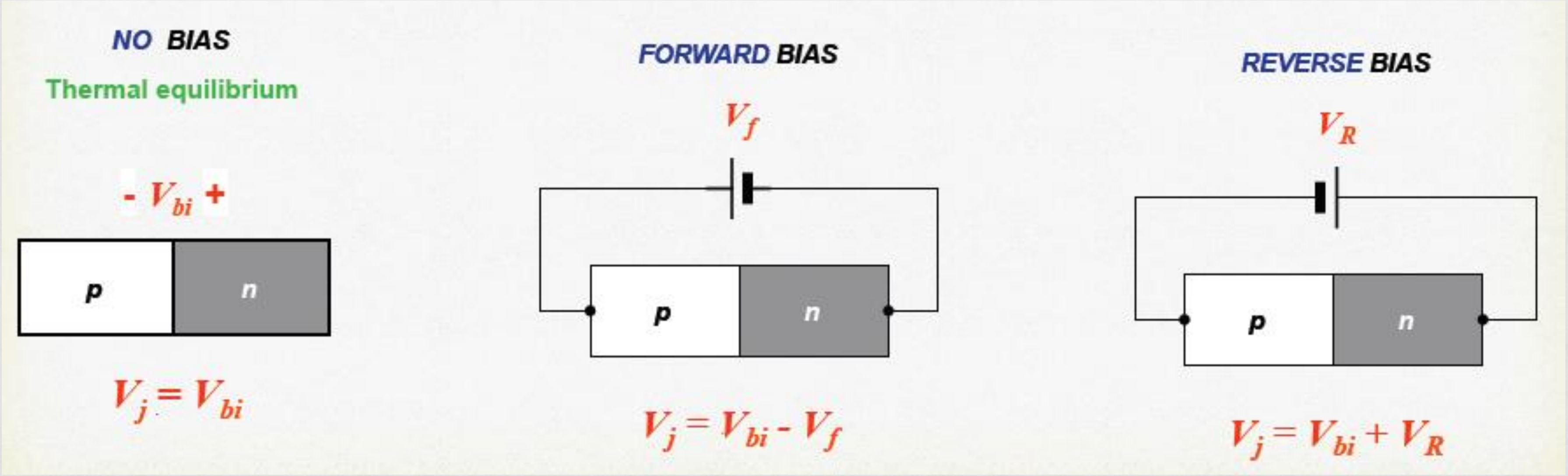
EC233
ELECTRONIC DEVICES 1

SHEET 8 SOLUTIONS

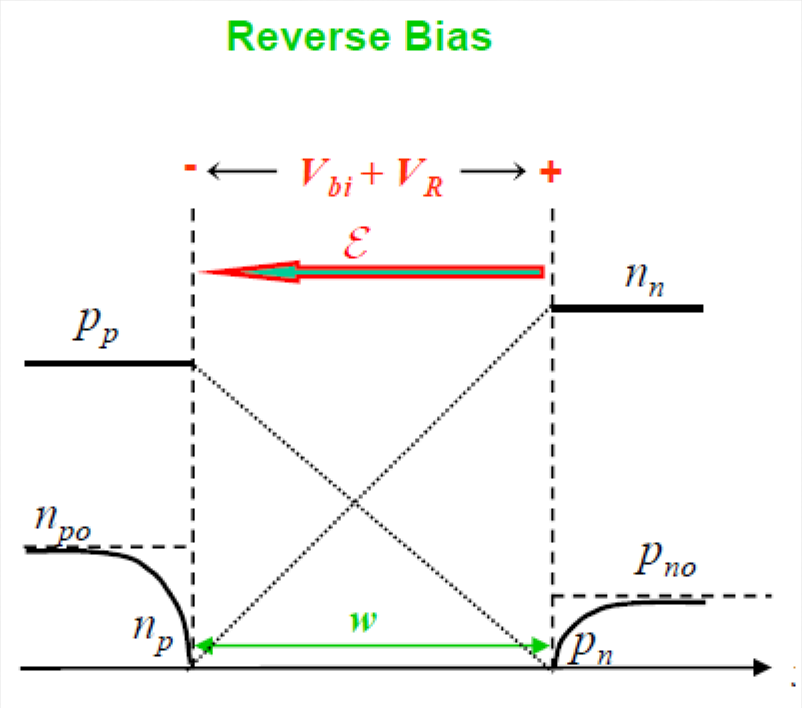
PART I: TRUE/FALSE

1. In a reverse biased pn-junction, the p-side is connected to a higher potential than the n-side. ✖



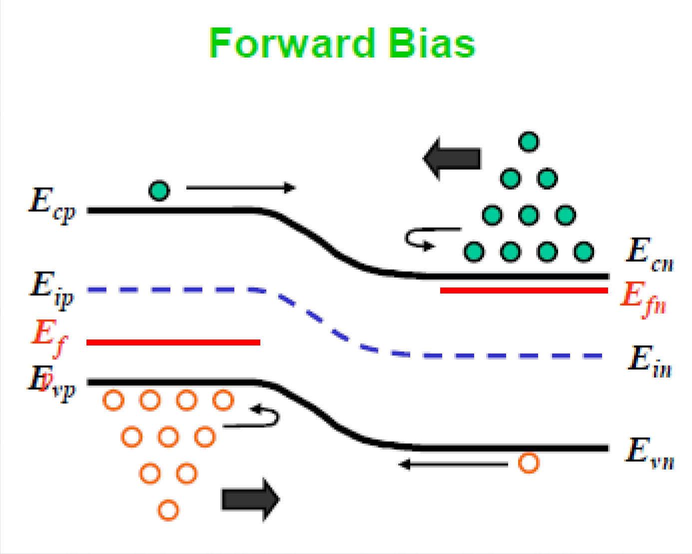
PART I: TRUE/FALSE

2. In a reverse-biased pn- junction, the minority carrier concentration increase relative to their equilibrium values. ✖



PART I: TRUE/FALSE

3. In a forward- biased pn- junction, the Quasi- Fermi level in the p-side is higher than that in the n-side. ✖

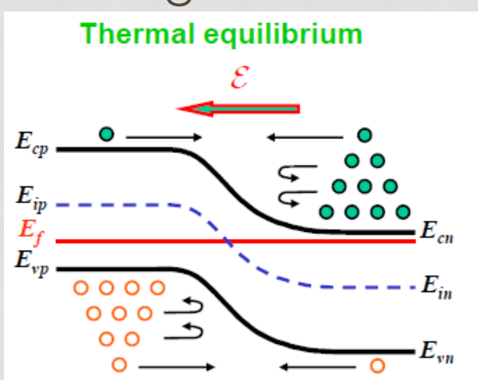


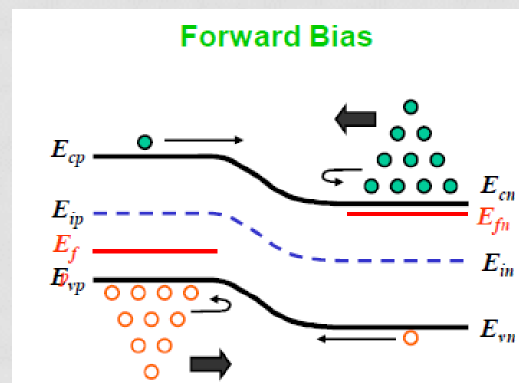
PART I: TRUE/FALSE

4. In a pn-junction diode, the higher is the doping concentration, the higher is the reverse saturation current. ✖

$$I_o = Aq\left[\frac{D_p p_{no}}{L_p} + \frac{D_n n_{po}}{L_n}\right] = Aq\left[\frac{D_p}{L_p}\frac{n_i^2}{N_d} + \frac{D_n}{L_n}\frac{n_i^2}{N_a}\right]$$

5. Under forward bias, a reduction in potential barrier is associated by an increasing diffusion current. ✓





6. The drift of minority carriers through the depletion layer controls the reverse saturation current. ✖

PART II

- The I-V characteristics of a pn-junction diode in the forward regime appear on a logarithmic scale as a straight line of slope ……………..

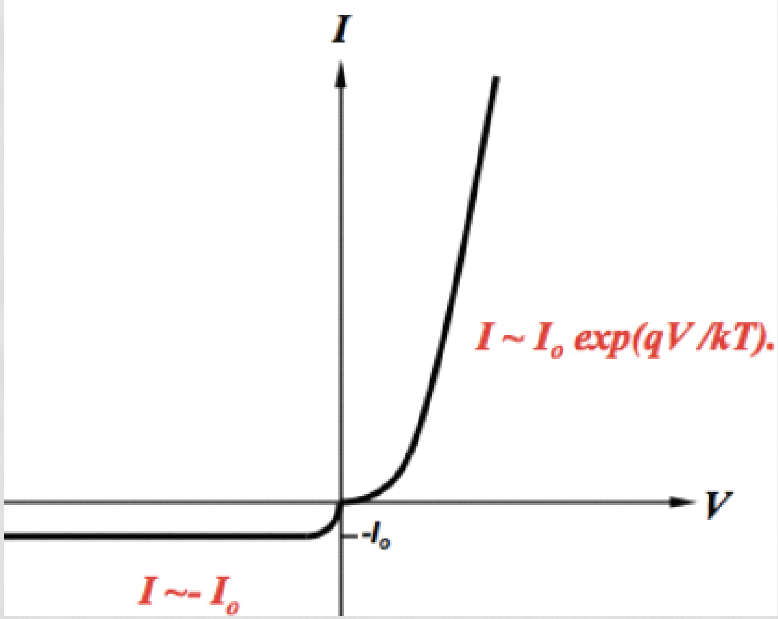
(a) Zero

(b) KT/q

(c) q/KT

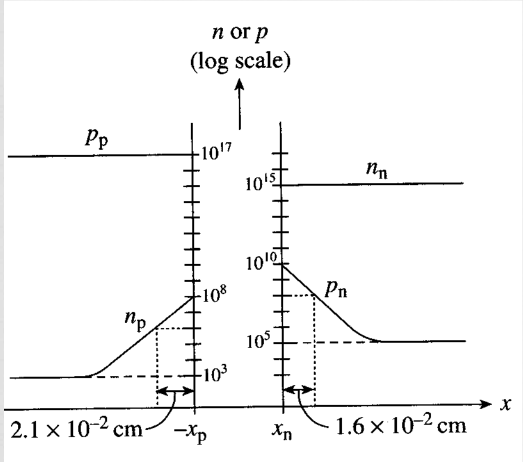
(d) KT

$$I = I_o\left(e^{qV/kT} - 1\right)$$



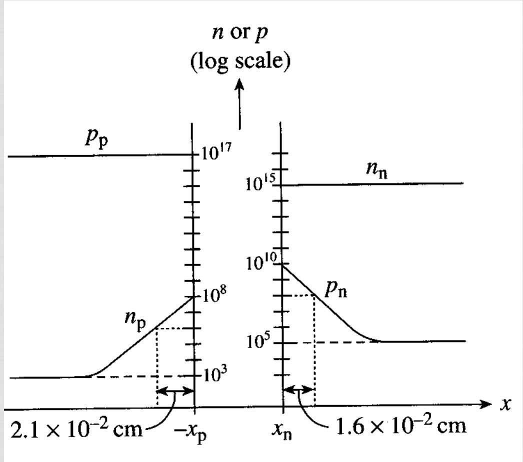
PART III: PROBLEM 1

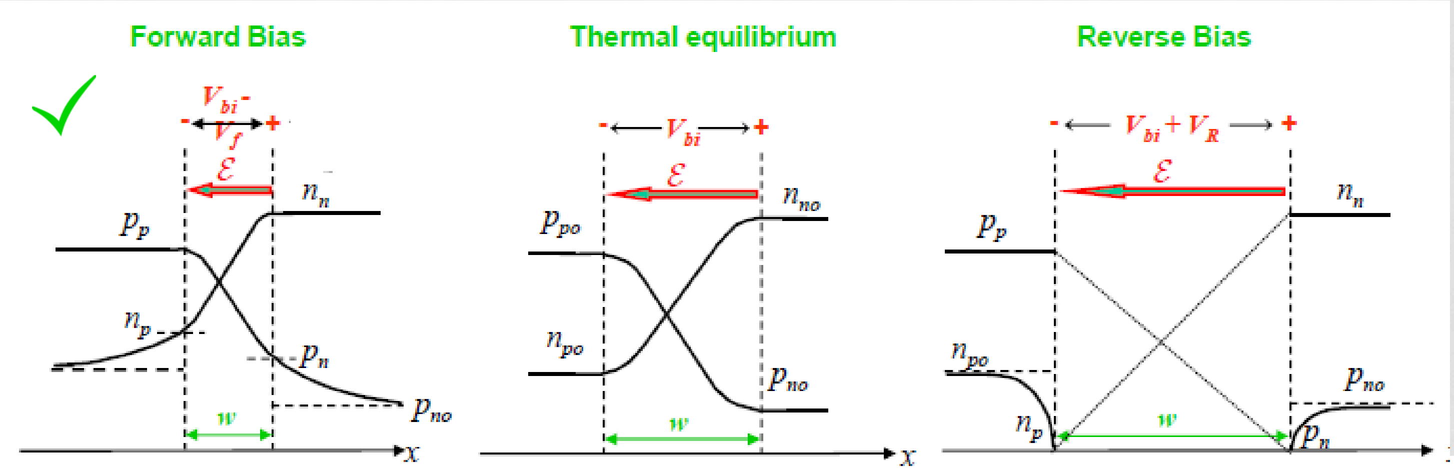
I-What is the bias condition of the diode?



PART III: PROBLEM 1

I-What is the bias condition of the diode?





PART III: PROBLEM 1

II - Low- level injection conditions:

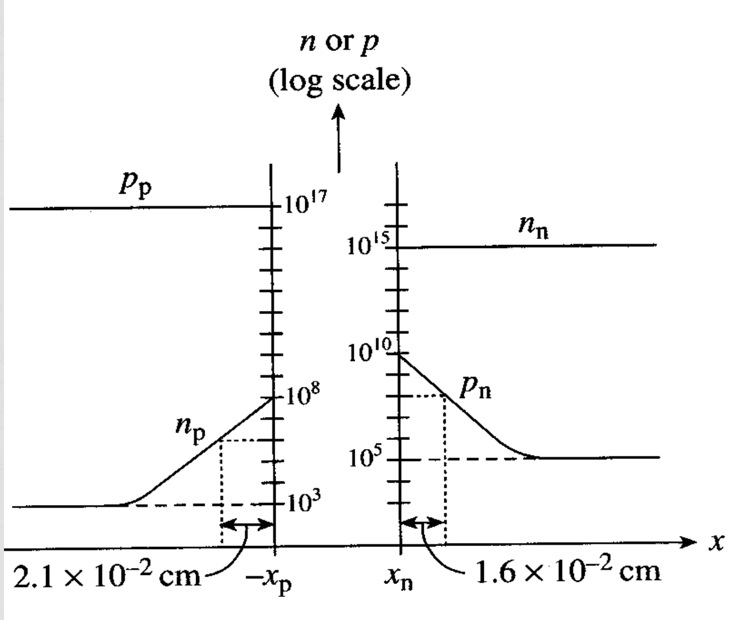
(a) prevail only in the neutral p - region
(b) prevail only in the neutral n - region
(c) prevail in both the neutral p - and n- regions
(d) do not prevail in any region

Compare: $\Delta p_n \qquad n_n$

$$10^{10} - 10^{5} \ll 10^{15}$$

$\Delta n_p \qquad p_p$

$$10^{8} - 10^{3} \ll 10^{17}$$



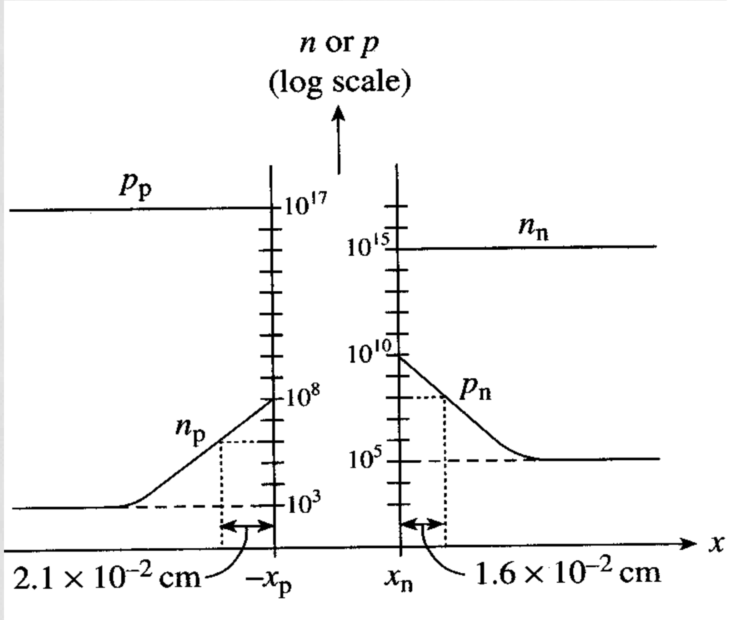
PART III: PROBLEM 1

III - Calculate the built in voltage of the diode?

$$V_{bi} = \frac{KT}{q}\ln\left(\frac{N_d N_a}{n_i^2}\right)$$

where $N_d \approx n_n$ and $N_a \approx p_p$

$$V_{bi} = 0.0259\ln\left(\frac{10^{15}10^{17}}{(10^{10})^2}\right)$$ =0.7 Volts



IV - Calculate the external applied voltage V?

$$\Delta p = p_{no}\left(e^{qV/kT} - 1\right)$$

$$V = \frac{kT}{q}\ln\left(\frac{\Delta p}{p_{no}} + 1\right)$$

$$V = 0.0259\ln\left(\frac{10^{10}-10^{5}}{10^{5}} + 1\right)$$ =0.29 Volts

PART III: PROBLEM 1

A Si p^+-n junction has a donor doping of 5 x 10^{16} cm^{-3} on the n-side and a cross- sectional area of 10^{-3} cm^2. If τ_p = 1μs and D_p = 10cm²/s , calculate the current with a forward bias of 0.5 V at 300k.

$$I = I_o\left(e^{qV/kT} - 1\right)$$

$$I_o = Aq\left[\frac{D_p p_{no}}{L_p} + \frac{D_n n_{po}}{L_n}\right] = Aq\left[\frac{D_p}{L_p}\frac{n_i^2}{N_d} + \frac{D_n}{L_n}\frac{n_i^2}{N_a}\right]$$

Neglected!!

$$I = Aq\,\frac{D_p}{L_p}\frac{n_i^2}{N_D}\left(e^{\frac{qV}{KT}} - 1\right)$$

Substitute with $L_p = \sqrt{D_p \tau_p}$