EE 471: Transport Phenomena in Solid State Devices

HW 1

Due: 2/2/18

Please show all working (including equations you use to calculate your answers).

All numerical answers should include units

Calculate numerical answers to 3 sig. figs.

1. A silicon sample is 7 mm in length, 1.5 mm in width and 0.25 mm high. It has been doped with Boron with a doping density of 5.5×10^{16} cm^{-3}. Assume the temperature is 300°K.

    a. Is the sample N-type or P-type? *(2 points)*
    b. What is the majority carrier type? *(2 points)*
    c. What is the majority carrier density assuming complete ionization? *(2 points)*
    d. What is the minority carrier density? *(3 points)*
    e. Where is the Fermi level? *(3 points)*
    f. What is the total number of holes you would find in the sample? *(3 points)*

2. The same sample is now counter-doped with Arsenic at a density of 9.0×10^{16} cm^{-3}.

    a. Is the sample now N-type or P-type? *(2 points)*
    b. What is the majority carrier type? *(2 points)*
    c. What is the majority carrier density assuming complete ionization? *(2 points)*
    d. What is the minority carrier density? *(3 points)*
    e. Where is the Fermi level? *(3 points)*
    f. What is the total number of holes you would find in the sample? *(3 points)*

3. At 300ºK, N_c and N_v in gallium arsenide are 4.7×10^{17} and 7.0×10^{18} cm^{-3} respectively and vary as $T^{3/2}$. The bandgap in gallium arsenide is 1.42 eV.
    a. Calculate the intrinsic carrier concentration in gallium arsenide at 300º K. *(4 points)*
    b. What is the value of the thermal energy (kT) in *eV* at 250ºK ? *(3 points)*
    c. What are the values of N_c and N_v for gallium arsenide at 250ºK? *(4 points)*
    d. Calculate the intrinsic carrier concentration in gallium arsenide at 250ºK. *(4 points*) (Assume the bandgap is independent of temperature)