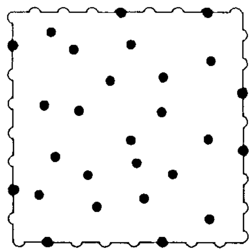
In the dilute-gas limit, the free energy of an ideal gas of atoms is $F = Nk_BT(\ln(N/n_QV) - 1)$, where N is the number of atoms, V is the volume of the container, T is the temperature of the gas, and k_B is Boltzmann's constant. The quantum density is $n_Q = 3.03/\lambda_t^3$, where λ_t is the de Broglie wavelength of a particle with average thermal energy.

a) Calculate n_Q for a gas of Ar atoms at T = 300K. Argon has an atomic weight of 40. (See the list of constants below.)

b) Calculate the entropy of 1 liter of Ar gas at a pressure of 1 atmosphere and a temperature of 300K.

c) The walls of the container have at total of M surface sites to which atoms can attach with a constant binding energy Δ. Show that the free energy of N_s atoms bound to the surface is $F = -N_s\Delta - N_sk_BT(\ln(M/N_s) + 1)$, assuming that $M \gg N_s \gg 1$.

Schematic picture:
(Imagine in 3-d.)



d) Calculate the binding energy Δ in terms of T, N, V, n_Q, N_s and M, assuming that $N \gg M \gg N_s \gg 1$.

e) Evaluate Δ (preferably in eV) assuming V = 1 liter, T = 300K, and that 1% of the surface sites are occupied on average.

Constants: $m_{proton} = 1.673 \times 10^{-27}$ kg, $k_B = 1.381 \times 10^{-23}$ J/K $= 8.6175 \times 10^{-5}$ eV/K,
$h = 6.625 \times 10^{-34}$ J-s $= 4.14 \times 10^{-15}$ eV-s, 1 atm = 10^5 Pa.