Solutions to Tutorial Sheet-9 IEC103

Q1. Determine the dc current gain β_{DC} and emitter current I_E of a transistor whose $I_B = 50\,\mu A$ and $I_C = 3.65\,mA$

Sol.

$$\beta_{DC} = \frac{I_C}{I_B} = \frac{3.65\,mA}{50\,\mu A} = \frac{3.65}{50} \times 10^3 = 73$$

$$I_E = I_C + I_B = 3.65\,mA + 50\,\mu A$$

$$= 3.65 + 0.05\,mA$$

$$= 3.7\,mA$$

Q2 Sketch an ideal family of collector curves for the circuit shown in Fig. Q2a) for $I_B = 5\mu A$ to $25\mu A$ in $5\mu A$ increments. Assume $\beta_{DC} = 100$ and that V_{CE} does not exceed breakdown.

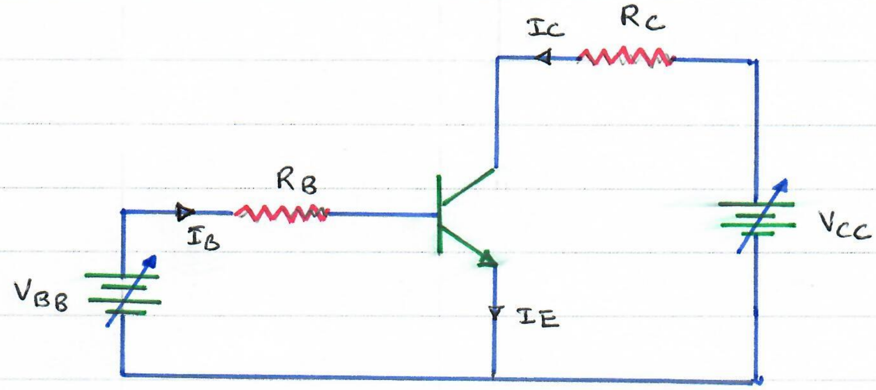

Fig. Q2a)

Sol. Using the relationship $I_C = \beta_{DC} I_B$ values of I_C are calculated and tabulated in the Table below. The resulting curves are plotted in Fig. Q

I_B	I_C
$5\mu A$	0.5mA
$10\mu A$	1.0mA
$15\mu A$	1.5mA
$20\mu A$	2.0mA
$25\mu A$	2.5mA

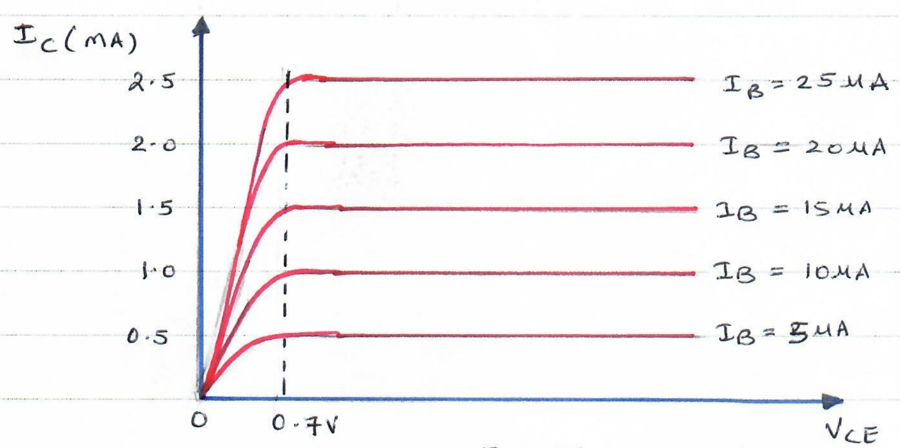

Fig. Q2b)

(Q3) Determine the values of I_B, I_C, I_E, V_{BE}, V_{CE} and V_{CB} in the circuit shown in Fig. Q below. The transistor is a silicon transistor with $\beta_{dc} = 150$.

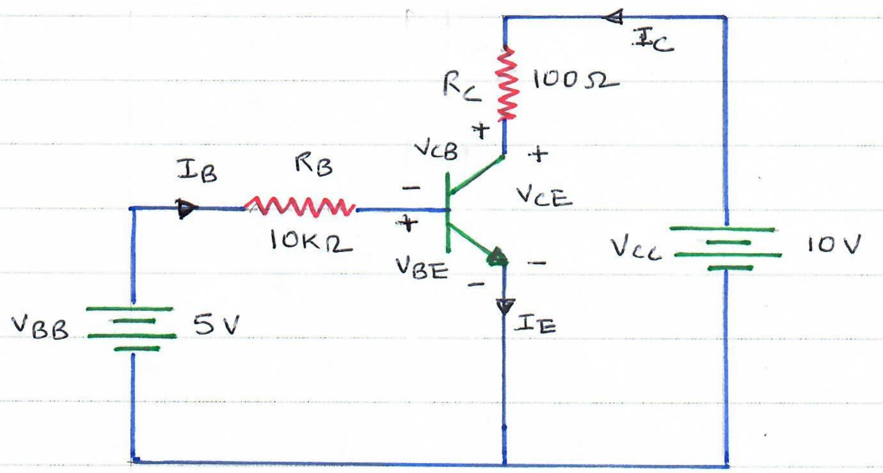

Fig. Q

Sol.

$$I_B = \frac{V_{BB} - V_{BE}}{R_B} = \frac{5 - 0.7}{10K} = \frac{4.3}{10} \text{ mA} = 0.43\text{ mA}$$

$$I_C = \beta_{DC} I_B = 150 \times 0.43 \text{ mA} = 64.5\text{ mA}$$

$$I_E = I_C + I_B = 64.5 + 0.43 \text{ mA} = 64.93\text{ mA}$$

$$V_{BE} = 0.7\text{V}$$

$$-V_{CC} + I_C R_C + V_{CE} = 0$$

$$\Rightarrow V_{CE} = V_{CC} - I_C R_C = 10 - 64.5 \times 10^{-3} \times 100 = 3.55\text{V}$$

$$V_{CB} = V_{CE} - V_{BE} = 3.55 - 0.7 = 2.85\text{ V}$$

(Q4) For the transistor circuit shown in Fig. Q4, find

i) V_{CB}, Is collector base junction forward or reverse biased

ii) Power consumed by transistor.

Neglect leakage current.

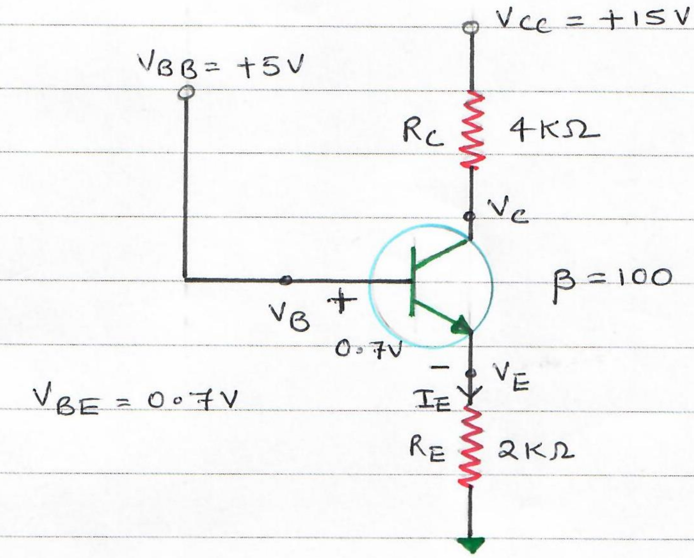

Fig. Q4

Sol.

i)

$$V_B = V_{BE} + I_E R_E$$

$$= 0.7 + I_E \times 2 \times 10^3 = 5$$

$$\Rightarrow I_E = \frac{5-0.7}{2} \text{ mA} = \frac{4.3}{2} = 2.15 \text{ mA}$$

$$\beta = \frac{\alpha}{1-\alpha} \quad \Rightarrow \quad \alpha = \frac{\beta}{1+\beta} = \frac{100}{101}$$

$$I_C = \alpha I_E = \frac{100}{101} \times 2.15 \text{ mA} = \frac{215}{101} \text{ mA} = 2.1287 \text{ mA}$$

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

$$= 15 - \frac{215}{101} \times 10^{-3} \times 4 \times 10^3$$

$$= 15 - \frac{860}{101} = 6.4851 \text{ V}$$

$$V_{CB} = V_C - V_B = 6.4851 - 5 = 1.4851$$

The transistor is an NPN transistor. Collector is at higher potential than base, so the collector-base junction is reverse biased.

ii) Power dissipated by the transistor is difference between the input power by the supplies and the power dissipated by resistors.

$$P_{transistor} = P_{supply} - P_{resistors}$$

$$P_{supplied} = V_{BB} I_B + V_{CC} I_C$$

$$I_B = \frac{I_C}{\beta} = \frac{\left(\frac{215}{101}\right)}{100} \text{ mA} = \frac{215}{101 \times 100} \text{ mA}$$

$$= 21.287\ \mu A$$

$V_{BB} = 5V$; $V_{CC} = 15V$; $I_B = 21.287\ \mu A$; $I_C = 2.1287$ mA

$$P_{supplied} = 5 \times 21.287 \times 10^{-6} + 15 \times 2.1287 \times 10^{-3}$$

$$= 0.032037 \text{ W}$$

$$P_{resistors} = I_C^2 R_C + I_E^2 R_E$$

$$= (2.1287 \times 10^{-3})^2 \times 4 \times 10^3 + (2.15 \times 10^{-3})^2 \times 2 \times 10^3$$

$$= 4.5314 \times 10^{-6} \times 4 \times 10^3 + 4.6225 \times 10^{-6} \times 2 \times 10^3$$

$$= 18.126 \times 10^{-3} + 9.245 \times 10^{-3}$$

$$= 27.37 \times 10^{-3} = 0.027371 \text{ W}$$

$$P_{transistor} = P_{supplied} - P_{resistors}$$

$$= 0.032037 - 0.027371$$

$$= 0.004666 \text{ W}$$

$$= 4.666 \text{ mW}$$