Course:	**Semiconductor Device Fundamentals**
Level:	**Undergraduate**
Module:	**B**
Test:	**B13**
Type:	**Closed Book, Closed Notes**
Note:	**Available Info/Equation Sheets**

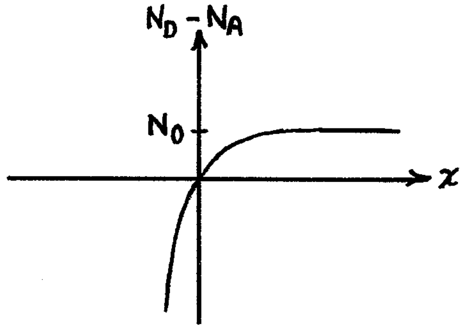
Problem Weighting--- **T2-1...16 (8 each diagram)**
T2-2...16 (a-5, b-5, c-6)
T2-3...16
T2-4...16
T2-5...16 (a-5, b-6, c-5)
T2-6...20 (a-6, b-8, c-6)

NAME______________________ T2 - 1 ______________SCORE

During the course of the PN junction discussion we encountered three phenomena which can give rise to large junction currents under certain conditions; namely, avalanching, the Zener process, and punch-through. Using the **energy band diagram**, describe **TWO** of the cited three phenomena. (If desired, you may add a few words to forestall a misinterpretation of your diagrams.)

NAME______________________________ T2 - 2 ________________SCORE

The doping profile inside a PN junction diode is as shown below.

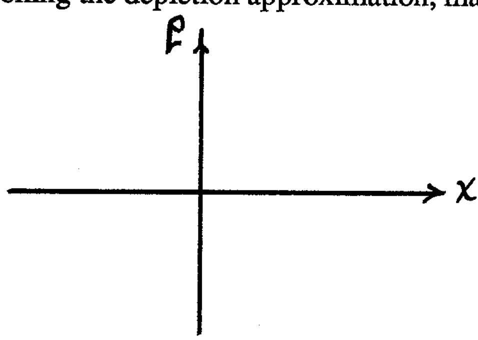


$$N_D - N_A = N_0\,(1 - e^{-ax})$$

where N_0 and <u>a</u> are constants

(a) Give a concise statement of the depletion approximation.

(b) Invoking the depletion approximation, make a sketch of the charge density inside the diode.



(c) Work out an expression for the electric field, $\mathcal{E}(x)$, inside the depletion region.

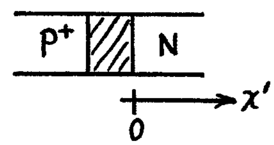
NAME________________________ **T2 - 3** _______________SCORE

In the charge-control analysis of the PN junction transient response we showed that, for a P^+-N diode,

$$\frac{dQ_P}{dt} = i - \frac{Q_P}{\tau_p}$$

where

$$Q_P \equiv qA \int_0^{\infty} \Delta p_n(x')dx'$$



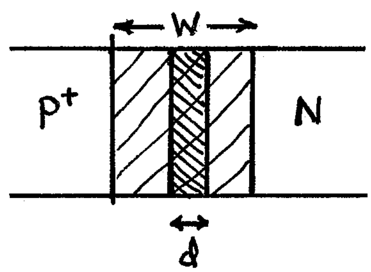
Moreover, in the standard derivation of the Ideal Diode Equation, we concluded

$$\Delta p_n(x') = \frac{n_i^2}{N_D}(e^{qV_A/kT} - 1)\, e^{-x'/L_P}$$

Using only the relationships cited in this problem, show that one can establish the Ideal Diode Equation valid for a P^+-N junction diode.

NAME________________________ T2 - 4 _______________SCORE

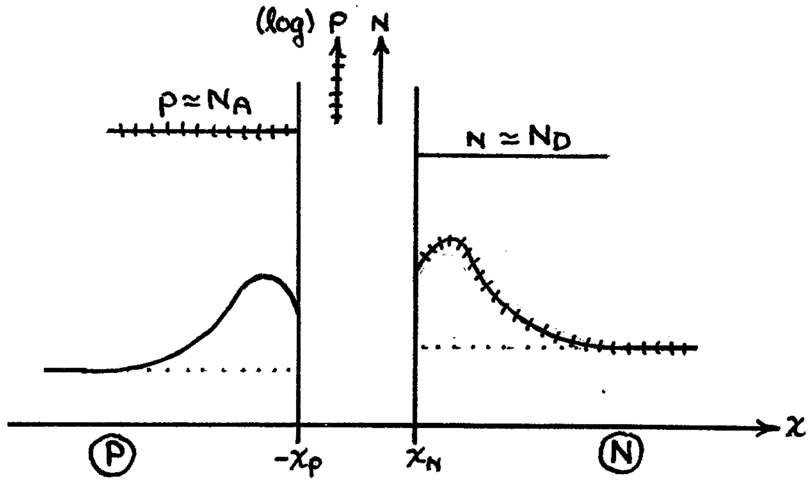
Inside a Si diode, maintained at room temperature, there is a region of width d which contains **three** times as many R-G centers as adjoining regions. This special region (as envisioned below) lies totally inside the depletion region when the diode is zero biased.



Derive an expression for the R-G current ($I_{R\text{-}G}$) to be expected from the diode under reverse bias conditions. (Assume the applied reverse-bias voltage is greater than a few kT/q volts.) RECORD ALL DERIVATIONAL STEPS.

NAME__________________________ T2 - 5 ________________SCORE

The carrier concentrations inside an ideal pn junction diode are as shown below.



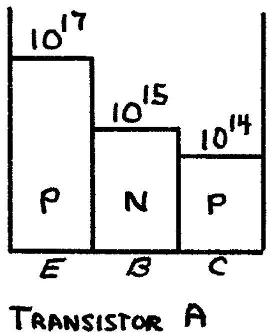
(a) Is the junction forward or reverse biased; i.e., is the p-side potential positive or negative relative to the n-side potential? EXPLAIN how you arrived at your answer.

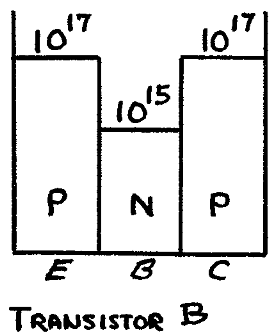
(b) What is the direction of current flow inside the diode? (To avoid confusion, specifiy if the current flows from P → N or N → P.) EXPLAIN how you arrived at your answer.

(c) Do low level injection conditions prevail inside the diode? EXPLAIN how you arrived at your answer.

NAME______________________ T2 - 6 ______________SCORE

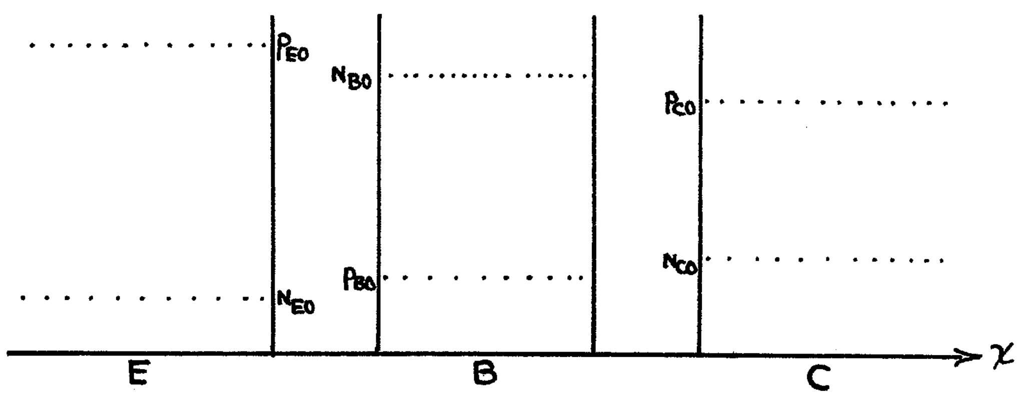
Two ideal transistors (BJT's) are identical except for the dopings of their collector regions. The doping profiles of Transistors A and B are shown below.





(a) Which transistor will exhibit the larger sensitivity to base-width modulation under active mode operation? EXPLAIN.

(b) Sketch the **minority and majority** carrier distributions in the quasi-neutral regions of Transistor A under active mode biasing. Assume low level injection conditions prevail and $W_B << L_B$.



(c) Complete the following table by indicating the polarity (**F** = forward or **R** = reverse) of the bias being applied across the emitter-base and collector-base junctions of a BJT under the specified biasing mode.

Biasing Mode	Polarity of bias: emitter - base	Polarity of bias: collector - base
Active		
Cut - off		
Saturation		