Equations with One Variable

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In the following question I recommend that you solve using all the possible methods for practice

1. Calculate the location of conduction with respect to the Fermi-Level in an n-type semiconductor with a doping of $N_D = 10^{20} cm^{-3}$ using Maxwell-Boltzmann statistics. Repeat the calculations with the Fermi-Dirac statistics.

2. Calculate the location of conduction with respect to the Fermi-Level in an n-type semiconductor with a doping of $N_D = 10^{16} cm^{-3}$ using Maxwell-Boltzmann statistics. Repeat the calculations with the Fermi-Dirac statistics.

3. Compare and comment on the results of Q1 and Q2

4. Calculate the interatomic distance of NaCl given that the potential energy between two ions is

$$F(r) = -\frac{e^2}{4\pi\varepsilon_0 r} + V_0 e^{r/r_0}$$

   $V_0 = 1.09 \times 10^3 \ eV$ and $r_0 = 0.33 Ang$

5. In a piece of an n-type semiconductor the equation for carrier concentration (electron) accounting for incomplete ionization is given by

$$\frac{N_D N_C}{N_C + 2ne^{(E_C - E_D)/k_B T}} + \frac{N_C N_V}{n} e^{-E_G/k_B T} = n$$

   Assume $E_C - E_D = 10 \ meV$ $E_G = 1.1 eV$. Calculate the carrier concentration at T = 50 K, 300 K and 600 K. Analyze your results. From where do we get the above equation – From Charge neutrality condition.

6. A MOS Capacitor is a combination of two capacitors oxide and semiconductor in series. Manipulating the Poisson's equation for the MOS structure allows us to write the sheet charge density (C/cm^2) at the oxide-semiconductor interface as

$$\left|\frac{Q_s}{\epsilon_S}\right| = \left[\frac{\sqrt{2} k_B T}{q L_D}\right] \left[\left(e^{\frac{-q\phi}{k_B T}} + \frac{q\phi}{k_B T} - 1\right) + \frac{n_0}{p_0}\left(e^{\frac{q\phi}{k_B T}} - \frac{q\phi}{k_B T} - 1\right)\right]^{0.5}$$

   where $L_D = \sqrt{\frac{\varepsilon_{Si} kT}{e^2 N_A}}$ and ϕ_S is the potential drop across the semiconductor. Calculate the potential drop across the semiconductor when $Q_S = 10^{-7} C/cm^{-2}, \ 10^{-8}, C/cm^{-2}$. Assume $N_A = 4 \times 10^{15} cm^{-3}$, $T = 300K$