

# HW # 4

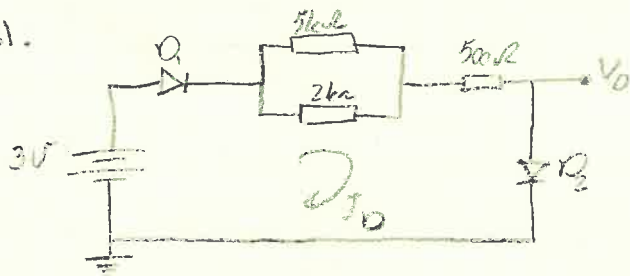
1-30.

$$V_0 = V_D = \frac{kT}{q} \ln\left(\frac{I_D}{I_S}\right) \quad I_D = 6.1 = 5 \text{ nA}$$

$$= 26 \text{ mV} \ln\left(\frac{5 \text{ nA}}{1 \text{ nA}}\right) = 41.84 \text{ mV}$$

$$V_0 = V_D = \frac{kT}{q} \ln\left(\frac{I_D}{I_S} + 1\right) = 26 \text{ mV} \ln\left(\frac{5 \text{ nA}}{1 \text{ nA}} + 1\right) = 46.59 \text{ mV} \checkmark$$

1-31.



$$R_{eq} = (5k \parallel 2k) + 500\Omega = 1.92k\Omega$$

KVL:

$$-3 + 0.026 \ln\left(\frac{I_D}{1 \text{ nA}} + 1\right) + 1.92 \times 10^3 I_D + 0.026 \ln\left(\frac{I_D}{4 \text{ nA}} + 1\right) = 0$$

$$I_D = 1.196 \text{ mA}$$

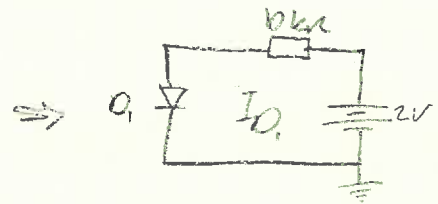
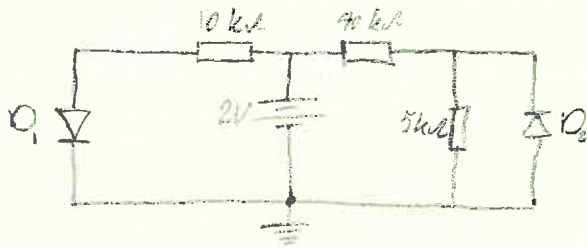
$$V_0 = V_D = 0.026 \ln\left(\frac{1.196 \times 10^{-3}}{4 \times 10^{-9}} + 1\right) = 0.3278 \text{ V}$$

1-32.

$$I_{S1} = 175 \text{ nA} \quad I_{S2} = 100 \text{ nA}$$

$$V_0 = 0.026 \ln\left(\frac{400 \times 10^{-3}}{175 \times 10^{-9}}\right) = 0.381 \text{ V} = 381 \text{ mV}$$

1-33.



KVL:

$$0.026 \ln\left(\frac{I_{D1}}{100 \times 10^{-12}} + 1\right) + 10 \times 10^3 I_{D1} + 2 = 0 \Rightarrow I_{D1} = 0.163 \text{ mA}$$

$$V_{D1} = 0.026 \ln\left(\frac{0.163 \times 10^{-3}}{100 \times 10^{-12}} + 1\right) = 0.372 \text{ V}$$

$$V_{D2} = \frac{5 \text{ k}\Omega}{5 \text{ k}\Omega + 40 \text{ k}\Omega} \times 2 = 0.222 \text{ V} \Rightarrow I_{5 \text{ k}\Omega} = \frac{0.222}{5 \text{ k}\Omega} = 44.4 \mu\text{A}$$

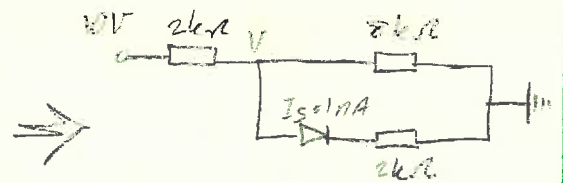
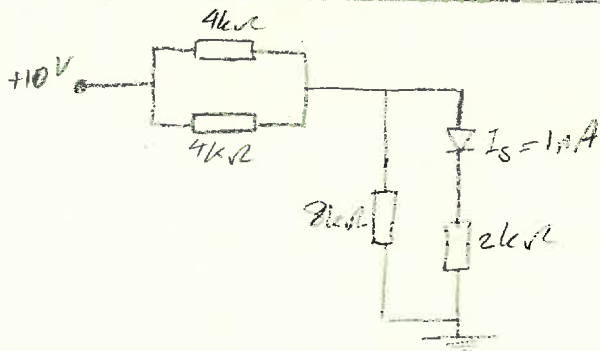
Or KCL:

$$\frac{2 - V}{40 \times 10^3} + \frac{0 - V}{5 \times 10^3} + 100 \times 10^{-12} \left(e^{\frac{-V}{0.026}} - 1\right) = 0$$

$$V = 0.2222 \text{ V}$$

$$I_{5 \text{ k}\Omega} = \frac{V}{5 \text{ k}\Omega} = \frac{0.222}{5000} = 44.44 \mu\text{A}$$

1-34.



KCL:

$$\frac{10 - V}{2000} = \frac{V - 0}{2000} + I_D \quad (1)$$

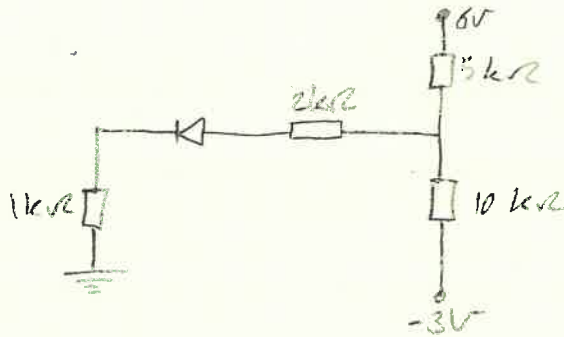
$$V_D = I_D \times 2000 + 0.026 \ln\left(\frac{I_D}{1 \times 10^{-9}} + 1\right) \quad (2)$$

$$(1) \text{ into } (2) \Rightarrow I_D = 2.12 \text{ mA}$$

$$V_D = 0.026 \ln \left( \frac{I_D}{1 \times 10^{-9}} + 1 \right) = 0.026 \ln \left( \frac{2.12 \times 10^{-3}}{1 \times 10^{-9}} + 1 \right)$$

$$V_D = 0.3787 \text{ V}$$

1-35.



KCL:

$$\frac{6-V}{5} = \frac{V+3}{10} + \frac{V-V_D}{3} \quad (1)$$

$$V_D = 0.026 \ln \left( \frac{\frac{V-V_D}{3}}{2 \times 10^{-6}} + 1 \right) \quad (2)$$

(1) and (2)  $\Rightarrow V_D = 0.141 \text{ V}$

$$I_D = I_S \left( e^{\frac{qV_D}{kT}} - 1 \right)$$

$$I_D = 2 \times 10^{-6} \left( e^{\frac{0.141}{0.026}} - 1 \right) = 0.4512 \text{ mA}$$