

Thermal Physics II

2nd short test – 13 March 2013

given and surname :

university number :

course of study :

marks obtained :

total marks :

comments :

1. How are the Helmholtz free energy and the internal energy related?

2. What are the natural variables that allow for the use of the Helmholtz free energy as a thermodynamic potential for a gas?

3. State the relation between the number of states of the system and the number of states of its heat reservoir within the canonical description.

4. Define the Boltzmann factor for a quantum state with energy E_1 and the partition functions of a system with discrete energies E_j .

5. Consider an ion with two energy states at $E_1 = -30$ eV and $E_2 = -20$ eV embedded in a gas with a temperature such that $k_B T = 10$ eV. Calculate the ratio of the occupation probabilities for these two states.

6. Give the basic relation that connects the thermodynamical and statistical descriptions of many-body systems in the canonical ensemble.

7. Atoms may have magnetic moments $\pm\mu$. What is the average magnetic moment if the probabilities are $P(+\mu) = 0.8$ and $P(-\mu) = 0.2$?

8. A system is made of two independent subsystems with internal energies, U_1 and U_2 , and partition functions, Z_1 and Z_2 . State the internal energy, partition function and Helmholtz free energy of the combined system.

9. Which quantity in the statistical description of many-body systems is defined by the temperature of the system? What happens to this quantity if the temperature is doubled?

10. State the partition function for an ideal gas (N particles in volume V).

11. Given the fact that the differential of the Gibbs energy (enthalpy) is given by $dH = TdS + Vdp$, derive the Maxwell-relation $(\partial T/\partial p)_S = (\partial V/\partial S)_p$.