Tfy-3.4311 Materials Physics II Examination 23.10.2013
(1st midterm)

Try to answer shortly by listing the essential arguments (phenomena, materials properties, other quantities, relations, ...) in a proper order. Short equations and figures with explanations are also a good way to clarify dependencies and trends. The exact forms of different equations are not important but the quantities and their relations needed to describe a phenomenon or property.

1. *Charge carrier density in homogeneous intrinsic or doped semiconductors.*
   (a) Which are the approximations and quantities used to describe electron and hole densities in intrinsic semiconductors? Why these approximations are made? (2 p)
   (b) How do the charge carrier densities and the chemical potential behave in an intrinsic semiconductor as a function of the temperature? What is the magnitude of typical densities at room temperature? (2 p)
   (c) How is the model for intrinsic semiconductors generalized to doped semiconductors? (1 p)
   (d) Consider a semiconductor doped by donor impurities. What is the magnitude of the impurity concentration in typical doping? How do the charge carrier densities and the chemical potential behave as a function of the temperature? (2 p)
2. *Conductivity of doped semiconductors.*
   (a) How does the conductivity behave as a function of temperature? What are the temperature dependent quantities and processes affecting the conductivity? (2 p)
   (b) How does the magnitude of the electric field affect the electron mobility in elemental and compound semiconductors? Which are the field dependent processes affecting the mobility? (2 p)
3. *pn junction.*
   (a) Which principles (Starting point of the Schottky model and the approximations made in it) and materials parameters determine the voltage step and the width of the depletion zone in equilibrium? (2 p)
   (b) Which are the currents flowing in equilibrium (Explain their origins)? (1 p)
   (c) How is the equilibrium model generalized to the case of an external bias voltage over the junction? What is the meaning of quasi-Fermi levels? (2 p)
   (d) Which are the current components flowing (explain their origins and magnitudes) and the form of the total current? Which are the materials parameters determining the current? (2 p)
4. *Response of materials to an external magnetic field*
   (a) Describe the response of open shell atoms to the external magnetic field $\mathbf{B}_0$ in terms of magnetic moments, quantized energy levels, and their filling at a finite temperature. How the resulting susceptibility depends on the temperature (4 p)
   (b) How does the response of delocalized valence electrons in metal differ from that of open-shell ions? Why? (1 p)
5. *Spontaneous magnetism, band model*
   (a) What is the reason for ferromagnetism in a free electron gas? (2 p)
   (b) Which are the competing effects in the Stoner model determining whether or not a metal is ferromagnetic? (2 p)
   (c) How can the Stoner model be generalized to predict the temperature dependence of the magnetism? Which predicted features are in agreement and which in disagreement with experiments? Which are the reasons for the deviations? (3 p)