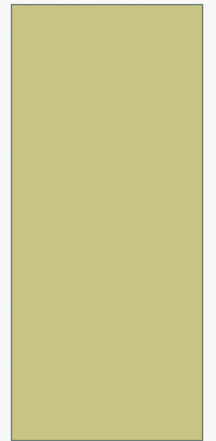


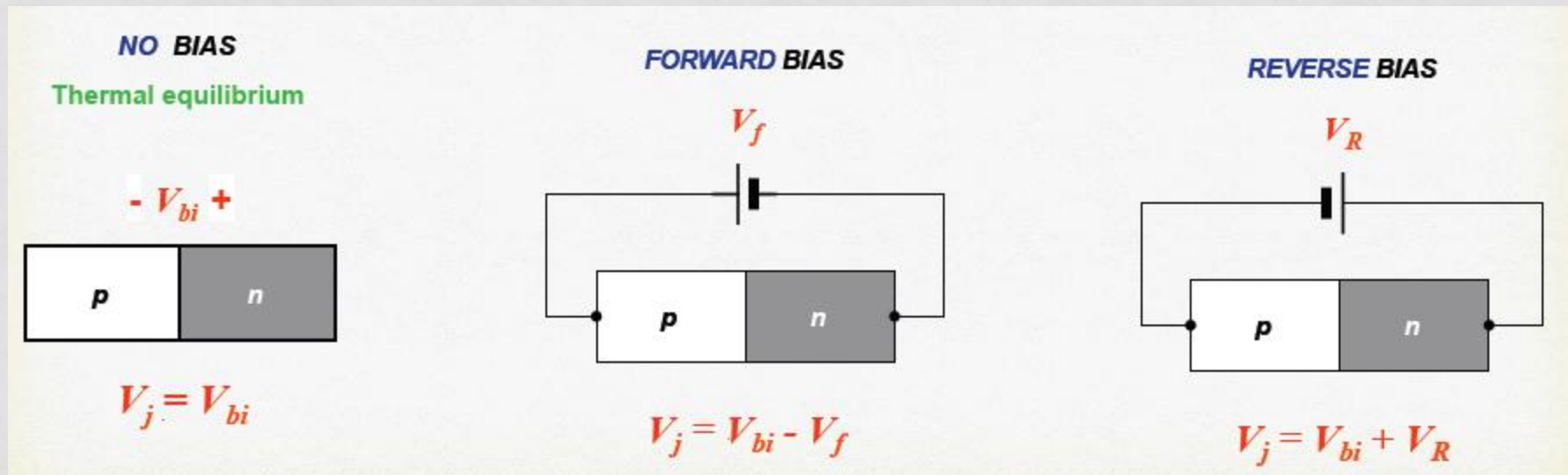
EC233
ELECTRONIC DEVICES 1

SHEET 8 SOLUTIONS



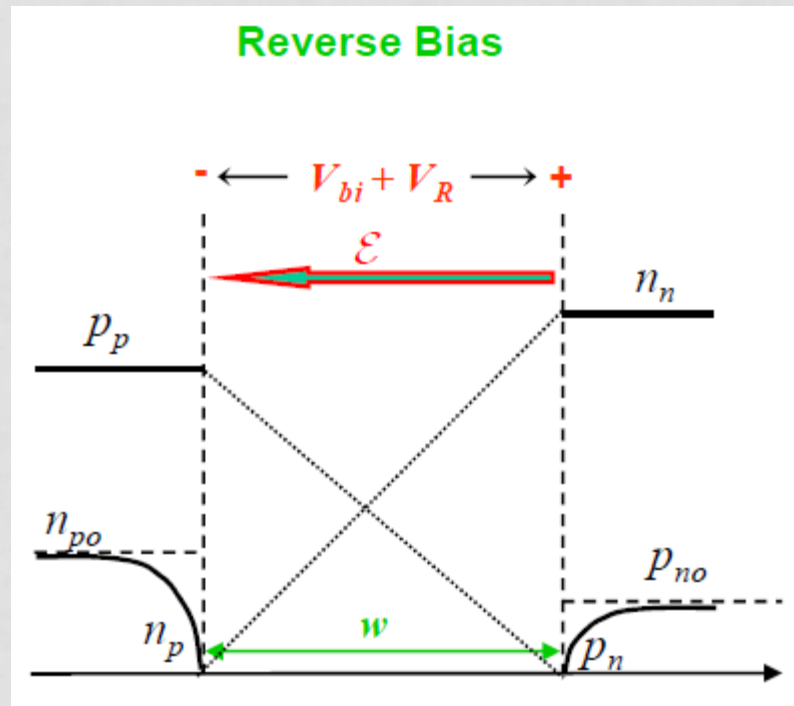
PART I: TRUE/FALSE

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



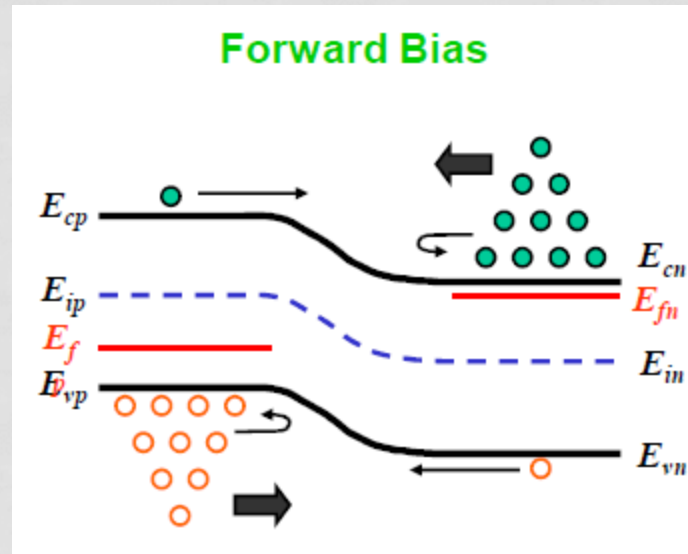
PART I: TRUE/FALSE

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. ❌

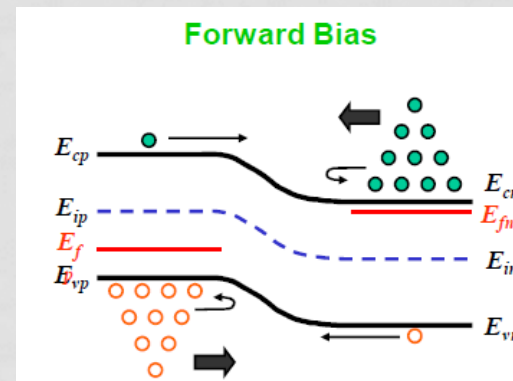
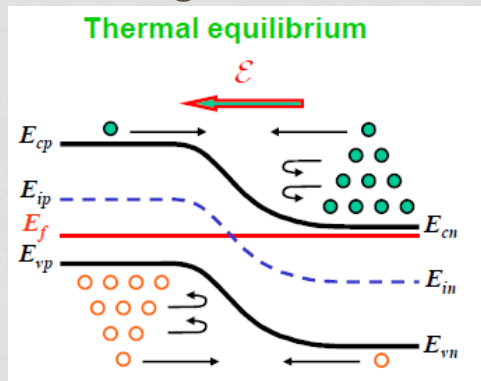


PART I: TRUE/FALSE

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. ✔️



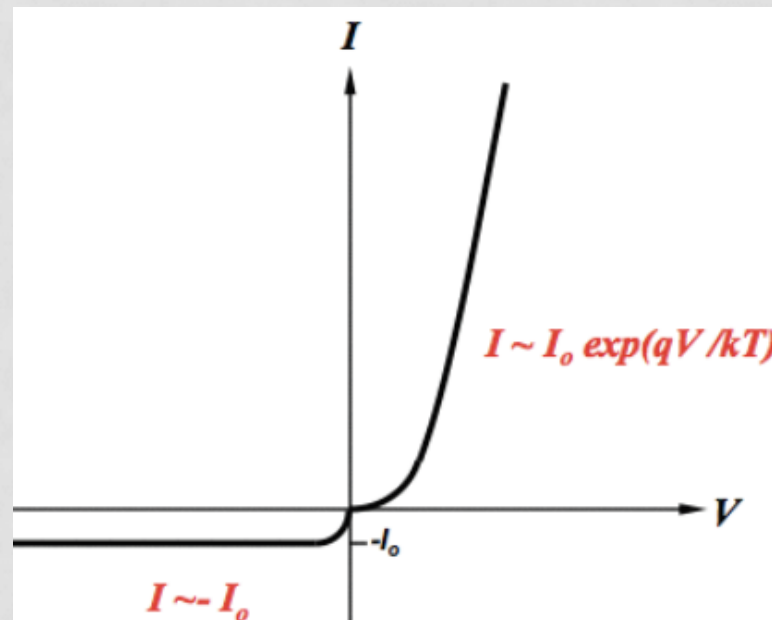
6. The drift of minority carriers through the depletion layer controls the reverse saturation current. ❌

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

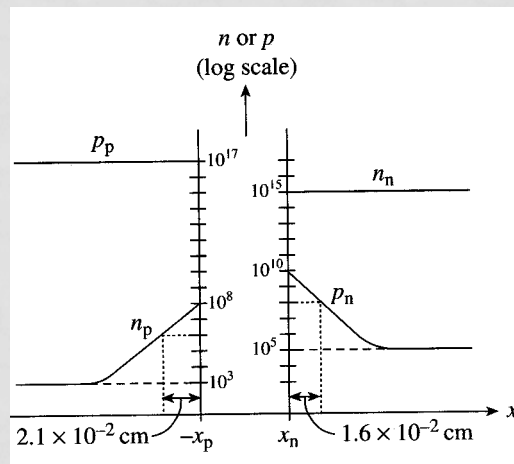
- (a) Zero
- (b) KT/q
- (c) q/KT
- (d) KT

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



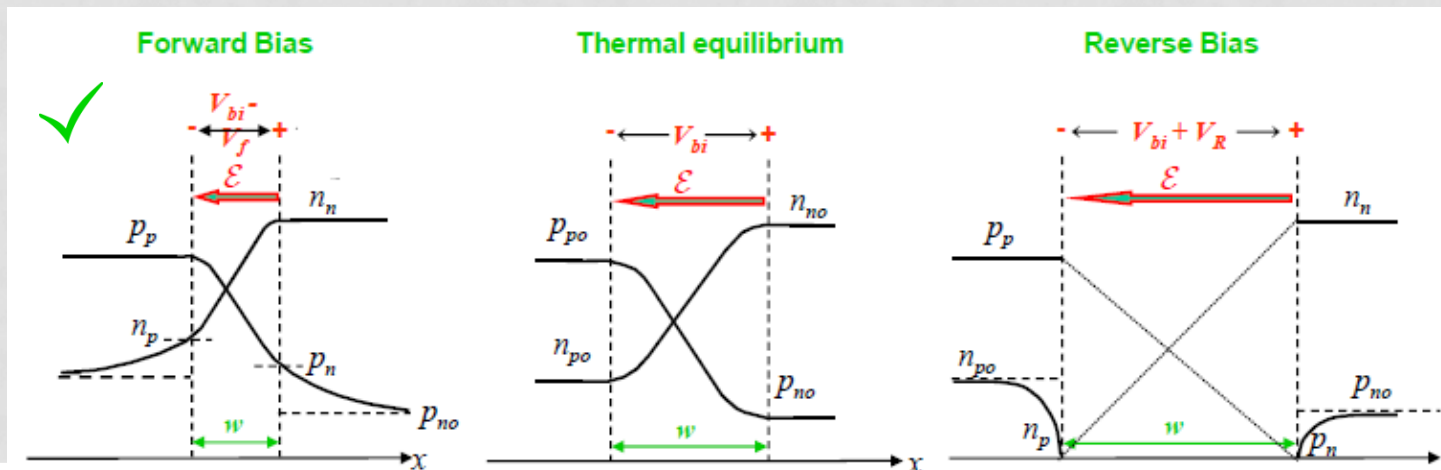
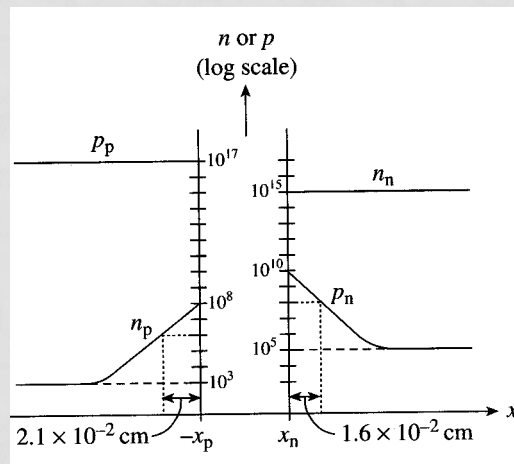
PART III: PROBLEM 1

I-What is the bias condition of the diode?



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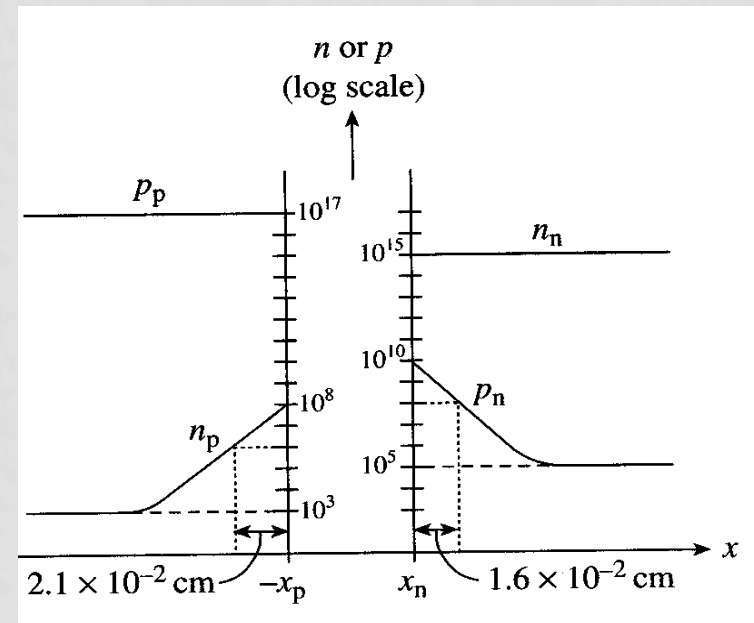
PART III: PROBLEM 1

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: Δp_n
 $10^{10} - 10^5 \ll 10^{15}$

Δn_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 $N_a \approx p_p$

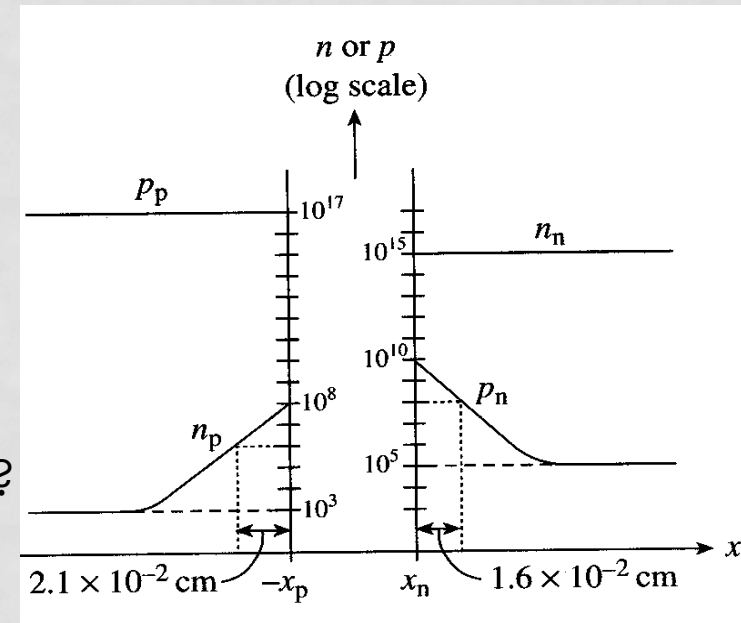
$$V_{bi} = 0.0259 \ln\left(\frac{10^{15} 10^{17}}{(10^{10})^2}\right) = 0.7 \text{ Volts}$$

IV - Calculate the external applied voltage V ?

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

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

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



PART III: PROBLEM 1

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

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

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

Neglected!!

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

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