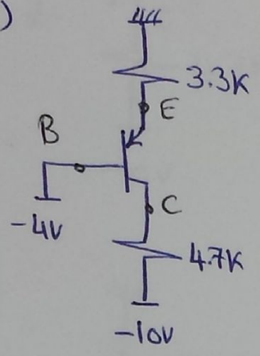
# BJT DC Analysis

## Problem 1:

$V_{BE} = V_{EB} = 0.7V$ , $\beta = 50$

(a)




Assume active:

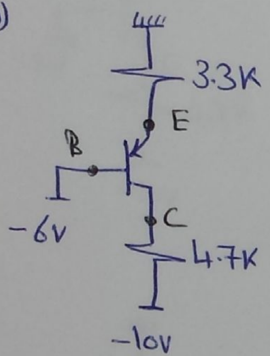
$V_B = -4V \rightarrow V_E = -3.3V$

$I_E = \frac{0-(-3.3)}{3.3K} = 1mA$ , $I_B = I_E/(\beta+1) = 19.6\mu A$

$I_C = \beta I_B = 0.98mA \rightarrow V_C = -5.39V$

$V_{EC} = 2.09 > 0.2 \rightarrow$ Assumption Correct

(b)




Assume active:

$V_B = -6V \rightarrow V_E = -5.3V$

$I_E = \frac{0-(-5.3)}{3.3K} = 1.6mA$ , $I_B = 31.5\mu A$

$I_C = 1.57mA \rightarrow V_C = -2.6V$

$V_{EC} = -5.3 + 2.6 = -2.7 < 0.2V$

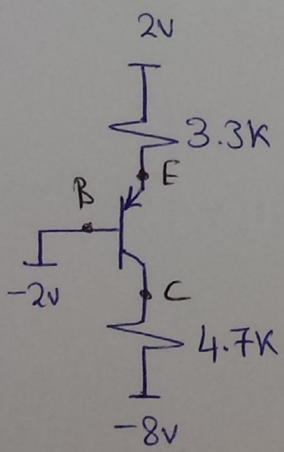
Assumption is wrong. Assume Saturation:

$V_B = -6V$ , $V_E = -5.3V$ , $V_C = -5.5V$

$I_C = 0.957mA$ , $I_E = 1.6mA \Rightarrow I_B = 0.64mA$

$I_C < \beta I_B \rightarrow$ Assumption right.

(c)



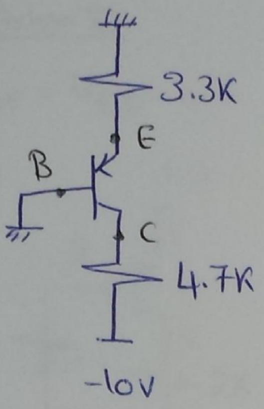

Assume active:

$V_B = -2V \rightarrow V_E = -1.3V$

$I_E = 1mA$ , $I_B = 19.6\mu A$

$I_C = 0.98mA$ , $V_C = -3.4V$

$V_{EC} = -1.3 + 3.4 = 2.1 > 0.2 \rightarrow$ Assumption Correct d)



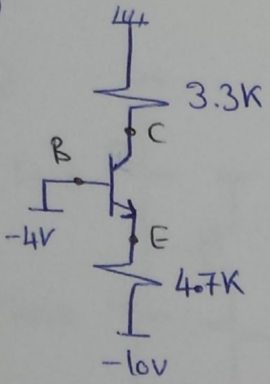

Assume active:

$V_B = 0 \rightarrow V_E = 0.7V$

$I_E = -0.212mA$

$\therefore$ The transistor is off

(e)




Assume active:

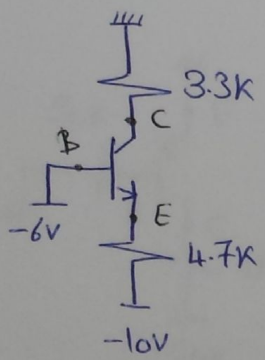
$V_B = -4V \rightarrow V_E = -4.7V$

$I_E = \frac{-4.7-(-10)}{4.7K} = 1.12mA$ $\quad\quad$ $I_B = 22\mu A$

$I_C = 1.1\ mA \rightarrow V_C = -3.64V$

$V_{CE} = -3.64-(-4.7) = 1.05 > 0.2V \rightarrow$ Assumption Correct

(f)




Assume active:

$V_B = -6V \rightarrow V_E = -6.7V$

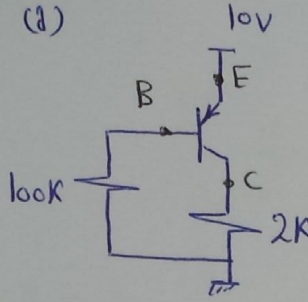
$I_E = 0.7mA \rightarrow I_B = 13\mu A$

$I_C = 0.68mA \rightarrow V_C = -2.27V$

$V_{CE} = 4.42V > 0.2V \rightarrow$ Assumption Correct roblem 2:

$U_{BE} = U_{EB} = 0.7$ , $\beta = 10$

(a)




Assume active:

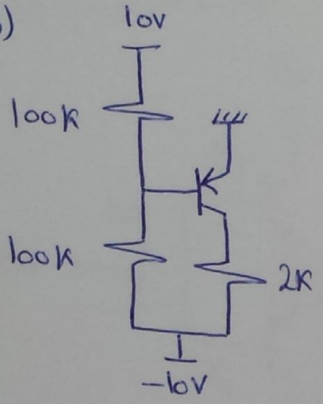
$U_E = 10v \rightarrow U_B = 9.3v$

$I_B = 93\mu A \rightarrow I_C = 930\mu A \rightarrow U_C = 1.86$

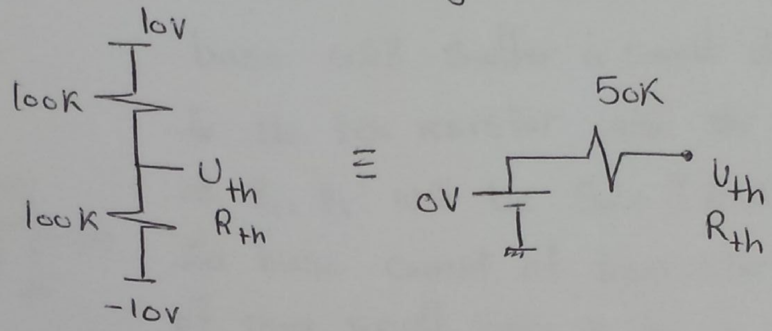
$I_E = 1.023 mA$

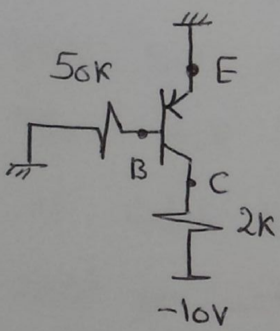
$V_{EC} = 8.14v > 0.2v$ Assumption Correct

(b)




Using Thivenin theory



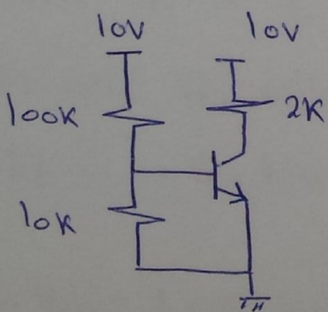

Assume active:

$U_E = 0 \rightarrow U_B = -0.7v$

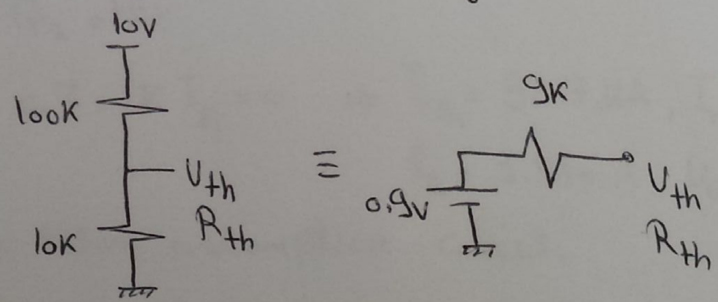
$I_B = -14\mu A$

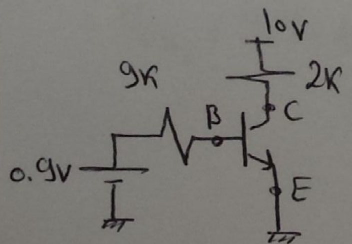
The transistor is off.

(C)




Using Thévenin theory



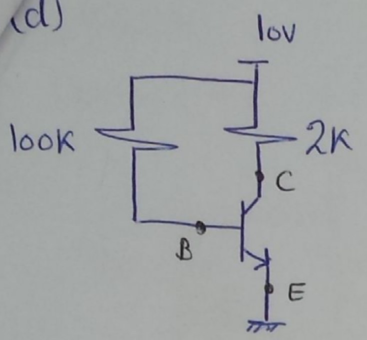




$U_B = 0.7v \rightarrow I_B = 22\mu A \rightarrow I_C = 220\mu A$

$U_C = 9.55v$ , $I_E = 242\mu A$

$V_{CE} = 9.55v > 0.2v \rightarrow$ Assumption Correct.

(d)




Assume active:

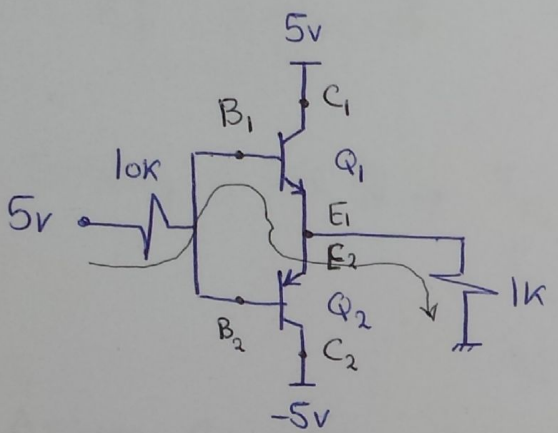
$V_B = 0.7V \rightarrow I_B = 93\mu A$

$I_C = 930\mu A \rightarrow V_C = 8.14V$

$V_{CE} = 8.14V > 0.2V \rightarrow$ Assumption Correct.

Problem 3:

$V_{BE} = V_{EB} = 0.7V$ , $\beta = 100$




In this problem the 5V supply at base will suffer a small drop due to the 10K resistor and the voltage at $B_1$, $B_2$ will be $5V - I(10K)$, with the base current of transistors being of very small value $\Rightarrow V_{B_1} = V_{B_2} = \underline{5V - \Delta V}$

With that $\Delta V$ of very small value $\rightarrow V_{E_1} = V_{E_2} = 5 - 0.7 - \Delta V$ (measuring from $Q_1$)
This will lead to $V_{E_1} = V_{E_2} = 4.3V - \Delta V$. This requires $V_{B_2}$ to be of value $4.3V - \Delta V - 0.7$ when going from $E_2$ to $B_2$ and that isn't what we actually measured at start! This means there must be either $Q_1$ or $Q_2$ off.

Assume $Q_1$ active, $Q_2$ off:

KVL: $-5 + 10K\, I_{B_1} + 0.7 + 1K\, I_{E_1} = 0 \Rightarrow I_{B_1} = 38.7\mu A$, $I_{C_1} = 3.87mA$

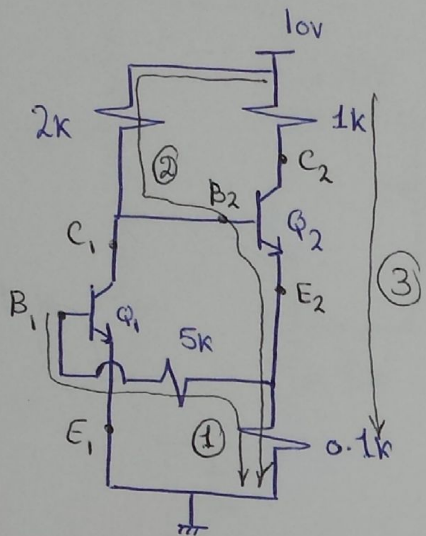
$I_{E_1} = 3.91mA$, $V_{E_1} = 3.9V$, $V_{B_1} = 4.6V$

$\therefore V_{CE_1} = 1.08V > 0.2V \rightarrow$ Active assumption correct.

$\therefore V_{EB_2} = 3.9 - 4.6 = -0.7V \rightarrow$ off assumption correct.

Problem 4:

$V_{BE} = 0.7v$ , $\beta = 50$




Assume $Q_1$, $Q_2$ active:

KVL @ loop 1:

$-0.7 - 5k I_{B_1} + 0.1k(I_{E_2} - I_{B_1}) = 0$

$-4.9k I_{B_1} + 0.1k I_{E_2} = 0.7 \rightarrow (1)$

KVL @ loop 2:

$-10 + 2k(I_{C_1} + I_{B_2}) + 0.7 + 0.1k(I_{E_2} - I_{B_1}) = 0$

$99.9k I_{B_1} + 0.14 I_{E_2} = 9.3 \rightarrow (2)$

Solving (1) and (2) $\rightarrow$ $I_{E_2} = 10.8mA$ , $I_{B_1} = 77.9\mu A$

$I_{C_2} = 10.6mA$

$V_{C_2} = -0.6v \rightarrow Q_2$ is not active

Assume $Q_1$ active, $Q_2$ saturation:

from KVL loop (2) $\rightarrow$ $99.9k I_{B_1} + 2k I_{B_2} + 0.1 I_{C_2} + 0.1 I_{B_2} = 9.3$

$99.9k I_{B_1} + 2.1k I_{B_2} + 0.1 I_{C_2} = 9.3 \rightarrow (3)$

KVL @ loop 3:

$-10 + I_{C_2}(1K) + 0.2 + 0.1k(I_{E_2} - I_{B_1}) = 0$

$1k I_{C_2} + 0.1k I_{C_2} + 0.1k I_{B_2} - 0.1k I_{B_1} = 10$

$1.1k I_{C_2} + 0.1k I_{B_2} - 0.1k I_{B_1} = 10 \rightarrow (4)$

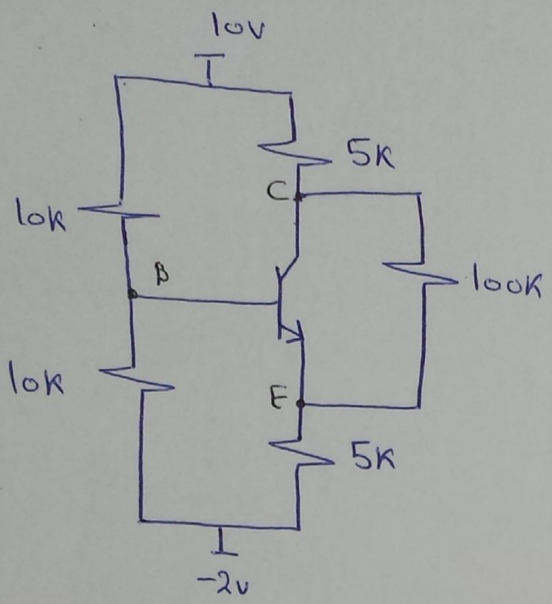
solving (1), (3), (4) $\rightarrow$ $I_{B_1} = 62.14\mu A$ , $I_{C_1} = 3.104mA$ , $I_{E_1} = 3.17mA$

$I_{B_2} = 1.04mA$ , $I_{C_2} = 9 mA$ , $I_{E_2} = 10.04mA$

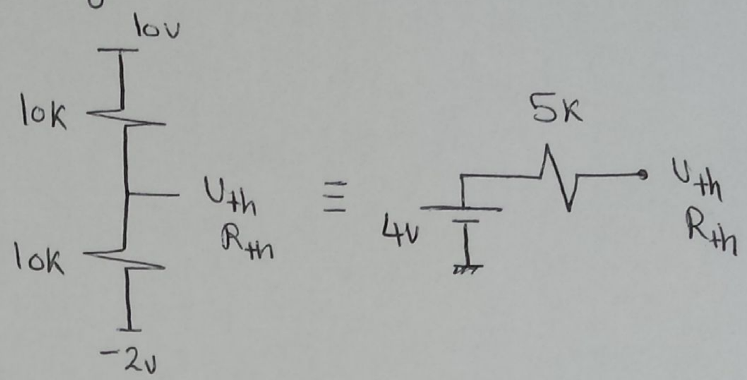
$V_{C_1} = 1.712v$ , $V_{B_1} = 0.7v$ , $V_{E_1} = 0V$ $\rightarrow$ $V_{CE_1} > 0.2v$ Assumption right

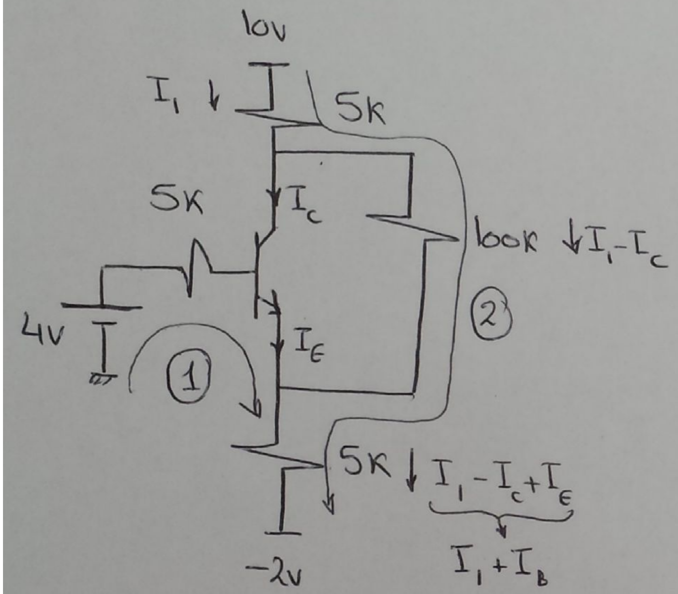
$V_{C_2} = 1v$ , $V_{B_2} = 1.71v$ , $V_{E_2} = 1v$ $\rightarrow$ $I_{C_2} < \beta I_{B_2}$ Assumption right

Problem 5: $(\beta = 100)$




Using Thivenen:




KVL @ loop 1:

$-4 + 5k\, I_B + 0.7 + 5k(I_1 + I_B) = 2 \rightarrow (1)$

KVL @ loop 2

$-10 + 5k\, I_1 + 100k(I_1 - I_c) + 5k(I_1 + I_B) = 2 \rightarrow (2)$

Solving (1), (2)

$I_1 = 1.04mA$ , $I_B = 10.2\mu A$ , $I_c = 1.02mA$

$V_c = 4.8v$ , $V_E = 3.25v$

$V_{CE} = 1.55v > 0.2v$

Assumption Correct.