University of Louisville
College of Arts and Sciences

Department of Physics and Astronomy PhD Qualifying Examination (Part I)

Fall 2009

Paper C – Thermodynamics & Statistical Mechanics

Time allowed – 90 minutes

Instructions and Information:

- Answer both questions
- This is a closed book examination
- Start each question on a new sheet of paper – use only one side of each sheet
- Write your identification number on the upper right hand corner of each answer sheet
- You may use a non programmable calculator
- Partial credit will be awarded.
- Correct answers without adequate explanations will not receive full credit.
- Make sure your work is legible and clear
- The points assigned to each part of each question are clearly indicated

1) A 0.5 kg ice cube at -10 ^{0}C is placed in 2 kg of water at 15 ^{0}C. Assume that the latent heat of fusion for water, the specific heat of water and that of ice can all be treated as a constant. They are 80 kcal/kg, 1 kcal/kg.K and 0.5 kcal/kg.K, respectively.

(a) Assuming no heat lost to the surroundings, calculate the equilibrium temperature of the system. (20)

(b) Calculate the change of entropy of the system. (15)

2) Consider an ideal monatomic gas in which each atom, in addition to the normal 3 degrees of freedom associated with its translational motion, has two internal energy states, one at energy ε_0 and the other at energy $\varepsilon_0 + \Delta$. The energy of an atom can thus be written as $\varepsilon = \frac{p_x^2 + p_y^2 + p_z^2}{2m} + \varepsilon_{\text{internal}}$, where p_x, p_y and p_z are the Cartesian components of its momentum, m is its mass, and $\varepsilon_{\text{internal}}$ takes the two discrete values mentioned previously. There are N such atoms in a volume V at temperature T.

(a) Calculate the partition function (25)

(b) Calculate the internal energy (20)

(c) Find the heat capacity at constant volume. (20)