Exercise 07

Name:	Matriculation number:
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The exercise is due on Wednesday, June 6, 8 am.

7.1 Text book

Read sections 3.2 to 3.4 and 4.3 in G.H. Findenegg, T. Hellweg „Statistische Thermodynamik".

7.2 Fermions, bosones, and distinguishable particles

Consider 5 particles in a one-dimensional box (equidistant energy levels).

(a) Calculate and compare the energy of the ground state for fermions, bosones, and distinguishable particles.

(b) Suppose that $N_\epsilon = 5$. What is the total number of microstates for fermions, bosones, and distinguishable particles?

7.3 Distinguishable particles: two-level system

Consider a particle, which has two spin states, up (+1) and down (-1). If a magnetic field $\mathbf{B}$ is applied, the energy of the two spin states is

$$E(\text{up}) = +\boldsymbol{\mu} \cdot \mathbf{B} \; ; \qquad E(\text{down}) = -\boldsymbol{\mu} \cdot \mathbf{B} \tag{3}$$

where $\boldsymbol{\mu}$ is the magnetic momentum and the energy difference between the two states is given by

$$\Delta E = E(\text{up}) - E(\text{down}) = 2\boldsymbol{\mu} \cdot \mathbf{B} \tag{4}$$

(a) Write down the partition function Q_1 for a single particle.

(b) Assume that $E(\text{down}) = 0$, write down the partition function Q_1^0.

(c) What is the partition function Q_N^0 for a system of N distinguishable particles?

(d) Determine the free energy F, the internal energy U, the entropy S and the heat capacity C_V.

(e) Plot the internal energy and the heat capacity as a function of the temperature.

7.4 Crystals

The table shows the molar heat capacity of crystalin KCl for a range of temperatures:

T (K	C_v (J /mol K)
50	21.1
100	39.0
175	46.1
250	48.6

(a) Can the Einstein model be applied to this ionic crystal? Hint: Determine the characteristic temperature Θ at $T = 100$ K, and calculate the molar heat capacity at $T = 175$ K.