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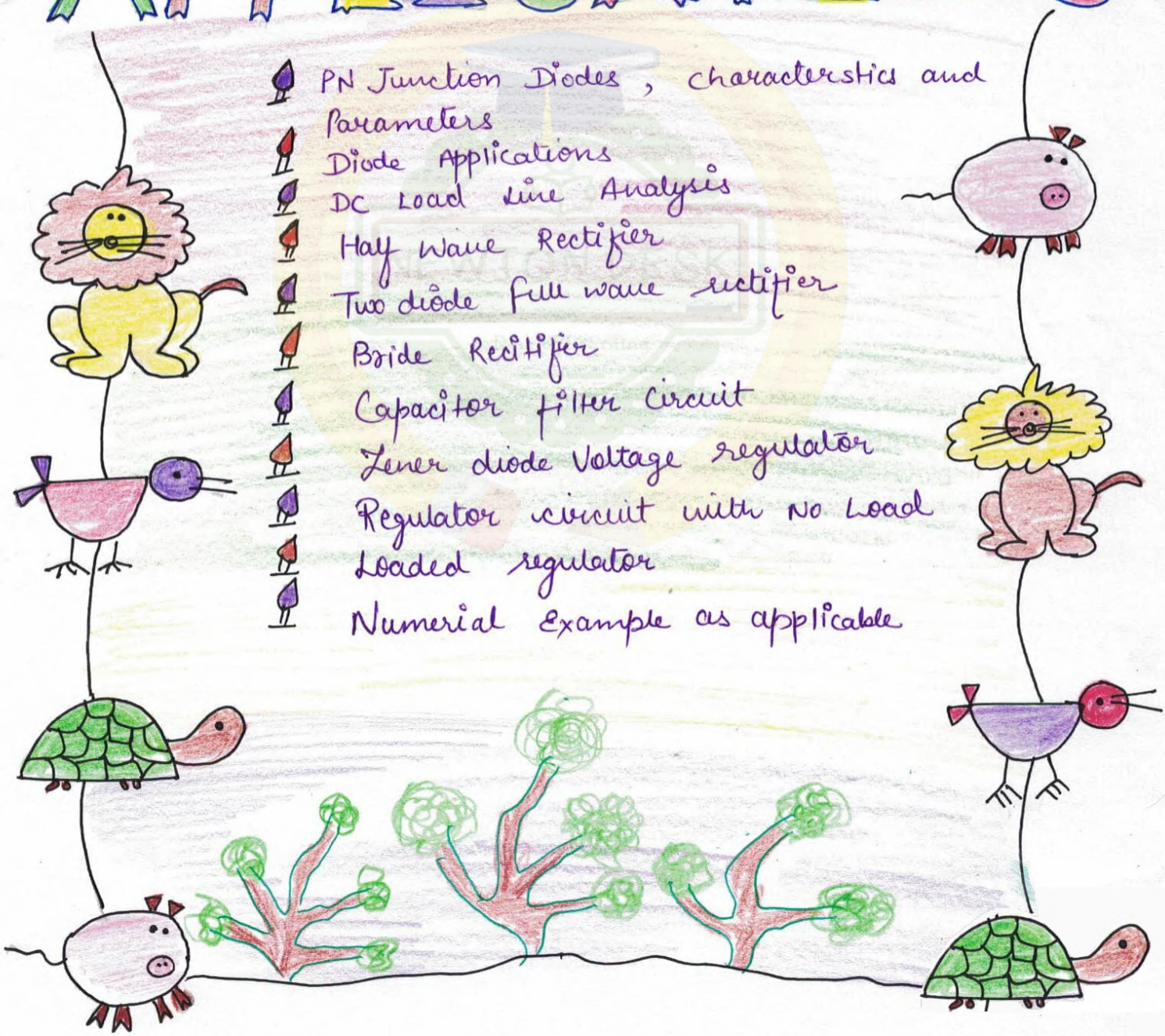
SEMICONDUCTOR DIODES AND ITS APPLICATIONS

- PN Junction Diodes, characteristics and Parameters
- Diode Applications
- DC Load line Analysis
- Half Wave Rectifier
- Two diode full wave rectifier
- Bride Rectifier
- Capacitor filter Circuit
- Zener diode Voltage regulator
- Regulator circuit with No Load
- Loaded regulator
- Numerial Example as applicable



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MODULE-1

SEMICONDUCTOR DIODES AND ITS APPLICATOONS

Extrinsic semiconductors are classified into

- n-type
- P-type

n-TYPE

when small amount of Pentavalent impurity is added to a pure semiconductor, it is known as n-type semiconductor

- typically examples of Pentavalent impurities are Arsenic (As) Antimony (Sb) Phosphorous (P) Bitmuni (Bi)
- Electrons are majority carries and holes are minority carriers.

P-TYPE

When a small amount of trivalent impurities are added to a pure semi-Conductor it is called P-Type semiconductor

- typically exmples of trivalent impurities are Gallium (Ga) Induim (In) Aluminuim (Al) Boron (B)
- Holes are majority carriers and electrons are minority carriers

P-n JUNCTION / SEMICONDUCTOR DIODE

When a P-type semiconductor is suitably joined to n-type semiconductor by special fabrication technique a P-n junction is formed (fig ①)

P-n junction is called as semiconductor diode / P-n junction diode / crystal diode

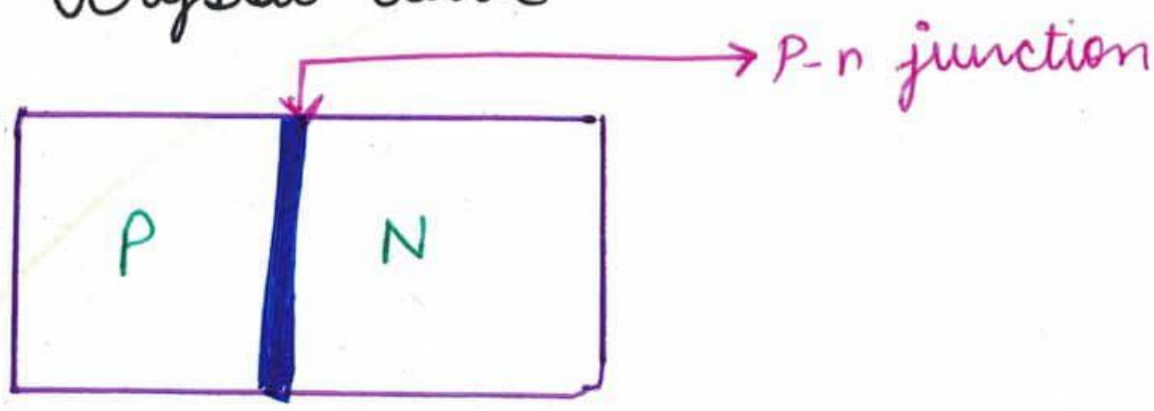

fig ① P-n Junction

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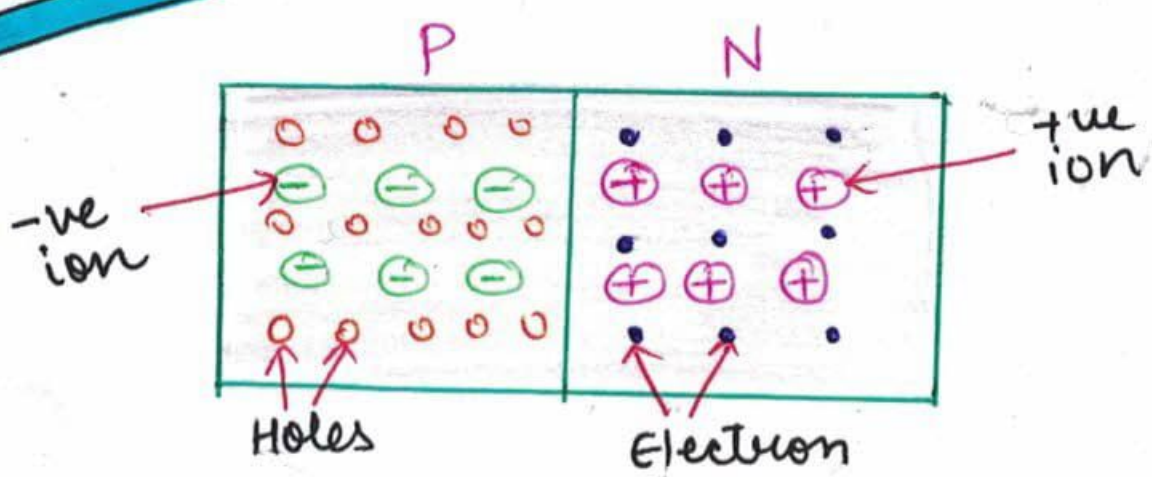
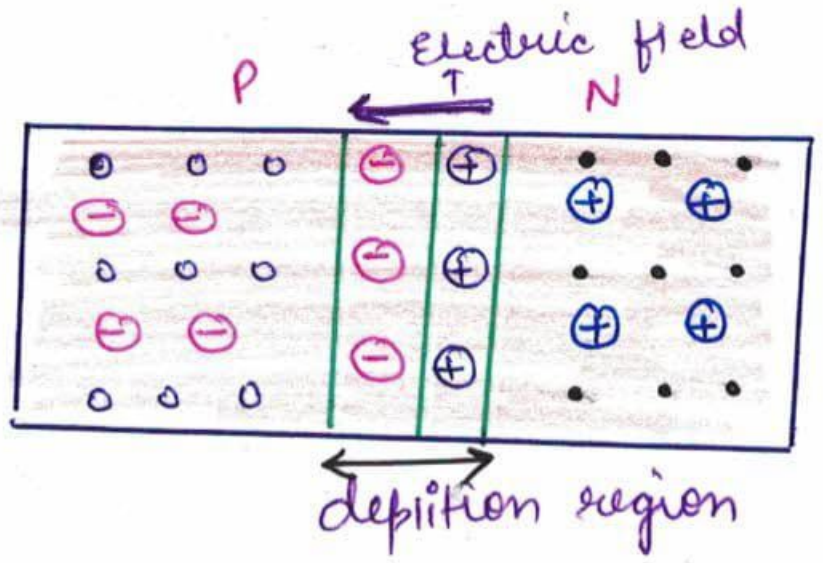
EXPLANATION

PROPERTIES OF P-N JUNCTION

FORMATION OF DEPLITION LAYER / UNBIASED P-N JUNCTION





- The P- region has holes (majority carriers) and negatively charged impurity atoms called negative ions (or acceptor ions)
- The n-region has free electrons (majority carriers) positively charged impurity atoms called positive ions (or donor ions)
- The holes from the P-region diffuse to the N-region where they combine with the electrons. This creates a layer of negative charges from the N-region diffuse to the near the junction
- The free electron from the N-region diffuse to the P-region, where they combine with holes. This creates a layer of +ve charges (Pentavalent ions) near the junction
- The region (layer) containing the +ve & -ve charges in the vicinity of the junction is called Depletion Region / depletion layer / Space charges region / transition region
- The electrons trying to diffuse into the P-region are repelled by the negative charge of the acceptor ions. Similarly the holes trying to diffuse into n-region are repelled by the +ve charge of the donor ions.

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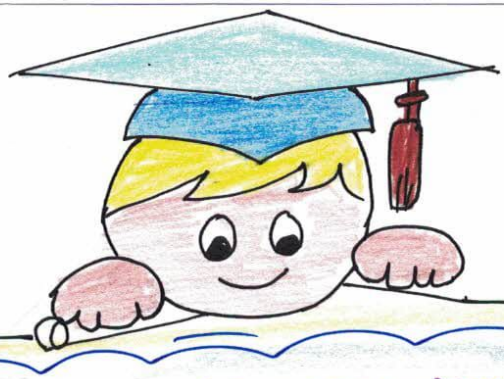

1. BARRIER VOLTAGE / BARRIER POTENTIAL / JUNCTION POTENTIAL / BUILT IN POTENTIAL / CUT IN POTENTIAL

- Once P-n junction is formed and depletion layer created the diffusion of charge carrier stops.
- The depletion region acts as a barrier to the further movement of charge carriers
- The depletion layer behaves like an insulators The positive & negative charges set up an electric field
- The Potential difference across the depletion layer is called **Barrier Potential (V_B)**

V_B = 0.6 V to 0.7 V for Si , V_B = 0.2 V to 0.3 V for Ge

2. EFFECT OF TEMPERATURE ON BARRIER VOLTAGE

- The barrier voltage depends upon ① Density ② Electronic charge ③ temperature
- for a given P-n junction the first two factors are Constant.
- For both Ge & Si the value of V_B ↓ by 2 mv/°C

$$\Delta V_B = -0.002 \times \Delta t$$

where Δt = Increase in temperature in °C

- A P-n junction across which no external voltage source is connected is known as **Unbiased P-N junction**

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Note

3. IN AN UNBIASED P-N JUNCTION

- The majority carrier current and minority carrier current are equal in magnitude and flow is opposite direction, thus there is no net flow of current accross the junction
- The higher the doping level the thinner will be the depletion layer and vice versa
- In 1919, William Henry Eccles coined the term 'diode' from the Greek roots 'dia' means 'through' and 'ode' means path.

BIASING THE P-N JUNCTION : (APPLYING DC VOLTAGE ACROSS PN JUNCTION

Connecting a P-N Junction to an external DC voltage is called Biasing.

The biasing is classified into two types namely

- FORWARD BIASING
- REVERSE BIASING

FORWAD BIASING

When external dc voltage applied to the junction is in such a direction that it cancles the potential barrier thus Permitting current flow. it is called forward Biasing

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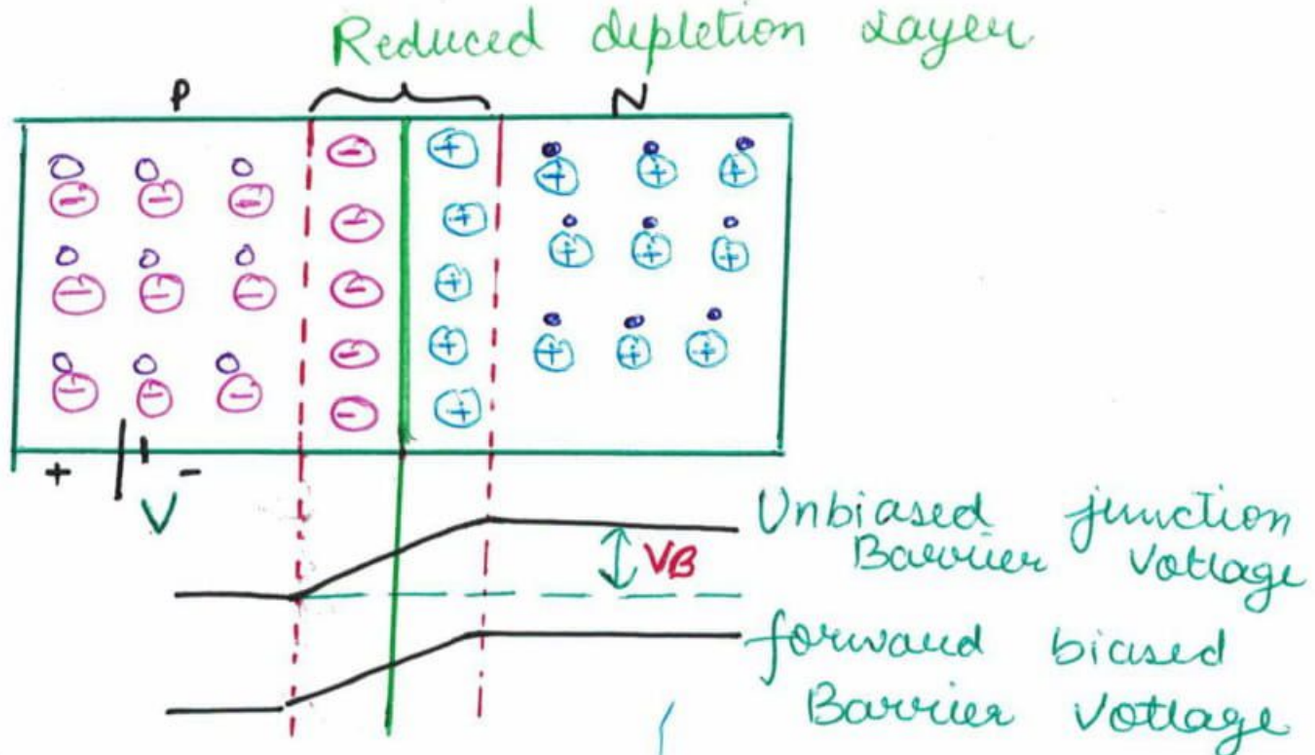
A Semiconductor diode is said to be forward biased when the positive terminal of the voltage source is connected to the P-side and -ve terminal to the n-side



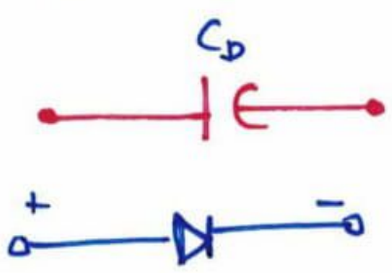
EXPLANATION

- The holes are repelled by the +ve terminal of the voltage source and are forced to move towards the junction
- The electrons are repelled by the -ve terminal of the voltage source and move towards the junction
- Some of the holes and electrons enter the depletion layer and recombine themselves, thus the width of the depletion layer and the barrier potential (Barrier jun^n) reduces.
- The junction forward resistence reduces and a large current (forward current) flow through the P-N function

NOTE — DIFFUSION OR STROAGE CAPACITANCE

- The capacitence which exists in a forward biased junction is called as **diffusion Capacitance**
- Diffusion Capacitance is much larger than the transition Capacitance (width of the depletion layer is very less)
- Typical Value of C_D = 0.02 mf
- Deffusion Capacitance C_D is given by

$$C_D = \frac{dQ}{dV} = \frac{\tau I_F}{\eta V_T} = \frac{\tau I_f}{V_f}$$



where τ = Mean life time of the carrier
I_F = Value of forward current
η = A constant (η = 1 for Ge)
V_f = Forward voltage (η = 2 for Si)
V_T = Volt equivalent of capacitence

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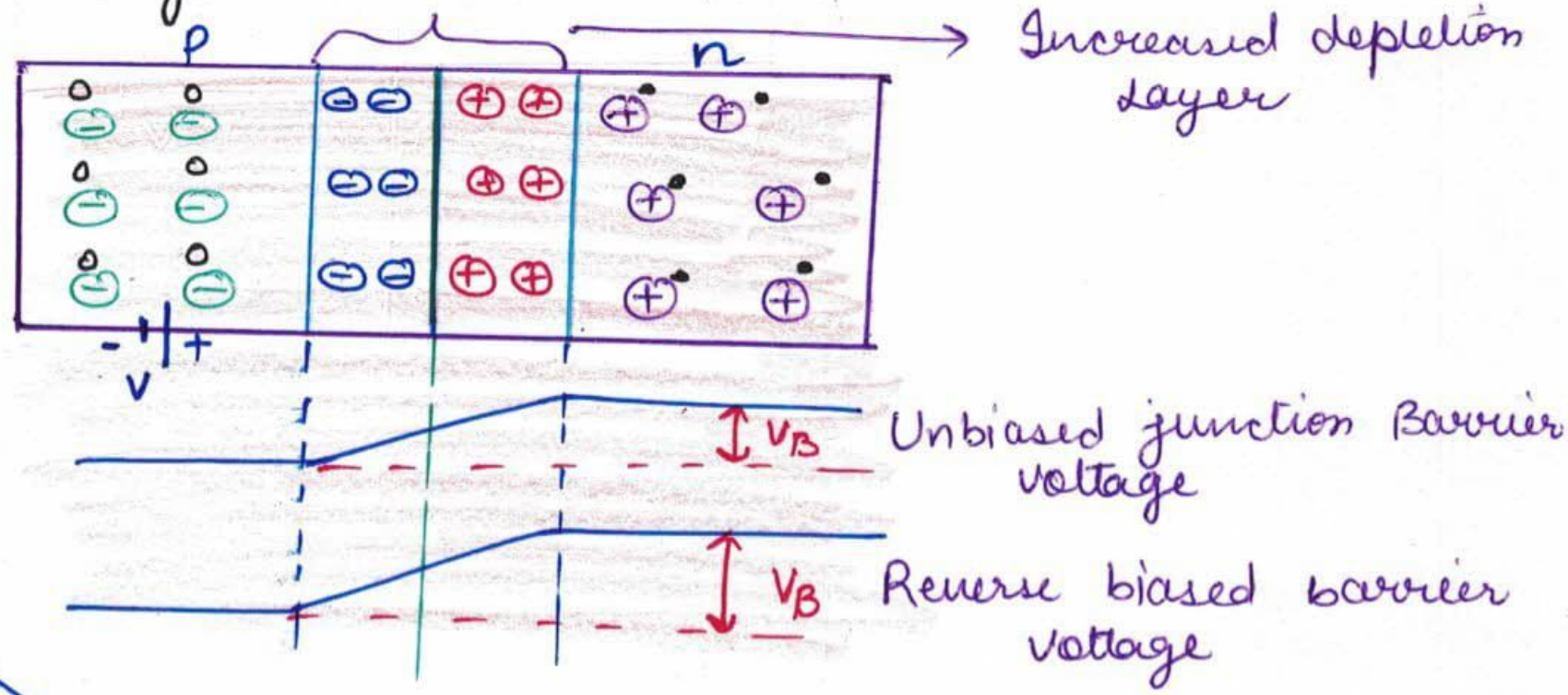
REVERSE BIASING

When the extended dc Voltage applied to the junction is in such a direction that Potential barrier is increased it is called Reverse Biasing.

A PN-junction is said to be reverse biased, when the Positive terminal of the voltage source is connected to the n-side and negative terminal to the P-side



EXPLANATION

- The holes in the P-region are attracted towards the negative terminal of the voltage source.
- The electrons in the n-region are attracted towards the +ve terminal of the voltage source.
- Thus the majority carrier are drawn away from the junction this wider the depletion layer and ↑ the barrier Potential
- The junction reverse resistence becomes very high and hence no current flows
- However a very small current flows due to minority carriers (of the order of MA (n) nA). This is called Reverse Saturation current (I_o)
- If reverse voltage is ↑ continuously the kinetic energy of minority carrier ↑ and a large reverse current flows. This damages (destroy) the junction (Diode) Permanently. This is called the Reverse Breakdown of a bridge.
- The reverse breakdown (junction Breakdown) causes due to the process.

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