Assignment 4

1. Consider a classroom (3 m x 10 m x 12 m) filled with N_2 at atmospheric pressure.
   a) What is the average magnitude of momentum of a N_2 molecule if its average speed at room temperature is 300 m/s?
   b) Double your answer to part (a) and call this the maximum allowed value for the magnitude of the molecule's momentum. What is the number of different quantum states accessible to this molecule?
   c) What is the kinetic energy of a N_2 molecule?
   d) What is the total kinetic energy of all the N_2 molecules in the room?
   e) If $V_p = 4/3\ \pi\ p_{min}^3$, what is the minimum value of p_{min} for a molecule such that there is just one quantum state available to it in the room?
   f) How much is the kinetic energy corresponding to p_{min} found in (e) and compare it to the answer to (c).

2. How many different states are available to a system of 10^{24} molecules, each of which can be in any one of 5 different states?

3. A certain system has 4 x 10^{24} degrees of freedom. By what factor does the number of available states increase if the internal energy is doubled? (Assume that the energy separating the quantum states is the same for both cases.)

4. Consider a nonrelativistic system A_0 composed of 3 interacting subsystems, A_1, A_2 and A_3 having degrees of freedom $R_1 = 4$, $R_2 = 5$ and $R_3 = 6$ respectively. Assume the energy comes in units of 1 with the total energy being given by $E_0 = E_1 + E_2 + E_3 = 4$.
   a) Make a table showing Ω_1, Ω_2, Ω_3 and Ω_0 for each of the possible distributions of the energy among the 3 systems.
   b) Which energy distribution is most probable and what is its probability?

5. Consider a nonrelativistic system consisting of two interacting subsystems having degrees of freedom $R_1 = 24 \times 10^{24}$ and $R_2 = 20 \times 10^{24}$. Construct a table listing Ω_1, Ω_2 and Ω_0. Which distribution is most probable?