Problem Solving Session 8

Problem:

Consider the binding of O_2 molecules from the air to myoglobin molecules. Each myoglobin molecule can bind one O_2 molecule and thereby lowering the energy by $-\epsilon_{ox}$ where $\epsilon_{ox} > 0$ The air can be approximated as an ideal gas.

(a) Write an expression for the grand partition function of this system in terms of the partial pressure of oxygen in the air. Neglect here the internal degrees of freedom of the molecules.

(b) Write an expression for the number of myoglobin molecules, $\langle N \rangle$, that have bound an O_2 molecule as a function of the temperature and partial pressure of oxygen in the air. Find the limit as temperature goes to zero and the limit as temperature becomes infinite.

(c) Consider a hypothetical molecule that has two, independent binding sites for an O_2 molecule. Find the grand partition function for this case.