STONY BROOK UNIVERSITY
DEPARTMENT OF PHYSICS AND ASTRONOMY

Placement Examination **Statistical Mechanics**, September 1, 2006

General instructions: Three problems are given. You should do any two. Each problem counts 20 points and the solution should typically take less than 45 minutes. Use one exam book for each problem and label it carefully with your name, the name of the problem's author and the date. You may use a one page help sheet, a calculator, and with the proctors approval a foreign language dictionary. No other materials may be used.

Statistical Mechanics I

Explain the mechanism which leads to Bose-Einstein condensation in the free quantum Bose gas in 3 dimensions, and compare this with the mechanism which leads to ferromagnetic order in the classical Heisenberg magnet in 3 dimensions.

Statistical Mechanics II

Gases of infinitely hard particles have equations of state

$$\frac{P}{kT} = f(V)$$

and specific heats which are independent of temperature. For such a gas compute c_P, c_V and the equation of adiabats in terms of $f(V)$.

Statistical Mechanics III

The water molecule in free space has an electrical dipole moment $p_0 = 0.39|e|$Å. In this problem, treat water vapor as a classical ideal gas of N molecules in a volume V, in equilibrium at temperature T. The molecules do not interact with each other but do feel a laboratory electric field because of their (classical) electric dipoles.

a) Suppose there is the electrical field has a strength E=1 10^6 V/m. What is the energy splitting (in eV) between the state of a molecule aligned and anti-aligned with the field? How does this compare with the thermal energy k_BT at temperature T=300K?

b) For the case $\boldsymbol{p_0 E} \square \boldsymbol{k_B T}$, find the polarization P (mean total dipole moment per unit volume) of water vapor to lowest order in E.

c) Also to lowest order in E, what is the fractional temperature change $\Delta T/T$ in an adiabatic process where the magnitude of the electrical field is reduced from **E** to zero? (The molecules have translational as well as orientational degrees of freedom.)