Name- Rajasree Loha

Roll - CSE214002 sec - B

Course Code - ECEUGES01

Course Title - Basic Electronics Engineering

Year - 1st Semester - 1st

~~Sec~~

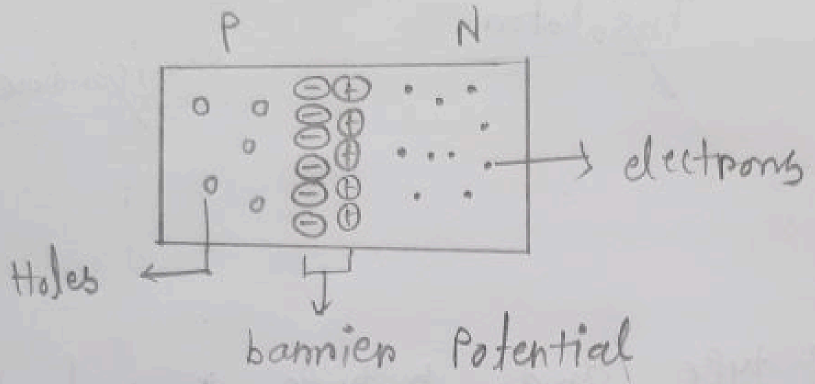
1)

(i) ~~metal~~ ~~Insulator~~ ~~Semiconductor~~

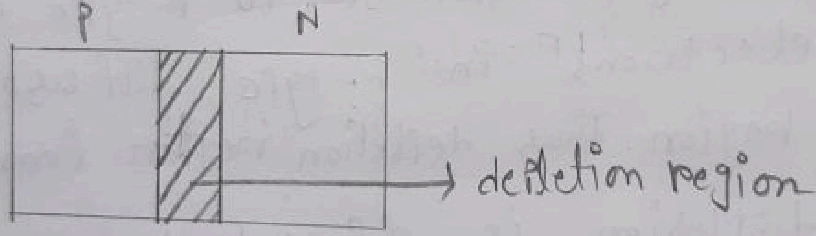
~~i) This can~~

5) (i) when p-type and n-type ~~s~~ materials are joined, diffusion occurs. Excess holes in p-type region diffuse to n-type, and excess electrons in n-type diffuse to p-type region. Thus depletion region formed.

(ii) This diffusion is opposed by the resulting electric field of the uncovered ionic charges. The positive ion cores in the n-type region oppose the diffusion of the p-type carriers from the p-type region and vice versa. This resulting electric field which oppose diffusion is called barrier potential V_0 in p-n junction diode under equilibrium.



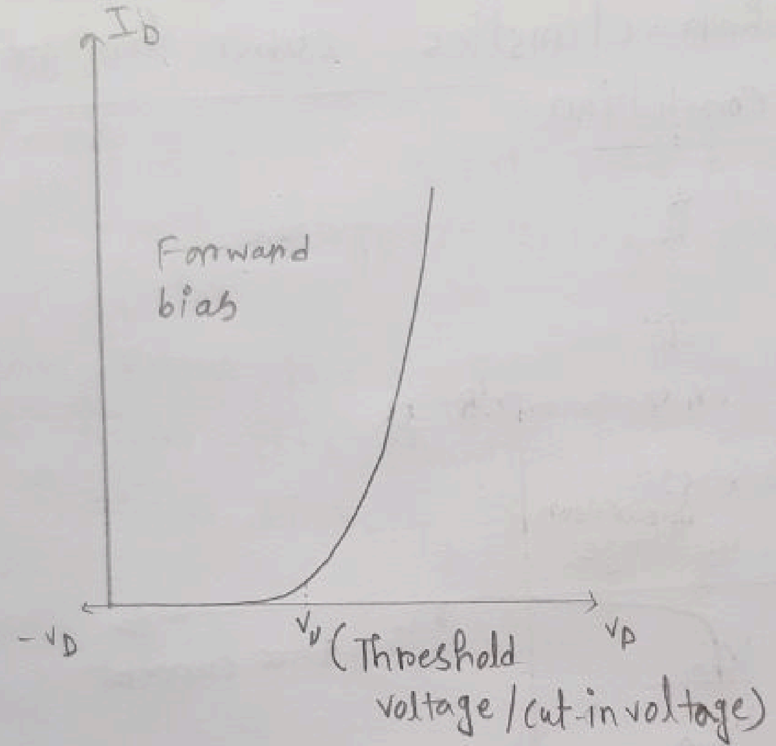
P-N junction diode



P-N junction diode

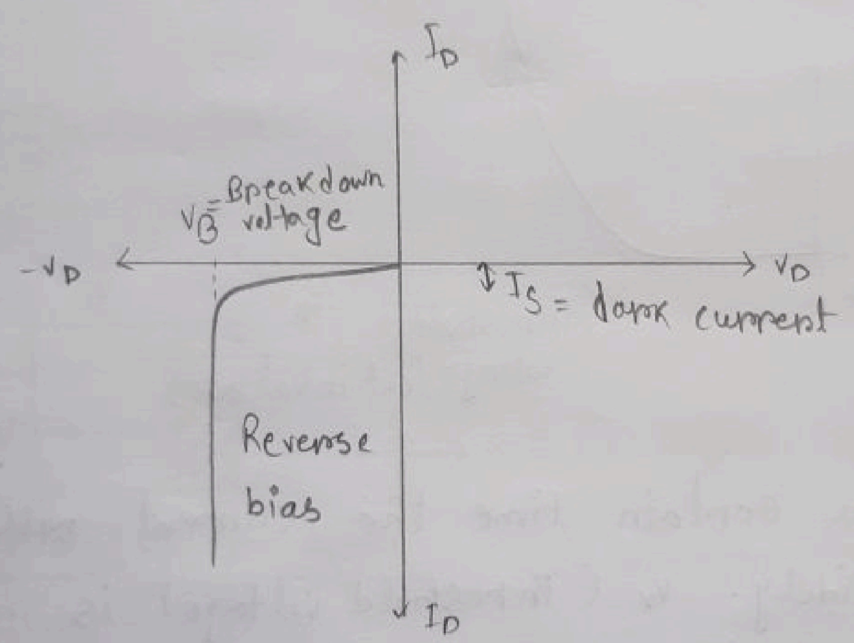
(ii) Explanation of the forward and ~~R~~ reverse bias characteristics curve of P-n junction diode from shockley diode equation.

V-I curve for forward bias condition characteristics



After a certain time the current will increase so rapidely. V_V (Threshold voltage) is also called cut-in / cut-off voltage. Cut-in voltage is different for different semiconductor. Like, cut-in voltage ~~of for~~ of Ge is 0.2V, whereas cut-in voltage of Si is 0.6 V. After some time (cut-in voltage) the diode will be a short circuit.

2) V-I characteristics curve for reverse bias condition



After a certain time gap the breakdown occurs in the diode in reverse biase condition. This breakdown is called 'Avalanche breakdown / high voltage break down'. I_S is called dark current here.

From the equation, $I_D = I_S(e^{\frac{V_D}{nV_T}} - 1)$ —(1),

where I_D = the current accross the diode

I_S = Reverse Saturation current

V_D = Applied voltage
η = Ideality factor (For Ge, $\eta = 1$
for Si, $\eta = 2$)
V_T = Thermal voltage (26mv at room temperature)

We can know the explanation of above characteristics curve from this equation [Eqn (1)]. Here for forward bias, $I_D \approx I_S e^{\frac{V_D}{\eta V_T}}$ and for reverse bias, $I_D \approx -I_S$.

9) Q-Point - The operating point of a device, also known as a bias point, quiescent point or Q-point, is the steady-state DC voltage or current at a specified terminal of an active device, such as a transistor with no input signal applied.

As the value of β and the value of V_{BE} are not same for every transistors, whenever a transistor is replaced, the Q-Point tends to change. So it is necessary to stabilize the Q-Point.

(ii)

$$I_B = \frac{V_{BB} - V_{BE}}{R_B}$$

$$= \frac{10 - 0.7}{360 \times 10^3} \quad [\because \text{ we know } V_{BE} = 0.7V]$$

$$= 2.58 \times 10^{-5} A$$

$$= 25.8 \mu A$$

$$I_C = \cancel{\beta I_B}$$

$$= \frac{V_{CC}}{R_C}$$

$$= \frac{10}{2 \times 10^3}$$

$$= 5 \times 10^{-3} A$$

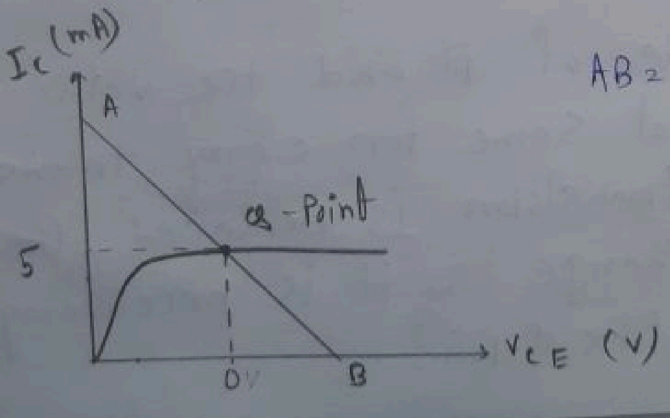
$$= 5 mA$$

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

$$= 10 - 5 \times 10^{-3} \times 2 \times 10^3$$

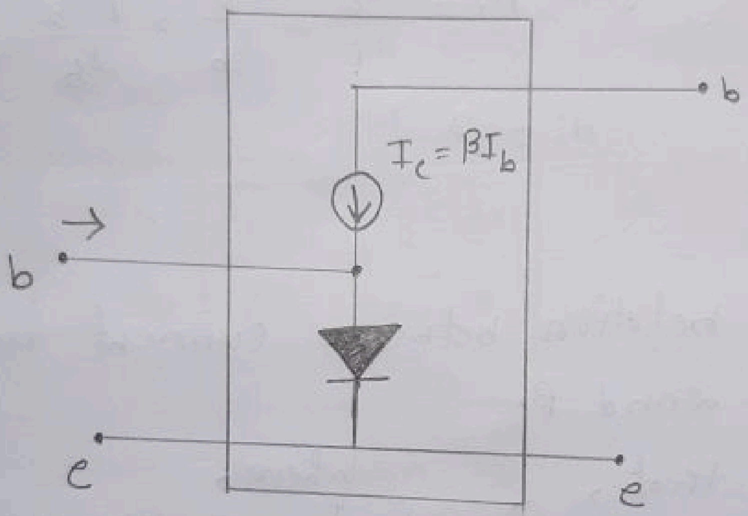
$$= 0 V$$

(iii)



AB = loadline

10)
(i) Small signal re model for CE mode BJT amplifier -



(ii) a) Input impedance - $Z_i = \frac{v_i}{I_i} = \frac{V_{be}}{I_b}$

$$Z_i = \frac{V_{be}}{I_b} \cong \frac{\beta I_b r_e}{I_b}$$

$$\therefore Z_i \cong \beta r_e$$

[where, β = current amplification of CE mode
r_e = forward resistance]

(b) output impedance, $Z_0 = r_0$

(c) voltage gain, $A_v = \frac{V_0}{V_i} = \frac{-R_L}{r_e}$ $\left[\begin{array}{l} V_0 = -I_0 R_L = -I_c R_L \\ = -\beta I_b R_L, V_i = I_i Z_i \\ = I_b \beta r_e \end{array} \right]$

(d) current gain, $A_i = \frac{I_0}{I_i} = \frac{I_c}{I_b} = \frac{\beta I_b}{I_b} = \beta$

$$A_i = \beta$$

8) (i) The relation between current amplification factors α and β -

we know that,

$$I_E = I_C + I_B$$

where, [I_E = Emitter current
I_C = Collector current
I_B = Base current]

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

$\left[\because \beta = \frac{I_C}{I_B}, \alpha = \frac{I_C}{I_E} \right]$

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

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

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

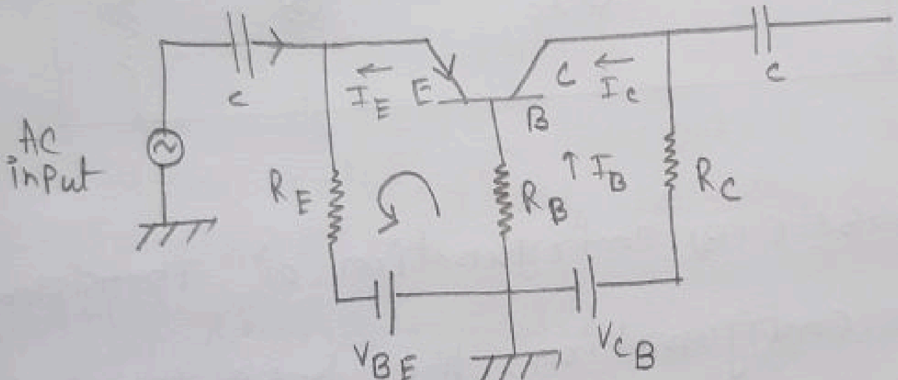
and, $\frac{1}{\alpha} - 1 = \frac{1}{\beta}$

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

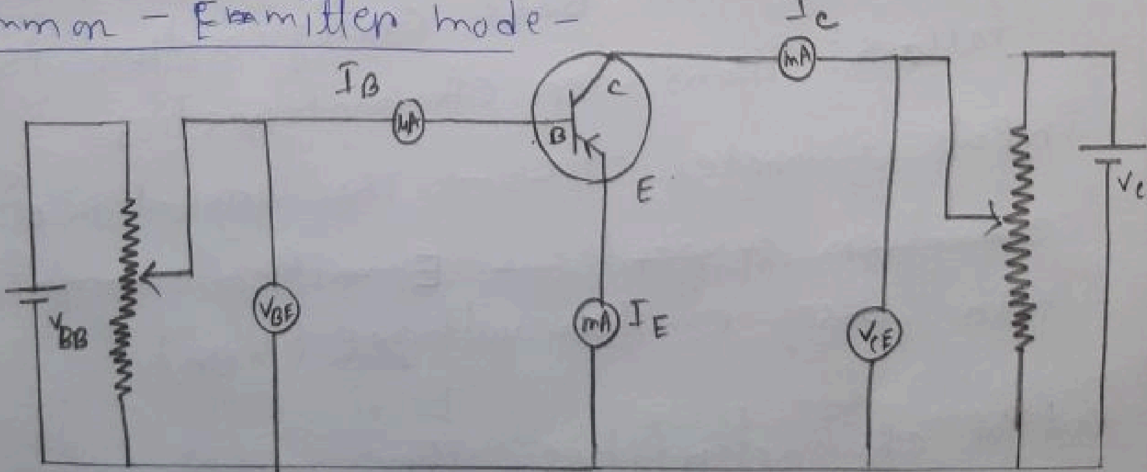
$\Rightarrow \beta = \frac{\alpha}{1-\alpha}$

(iii) The configuration of CB, CE and CC mode operation in a transistor-

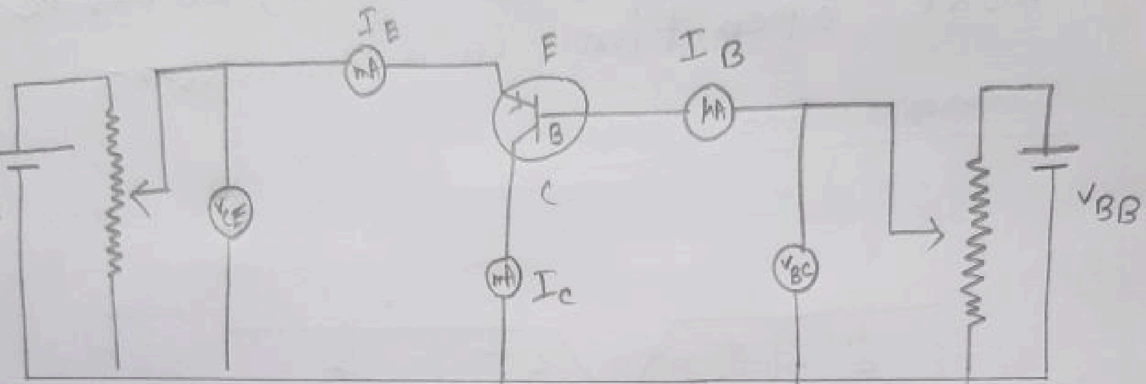
Common - Base mode-



Common - Emitter mode-



Common-Collector mode -



Common Base (CB) configuration of Transistor -

In CB configuration, the base terminal of the transistor will be ~~b~~ connected common between the output and the input terminals. The transistor characteristic under Common Base configuration is as follows: Transistor Characteristics

Input characteristics - The variation of ~~emmitter current (I~~ Emmitter current (I_E) with Base-emitter voltage (V_{BE})

Output characteristics - The variation of ~~emi~~ collector current (I_C) with Base-collector voltage (V_{CB})

CE configuration of transistor - The CE mode is the most widely used transistor configuration. The CE amplifiers are used when large current gain is needed. The input signal is applied between the base and emitter terminals while the output signal is taken between the collector and emitter terminals.

Input characteristics - The variation of ~~Emitter~~ Base current (I_B) with ~~Collector~~ Base-emitter voltage (V_{EB})

Output characteristics - The variation of ~~Base~~ Collector current (I_{CB}) with ~~Base~~ collector emitter (V_{CE}) voltage.

CC configuration of transistor - In CE mode, the collector terminal of the transistor will be connected common between the output and input terminals. The variation of of emitter current with collector-Base voltage, keeping collector Base voltage constant.

Input characteristics - The variation of ~~Collector~~ - Emitter current (I_E) with the Collector - Emitter voltage (V_{CE}).

output characteristics - The variation of Base current (I_B) with the collector - Base voltage (V_{BC}).

(i) Different current componants in P-nP transistor in active region with a suitable diagram - In a P-n-P transistor, the reverse saturation current (I_{CBo}) will comprises of the current due to the holes passing through the collector junction from the base to collector region (I_{hco}) and the current due to the electrons which are passing through the collector junction in the opposite direction. we know about some current componants like, I_C, I_B, I_E, I_{CBo}, I_{CEo} etc. There are some of relations between them. Like -

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$I_E = I_C + I_B$ [I_E = Emitter current, I_C = Collector ,, I_B = Base ,,]

$I_C = \alpha I_E$ [α = current amplification factor in CB mode of transistor]

$I_C = \alpha I_E + I_{CBO}$

$$I_C = \frac{\alpha I_B}{1-\alpha} + \frac{I_{CBO}}{1-\alpha}$$

$$I_{CEO} = \frac{I_{CBO}}{1-\alpha}$$

$I_{CEO} = (\beta+1) I_{CBO}$ [$\because \frac{1}{1-\alpha} = \beta+1$

$I_{CEO} \cong \beta I_{CBO}$ β = current amplification factor in CE mode of transistor]

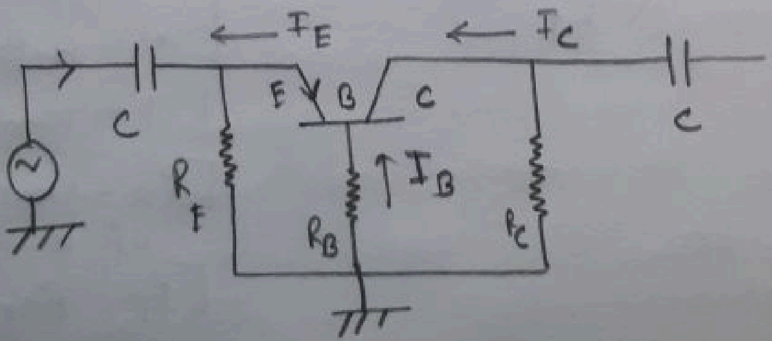
$I_C = \beta I_B$

$I_C = \beta I_B + 1 + I_{CEO}$

$I_C = \beta I_B + (1 + \beta I_{CBO})$

$I_E = I_B(\beta+1)$

<u>Diagram</u> – (for CB mode of transistor)



4) (i) the equilibrium concentrations of electrons (n_0) and holes (P_0) in a semiconductors can be expressed as -

(a) $n_0 = N_c e^{-\left(\frac{E_c - E_F}{KT}\right)}$ (b) $P_0 = N_v e^{-\left(\frac{E_F - E_v}{KT}\right)}$

we know that the Probability of getting electrons -

$n(E)\,dE = [Z_c(E)\,d(E)][F_c(E)]$

where,

[$n(E)\,dE$ = Probability of getting electrons]

[occupation of electrons = $F_c(E)$]

Hence, $n_0 = N_c e^{-\left(\frac{E_c - E_F}{KT}\right)}$ [If $E \downarrow E_F$ then n_0 decrease]

[N_0 = Concentration of electrons]

[N_c = number of density of bands]

[K = Boltzman constant]

[T = temperature]

[P_0 = concentrations of holes]

[E_F = fermy level]

$P_0 = N_v e^{-\left(\frac{E_F - E_v}{KT}\right)}$

(ii) For n-type meterial the minority hole concentration -

$$p_n = \frac{n_i^2}{n} \approx \frac{n_i^2}{N_D}$$ [N_D = ~~dofan~~ donor ion concentration]

For p-type meterial the minority electron concentration

$$n_p = \frac{n_i^2}{p} \approx \frac{n_i^2}{N_A}$$ [acceptor ion concentration = N_A]

we know that -

Now, $n_0 = n_i e^{(E_f - E_i)/KT}$

and $p_0 = n_i e^{(E_i - E_f)/KT}$

$\therefore n_0 p_0 = n_i \, n_i \, e^{(E_f - E_i + E_i - E_f)/KT}$

$n_0 p_0 = n_i^2$ (Proved)

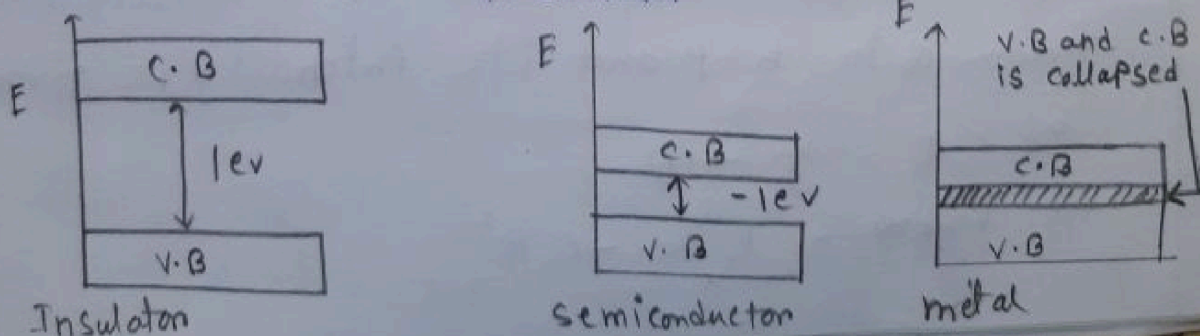
The Product of electron and hole concentrations of ~~electrons~~ under equilibrium is constant and can be expressed as- $n_0 p_0 = n_i^2$

1)(i) Distinguish between insolator, semiconductor and metal on the basis of energy band diagram -

metal- A crystaline solide is called a metal. If the upper energy band i.e. conduction band is fully filled, or the upper most filled band and the next unoccupied band overlap in energy. Here the electrons in the uppermost band find neighbouring ~~vacce~~ vacant states to move in, and thus behave as free particles. ~~It~~ This free particles (e⁻) Produce electric current. metal is a good conductor of electricity.

Insulator- In sone crystaline solids, the forbidden energy gap between the uppermost filled band, called the valance band, and the lowermost empty band called the conduction band, is ~~vero~~ very large. In this such solids, at ordinary temperatures only a few electrons can acquire enough thermal energy to move from the valance band into the conduction band. since only a few electrons are available in conduction band, an insulator is a bad conductor of electricity.

semiconductor - A material for which the width of the forbidden energy gap between valance and the conduction band is relatively small (~1ev) is refferred to as a semiconductor. As the forbidden gap is not very wide, some of the valance electrons acquire enough thermal energy to go into the conduction band. these electrons ~~b~~ then become free and can move. This electrons are cause of current conduction in semiconductor. semiconductor is not a good ~~so~~ current conductor like ~~as~~ metal but not such ~~as~~ bad current conductor like insulator.



[V·B = valance Band
C·B = conduction Band]

(iii) Einstein relation - the relation in which the mobility of charges in an ionic solution or semiconductor is equal to the magnitude of the charge times the diffusion coefficient divided by the product of the Baltzman constant and the absolute temperature.

The relation is - $\frac{D_n}{\mu_n} = \frac{D_p}{\mu_p} = \frac{KT}{e}$

(ii) Let, PQ is a conductor of length 'l' and a potential difference 'V' is applied across PQ. An electric field is developed directing from Q to P and its intensity is given by, $E = \frac{V}{l}$ — (1)

we know, $\vec{F} = -e\vec{E}$

If 'm' be the mass of the electron, then its acceleration,

$$\vec{a} = \frac{\vec{F}}{m}$$

$$\Rightarrow \vec{a} = \frac{-e\vec{E}}{m}$$

∵ The average thermal velocity of ~~electric~~ electrons is zero.

∴ $u = 0$

∴ Therefore using first equation of motion ($v = u + at$) we have

$$\vec{v_d} = 0 + \left(-\frac{e\vec{E}}{m}\right)\tau$$

$$\Rightarrow \vec{v_d} = \left(-\frac{e\vec{E}}{m}\right)\tau \quad \text{— (II)}$$

Numerically we can write,

$$|\vec{v_d}| = \frac{eE}{m}\tau$$

~~∴ Compari~~ ∵ From equation (1), $E = \frac{V}{l}$

$$\therefore v_d = \frac{e\tau}{m}\frac{V}{l} \quad \text{— (III)}$$

Now, $\vec{v_d} = -\frac{e\tau}{m}\vec{E}$

$$\Rightarrow \vec{v_d} = -\mu_n\vec{E}$$

$\Rightarrow |\vec{v_d}| = \mu_n |\vec{E}|$

$\Rightarrow v_d = \mu_n E$

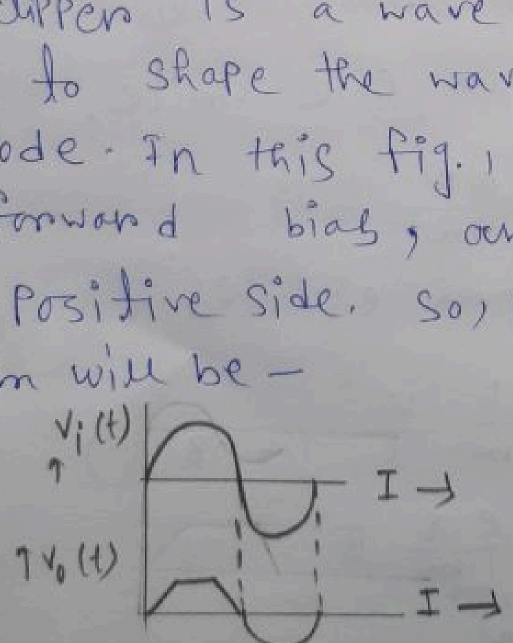
[$\frac{e\tau}{m}$ = Constant term
μ_m = mobility of a given metal]

[τ = The characteristics of specific metal]

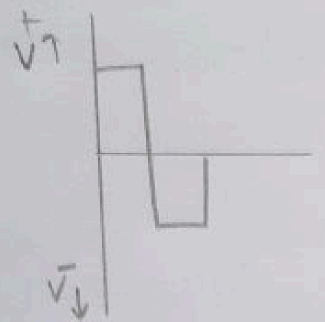
[e = Constant]

So the ~~equation~~ relation between drift valocity, mobility and electric field for an electron in a semiconductor under thermal equilibrium - $V = \mu_n E$ is established.

5) (i) The clipper is a wave shaper. It is used to shape the waves. It is one type of diode. In this fig. 1 the diode is in forward bias, and the battery is also in positive side. So, how the output diagram will be -

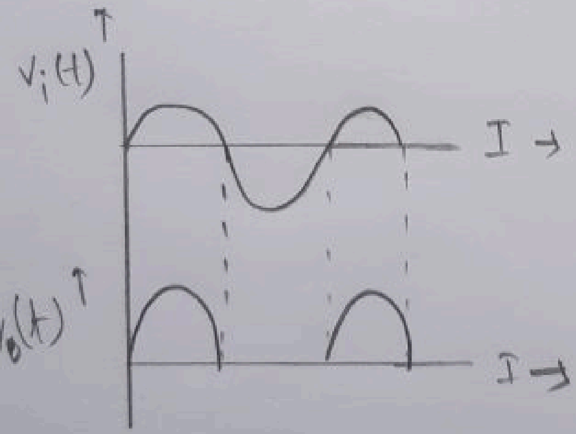


(ii)



In 1st circle ~~ke~~ the diode will off and in 2nd circle the diode will on. So we get no valtage in 1st ~~half~~ circle and we get a valtage in 2nd ~~h~~ circle (comple is also a wave shaper).

(iii)



It is the half-wave rectifier out wave-form.
The amplitude of cosine even harmonic components of it - ~~it's~~ ~~harmonic e~~. this is 85 times of it's cos amplitude.