

Answer preferably in English (Answers in Finnish, Swedish, and German are also understood).

1. Describe briefly the following concepts/phenomena:
 - (a) Fermi level position in an intrinsic semiconductor. Describe its dependence on band structure and on the temperature. (2 p)
 - (b) How does the mobility of charge carriers behave in doped semiconductors as a function of temperature? Why? (2 p)
 - (c) In which applications direct-band-gap semiconductors can be used, but the indirect-band-gap semiconductors cannot? Why? (2 p)
 - (d) The metal/semiconductor Schottky contact and barrier: How is the contact's electronic structure and electronic band scheme? (2 p) How does the contact operate as a rectifier? Compare also with a normal $p-n$ junction? (2 p)
 - (e) What is the reason for ferromagnetism in free electron gas? Does the phenomenon have relevance in some real systems? (2 p)
 - (f) Figure 1 compares the mean-field model with magnetization values measured for Ni. Where are theory and experiment in disagreement and why? (2 p)

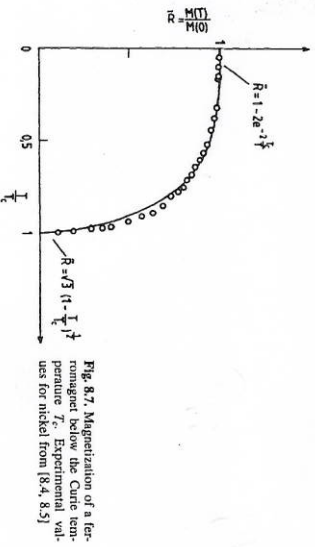


Figure 1: Dotted curve is the experimental result.

2. Microscopic picture of the current across a biased $p-n$ junction. Which component dominates the total current in the steady state? What is the procedure to calculate that component? Which are the ingredients (equations) needed. Which are the materials parameters determining the current (and the frequency region of the device). (5 p)
3. Magnetism is a quantum-mechanical phenomenon. How is the response of a material to an external field B_0 described in the quantum mechanical formalism? Describe the response also in terms of permanent magnetic moments, quantized energy levels of ions

in B_0 and their filling at a finite temperature. What about the interactions between magnetic moments? For which systems the description is valid more directly or with some modifications (Crystal-field splitting). (6 p)

4. Spin waves. Explain their physical ideal Sketch their dispersion spectrum and identify main features (functional dependence, different regions, typical magnitudes)! What type of phenomena do the spin waves explain? (5 p)