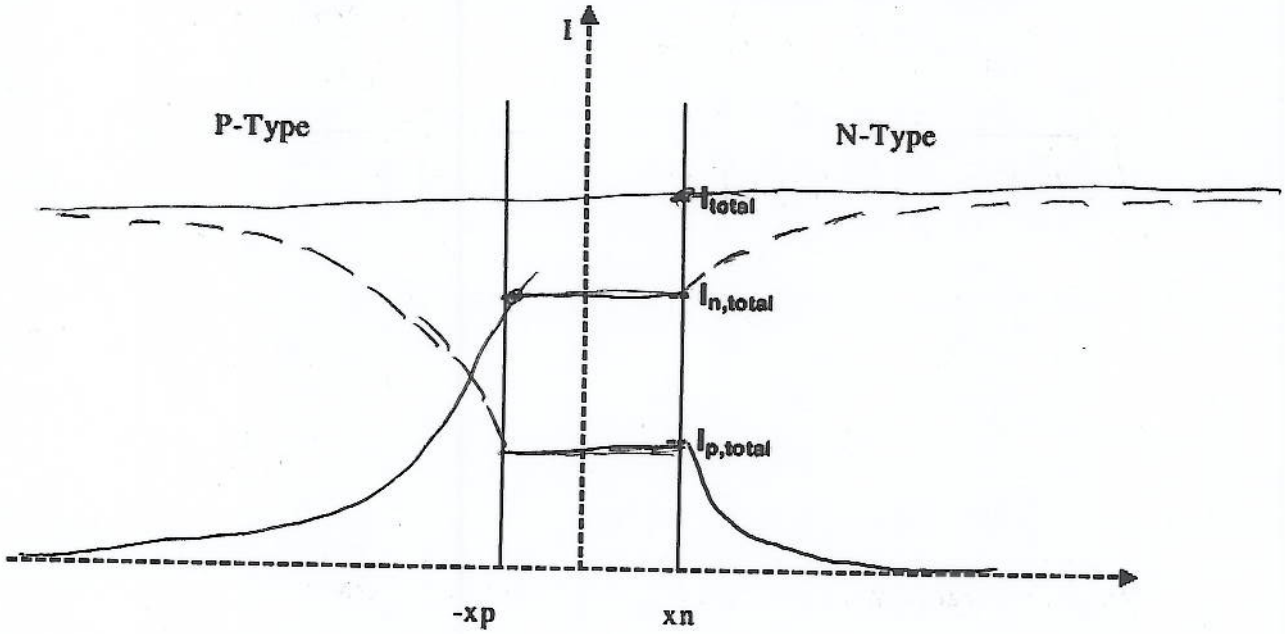
NAME: Solution

ECE344 Semiconductor Devices
Fall 2008

QUIZ-4

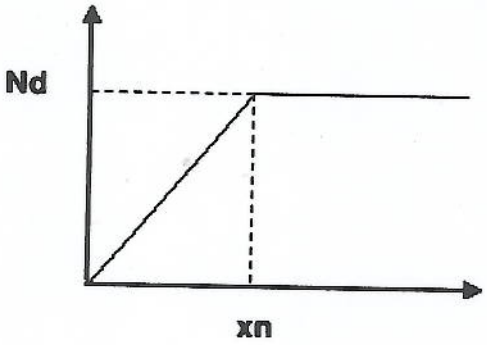
5 **Question 1:**

Consider a forward-biased ideal p-n diode (i.e. step junction, no R/G in the depletion region). On the following graph sketch the total current I_{total}, the total electron current $I_{n,tot}$ and total hole current $I_{p,tot}$ as a function of the position throughout the entire device. The values of each has been given at x_n.



5 **Question 2:**

Let us consider the following linear doping profile for the N-region of a P-N diode:



2 a- Using the depletion approximation, give the expression of the charge density ρ(x)

$\rho(x) = q(-n+p-N_A+N_D)$ Here $n = p \cong 0$ ($\ll N_D$) $\Rightarrow$ depletion approx.

$N_A = 0 \Rightarrow \rho(x) = qN_D(x)$

$$\Rightarrow \boxed{\rho(x) = q\left(\frac{N_D}{x_n}\right)x}$$

b- Give the expression of the electric field in [0,xn] by Solving the Poisson equation

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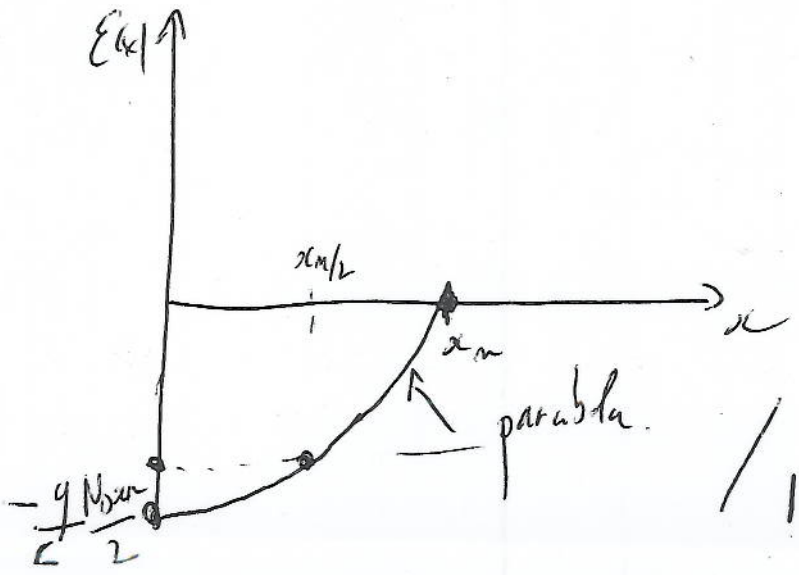
$$\boxed{\frac{d\mathcal{E}}{dx} = \frac{q}{\epsilon}\left(\frac{N_D}{x_n}\right)x} \qquad \mathcal{E}(x) = \frac{q}{\epsilon}\left(\frac{N_D}{x_n}\right)\frac{x^2}{2} + c$$

Depletion approx $\mathcal{E}(x_n) = 0 \Rightarrow c = -\frac{q}{\epsilon}\left(\frac{N_D}{x_n}\right)\frac{x_n^2}{2}$

$$\boxed{\mathcal{E}(x) = \frac{q}{\epsilon}\left(\frac{N_D}{x_n}\right)\left[\frac{x^2}{2} - \frac{x_n^2}{2}\right]}$$

1.5 **c- What is the value of the electric field at x=0, sketch a graph**

$$\mathcal{E}(0) = -\frac{q}{\epsilon}\left(\frac{N_D}{x_n}\right)\frac{x_n^2}{2} = -\frac{q}{\epsilon}\frac{N_D x_n}{2} \quad /0.5$$



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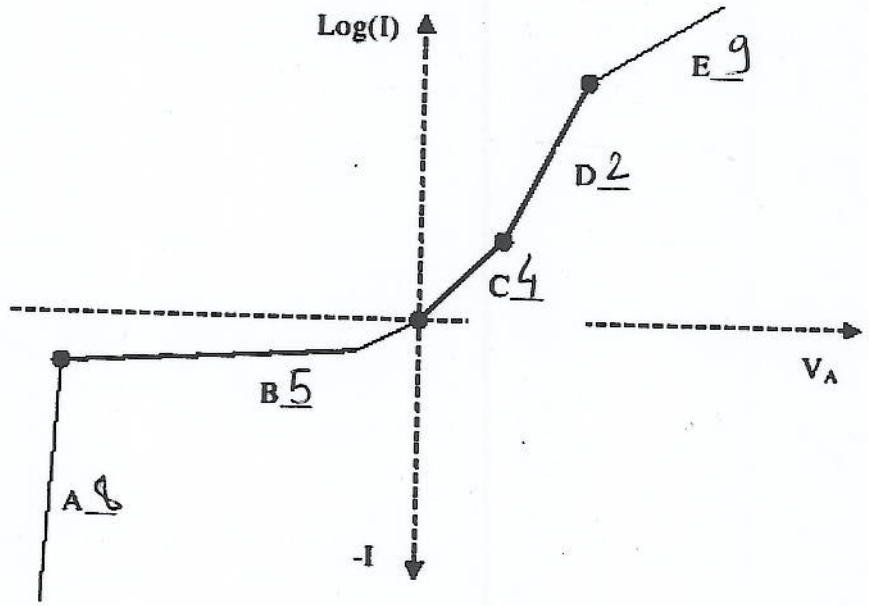
$$\begin{cases} \mathcal{E}\left(\frac{x_n}{2}\right) = \frac{q}{\epsilon}\left(\frac{N_D}{x_n}\right)\left[\frac{x_n^2}{8} - \frac{x_n^2}{2}\right] \\ = \frac{q}{\epsilon}\left(\frac{N_D}{2}\right)\left[\frac{3 \cdot x_n}{4}\right] \\ \mathcal{E}(x_n) = \mathcal{E}\left(\frac{x_n}{2}\right) \cdot \frac{3}{4} \end{cases}$$

5/ **Question 3:**

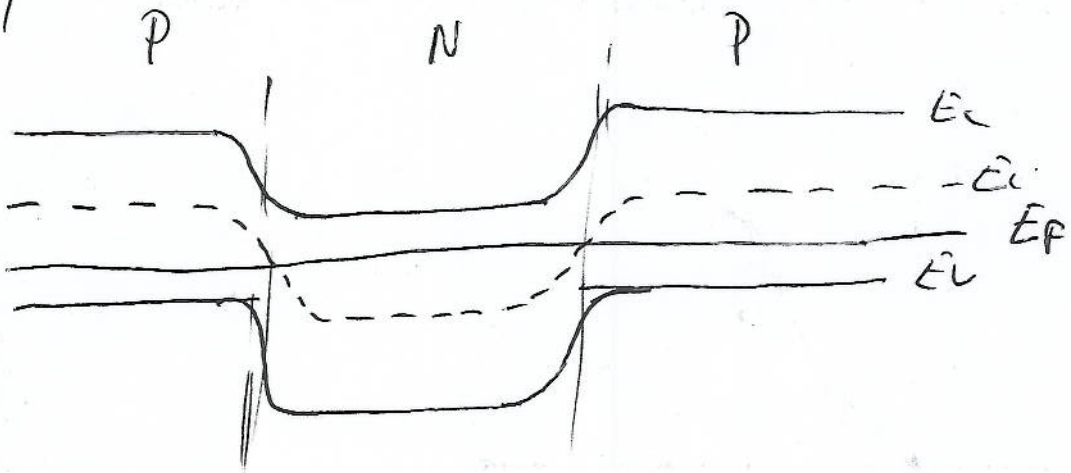
Below is a "measured " I-V Characteristics of the P-N Si diode. The scale for the current is logarithmic for the forward bias and linear for the reverse bias. For each different region of the curve, place the corresponding phenomena (number) adjacent to the letter.



1- **Photogeneration**
2- **Ideal region**
3- **Depletion approximation**
4- **Thermal recombination dominated current**
5- **Thermal generation dominated current**
6- **Band bending**
7- **Tunneling**
8- **Impact ionization**
9- **High-level injection**
10- **Accumulation**

5/ **Question 4:**

Sketch the energy band diagrams of a P-N-P and N-P-N devices. Indicate Ei, Ef,Ec,Ev



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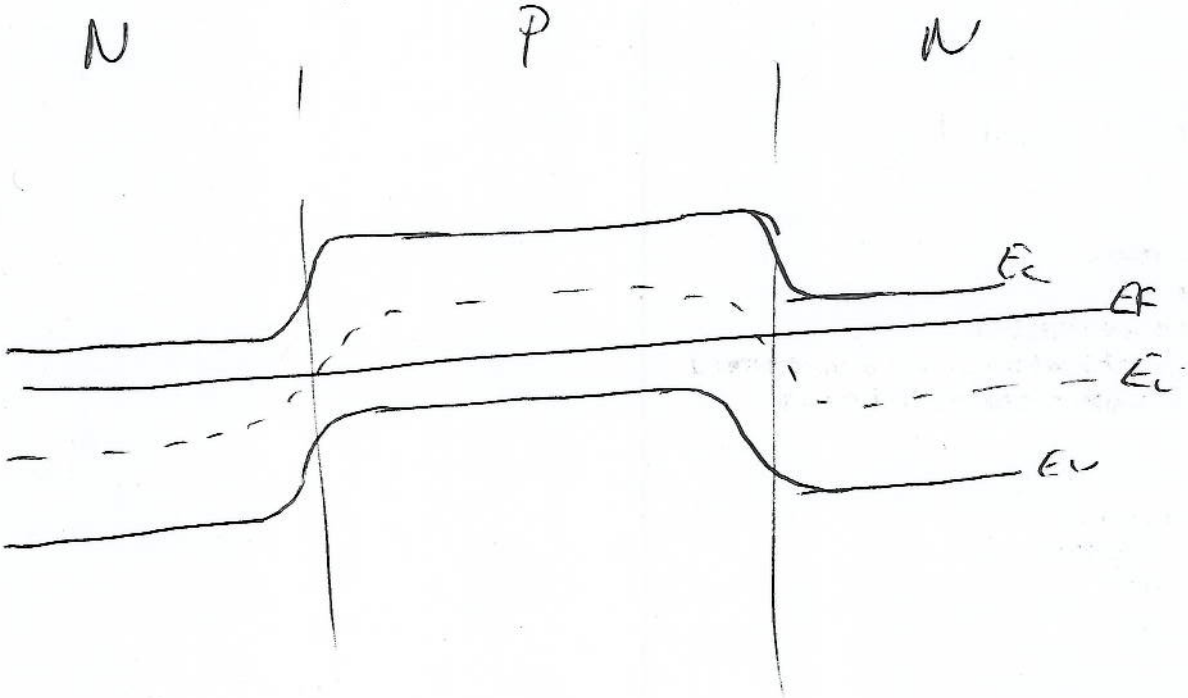

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