Háskóli Íslands
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1. A system consists of N noninteracting atoms. Each atom has three energy levels $E = 0, \pm\epsilon$. Evaluate the free energy, the entropy, and the heat capacity as functions of the temperature T when $kT >> \epsilon$.

2. In the eighties an experimental group was able to measure the heat capacity of a two-dimensional electron gas in a semiconducting crystal at a low temperature.

   (a) Calculate the internal energy U of an ideal two-dimensional gas of fermions.

   (b) Calculate the heat capacity of the system.

   (c) Derive the limiting behavior of the heat capacity in the cases $T \to 0$, and $T \to \infty$. Compare the results to the results for a three-dimensional fermion gas.

3. One-dimensional systems often have curious properties. Interacting one-dimensional electron systems in semiconductors at low temperature can be described as noninteracting particles with linear energy dispersion. Show that one-dimensional ideal fermi and bose gases with the energy dispersion $E = cp$ have identical heat capacities. Here p is a momentum and c a velocity.

4. Evaluate the entropy per spin S/N, the internal energy U/N, and the heat capacity C/N of the one-dimensional Ising model in no external magnetic field in the thermodynamic limit.