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Model Answer (B.Sc III semester – Physics)

(Basic Electronics)

Section-A

Answer-1

(i) (c)

(ii) (a)

(iii) (d)

(iv) (a)

(v) (c)

(vi) (b)

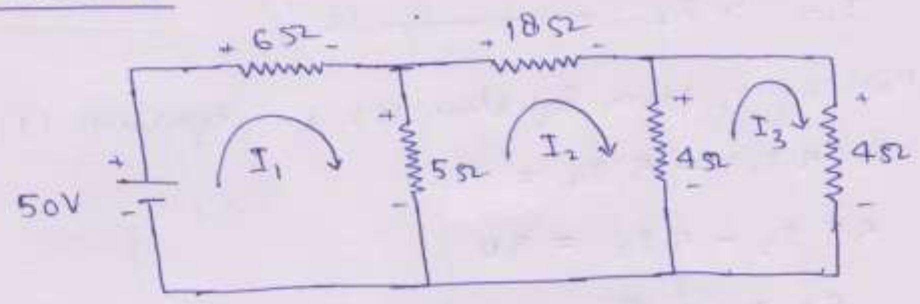
(vii) (c)

(viii) (b)

(ix) (a)

(x) (c)

Answer-2



Applying Kirchhoff's Voltage in loop 1.

$$6I_1 + 5(I_1 - I_2) - 50 = 0$$

$$11I_1 - 5I_2 = 50 \quad \text{——— (1)}$$

K.V.L in loop 2.

$$18I_2 + 4(I_2 - I_3) - 5(I_1 - I_2) = 0$$

$$27I_2 - 4I_3 - 5I_1 = 0 \quad \text{——— (2)}$$

K.V.L in loop 3.

$$4I_3 - 4(I_2 - I_3) = 0$$

$$8I_3 - 4I_2 = 0 \quad \text{——— (3)}$$

or

$$I_2 = 2I_3 \quad \text{——— (4)}$$

or $$I_3 = \frac{1}{2}I_2 \quad \text{——— (5)}$$

Putting the value of Equation (5) in equation (2)

$$27I_2 - \cancel{4}^{2}\left(\frac{I_2}{\cancel{2}}\right) - 5I_1 = 0$$

$$25I_2 - 5I_1 = 0$$

$5 I_1 = 25 I_2$

$I_1 = 5 I_2$ ———— (6)

Putting I_1 from Equation (6) in Equation (1)

$11(5 I_2) - 5 I_2 = 50$

$55 I_2 - 5 I_2 = 50$

$50 I_2 = 50$

$\boxed{I_2 = 1 \text{ Ampere}}$

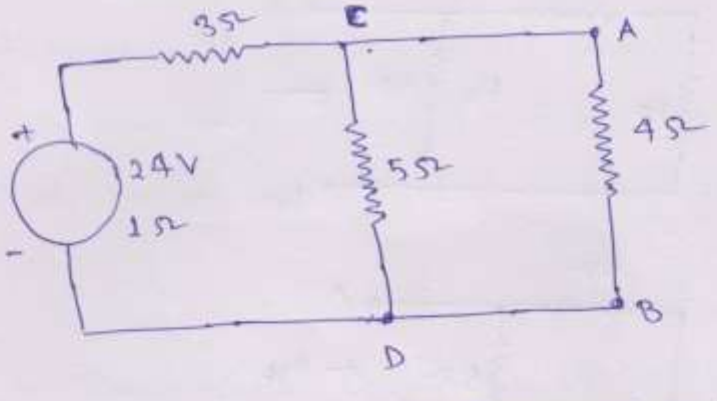
Therefore,

$\boxed{I_1 = 5 I_2 = 5 \text{ Ampere}}$

and

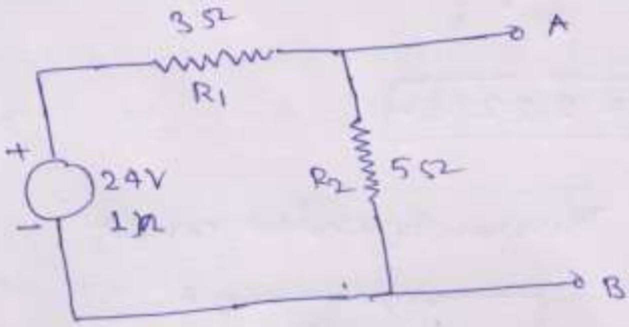
$\boxed{I_3 = \frac{I_2}{2} = 0.5 \text{ Ampere}}$

Answer-3



we have to find current flowing through the 4Ω resister.

Step-1



Thevenin voltage $(V_{th}) = V_{AB}$ (open circuit voltage)

$$= I R_2$$

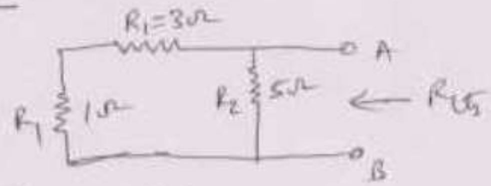
Therefore, $I = \frac{V}{R_1+R_1+R_1} = 24/3+5+1$

$$I = \frac{24 \text{ volt}}{9\ \Omega} = 2.667 \text{ Amp}$$

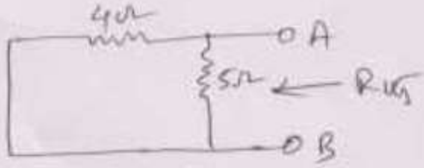
So $V_{th} = 2.667 \times 5 = 13.335$ volt

$$\boxed{V_{th} = 13.335 \text{ volt}}$$

Step-2



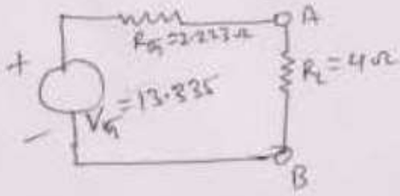
$\simeq$



$$\frac{1}{R_{th}} = \frac{1}{4} + \frac{1}{5}$$

$$R_{th} = 2.223\,\Omega$$

Step-3 Thevenin's Equivalent circuit



Therefore, current flowing through 4Ω resistor is

$$I = \frac{V_{th}}{R_{th} + R_L} = \frac{13.335}{2.223 + 4} = \frac{13.335}{6.223}$$

$$= 2.14286$$

$$\boxed{I = 2.143\ \text{Amp}}$$

Answer – 4

Total Number of Si atom in the Sample = 5×10^{28} atom/m^3

one Sb atom is replacing 2×10^9 atom of Si

So, Total Numbers of dopants = $\dfrac{5 \times 10^{28} \text{ atom}/m^3}{2 \times 10^9}$

$= 2.5 \times 10^{19}$ atom/m^3

Sb is Pentavalent impurity in Si Sample.
Therefore, Sb is behaving as a donor in Si.

Number of donor (N_d) = 2.5×10^{19} atom/m^3

Sample is kept at 300 K and This temperature is sufficient to ionized all the donor atom then

$N_d = n$ (Number of majority charge carrier)
i.e. electron

$$\boxed{N_d = n = 2.5 \times 10^{19} /m^3}$$

from, Law of mass action i.e.

$n.p = n_i^2$

given that $N_A = 0$, $N_d = N = 2.5 \times 10^{19} /m^3$

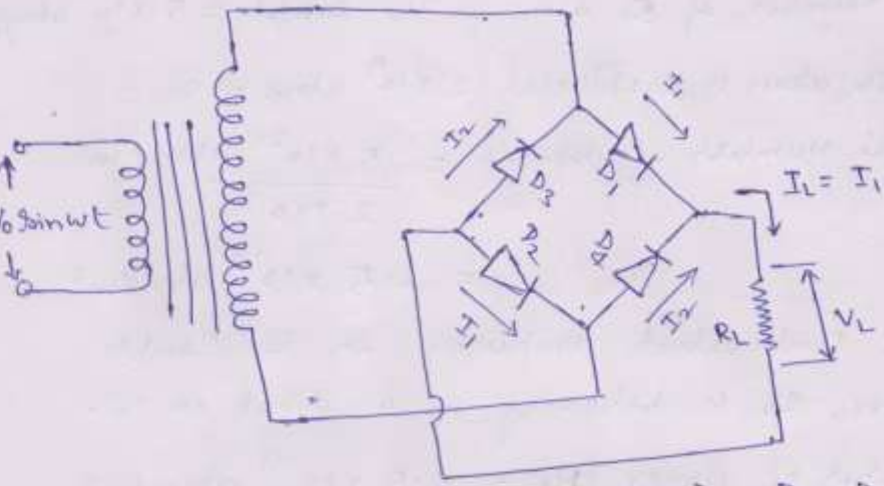
$n_i = 1.5 \times 10^{16} /m^3$

Number of minority carrier (i.e. holes)

$$p = \frac{n_i^2}{n} = \frac{(1.5 \times 10^{16})^2}{2.5 \times 10^{19}} = \frac{2.25 \times 10^{32} /m^6}{2.5 \times 10^{19} m^3}$$

$$\boxed{p = 9.0 \times 10^{12} m^{-3}}$$

Answer - 5

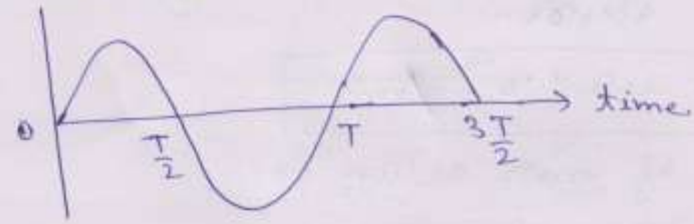


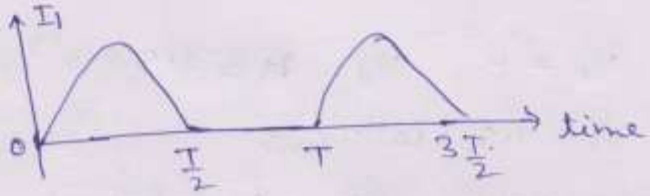
Bridge Rectifier.

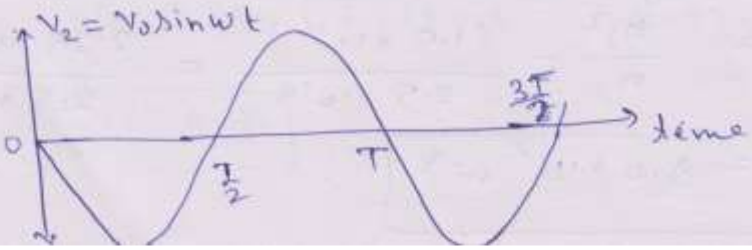
$D_1 = D_2 = D_3 = D_4$ = All diodes are identical i.e. forward resistance of all diodes are r_f.

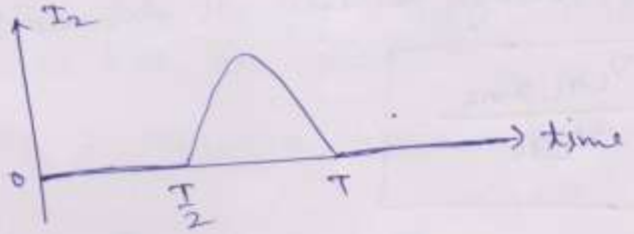
During positive half cycle.

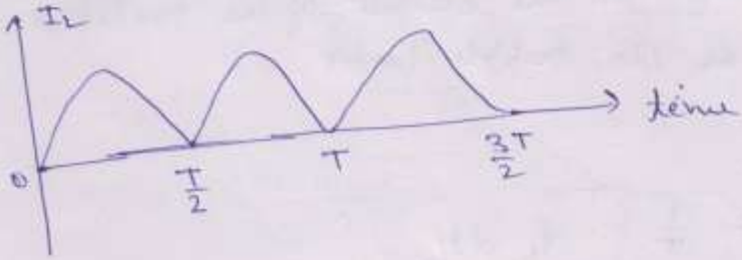
$V_1 = V_0 \sin wt$

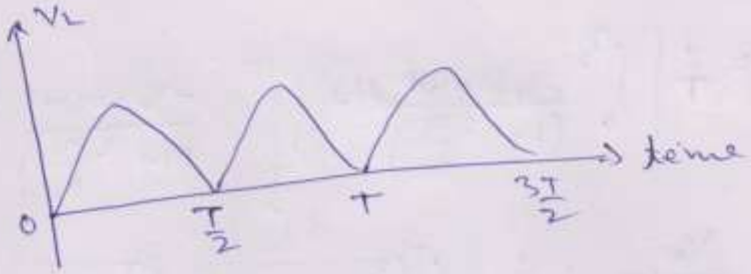












$$I_L = \frac{V_0 \sin \omega t}{(2r_f + R_L)} \quad \text{for } 0 \le t \le \frac{T}{2}$$

$$I_L = -\frac{V_0 \sin \omega t}{(2r_f + R_L)} \quad \text{for } \frac{T}{2} \le t \le T$$

$$V_L = \frac{V_0 \sin \omega t}{(2r_f + R_L)} \cdot R_L \quad \text{for } 0 \le t \le \frac{T}{2}$$

$$V_L = -\frac{V_0 \sin \omega t}{(2r_f + R_L)} R_L \quad \text{for } \frac{T}{2} \le t \le T$$

Ripple factor of Bridge rectifier is defined as

$$\boxed{r = \frac{V_{Lac,\,rms.}}{V_{Ldc}}}$$

i.e. The ratio of rms ripple voltage to the d.c. voltage in the output of the rectifier is known as its ripple factor.

Therefore,

$$V_{Ldc} = \frac{1}{T}\int_0^T v_L \, dt$$

$$V_{Ldc} = \frac{1}{T}\left[\int_0^{\frac{T}{2}} \frac{V_0 \sin wt}{\left(1+\frac{2r_f}{R_L}\right)} dt + \int_{\frac{T}{2}}^{T} \frac{-V_0 \sin wt}{\left(1+\frac{2r_f}{R_L}\right)} dt\right]$$

$$V_{Ldc} = \frac{V_0}{\left(1+\frac{2r_f}{R_L}\right)} \cdot \frac{1}{T}\left[\int_0^{T/2} \sin wt \, dt - \int_{\frac{T}{2}}^{T} \sin wt \, dt\right]$$

$$\boxed{V_{Ldc} = \frac{2V_0}{\pi\left(1+\frac{2r_f}{R_L}\right)}}$$

We know that, $V_{rms} = \frac{V_0}{\sqrt{2}}$

$$\boxed{V_{Ldc} = \frac{2\sqrt{2}\, V_{rms}}{\pi\left(1+\frac{2r_f}{R_L}\right)}}$$

Total voltage drop across Load (V_L) contains ac as well dc part i.e.

$$V_L = V_{Ldc} + V_{Lac}$$

$$V_{Lac} = V_L - V_{Ldc}$$

$$V_{L,ac} = \frac{V_0 \sin wt}{\left(1 + 2\frac{r_f}{R_L}\right)} - \frac{2V_0}{\pi\left(1 + 2\frac{r_f}{R_L}\right)} \quad \text{for } 0 \le t \le \frac{T}{2}$$

$$V_{Lac} = \frac{-V_0 \sin wt}{\left(1 + 2\frac{r_f}{R_L}\right)} - \frac{2V_0}{\pi\left(1 + \frac{2r_f}{R_L}\right)} \quad \text{for } \frac{T}{2} \le t \le T$$

$$V_{Lac,ms} = \frac{1}{T}\left[\int_0^T V_{Lac}^2 \, dt\right]$$

$$V_{Lac,ms} = \frac{1}{T}\left[\frac{V_0^2}{\left(1 + \frac{2r_f}{R_L}\right)^2}\left\{\int_0^{T/2} \left(\sin wt - \frac{1}{\pi}\right)^2 dt + \int_{T/2}^{T} \left(\sin wt + \frac{1}{\pi}\right)^2 dt\right\}\right]$$

$$V_{Lac,ms} = \frac{V_0^2}{\left(1 + \frac{2r_f}{R_L}\right)^2} \cdot \frac{\pi^2 - 8}{2\pi^2}$$

$$V_{Lac,rms} = \frac{V_0}{\pi\left(1 + \frac{2r_f}{R_L}\right)^2} \cdot \sqrt{\frac{\pi^2 - 8}{2}}$$

So,

ripple factor $(r) = \dfrac{V_{L\,ac,rms}}{V_{L\,dc}}$

$$r = \frac{\dfrac{V_0}{\cancel{\pi}\left(1+\cancel{\dfrac{2r_f}{R_L}}\right)} \cdot \sqrt{\dfrac{\pi^2-8}{2}}}{\dfrac{2\cancel{V_0}}{\cancel{\pi}\left(1+\cancel{\dfrac{2r_f}{R_L}}\right)}}$$

$$r = \sqrt{\frac{\pi^2-8}{8}}$$

$$\boxed{r \simeq 0.48}$$

Ans. 6: (i) Avalanche breakdown:-

zener diode is a P-N junction diode constructed for a definite breakdown voltage. The breakdown voltage depends on the doping density in the P & N type semiconductors. If doping is large, the breakdown in the reverse bias of junction is zener breakdown and if doping is low, it is avalanche breakdown. Thus, by changing the amount of doping zener diode can be constructed for different breakdown voltages. The ~~g~~ zener diodes are generally manufactured to offer breakdown voltage ranging from 2 volt to 200 volt.

(ii) Zener breakdown:-

If the doping is large, the breakdown in the reverse bias of junction is zener breakdown. Zener breakdown part is nearly parallel to current axis which implies that the potential difference almost remains constant even if the current thought the zener diode changes. Thus, the potential on a zener diode behaves as a reference. Hence, this diode is also called a reference diode and is mainly used in the circuits where constant voltage ~~is~~ is required and current demand is very large (i.e. as a voltage regulator).

Answer. 7

For a given Transistor we can define

$$\alpha = \frac{\Delta I_C}{\Delta I_E} \quad \text{———} (1)$$

$$\beta = \frac{\Delta I_C}{\Delta I_B} \quad \text{———} (2)$$

and

$$\gamma = \frac{\Delta I_E}{\Delta I_B} \quad \text{———} (3)$$

(i) $\beta = \frac{\Delta I_C}{\Delta I_B}$

we know

$$I_E = I_B + I_C \quad \text{———} (4)$$

or

$$\Delta I_E = \Delta I_B + \Delta I_C$$

$$\Delta I_B = \Delta I_E - \Delta I_C \quad \text{———} (5)$$

$$\beta = \frac{\Delta I_C}{\Delta I_E - \Delta I_C}$$

$$\beta = \frac{\Delta I_C}{\Delta I_E \left(1 - \frac{\Delta I_C}{\Delta I_E}\right)} = \frac{\frac{\Delta I_C}{\Delta I_E}}{\left(1 - \frac{\Delta I_C}{\Delta I_E}\right)}$$

we have $\alpha = \frac{\Delta I_C}{\Delta I_E}$ from definition

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

(ii) $\alpha = \frac{\Delta I_c}{\Delta I_E}$

We have $\Delta I_E = \Delta I_B + \Delta I_C$

$$\alpha = \frac{\Delta I_C}{\Delta I_B + \Delta I_C}$$

$$\alpha = \frac{\Delta I_c}{\Delta I_B\left(1 + \frac{\Delta I_c}{\Delta I_B}\right)} = \frac{\frac{\Delta I_c}{\Delta I_B}}{\left(1 + \frac{\Delta I_c}{\Delta I_B}\right)}$$

we have $\beta = \frac{\Delta I_c}{\Delta I_B}$ from definition

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

(iii) From (i) & (ii) we have

$$\beta = \frac{\alpha}{1-\alpha} \Rightarrow 1-\alpha = \frac{\alpha}{\beta} \quad \text{and} \quad \text{—— (a)}$$

$$\alpha = \frac{\beta}{1+\beta} \quad \text{—— (b)}$$

How putting value of α in equation (a) from (b), we get

$$1-\alpha = \frac{\frac{\beta}{1+\beta}}{\beta} = \frac{\cancel{\beta}}{1+\beta} \times \frac{1}{\cancel{\beta}} = \frac{1}{1+\beta}$$

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

Ans. 8:- Common Emitter (CE) Amplifier:-

Figure 1 and 2 shows the circuit of a single stage CE amplifier using an NPN transistor.

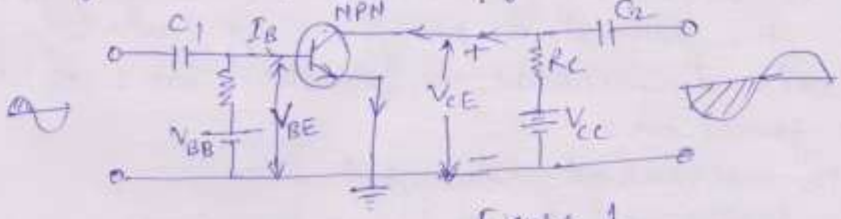


Figure 1

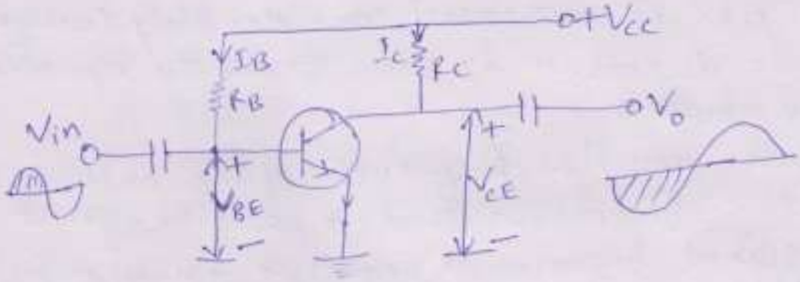


Figure 2

Here, base is the driven element. The input signal is injected into the base-emitter circuit whereas output signal is taken out from the collector-emitter circuit. The E/B junction is forward-biased by V_{BB} and C/B junction is reversed-biased by V_{CC} (in fact, same battery V_{CC} provide dc Power for both base and collector.)

The Q-point or working condition is determined by V_{CC} together with R_B and R_C. The dc equation is $I_B \cong V_{BB}/R_B$ —neglecting V_{BE}

$I_C = \beta I_B$ and $V_{CE} = V_{CC} - I_C R_C$

Now, let us see what happens when an ac signal is applied at the input terminals of the circuit.

circuit operations:-

when positive half-cycle of the signal is applied.

(i) V_{BE} is increased because it is already positive w.r.t. the ground as per biasing rule.

(ii) It leads to increase in forward bias of base-emitter junction.

(iii) I_B is increased somewhat.

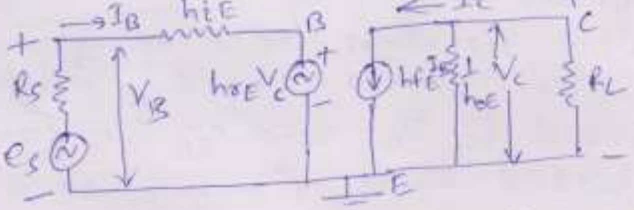
(iv) I_C is increased by β times the increased in I_B.

(v) Drop $I_C R_C$ is increased considerably consequently.

(vi) V_{CE} is decreased as seen from the equation given above.

Here, negative half-cycle of the output is obtained. It means that a positive-going input signal becomes a negative going output signal as in figure 2.

CE gain's using h-parameters:-



The hybrid equivalent circuit of CE amplifier is shown in figure. Here Rin has not been considered since it does not effect the a.c. operation, R_s is the internal resistance of the source.

The hybrid equations of the equivalent circuit are

$$V_B = h_{iE} I_B + h_{rE} V_C \quad \text{—(1)}$$
$$I_C = h_{fE} I_B + h_{oE} V_C \quad \text{—(2)}$$

$$V_B = e_s - I_B R_s \quad \text{--- (3)}$$
$$V_C = -I_C R_L \quad \text{--- (4)}$$

Substituting the value of V_C from equation (4) in (2).

$$I_C = h_{FE} I_B + h_{oE}(-I_C R_L)$$
$$I_C = \frac{h_{FE} I_B}{1 + h_{oE} R_L} \quad \text{--- (5)}$$

(i) Current gain:-

$$A_{iE} = \frac{\text{Output current}}{\text{Input current}} = \frac{I_C}{I_B}$$
$$A_{iE} = h_{FE}/1 + h_{oE} R_L \quad \text{--- (6)}$$

(ii) Input resistance:-

Substituting the value of V_C from (4) in (1)

$$V_B = h_{iE} I_B - h_{rE} I_C R_L$$

Now putting the value of I_C from equation (5)

$$V_B = h_{iE} I_B - \frac{h_{rE} h_{fE} I_B R_L}{1 + h_{oE} R_L} = I_B \left[h_{iE} - \frac{h_{rE} h_{fE} R_C}{1 + h_{oE} R_L} \right]$$

$\therefore$ Input resistance $R_{iE} = \frac{V_B}{I_B} = h_{iE} - \frac{h_{rE} h_{fE} R_L}{1 + h_{oE} R_L}$ --- (7)

(iii) Voltage gain:-

$$A_{VE} = \frac{\text{Output voltage}}{\text{Input voltage}} = -\text{Current gain} \times \frac{R_C}{R_{iE}}$$

$= -\frac{A_{iE} R_L}{R_{iE}}$. Here (−) sign shows that the output voltage in phase opposite to the input voltage.

Substituting the values of A_{iE} and R_{iE} from (6) and (7) we get

$$A_{VE} = \frac{-h_{fE}}{1 + h_{oE} R_L} \times \frac{R_L}{h_{iE} - \frac{h_{rE} h_{fE} R_L}{1 + h_{oE} R_L}} = \frac{-h_{fE} R_L}{h_{iE}(1 + h_{oE} R_L) - h_{rE} h_{fE} R_L}$$

$$= \frac{-h_{fE} R_L}{h_{iE}(1 + h_{oE} R_L) - h_{rE} h_{fE} R_L} = \frac{-h_{fE} R_L}{h_{iE} + (h_{iE} h_{oE} - h_{rE} h_{fE}) R_L} \quad \text{--- (8)}$$

(iv) Power gain:- voltage gain x current gain

$$A_{PE} = |A_{VE}| \times |A_{iE}|$$

$$= \frac{h_{fE}R_L}{h_{iE} + (h_{iE}h_{oE} - h_{rE}h_{fE})R_L} \times \frac{h_{fE}}{1 + h_{oE}R_L} = \cancel{h_{fE}^2 R_L}$$

$$= \frac{h_{fE}^2 R_L}{\{h_{iE} + (h_{iE}h_{oE} - h_{rE}h_{fE})R_L\} \times (1 + h_{oE}R_L)} \quad (9)$$

(v) Output resistance:-

$$R_{oE} = \frac{\text{Output voltage}}{\text{input current}} = \frac{V_c}{I_c}$$ (when input

Signal source e_s is replaced by its internal resistance R_S and the voltage source V_c is applied at the output terminal instead of load R_L). Then $V_C = (I_c - h_{fE}I_B) \times \frac{1}{h_{oE}}$ (since h_{oE} is the output admittance, so output impedance $= \frac{1}{h_{oE}}$).

and $I_B = \frac{-h_{rE}V_c}{h_{iE} + R_S}$, on solving these equation,

$$h_{oE}V_c = I_c + \frac{h_{fE}h_{rE}V_c}{h_{iE} + R_S} = \frac{I_c}{h_{oE} - \frac{h_{fE}h_{rE}}{h_{iE} + R_S}}$$

Hence output resistance $R_{oE} = \frac{1}{h_{oE} - \frac{h_{fE}h_{rE}}{h_{iE} + R_S}}$

$$= \frac{h_{iE} + R_S}{h_{oE}(h_{iE} + R_S) - h_{fE}h_{rE}}$$