Name: ____________________________

Advanced Solid State Physics — Prof. Dr. W. Kuch
Winter semester 2014/2015
11th exercise sheet

Submission: Tuesday, 13. January 2015, before the lecture
(or drop until 10 o'clock of the same day in mailbox between rooms 1.2.38 and 1.2.40)

30. Paramagnetism (*) (4 points)

Vanadium has an electronic configuration [Ar]$3d^3 4s^2$. We consider vanadium vapor (approximated as ideal gas) at 1.0 bar pressure and exclude condensation.

a) Calculate the value of the saturation magnetization M_S at 300 K.
b) Calculate the value of the paramagnetic susceptibility at 300 K.
c) To which temperature the vanadium vapor needs to be cooled to have a magnetization of 0.75 M_S in a magnetic field $\mu_0 H = 7$ T?

31. Ferromagnetic resonance (*) (4 points)

Consider the analogy between mechanical rotations and the interpretation of atomic magnetic moments as quantum mechanical angular momenta to determine the precessional frequency ω of a magnetic dipole $\vec{m}$ in an external field $\vec{H}$, which is applied under an angle $\vartheta \neq 0$ with respect to $\vec{m}$. The torque $\vec{D}$ of the magnetic field on the magnetic moment $\vec{m}$ can be derived from the energy of a magnetic dipole in an external field $\vec{H}$ as $\vec{D} = \mu_0 \vec{m} \times \vec{H}$. Show that $\omega = \frac{\mu_0 e g}{2 m_e} H$.

32. g factor (*) (4 points)

In electron magnetic resonance experiments on solids g factors $g' \geq 2$ are measured, while according to the definition of atomic magnetic moments, as it was discussed in the lecture, it should be $g_J \leq 2$. This variance is explained by the fact that in electron spin resonance experiments the orbital angular momentum of the electrons is compensated by an opposite angular momentum of the lattice. It is thus $g_\ell L_z + g_s S_z = g' S_z$, while for the atomic moments the corresponding definition is $g_\ell L_z + g_s S_z = g_J J_z$.

Determine the ratio between orbital magnetic moment $g_\ell L_z \mu_B$ and spin magnetic moment $g_S S_z \mu_B$ for $g' = 2.1$, measured in a magnetic resonance experiment. What would be the corresponding value of g_J? (We assume a more than half-filled shell.)