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Question 1: [10-points]

The cut-in voltage of each diode in the circuit shown in Figure Q1 is $V_\gamma = 0.7\,V$.

Determine I_{D1}, I_{D2}, I_{D3}, and V_A for the following:

- $V_1 = 25V,\ V_2 = -10V,\ and\ V_3 = -8V$
- $R_1 = 4.9k\Omega, R_2 = 1.5k\Omega, R_3 = 15k\Omega, and\ R_4 = 24\ k\Omega;$
    - Hint: Assume All Diodes are ON

@Node A

−0.7−10 −0.7−−8

$$\frac{25-VA}{4.9k} = \frac{VA+9.3}{24k} + \frac{VA+7.3}{15k\Omega} + \frac{VA-0.7}{1.5k}$$

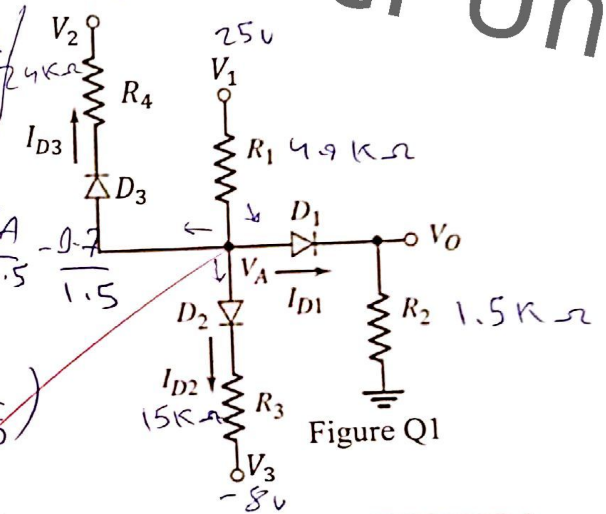

Figure Q1

$$\frac{25}{4.9} - \frac{VA}{4.9} = \frac{VA}{24} + \frac{9.3}{24} + \frac{VA}{15} + \frac{7.3}{15} + \frac{VA}{1.5} - \frac{0.7}{1.5}$$

$$\frac{25}{4.9} - \frac{9.3}{24} - \frac{7.3}{15} + \frac{0.7}{1.5} = VA\left(\frac{1}{4.9} + \frac{1}{24} + \frac{1}{15} + \frac{1}{1.5}\right)$$

$$4.49 = VA\,(0.979)$$

$$VA = 4.5863$$

$$Vo = 4.5863 - 0.7 = 3.886$$

$$ID_1 = \frac{4.586-0.7}{1.5} = \underline{2.59\,mA}$$

$$ID_2 = \frac{4.586+8-0.7}{15} = \cancel{0.839\,mA}\ \ 0.7924\,mA$$

$$ID_3 = \frac{4.586+9.3}{24} = 0.5785\,mA$$

Your Final Answer	
I_{D1}	2.59mA
I_{D2}	0.792mA
I_{D3}	0.5785mA
V_A	4.5863
V_O	3.886

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Question 2 [10-points] Consider the circuit in Figure Q2. Each diode cut-in voltage is $V_\gamma = 0.7\ V$. Determine $I_{D1}, I_{D2},$ and V_A for $R_2 = 1.1\ k\Omega$,

~~D1, D2 off~~

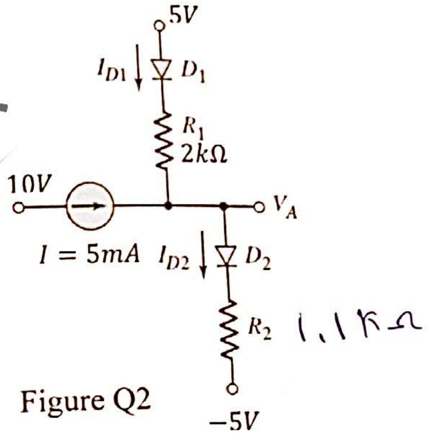

Figure Q2

Assume D1, D2 on

$$\frac{\overset{4.3}{5-\cancel{0.7}}-VA}{2K\Omega}+5mA=\frac{VA-0.7+5}{1.1}$$

$$\frac{4.3}{2K}-\frac{VA}{2K}+5mA=\frac{VA}{1.1}+\frac{4.3}{1.1}$$

$$3.241=1.41VA$$

$$VA=2.2985$$

$$ID_1=\frac{5-0.7-2.2985}{2K\Omega}=1mA$$

$$ID_2=\frac{2.2985+4.3}{1.1K}=5.99mA$$

Your Final Answer	
I_{D1}	~~0~~ 1mA
I_{D2}	~~5mA~~ 6mA
V_A	~~0~~ 2.2985V

5.99

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Question 3: [20-points]
The pnp transistor shown in Figure Q3 has a common-base current gain $\alpha = 0.9860$.

(a) Determine the emitter current such that $V_C = -1.2\ V$.
(b) What is the base current?
(c) Using the results of part (a) and assuming $I_{EO} = 2 \times 10^{-15}\ A$, determine V_{EB}.

V_C

$-1.2 = i_C R_C - 10$

$8.8 = i_C 5K$

$i_C = 1.76 mA$

$i_E = \cancel{\alpha} \frac{i_C}{\alpha}$

$i_E = 1.785 mA$

$i_B = i_E - i_C$

$= (1.785 - 1.76) mA$

$= 25 \mu A$

$i_E = 1.785 mA$

$i_E = i_{E0} e^{\frac{V_{EB}}{V_T}}$

$1.785 \times 10^{-3} = 2 \times 10^{-15} e^{\frac{V_{EB}}{V_T}}$

$0.026 \ln\left(\frac{1.785 \times 10^{-3}}{2 \times 10^{-15}}\right) = V_{EB} = 0.7154$

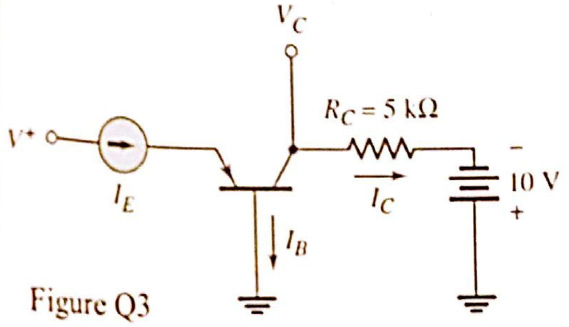

Figure Q3

Your Final Answer	
emitter current	1.785mA
base current	25 μA
v_{EB}	0.7154v

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Question 4: [20-points]

$\alpha = 0.989$

10 (a) For the circuit in Figure Q4, determine V_{B1} and I_E such that $V_B = V_C$.

- Assume $\beta = 90$.

2 (b) What value of V_{B2} results in $V_{CE} = 2V$?

$\frac{i_C}{i_E} = \alpha$ $i_C = \alpha i_E$

$i_E \neq \frac{i_C}{\alpha}$

$10 - -5 = i_C R_C + i_E R_E + V_{CE}$

$15 = i_C(2k\Omega) + i_E(1k\Omega) + 0.7$

$14.3 = \alpha i_E(2k\Omega) + i_E(1k\Omega)$

$14.3 = (0.989 \times 2 + 1)\, i_E$

$14.3 = 2.978\, i_E$

$i_E = 4.802\ mA$

$i_C = 4.75\ mA$

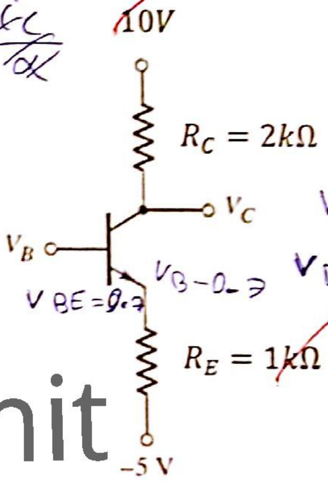
$V_{B1} = 10 - 4.75 \times 2$

$15 = i_C R_C + i_E R_E + 2$

$13 = 2.978\, i_E$

$i_C = 4.317$

?.



$V_B = V_C$

$V_{BE} = V_{CE}$

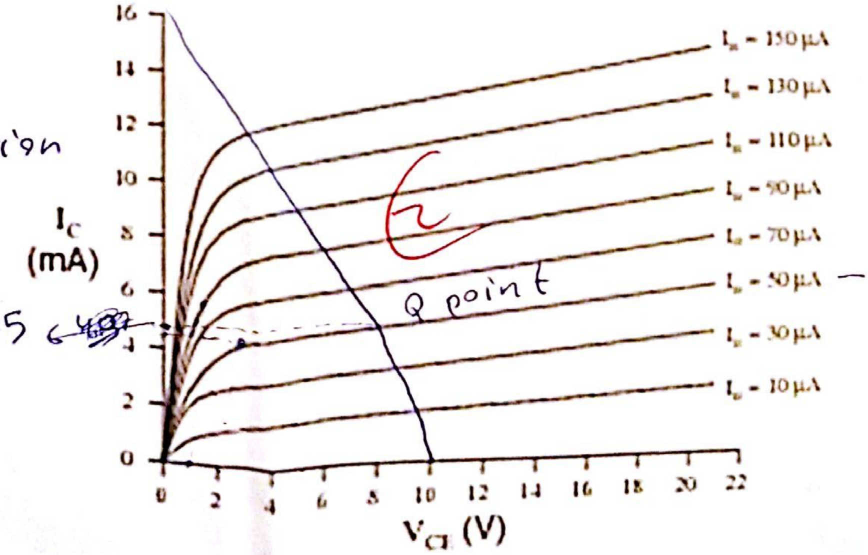
Figure Q4

Your Final Answer	
v_{B1}	0.5 v
I_E	4.802 mA
v_{B2}	0.06534 V

4 (c) Write the load line equation for part (a) and then plot it over the figure below, show me the Q point, is the Q point closer to saturation or cutoff?

Q point is closer to the saturation 2

4.75 ~~6.43~~



Some useful Equations:
$I_Z(max) = \frac{I_L(max)\cdot[V_{PS}(max)-V_Z]-I_L(min)\cdot[V_{PS}(min)-V_Z]}{V_{PS}(min)-0.9V_Z-0.1V_{PS}(max)}$ for $I_Z(min) = 0.1I_Z(max)$
$R_i = \frac{V_{PS}(max) - V_Z}{I_Z(max) + I_L(min)}$

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Question 5: [20-points]

A Zener diode is connected in a voltage regulator circuit as shown in Figure Q5. The Zener voltage is $V_Z = 10V$ and the Zener resistance is assumed to be $r_z = 0$.

(a) Determine the value of R_i such that the Zener diode remains in breakdown if the load current varies from $I_L = 50$ to $500\ mA$ and if the input voltage varies from $V_I = 15$ to $20\ V$.

- Assume: $I_Z(min) = 0.4I_Z(max)$.

(b) Determine the power rating required for the Zener diode and the load resistor.

$V_I \; \overset{min}{15} - \overset{max}{20}$ $\quad I_L$ (50 to 500) mA

$I_Z(min) = 0.4\, I_Z(max)$

~~$I_Z(max)$~~

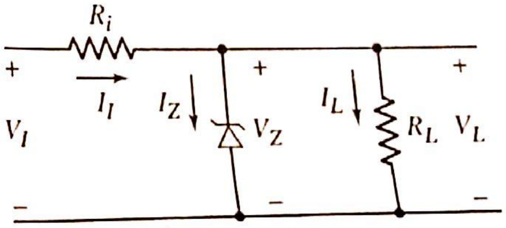

Figure Q5

① $R_i = \frac{V_{ps}(max) - V_Z}{I_Z(max) + I_L(min)}$

② $R_i = \frac{V_{ps}(min) - V_Z}{I_Z(min) + I_L(max)}$

① $R_i = \frac{20-10}{I_Z(max) + 50mA}$

② $R_i = \frac{15-10}{I_Z(min) + 500mA}$

$\frac{\cancel{20-10}\ 10}{I_Z(max) + 50mA} = \frac{\cancel{15-10}\ 5}{I_Z(min) + 500mA}$

4750 $\quad$ 1900 ~~1.9~~

Your Final Answer	
R_i	~~$\frac{1}{30}$ KΩ~~ 2.0833 Ω
Power ratings	47.5 W $P_L(max)$: ?

$\overset{0.4 I_Z(max)}{\cancel{1}0 I_Z(min)} + 5000\ mA = 5\, I_Z(max) + 250\ mA$

$4 I_Z(max) + 5000\ mA = 5 I_Z(max) + 250$

$I_Z(max) =$ ~~250 mA~~ 4750 mA 4.750

$I_Z(min) = 0.4 \times$ ~~250 mA = 100 mA~~ 1.9 A

~~$R_i = \frac{20-10}{250+50} = \frac{1}{30}\ K\Omega$~~

$R_i = \frac{20-10}{4.75 + \cancel{500mA} + 0.05} = 42.1$

$\frac{1}{480}$

$P_Z = I_Z(max) \times V_Z$

$=$

$$\frac{V_I - V_1 - 0.7}{1} + \cancel{V_1} + \frac{15 - V_1}{2} + \frac{V_1}{2} = 0$$

$$= \frac{V_1}{1}$$

6.8

$$V_I - \cancel{0.7} + \frac{\cancel{15}}{2} = 2.5 V_1$$

$V_I = 5.7$

$V_1 = 0.44$

Question 6: [10-points]

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For the circuit in Figure Q6:

a) Plot v_O versus v_I for $0 \leq v_I \leq 15V$.

- Assume $V_\gamma = 0.7V$.

b) Indicate all breakpoints.

~~$0 < V_I < 0.7$ Diode is off~~

$V_I = 0$ → diode is off

$V_1 = 15 \times \frac{1}{3} = 5v$

$0 < V_I < 5.7$ $v_o = v_I$

$V_I > 5.7$ diode is on → $v_o = 5.7$

$v_o = V_I - 1k\Omega (i_D)$

$v_o(V_I = 15) = 15 - 1k \times 9.3mA$

$= 15 - 9.3 = 5.7v$

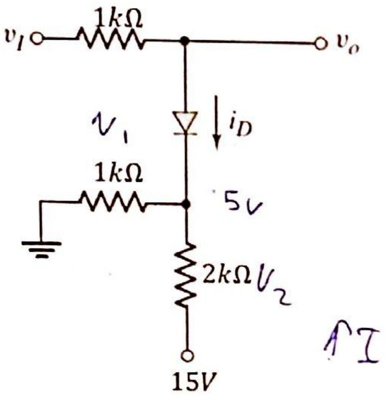


Figure Q6

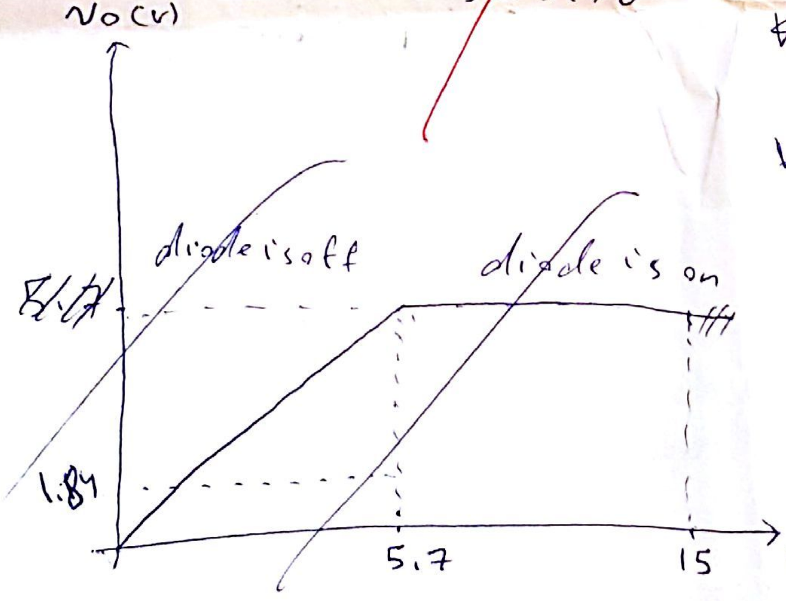
$$i_D = \frac{v_I - 5.7}{1k\Omega}$$

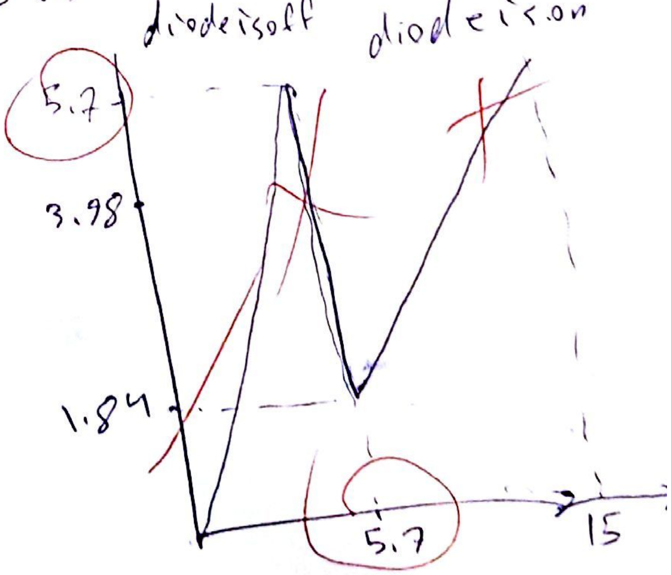
$\frac{15}{3k}$

$V_I = 15$ 9.3 mA

$$i_D = \frac{15 - 5.7}{1k} = \frac{9.3}{1k} = 9.3mA$$

$V_I = 15$ $v_o =$ 5.7





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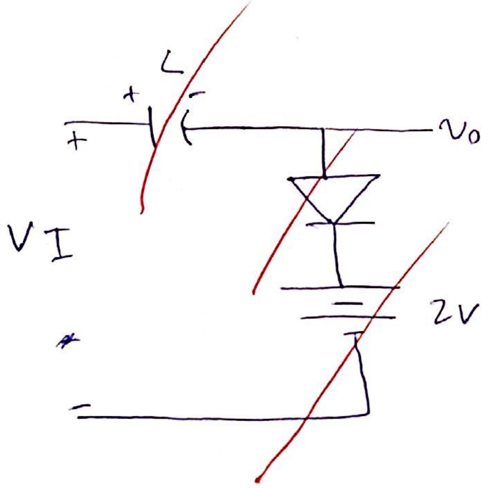
Question 7. [10-points] Design a diode clamper to generate a steady-state output voltage v_O from the input voltage v_I shown in Figure Q7

- Assume $V_\gamma = 0.7V$.



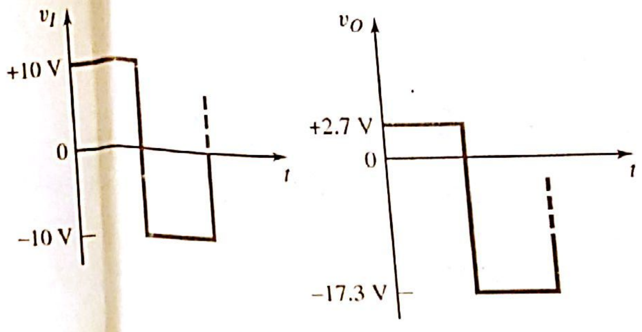


Figure Q7

- What happens if $V_\gamma = 0V$?