The free energy of a monatomic spinless classical gas at temperature T takes the form

$$F = -Nk_BT\,[\ln \{(Ak_BT)^{3/2}\, V / N\} + 1]$$

N is the number of particles, mass M, contained in the volume V.

(a) Calculate the constant A.

Suppose, in addition, that the walls of the container offer added states in which a few gas atoms can trap. There are n sites that can each hold either zero atoms, or one atom in a doubly degenerate state of energy ε. These states are now occupied at random by atoms of the gas.

(b) In terms of a chemical potential μ, write down the grand partition function for one site on the walls. Using this result, or by any other method, calculate the probability of occupation $\langle \nu \rangle$ of one site for given μ and T.

(c) Under what conditions will the gas atoms and wall sites come to equilibrium?

(d) Given that $n\langle \nu \rangle \ll N$, so that the number N of atoms in the gas phase is not significantly altered, calculate in terms of N, V, T and ε the total number $n\langle \nu \rangle$ of gas atoms trapped at wall sites.