3/05/02. **Due:** Tuesday, March 12, 2002 (in class).

Physics 540: Statistical Mechanics I

Read: LL 25-26,34
Problems to study: K.2 problems 3,4

"**LL** 1" means section 1 from Landau and Lifshitz book

Homework 5

Exercise 1

Using the equation of state $PV = NT$ and the expression for the internal energy $E = c_v NT$ of an ideal gas

a) Derive an expression for chemical potential as a function of temperature and pressure $\mu(P,T)$ for an ideal gas.

b) Derive the pressure of an ideal gas as a function of an altitude in constant gravitational field $g = 9.8m/s^2$ using the result of a). Assume that temperature of the gas is constant and does not depend on the altitude.

c) Derive the density of the gas as a function of an altitude using the result of b).

d) Estimate how much the density of N_2 molecules drops at the top of Everest (height about 9km), assuming $T = 300K$.

Exercise 2

The canonical partition function of a classical, monoatomic, ideal gas in a cylinder rotating with angular velocity ω is given by (see K.2 pr 4)

$$Z = \frac{1}{N!}\left[\pi R^2 L \left(\frac{2\pi m T}{h^2}\right)^{\frac{3}{2}} \frac{e^x - 1}{x}\right]^N ,$$

where $x = \frac{m\omega^2 R^2}{2T}$.

a) Find the angular momentum M of the rotating gas as a function of temperature and angular velocity.

b) Consider the limits of the obtained expression for M corresponding to very high and very low temperatures. Give the physical interpretation of obtained results. What is the criterion of "high" and "low" in this case?

c) How much energy one should supply to heat the gas from a very low temperature T_0 to a very high temperature T_f? Denote the initial angular velocity of the cylinder as ω_0. Neglect the moment of inertia of the cylinder (vessel) itself.