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① $I = I_0 \left(e^{\frac{V}{\eta(V_T)}} - 1 \right) A$

I_0 → Reverse saturation current in amperes
V = Applied voltage
η = 1 for germanium diode
= 2 for silicon diode
V_T = voltage equivalent of temp. in volts

$V_T = KT$ volts
K = Boltzman's constant = $8.62 \times 10(-5)$ ev°/K.
T = 27 + 273 = 300°K
$V_T = 8.62 \times 10(-5) \times 300 = 0.02586\ V = 26\ mV$

The value of V-T also can be expressed

$$V_T = \frac{I}{\frac{1}{K}} = \frac{T}{\frac{1}{8.62 \times 10(-5)}} = \frac{T}{11600}$$

At 300°K, we get V_T = 26 mV

The diode current eqn is applicable for all the conditions of diode i.e, unbiased, forward biased and reverse biased

when unbiased, V = 0, we get,

$I = I_0 (e^0 - 1)\ A = 0A$

Thus, there is no current through diode when unbiased.

② Avalanche Breakdown :- The avalanche breakdown occurs when a high reverse voltage is applied across the diode. As we increase the applied reverse voltage, the electric field across the junction increases. This electric field exerts a force on the electrons at the junction and frees them from covalent bonds

Zener Breakdown :- Zener Breakdown is a controlled way of creating breakdown in p-n junction diodes. The p-n junction has to be heavily doped so that the electrons in the valance bond of P-type

region can jump easily to the conduction band of n-type region. This temporary breakdown occurs due to the high electric field

④ Threshold voltage :- For a p-n diode to conduct, a certain voltage greater than the barrier potential has to be supplied. This voltage is called the threshold voltage. Si (0.7 V) Ge (0.3V)

Knee voltage :- Knee voltage is the forward voltage at which the flow of current through the PN junction of the diode increases rapidly. The knee voltage is generally observed in Zener diodes

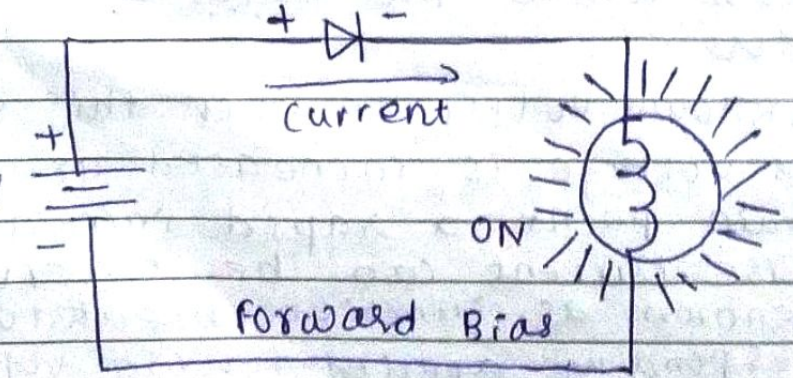
Breakdown voltage :- It is the voltage at which the currents starts flowing or increases in forward biased PN junction. It is the reverse voltage at which the breakdown of junction takes place and reverse current rapidly increases.

⑤ In a p-n junction, without an external applied voltage, an equilibrium condition is reached in which a potential difference forms across the junction. This potential difference is called built-in potential. At the junction, the free electrons in the n-type are attracted to the positive holes in the p-type

The P and N sides of the diode are electrically neutral. Due to diffusion of electrons from N to P side and diffusion of holes from P to N side

× From N-side to P-side

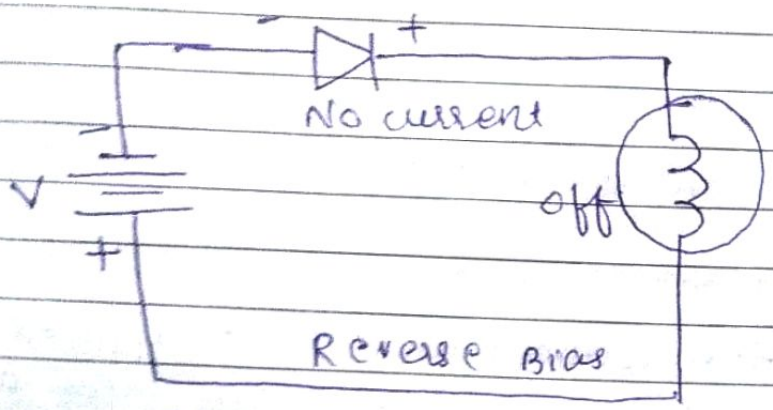
⑥ Forward Bias :-



forward bias:
forward bias occurs when a voltage is applied across the solar cell such that the electric field formed by the P-N junction is increased.

Reverse Bias:-

In reverse bias a voltage is applied across the device such that the electric field ~~in the~~ at the junction increases. The higher electric field in the depletion region decreases the probability that carriers can diffuse from one side of the junction to the another.

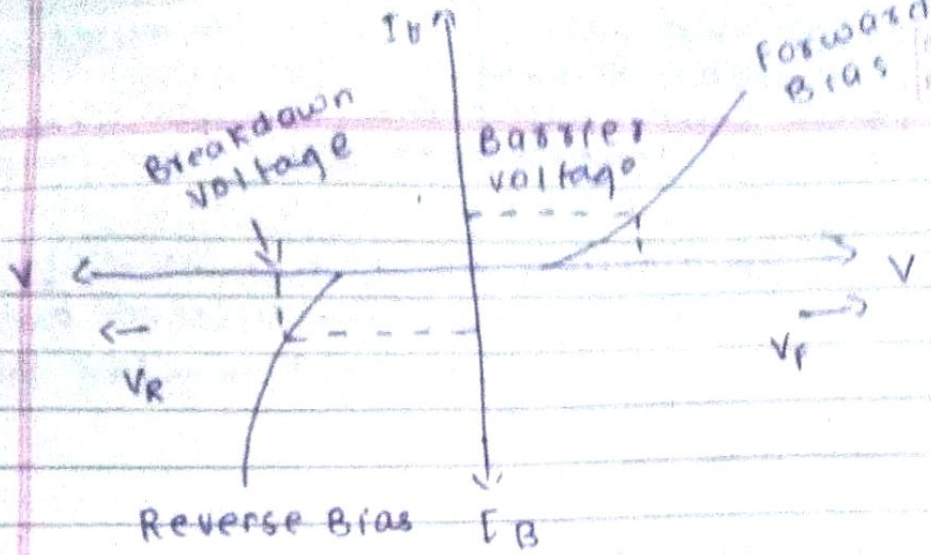


Q) → Minority charge carrier:- A p-n junction ~~diode~~ is known as minority charge carrier device since the current conduction is controlled by the diffusion of minority carriers (i.e. electrons in the p region and holes in the n region) in a p-n junction diode.

→ Majority chargee carrier:- On the p side, the holes constitute the dominant carriers ~~are~~ and so are called majority carriers. On the n side, the electrons are the majority carriers while the holes are the minority carriers.

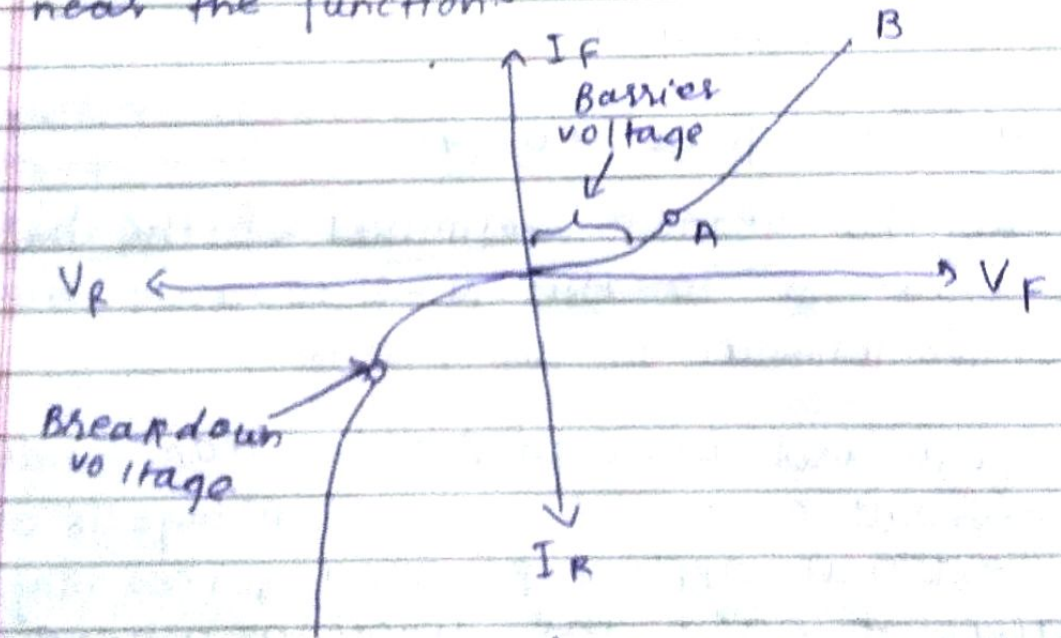
→ Breakdown voltage:- when this applied reverse bias voltage is increased gradually at a certain point a rapid increase in the reverse current can be observed. This is known as junction breakdown. The corresponding applied reverse voltage at this point is known as Breakdown voltage of the PN junction diode

(8)



→ Knee voltage explained in ques no. (7)

(9) The depletion region is caused by the diffusion of charges. Because of the concentration of gradient holes diffuse from p-side to the n-side across the junction while electrons diffuse from the n-side to the p-side. The holes and the electrons diffusing towards each other combine near the junction.



Volt ampere (V-I) characteristics of a pn junction or semiconductor diode is the curve between voltage across the junction and the current through the circuit. Normally the voltage is taken along the x-axis and current along y-axis

(10) The electron-hole pair is the fundamental unit of generation and recombination in inorganic semiconductors, corresponding to an electron transitioning between the valance band and conduction band. where generation of electron is a transition from the valance band to the conduction band and recombination leads to a reverse transition.

$$E_g = \frac{hc}{\lambda}$$

$E_g = 1.42$ eV

$1 eV = 1.602 \times 10^{-19}$ J

$\Rightarrow 1.42$ eV $= 2.30 \times 10^{-19}$ J

$c = 3 \times 10^8$ m/s

$h = 6.63 \times 10^{-34}$ m^2 kg/s

$$\lambda = \frac{hc}{E_g} = \frac{6.63 \times 10^{-34} \text{ m}^2 \text{ kg/s} \times 3 \times 10^8 \text{ m/s}}{2.30 \times 10^{-19} \text{ J}}$$

8.60×10^{-7} m $= 860$ nm

(12) same as ques. no. (9)

~~when the negative terminal of the battery is connected to the N-side and the positive terminal to the P-side~~

A forward-biased PN junction conducts a current once the barrier voltage is overcome. The external applied potential forces majority carriers toward the junction where recombination takes place, allowing current flow. A reverse-biased PN junction conducts almost no-current