LULEÅ UNIVERSITY OF TECHNOLOGY
Division of Physics

Course code	F7035T
Examination date Time	2015-08-29 09.00 - 14.00

Examination in: STATISTICAL PHYSICS AND THERMODYNAMICS
Total number of problems: 5
Teacher on duty: Hans Weber — Tel: (49)2088, Room E304
Examiner: Hans Weber — Tel: (49)2088, Room E304

Allowed aids: Fysikalia, Physics Handbook, Beta, calculator, COLLECTION OF FORMULAE

Define notations and motivate assumptions and approximations. Present the solutions so that they are easy to follow. Maximum number of point is 15 p. 7.0 points is required to pass the examination. Grades 3: 7.0, 4: 9.5, 5: 12.0

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1. **Three questions**

   1. What would be the greatest effect on the ideal gas law if there is a slight attractive force between the molecules?
      - A. At low densities, the pressure would be less than that predicted by the ideal gas law.
      - B. At high densities, the pressure would be less than that predicted by the ideal gas law.
      - C. At high densities, the pressure would be greater than that predicted by the ideal gas law.
      - D. At low densities, the pressure would be higher than that predicted by the ideal gas law.
      - E. There is no effect.
   2. Which has higher entropy - a mole of ideal gas at 20 ^{o}C occupying 10 liters or a mole of the same gas at 20 ^{o}C occupying 100 liters?
      - A. The gas in 10 liters
      - B. The gas in 100 liters
      - C. No difference
      - D. The statement contains not enough information.
   3. How much higher entropy does a mole of ideal gas at 20 ^{o}C occupying 100 liters have compared to a mole of gas at 20 ^{o}C occupying 10 liters?

   (3p)

2. **Pressure of an ideal Fermi gas**

   Determine the pressure of an ideal Fermi gas (spin = $\frac{1}{2}$) at near zero temperature (set T = 0 K). The particles have a density of N/V and their mass is m. Use this to calculate the pressure of the conduction electrons of a metal where $N/V = 1.0 \cdot 10^{28}\text{m}^{-3}$. (3p)

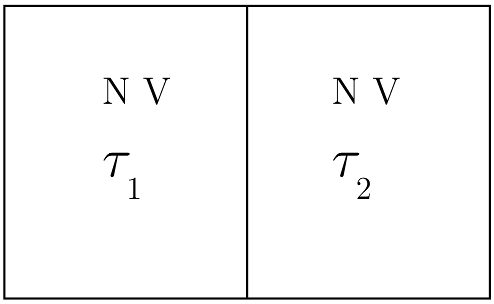
TURN PAGE!

3. **Ideal mono atomic gas**

An ideal mono atomic gas confined in a box. The box is devided into two sub parts (compartment 1 and 2) according to the figure below. Compartments one 1 and two 2 have the same volume V and the same number of atoms N. For compartment one 1 the temperature is τ_1 and for compartment two 2 the temperature is τ_2.

Calculate the change of entropy as the wall between compartment 1 and 2 is removed. The total system consisting of 1 and 2 can be considered a closed system.

(3p)



4. **Rotation of a di–atomic molecule**

The kinetic energy of a di–atomic molecule consists of a translational part and a rotational part. The rotational energy $\epsilon(j)$ has quantised levels and for a di–atomic molecule these are given by:

$$\epsilon(j) = j(j+1)\epsilon_0$$

where j is an integer with the following values $j = 0, 1, 2, ...$ The degeneracy $g(j)$ of each level is given by:

$$g(j) = 2j + 1.$$

a) Calculate the partition function for the rotational degrees of freedom $Z_R(\tau)$.

b) Approximate $Z_R(\tau)$ in the limit $\tau >> \epsilon_0$ by an integral and calculate the specific heat C_v in this limit.

c) Approximate $Z_R(\tau)$ in the limit $\tau << \epsilon_0$ by truncating the sum to two terms and calculate the specific heat C_v in this limit.

d) Draw a figure showing the results from b) and c)

(3p)

5. **Entropy**

Use simple arguments concerning the specific heat C_v to answer the following questions.

a) For a metal the temperature is changed from $300K$ to $800K$. By how large a factor will the entropy change for the conduction electrons?

b) For the electromagnetic radiation inside a cavity the temperature is changed from $500K$ to $1200K$. By how large a factor will the entropy change for the radiation field inside the cavity?

(3p)

GOOD LUCK !