Homework 2, due Oct. 11, 2007

1. (a) A system initially with volume 10 liters and temperature $T = 0^C$ is compressed **adiabatically** to a state with volume 5 liters and temperature $T = 100^oC$. In this process, 1000J of work is done on the system. By how much does the internal energy of the system change in this process?

   (b) Instead, we start from the same initial state as above, and end at the same final state as above, by going through the following two steps. Step 1: the system is first heated **isochorically** (constant volume) to the final temperature $T = 100^oC$. Step 2: the system is then compressed **isothermally** (constant temperature) to the final volume of 5 liters. In the first step, 800J of heat had to be added to the system. In the second step, 1900J of heat flowed out of the system. Compute the energy changes and amounts of work done in each of these two steps.

   (c) Can this system be regarded as an ideal gas? Why or why not?

2. The temperature of an ideal gas at initial pressure P_1 and volume V_1 is increased isochorically until the pressure has doubled. The gas is then expanded isothermally (constant temperature) until the pressure drops to its original value. Then it is compressed **isobarically** (constant pressure) until the volume returns to its initial value.

   (a) Sketch these processes in the P-V plane and the P-T plane.

   (b) Compute the work done in each process, and the net work done in the cycle, if $n = 2$ kilomoles, $P_1 = 10^5 PA$, and $V_1 = 2m^3$.

3. Look up "bulk modulus" and "coefficient of thermal expansion" on Wikipedia (google it). Use the data found there to answer the following question: What pressure ΔP is needed to keep stainless steel from expanding, when heated from 20^oC to 25^oC. Assume that the coefficients are constant over this temperature range, and show your work. Consider the pressure needed on a little steel nugget, to prevent its volume from expanding in any direction. Hint: this question is about expansion in any direction, not just one linear direction. Be careful about a factor of 3.

4. A hypothetical substance has expansivity $\beta = aT^3/v$ and isothermal compressibility $\kappa = b/v$, where a and b are constants. Find the equation of state (including an unknown constants of integration).

5. Problem 3-4 in book. (An aside, which is irrelevant to this problem: yes, ice does float, even in boiling water (try it at home!). Fig. 2.5 in the book is off.)

6. Problem 3-10 in book.
7. Problem 4-2 in book.
8. Problem 4-3 in book.
9. Problem 4-4 in book.