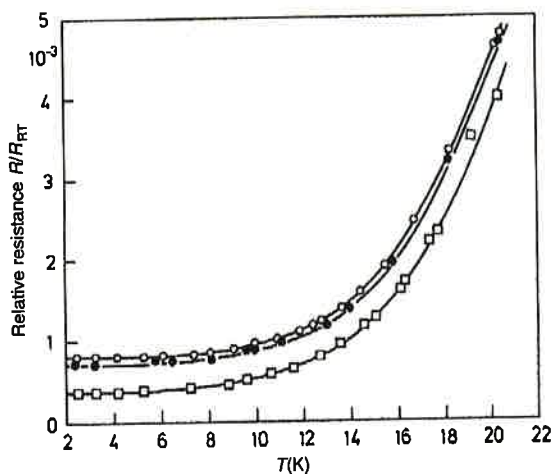


PHYS-E0421 Solid State Physics (5cr), Spring 2016

First midterm exam, 8 April 2016 at 1:00 p.m.

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. Semiclassical dynamics of electrons in real space and \mathbf{k} space. Describe the equations of motion and the concepts involved. (2 p)
2. Explain how the electrons in a metal carry electric current. How does the electric field alter the distribution function of electrons? What are the processes and parameters affecting this and the resulting net current? The figure below shows measurements results for the electrical resistance of sodium. Explain what can be seen in the figure and the mechanisms behind the behavior. (5 p)
3. Why and how is it possible to use electric current for cooling? (2 p)
4. How do the carrier density, mobility and conductivity behave in doped semiconductors as a function of temperature? Why? (4 p)
5. What are band offsets and band bending in semiconductor heterostructures? Which properties do they depend on? What are the related length scales? (2 p)
6. Explain the electronic structure at the p - n junction in equilibrium. Which principles and material parameters determine the voltage step across the interface and the width of the depletion zone? Which currents are flowing? Discuss the non-equilibrium case (external bias) and explain why the junction works as a diode. (4 p)
7. Describe the operating principles of a light emitting diode. (2 p)
8. 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.)? (4 p)



Temperature dependence of the electrical resistance of different Na samples.