LULEÅ TEKNISKA UNIVERSITET
Sro Fysik

Kurskod	MTF072
Tentamensdatum	2000-12-14
Skrivtid	09.00–14.00

Tentamen i: **STATISTISK MEKANIK OCH TERMODYNAMIK**
Totala antalet uppgifter: 5
Jourhavande lärare: Hans Weber Tel: 72088, 070–5936917, Rum E111
Examinator: Hans Weber Tel: 72088, Rum E111
Resultaten anslås : Onsdagen den 3 januari 2001 i korridoren, E-huset
Tentamensrättningen får granskas: Tid meddelas senare

Tillåtna hjälpmedel: FYSIKALIA, BETA, Räknedosa, Formelblad för Statistisk Mekanik.

Define notations and motivate assumptions and approximations. Present the solutions so that they are easy to follow.
Definiera beteckningar samt motivera antaganden och approximationer. Presentera lösningarna så att de blir lätta att följa.
Maximalt antal poäng: 25 p. För godkänt krävs 11 p.
Maximum number of point is 25 p. 11 points is required to pass the examination.

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1. **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.

   (5p)

2. **Helium** ^3He

   Helium ^3He has spin $= \frac{1}{2}$ and may at low temperatures to a good approximation be described as an ideal Fermi gas. At these low temperatures ^3He is in the liquid phase with a density of $\rho = 83$ kg m^{-3}. Determine the Fermi temperature T_F and also the specific heat C_v of ^3He at T=0.5 K.

   (5p)

3. **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 $n = 3$.

(5p)

4. **Diatomic molecule**

An ideal gas consists of N identical molecules. Each molecule consists of two atoms with the following rotational energy levels: $E(j) = j(j+1)\frac{\hbar^2}{2I}$, $j = 0, 1, 2, ...$ Where I is the moment of inertia. Each level is $(2j + 1)$ times degenerate. Determine to lowest order in temperature the contribution to C_v from the rotational degrees of freedom.

(5p)

5. **Chemical reactions**

In a chemical reaction the ideal mono atomic gases A and B can react $A + B \rightleftharpoons AB$ to form the ideal gas AB. At a certain temperature and volume, the total pressure is 1 atmosphere and all the partial pressures are equal for the three gases. What will the total pressure be if the volume is doubled at constant temperature?

(5p)

LYCKA TILL ! / GOOD LUCK !