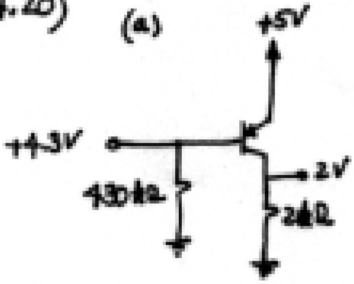
HW #4 Solution

4.20) (a)

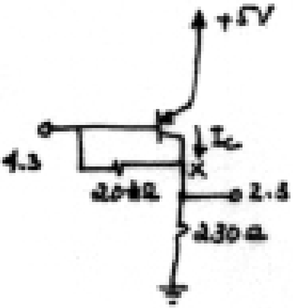


$I_C = \frac{2}{2k} = 1\,mA$

$I_B = \frac{4.3}{430k} = 0.01\,mA$

$\Rightarrow \beta = \frac{I_C}{I_B} = \frac{1}{0.01} = \boxed{100}$

P4.20 cnt'd) (b)



KCL on node X

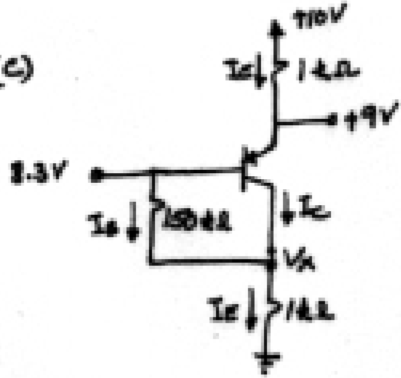
$I_C + \frac{4.3 - 2.3}{20k} = \frac{2.3}{230}$

$\Rightarrow I_C = 9.9\,mA$

$I_B = \frac{4.3 - 2.3}{20k} = 0.1\,mA$

$\Rightarrow \beta = \frac{I_C}{I_B} = \frac{9.9\,mA}{0.1\,mA} = \boxed{99}$

(c)



$I_E = \frac{10 - 9}{1k} = 1\,mA$

$I_E = I_B + I_C = \frac{V_x}{1k} = 1\,mA$

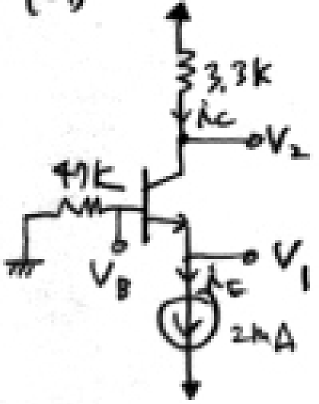
$\Rightarrow V_x = 1V$

$\Rightarrow I_B = \frac{8.3 - 1}{150k} = 48.7\,\mu A$

$I_C = I_E - I_B = 0.951\,mA$

$\beta = \frac{I_C}{I_B} = \boxed{19.5}$

4-35, (a)



$\beta=\infty \rightarrow \alpha=1 \rightarrow \begin{cases} i_B=0 \\ i_E=i_C \end{cases}$

Since $i_B=0$, no voltage drop at 47kΩ resistor.

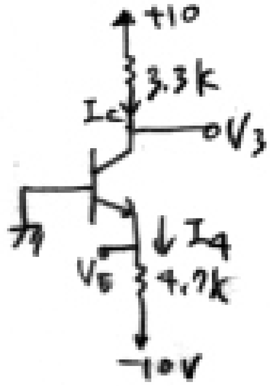
$\therefore V_B=0$

$\Rightarrow \boxed{V_1=-0.7V}$ ($\because V_{BE}=0.7V$)

$V_2 = 10-3.3K\times i_C$

$= 10-3.3K\cdot 2m = \boxed{3.4(V)}$ → check ($V_{BE}=0.7$, $V_{BC}=-3$

(b)



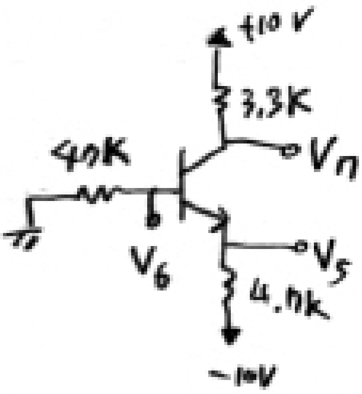
$V_{BE}=0.7 \rightarrow V_E=-0.7$ ($\because V_B=0$)

$I_4 = \dfrac{V_E-(-10)}{4.7K} = \boxed{2mA}$

$V_3 = 10-3.3K\cdot I_C = 10-3.3K\times 2m = \boxed{3.4V}$

→ ($V_{BE}=0.7>0$, $V_{BC}=-3.4<0$)

(c)



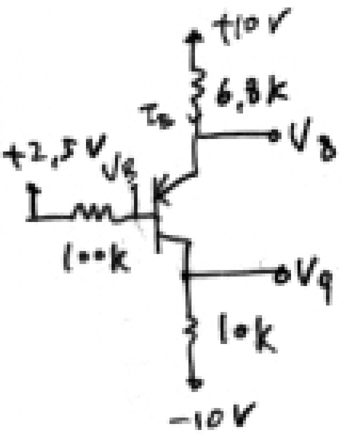
$\boxed{V_6=0}$ ($\because I_B=0$)

$\boxed{V_5=-0.7}$ ($\because V_{BE}=0.7V$)

$V_7 = 10-3.3K\cdot I_C = 10-3.3K\cdot 2m = \boxed{3.4V}$

($V_{BE}=0.7>0$, $V_{BC}=-3.4V<0$)

(d)



$V_B=2.5V \rightarrow \boxed{V_8=3.2V}$ ($\because V_{EB}=0.7$ in PNP)

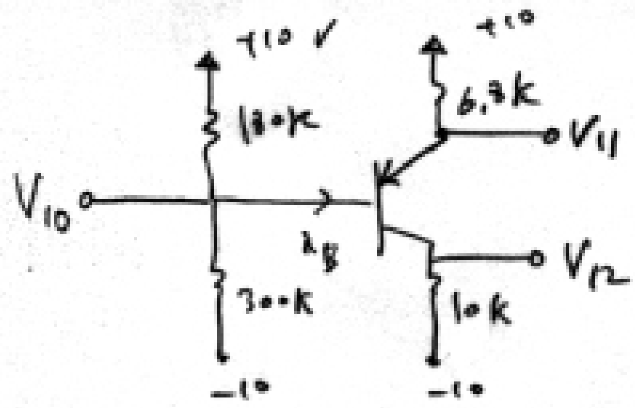
$I_E = \dfrac{10-3.2}{6.8K} = 1mA$

$V_9 = 1mA\times 10K - 10$

$= \boxed{0V}$

$\left(\begin{array}{l} V_{EB}=0.7>0 \\ V_{CB}=-2.5<0 \end{array} \right)$

(e)



since $i_B = 0$,

$$V_{10} = 20 \cdot \frac{300k}{180k + 300k} - 10$$

$$= \boxed{2.5V}$$

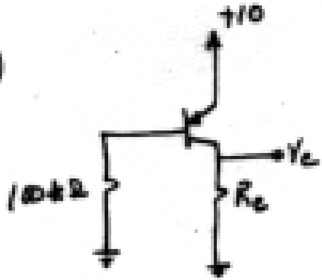
$$\boxed{V_{11} = 3.2V} \quad (\because V_{EB} = 0.7V)$$

$$V_{12} = \frac{10 - 3.2}{6.8k} \times 10k - 10$$

$$= \boxed{0V}$$

$(V_{EB} = 0.7 > 0,\ V_{CB} = -2.5 < 0)$

4.38)



$\beta = 50$; want $V_c = 5V$

$I_B = \frac{10-0.7}{100k} = \frac{9.3}{100k} = 0.093mA$

$I_c = \frac{V_c}{R_c} = \frac{5}{R_c}$

$I_c = \beta I_B \Rightarrow \frac{5}{R_c} = 50(0.093m)$

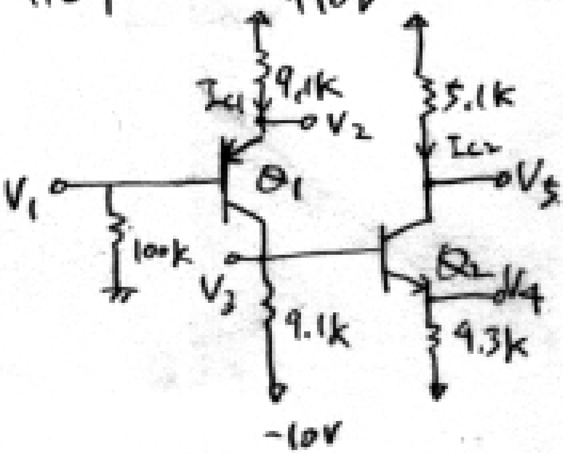
$\Rightarrow \boxed{R_c = 1.08k\Omega}$

if $\beta = 100 \Rightarrow I_c = 100(0.093m) = 9.3mA$

if $R_c = 1.08k\Omega \Rightarrow V_c = 9.3m(1.08k) = 10.04V$

$V_B = 9.3$, $V_c = 10.04 \Rightarrow V_c > V_B$, therefore transistor is in saturation region.

4.39



(a) $\beta = \infty \rightarrow i_B = 0$ & $i_E = i_C$

assume every BJT is in active.

$\boxed{V_1 = 0\,V}$ ($\because$ $i_B = 0$ so no Vdrop across 100kΩ resistor)

$\boxed{V_2 = 0.7V}$ ($\because$ $V_{EB} = 0.7$)

$$I_E = \frac{10 - 0.7}{9.1k} = 1.022\,mA$$

$$V_3 = 9.1k \cdot I_{C1} - 10 = \boxed{-0.7V}$$

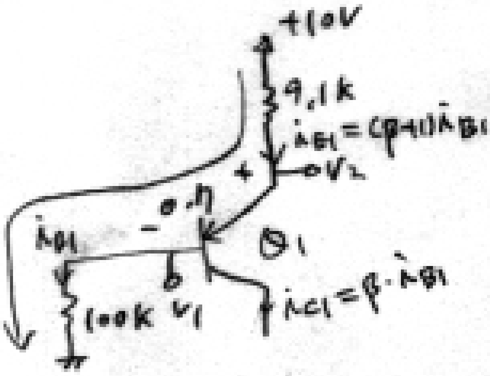
$\boxed{V_4 = -1.4V}$ ($\because$ $V_{BE} = 0.7V$)

$$V_5 = 10 - 5.1k \times I_{C2}, \quad I_{C2} = I_{E2} = \frac{-1.4 - (-10)}{4.3K}$$

$\therefore \boxed{V_5 = -0.2V}$ $\left(\begin{array}{l} V_{CB,Q_1} = V_3 - V_1 = -0.7 < 0 \\ V_{BC,Q_2} = V_3 - V_5 = -0.5 < 0 \end{array} \right)$

(b) $i_B \neq 0$, $i_C = \beta i_B$, $i_E = (\beta+1) i_B$, $\beta = 100$

KVL including B-E junction of Q_1 gives



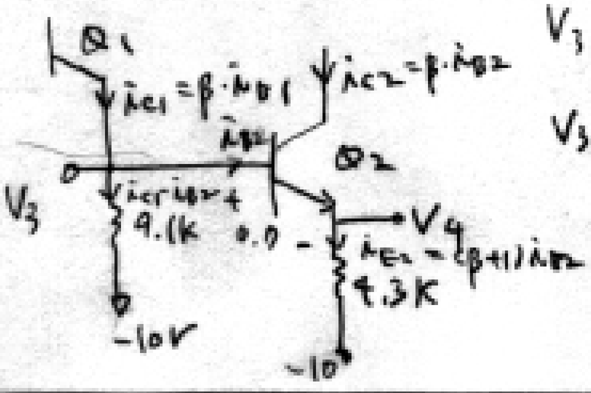
$$10 = 9.1k \cdot (\beta+1) i_{B1} + 0.7 + 100k \cdot i_{B1}$$

$$\therefore i_{B1} = \frac{10 - 0.7}{(\beta+1) \cdot 9.1k + 100k} = 9.1250\,\mu A \quad (\beta = 100)$$

$$V_1 = i_{B1} \times 100k = \boxed{0.9126\,(V)}$$

$$V_2 = 0.7 + V_1 = \boxed{1.6126\,(V)}$$

To find V_3, we notice that V_3 can be found in 2 ways.



$$V_3 = 9.1k \cdot (i_{C1} - i_{B2}) - 10V \quad ①$$

$$V_3 = 0.7 + i_{E2} \cdot 4.3k - 10V \quad ②$$

(continued 4.39 (b))

① = ② ⇒ $9.1K \cdot (\beta \cdot i_{B1} - i_{B2}) - \cancel{10V} = 0.7 + (\beta+1) i_{B2} \cdot 4.3K - \cancel{10V}$

$\Rightarrow i_{B2}((\beta+1)\cdot 4.3K + 9.1K) = 9.1K \cdot \beta \cdot i_{B1} - 0.7$

$\therefore i_{B2} = \dfrac{9.1K \cdot 100 \cdot 9.1257\mu - 0.7}{101 \cdot 4.3k + 9.1k} = 17.15\mu A$

$V_3 = (i_{C1} - i_{B2}) \cdot 9.1k - 10$

$= (100 \cdot 9.1257\mu - 17.15\mu) \cdot 9.1k - 10 = \boxed{-1.8517(V)}$

$V_4 = V_3 - 0.7 = \boxed{-2.5517(V)}$

$V_5 = 10 - 5.1K \cdot i_{C2} = 10 - 5.1K \cdot 100 \cdot 17.15\mu = \boxed{1.2534(V)}$

Finally, we check our assumption that Q_1, Q_2 are in active.

$V_{CB,Q1} = V_3 - V_1 = -2.7643 < 0$

$V_{BC,Q2} = V_3 - V_5 = -3.1051 < 0$

(c) Follow the same procedure in (b) except $\beta = 10$

$i_{B1} = 46.47\mu A$

$\boxed{V_1 = 4.6477}$

$\boxed{V_2 = 5.3477}$

$i_{B2} = 62.578\mu A$

$\boxed{V_3 = -6.3401}$

$\boxed{V_4 = -7.0401}$

$\boxed{V_5 = 6.8085}$

$V_{CB,Q1} = -10.98 < 0$

$V_{BC,Q2} = -13.14 < 0$