

PHY 292S

Problem Set #1

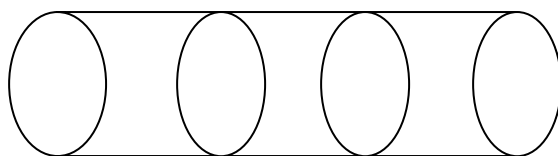
Winter 2008

Due on Thursday, March 13th before the lecture.

1. (Problem 1.12 on p. 8 of Schroeder) Calculate the average volume per molecule for an ideal gas at room temperature and atmospheric pressure. Then take the cube root to get an estimate of the average distance between molecules. How does this distance compare to the size of a small molecule like N_2 or H_2O ? (Express your answers in nm^3 .)
2. (Problem 1.23 on p. 17 of Schroeder) Calculate the total thermal energy in a liter of helium at room temperature and atmospheric pressure. Then repeat the calculation for a liter of air. (Express your answers in Joule.)
3. (Problem 2.3 on p. 52 of Schroeder. Use your favorite computer program. For a computer help, see <http://departments.weber.edu/physics/thermal/computer.html>)

Suppose you flip 50 fair coins.

- (a) How many possible outcomes (microstates) are there?
 - (b) How many ways are there of getting exactly 25 heads and 25 tails?
 - (c) What is the probability of getting exactly 25 heads and 25 tails?
 - (d) What is the probability of getting exactly 30 heads and 20 tails?
 - (e) What is the probability of getting exactly 40 heads and 10 tails?
 - (f) What is the probability of getting 50 heads and no tails?
 - (g) Plot a graph of the probability of getting n heads, as a function of n .
4. The following figure shows a long, hollow cylinder mentally divided into three regions of equal length. Let each region correspond to "a spatial location," and a region may contain more than one molecule.



- (a) If you put only one molecule (labeled A) into the cylinder, how many different "spatial arrangements" are there and, consequently, how many different microstates are there? Show the different spatial arrangements with sketches.
- (b) Repeat the analysis with two molecules (labeled A and B and hence regarded as distinguishable).
- (c) Repeat with three molecules (A, B, and C). Now you may skip the sketches - except as an aid to your thinking.
- (d) Generalize to N labeled molecules.

- (e) If the cylinder were expanded lengthwise, so that there were now four regions (each of the original size), how would your answers to parts (a) through (d) change?
- (f) We can reason that the number of regions is proportional to the cylinder's volume. How, then, is the number of microstates for N molecules related to the volume-on the basis of your analysis here?
5. (Problem 2.24 on p. 67 of Schroeder) For a single large two-state paramagnet, the multiplicity function is very sharply peaked about $N_{\uparrow} = N/2$.
- (a) Use Stirling's approximation to estimate the height of the peak in the multiplicity function.
- (b) Use the methods of this section to derive a formula for the multiplicity function in the vicinity of the peak, in terms of $x \equiv N_{\uparrow} - N/2$. Check that your formula agrees with your answer to part (a) when $x=0$.
- (c) How wide is the peak in the multiplicity function?
- (d) Suppose you flip 1,000,000 coins. Would you be surprised to obtain 501,000 heads and 499,000 tails? Would you be surprised to obtain 510,000 heads and 490,000 tails? Explain.