Physics 480 and 581: Homework #3
Due November 9, 2011

1. (10 points)

   Dilute solutions can often be treated as an ideal gas. Use the Sackur-Tetrode equation `http://en.wikipedia.org/wiki/Sackur-Tetrode_equation` and the relation $\mu = -T(\frac{dS}{dN})_{E,V}$ to show that for an ideal gas, $\mu = \mu^0 + RT\ln c$ where c is the concentration with respect to a reference concentration. Does the reference concentration affect μ^0?

2. (10 points)

   A cylindrical transmembrane protein (R=1.0 nm) is found to diffuse in a lipid membrane with $D = 1.0\ \mu\text{m}^2\text{s}^{-1}$. Use the Saffman-Delbrück theory to find the diffusion constant of a cluster of these proteins as a function of the number of proteins. Plot your results from $N = 1$ to $N = 100$. Clearly state your assumptions.

3. (581 only: 10 points)

   Show that for a particle undergoing Brownian motion and trapped in a 1D box of length L

$$< x^2 > (t) = \frac{L^2}{6} - \frac{16L^2}{\pi^4} \sum_{n=1(\text{odd})}^{\infty} \frac{1}{n^4} \exp(-\frac{1}{2}(\frac{n\pi\sigma}{L}t))$$

   where $\sigma^2 = 2D$. Hint: See Kusumi, Biophysical Journal, vol 65, 2021-2040, 1993.

   What is $< r^2 >$ for a particle trapped in a rectangular volume of size L_1, L_2, L_3?