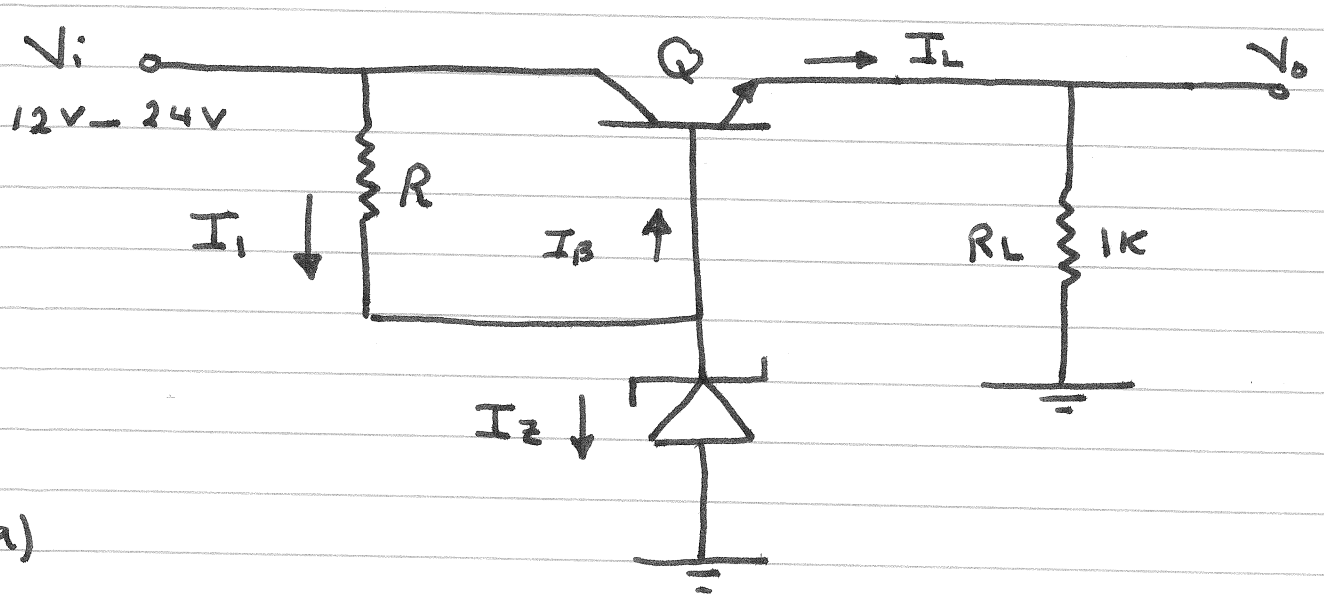
Homework Solutions Voltage Regulators EE 338

Problem 1 :



a)

$$V_o = V_{EB} + V_Z = 9\text{ V}$$

$$\therefore V_Z = V_o - V_{EB} = 9 + 0.7 = 9.7\text{ V}$$

b) $$I_Z = I_1 - I_B \geq 10\text{mA}$$

$$I_Z = \frac{V_i - V_Z}{R} - \frac{I_L}{\beta+1} \geq 10\text{mA}$$

$$\frac{V_{i(min)} - V_Z}{R} - \frac{V_o}{(1+\beta)R_L} \geq 10\text{mA}$$

$$\therefore R \leq 0.228\text{ K}\Omega$$

$$\therefore R_{,max} = 0.228\text{ K}\Omega$$

c) $$P_{D,max} = V_Z\, I_{Z(max)}$$

$$I_{Z(max)} = I_{1(max)} - I_B$$

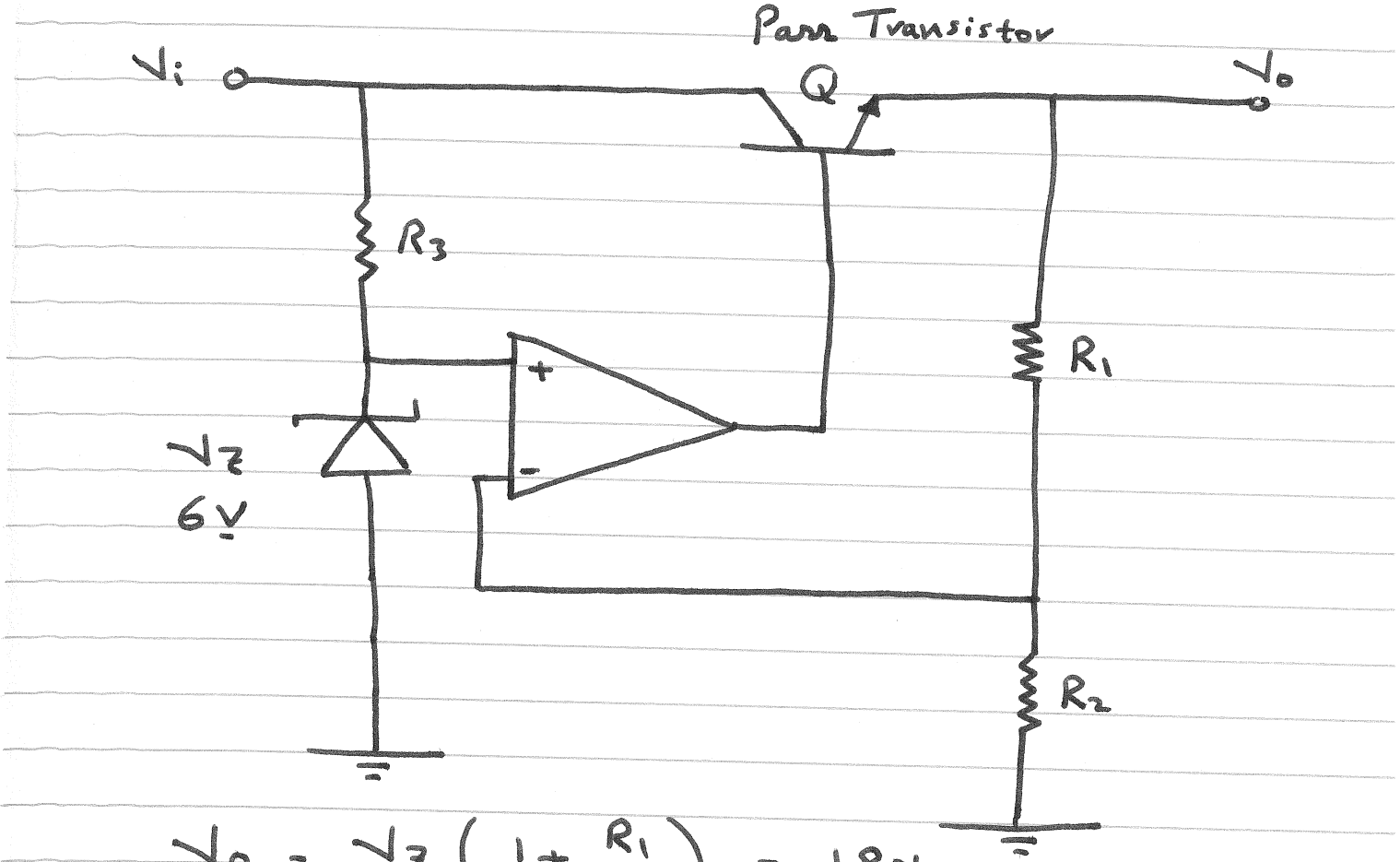
$$I_{1(max)} = \frac{V_{i(max)} - V_Z}{R} = 62.72\ mA$$

$$I_B = \frac{I_L}{\beta+1} = \frac{V_o}{(\beta+1)R_L} = 0.089\ mA$$

$$\therefore I_{Z(max)} = 62.63\ mA$$

$$\therefore P_{D,max} = 607.5\ mW$$

Problem 2 :



$$V_o = V_z\left(1 + \frac{R_1}{R_2}\right) = 18V$$

$$\therefore \frac{R_1}{R_2} = 2$$

let $R_1 = 20K$, $\therefore R_2 = 10K$

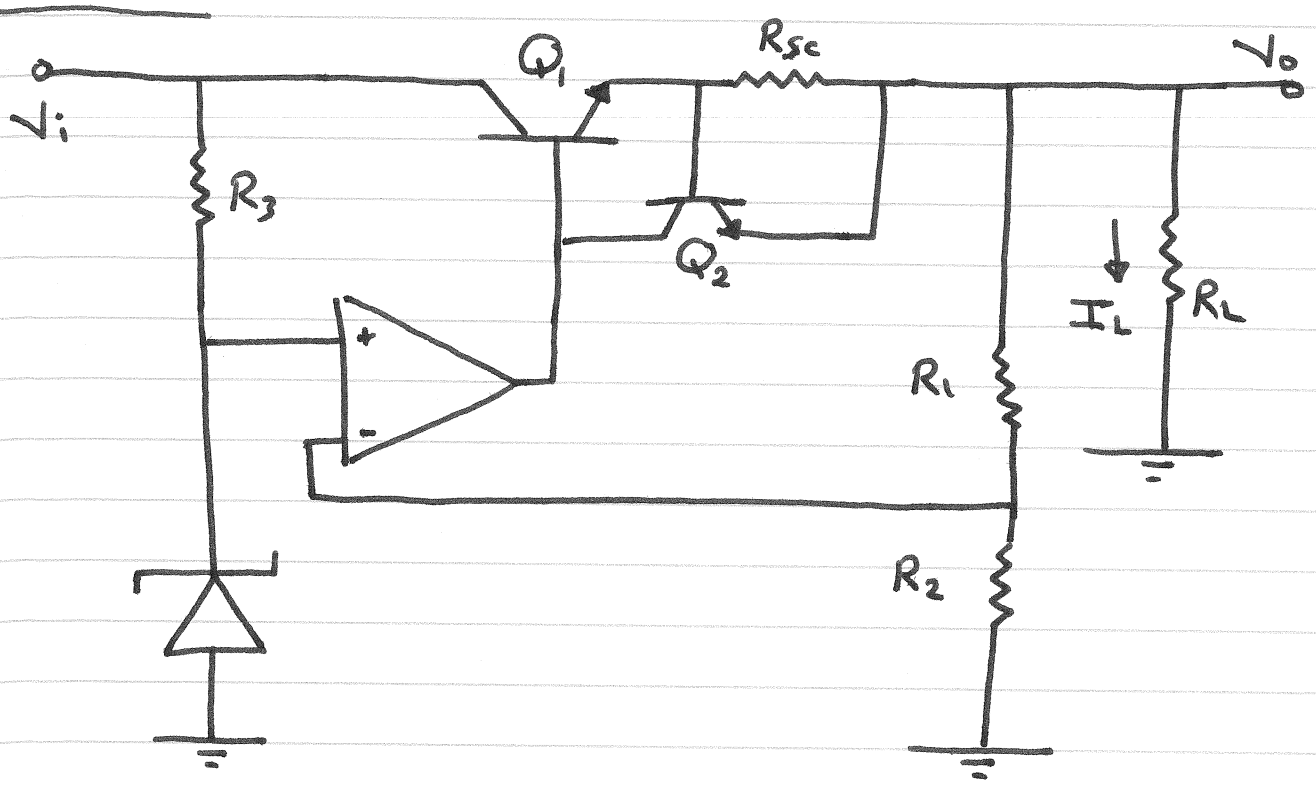
$$I_z = \frac{V_i - V_z}{R_3} \geq 20mA$$

$$\therefore \frac{V_{i(min)} - V_z}{R_3} \geq 20mA$$

$$\therefore R_3 \leq 0.7K$$

$\therefore$ let $R_3 = 0.5K$

Problem 3 :



a) $R_{sc} = \frac{0.7V}{0.5A} = 1.4\,\Omega$

b) When $R_L = 100\,\Omega$, $I_L = \frac{25}{100} = 0.25A$

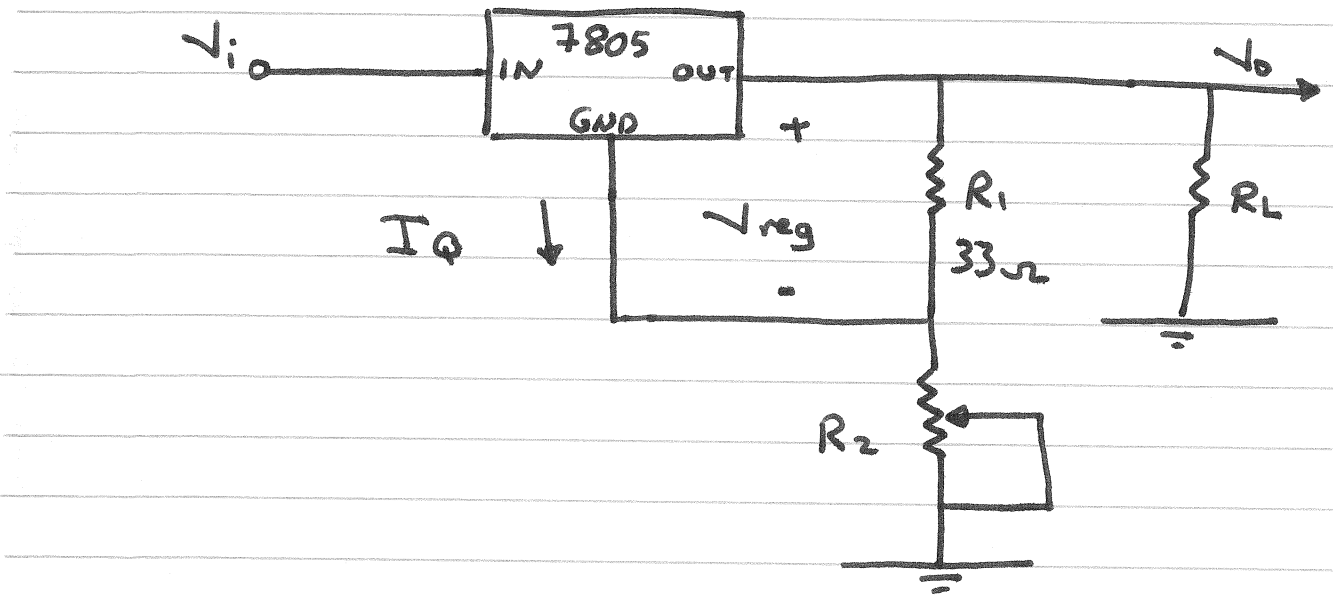
Since $I_L < I_{L,max}$, $\therefore V_o = 25V$

c) When $R_L = 10\,\Omega$, $I_L = \frac{25}{10} = 2.5\,A$

Since $I_L > I_{L,max}$; Current Limiting will occure

$V_o = I_{L,max} R_L = 5V$

Problem 4 :



a) $$V_L = V_{reg}\left(1 + \frac{R_2}{R_1}\right) + R_2 I_Q$$

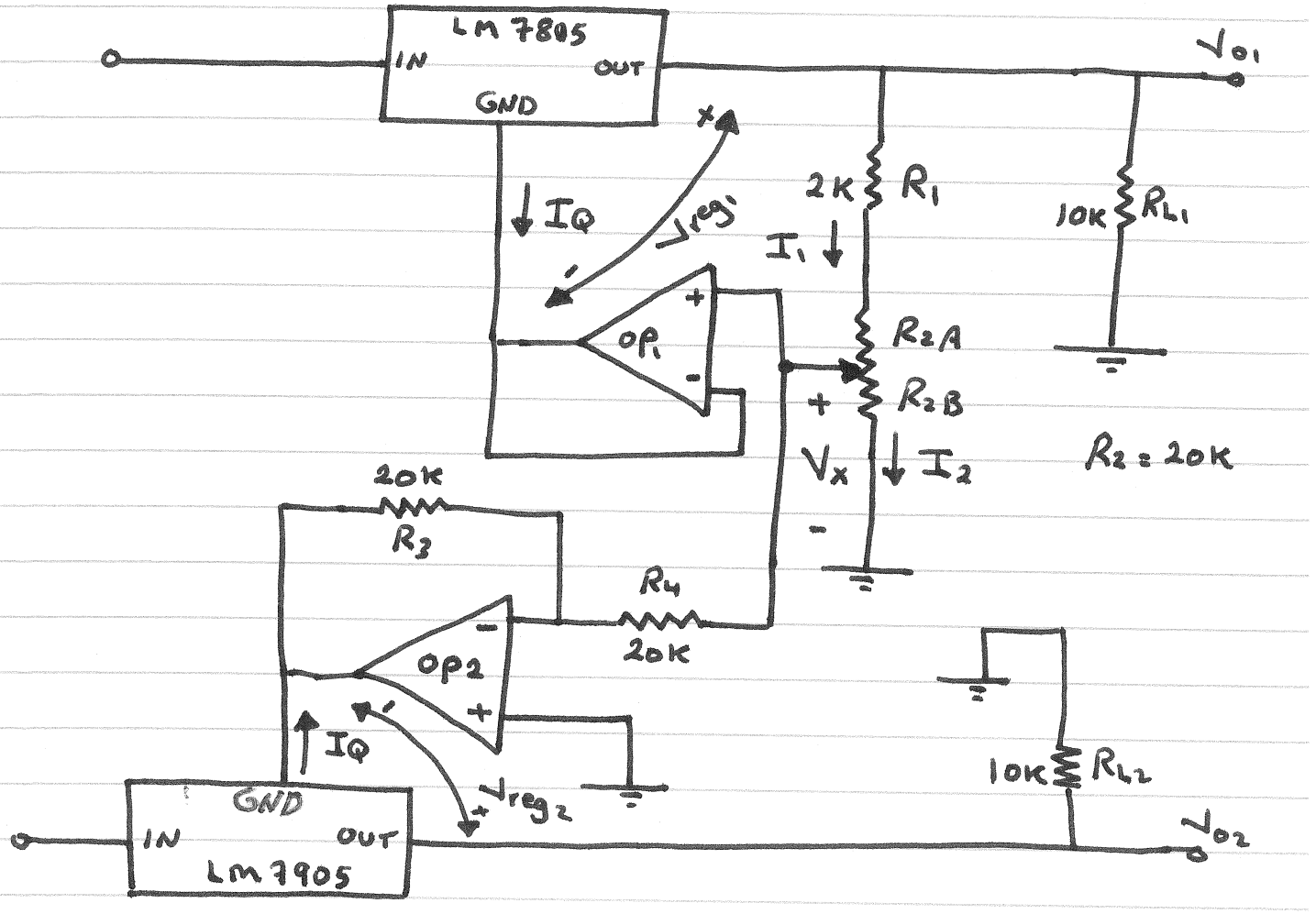
$$V_L = \begin{cases} 5\text{ V} & \text{when } R_2 = 0 \\ 21.15\text{V} & \text{when } R_2 = 100\,\Omega \end{cases}$$

$$21.15\text{ V} \geq V_L \geq 5\text{ V}$$

b) When $I_Q = 7\text{mA}$ and $R_2 = 100\,\Omega$

$$V_L = 20.85\text{ V}$$

Problem 5 :



$$I_1 = \frac{V_{reg_1}}{R_1 + R_{2A}}$$

$$I_2 = \frac{R_4}{R_4 + R_{2B}} I_1$$

$$V_{o1} = R_1 I_1 + R_{2A} I_1 + R_{2B} I_2$$

$$V_{o1} = V_{reg_1} + R_{2B} I_2$$

$$V_{o1} = V_{reg_1} + V_{reg_1} \frac{R_4 \| R_{2B}}{R_1 + R_{2A}}$$

$$V_{o1} = V_{reg_1} \left(1 + \frac{R_4 \| R_{2B}}{R_1 + R_{2A}} \right)$$

$$V_{o2} = V_{reg_2} + V_{op_2}$$

$$V_{o2} = V_{reg_2} - \frac{R_3}{R_4} V_x$$

$$V_x = R_{2B} I_2 = V_{reg_1} \frac{R_4 \| R_{2B}}{R_1 + R_{2A}}$$

$$V_{reg_1} = - V_{reg_2}$$

$$\therefore V_x = - V_{reg_2} \frac{R_4 \| R_{2B}}{R_1 + R_{2A}}$$

$$\therefore V_{o2} = V_{reg_2} \left(1 + \frac{R_4 \| R_{2B}}{R_1 + R_{2A}} \right)$$

$$V_{o1} = V_{reg_1} \left(1 + \frac{R_4 \| R_{2B}}{R_1 + R_{2A}} \right)$$

a) For $R_{2A} = R_{2B} = 10k$

$V_{o1} = 7.45 \pm$

$V_{o2} = -7.45 \pm$

b) For $R_{2A} = 0\Omega$, and $R_{2B} = 20k$

$V_{o1} = 18.9 \pm$

$V_{o2} = -18.9 \pm$

c) For $R_{2A} = 20k$, and $R_{2B} = 0\Omega$

$V_{o1} = 5 \pm$

$V_{o2} = -5 \pm$