**Practice test:** This gives you an idea of the sort of questions on the final and the areas of the course that you should study. Some of these questions are a bit shorter than the actual test questions…hey, it’s surprisingly hard making up questions. A solution will be posted as soon as I get it done.

1. Determine the ΔG° for the following reaction:

C2H4 (g) + H2O (l) → C2H5OH (l)

Tabulated ΔG° values:

ΔG(C2H5OH (l)) = -175 kJ/mol

ΔG°(C2H4 (g)) = 68 kJ/mol

ΔG°(H2O (l)) = -237 kJ/mol

Is the reaction spontaneous?

2. The specific heat capacity of penne pasta noodles is approximately 1800 J/kg K. Suppose you toss 340 g of this pasta (at 25oC) into 1.5 liters of boiling water. The specific heat capacity of water is 4186 J/ kg K.

(a) What is the temperature of the water/pasta just after the noodles are added assuming the water and noodles come to equilibrium quickly and before the stove provides more heat?

(b) What is the change in the entropy of the system?

3. A rigid box contains 3 moles of helium gas initially at 298 K at atmospheric pressure. Assume helium acts as an ideal gas. (mHe = 4 a.m.u)

(a) What is the volume of the box?

(b) You supply heat to raise the temperature of the gas to 400 K. How many Joules of heat do you supply? [Hint: what is the heat capacity of a monatomic ideal gas?]

(c) What is the pressure of the gas at 400 K?

(d) What is the change in entropy, S, of the gas in being heated from 298 K to 400 K?

(e) Use the Sackur-Tetrode equation to calculate the entropy of the gas, S, when it is at 298 K.

4. A Carnot engine is run between temperatures of 300 K and 250K.

(a) What is the efficiency of this engine?

(b) In order to extract 1 kW of work from the engine, how much heat must be supplied from the high temperature reservoir?

(c) If the engine is reversed and run as a refrigerator, what is the coefficient of performance (COP) [COP = heat energy extracted/ work done].

(d) For an energy efficient cooling system which is better high COP or low COP?

5. The paramagnet has two energy level +B and –B corresponding to spin down and spin up respectively.

(a) Write the partition function for this system.

(b) If B=0.1 T and =0.4 eV/T then find the probabilities of a spin being in the spin up and a spin down state at room temperature and at 400 K.

(c) What is the average energy per spin at 400 K?

6. (a) Explain the meaning of each of the two added terms (-Nb and +aN2/V2) in the van der Waals equation of state. Which one models repulsion and which one attraction? Explain.

(b) The value of b in the (V-Nb) term is 2.8 x 10-29 m3 for neon. What does this suggest is the size of a neon atom?

7. (a) Starting with the Helmholtz free energy definition F=U-TS and the thermodynamic identity dU=TdS-PdV+dN derive the partial differential relations

(b) For a two level system of energy 0 and  the Helmholtz Free energy in a high temperature limit is F=-kTln(2-/kT). Find the entropy of this state.