Course:	**Semiconductor Device Fundamentals**
Level:	**Undergraduate**
Module:	**B**
Test:	**B18**
Type:	**Closed Book, Closed Notes**
Note:	**Available Info/Equation Sheets**

Problem Weighting--- **T2-1...36 (6 each part)**
T2-2...22 (a-6, b-6, c-10)
T2-3...18 (a-6, b-12)
T2-4...24 (8 each part)

T2 - 1

(a) Sketch the general form of the reverse bias I-V_A characteristics exhibited by silicon PN junction diodes maintained at room temperature. Note any deviations from the ideal on your sketch.

(b) Sketch the general form of the current transient observed when a PN junction diode is rapidly pulsed from forward bias to reverse bias.

(c) Explain, through the use of a sketch, what is meant by the term "punch-through" as it relates to the Bipolar Junction Transistor.

(d) Using the energy band diagram, indicate how one visualizes "avalanching" in a reverse biased PN junction diode.

(e) Using the energy band diagram, indicate how one explains the origin of I_{R-G}, the recombination-generation current, in reverse biased PN junction diodes.

(f) Draw the energy band diagram for a PNP Bipolar Junction Transistor (BJT) under active mode biasing. Label the emitter, base and collector region E, B, and C respectively.

T2-2

The doping profile inside a special PN junction diode is as shown in Fig. PT2-2.

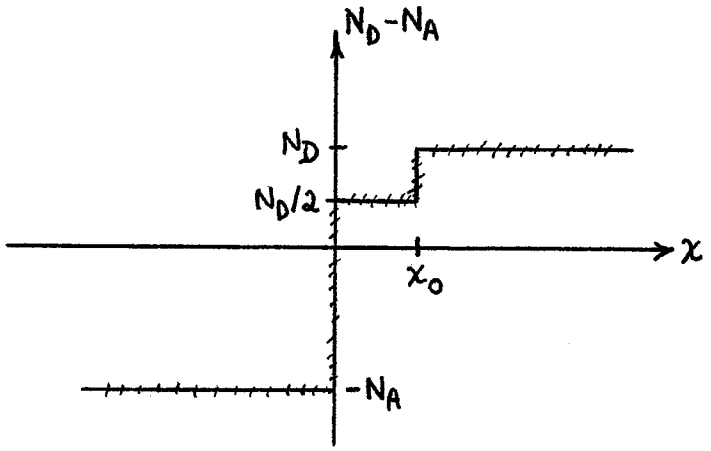


Fig. PT2-2

(a) An expression for V_{bi}, the built-in voltage across the device under equilibrium conditions, is desired. Complete the derivation of V_{bi} started in the answer booklet.

(b) Assuming $x_n > x_o$ and invoking the depletion approximation, sketch the charge density ρ versus x inside the device.

(c) We know

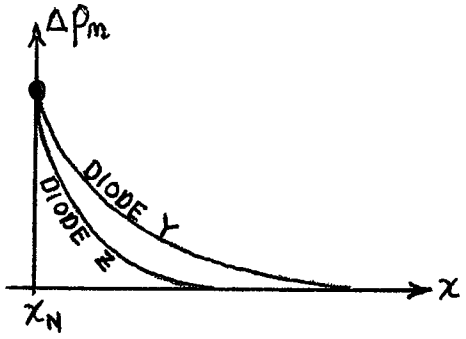
$$\mathcal{E}(x) = -\frac{qN_A}{K_S\epsilon_o}(x_p + x) \qquad \text{...for } -x_p \leq x \leq 0$$

$$\mathcal{E}(x) = -\frac{qN_D}{K_S\epsilon_o}(x_n - x) \qquad \text{...for } x_o \leq x \leq x_n$$

Work out an expression for $\mathcal{E}(x)$ valid over the range $0 \leq x \leq x_o$.

T2-3

A plot of the excess minority carrier concentration inside two ideal P^+-N diodes maintained at room temperature is as pictured in Fig. PT2-3.



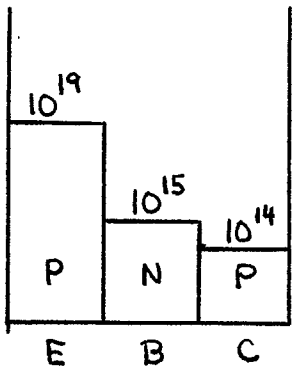
...Fig. PT2-3

(a) Are the diodes forward or reversed biased?

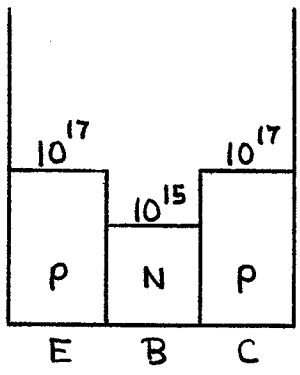
(b) The n-side doping (N_D) and the area of the two diodes are the same. Which diode is carrying the larger current? Carefully explain your answer to receive credit.

T2-4

A comparison is to be made between two ideal transistors (BJT's) which have mostly identical parameters except for the dopings of their emitter and collector regions. The doping profiles of Transistors A and B are shown in Fig. PT2-4.



Transistor A



Transistor B

Fig. PT2-4

Make sure to explain your answers to receive credit.

(a) Assuming the transport factor (α_T) in both transistors is unity and $D_E W/L_E$ (of Transistor A) $\simeq$ $D_E W/L_E$ (of Transistor B) at the operational point, which transistor will exhibit the larger active mode common-base current gain (α_{dc}) ? Explain.

(b) Which transistor will exhibit the larger sensitivity to base width modulation under active mode operation? Explain.

(c) Which transistor will exhibit the larger V_{CBO}? Explain.
(V_{CBO} is the maximum collector-base voltage which can be applied under common-base operation when $I_E = 0$.)