PHY 418 **Midterm Exam** **Spring 2013**

Please cross out any work you do not wish me to look at, and place a box around your final answer for each part.

1) [50 points total] You must explain your answer completely for all parts!

A box is partitioned by a wall into two parts, the right side and the left side. Each side is filled with an identical classical ideal gas of non-interacting, non-relativisitic, indistinguishable point particles of mass m. The gas on each side of the box has the same number of particles N. The volume of the left side of the box is V_1 and the volume of the right side of the box is V_2. The wall separating the two sides of the box is adiabatic (does not conduct heat), immoveable, and non-porous. Initially the gas on the left side is in equilibrium at temperature T_1, while the gas on the right side is in equilibrium at temperature T_2. The wall is now removed and each gas is free to fill the entire volume. The system then comes into its new state of equilibrium.

a) [5 pts] Is the final entropy of the total system larger or smaller than the initial total entropy?

b) [10 pts] What is the final temperature T_f of the gas?

c) [15 pts] What is the final total pressure p_f of the gas? Express p_f only in terms of T_1 and T_2 and the initial pressures of the two sides p_1 and p_2. If initially we had $T_1 = T_2$, is p_f greater or smaller than the average initial pressure $\bar{p} = (p_1 + p_2)/2$?

d) [20 pts] Compute the change in total entropy ΔS that results from removing the wall. Express your answer in terms of the variables T_1, T_2, V_1, V_2 and N only. Show that $\Delta S = 0$ if $V_1 = V_2$ and $T_1 = T_2$.

2) [50 points total]

Consider a classical ideal gas of N non-interacting, non-relativisitic, indistinguishable atoms of mass m, confined to a box of volume V and in equilibrium at temperature T. Each atom i has a net spin s_i which can be in one of three possible states, $s_i = -1, 0, +1$. The magnetic moment produced by this spin interacts with an external magnetic field $\mathbf{h} = h\hat{z}$ giving a contribution to the atom's energy, $\epsilon_i = -\mu h s_i$.

a) [15 pts] Find the canonical partition function $Q_N(T, V, h)$.

b) [5 pts] Find the pressure p as a function of T, V, N and h.

c) [10 pts] Find the average total energy $\langle E \rangle$ of the gas as a function of T, V, N and h.

d) [10 pts] Find the average total magnetization $\langle M \rangle = \mu \sum_{i=1}^{N} \langle s_i \rangle$ of the gas as a function of T, V, N and h.

e) [5 pts] Find the chemical potential μ of the gas as a function of T, V, N and h.