M513 Equilibrium Statistical Mechanics and Kinetic Theory Ninnat Dangniam

Homework Assignment 2

DUE: Thursday 10 Jan 60 points

1. Entropy of mixing (10 points). Pathria 3.13.

You may use the partition function for the ideal gas in the *canonical ensemble* computed in the lectures or given on p.55 of Pathria.

For part **(a)**, compute the Helmholtz free energy F, the internal energy E, the pressure P, and the entropy S of the mixed gas.

For part **(b)**, is there an entropy difference between the two cases if the two species of gas molecules have the same mass?

2. Relativistic gas I (10 points). Pathria 3.15

Note that γ is the ratio C_V/C_P of specific heat at constant volume and pressure given by

$$C_V = \frac{\partial U}{\partial T}\Big|_V = 3Nk_B,$$
$$C_P = \frac{\partial H}{\partial T}\Big|_P = \frac{\partial(U+PV)}{\partial T}\Big|_P$$

respectively.

3. Relativistic gas II (10 points). Pathria 3.24

4. Electric dipoles in an external field (15 points) Pathria 3.35.

For part **(a)**, compute the Helmholtz free energy F, the internal energy E, and the pressure P of the system of dipoles in addition to the electrical properties. Find the internal energy in the limit $|\mu E| \ll k_B T$ and discuss whether the result makes sense.

5. Mean force between dipoles (10 points) Pathria 3.36

To get the correct result for this problem, you would need to normalize each integral over a solid angle by 4π. That is, use

$$\int \frac{d\Omega}{4\pi} = \int_0^{\pi} \frac{d\theta \sin\theta}{2} \int_0^{2\pi} \frac{d\phi}{2\pi}$$

6. Bohr-van Leeuwen theorem (5 points) Pathria 3.43