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Fachbereich Physik
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Advanced Statistical Physics (WS11/12)
Problem sheet 7

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Problem 1: Internal Energy and Equation of State

Let the internal energy be:

$$U(S,V,N) = aS^2/N + bV^2/N,$$

with constants a and b.

Calculate T, P and μ and from that derive the equation of state $\mu(T,P)$.

Problem 2: Ideal Gas, Expansion

An ideal gas, characterized by the ratio of the specific heats $\gamma = C_P/C_V$, expands quasistatically starting from a volume V_i and a temperature T_i to a final volume V_f.

Calculate the final temperature T_f of the gas, the performed work and the added amount of heat for

a) an isothermal process and

b) an adiabatic process.

Problem 3: Quasistatic Heating

A system is heated from temperature T_a to T_b at constant pressure and is characterized by the heat capacity C_P.

Consider the following processes:

a) The system is connected to a heat reservoir of temperature T_b and the heat is transferred quasistatically.

b) In the first place, the system is connected to a heat reservoir of temperature $(T_a+T_b)/2$. After equalibration, the system is connected to a heat reservoir of temperature T_b. Both steps are carried out sufficiently slow.

Calculate the change in entropy of the system and the reservoir for both cases. In which case is the change of the total entropy smaller?

Problem 4: Rubber Band

The free energy of a rubber band may be written as:

$$F(T, L) = \frac{1}{2} a\, T\, L^2 - b\, T\, \ln(T),$$

where L is the band's length and the constants $a, b > 0$. Throughout the calculations L takes the role of the volume V and the force exerted on the rubber band f plays the role of the pressure P. Note that the force is negative, $f < 0$, i.e. it corresponds to an externally applied pulling.

a) Calculate the entropy S and the force f from the free energy. How does $L(T, f)$ depend on the temperature T at constant f?

b) Consider an adiabatic change of the length of the rubber band. How does the temperature change depend on the change of length? (An adiabatic change of length is realised by fast expansion or relaxation of the rubber band.)