Exercises for the lecture:
"Experimental physics 5c, Condensed matter physics"
Winter semester 2019/20
Prof. Dr. H.J. Elmers
Dr. T. Mashoff

JOHANNES GUTENBERG UNIVERSITÄT MAINZ

Exercise sheet # 9
Group A: Monday 13-14, Lorentz-Room
Group B: Tuesday 10-11, Seminar room A
Group C: Wednesday 10-11, Galilei-Room
Group D: Friday 14-15 Seminar room 1 KP

Issued: 11/12/2019
Due: 16/12/2019, 12:00 p.m.
Mailbox No. 23 in the physics building

Exercise 22 (2+1+1+1P)

In Aluminium (Debye-temperature $\theta = 428\,\mathrm{K}$, density $\rho = 2.7\,\mathrm{g/cm^3}$, molar mass M=27 g/mol), three electrons per atom contribute to the electron gas.
a) Determine the ratio between the phonon part C_{ph} (Debye-model) and the electron part C_{el} (free electron gas) of the heat capacity for $T \ll \theta$.
b) Determine the Fermi-temperature T_F of Aluminium.
c) At which temperature is $C_{ph}(T) = C_{el}(T)$?
d) What is the ratio at room temperature? (Use the high-temperature value for C_{ph}, i.e. Dulong-Petit)

Exercise 23 (4P)

Use the internal energy $U = V \int_0^{E_F} D(E)EdE$ to deduce a relation between the pressure and the volume of a non interacting free electron gas at 0 K.
How large is this pressure for Copper (electron density: $n_{Cu} = 8.47 \times 10^{28}\,\mathrm{m^{-3}}$)?
Advice: Use the thermodynamical relation $p = -(\frac{\partial U}{\partial V})_{T,N}$.

Exercise 24 (3P)

The specific resistance of aluminium is $\rho = 2.65 \times 10^{-8}\,\Omega\mathrm{m}$ at 300 K. Aluminium has a face centered cubic structure with a lattice constant of $a = 0.405\,\mathrm{nm}$. (Advice: 3 electrons per atom participate in the electron gas. Use the free electron mass for the effective mass m*)
Calculate:

a) The relaxation time, and
b) the drift velocity of the electrons v_D in a wire with a profile of $1\,\mathrm{mm^2}$ and a flowing current of 1 A.