PHYS 430 - SUPPLEMENTARY EXAMINATIONS FOR GRADUATION
February 2006

Name and Surname:
Student ID:
Department:
Signature:

1. Discuss the following concepts. Do not use equations. You will not get any points if you use mainly equations to define the concepts. (4 points each)
   a) Entropy
   b) Equipartition Theorem
   c) Fermi and Bose Distributions
   d) Thermodynamic Potential
   e) Reversible Process
2. Compare the three distributions that we have discussed: micro canonical, canonical and grand canonical distributions. Specify the quantities that are fixed by external influences and the quantities that are allowed to change. (20 points)
3. Using the canonical distribution, calculate the free energy and then the entropy of a classical ideal gas of particles without any internal structure. Express you result in terms of V, the volume of the container, N the number of particles, and T, the temperature of the gas. The energy of the particles forming the gas has the energy momentum relation given by $\epsilon = cp$ where p is the magnitude of the momentum of the particle. Your answer should not contain any arbitrary unknowns, it can contain physical constants.

4. Consider two particles. Each particle can be in two different states having the energies 0 and $\epsilon > 0$ respectively. The system is at a temperature T. Write the partition function for this system if

   a) the particles are distinguishable (10 points)

   b) the particles are indistinguishable bosons (10 points)

   c) the particles are indistinguishable fermions (10 points)

5. Show that

$$\left(\frac{\partial E}{\partial V}\right)_T = T\left(\frac{\partial P}{\partial T}\right)_V - P$$

   for any thermodynamical system (10 points). Using this result, show that for the Van Der Waals' gas(10 points),

$$\left(\frac{\partial E}{\partial V}\right)_T = a\left(\frac{N}{V}\right)^2$$

You can use the following formulas/definitions without deriving them:

$$\begin{aligned}
dE &= TdS - PdV + \mu dN \\
dF &= -SdT - PdV + \mu dN \\
dW &= TdS + VdP + \mu dN \\
d\Phi &= -SdT + VdP + \mu dN \\
F &= E - ST \ ; \quad W = E + PV \ ; \quad \Phi = E - ST + PV \\
S &= \ln \Delta\Gamma(E) \ ; \quad \Delta\Gamma(E) = \Delta E \frac{\partial}{\partial E}\Gamma(E) \\
\ln N! &\simeq N \ln N - N \\
\int_0^\infty x^n e^{-x} &= n! \\
\beta &= \frac{1}{T}, \qquad k = 1
\end{aligned}$$

The equation of state of a Van der Waals gas is:

$$\left(P + a\left(\frac{N}{V}\right)^2\right)(V - Nb) = NT$$

For anything else, you need to derive it.