-: Chapter ⇒ 14 :-

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14th August 2021

Semiconductor Electronics:- Materials, Devices and Simple circuits

⇒ Classification of Material

(1) Conductor ⇒ Easily allow electricity to pass through (α = +ve)

(2) Insulator

$R = R_0(1 + \alpha \Delta t)$

$t \uparrow$ Resistance $\uparrow$

(3) Semiconductor ⇒

Do not allow flow of charges easily

Conductivity lies between conductor and Insulator.

$\alpha = -ve$ $t \uparrow$ Resistance $\downarrow$ or conductivity $\uparrow$

⇒ It is used in controlling flow of charge.

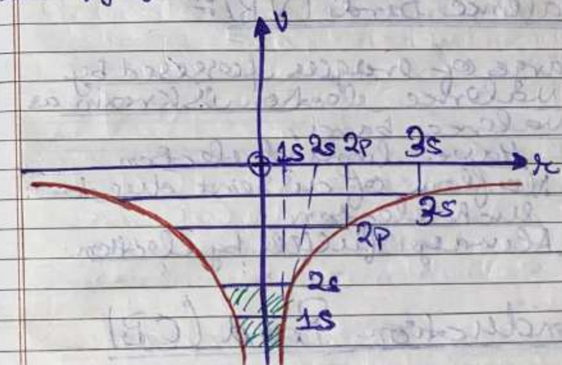
⇒ Energy Bands in Solids

Based on Pauli's Exclusion principle.

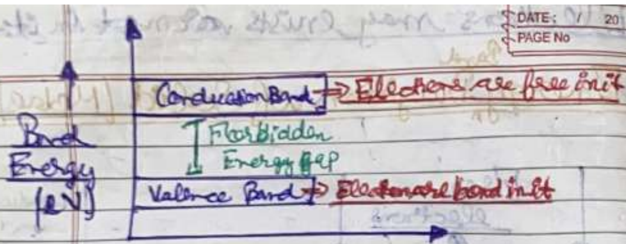
In an isolated atom electrons present in energy level but in solid, atoms are not isolated. There is an interaction among each other, due to this energy level splitted into different energy levels. Quantity of these different energy levels depends on the quantity of interacting atoms. Splitting of sharp and closely compact energy levels result into energy bands. This is discrete in nature.

(#) Energy Band Diagram :-

Potential energy of e^- ⇒ $U \Rightarrow \dfrac{-K(ze)(e)}{r}$



-: For Single atom :-



* Forbidden energy gap is denoted by ΔE_g.
* In this no free electrons exists that means electrons will be either in Valence Band or in Conduction Band

$$\therefore \Delta E_g \Rightarrow (CB)_{min} - (V.B)_{max}$$

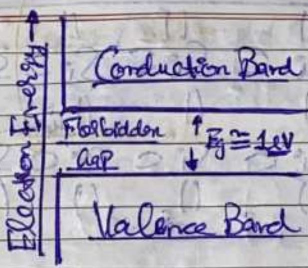
Energy gap between conduction band and valence band, where no free electrons can exists is called Forbidden Energy band.

⇒ Energy band Diagram in Conductor, Insulators and Semiconductor.

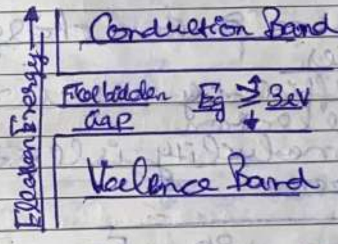
In Conductor

So in $\Delta E_g = 0$ or No gap is there

In Semiconductor:-



In Insulator



28th August, 2021
Lecture ⇒ 2

⇒ Concept of "HOLES" in Semiconductor

Due to external energy (temp or radiation) when electron goes from valence band to conduction band (i.e bonded electrons becomes free) a vacancy of free e⁻ is create in valence band, which has same charge as electron but positive. This positively charged vacancy is termed as hole and shown in figure.

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:. Energy band :- Range of energy possessed by electron in a solid is known as energy band.

:. Valence Band (VB) :-

Range of energies possessed by valence electron is known as valence band.

(a) Have bonded electron.
(b) No flow of current due to such electron
(c) Always fulfill by electron

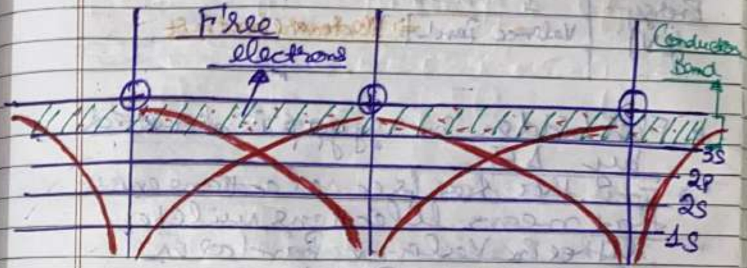
:. Conduction Band (CB)

Range of energies possessed by free electrons is known as conduction band.

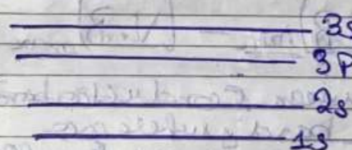
(a) It has conducting electrons
(b) Current flow due to such electrons
(c) If conduction band is fully empty then current conduction is not possible.

(d) Electrons may exists in it:-

Energy Band Diagram of Solid (Metal) :-



In Atom



In atom energy level is continuous

In Solids :-

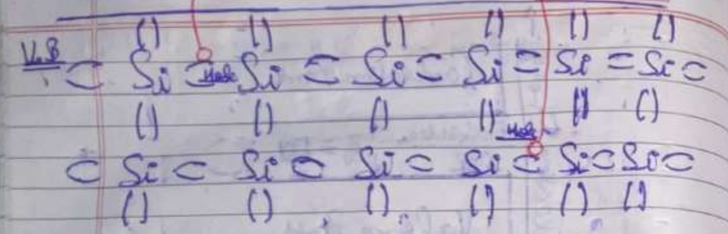
} Valence Band

In solid energy level are some discrete and are in range

Maximum energy level upto which electrons are filled is called fermi Energy level.

Valence Band is partially or fully Filled.

C.B → Free electrons



- It is deficiency of electron in V.B
- It acts as positive charge carrier
- It's efficiency mass is more than electron
- It's mobility is less than electron

$$\boxed{n \Rightarrow A\,T^{3/2}\,e^{-\frac{E_g}{2KT}} \quad \text{or} \quad n \Rightarrow A\,T^{3/2}\exp\left[-\frac{E_g}{2KT}\right]}$$

Where n = No of free electrons

T :- Absolute Temperature

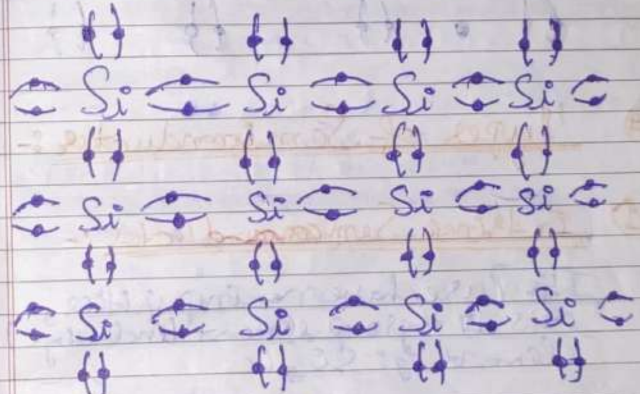
Eg : Energy gap b/w C.B and V.B

K = boltzmann Constant = 1.38×10^{-23}

* In silicon at room temperature out of 10^{12} Si atoms only one electron goes from V.B to C.B.

* In germanium at room temperature out of 10^{9} Ge atoms only one electron goes from VB to CB.

$\sigma_{Ge\ conductivity} > \sigma_{Si\ conductivity}$



at 0K

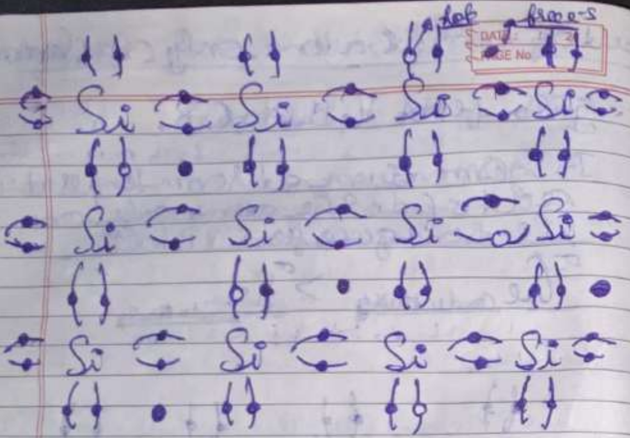
Valence band fully filled and Conduction band fully empty

⇒ It will behave as perfect Insulator

At high temperature

Valence band partially empty, conduction band partially filled

⇒ Poor Conductor ⇒ It Behaves



Types of Semiconductor :-

(1) Intrinsic Semiconductor :-

It is Pure have no impurities, it is IV th group element (including C) element eg: Si, Ge

$(\Delta E_g)_{Si} \Rightarrow 1.1\,eV$ $(\Delta E_g)_{Ge} \Rightarrow 0.7\,eV$

(2) Extrinsic Semiconductor :-

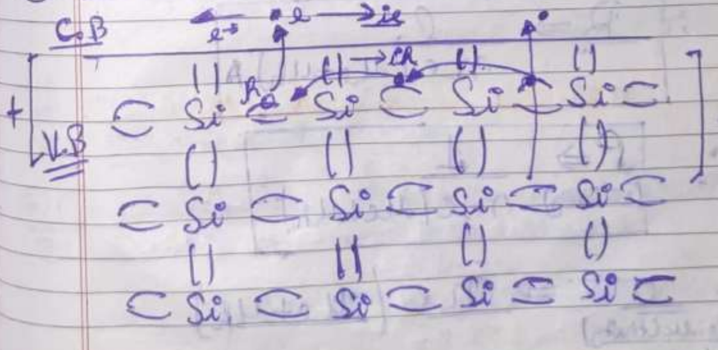
It has desired impurity also called as Doping and this type of semiconductor is called Doped Semiconductor.
If doping is done of III rd group then this semiconductor is called ⇒ p type semiconductor

And if it is doped of V th group (P, As) then it is called ⇒ N-type Semiconductor
(to increase conductivity)
[The particle which we are adding are called Dopants]

- The impurity added may be ≈ 1 part per million (ppm).
- The dopant atom should take the position of semiconductor atom in the lattice
- The size of the dopant atom should be almost the same as that of the crystal atom.
- The presence of the dopant atom should not disturb the crystal lattice.

⇒ Doping of a semiconductor increases its electrical conductivity to a great extent.

Intrinsic Semiconductor



∴ Approx 10^8 Si atoms contribute in one e-h pair and if its pure Semiconductor then $n_e = n_h = n_i = n$

When n = Number density
$n_i \Rightarrow$ No. of intrinsic carrier/volume

∴ $\boxed{i \Rightarrow i_e + i_h}$ $i \Rightarrow$ Net/Total Current

Current in Intrinsic Semiconductor

$V_d \Rightarrow$ Drift Velocity
$V_d \Rightarrow \mu E$
$n_e = n_h = n$
$\mu \Rightarrow$ mobility
E = Electric Field

$$i \Rightarrow i_e + i_h$$
$$i \Rightarrow n_e e A (V_d)_e + n_h e A (V_d)_h$$
$$i \Rightarrow n e A \mu_e E + n e A \mu_h E$$
$$\frac{V}{R} \Rightarrow n e A \mu_e \frac{V}{l} + n e A \mu_h \frac{V}{l}$$

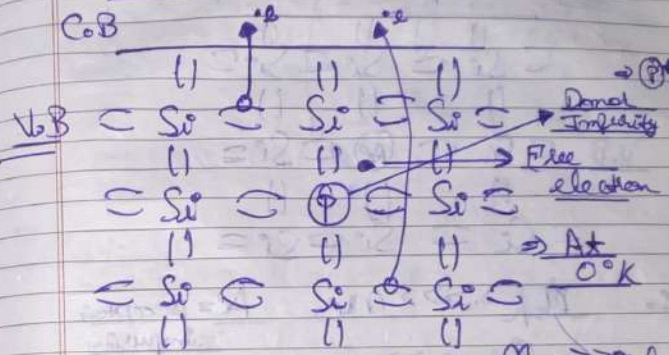
∴ $$\boxed{R \Rightarrow \frac{l}{ne(\mu_e+\mu_h)A}}$$

∴ $$\boxed{\rho \Rightarrow \frac{1}{ne(\mu_e+\mu_h)}}$$ (Resistivity)

∴ σ (Conductivity) $\Rightarrow ne(\mu_e + \mu_h)$

Extrinsic Semiconductor

(a) N-type (15th Group)



$n_e >> n_h$

∴ e-h pair :- 1 in 10^8
Impurity :- 1 in 10^6] $n_e >> n_h$
$\Rightarrow i_e >> i_h$
∴ $i_{total} \cong i_e$

$h \Rightarrow$ Minority Charge Carrier
$e \Rightarrow$ Majority Charge Carrier

Overall charge on Semiconductor ⇒ Neutral
Donor atom ⇒ Positive +ve

(b) P-Type Semiconductor [13th Group]

$\therefore$ $n_h >>> n_e$ Al = Acceptor impurity

$i_h >>> i_e$ Al^- ⇒ Negative charge

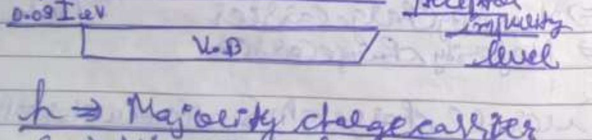
$i_{total} \cong i_h$

Total charge on Semiconductor ⇒ Neutral

e-h pair ⇒ 1 in 10^8

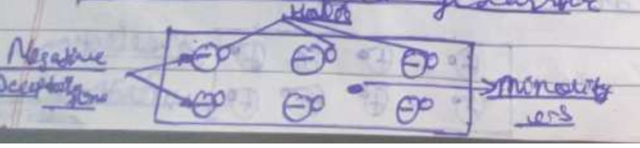
Al ⇒ 1 in 10^6

$\mu_h < \mu_e$



h ⇒ Majority charge carrier

e ⇒ Minority charge carrier



:. Note:-

Intrinsic Semiconductor

$n_e \cdot n_h \Rightarrow n_i^2$ [Mass action law]

For p-type :- Let Acceptor impurity concentration is N_A

$\therefore$ $n_h \cong n_A$

$\therefore$ $n_e \Rightarrow \frac{n_i^2}{n_h \neq n_A}$

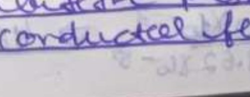
For N-Type : Let Donor impurity Concentration ⇒ N_D

$\therefore$ $n_e \Rightarrow n_D$

$\Rightarrow$ $n_h \Rightarrow \frac{n_i^2}{n_D}$

1: The mean free path of conduction electron in copper is about 4×10^{-8} m. For a copper block, find the electric field which can give, on an average 1 eV energy to a conduction electron

Ans:-



$(qE) d \Rightarrow 1 eV$

$E \Rightarrow \frac{1}{4 \times 10^{-8}}$

$E \Rightarrow 2.5 \times 10^{7}$ V/m

2:- Calculate the Resistivity of an N-type semiconductor from the following data, density of conduction electrons $\Rightarrow 8 \times 10^{+19}\ cm^{-3}$, density of holes $\Rightarrow 5 \times 10^{17}\ cm^{-3}$, mobility of conduction electron $= 2.3 \times 10^{4}\ cm^2 V^{-1} s^{-1}$ and mobility of holes $= 100\ cm^2 V^{-1} s^{-1}$.

Ans 2:-

$$\rho \Rightarrow \frac{1}{e n_e \mu_e + h n_h \mu_h}$$

$\therefore \quad e \Rightarrow h$

$\therefore \quad \rho = 0.34\ \Omega m$ (Ans)

3:- A doped semiconductor has impurity levels 30 meV below the conduction band (a) Is the material n-type or p-type.?

(b) In a thermal collision an amount kT energy is given to the extra electron loosely bound to the impurity ion and this electron is just able to jump into the conduction band. Calculate the temperature T.

Ans 3: (a) Hence the doped Semiconductor is of n-type because it is just below the conduction band.

(b) Here $kT \Rightarrow 30\ meV = 30 \times 10^{-3}\ eV$

$$T \Rightarrow \frac{30 \times 10^{-3}}{8.62 \times 10^{-5}} \Rightarrow 464\ K \text{ (Ans)}$$

4: The energy of a photon of sodium light ($\lambda = 589\ nm$) equals the band gap of a semiconducting material. (a) Find the minimum energy E required to create a hole-electron pair. (b) Find the value of E/kT at a temperature of 300 K.

Ans 4: (a) Minimum Energy $\Rightarrow E = E_g = \frac{hc}{\lambda}$

$$\therefore \quad E_g \Rightarrow \frac{6.626 \times 10^{-34}\ m^2 kg/s \times 3 \times 10^8\ m/s}{589 \times 10^{-9}\ m}$$

$$E_g \Rightarrow 2.1\ eV$$

(b) $$\frac{E}{kT} \Rightarrow \frac{2.1\ eV}{8.62 \times 10^{-5} \times 300\ K} \Rightarrow 81 \text{ (Ans)}$$

5:- A p-type semiconductor has acceptor levels 57 meV above the valence band calculate the maximum wavelength of light which can create a hole.

Ans 5:-

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

$$\therefore \lambda \Rightarrow \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{57 \times 10^{-3} \times 1.6 \times 10^{-19}}$$

$$\lambda \Rightarrow 0.2171 \times 10^{-14}\ m$$

$$\lambda \Rightarrow 2.18 \times 10^{-15}\ m \text{ (Ans)}$$

6: The band gap in germanium is $\Delta E = 0.68 eV$. Assuming that the number of hole-electron pair is proportional to $e^{-\Delta E/2KT}$, find the percentage increase in the number of charge carriers in pure germanium as the temperature is increased from 300K to 320K.

Ans 6: band gap $\Rightarrow \Delta E = 0.68 eV$

Let N_1 = Number of charge carriers at T_1

And N_2 = Number of charge carriers at T_2

$\therefore \quad N_1 \Rightarrow N_0 e^{-\Delta E/2KT_1}$

$\therefore \quad N_2 = N_0 e^{-\Delta E/2KT_2}$

$$\% \text{ increase} \Rightarrow \frac{N_2 - N_1}{N_1} \times 100$$

$$\% \text{ increase} \Rightarrow \frac{N_0 \left[e^{-\Delta E/2KT_2} - e^{-\Delta E/2KT_1}\right]}{N_0 e^{-\Delta E/2KT_1}}$$

$$\% \text{ increase} \Rightarrow \frac{e^{-\Delta E/2KT_2}}{e^{-\Delta E/2KT_1}} - \frac{e^{-\Delta E/2KT_1}}{e^{-\Delta E/2KT_1}}$$

$$\% \text{ increase} \Rightarrow \left[e^{\frac{\Delta E}{2KT_1} - \frac{\Delta E}{2KT_2}} - 1\right] \times 100$$

$$\% \Rightarrow e^{\frac{\Delta E}{2K}\left[\frac{1}{T_1} - \frac{1}{T_2}\right]} - 1$$

$$\% \Rightarrow \left(e^{\frac{0.68 eV}{2 \times 8.62 \times 10^{-5}}\left[\frac{1}{300} - \frac{1}{320}\right]} - 1\right)$$

$$\% \Rightarrow 100\left[e^{0.82} - 1\right] \Rightarrow 100 \times 1.27$$

$$\% \Rightarrow 127 \text{ [Answer]}$$

7: The concentration of hole electron pairs in pure silicon at $T = 300K$ is 7×10^{15} per cubic metre. Antimony is doped into silicon in proportion of 1 atom to 10^7 atoms. Assuming that half of the impurity atoms contribute electrons in the conduction band, calculate the factor by which the number of charge carriers increases due to doping. The number of silicon atoms per cubic metre is 5×10^{28} is:

Ans 7: The number of charge carriers before doping = Number of holes + number of charge carriers $\Rightarrow 2 \times 10^{15} \times 7$

$\Rightarrow 14 \times 10^{15} m^{-3}$

Since antimony is doped in the proportion of 1 in 10^7 atoms

No. of antimony atoms $\Rightarrow \frac{1}{10^7} \times 5 \times 10^{28}$

$\Rightarrow 5 \times 10^{21}$

As half of these atoms contribute

electrons to the conduction band.

No. of extra conduction electrons
$\Rightarrow 2.5 \times 10^{21}$

The factor by which no. of charges increased $\Rightarrow \frac{2.5 \times 10^{21}}{14 \times 10^{15}}$

$\Rightarrow 1.8 \times 10^{5}$ Ans

8: A strip of copper and another of germanium are cooled from room temperature to 80K. The resistance of :-

Ans 8: Copper is conductor and germanium is semiconductor so when cooled:
Resistance of copper strip decreases and that of germanium increases

9: The forbidden energy band gap in conductors, semiconductors and insulators are EG_1, EG_2 and EG_3 respectively. The relation among them is:-

Ans 9:- $EG_3 > EG_2 > EG_1$

10:- The valence band at 0K is

Ans 10: (A) Completely filled

11:- Electric conduction in semiconductor takes place due to:

Ans 11: Both electrons and holes

12:- An electric field is applied to a semiconductor. Let the number of charge carriers be n and average drift speed be v. If the temperature is increased.

Ans 12:- So:- drift speed & Relaxation Time

So: n will increase and v will decrease

13:- P-type semiconductor is formed when

Ans 13:- B:- Al impurity is mixed in Si
C:- B impurity is mixed in Ge.

14:- In intrinsic semiconductor

Ans 14:- The gap between conduction band and valence band is nearly about 1 eV.

15:- The free electron concentration (n) in the conduction band of a semiconductor at a temperature T kelvin is described in terms of Eg and T as $n = AT^{x} e^{-Eg/2kT}$ find x

Ans 15: $x \Rightarrow \frac{3}{2} \Rightarrow 1.5$ (From Formula)

16:- The mobility of electrons and holes in a sample of intrinsic germanium at room temperature are 0.36 and 0.14 $m^2/V\text{-}S$. If electron and hole densities each are equal to $2.5 \times 10^{19}/m^3$. The conductivity of germanium will be in mhom-m.

Ans 16:- $\sigma \Rightarrow \frac{1}{\rho} = e(\mu_e n_e + \mu_h n_h)$

$\sigma \Rightarrow 1.6 \times 10^{-19}(0.36 + 0.14) \times 2.5 \times 10^{19}$

$\sigma \Rightarrow 2\ \Omega m$

17:- In a P-type semiconductor, the acceptor level is 6.2 eV above the valence band. The maximum wave length (in A^o) of light required to produce a hole will be

Ans 17:- $E \Rightarrow \frac{hc}{\lambda}$

$\lambda \Rightarrow \frac{12400\ eV \times 10}{6.2}$

$\lambda \Rightarrow 2000\ A^o$ (Ans)

18:- A P-type silicon semiconductor is made by adding one atom of indium per 5×10^7 atoms of silicon is 25×10^{28} atom/m^3. If the number of acceptor atoms in per cubic cm of silicon is $y \times 10^{15}$ atom/cm^3 then find y:-

Ans 18:- 1 Indium $\Rightarrow 5 \times 10^7$ Si

$\frac{1}{5 \times 10^7} I \Rightarrow 1 Si$

So:- 25×10^{28} atom/$m^3 \Rightarrow \frac{25 \times 10^{28}}{5 \times 10^7}/m^3$

$\Rightarrow \frac{25 \times 10^{28}}{5 \times 10^7} \times 10^{-6}/cm^3$

Ans $\Rightarrow 5 \times 10^{15}$ In atom/cm^3

So :- $y \Rightarrow 5$

19:- If the conductance of pure silicon crystal at 300k temp is 7×10^{-6} mho/cm. Find the electron hole pair per cm^3 is 1.072×10^{10} at this temp, $\mu_n = 1350\ cm^2$/volt sec and $\mu_h \Rightarrow 480\ cm^2$/volt sec)

Ans 19:- So $n_e \Rightarrow n_h \Rightarrow 1.072 \times 10^{10}$

$\sigma \Rightarrow n_e e \mu_e + n_h e \mu_h$

$\sigma \Rightarrow n_e e(\mu_e + \mu_h)$

$\sigma \Rightarrow 1.072 \times 10^{10} \times 1.6 \times 10^{-19}(\mu_e + \mu_h)$

$\therefore$ $n_h \Rightarrow 1.25 \times 10^{10}$ /cm^3

$n_h = \frac{5}{y} \times 10^{10}$ cm^3

$\frac{5}{y} \Rightarrow \frac{\cancel{1.20}\ 25}{\cancel{100}}$

$\boxed{y \Rightarrow 4}$ Ans:-

23:- Pure Si at 300 K has equal electron (n_e) and (nh) concentration of 1.5×10^{16} m^{-3}. Doping by indium increases n_h to 4.5×10^{22} m^{-3}. If n_e is developed so to $y \times 10^{9}$ m^{-3}. Find y.

A23:- $n_e \times n_h \Rightarrow n_i^2$ — (1)

$n_e' \times n_h' \Rightarrow n_i^2$ — (2)

$\therefore$ $\frac{n_e \times n_h}{n_e' \times n_h'} \Rightarrow 1$

$1.5 \times 10^{16} \times 1.5 \times 10^{16} \Rightarrow n_e' \times 4.5 \times 10^{22}$

$\frac{15}{10} \times 10^{16} \times \frac{15}{10} \times 10^{16} = n_e' \times \frac{45}{10} \times 10^{22}$

$\frac{5 \times 10^{15} \times 10^{16}}{10^{22}} \Rightarrow n_e'$

5×10^{9} m^{-3} $\Rightarrow n_e'$

So:- $y \Rightarrow 5$ Answer

24:- The length of a germanium rod is 0.58 cm and its area of cross section is 1 mm^2. If for germanium $n_i = 2.5 \times 10^{19}$ m^{-3}, $\mu_h = 0.19$ m^2/V-s, $\mu_e \Rightarrow 0.39$ m^2/V-s then the resistance of the rod (in kΩ) will be:-

Ans24:- $R \Rightarrow \frac{l}{n_i e A(\mu_e + \mu_h)}$

$R \Rightarrow \frac{0.58\text{ cm} \times 10^{-2}}{2.5 \times 10^{19} \times 1.6 \times 10^{-19} \times 10^{-6}(\mu_e + \mu_h)}$

$R \Rightarrow 2.5$ kΩ

25:- The contribution in the total current flowing through a semiconductor due to electrons and holes are $\frac{3}{4}$ and $\frac{1}{4}$ respectively. If the drift velocity of electrons is 5/2 times that of holes at this temperature. If the ratio of the concentrations of electrons and holes is y : 5. Find y.

Ans25:- Given $I_e \Rightarrow \frac{3}{4}$ $I_h \Rightarrow 1/4$

$V_{de} \Rightarrow \frac{5}{2} V_{dh}$

$I = n e A V_d$

$I_e \Rightarrow n_e e A \times V_{de}$ — (1)

$\therefore \sigma \Rightarrow 1.6 \times 10^{-19} \times 1.072 \times 10^{10} \times 1830$

$\sigma \Rightarrow 3.14 \times 10^{-6}$ mho/cm

$\sigma \Rightarrow Z \times \pi \times 10^{-6}$ mho/cm

$\therefore Z \Rightarrow 1$ (Answer)

20: Forbidden energy gap of Ge is 0.8 eV. maximum wave length of incident radiation for producing electron-hole pair in germanium semiconductor (in μm) is:

A20: $E \Rightarrow 0.8$ eV

$\lambda_{max} \Rightarrow \frac{12400 \text{ eV}-A^{0} \times 10}{0.8}$

$\lambda_{max} \Rightarrow 15.5 \times 10^{3}$

$\lambda_{max} \Rightarrow 1.55 A^{0}$

21: Mobility of electron in N-type Ge is 5000 cm²/volt sec and conductivity 5 mho/cm. If effect of holes is negligible add impurity concentration is $\frac{25}{y} \times 10^{19}$/cm³. Find y.

Ans 21: $\mu_e \Rightarrow 5000$ cm²/volt sec

$\sigma \Rightarrow 5$ mho/cm $\mu_h \approx 0$

So: $\sigma \Rightarrow ne(\mu_e + \mu_h)$

$5 \Rightarrow 1.6 \times 10^{-19} \times n (5000 \text{ cm}^2/\text{Vs})$

$\frac{5}{1.6 \times 10^{-19} \times 5000} \Rightarrow n$

$\therefore n \Rightarrow 6.25 \times 10^{15}$ cm⁻³

$\therefore n \Rightarrow \frac{625}{100} \times 10^{15}$ cm⁻³

$n = \frac{25}{y} \times 10^{15}$ cm⁻³

$\frac{25}{y} \Rightarrow \frac{625}{100}$ $y \Rightarrow 04$ (Ans)

22: The intrinsic carrier density in germanium crystal at 300K is 2.5×10^{13} per cm³. If the electron density in an N-type germanium crystal at 300K be 0.5×10^{17} per cm³, the hole density (per cm³) in this N-type crystal at 300K is $\frac{5}{y} \times 10^{10}$. Find y.

A22: $n_e \times n_h \Rightarrow n_i^2$

$0.5 \times 10^{17} \times n_h \Rightarrow (2.5 \times 10^{13})^2$

$\frac{0.5}{10} \times 10^{16} \times n_h \Rightarrow \frac{25}{100} \times 25 \times 10^{26}$

$n_h \Rightarrow 125 \times 10^{10}$ /cm³

$I_h \Rightarrow n_h \times e \times A\, V_{dh}$

$$\frac{I_n}{I_h} \Rightarrow \frac{n_e}{n_h} \times \frac{V_{de}}{V_{dh}}$$

$$\frac{3}{4} \times \frac{4}{1} \Rightarrow \frac{n_e}{n_h} \times \frac{5}{2}\frac{V_{dh}}{V_{dh}}$$

So: $\frac{n_e}{n_h} \Rightarrow \frac{6}{5}$

Ratio : $6 : 5$
$= 4 \Rightarrow 6$

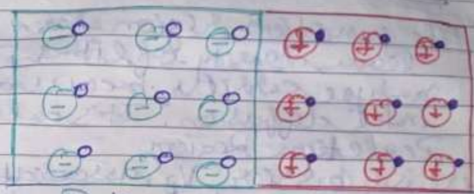
29th August, 2021
Lecture ⇒ 3

⇒ P-N Junction

Techniques for Making P-N Junction

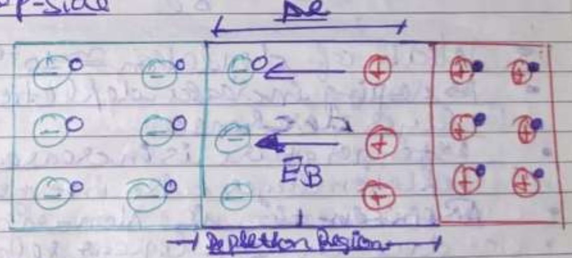
(1) Alloy Method or Alloy Junction
(2) Diffusion Junction:
(3) Vapour deposited junction or Epitaxial junction.

⇒ When a P-type semiconductor is joined in N-type semiconductor such that crystal structure remain continuous at the boundary. The resulting arrangement is called P-N Junction Diode or Semiconductor Diode or Crystal Diode



P-type N-type

In a p-n junction Diode, holes are majority carrier on p-side and electron on n-sides, holes, thus diffuse to n-side and electrons to p-side



This diffusion causes an excess positive charge in the n region and an excess negative charge in p-region near the junction. This double layer of charge creates an electric field which exerts a force on the electrons and holes against their diffusion. In the equilibrium position, there is a barrier for charge motion with the n-side at a higher potential than the p-side.

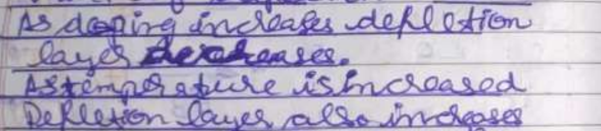
* The junction region has a very low density of either p or n-type carriers, because of inter diffusion. It is called Depletion Region

There is a barrier V_B associated with it as described above. This is called potential barrier.

In Depletion layer:- No free charges only fixed ions in this layer

$$E_B \Rightarrow \frac{V_B}{\Delta l}$$

- Width of depletion $\simeq 10^{-6}$ m
- As doping increases depletion layer decreases.
- As temperature is increased Depletion layer also increases
- P-N Junction is Non-ohmic, due to non-linear relation between I and V



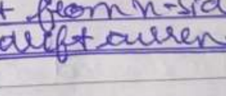
V_B depends on (i) Doping Density
(ii) Temperature

$(V_B)_{Si} \Rightarrow 0.7$ V $\quad (V_B)_{Ge} \Rightarrow 0.3$ V

$$\boxed{\Delta V_B \Rightarrow -0.002\,\Delta T}$$

So on: $T \uparrow$ $V_B \downarrow$ (Decreases)

Representation of P-N Junction Diodes



∴ Because of concentration difference, holes try to diffuse from the p-side to the n-side at the p-n junction. The diffusion give rise to a current from p-side to n-side called Diffusion current.

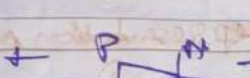
∴ Because of the thermal collisions electron-hole pair are created at every part of a diode. However, if an electron-hole pair is created in the depletion region, the electron is pushed by the electric field towards the n-side and the hole towards the p-side. This gives rise to a current from n-side to p-side called the drift current.

If there is no biasing diffusion current = Drift current. So total current is zero.

Biasing of P-N Junction

Biasing ⇒ Study of application of potential Difference across Diode.

⇒ Forward Biasing



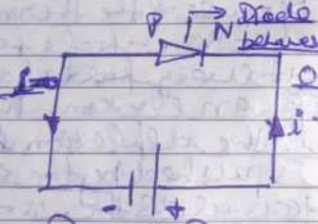
⇒ Reverse Biasing

Normal ideal condition i.e P-N junction ideal

P → N Diode behaves as Short Circuit = (open wire)

Forward Bias

P → N Diode behaves as Open Circuit



Reverse Bias

⇒ Forward Bias

If we apply a voltage 'V' such that P-Side is positive and N-Side is negative as shown in figure.

The applied voltage is opposite to the junction barrier potential due to this effective potential barrier decreases, junction width also decreases, so more majority carrier will be allowed to flow across junction. It means the current flow in principally due to majority charge carriers and it is in the order of mA called the Forward Bias

F.B = Current flow due to majority charge carrier

$i_{Diffusion} > i_{Drift\ current}$

So :- i_{net} ⇒ Direction of Diffusion current i.e from P → N

⇒ Reverse Bias :-

If we apply a voltage "V" such that P-side is negative and N-side is positive as shown in Diagram. The applied voltage is in same direction as the junction barrier potential. Due to this effective potential barrier increases, junction width also increases, so no majority carriers will be allowed to flow across junction. Only minority carriers will be drifted. It means the current flow in principally due to minority charge carriers and is very small (in the order of μA).

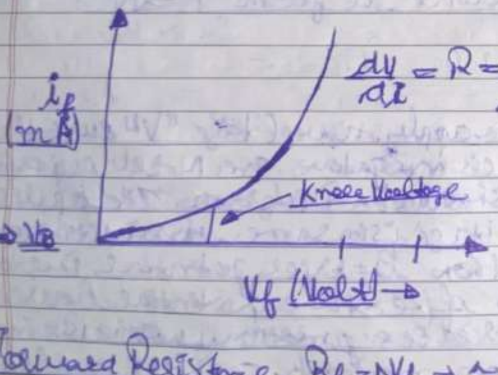
This bias is called as Reversed Bias.

- In Reverse bias, the current is very small and nearly constant with bias (termed as reverse saturation current).

If the reverse bias is increased further beyond a certain limit, above particular high voltage break down of depletion layer started.

Zener Breakdown — Avalanche Breakdown

⇒ Characteristics curves of Forward Bias

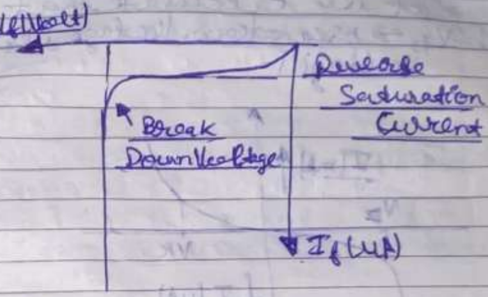


$\frac{dV}{dI} = R =$ dynamic Resistance

Forward Resistance $R_f = \frac{\Delta V_f}{\Delta I_f} \Rightarrow \simeq 100\Omega$

Order of knee or cut in Voltage
Ge ⟶ 0.3V
Si ⟶ 0.7V

⇒ Characteristics curve of Reverse Bias



Reverse Resistance $R_f \Rightarrow \frac{\Delta V_f}{\Delta I_f} \Rightarrow 10^6\Omega$

Breakdown Voltage
Ge ⇒ 25V
Si ⇒ 35V.

26:- In a P-N Junction Diode not connected to any circuit:-

Ans 26:- (c) There is an electric field at the junction directed from N-type to the P-type

27:- When p-n junction diode is forward bias

Ans 27:- (1) both the depletion region and barrier height are reduced

28:- The V-I characteristic for an p-n

Junction Diode is plotted as shown in the figure. From the plot we calculate that [V_B → breakdown voltage ; V_K → knee voltage]

Ans28:- (1) the forward bias resistance is very high, almost infinity for small values of V and after the certain value it becomes very low

(2) The reverse bias resistance of diode is very high in the beginning upto breakdown voltage is not achieved.

29:- The depletion region of a P-N Diode, under open circuit condition contains

A29:- (C) Unmasked immobile impurity ions

30:- Which is the wrong statement in the following sentence? A device in which P and N type semiconductors are used is more useful than a vacuum tube because:-

A30:- (D) Its efficiency is high due to a high voltage drop across the junction

31:- Depletion layer of P-N junction is caused by

Ans31:- (B) Diffusion of free charge carriers

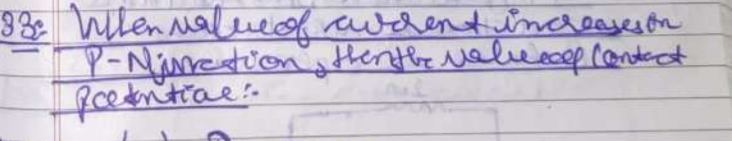
32:- The contact potential at the junction site in a P-N junction is:-

Ans32:- (B) negative on P side and positive on N-side

33:- When value of current increases in P-N junction, then the value of contact potential:-

Ans33:- (1) Decrease

34:- In which case is the junction Diode is not Reverse Bias:-



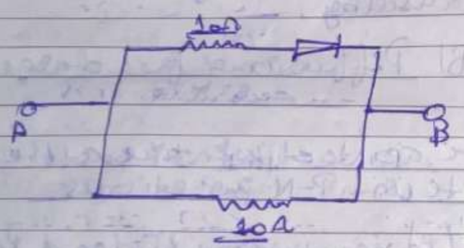
Ans34:- Soln F.B $V_A > V_B$

Soln (B) option $V_A > V_B$

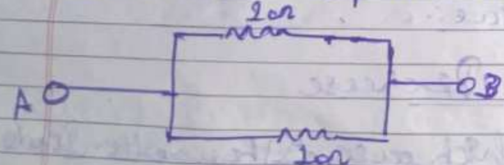
?. 

is not Reverse Bias

35:- If V_A and V_B denote the potentials of A and B, then the equivalent between A and B in the adjoint electric circuit is:-



Ans35: Soln $V_A > V_B$ it means it is in forward Bias and in this condition semiconductor behave as open wire.



$R_{AB} \Rightarrow 5\Omega$ (in parallel)

So: (2) 5 ohm in $V_A > V_B$

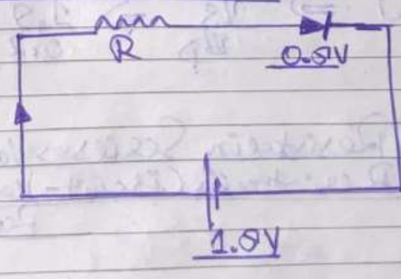
36: The Avalanche breakdown in P-N junction is due to:-

Ans36: (B) Cumulative effect of conduction band electron collision.

37: If the two ends of a P-N junction is joined by a wire:-

Ans37: (A) There will not be a steady current in the circuit

38: The diode used in the circuit shown in the figure has a constant voltage drop of 0.5V at all currents and a maximum power rating of 100 milliwatts. What should be the value of the resistor R (in Ω) connected in series with the diode for obtaining maximum current.

Ans38: 

Voltage Drop across Diode $|V_D| \Rightarrow 0.5V$

Power maximum $P \Rightarrow 100\,mW$

$P \Rightarrow 100 \times 10^{-3}\,W$

So:- Voltage of Source $(V_S) \Rightarrow 1.5V$

Resistance of Diode $(R_D) \Rightarrow \frac{V_D^2}{P}$

$$R_D \Rightarrow \frac{0.5 \times 0.5}{100 \times 10^{-3} \times 10 \times 10}$$

$$R_D \Rightarrow \frac{25}{10^4} \times 10^8$$

$$R_D \Rightarrow 2.5\,\Omega$$

Current in Diode $(I_D) \Rightarrow \frac{V_D}{R_D}$

$$I_D \Rightarrow \frac{0.5}{2.5} \Rightarrow 0.2\,\Omega$$

∴ Value Resistance in circuit

$$(R) \Rightarrow \frac{V_S}{I_D} \Rightarrow \frac{1.5}{0.2} \Rightarrow 7.5\,\Omega$$

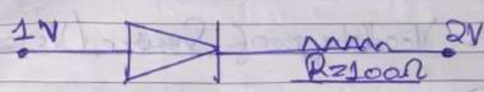
∴ Value of Resistance in Series ⇒ Value of Resistance in Circuit − Value of Resistance of Diode

Resistance in Series $\Rightarrow 7.5\,\Omega - 2.5\,\Omega$

$\Rightarrow 5\,\Omega$ Ans

39:- In the arrangement shown in figure, the current (in A) through ideal diode is:-

Ans 39:-



Since $V_B > V_A$ So it is in Reverse Bias and in ideal condition Reverse Bias behaves as open circuit So current ⇒ zero.

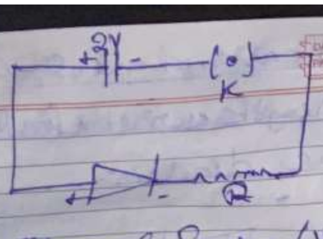
40:- A diode made forward biased by a two volt battery however there is a drop of 0.5V across the diode which is independent of current. Also a current greater than 10mA produces large joule loss and damages diode. If Diode is to be operated at 5mA. The series resistance (in Ω) to be put is:-

Ans 40:- Voltage across Diode $(V_D) \Rightarrow 0.5V$

Current at which Diode is Operated $\Rightarrow (I_D) \Rightarrow 5mA = 5 \times 10^{-3}A$

So: Resistance of Diode $(R_D) = \frac{V_D}{I_D}$

$$R_D \Rightarrow \frac{0.5}{5 \times 10^{-3}} \Rightarrow 100\,\Omega$$



So:- Voltage of Source $(V_s) = 2V$

∴ Resistance in Circuit $R \Rightarrow \frac{V_s}{I_D}$

$$R \Rightarrow \frac{2}{5\times10^{-3}} \Rightarrow 400\Omega$$

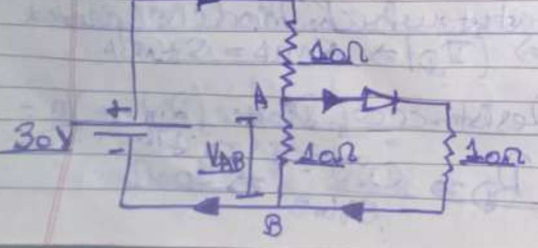
Resistance in series $\Rightarrow R - R_D$

$$R_S \Rightarrow 400 - 100\Omega$$

$$R_S \Rightarrow 300\ \Omega \text{ (Ans)}$$

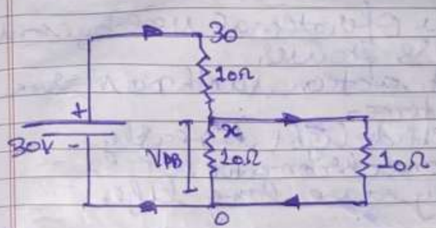
41:- For given circuit the potential difference V_{AB} (in V)

Ans:-



Ans 41:- Since Diode is forward Bias

So it is considered as open/straight wire



$$So.\ \frac{x-30}{10} + \frac{x-0}{10} + \frac{x-0}{10} = 0$$

$$3x \Rightarrow 30$$

$$x = 10$$

∴ $V_{AB} \Rightarrow 10V$ (Answer)

2nd September 2021

Lecture ⇒ 4

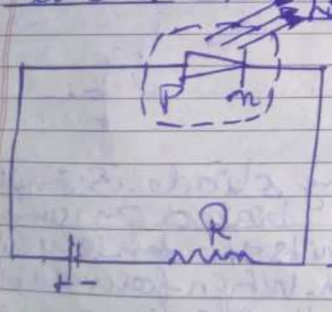
⇒ Light Emitting Diode (LED) :-

A light emitting diode is simply a forward biased p-n junction which emits spontaneous light radiation. When forward bias is applied, the electron and holes at the junction recombine and energy released is emitted in the form of light for visible radiation Phosphorous doped GaAs

is commonly used. The advantage of LED's are:-

(i) Low operational voltage and less power.
(ii) Fast action with no warm up time.
(iii) Emitted light is nearly monochromatic.
(iv) They have long life.

I-V characteristics of LED are similar to that of Si junction diode but the threshold voltage are much higher and slightly different for each colour. The reverse breakdown voltages of LED's are very low, about 5V.

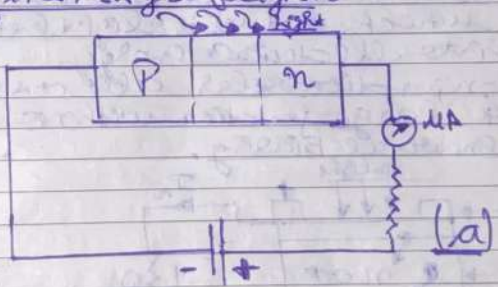


LED Symbol

⇒ Photodiode

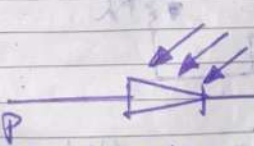
It is a reversed biased p-n junction, illuminated by Radiation. When a p-n junction is reversed biased with no current, a very small reverse saturated current flows across the junction called the dark current. When the junction is illuminated with light, electron-hole pairs are created at the junction, due to which additional charge current begins to flow across the junction, the current is solely due to minority charge carriers.

(i) Photodiode is used to measure light intensity because reverse bias current increases with increase of intensity of light.



(a)

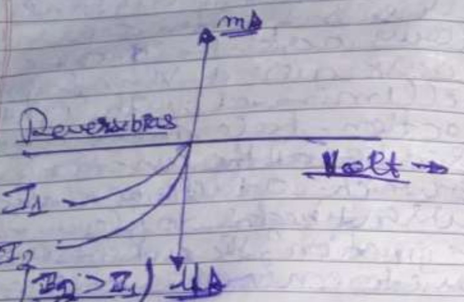
(b)



Symbol

The characteristics curves of a photodiode

for two different illuminations
l_1 and l_2 ($l_2 > l_1$) are
shown in figure



⇒ Solar Cell

A solar cell is a junction Diode which converts light energy into electrical energy.

A p-n junction solar cell consists of a large junction with no external biasing.

(a) Construction and Working

Symbol

Surface layer of p-region is made very thin so that the incident photons may easily penetrate to reach the junction which is the active region. In an operation in the photovoltaic mode i.e. generation of voltage due to bombardment of optical photons, the materials suitable for photocells are silicon (Si), gallium Arsenide (GaAs), cadmium Sulphide (CdS) and cadmium Selenide (CdSe).

Working:- When photons of energy greater than band gap ($h\nu > E_g$) are made incident on the junction, electron-hole pairs are created which move in opposite direction due to junction field. These are collected at two sides of junction thus producing photovoltage, this give rise to photocurrent. Solar cells are used in satellites to recharge their batteries.

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Reverse Breakdown:-

If the reverse bias voltage is made too high, the current through the PN junction increases rapidly at V_Z. The voltage at which this happens is called breakdown voltage or Zener Voltage.

(a) **Zener Breakdown:-** When reverse bias is increased the electric field at the junction also increased. At some stage the electric field becomes so high that it breaks the covalent bonds creating electron, hole pairs thus a large number of carriers are generated. This carries a large current to flow. This mechanism is known as Zener Breakdown.

[when Semi-Conductor ⇒ Heavily Doped] with thin depletion layer

(b) **Avalanche Breakdown:-** At high reverse bias voltage, due to high electric field, the minority charge carriers while crossing the junction acquires very high velocities. These by collision breaks down the covalent bonds, generating more carriers. A chain reaction is established, giving rise to high current. This is called

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Avalanche breakdown
[Semiconductor ⇒ lightly Doped with thin depletion layer]

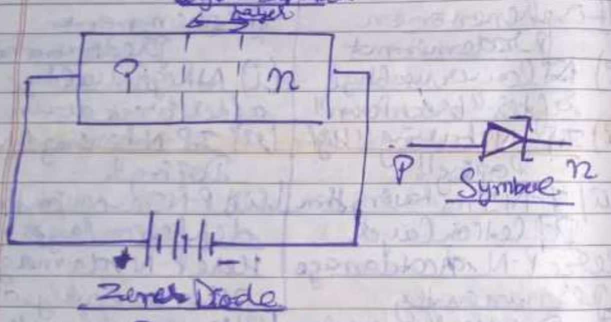
Zener Break Down	Avalanche Break Down
Where covalent bonds of depletion layer is self break due to high electric field of very-high Reverse bias Voltage	Here covalent bonds of depletion layer are broken by collision of "Minorities" which acquires high K.E. from high Electric Field.
This phenomenon predominant (i) At lower voltage after "breakDown" (ii) In P-N having "High Doping" (iii) P-N Jn. having thin Depletion layer	This phenomenon predominant (i) At high voltage after break down (ii) In P-N having "Low Doping" (iii) P-N Jn having thick depletion layer
Here P-N not damage permanently "In D-C voltage stabilizer Zener phenomenon is used".	Here P-N damage permanently due to "Heating effect" due to abruptly increase of minorities during repetitive collisions.

⇒ Zener Diode

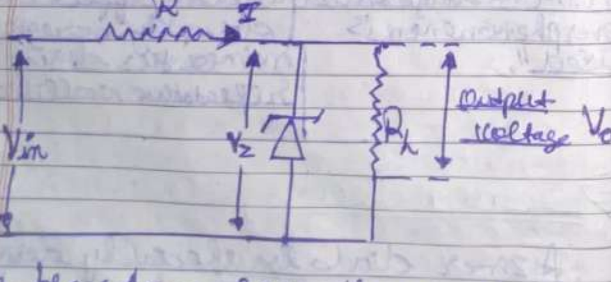
A zener diode is a specially designed heavily p-n junction having a very then depletion layer and having a very sharp breakdown voltage. It is always operated in breakdown region. Its breakdown voltage V_Z is less than 6V.

(#) Zener Diode as a Voltage Barrier:

Zener diode may be used as a voltage regulator. The circuit of Zener-Diode is shown in figure.



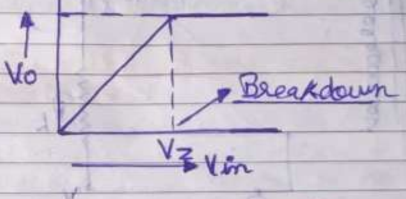
Zener Diode



In breakdown region the equation

$V_O \Rightarrow V_Z \Rightarrow V_{in} - IR$

Clearly, when the input voltage exceeds zener voltage to keep the voltage regularity, the extra input voltage appears across series resistance R. The voltage regulation curve is shown in figure.



⇒ Junction Diode as Rectifier

A rectifier is a device which converts an alternating current (or voltage) into a direct (or unidirectional) current (or voltage). A p-n junction diode can work as an excellent rectifier. It offers a low resistance for the current to flow when it is in forward bias, but a very high resistance when in Reverse Biased. Thus it allows current. Thus, it allows current through it only in one direction and acts as a rectifier. The junction diode can be used either as a half-wave rectifier or as a full-wave rectifier.

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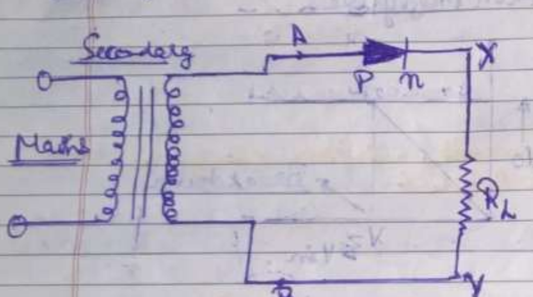
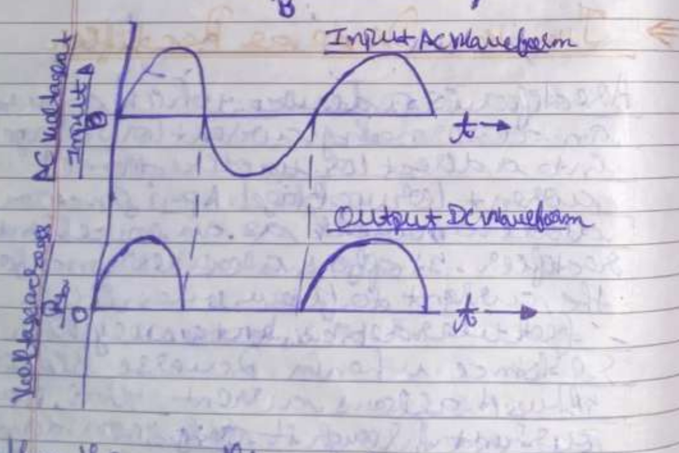
(i) p-n junction diode as half-wave rectifier:

A simple rectifier circuit called the half-wave rectifier using only one diode.



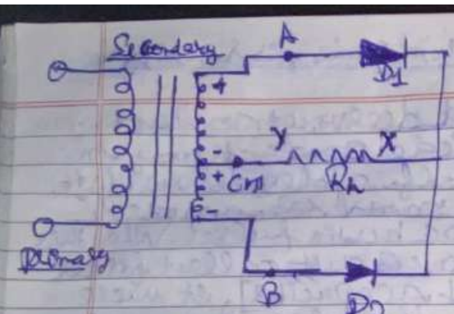


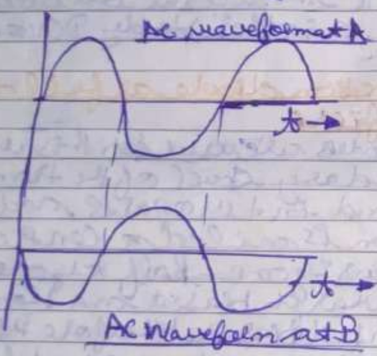
When the voltage at A is positive, the diode is forward biased and then it conducts, and when the voltage at A is negative, the diode is reverse biased and does not conduct. Since the diode conducts only in the positive half cycles, the voltage between X and Y or across R_L will be DC but in pulses. When this is given to a circuit called filter [normally a capacitor], it will smoothen the pulses and will produce a rather steady DC voltage.

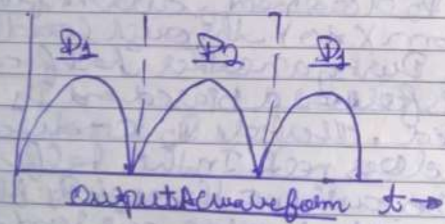
(ii) p-n Junction diode as full-wave Rectifier:

Two diodes are used for this purpose. The secondary coil of the transformer is wound in two parts and the junction is called a Centre-Tap (CT). During one half cycle D_1 is forward biased and then D_2 is reversed biased. Therefore D_1 conducts but D_2 does not, current flows from X to Y through load Resistance R_L. During another half cycle D_2 is forward biased and D_1 reverse biased. Therefore D_2 conducts and D_1 does not. In this half cycle also current through R_L flows from X to Y. Thus current through R_L in both the half cycles is in one direction i.e. from X to Y.

(a) Full Wave Rectifier







⇒ Transistor

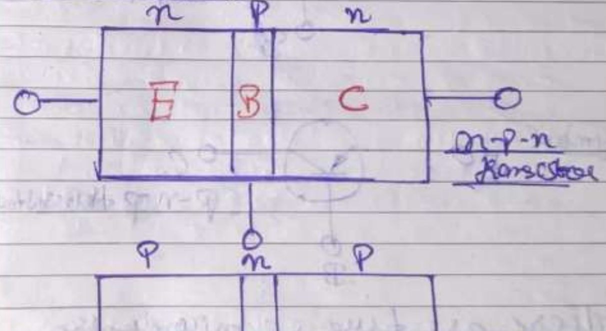
3rd Sept, 2021
Lecture ⇒ 5

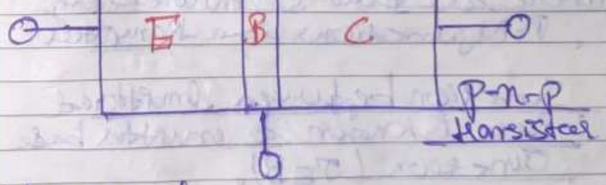
Transistor is a three terminal device which transfers a signal from low resistance circuit to high resistance circuit.

It is formed when a thin layer of one type of intrinsic semiconductor (P or N type) is sandwitched between two thick layers of other type of intrinsic semiconductor.

Each transistor have three terminals which are:-

(i) Emitter
(ii) Base
(iii) Collector





Transistor have:-

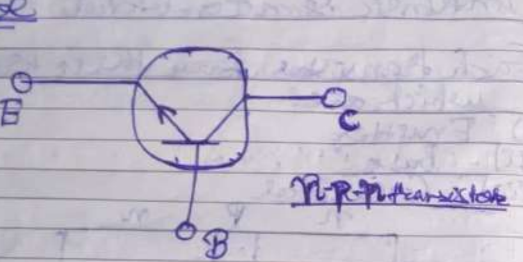
1. 2 PN Junction
2. It is also called as Triode
3. It is also known as Bipolar Junction Transistor (BJT)

(4) Middle region is lightly doped and it is very thin = Base

(5) Emitter side is heavily doped.

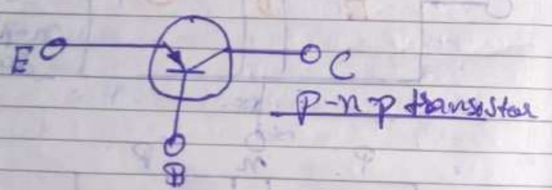
(6) Collector has physically large region and moderately doped

Symbol



n-p-n transistor

Symbol



P-n-p transistor

There are two semiconducting P-N junctions in a transistor

(i) Junction between Emitter and Base is known as emitter base Junction (J_{EB}).

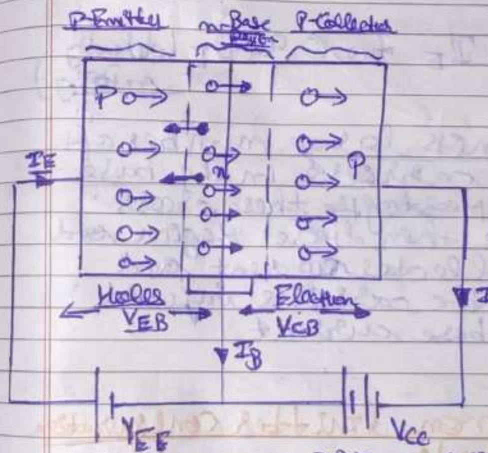
(ii) Junction between base and collector is known as base-collector junction (J_{CB})

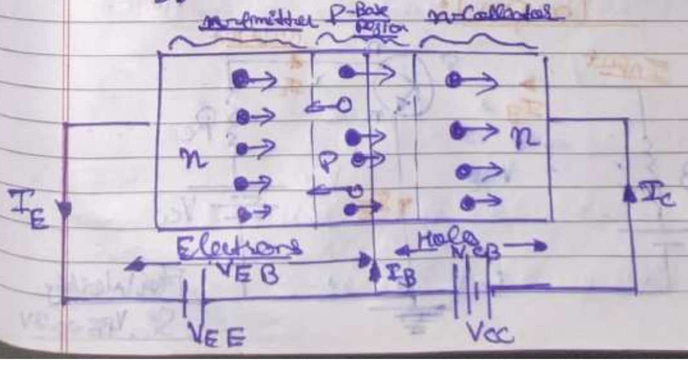
∴ In normal operation EB junction is Forward Biased.

∴ In normal operation BC junction is in Reverse Bias.

⇒ For Biasing two battery are required.

3 terminal → Input ⇒ 2 terminal ; Output ⇒ 2 terminal] i.e. 1 terminal must be common





So in Both Base is Common

For both

$I_E = I_B + I_C$

$I_E >> I_B$

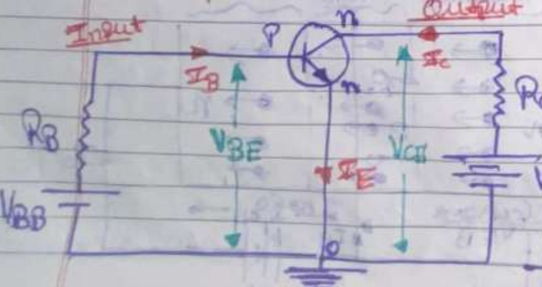
$I_C >> I_B$

and $I_E \simeq I_C$ (Almost)

$I_C \approx 0.95 I_E$ to $0.99 I_E$ (depending on Doping)

Emitter emits large number of charge carriers in the base region. Most of the these cross over the thin base Region and make collector current and some of the carriers injected make base current.

(#) Common Emitter configuration (npn):-



For working Si $V_{BE} \approx 0.7V$

So here $V_{CC} > V_{BB}$ (To make collector base Junction R-B)

$I_E = I_B + I_C$ (Always true)

$\therefore I_C \cong I_E$

$I_B << I_E$ and $I_B << I_C$

Current amplification factor $= \beta = \frac{I_C}{I_B}$

So: $\beta \approx 20$ to 200 (Value)

$\therefore \alpha \Rightarrow \frac{I_C}{I_E} \approx 0.98$ to 0.99 (Value)

Equation:- $I_E \Rightarrow I_B + I_C$

$\frac{I_E}{I_C} \Rightarrow \frac{I_B}{I_C} + 1$

$$\boxed{\frac{1}{\alpha} = \frac{1}{\beta} + 1}$$ Important Result

$\Rightarrow V_{BE} \Rightarrow V_{BB} - I_B R_B$ — (1)

$V_{CE} \Rightarrow V_{CC} - I_C R_C$ — (2)

$R_i \Rightarrow \left.\frac{\Delta V_{BE}}{\Delta I_B}\right|_{\text{At } V_{CE} = \text{Constant}}$

(Dynamic Resistance in Input)

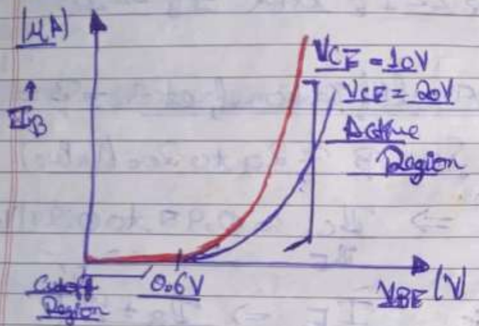
$R_O \Rightarrow \left.\frac{\Delta V_{CE}}{\Delta I_C}\right|_{\text{At } I_B = \text{Constant}}$

(Dynamic Resistance in Output)

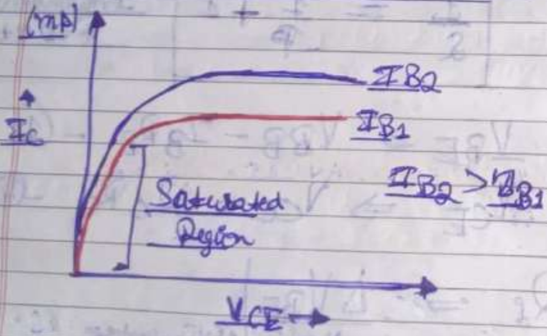
∴ Transconductance :-

$$g_m \Rightarrow \frac{\Delta I_C}{\Delta V_{BE}}$$

⇒ Input Characteristics curve



⇒ Output Characteristics Curve



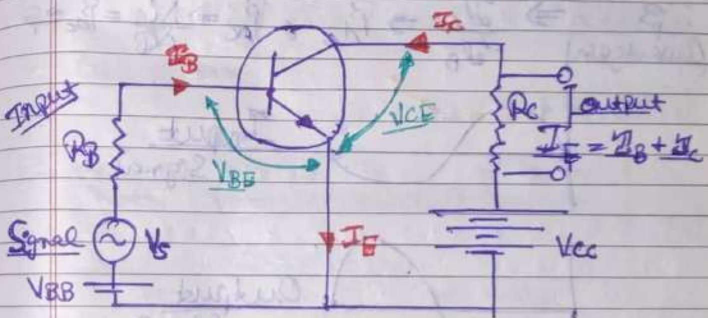
Cutoff Region ⇒ Base - emitter junction is not properly forward bias

Active Region :- BE ⇒ Forward Bias
B.C ⇒ Reverse Bias

Saturated Region :- Base - collector junction is not properly reverse biased.

4th Sept, 2021
Lecture ⇒ 6

⇒ Transistor as Amplifier :-



In Active mode

$$V_{BE} \Rightarrow V_{BB} + V_S - I_B R_B$$

$$V_{CE} = V_{CC} - I_C R_C$$

∴ $$\Delta V_{BE} \Rightarrow \Delta V_{BB} + \Delta V_S - R_B \Delta i_B$$

In Active mode $\Delta V_{BE} = 0$ and $\Delta V_{BB} = 0$ (Due to Constant V. Drop)

∴ $$\boxed{\Delta V_S \Rightarrow R_B \Delta i_B}$$

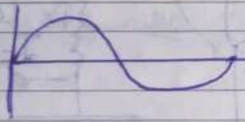
$\therefore \Delta V_{CE} = \Delta \cancel{V_{CC}}^{0} - R_C \Delta I_C \Rightarrow \Delta V_0$

Voltage Amplification factor (A_V)

$$A_V \Rightarrow \frac{\Delta V_0}{\Delta V_i} \Rightarrow -\left(\frac{\Delta I_C}{\Delta I_B}\right) \times \frac{R_C}{R_B}$$

Voltage gain $\Rightarrow$ Current Gain $\times$ Resistance gain

$\therefore \beta$ (Current gain) $\Rightarrow \frac{I_C}{I_B} \Rightarrow \beta_{dc}$ & $\beta_{ac} \Rightarrow \frac{\Delta I_C}{\Delta I_B} = \beta_{ac} \Rightarrow \beta$



Input Signal

Output Signal

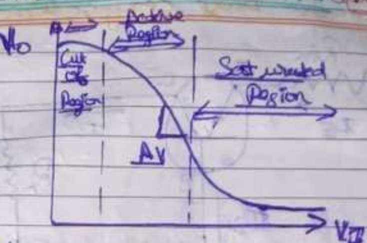
Phase Difference between Input Signal/Voltage and output Signal/Voltage $\Rightarrow \pi \Rightarrow 180°$

Power Gain $\Rightarrow$ Voltage Gain $\times$ Current Gain

$$\Rightarrow -\beta \times \frac{R_C}{R_B} \times \beta$$

Power Gain $\Rightarrow -\beta^2 \times \frac{R_C}{R_B}$ [Resistance Gain]

$\Rightarrow$ Transistor as Switch



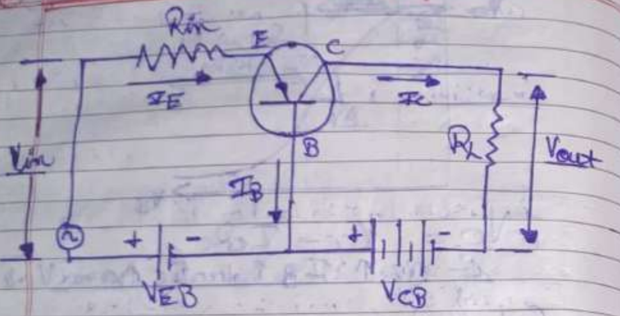
$V_0 = V_{CC} - I_C R_C$

if $V_i \uparrow$ $I_B \uparrow$ then $I_C \uparrow$ and $V_0 \downarrow$

- Cutoff Region
  $V_0 \Rightarrow$ high $V_i \Rightarrow$ low
- Active Region
  Both Properly Biased
- Saturated Region
  $V_0 \Rightarrow$ low $V_i \Rightarrow$ High

Emitter-Base	Collector-Base	Region
Forward Biased	Reverse Biased	Active
Reverse Biased	Forward Biased	Inverse Active
Reverse Biased	Reverse Biased	Cutoff
Forward Biased	Forward Biased	Saturation

Common-base configuration



(i) Input current = I_e

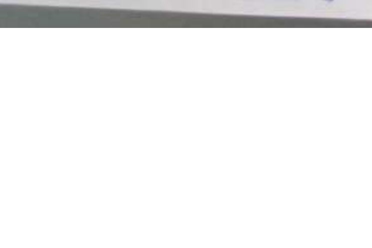
(ii) Input Voltage ⇒ V_{EB}

(iii) Output Voltage ⇒ V_{CB}

(iv) Output Current ⇒ I_C

With small increase in emitter-base voltage V_{EB}, the emitter current I_E increases rapidly due to small input resistance

(v) Input characteristics:-



If V_{CB} = Constant, curve between I_E and V_{EB} is known as Input characteristics. It is also known as emitter characteristics

Dynamic Input Resistance of a transistor is given by:

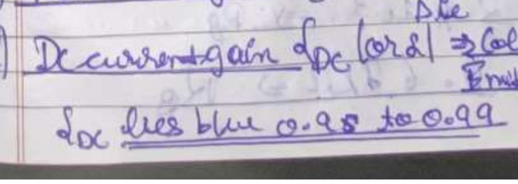
$$R_i \Rightarrow \left(\frac{\Delta V_{EB}}{\Delta I_e}\right)_{V_{CB} \Rightarrow \text{Constant}}$$

{R_i is of order of 100 Ω}

(vi) Output characteristics:- Taking the emitter current I_E constant, the curve between I_C and V_{CB} are known as output characteristics.

Dynamic Output Resistance

$$R_O \Rightarrow \left(\frac{\Delta V_{CB}}{\Delta I_C}\right)_{I_E = \text{Constant}}$$



Transistor as CB. Amplifier

(1) Ac current gain $\alpha_C \Rightarrow \frac{\Delta i_c}{\Delta i_e}$

(2) Dc current gain α_{DC} (or α) $\Rightarrow \frac{\text{Collector current } (i_c)}{\text{Emitter current } (i_e)}$

α_{DC} lies b/w 0.95 to 0.99 (Value)

(3) Voltage gain $A_V \Rightarrow \frac{\Delta V_o}{\Delta V_i}$

$\Rightarrow A_V \Rightarrow \beta_{ac} \times$ Resistance gain

(4) Power gain $\Rightarrow \beta^2_{ac} \times$ Resistance gain

42:- An NPN transistor is used in common emitter configuration as an amplifier with 1 kΩ load resistance. Signal voltage of 10 mV is applied across the base emitter. This produces a 3 mA change in the collector current and 15 μA change in the base current of the amplifier. The input resistance and voltage gain are

Ans 42:- $R_L = R_C = R_O \Rightarrow 1k\Omega \Rightarrow 1000\Omega$

$\Delta V_i \Rightarrow 10mV \Rightarrow 10 \times 10^{-3} V$

$\Delta I_B \Rightarrow 15 \mu A \Rightarrow 15 \times 10^{-6} A$

$\Delta I_C \Rightarrow 3mA \Rightarrow 3 \times 10^{-3} A$

$\Delta V_i \Rightarrow R_B \Delta I_B$

$10 \times 10^{-3} \Rightarrow R_B \times 15 \times 10^{-6}$

$\frac{2}{3} \times 10^3 \Rightarrow R_B$

$0.67 k\Omega \Rightarrow R_B$

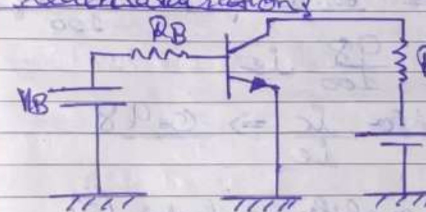
$\therefore$ Voltage gain $\Rightarrow \frac{\Delta I_C}{\Delta I_B} \times \frac{R_C}{R_B}$

$\Rightarrow \frac{3 \times 10^{-3}}{15 \times 10^{-6}} \times \frac{1000 \times 3}{2 \times 1000}$

Voltage gain $\Rightarrow \frac{10^3}{5} \times \frac{3}{2}$

Voltage gain $\Rightarrow 300$

43:- A common emitter amplifier circuit, built using an n-p-n transistor, is shown in the figure. Its dc current gain is 250, $R_C = 1k\Omega$ and $V_{CC} \Rightarrow 10V$. What is the minimum base current for V_{CE} to reach saturation?



Ans 43:- $\beta \Rightarrow 250 = \frac{i_C}{i_B}$

$R_C \Rightarrow 1k\Omega \Rightarrow 1000\Omega$

$V_{CC} \Rightarrow 10V$

$V_{CE} \xrightarrow{} 0 = V_{CC} - I_C R_C$

$V_{CC} \Rightarrow I_C R_C$

$10 = 1000 \times I_C$

$10^{-2} \Rightarrow I_C$

$250 = \frac{10^{-2}}{I_B}$

$I_B \Rightarrow \frac{1}{25000}$

$I_B \Rightarrow 40 \mu A$

(Answer)

44: In an N-P-N transistor 10^{10} electrons enter the emitter in 10^{-6} s. 2% of the electrons are lost in the base. Calculate the current transfer ratio and current amplification factor.

Ans 44:- $i_e \Rightarrow \frac{ne}{t} = \frac{10^{10} \times 1.6 \times 10^{-19}}{10^{-6}}$

$i_e \Rightarrow 1.6 \times 10^{-3}$ A

$i_B = 2\%$ of $i_e = \frac{2}{100}$ of i_e

$i_c \Rightarrow \frac{98}{100} i_e$

∴ (i) Ratio $\frac{i_c}{i_e} \Rightarrow 0.98$

(ii) Current amplification factor (β)

$\beta \Rightarrow 49$ (Answer)

45: A transistor is connected in common-emitter (CE) configuration. The collector supply is 8V and a voltage drop across a resistor of 800Ω in the collector circuit is 0.5V. If the current gain factor (α) is 0.96, find the base-current.

Ans 45:- $\frac{1}{\alpha} = \frac{1}{\beta} + 1$

$\frac{1}{0.96} = \frac{1}{\beta} + 1$

$\frac{100-96}{96} \Rightarrow \frac{1}{\beta}$ $\beta \Rightarrow \frac{96}{4}$

∴ $\beta \Rightarrow 24$

Sol:- $i_c \Rightarrow \frac{0.5V}{800} \Rightarrow \frac{5}{8000}$ Ampere

$\beta = \frac{i_c}{i_B}$ $i_B \Rightarrow \frac{i_c}{\beta}$

$I_B \Rightarrow \frac{5 \times 10^{-3}}{8 \times 24} \Rightarrow 26\mu A$ (Ans)

46: In a transistor:-

Ans 46: (c) Base has least concentration of impurity:-

47: The thinnest part of transistor is:-

Ans 47: (2) Base

48: A N-P-N transistor conducts when:-

Ans 48: (B) Collector is positive and emitter is negative with respect to base.

49: To use transistor as an amplifier:-

Ans 49: (1) Emitter base junction is in forward biased and collector junction is reverse biased.

50: In a N-P-N transistor circuit, the collector current is 10 mA. If 90% of the electrons reach the collector, the emitter current (I_E) and base current (I_B) are given by:-

Ans 50:- $I_C \Rightarrow 10\,mA \Rightarrow 10 \times 10^{-3} A$

So: $90\%\, I_E = I_C$

$$\frac{90}{100} \times I_E \Rightarrow 10 \times 10^{-3}$$

$$I_E \Rightarrow \frac{1}{90}$$

$$I_E \Rightarrow 0.11 \times 10^{-1}$$

$$I_E = 11\,mA$$

So: $I_E = I_B + I_C$

$$11 \Rightarrow I_B + 10\,mA$$

$$\boxed{1\,mA = I_B}$$ Answer

51: When N-P-N transistor is used as an amplifier:-

Ans 51: (4) Holes move from base to emitter

52:- Which of the following is true:-

Ans 52: (2) Common emitter is commonly used because current gain is maximum.

53: For transistor relation in current amplification factors is:-

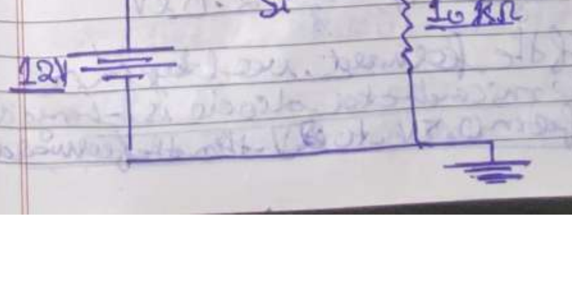
Ans 53:

$$\frac{1}{\alpha} - 1 = \frac{1}{\beta}$$

$$\therefore \frac{1}{\alpha} \Rightarrow \frac{\beta+1}{\beta}$$

$$\boxed{\alpha \Rightarrow \frac{\beta}{\beta+1}} \qquad \boxed{\frac{\alpha}{1-\alpha} = \beta}$$

54: Two junction diodes one of germanium (Ge) and other of silicon (Si) are connected as shown in figure to a battery of emf 12V and a load resistance of 10kΩ. The germanium diode conducts at 0.3V and silicon diode at 0.7V. When a current flows in the circuit, the potential (in V) of terminal Y will be:-



Ans 54: So both the Diodes are in forward Bias:- So the Kromin... Resistance is minimum. So it will go through a path of hee

The potential (V) of Y $\Rightarrow 12 - 0.3$

$\Rightarrow 11.7$ Volt

55: When light falls on a photo diode, its conductivity increases. Experimentally it is found that the conductivity changes only when the wavelength of the incident light is less than 620nm. The bandgap (in eV) of the diode is:

Ans 55: So: $E_g \Rightarrow \frac{hc}{\lambda}$

$$E_g \Rightarrow \frac{6.626 \times 10^{-34} \times 3 \times 10^{8}}{620 \times 10^{-9}}$$

$$E_g \Rightarrow \frac{19.8}{620} \times 10^{-17}$$

$$E_g(\text{in eV}) \Rightarrow \frac{19.8 \times 10^{-17}}{620 \times 1.6 \times 10^{-19}}$$

$$E_g(\text{in eV}) \Rightarrow 2.0\,eV$$

56: If the forward voltage in a semiconductor diode is changed from 0.5V to 2V, then the forward current changes by 1.5mA. The forward resistance (kΩ) of the diode will be:

Ans 56: $R_f \Rightarrow \frac{\Delta V}{\Delta I}$

$\Delta V \Rightarrow 2 - 0.5 \Rightarrow 1.5\,V$

$\Delta I \Rightarrow 1.5\,mA$

$$R_f \Rightarrow \frac{1.5}{1.5 \times 10^{-3}} \Rightarrow 1000\,\Omega$$

$R_f \Rightarrow 1\,K\Omega$

57: When the reverse potential in a semiconductor diode are 10V and 20V then the corresponding reverse currents are 25µA and 50µA respectively. The reverse resistance (KΩ) of junction diode will be:

Ans 57: $R_R \Rightarrow \frac{\Delta V}{\Delta I}$

$$R_R \Rightarrow \frac{10}{25 \times 10^{-6}} \Rightarrow \frac{2}{5} \times 10^{6}$$

$$R_R \Rightarrow 4 \times 10^{5}\,\Omega$$

or 400 KΩ (Answer)

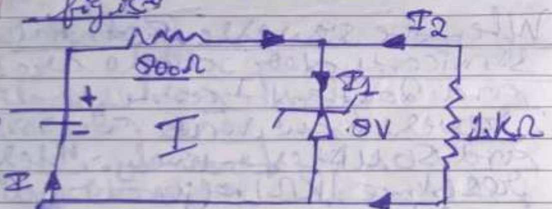
58: If the frequency of input alternating potential is 50Hz, then the ripple frequency (Hz) of output potential of full wave rectifier will be:

Ans 58:- Output Frequency ⇒ 2 × Input frequency

Ripple frequency ⇒ 2 × 50Hz

⇒ 100 Hz

59:- The current (mA) flowing through the zener diode in fig is:



Ans 59: Zener Voltage ⇒ 5V

Let current in Zener branch ⇒ I_1 and current in Load ⇒ I_2

We know $V_{1k\Omega}$ ⇒ V_{Zener}

$I_2 \times 1\times10^3 \Omega \Rightarrow 5V$

$I_2 \Rightarrow 5mA$

Loop law in "I"

∴ $10 - 500\times I - 5 = 0$

$10 = 500I + 5$

$10 - 5 = 500I$

$10^{-2} \Rightarrow I$

We know $I = I_1 + I_2$

$10^{-2}A \Rightarrow I_1 + 5\times10^{-3}A$

$\frac{1}{100} - \frac{5}{1000} \Rightarrow I_1$

$10mA - 5mA = I_1$

∴ $I_1 \Rightarrow 5mA$ (Answer)

60:- The depletion layer in silicon diode is 1μm wide and the knee potential is 0.6V, then the electric field in the depletion layer will be $x\times10^5$ V/m, find x

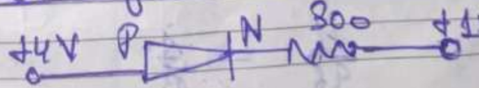
Ans 60: $E \Rightarrow \frac{V}{\Delta x}$

$E \Rightarrow \frac{0.6}{1\times10^{-6}}$

$E \Rightarrow 6\times10^5$ V/m

∴ $x \Rightarrow 6$ (Answer)

61:- In the circuit given below, the value of the current (mA) is:



Ans 61: Since $V_D > V_B$ So
It is in forward Bias and
at ideal condition it
behaves as straight wire

4V 300 1V

$I \Rightarrow \frac{3}{300} \Rightarrow 10\,mA$

62: For a transistor $\alpha = 0.9$, the value of β = ?

Ans 62: $\frac{1}{0.9} = \frac{1}{\beta} + 1$

$\frac{10 - 9}{9} \Rightarrow \frac{1}{\beta}$

$\therefore \beta \Rightarrow 9$ (Answer)

63: In a P-N-P transistor working as a common-base amplifier current gain is 0.96 and emitter current is 7.2 mA. The base current (mA) is:

Ans 63: $\alpha = 0.96$

$\frac{1}{0.96} - 1 = \frac{1}{\beta}$

$\frac{4}{96} = \frac{1}{\beta}$

$\therefore \beta \Rightarrow \frac{96}{4} \Rightarrow 24$

Also: $\alpha \Rightarrow \frac{I_C}{I_E}$

$\frac{0.96}{100} \Rightarrow \frac{I_C \times 10}{7.2 \times 10^{-3} A}$

$\frac{96}{100} \Rightarrow \frac{I_C}{72} \times 10^4$

$I_C \Rightarrow \frac{96 \times 72}{10^6}$ Ampere

So: $\beta \Rightarrow \frac{I_C}{I_b}$

$24 \Rightarrow \frac{96 \times 72}{10^6 \times I_b}$

$I_B \Rightarrow \frac{288}{10^3} \times 10^{-3}$

$I_B \Rightarrow 0.288\,mA$

$I_B \Rightarrow 0.29\,mA$ (Answer)

64: In the fig, a common emitter configuration on N-P-N transistor with current gain $\beta \Rightarrow 100$ is used. The output voltage (mV) of the amplifier will be:

Ans 64: Sol. $V_{BE} \Rightarrow I_B \times R_B$

$$1 \times 10^{-3} = I_B \times 1 \times 10^{3}$$

$$10^{-6} = I_B$$

Now: $\beta = \frac{I_C}{I_B}$

$$100 = \frac{I_C}{I_B}$$

$$I_B \Rightarrow 100 \times 10^{-6}$$

$$I_C \Rightarrow 10^{-4}$$

Sol: $V_{CE} \Rightarrow V_0 \Rightarrow I_C R_C$

$$V_0 \Rightarrow 10^{-4} \times 10 \times 10^{3}$$

$$\Rightarrow 10^{-4} \times 10^{4}$$

$V_0 \Rightarrow 1$ Volt (Answer)

65: In an N-P-N transistor the values of base current and collector current are 100 μA and 9 mA respectively. The emitter current (mA) will be:

Ans 65: $I_E = I_B + I_C$

$$I_E \Rightarrow 10 \times 10^{-6} + 9 \times 10^{-3}$$

$$I_E \Rightarrow \frac{901}{10^{5}} = 9.01 \times 10^{-3}$$

$I_E = 9.1$ mA (Answer)

66: In a common emitter circuit If V_{CE} is changed to 0.2V, then collector current changing by 4×10^{-3} mA. Output resist (kΩ) will be:

Ans 66: $\Delta V_{CE} \Rightarrow \Delta I_C R_C$ ($R_C = R_0$)

$$\frac{0.2V}{10} \Rightarrow {}^{2}4 \times 10^{-3} \times 10^{-3} \times R_C$$

$$\frac{1}{2} \times \frac{1}{10^{-5}} = R_C$$

$$0.5 \times 10^{5} \Rightarrow R_C$$

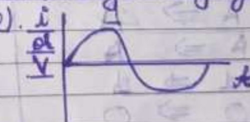
$$5 \times 10^{4} \Rightarrow R_C$$

∴ Resistance Output ⇒ 50 ~~(k)~~ Ohm

5th Sept, 2021
Lecture ⇒ 7

⇒ Logic Gate

(1) Analog Signal
⇒ It a continously varying signal (current or voltage).



(2) Digital Signal
It can have only two discrete value High or Low