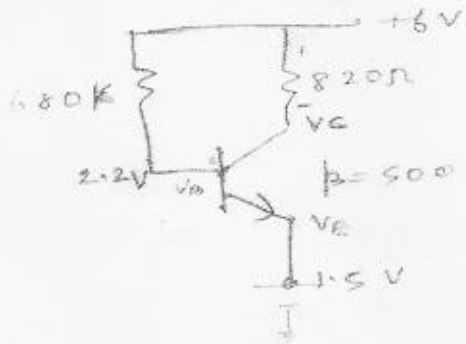
BJT

1(a)



$$I_B = \frac{6 - 2.2}{680\,K}$$

$$= 5.58\,\mu A$$

$$I_C = \beta I_B$$

$$= 500 \times 5.58\,\mu A$$

$$= 2.79\,mA$$

$$V_C = 6 - 820 \times 2.79 \times 10^{-3}$$

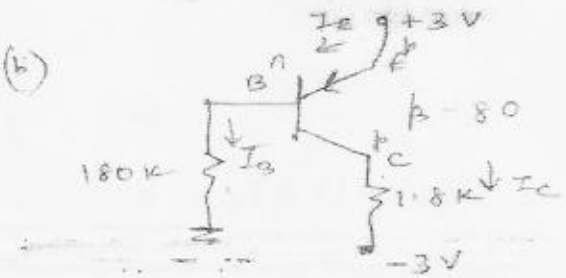
$$V_C = 3.708\,V$$

$$V_{CE} = 3.708 - 1.5$$

$$= 2.208\,V$$

$$(V_{CE}, I_C) = (2.208\,V, 2.79\,mA)$$

1(b)



$$V_B = 2.3\,V$$

$$I_B = \frac{2.3}{180\,K}$$

$$= 12.77\,\mu A$$

$$I_C = \beta I_B$$

$$= 1.02\,mA$$

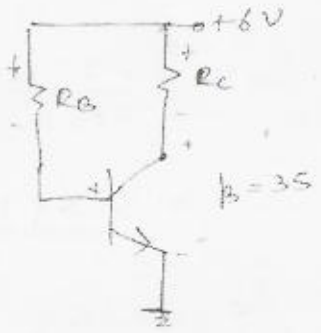
$$I_C = \frac{V_C - (-3)}{1.8\,K}$$

$$1.02\,mA \times 1.8\,K - 3 = V_C$$

$$V_C = -1.164\,V$$

$$V_{CE} = -4.164\,V$$

2.



$V_{CE} = 3V$

$I_C = 0.5mA$

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

$= 0.0143mA$

$6 - I_C R_C - V_{CE} = 0$

$6 - 0.5mA \times R_C - 3 = 0$

$0.5mA \times R_C = 3$

$R_C = \frac{3}{0.5} \times 10^3$

$R_C = 6K\Omega$

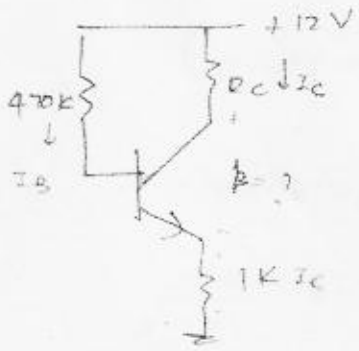
$6V - I_B R_B - 0.7 = 0$

$5.3 - I_B R_B$

$R_B = \frac{5.3}{0.0143} \times 10^3$

$R_B = 370.629K\Omega$

3.



$V_{CE} = 4V$

$I_C = 2mA$

R_C & β

$12 - I_C R_C - V_{CE} - 1K \times I_E = 0$

$12 - 470K \times I_B - 0.7 - 1K \times I_E = 0$

$I_C = \beta I_B = 2mA$

$I_B = \frac{2mA}{\beta}$

$I_E = (\beta + 1) I_B$

$= \left(\frac{\beta+1}{\beta}\right) 2mA$

$12 - 2mA \times R_C - 4 - 1K \times \left(\frac{\beta+1}{\beta}\right) 2mA = 0$

$12 - 470K \times \frac{2mA}{\beta} - 0.7 - 1K \times \left(\frac{\beta+1}{\beta}\right) 2mA = 0$

$8 - 2mA \times R_C - 2\left(\frac{\beta+1}{\beta}\right) = 0$

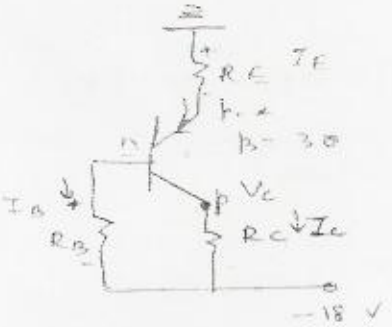
$8 - 2mA \times R_C - 2 \times \left(\frac{101.86}{100.86}\right) = 0$

$11.3 - \frac{940}{\beta} - 2\left(\frac{\beta+1}{\beta}\right) = 0$

$8 - 2 \times \left(\frac{101.86}{100.86}\right) = 2mA \times R_C$

$11.3\beta - 940 - 2\beta - 2 = 0$

4.



$V_{CE} = -8V$

$I_C = 2mA$

$V_C = -12V$

$$\frac{V_C - (-18)}{R_C} = I_C$$

$$R_C = \frac{V_C + 18}{2\ mA}$$

$$= \frac{6}{2\ mA} = 3K\Omega$$

$$I_B = \frac{2}{30}\ mA = 0.0666mA$$

$I_E = 2.066mA$

$$-I_E R_E - 0.7 - I_B R_B + 18 = 0$$

$V_{CE} = V_C - V_E$

$-8 = -12 - V_E$

$V_E = -4V$

$$R_E = \frac{0-(-4)}{I_E} = \frac{4}{2.066mA}$$

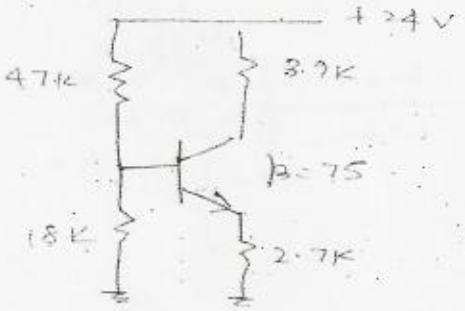
$= 1.94K\Omega$

$$-2.066\times10^{-3}\times1.936\times10^{3} - 0.7 - 0.0666\times10^{-3}\times R_B + 18 = 0$$

$$13.3 = 0.0666\times10^{-3}\times R_B$$

$R_B = 199.7K\Omega$

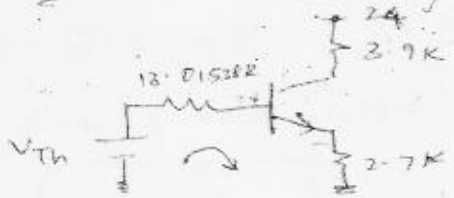
5.



$$V_{Th} = \frac{24\times18}{47+18}$$

$= 6.646V$

$R_{Th} = 13.01538K$



$6.646 - 13.01538\,K \times I_B - 0.7 - 2.7K \times 76 \times I_B = 0$

$5.746 = I_B(13.01538 + 205.2\,K)$

$\boxed{I_B = 27.25\,\mu A}$

$I_C = 2.043\,mA$

$I_E = 2.071\,mA$

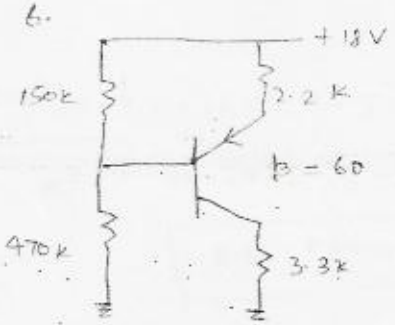
$24 - I_C R_C - V_{CE} - I_E R_E = 0$

$V_{CE} = 24 - 2.043mA \times 3.9\times10^3 - 2.071\times10^{-3}\times2.7K$

$\boxed{V_{CE} = 10.4406V}$

$\boxed{(V_{CE}, I_C) = (10.44V, 2.043mA)}$

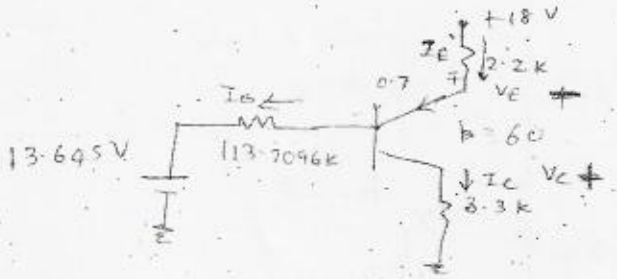
6.



$V_{Th} = \frac{18 \times 470}{(470 + 150)}$

$= 13.645V$

$R_{Th} = 113.7096K$

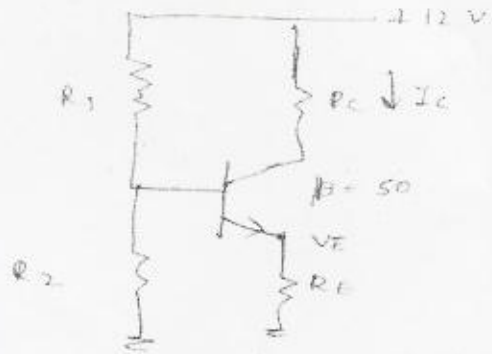


$18 - I_E \times 2.2K - 0.7 - 113.7096K \times I_B - 13.645V = 0$

$3.655 = (61 \times 2.2K + 113.7096K)\, I_B$

$\boxed{I_B = 14.74\,\mu A}$ $I_E = 0.9\,mA$

7.



$V_{CE} = 4\ V$

$I_C = 1.5\ mA$

$R_E = 1.5\ K$

$V_E = I_E R_E$

$V_E = \frac{I_C}{\beta}(\beta+1) \times 1.5\ K$

$= 1.5 \times 1.5 \times \frac{51}{50}$

$\boxed{V_E = 2.295\ V}$

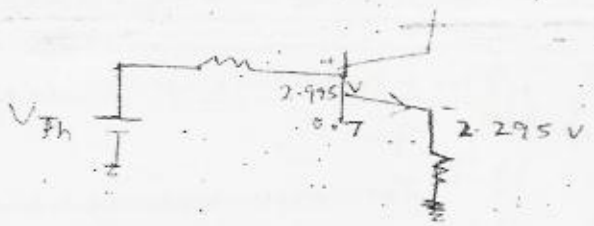
$V_{CE} = 4 = V_C - V_E$

$\boxed{V_C = 6.295\ V}$

$I_C = \frac{12 - 6.295}{R_C}$

$R_C = \frac{12 - 6.295}{1.5\ mA}$

$\boxed{R_C = 3.803\ K}$



$R_B = \frac{R_1 R_2}{R_1 + R_2}$

$I_B = \frac{V_{th} - 2.995}{R_B}$

$\boxed{I_B = 30\ \mu A}$

Assume $R_B = 100\ K$

$I_B \times \frac{R_1 R_2}{R_1 + R_2} = \frac{12 \times R_2}{R_1 + R_2} - 2.995$

$30\ \mu A \times 100\ K + 2.995 = V_{th}$

$\boxed{V_{th} = 5.995\ V}$

$$100K = \frac{R_1 R_2}{R_1 + R_2}$$

$$5.995 = \frac{12 R_2}{R_1 + R_2}$$

$$5.995 = \frac{12 R_2}{R_1 + R_2}$$

$$R_1 + R_2 = \frac{12 R_2}{5.995}$$

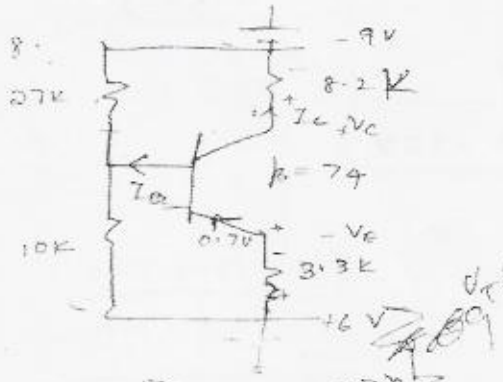
$$R_1 + R_2 = \frac{R_1 R_2}{100K}$$

$$100K = \frac{R_1 R_2}{12 R_2} \times 5.995$$

$$R_1 = \frac{100K \times 12}{5.995}$$

$R_1 = 200.166 K\Omega$

$R_2 \simeq 200\ K\Omega$

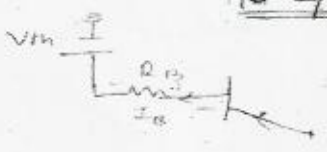


$$R_B = \frac{10 \times 27}{37} = 7.297\ K\Omega$$

$I_E = 75 I_B$

$$V_{th} = \frac{+15 \times 27}{37}$$

$V_{th} = 10.9\ V$



$-9\ V + 8.2K \times I_C - V_{CE} + 3.3K \times I_E - 6V = 0$

$V_{CE} = -15 + 8.2K \times I_C + 3.3K I_E$

$V_{th} + I_B \times 7.297K + 0.7V - 6V + 3.3K I_E = 0$

$\frac{10}{37} \times -9 - \frac{27}{37} \times +6 = I_B$

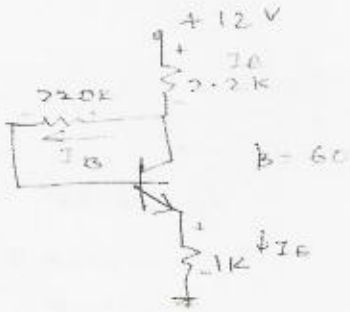
$I_B = 36.7\ \mu A$

$I_C = 2.715\ mA$

$I_E = 2.752\ mA$

$V_{CE} = -15 + 8.2K \times 2.715\ mA + 3.3K \times 2.75$

Q.



$12 - I_B \times 220K - 0.7 - 6I_B = 0$

$11.3 = I_B(220K + 6)$

$I_B = 40.21\,\mu A$

$I_C = 2.4128\,mA$

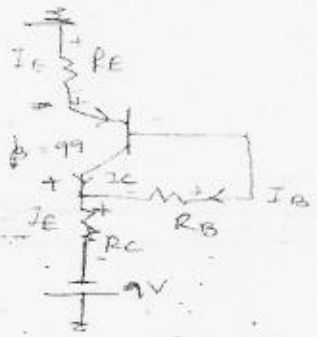
$I_E = 2.453\,mA$

$12 - 2.2K \times 2.453 - V_{CE} - 1K \times 2.453 = 0$

$V_{CE} = 12 - 2.2 \times 2.453 - 2.453$

$V_E = 4.15V$

10.



$-I_E R_E - 0.7 - I_B R_B - I_E R_C + 9 = 0$

$8.3 = 100 I_B \times R_C + I_B R_B + 0.7$

$-I_E R_E + V_{CE} - I_E R_C + 9V = 0$

$V_{CE} = 3V$ $\quad I_C = 1.98\,mA$ $\quad I_B = 20\,\mu A$ $\quad I_E = 2mA$

$V_E = -3V$

$R_E = \frac{0 - V_E}{2} = \frac{3}{2mA} = 1.5k\Omega$

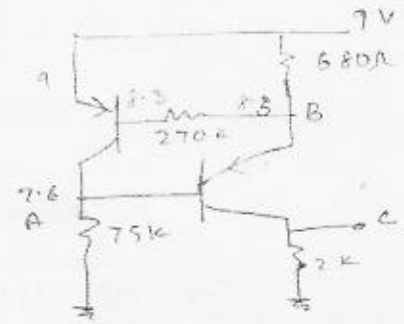
$-2 \times 10^{-3} \times 1.5K + (-3V) - 2mA \times R_C = 0$

$3 = 2mA \times R_C$

$R_C = 1.5K\Omega$

$8.3 = 100 \times 20\mu A \times 1.5K + 20\mu A \times R_B + 100 \times 20\mu A \times 1.5K$

11.



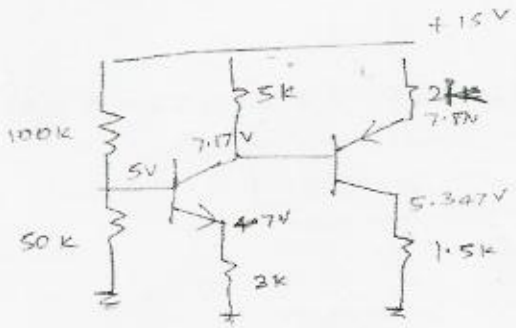
$I_E = 1.03mA$

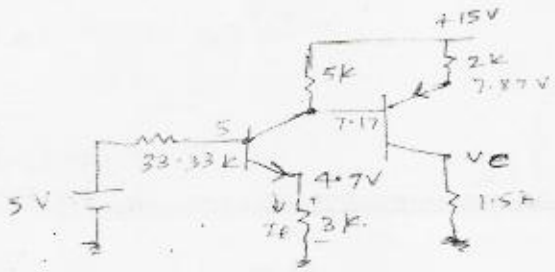
$V_B = 8.3V$

$V_C = 2.06\ V$

$V_A = 7.6\ V$

12. $\beta = \infty$





$I_B = 0$

$I_{E_1} = \frac{4.7}{3K} = 1.566mA$ $\quad I_{C_1} = 1.566mA$

$V_C = 15 - 1.566 \times 5$

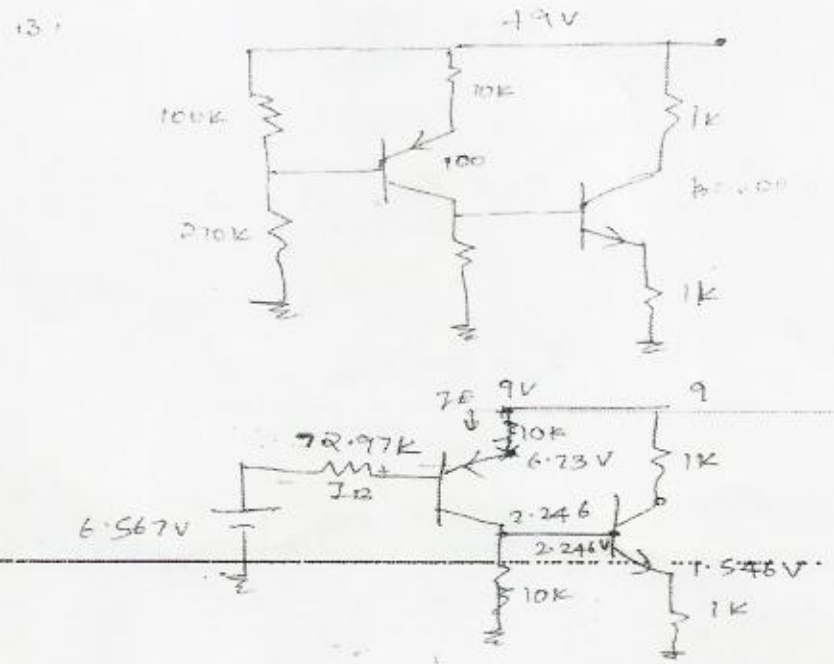
$= 7.87V$

$I_{E_2} = \frac{15 - 7.87}{2K} = 3.565mA$

$I_{C_2} = 3.565mA$ $\quad V_C = 3.565 \times 1.5$

$= 5.3475\ V$

13.



$$9V - 10K \times I_B - 72.97K \times I_B - 6.567 = 0$$

$$2.433V = 10K \times 101 I_B + 72.97K \times I_B$$

$$I_B = \frac{2.433}{(10 \times 101 + 72.97)K}$$

$$I_B = 2.246 \mu A$$

$$I_E = 0.227mA$$

$$I_C = 0.2246mA$$

$$I_{E_2} = \frac{1.546}{1K} = 1.546mA$$

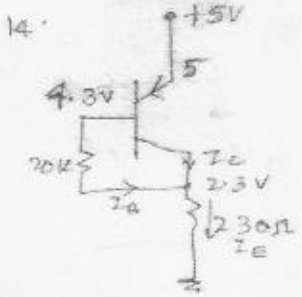
$$I_{C_2} = 1.5306mA$$

$$V_C = 9 - 1.5306mA \times 1K$$

$$= 7.47V$$

$V_{CE} = 5.924V$

14.



$$I_E = \frac{2.3}{230}$$

$$= 10\,mA$$

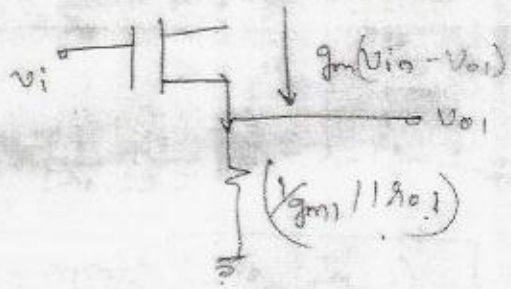
$$I_B = \frac{2}{20K}$$

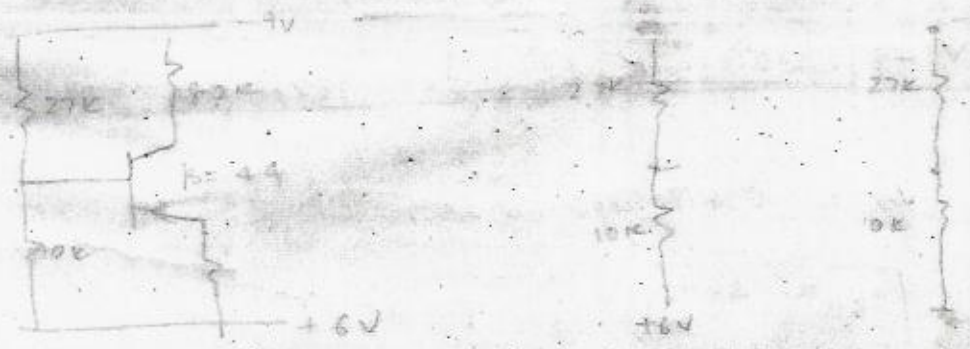
$$= 0.1\,mA$$

$$I_E = (\beta+1)\, I_B$$

$$10 = (\beta+1)\, 0.1$$

$$\beta + 1 = 100 \quad \boxed{\beta = 99}$$





$$R_{in} = \frac{270}{37}$$

$$= 7.297K$$

$$\frac{-9 \times 10}{37}$$

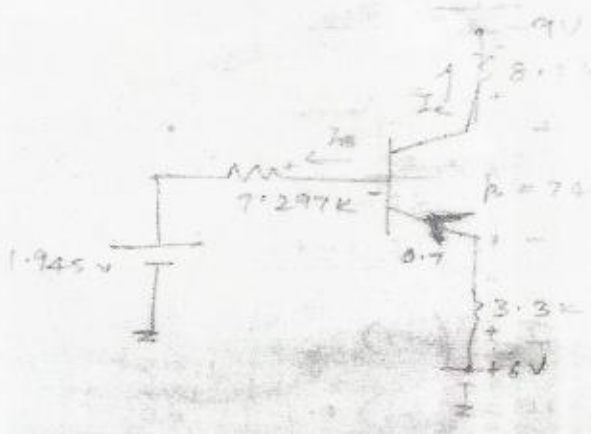
$$= -2.43\,V$$

$$\frac{6 \times 27}{37} = 4.378\,V$$

$$V_{in} = 4.378 - 2.43$$

$$= 1.945\,V$$

13



$$-1.945 + 7.297K I_B + 0.7 + 3.3K \times 75 \times I_B - 6 = 0$$

$$7.297K I_B + 3.3K \times 75 I_B = 5.3 - 1.945$$

$$I_B = \frac{3.355}{(7.297 + 3.3K \times 75)}$$

$$I_B = 13.16\,\mu A$$

$$I_C = 0.974\,mA$$

$$-9V + 8.2K \times 0.974mA - V_{CE} + 3.3K \times 0.987mA - 6V = 0$$

$$V_{CE} = -15 + 7.9868 + 3.257$$

$$V_{CE} = -3.756\,V$$