LULEÅ TEKNISKA UNIVERSITET
Sro Fysik

Kurskod	MTF072
Tentamensdatum Skrivtid	2001-04-17 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 2 maj 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 are required to pass the examination.

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1. **Photons**

   At a blast of an atomic bomb temperatures in the range of 10^6K can be reached. Assume this is true for a 'fire' ball of diameter $d = 10$cm. Evaluate the following:

   a) The total emitted power from this 'fire' ball.

   b) What is the radiation flux at a distance of 2.0 km?

   c) At what wavelength λ peaks the output of power?

   (5p)

2. **Identical particles**

   A system consists of two particles. Each particle can be in one of the following three states with the energies: 0, ϵ and 3ϵ. The system is coupled to a heat reservoir of temperature τ.

   a) Evaluate an expression for the partition function Z if we consider the particles to be classical (ie we can label the particles as 1 and 2).

   b) What will Z if the particles are bosons?

   c) What will Z if the particles are fermions?

   (5p)

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.

(5p)

4. **Binding of O_2 to hemoglobin**

A hemoglobin molecule can bind four O_2 molecules. Assume ϵ is the energy of each bound O_2, relative to O_2 at rest at infinite distance. Let λ denote the absolute activity $e^{\mu/\tau}$ of free O_2 (in solution).

(a) What is the probability that one and only one O_2 is adsorbed on a hemoglobin molecule?

(b) What is the probability that four O_2 are adsorbed on a hemoglobin molecule?

(c) Make a sketch of these probabilities as a function of λ.

(5p)

5. **Interstitial atoms**

The atoms in a crystal of a monoatomic substance can be assumed to sit in either their original lattice positions or in so called interstitial positions. Atoms sitting at a interstitial position have a higher energy compared to if they had been at an ordinary site. The difference in energy is denoted by ϵ. The crystal has N atoms, N lattice sites and N interstitial positions. At a temperature τ, n interstitial sites are occupied by atoms.
Calculate the fraction n/N if $\tau << \epsilon$ and N and $n >> 1$.
(use the approximation $\ln n! = n \ln n - n$)

(5p)

LYCKA TILL ! / GOOD LUCK !