Multiple Diode Circuits

Consider the following
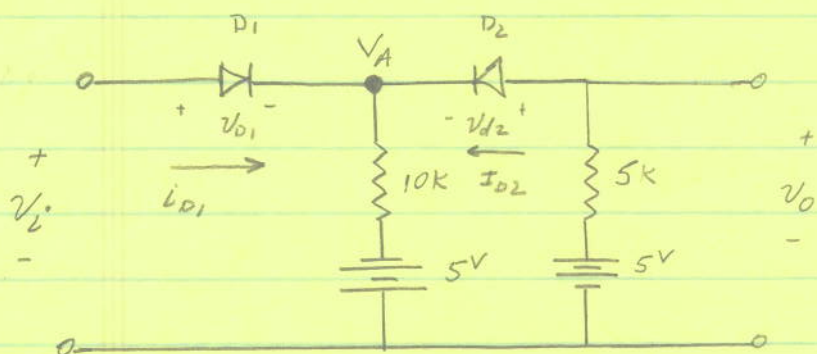
Assume $V_\gamma = 0.7^V$

Find V_o for a) $V_I = 0^V$, b) $V_I = 4^V$

a) $\underline{V_I = 0^V}$

Lets assume that $\underline{D1 \text{ is off}}$, $\underline{D2 \text{ is ON}}$

then KCL: $\quad -5^V + i_{D2} \, 5k + 0.7^V + i_{D2} \, 10k - 5^V = 0$

$$i_{D2} = \frac{10^V - 0.7^V}{10k + 5k} = \underline{0.62 \, mA}$$

$$V_o = 5^V - (0.62^{mA})(5k) = \underline{\underline{1.9^V}}$$

$$V_{D2} = V_o - V_A = 1.9 - (-5^V + 10(0.62)) =$$
$$= 1.9 - 1.2 = \underline{\underline{0.7^V}} \quad (\underline{ON})$$

$$V_{D1} = -V_A = -1.2^V \quad (\underline{OFF})$$

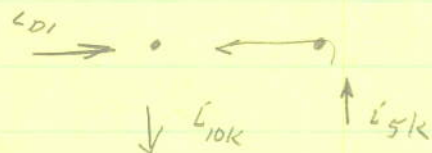$\therefore$ Our Assumptions are correct!

Suppose we had assumed D_1 & D_2 were ON, then?

$$V_A = V_I - V_\gamma = -0.7^V$$

$$V_O = V_A + V_\delta = 0^V$$

$$i_{5k} = \frac{5^V - 0^V}{5k} = 1^{mA}$$

$$i_{10k} = \frac{-0.7^V - (-5^V)}{10k} = 0.43^{mA}$$

$$i_{D1} = i_{10k} - i_{5k} = 0.43^{mA} - 1^{mA} = \boxed{-0.57^{mA}}$$

We know that this can not be, since reverse current does not flow through a forward biased diode.

Suppose we had assumed $D1$ & $D2$ OFF?

$$V_O = 5^V$$

$$V_a = -5^V$$

$$V_{d_1} = V_I - V_a = 0 - (-5^V) = \underline{5^V} \quad Fwd\ bias$$

$$V_{d_2} = V_O - V_a = 5^V - (-5^V) = \underline{10^V} \quad Fwd\ bias$$

Suppose we had $D1$ ON & $D2$ OFF?

$$V_a = -0.7$$

$$V_O = 5^V$$

$$V_{d_2} = 5 - (-0.7) = 5.7^V \quad Fwd\ bias$$
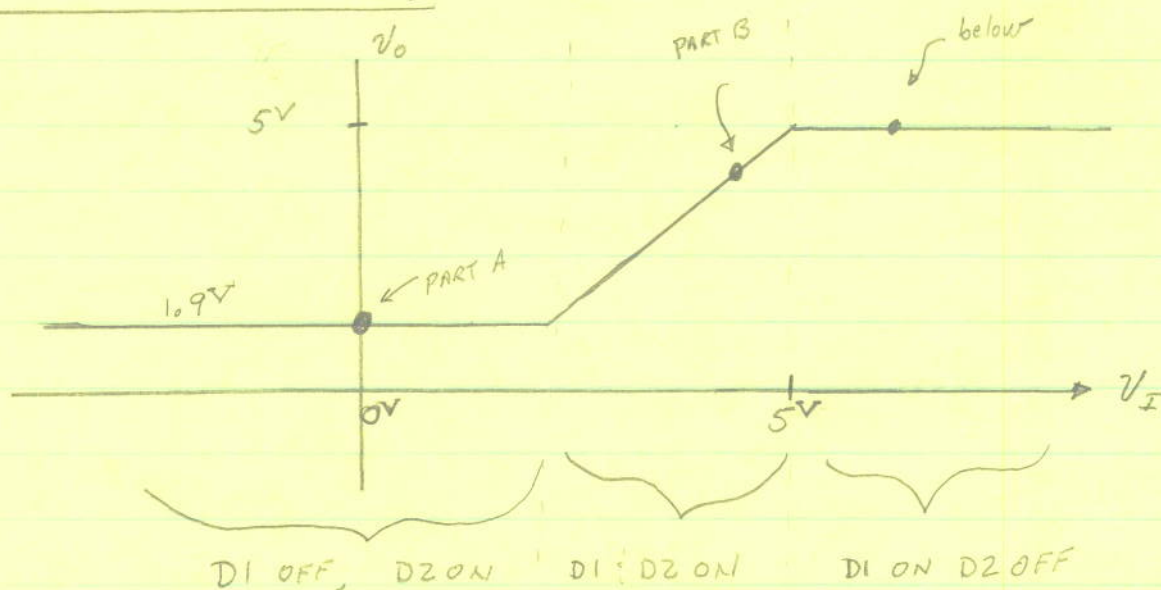
b) $\underline{V_I = 4^V}$

Assume $D1 \ \& \ D2$ are ON.

Then $V_0 = V_I - 0.7^V + 0.7^V = V_I = 4^V$

$i_{5k} = i_{D2} = \dfrac{5^V - 4^V}{5k} = 0.2^{mA} \uparrow up$

$i_{10k} = \dfrac{V_A - (-5^V)}{10k} = \dfrac{(4 - 0.7)(+5)}{10k} = \dfrac{3.3 + 5}{10k} = 0.83^{mA} \downarrow$

$i_{D1} = i_{10k} - i_{5k} = 0.83 - 0.2 = \underline{0.63^{mA}}$

c) $\underline{\text{SKETCH} \quad V_0 \ \text{vs.} \ V_I}$

$D1$ OFF, $D2$ ON $D1 \ \& \ D2$ ON $D1$ ON $D2$ OFF

Let $\underline{V_I = 5.1^V}$, $\underline{D1 \ ON}$, $\underline{D2 \ OFF}$

$V_a = V_I - 0.7^V = 4.4^V$

$V_{d2} = V_0 - V_a = 5.0 - 4.4 = 0.6^V \ (OFF)$