COLLEGE OF ENGINEERING & TECHNOLOGY

Department: Electronics and Communications Engineering
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Course Title: Advanced Devices Fall 2015
Course No.: EC738 Problem Set #1

Intrinsic and Extrinsic Semiconductors

Intrinsic Silicon

Question 1 :
Plot (on the same graph) both the Fermi-Dirac and Boltzman functions as a function of energy (in eV) for T= -100C, 0C and 100C.
Hint: use eqn. 2.4-2.6

Question 2:
Plot the intrinsic carrier concentration for silicon, n_i, as a function of temperature for the range of -100C to +100C.
Note that from eqn. 2.10:
$N_c(T) = N_{co} (T/300)^{3/2}$
$N_v(T) = N_{vo} (T/300)^{3/2}$
$N_{co} = 3.22 \times 10^{19} cm^{-3}$, $N_{vo} = 1.8 \times 10^{19} cm^{-3}$

Hint: use eqn. 2.13

Extrinsic Silicon

Question 3:
Plot the Fermi level separation from intrinsic energy level (Ei) as a function of temperature between -100C and 100C, for the following cases:

3a- Intrinsic Si doped with B (boron), with doping of (i) 1×10^{15} and (ii) $1 \times 10^{17} cm^{-3}$
3b- Si doped with As (Arsenic) with doping of (i) 1×10^{15} and (ii) $1 \times 10^{17} cm^{-3}$
3c- Si doped with both As ($5 \times 10^{16} cm^{-3}$) and B ($1 \times 10^{17} cm^{-3}$)
Hint:

- Use eqn 2.20, 2.22
- Use the temperature dependence equations for $N_C(T)$ and $N_V(T)$ from question 2
- For mixed N_a & N_d, the effective $N_{doping} = N_d - N_a$.
- The plot will be something close to Fig. 2.7

Question 4:
Plot the Fermi level separation from conduction or valence band edge, as a function of doping, for:

- n-type doping, with N_d from 10^{15} - $10^{18} cm^{-3}$, at T=200K, 300K and 400K
- p-type doping, with N_A from 10^{15} - $10^{18} cm^{-3}$, at T=200K, 300K and 400K

Hint: This is very close to Question 3