Universität Leipzig
Institut für Theoretische Physik
Prof. Dr. B. Rosenow

Statistical Physics, Spring 2011
Problem Set 12

Course Information:

- ☞ Class times: lectures Monday and Thursday, 11:00-12:30 in SR 218, tutorials Friday, 9:15-10:45 in SR 221
- ☞ Final exam: July 11, 13:30 in ThHS
- ☞ The course website is www.uni-leipzig.de/~stp/Statistical_Physics.html

Problem 36: A Real Gas (4 Marks)

For a low density real gas, the equation of state can be obtained by the density (virial expansion). In the lowest order

$$pV = NT\left(1 + A(T)\frac{N}{V}\right),$$

where $A(T)$ is a continuous function.

(a) Show that the heat capacity must have the form

$$C_V = \frac{3}{2}N - \frac{N^2}{V}\frac{d}{dT}\left(T^2\frac{d}{dT}A(T)\right).$$

hint: Use that in the limit $V \to \infty$, the gas is ideal. Then calculate $C_V(T, N, V)$ from $C_V(T, N, \infty)$ and $(\partial C_V/\partial V)_{TN}$.

(b) Calculate the energy $E(T, N, V)$ and the entropy $S(T, N, V)$.

(c) Which conditions must the function $A(T)$ fulfill such that the gas is stable?

Problem 37: Van-der-Waals-Gas (6 Marks)

The equation

$$\tilde{p}(\tilde{T}, \tilde{v}) = \frac{8\tilde{T}}{3\tilde{v} - 1} - \frac{3}{\tilde{v}^2}$$

is the equation of state of the Van-der-Waals-Gas in reduced form.

Determine the limits $\tilde{v}_{1,2}(\tilde{p})$ of the two-phase area in the vicinity of the critical point $\tilde{T} = 1 = \tilde{v}$ using the Maxwell-construction. For this, expand the state-equation as far as necessary for small deviations of temperature and volume from the critical values.

Problem 38: The Photon Gas (4 Marks)

Electromagnetic radiation in a cavity can be thought of as an ideal gas of photons. If the cavity radiation is in thermal equilibrium with the cavity wall, then the internal energy is $E(T, V) = V\epsilon(T)$, and the pressure is $p(T, V) = \epsilon(T)/3$. Calculate $\epsilon(T)$.

Hint: Use only thermodynamic relations. With the above information, you can calculate $\epsilon(T)$ up to an unknown factor.