COLLEGE OF ENGINEERING & TECHNOLOGY

Department: Electronics and Communications Engineering

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Course Title: Electronic Devices I

Course Code: EC 233

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Sheet 4

I. Indicate whether each of the following statements is true or false *(give reasons)*:

1- When an intrinsic semiconductor is doped with N_D donors, the new electron concentration is $n = n_i + N_D$.

2- The electron and hole concentration expressions, $n=N_c \exp[(E_f - E_c)/kT]$ and $p=N_v \exp[(E_v - E_f)/kT]$, are valid only if E_f lies in the forbidden gap more than 3kT from either band edge.

3- The electron and hole concentrations of a silicon wafer doped with $10^{15}cm^{-3}$ donor atoms at 300 K is equal to 10^{15} and 2.25×10^{5} cm^{-3} respectively.

II. Solve the following problems:

Boltzmann constant $k = 8.617\times10^{-5}$ eV/K, Planck's constant $h = 6.63\times10^{-34}$ J.s, $\hbar = h / 2\pi$.

At 300 K:

Material	m_n^*/m_o	m_p^*/m_o	E_G (eV)	n_i (cm^{-3})
Silicon (Si)	1.1835	0.8048	1.12	1×10^{10}
Germanium (Ge)	0.55	0.36	0.66	2×10^{13}
Gallium Arsenide (GaAs)	0.066	0.52	1.42	2×10^{6}

1- A silicon wafer is uniformly doped with acceptor impurities of concentration 10^{15} cm^3. What are the equilibrium electron and hole concentrations at 0 K?

2- The electron concentration in a piece of silicon at 300 K under equilibrium conditions 10^5 cm^{-3}. Find the hole concentration.

3- Determine the location of Fermi level with respect to the top of valence band in n-type germanium at 300 K, if the impurity content is one part in 10^6. There are $4.4x10^{28}$ atoms/m^3 in Ge. Let $N_c = 4.83x10^{21}$ $T^{3/2}$, Eg = 0.72 eV.

4- Find the equilibrium electron and hole concentrations and the location of Fermi level (with respect to the intrinsic Fermi level Ei) in Si at 300 K, if the Si contains $8x10^{22}$ m^{-3} As atoms (group 5) and $2x10^{22}$ m^{-3} Br (group 3) atoms.

5- The resistivity of pure Ge at a particular temperature is 0.52 Ω m. If it is doped with 10^{20} atoms/m^3 of a trivalent impurity estimate the new value of resistivity. Assume the mobility of holes and electrons are 0.2 and 0.4 m^2/V.s

6- Determine the concentration of electrons and holes in a sample of Ge at 300k, which has a concentration of donor atoms = $2*10^{20}$ m^{-3} and concentration of acceptor atoms = $3*10^{14}cm^{-3}$, is this p-type? Given that n_i= 2.5*1013cm^{-3}, μ_n =3800 cm^2/V.sec, and μ_p = 1800 cm^2/V.sec.

This work had been prepared with the help of Dr. Wael Fikry and Dr. Tarek Abd El_Kader.

Good Luck ☺