Advanced Theoretical Physics
WS 09/10

Prof. Dr. Dieter Bauer
Dipl.-Phys. Andrea Sengebusch

Seminar 2

Keywords:

0., 1., 2. law of thermodynamics,

temperature,

Carnot engine,

fundamental equation of thermodynamics,

thermodynamic potentials

Questions:

1. All real processes in the macroscopic world are irreversible. Why can we nevertheless use thermodynamics to calculate something?
2. Is the ideal gas law applicable to gases made of diatomic molecules such as N_2? If yes, what is the internal energy of one mole of such a gas at (a) very low, (b) intermediate, and (c) very high temperatures?
3. Show that the content of internal energy in your flat is independent of the room temperature. So why do you heat in winter time?

Assignment 2

(due October 26, 2009)

Thermodynamic potentials

2.1 Prepare Tables (like Table 1 for the enthalpy overleaf) for the internal energy, the Helmholtz free energy, the Gibbs free energy, and the grand potential.

Heat capacity

2.2 Show that $C_{V,N}$ of a van der Waals gas may depend on T but not on V.

Free expansion

2.3 The Joule coefficient $(\partial T/\partial V)_{U,N}$ tells us whether a working substance cools or heats in a free expansion. Show that the Joule coefficient can be written as

$$\left(\frac{\partial T}{\partial V}\right)_{U,N} = \frac{1}{C_{V,N}}\left[p - T\left(\frac{\partial p}{\partial T}\right)_{V,N}\right]$$

and evaluate it for an ideal gas and a van der Waals gas (assuming $C_{V,N}$ given).

2.4 An ideal gas of volume V_1 expands adiabatically into vacuum to a volume V_2. Is this a reversible or irreversible process? What is the change in entropy?

Table 1

Enthalpy	$H(S,Y,N)$
Total differential	$\mathrm{d}H = T\,\mathrm{d}S - X\,\mathrm{d}Y + \mu\,\mathrm{d}N$
Fundamental equation	$H = U - XY = TS + \mu N$
Equations of state	$T = \left(\frac{\partial H}{\partial S}\right)_{Y,N}, \quad X = -\left(\frac{\partial H}{\partial Y}\right)_{S,N}, \quad \mu = \left(\frac{\partial H}{\partial N}\right)_{S,Y}$
Maxwell relations	$\left(\frac{\partial T}{\partial Y}\right)_{S,N} = -\left(\frac{\partial X}{\partial S}\right)_{Y,N}, \quad \left(\frac{\partial T}{\partial N}\right)_{S,Y} = \left(\frac{\partial \mu}{\partial S}\right)_{Y,N},$
	$\left(\frac{\partial X}{\partial N}\right)_{S,Y} = -\left(\frac{\partial \mu}{\partial Y}\right)_{S,N}$