

## ECE 441 HW #2

**Instructor: Prof. Leburton**

Problem 1. Consider a sample of germanium with  $3 \times 10^{15} \text{ cm}^{-3}$  gallium atoms. Determine the following quantities at room temperature for this sample.

- Majority carrier type
- Majority carrier concentration
- Minority carrier concentration
- Conductivity
- Repeat parts a),b),c),and d) assuming that, in addition to the  $3 \times 10^{15} \text{ cm}^{-3}$  gallium atoms, there are also  $1 \times 10^{16} \text{ cm}^{-3}$  arsenic atoms in this sample.

Problem 2. a) Calculate the root-mean-square velocity of an electron in silicon at room temperature, assuming it has a thermal kinetic energy  $m^* v^2/2$  equal to  $3kT/2$ , where  $kT$  is 0.025 eV. The effective mass  $m^*$  of an electron in silicon is about 26 percent that of an electron in free space and can be taken to be  $2 \times 10^{-31} \text{ kg}$ . (Be careful with your units.)

b) Calculate the average net velocity of an electron in silicon moving under the influence of an electric field of  $10^3 \text{ V/cm}$ .

Problem 3. The conductivity of copper is approximately  $6 \times 10^5 \text{ mho/cm}$  at room temperature and is due to the mobility of electrons (one per atom) free to move under the influence of an electric field. The concentration of these conduction electrons is approximately  $10^{23} \text{ cm}^{-3}$ .

- Calculate the electron mobility in copper at room temperature. How does this compare with Si and Ge?
- Calculate the net average velocity of the electrons in the direction of the current flow (assume it is the x-direction) in a  $0.1\text{-mm}^2$  cross-sectional area wire carrying a current of 1 A. [Assume that the current is due to the cooperative motion of the electrons (“drift”) superimposed on their random thermal velocity (which by itself does not lead to any net current).]