5M5Spring 01B

Consider a model for Xenon atoms adsorbed on the surface of a solid. A Xenon atom can be either tightly bound to a site on the solid with energy E_A or it can roam freely along the surface but with constant potential energy V. The surface has area A and a total of N_A adsorption sites. Assume the total number of Xenon atoms, N, is much smaller than N_A and that a site can only be occupied by at most 1 Xenon atom.

(a) First consider the two dimensional gas of N_S Xenon atoms that are <u>not</u> bound to adsorption sites. Find their partition function and Helmholtz free energy F. Treat the problem in the high temperature limit. Find the chemical potential, $\mu = \frac{\partial F}{\partial N_S}$, as a function of the gas density N_S/A.

(b) Next consider those $N - N_S$ atoms that <u>are</u> bound to adsorption sites. Find the mean energy, the entropy, and the Helmholtz free energy for those atoms.

(c) Show that in equilibrium, N_S is determined by,

$$\frac{N_S(N-N_S)}{N_A+N_S-N} = C(T)\exp\left(\frac{E_A-V}{k_BT}\right)$$

and find the function $C(T)$.

The following formulas may be useful:

$\log N! \approx N \log N - N$

$$\int_{-\infty}^{\infty} e^{-\alpha x^2}\,dx = \sqrt{\frac{\pi}{\alpha}}$$