Junction Diodes and Transistors

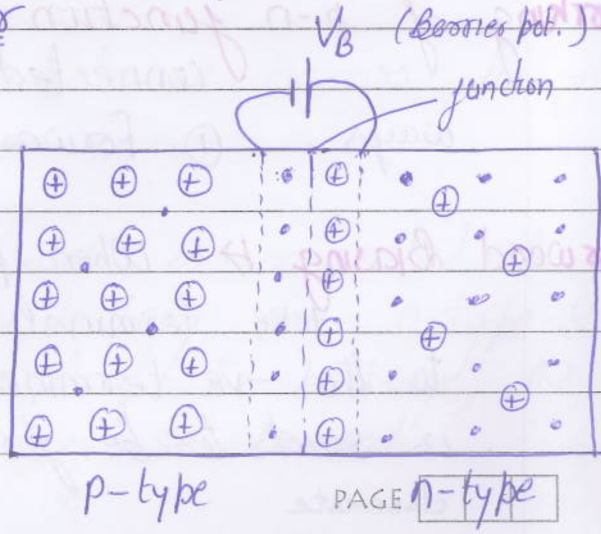
P-N-Junction ↦ It is a single crystal of Ge or Si doped in such a manner that one half portion of it acts as p type S.C and other half as n-type S.C.

It must be noted carefully that p-n junction can't be made just by placing p-type s.c. with n-type S.C. Because even the most smoothly polished surfaces when pressed against each other have very small area in contact and moreover fine dust particles on their surfaces causes discontinuity for the exchange of charge carriers across the junction.

A p-n junction is key to all the S.C.Ds.

Unbiased p-n junction, depletion region and potential barrier ↦

As soon as the p-n junction is formed, ~~elec~~ ~~of~~ majority charge carriers electrons of n region start diffusing towards the p-region ~~and holes of p-region towards n-region~~ and combine with hole and get neutralized. Similarly hole of p-region diffuse into n-region and combine with electrons to get neutralized. Thus a small region in the vicinity of junction which has no free charge carriers is called the <u>depletion layer</u>



The accumulation of -ve charge in p-region and +ve charge in n-region produces a sort of ~~junction~~ fictitious battery across the junction and hence a barrier potential sets up across the junction.

This barrier potential opposes the diffusion of $\bar{e}$s and holes across the junction. Thus an electron needs an energy equal to eV_B to cross the junction.

The barrier potential V_B at which e^{-}s and holes ceases to diffuse across the junction of unbiased (when no external battery is connected) p-n junction is 0.7 V for Si S.C and 0.3V for Ge S.C.

The thick ness of depletion layer is very low of the order of 10^{-6} m. Thus a very strong electric field develops across the layer

ie $E = \frac{V_B}{d}$ $\{\because V = Ed\}$

$\Rightarrow E = \frac{.7V}{10^{-6}m} = 0.7 \times 10^{+6} Vm^{-1}$

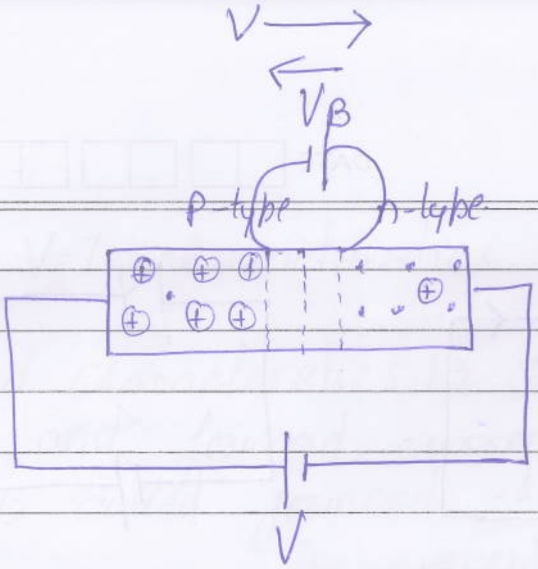
or $E = 7 \times 10^{+5} Vm^{-1}$ for Si.

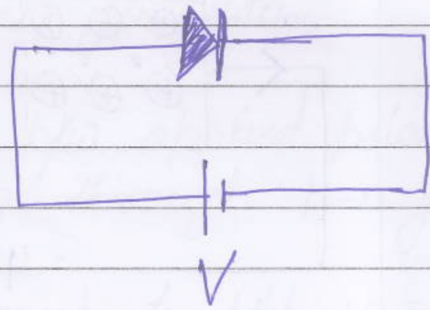
and $E = 3 \times 10^{5} Vm^{-1}$ for Ge.

Symbol ↦

Working of p-n junction ↦ A p-n junction can be connected across a battery in two ways. ① Forward Biasing ② Reverse Biasing

Forward Biasing ↦ When p-type S.C. is connected to the +ve terminal and n-type S.C. is connected to the −ve terminal of battery, the p-n junction is said to be forward biased.



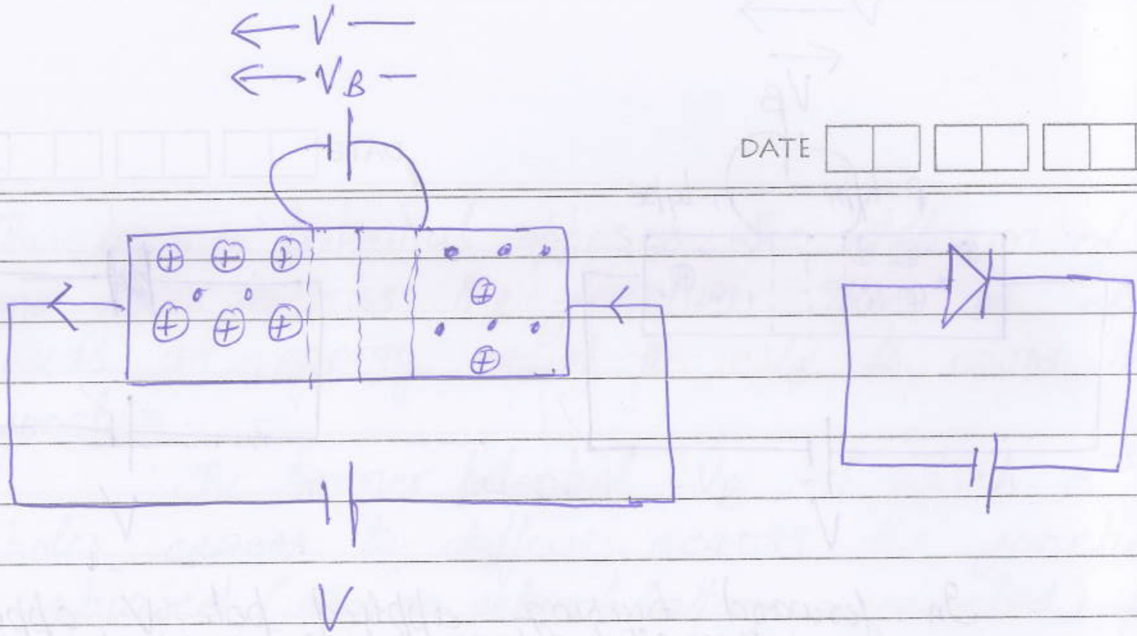


In forward biasing applied pot. V opposes the barrier pot. V_B, Hence effective barrier pot. decreases to $V_B - V$. Thus holes of p-region and electro of n-region start moving towards the junction, ~~where~~ thus electron-hole combinations takes place. For every $\bar{e}$-ho combination near the junction, a covalent bond bre near the +ve terminal of battery. The electrons so produced enter into the +ve term. of battery and h again repelled towards the junction. Equal number electrons are released by the −ve terminal of bat which enter into the n-region. Thus large forw current flows through the circuit from n-type SC to p-type S.C. out side the junction and from p-typ to n-type S.C inside the junction.

The width of the depletion layer reduces. Because electrons and holes diffuse towards the junction and hence electrons and holes ~~have to travel a very small distance for their com~~ combination took place clo to the junction.

The effective resistance across the junc is very low.

Reverse Biasing ↦ When p-type S.C. is connected to the −ve terminal of the battery and n-type S.C. connected to the +ve terminal of the battery, the p- junction is said to be reverse biased.



In reverse biasing applied pot. V and barrier pot. V_B are in same direction. Thus barrier pot. increases to $V_B + V$. Hence no movement of electrons and holes occur, Moreover majority charge carriers are pulled away from the junction by the battery. Thus no current flows across the junction across the majority charge carriers.

However some reverse current or leakage current flows due to minority charge carriers.

Since e^-s and holes are pulled away from the junction. Thus diffused e^-s and holes have to travel a longer path after crossing the junction for electron-hole combinations. Thus thickness of the depletion layer increases.

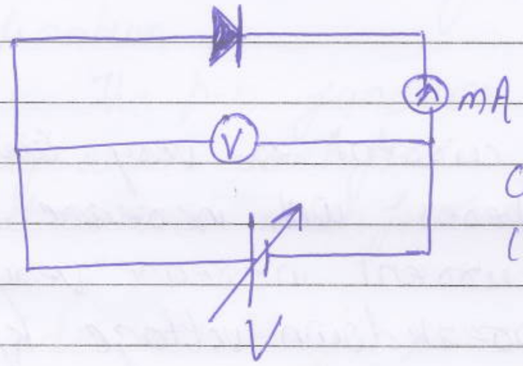
The direction of reverse current is p-type to n-type S.C. in the ext. circuit.

Characteristics of p-n junction diode ↳ A graph between current flowing through a p-n junction with applied pot. across the junction is called

V-I characterstics of a p-n junction.

Forward Characterstics ↦ The graph b/w applied potentia and forward current flowing through p-n jun is called forward characterstics.

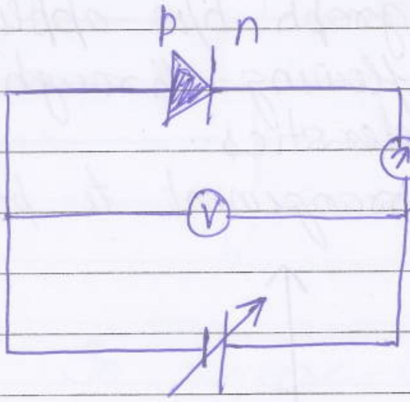
The circuit arrangement to plot V-I gr is as shown.

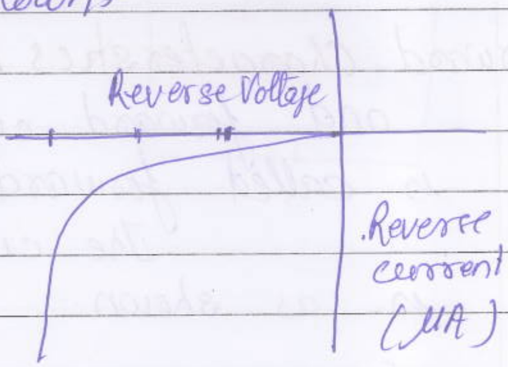


Initially with increase in applied pot. current grows very slowly and after certain voltage V_K known as knee voltage it increases very rapidly (exponentially). It happens because upto knee voltage V_K (0.7 V for Si crystal) only a fel elect ~~ea~~ acquire a sufficient amount of energy to cros the junction w/a after knee voltage all the electron gain energy sufficient to cross the junction. Thus current increases sharply.

Reverse Characteristics ↦ A graph b/w applied reverse vol and reverse current flowing through a p-n junction is called reverse characterstics.

The circuit arrangement to plot reverse characteristics is as shown.





The reverse current is very low of the order of micro amperes. With increase in reverse voltage, reverse current increase very slowly but after certain breakdown voltage K/a zener voltage reverse current suddenly increases to a very large value.

Zener voltage depends upon the dopant density and the depletion layer and it ~~rages~~ ranges from 1V to 2V to several hundred volts.

***Dynamic resistance of a junction diode** ↦ Junction diodes donot obey Ohm's law. Their resistance vary with applied potential. Thus it is useful to define a quantity K/a dynamic or ac resistance of the diode.

It is d/a the ratio of the small change in applied voltage ΔV to the corresponding change in current ΔI.

ie $R_{dyna} = \frac{\Delta V}{\Delta I}$

Photodiodes => Operated in reverse biased
LED => ——— Forward biased
Solar Cells => same as of photodiode

DATE

Junction Diode as rectifier ↦

A junction diode offers a very small resistance in forward biasing and offers a very high resistance in reverse biasing. Thus diode conducts only when it is forward biased. This property of the diode is used to convert AC i[nto] DC.

The conversion of AC into DC is called rectification.

The p-n junction can be used as
① half wave rectifier
② Full wave rectifier.

Junction diode as half wave rectifier ↦