Worksheet 6: (Due Nov. 18th)(show your work)

1) Consider our 2 equal volume system again with N total particles and N/2 particles in each connected volume (or box) at "perfect" equilibrium (N is large). Consider now, the multiplicity of a state near this "perfect" equilibrium. If I move $\sqrt{(N/2)}$ particles from one box to another, what is the new multiplicity in terms of the "perfect" equilibrium multiplicity? How big a change is this for, say, a mole of gas? (Hint: Use the Stirling approximation from class.)

Assume the multiplicity at our perfect equilibrium can be written:

$$W_{equib} = \frac{N!}{(N/2)!(N/2)!}$$

What can you say qualitatively about the sharpness of this more realistic equilibrium? I.e. how much does the multiplicity change? (consider too that the square root of Avagadro's Number is a very small fraction of Avagadro's Number).

2) A perfect blackbody emitter is also a perfect blackbody absorber. Asumme the earth absorbs all the energy incident on it from the sun and re-emits this energy isotropically as a blackbody at some temperature T. What is T? (From earlier this year: $P_{sun} = 3.92 \times 10^{26}$ Watts, and remember I said this here problem would come later...)

Ah, but this answer leaves us with a bit of a chill. Consider the following. From the surface of a blackbody, we already know the intensity of the radiation leaving is some factor$\times T^4$. Now think about what happens if we put a sheet of blackbody stuff around the previous blackbody. The black body sheet absorbs some of the energy incident on it and comes to some equilibrium temperature. At the equilibrium temperature, the sheet radiates energy (equally) both out and in. Now consider an earth with a surface that absorbs visible light (assume the entire energy of the sun is visible light) and an atmosphere that absorbs in the infared (consider the wavelength that the earth as a blackbody radiates). If we treat this blackbody sheet with the temperature we found before, what is the new temperature at the surface of the earth? (Think about the energy Intesity as a flow.) How do you like this answer?

3) Consider the sun compactifying into a white dwarf star. The total energy of the system will be made up of the total energy of the electrons and the gravitational energy of the star. The gravitational energy comes from the assembing of particles into the star:

$$U_{grav} = -\int_0^{M_{tot}} \frac{GM_{inside}}{r} dm$$

Make an expression for the total energy as the sum of the electrons energy and the gravitational energy. Graph it. Find the value of the radius where the energy is a minimum mathematically. Campare this to the radius of the earth. Assume the sun is made up of equal numbers of electrons, neutrons and protons for your calculation and use $M_{sun} = 2 \times 10^{30}\ kg$. Hint: get dm in terms of dr using density.