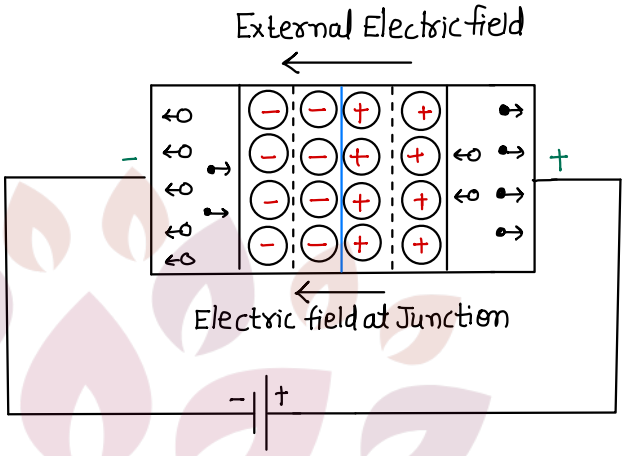
19. Write the name of device 'Y' in the following given diagram. Explain its working making with circuit diagram.



REVERSE BIAS

→ Process of connecting battery with diode is called Biasing of diode.
→ when we connect -ve terminal of Battery with p-type and +ve terminal with n-type of diode then biasing Known as Reverse Bias.



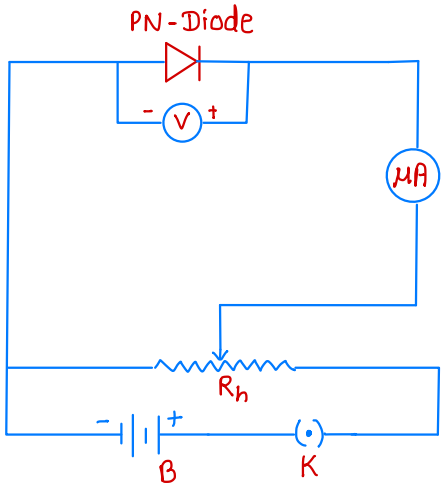


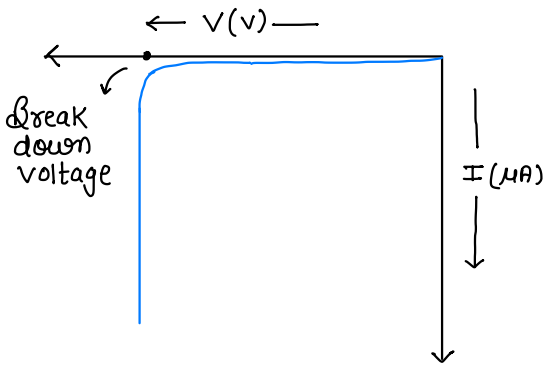
Working - In this bias the direction of the external electric field is just same to electric field at junction (Barrier electric field).

→ Due to this, the value of potential barrier present at the junction increase.
→ Due to this majority charge carriers move away from junction but minority charge carrier move towards junction. Due to it a small negligible current of μA flows.
→ Due to very less conc. of minority charge carries, no significant effect of value of external electric field on this current.

So, in reverse bias - (i) Applied field is in same direction to Junction electric field.
(ii) Depletion layer increase
(iii) Current through minority charge carrier
(iv) Magnitude of current is in μA.

V-I Characterstics Curve - Graph b/w potential difference and current flowing in diode is called as characterstic curve of diode.





For the diode in reverse bias, the current is very small (μA) and almost remains constant with change in bias. It is called reverse saturation current. However, for special case at very high reverse bias, the current suddenly increases.

Break down voltage - Voltage applied across diode in R.B at which current increases rapidly, is called Break down voltage.

Filter Circuit

A circuit which convert impure DC into pure DC is called filter circuit.