SM Spring96B

A large number of monatomic gas atoms of mass m are confined to a cubic box of volume $V = L^3$. One wall of the box of area $A = L^2$ adsorbs atoms with a binding energy ϕ. The atoms are otherwise free to move and may be treated as non-interacting indistinguishable quantum particles, both on the surface and in the gas. The temperature T is constant throughout the system.

(a) Write down the condition which ensures that the gas atoms are in a regime of temperature where the effects of Fermi and Bose-Einstein statistics can be ignored.

In the following, assume that the gas is always in the regime specified in part (a).

(b) Calculate the partition function for N_g particles in the gas, expressing your answer in terms of N_g, V, and $\gamma \equiv (2m\, k_B T/\hbar^2)^{1/2}$.

(c) Calculate the partition function for N_s particles on the surface, also assuming it is a large number and giving the answer in terms of N_s, A, ϕ, and γ.

(d) From parts (b) and (c), find expressions for the chemical potentials for the atoms in the gas μ_g and on the surface μ_s.

(e) Calculate n_s, the density per unit area of atoms on the surface in equilibrium at temperature T, when there are n_g atoms per unit volume in the gas. Give an expression in terms of the quantities defined above.