PHYS-E0421 Solid State Physics (5cr), Spring 2019
First midterm exam, 9 April 2019 at 16:30

Even quite short answers to the questions are sufficient in most cases (with supporting schematic figures) as long as you focus on the main points.

1. Describe briefly the following concepts / phenomena:
   a) Bloch wavefunction. (1p)
   b) Fermi-velocity. (1p)
   c) Effective mass tensor. (1p)
   d) Relaxation time approximation in the context of Boltzmann transport equation. (1p)
   e) Why and how is it possible to use electric current for cooling? (1p)
   f) Ohmic and Schottky contacts in metal-semiconductor junction. (1p)
   g) In which applications can the direct band gap semiconductors be used, but the indirect band gap semiconductors cannot? Why? (1p)
   h) Temperature dependence of the defect diffusion rate (in e.g. interstitial mechanism) and its microscopic origin. (1p)

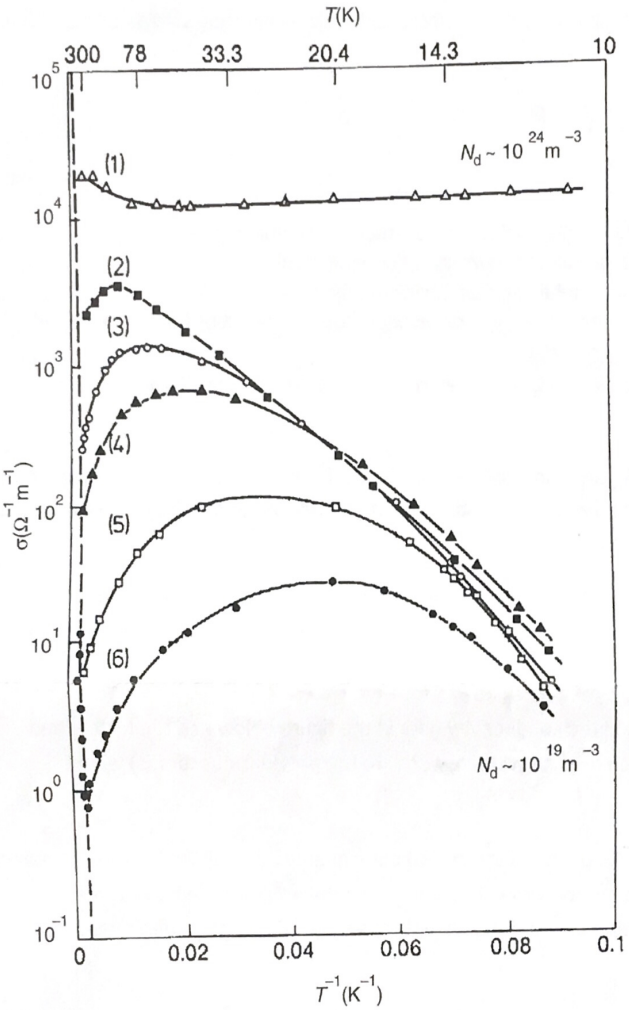
2. What are the dominant scattering mechanisms limiting electrical conductivity in metals at low and high temperature limits? Describe the role of elastic vs inelastic scattering processes in restoring the equilibrium distribution function. (2p)

3. Discuss and compare charge carrier densities in metals and doped semiconductors (orders of magnitude, temperature dependences, occupations of bands in terms of both the energy and the $\boldsymbol{k}$ value). (3p)

4. Explain qualitatively the features in the conductivity data in the figure below and the factors and physical processes behind. You can refer to your answer(s) to the previous question(s) where needed. (3 p)

5. Explain (and draw) the electronic structure at the *p-n* junction in equilibrium. What causes the band bending? Which principles and material parameters determine the potential step across the interface and the width of the depletion zone? Explain the principle of operation of photovoltaic cells (solar cells). (5 p)

6. Give some examples of point defects, line defects and planar defects. How and why do lattice defects affect various macroscopic materials properties (electric, optical, mechanical etc.)? Give at least three examples. (4 p)



Temperature dependence of the electronic conductivity of *n*-type Ge.