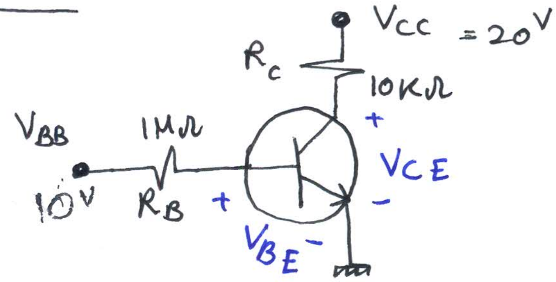
Ch.5 HW Soln.

[6] $I_B = 20\,\mu A$, $\beta_{DC} = 50$

$V_{BB} = ?$, Q-point : $V_{CE}, I_C = ??$



$\because$ $V_{BB} = V_{BE} + I_B R_B$

$= 0.7 + 20*10^{-6}*1*10^{6}$ $\therefore$ $\boxed{V_{BB} = 20.7\ V}$

$\because$ $I_C = \beta_{DC} I_B = 50 * 20\,\mu A$ $\therefore$ $\boxed{I_C = 1\,mA}$

$= 1000\,\mu A$

$\because$ $V_{CE} = V_{CC} - I_C R_C$ $\therefore$ $\boxed{V_{CE} = 10^V}$

$= 20 - 1*10^{-3} * 10*10^{3}$

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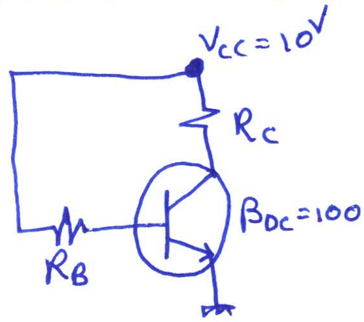
[7] $V_{BB} = V_{CC} = 10$, $I_C = 5mA$, $V_{CE} = 4^V$, $\beta_{DC} = 100$

R_B? R_C? P_{min}?

Assume a base-biased-transistor circuit:



$\because$ $V_{CE} = V_{CC} - I_C R_C$ $\therefore$ $R_C = \dfrac{V_{CE} - V_{CE}}{-I_C} = \dfrac{4 - 10}{-5*10^{-3}}$

$\therefore$ $\boxed{R_C = 1.2\,K\Omega}$

$\because$ $V_{BC} = V_{BE} + I_B R_B = V_{BE} + \dfrac{I_C}{\beta_{DC}} R_B$

$\therefore$ $R_B = \beta_{DC} \dfrac{V_{CC} - V_{BE}}{I_C} = 100 \dfrac{10 - 0.7}{5*10^{-3}}$ $\therefore$ $\boxed{R_B = 186\ K\Omega}$

$\because$ minimum diss Power $= P_{min} = V_{CE} I_C = 4^V * 5\,mA$ $\therefore$ $\boxed{P_{min} = 20\,mW}$

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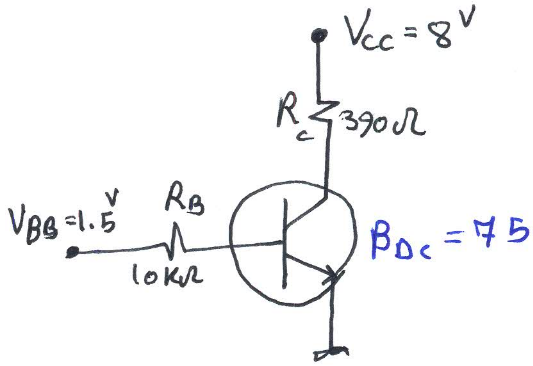
$\because I_{c(sat)} = \dfrac{V_{cc}}{R_c} = \dfrac{8^V}{390\Omega}$



$\therefore I_{c(sat)} = 20.5\ mA$

$\because V_{BB} = V_{BE} + I_B R_B$

$\therefore I_B = \dfrac{V_{BB} - V_{BE}}{R_B} = \dfrac{1.5 - 0.7}{10\,k} = 0.08\ mA = 80\ \mu A$

if transistor were in ~~dl~~ linear region :-

$I_c = \beta_{DC} I_B = 75 \times 80\ \mu A = 6000\ \mu A$

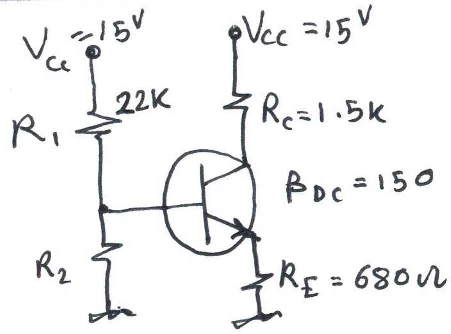
$\therefore I_c = 6\ mA$

as $0 < 6\ mA < I_{c(sat)} = 20.5$

cut-off ⟶ 0   ← sat.

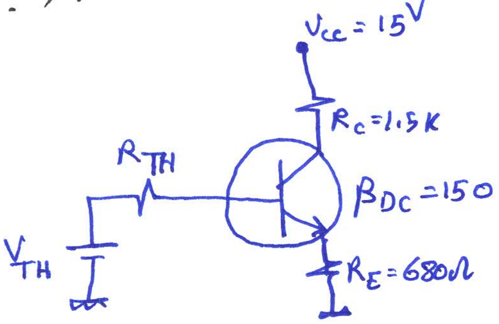
$\therefore$ The transistor is biased in linear region

$\boxed{12}$ $R_2|_{min}$?? , for saturation



$R_{TH} = R_1 // R_2$

$= \dfrac{R_1 R_2}{R_1 + R_2}$



$V_{TH} = \dfrac{V_{cc} R_2}{R_1 + R_2} = \dfrac{V_{cc}}{R_1}\left(\dfrac{R_1 R_2}{R_1 + R_2}\right) = V_{cc}\dfrac{R_{TH}}{R_1}$

$\because V_{TH} = I_c R_E + V_{BE} + I_B R_{TH}$

$\therefore \dfrac{V_{cc}}{R_1} R_{TH} = I_c R_E + V_{BE} + \dfrac{I_c}{\beta_{DC}} R_{TH}$

$\therefore R_{TH}\left(\dfrac{V_{cc}}{R_1} - \dfrac{I_c}{\beta_{DC}}\right) = I_c R_E + V_{BE}$

or $R_{TH} = \dfrac{I_c R_E + V_{BE}}{\dfrac{V_{cc}}{R_1} - \dfrac{I_c}{\beta_{DC}}}$

$$\therefore \quad I_{E(sat)} = \frac{V_{CC}}{R_C + R_E} = \frac{15}{1.5*10^3 + 680} \simeq 6.88 \text{ mA}$$

$$\therefore \quad R_{TH} = \frac{6.88*10^{-3} * 680 + 0.7}{\frac{15}{22*10^3} - \frac{6.88*10^{-3}}{150}}$$

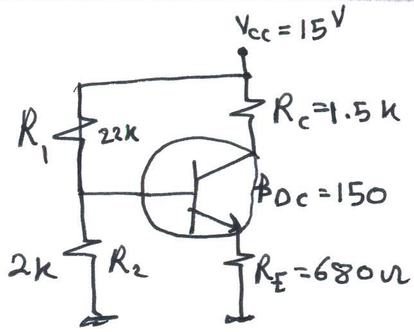
$$\therefore \quad R_{TH} \simeq 8.457 \text{ K}\Omega$$

$$\therefore \quad \because R_{TH} = R_1 // R_2 \quad \therefore \frac{1}{R_{TH}} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\therefore \quad R_2 = \frac{1}{\frac{1}{R_{TH}} - \frac{1}{R_1}} = \frac{1}{\frac{1}{8.457K} - \frac{1}{22K}}$$

$$\therefore \quad \boxed{R_2|_{min} \simeq 13.74 \text{ K}\Omega}$$

$\boxed{13}$ I_C ? V_{CE} ?



$$V_{TH} = \frac{R_2}{R_1 + R_2} V_{CC} = \frac{2}{22+2} * 15$$

$$\therefore \quad V_{TH} = 1.25 V$$

$$R_{TH} = R_1 // R_2 = \frac{R_1 R_2}{R_1 + R_2} = \frac{2*22}{22+2} = \frac{11}{6} \text{ K}\Omega$$

$$\because \quad V_{TH} = I_E R_E + V_{BE} + I_B R_{TH}$$

$$\simeq I_C R_E + V_{BE} + I_C R_{TH} / \beta_{DC}$$

$$\therefore \quad I_C = \frac{V_{TH} - V_{BE}}{R_E + \frac{R_{TH}}{\beta_{DC}}} = \frac{1.25 - 0.7}{680 + \frac{11/6*10^3}{150}}$$

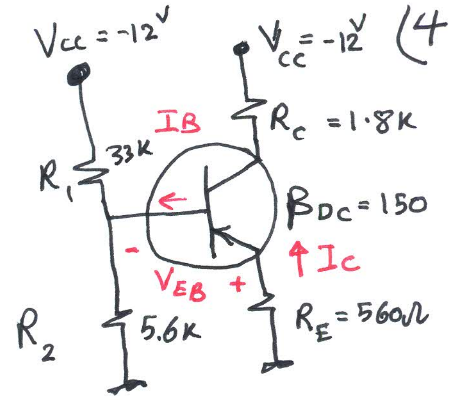
$$\therefore \quad \boxed{I_C \simeq 794.5 \mu A}$$

$$\because \quad V_{CE} = V_{CC} - I_C (R_C + R_E)$$

$$= 15 - 794.5*10^{-6} (1.5*10^3 + 680)$$

$$\therefore \quad \boxed{V_{CE} \simeq 13.27 V}$$

17 a) $V_{TH} = \frac{V_{CC} R_2}{R_1 + R_2} = \frac{-12 * 5.6K}{33K + 5.6K} \simeq -1.74^V$ (4



$R_{TH} = \frac{R_1 R_2}{R_1 + R_2} = \frac{33K * 5.6K}{38.6K} \simeq 4.79\,K\Omega$

$V_{TH} = -I_B R_{TH} - V_{EB} - I_E R_E$

$\simeq -\frac{I_C}{\beta_{DC}} R_{TH} - V_{EB} - I_C R_E$

$\therefore I_C = \frac{-V_{TH} - V_{EB}}{R_E + \frac{R_{TH}}{\beta_{DC}}} = \frac{1.74 - 0.7}{560 + \frac{4.79 * 10^3}{150}} \simeq 1.76\ mA$

$\therefore \boxed{I_C = 1.76\ mA}$

$V_{CE} = V_C - V_E = (V_{CC} + I_C R_C) - (-I_C R_E) = V_{CC} + I_C (R_C + R_E)$

$= -12 + 1.76 * 10^{-3} (1.8 * 10^3 + 560)$

$\therefore \boxed{V_{CE} = -7.85^V}$

b) $P_{D(min)} = I_C V_{EC} = |I_C V_{CE}| = |1.76mA * -7.85|$

$\therefore \boxed{P_{D(min)} = 13.81\ mW}$

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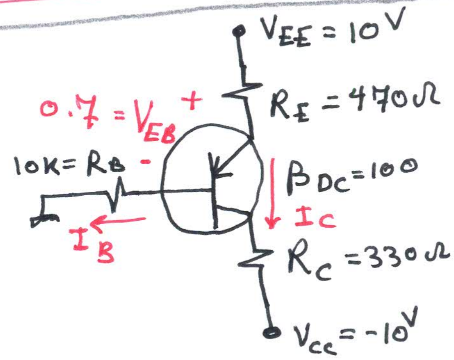
23 I_C, V_{CE} ??



$V_{EE} = I_E R_E + V_{EB} + I_B R_B$

$\simeq I_C R_E + V_{EB} + I_C \frac{R_B}{\beta_{DC}}$

$\therefore I_C = \frac{V_{EE} - V_{EB}}{R_E + \frac{R_B}{\beta_{DC}}} = \frac{10 - 0.7}{470 + \frac{10 * 10^3}{100}}$

$\therefore \boxed{I_C \simeq 16.32\ mA}$

$V_{CE} = (V_{CC} + I_C R_C) - (-I_C R_E + V_{EE})$

$= V_{CC} - V_{EE} + I_C (R_C + R_E)$

$= -10 - (10) + 16.32 * 10^{-3} (330 + 470)$

$\therefore \boxed{V_{CE} = -6.94^V}$

$\boxed{24}$ V_B ?, V_C ?, I_C ?

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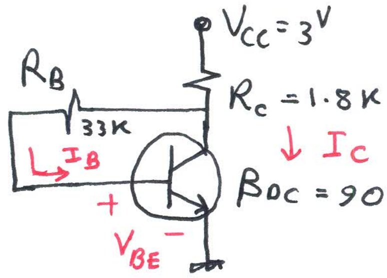

as $V_{BE} = 0.7$, $V_E = 0^V$

$\therefore V_B = V_{BE} - V_E = \underline{0.7^V}$

$\because V_{CC} = (I_C + I_B) R_C + I_B R_B + V_{BE}$

$\simeq I_C R_C + \frac{I_C}{\beta_{DC}} R_B + V_{BE}$

$\therefore I_C = \frac{V_{CC} - V_{BE}}{R_C + R_B/\beta_{DC}} = \frac{3 - 0.7}{1.8 * 10^3 + \frac{33 * 10^3}{90}}$

$\therefore \boxed{I_C \simeq 1.06 \text{ mA}}$

$\because V_C = V_{CE} = V_{CC} - (I_C + I_B) R_C$

$\simeq V_{CC} - I_C R_C$

$= 3 - 1.06 * 10^{-3} * 1.8 * 10^3$

$\boxed{\therefore V_C = 1.09 V}$