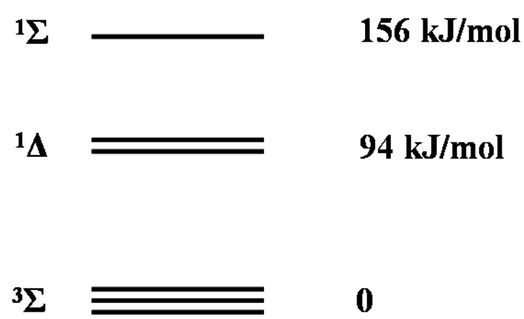
CHM 8309 Sample Questions for Final Exam

1. Assume we have a hypothetical two-dimensional square ideal gas system of area A with either 1 or 2 molecules, (i.e., N = 1 or 2) of mass m where the quantum numbers, n_x and n_y of each molecule can be either 1 or 2. Write the grand-canonical partition function, Ξ for this system at a temperature T. Assume the chemical potential for this system at this temperature is μ.

Hints:

- Use the $\Xi(\mu,V,T)=\sum_N \sum_E \Omega(N,V,E)e^{-E(N)/kT}e^{\mu N/kT}$ form of the partition function, where Ω is the degeneracy of the states, and V is the dimensional 'volume' or area in this two-dimensional case.
- Number of ways of binning N objects in n_1, n_2, … bins is $W=\dfrac{N!}{n_1!n_2!n_3!\cdots}$

2. The three lowest electronic energy levels of the O_2 molecule are shown on the right. Other electronic levels are higher in energy and are disregarded.



a. At 2000 K, what are the probabilities of observing each of the three levels, $^3\Sigma$, $^1\Delta$, and $^1\Sigma$. What can we say about the distribution of a sample of O_2 molecules among these electronic levels?

b. Determine the average energy $\langle \varepsilon_{elec} \rangle$, average square energy $\langle \varepsilon_{elec}^2 \rangle$, and the root mean square deviation of the electronic energy $\sigma_\varepsilon = \sqrt{\langle \varepsilon_{elec}^2 \rangle - \langle \varepsilon_{elec} \rangle^2}$ at 2000 K.

3. Distinguishable and indistinguishable particles

a) We have two particles to be distributed in a system with four equally spaced levels.

If the particles are distinguishable, i.e., they can be given distinct labels, how many distinct ways are there to distribute these two particles among these four levels.

b) If the particles are indistinguishable i.e., they cannot be given distinct labels, how many distinct ways are there to distribute these two particles among these four levels.

c) If the particles are indistinguishable and there can only be one particle in each level (the particles are so called Fermions) how many distinct ways are there to distribute these two particles among these four levels.