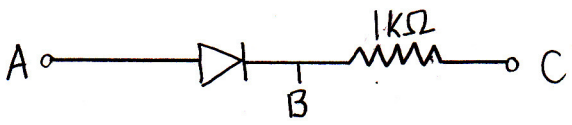
HW 5 Solution

① 

$V_{AC} = R I_{AC} + V_d$

ⓐ $I_{AC} = \frac{V_{AC} - V_d}{R}$

ⓑ $I_{AC} = I_o (e^{q V_d / KT} - 1)$

Equate ⓐ, ⓑ:

$\ln\left[\frac{I_{AC}}{I_o} + 1\right] = \ln e^{\frac{q V_d}{KT}}$

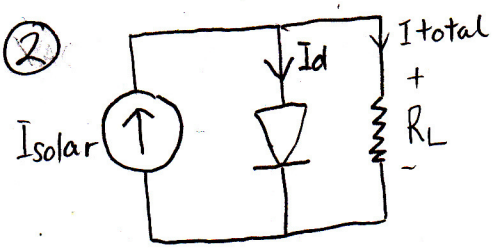
$\ln\left[\frac{I_{AC}}{I_o} + 1\right] = \frac{q V_d}{KT}$

$V_d = \frac{KT}{q} \ln\left[\frac{I_{AC}}{I_o} + 1\right]$

ⓐ $V_{BC} = R I_{AC}$

ⓐ $V_d = \frac{KT}{q} \ln\left[\frac{\frac{V_{AC} - V_d}{R}}{I_o} + 1\right]$ ← Solve with iteration process. (Assume diode is on).

V_{AC}	V_d	V_{BC}	
-10	0	0	
-7.5	0	0	
-5	0	0	
0	0	0	↑ diode off
5	0.756 V	4.244 V	↓ diode on
7.5	0.768 V	6.732 V	
10	0.776 V	9.234 V	

② 

$I_{total} = I_{solar} - I_d$

$I_{total} = I_{solar} - I_o (e^{\frac{q V_d}{KT}} - 1)$

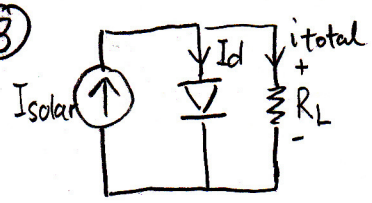
$I_{solar} = I_{total} + I_o e^{\frac{q V_d}{KT}} - 1$

$= \frac{v_D}{R_L} + I_o e^{\frac{q V_d}{KT}} - 1$ with a V_d turn-on voltage 0.7 V

$= \frac{0.7}{1000} + 10^{-15} e^{\frac{0.7}{0.0259}} - 10^{-15}$

$I_{solar} = 1.247\ mA$

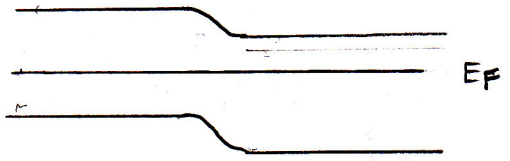
③



$$I_{total} = I_{solar} - I_D$$
$$= I_{solar} - I_D\left(e^{\frac{qV_d}{KT}} - 1\right)$$
$$= 1.247\,mA - 0.547\,mA$$
$$= 0.7\,mA$$
$$P = IV = I^2 \cdot R = (0.7mA)^2 \cdot R_L$$
$$= (0.7mA)^2 \cdot 1000\Omega$$
$$P = 0.4\,mW$$

④ $N_A = 10^{18}\,cm^{-3}$ $N_D = 10^{14}\,cm^{-3}$

a) 0 Applied Voltage

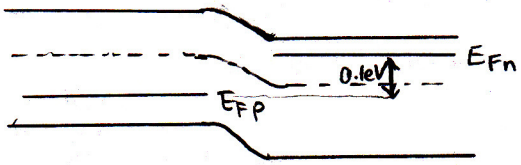


b) $V_{bi} = \frac{KT}{q} \ln\left(\frac{N_A \cdot N_D}{n_i^2}\right)$
$= 0.0259 \ln\left(\frac{10^{32}}{10^{20}}\right)$
$= 0.0259\,(27.631)$
$= 0.718V$

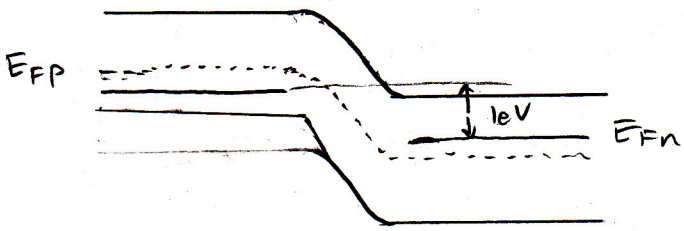
$V_A = 0.1V$

$E_{Fp} - E_{Fn} = -qV_A$

$E_{Fn} - E_{Fp} = .1eV$

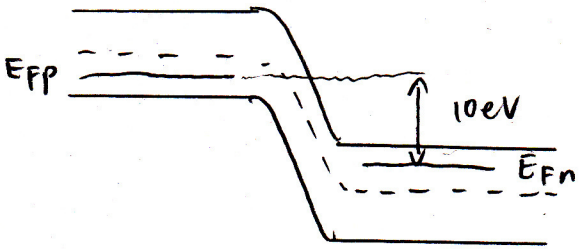


$V_A = -1V$



$E_{Fp} - E_{Fn} = = 1eV$

$V_A = -10V$



$E_{Fp} - E_{Fn} = 10eV$