LULEÅ UNIVERSITY OF TECHNOLOGY
Division of Physics

Course code	F7035T
Examination date	2013-03-28
Time	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. **Entropy**

   Use simple argumentes concrning the specific heat C_v to answer the following questions.

   a) For a metal the temperature is changed from $200K$ to $800K$. By how large a factor will the entropy change for the conduction electrons?

   b) For the elctromagnetic radiation inside a cavety the temperature is changed from $500K$ to $2000K$. By how large a factor will the entropy change for the radiation field inside the cavity?

   (3p)

2. **Astrophysics Black holes and star atmospheres**

   a) The entropy of a non–rotating non–charged black hole is given by $\sigma = \frac{c^3 A}{4G\hbar}$ where $A = 4\pi R_s^2$ is the area of the black hole, $R_s = \frac{2GM}{c^2}$ is the Schwarzschild radius, M is the mass and G is Newton's constant of gravitation. The energy is given by $E = mc^2$. Evaluate the temperature of the black hole.

   b) The energy levels of atomic hydrogen are given by: $E_n = -\frac{13.6}{n^2}$ eV, where $n = 1, 2, 3, 4, ...$ is the principal quantum number and each energy level has degeneracy $2n^2$. In the atmosphere of a star containing atomic hydrogen the average kinetic energy is 1.0 eV. Evaluate the ratio between the number of atoms in the excited levels with $n = 2$ and $n = 3$.

   (3p)

TURN PAGE!

3. **Doppler effect in a gas**

A way to determine the temperature of a star is to study the Doppler broadening of spectral lines. A classical gas, made up of atoms of mass m, is in a stars atmosphere at temperature τ. The atoms emit light that we analyse in a spectroscope. If the atoms where stationary we would observe light of frequency ν_0. Due to the Doppler broadening emitted light from an atom with velocity v_x in the x direction will not have the frequency ν_0 but a frequency ν given approximately by

$$\nu = \nu_0(1 + v_x/c)$$

where c is the speed of light. This means that we observe a broadening of the spectral lines. Determine

a) The average frequency $< \nu >$ of the light observed in our spectroscope.

b) The broadening $\sqrt{< (\nu - < \nu >)^2 >}$ of the observed light.

(3p)

4. **Paramagnetic system**

A paramagnetic system consists of particles of spin 1 and magnetic moment m. Each spin can point in three directions, parallel, anti–parallel and transverse to an external magnetic field. The corresponding energies are $-mB, +mB$ and 0. Determine the change of entropy for a particle as the magnetic field changes from 0 to B_0 at constant temperature. Show that for $1 << \frac{\tau}{mB_0}$ the decrease in entropy depends on the temperature τ as $\frac{A}{\tau^2}$, determine A.

(3p)

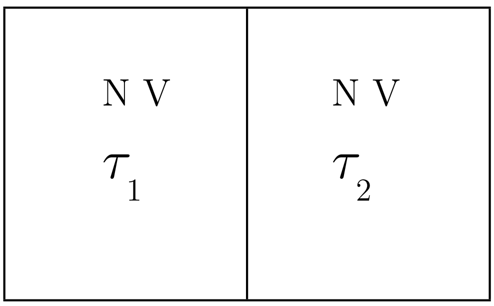
5. **Ideal mono atomic gas Ideal enatomig gas**

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

Calculate the change of entropy as the wall between compartment 1 and 2 is removed.

There is no exchange of energy to the world outside the box.

(3p)



GOOD LUCK !