Exam January 1993

Translated by Bo Jakobsen (Autumn 2010)

The course was 9 ects points, and the exam an open book exam.

The exam consists of 6 related problems.

The molar entropy and energy is given by the following expression for an ideal gas:

$$S = R\ln(\alpha v T^{\mu}); \quad u = R\mu T \tag{1}$$

where T is the absolute temperature, and v the molar volume. R is the gas constant, and α and μ are substance dependent constants.

1) State the value of μ of an mono-atomic ideal-gas. Furthermore, state for any value of μ the molar specific heat at constant pressure and volume.

Two containers, both with volume V, are connected by a narrow tube through which a reversible working pump can transport gas from one container to the other. The volume of the tube can be neglected.

2) State the total entropy S and energy U, when container 1 contains $n \cdot (1 + \epsilon)$ mole and container 2 contains $n \cdot (1 - \epsilon)$ mole of the ideal gas, and when both containers are in thermal equilibrium with a heat reservoir at temperature T.

3) Show that S is maximal for $\epsilon = 0$, and state an approximated expression for S when $\epsilon \ll 1$, by Taylor expansion to 2. order in ϵ.

4) The system is isolated when in the state with temperature T and displacement parameter ϵ. The passage trough the tube is now opened, allowing the gas to flow freely from one container to the other. Give the temperature T', entropy S', and energy U' for the new equilibrium state.

5) If one now uses the pressure difference for performing reversible work on the surroundings (instead of free flow as in 4)), what is the temperature T'', entropy S'' and energy U'' of the final state.

6) The pressure difference is now (like in problem 5) used for reversible work, but we let the containers have a heat conduction contact to a heat reservoir throughout the whole process, so that the temperature is fixed at T. Will the system under this process receive or give up heat to the heat reservoir? (argue the answer).