ELEC-3140 Semiconductor physics **Mid-term exam 2, Dec 5, 2023**

Write your name, student number, degree programme, course code, and date of the exam in one of the answer papers. Write your name and student number in each of the answer papers.

1. Explain briefly and exactly (with a couple of sentences):
   a) modulation doping,
   b) free carrier absorption,
   c) continuity equation,
   d) quasi-Fermi level,
   e) Kramers-Kronig relation, and
   f) excess carrier concentration.

2. Describe the different recombination processes in semiconductors and evaluate in which circumstances (high/low temperature, high/low injection level, etc.) each process is significant.

3. a) Describe the two main scattering mechanisms of charge carriers moving in a semiconductor. What is their temperature dependence qualitatively? b) Describe what a phonon is. List different kinds of phonons you know. Describe qualitatively how the dispersion curves of different phonons behave.

4. Describe the formation of depletion region in a pn-junction. List the assumptions made in the abrupt depletion region approximation. Especially discuss how the built-in potential is determined. Describe the different current components occurring in the pn-junction, and how they change when external bias is applied to the junction.

5. Let us consider an abrupt pn-junction in silicon ($n_i = 1 \cdot 10^{10}$ cm^{-3}) with doping concentrations of $N_A = 1 \cdot 10^{16}$ cm^{-3} and $N_D = 2 \cdot 10^{17}$ cm^{-3}. a) Calculate the built-in voltage of the junction. b) Calculate the width of the depletion region, the maximal value of the electric field and the potential difference over the n-side when the external bias is $V_a = -3$ V.

Constants and material parameters on the other side!