Physics 6311: Statistical Mechanics - Homework 6

---

due date: Tuesday, March 5, 2019

Problem 1: Generalized equipartition theorem (10 points)

Consider a classical Hamiltonian of the form

$$H = \sum_{i=1}^{3N} \frac{1}{2} A_i |q_i|^n + \sum_{i=1}^{3N} \frac{1}{2} B_i p_i^2$$

where $n > 0$ is an exponent that characterizes the potential energy and A_i and B_i are positive constants. Using the canonical ensemble, calculate the internal energy and the specific heat at constant volume as functions of temperature.

Problem 2: Ideal gas with movable piston (15 points)

A classical ideal gas of N particles is in a cylindrical vessel of cross section A. The top of the vessel is closed by a movable piston of mass M.

a) Calculate the partition function for the system consisting of gas + piston in the canonical ensemble.

b) Determine the equation of state, the average volume and the heat capacity.

c) Discuss which heat capacity you are actually calculating.

Problem 3: Broadening of spectral lines (15 points)

The atoms of a star emit light. The emission frequency of a particular element is ν_0 if the atom is a rest. Due to the thermal motion (temperature T) the observed frequency is shifted (Doppler effect) to

$$\nu = \nu_0 \left(1 - \frac{v}{c} \cos\theta\right)$$

where v is the velocity of the atom and θ is the angle between the directions of motion and observation. Calculate the resulting intensity distribution $\rho(\nu)$. What is the width of the spectral line? (Assume the atoms to be noninteracting and to move non-relativistically!)