

1. Übungsblatt zur Statistische Physik I

Thermodynamik

Abgabe: Mittwoch, 29 Apr., bis 16:00 Uhr, Raum E-W 705

Exercise 1 (2 points): *Euler and Gibbs-Duhem Equations*

From the definition of a homogeneous first-order function, for the internal energy we have

$$U(\lambda S, \lambda V, \lambda N) = \lambda U(S, V, N)$$

for arbitrary λ . Use this property to derive the Euler equation

$$U = TS - PV + \mu N,$$

and thus the Gibbs-Duhem relation

$$SdT - VdP + Nd\mu = 0.$$

Exercise 2 (2 points): *Equilibrium conditions*

Consider a container initially divided into two compartments with a fixed, insulating, impermeable wall. The parameters of the left compartment are $U^{(1)}$, $V^{(1)}$, $T^{(1)}$, ... and of the right $U^{(2)}$, $V^{(2)}$, $T^{(2)}$, ...

- If the wall is made heat-conducting, show that in equilibrium $T^{(1)} = T^{(2)}$.
- If the wall is made heat-conducting and moveable, show that in equilibrium $T^{(1)} = T^{(2)}$ and $P^{(1)} = P^{(2)}$.
- If the wall is made heat-conducting and permeable, show that in equilibrium $T^{(1)} = T^{(2)}$ and $\mu^{(1)} = \mu^{(2)}$.
- For this latter case show that, away from equilibrium with $T^{(1)} > T^{(2)}$ and $\mu^{(1)} > \mu^{(2)}$, both heat and particles flow from the left compartment to the right.

Exercise 3 (2 points): *Free Energy*

Show that, for a process carried out at fixed temperature and particle number, the change in the free energy obeys

$$|\Delta W| \leq (-\Delta F),$$

with ΔW the work done on the system. Explain how this implies that the free energy acts as a potential function under such conditions.

Exercise 4 (4 points): *Antwortkoeffizienten*

Prove the following relationship:

$$c_P = c_V + \frac{TV\alpha^2}{N\kappa_T}.$$

[Hint: First show that $TdS = Nc_PdT - TV\alpha dP$.]

Bitte Rückseite beachten! →

- **Internetseite der Veranstaltung:** http://www.itp.tu-berlin.de/menu/lehre/lv/ss09/wpfv/statphys_i/
- **Vorlesung:** Montags & Donnerstags, 14:15 bis 15:45, E-W 202
- **Literatur:**
 - H. B. Callen, Thermodynamics and an Introduction to Thermostatistics
- **Übung:** Donnerstags, 10:15 bis 11:45, E-W 733
- **Scheinkriterien:** 50% der Punkte aus den Übungszetteln (Zweierabgabe), aktive Teilnahme an den Tutorien
- **Sprechstunden:**
 - Prof. Dr. H. Stark: Fr. 11:30 - 12:30, E-W 709
 - Dr. C. Emary: Di, 16:00 - 17:00 Uhr, E-W 705