Assignment 1

443 Statistical Physics 2008/2009

Lecturer: Stefan Sint

(due Wednesday, 29 October 2008 during class)

Problem 1 (8/20 points)

The van-der-Waals gas is a model for a real gas and defined by the equation of state

$$(P + \frac{a}{V^2})(V - b) = NkT,$$

with constants a, b which depend on the substance.

a) Determine the dimensions of the constants a and b.

b) For the ideal gas we found that adiabatics are characterised by $PV^\kappa =$ const. with $\kappa = C_P/C_V$. Derive the corresponding relation for the van-der-Waals gas.

c) Starting from the TdS-equations compute the volume dependence of the internal energy $U = U(V, T)$ for the van-der-Waals gas.

Problem 2 (12/20 points)

a) In class we have seen the $P - V$ diagram for a Carnot cycle. Draw the corresponding $P - T$ and $V - T$ diagrams, and give the equations which determine their segments AB, BC, CD, DA (assume an ideal gas medium).

b) Consider a Carnot engine which is being operated with a van-der-Waals gas (cf. problem 1), where we assume $b = 0$ for simplicity. Compute the efficiency of the engine and compare it to the ideal gas case treated in class.

c) Consider another engine, which is operated reversably between temperatures T_1 and T_2, such that its $V - T$ diagram becomes a rectangle. Compute its efficiency using the ideal gas as a medium. How does it compare to the efficiency of the Carnot engine?