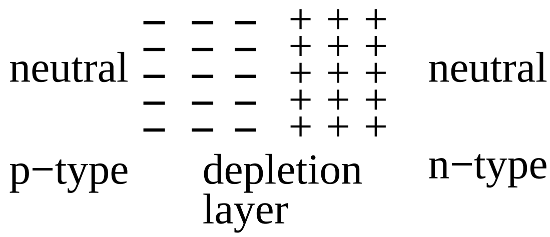
Physics 238C **Spring 2011**

Condensed Matter Physics **due 2:00 pm Thursday April 21**

PROBLEM SET 3

Reading: Ashcroft and Mermin (AM) Chapter 29

1. A p-n junction in equilibrium has a charge distribution in the depletion region as shown:



The density of acceptors in the p side is N_A and the density of donors on the n side is N_D and the thickness of the depletion regions are d_n and d_p.

(a) If $N_D = N_A = 10^{17}$ cm^{-3} find the total thickness of the depletion region $d = d_p + d_n$ for a junction in silicon. Assume a Si band gap and that the dopings are high enough that the valence band edge is near μ in the p region and the conduction band edge is near μ in the n region.

(b) Find the thickness $d = d_p + d_n$ if a reverse bias voltage of 5.0 volts is applied.

2. A certain fictitious semiconductor has nondegenerate valence and conduction bands centered at $\vec{k} = 0$ (i.e., like InSb, but with only one hole band). At room temperature its parameters are the following: band gap =0.5 eV, $m_e^* = m_v^* = 0.1$ m, $\varepsilon = 20$, electron mean free path = hole mean free path = 10^2 $\AA$, recombination time = 10^{-3} secs. To form a pn junction it is doped with a concentration of 10$\AA$, recombination time = 10^{-3} secs. To form a pn junction it is doped with a concentration of 10^{22} m^{-3} acceptor impuritites on one side and 10^{22} m^{-3} donor impurities on the other. Assuming that at room temperature all donors and acceptors are ionized, calculate

(a) the diffusion coefficient (identical for electrons and holes)

(b) the diffusion length

(c) the minority carrier density on each side

(d) the saturation current density

(e) the current density at a bias of 0.05 V in (i) the forward, and (ii) the reverse direction

[Note: Parts of this question refer to material covered in Ch. 28 of AM as well as that covered in pages 601-611 of Ch. 29.]