Problem 1. (15 points) Consider one mole of non-interacting hypothetical particles at a given temperature T. Assume each particle can occupy one of the three energy levels with the following energies: $\varepsilon_0 = 0$; $\varepsilon_1 = 3\varepsilon$; $\varepsilon_2 = 5\varepsilon$. The degeneracy numbers for these energy levels are 3, 1, and 5, respectively. Answer the following five questions:

A. Write the expression for the molecular partition function *q*.

B. What are the values of *q* at T→ 0 and at T → ∞?

C. You found that at 0 ºC the two upper levels are equally populated. Determine the value of ε.

D. Calculate the total energy of the system at this temperature.

E. Calculate the entropy of the system at this temperature.

Problem 2. (10 points) You use microwave spectroscopy to analyze a gas sample containing a mixture of H_2, Ne, N_2, NO, O_2, CH_4, and CO_2. The absorption spectrum corresponding to pure rotational transitions consists of a series of equally-spaced peaks separated by 3.4077 cm^{-1}. (*Note* this material will be covered in the Tuesday lecture). Based on this information answer the following questions:

A. Identify the molecule responsible for the observed microwave absorption spectrum. *Explain your reasoning.*

B. Using the spectral information that you obtained, determine the bond length in that molecule. *Show your calculations*. (Make sure you convert cm^{-1} to m^{-1} properly)