PHY 410 – Spring 2008 Exam #1

(1 Hour)

PLEASE WAIT UNTIL YOU ARE TOLD TO BEGIN THE EXAM

While waiting, carefully fill in the information requested below

Your Name:……………………………………………………………….

Your Student Number:…………………………………………………

There are 4 problems. Please answer them all.

USEFUL CONSTANTS AND EQUATIONS

Avogadro's Number N_A= 6.022 x 10^{23}
Boltzmann's constant k = 1.381 x 10^{-23} J/K
Gas constant R = kN_A = 8.31 J/mol.K

Stirling's formula: $\ln x! \sim x \ln x - x$ when $x >> 1$

Problem 1 (15 points)

a) Five moles of ideal Argon gas are heated from 300K to 400K in a fixed volume V. How much heat is required to heat the gas?

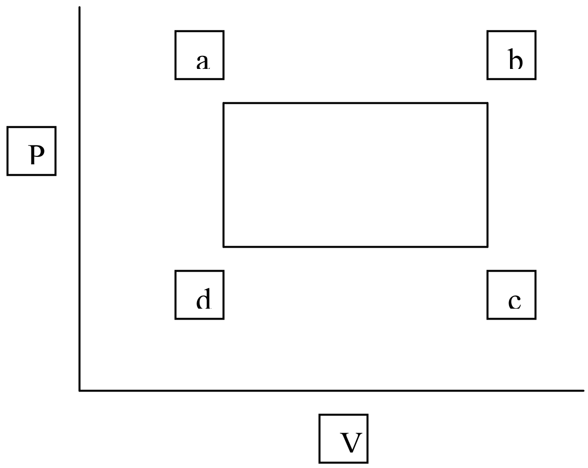
b) If instead of fixing the volume we keep the pressure fixed in (a) how much heat will be required to increase the temperature from 300K to 400K?

c) If instead of Argon we have 5 moles of CO gas how much heat will be required to heat the gas from 300K to 400K when the volume is constant?

d) An unknown one mole of gas is heated from 1000K to 1100K at constant volume and it takes about 4.5 kJoules of heat. What can you tell about the gas (mono, di, tri, etc) and why?

Problem 2 (10 points)

One mole of a perfect gas performs a quasistatic cycle consisting of four successive stages: from a (P_1,V_1) to b (P_1,V_2) to c (P_2,V_2) to d (P_2,V_1) to a (P_1,V_1). Find the work done by the gas and the heat absorbed by the gas during this cyclic process.



Problem 3 (15 points)

Consider a system containing two sets of harmonic oscillators (Einstein solids), A and B, each containing 2 oscillators sharing a total of 5 units of energy ($q = q_A + q_B = 5$), which is fixed.

a) How many different macrostates are available to this system and what are they?

b) How many different microstates are available to this system? What is the probability of observing any one of these microstates.

c) Assuming that this system is in thermal equilibrium, what is the probability of finding all the energy in A

d) What is the probability of finding exactly 2 units of the energy in B, $q_B = 2$?

Problem 4 (10 points)

Consider a system of N dipoles in the presence of a magnetic field. The dipoles can orient either parallel (↑) or antiparallel (↓) to the field.

a) How do you describe the microstates for this system? Give an example of a microstate for N=4

b) How do you describe a macrostate for this system? Write down all the macrostates for N=4.

c) Write down an expression for the multiplicity Ω of a macrostate in terms of N and another variable describing the macrostate. .

d) Using Stirling formula (given on the front page) write down an expression for Ω in terms of N and $N_{\downarrow}$ when N, $N_{\downarrow}$, and $N_{\uparrow}$ are all >> 1.