University of Louisville
College of Arts and Sciences

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

Spring 2016

Paper C – Thermal Physics

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 is clearly indicated

Thermal Physics Basic

One kg of water at a temperature of 5 ^{0}C is placed inside an insulated container. [0 ^{0}C = 273 K]

(a) How much heat must be extracted to cool the water to 0 ^{0}C ? (4)
[Specific heat of water = 4200 J/kg. ^{0}C]

(b) How much heat must be extracted to freeze all the water ? (4)
[Latent heat of fusion of water = 350 x 10^3 J/kg]

(c) How much heat must be extracted to cool the ice to -28 ^{0}C ? (4)
[Specific heat of ice = 2000 J/kg.K]

A steel rod is now inserted into the container allowing heat to escape to the surroundings (kept at a constant -28 ^{0}C) at a rate of 196 Watts.

(d) How many joules of heat has escaped after 1000 seconds ? (4)

(e) What is the temperature and composition (how much water and how much ice) of the contents of the container after 1000 seconds ? (7)

(f) Evaluate the entropy change of the surroundings after this time. (5)

(g) Evaluate the entropy change of the water in this time. (7)

Thermal Physics Intermediate

Consider a classical one-dimensional system composed of N localized anharmonic oscillators. The potential energy of each oscillator is given by

$$V(x) = ax^2 + bx^4,$$

where x is the position of the oscillator. Both parameters, a and b, are positive. Assume that b is very small in value and thus can be treated as an expansion parameter. To first order in b, and at a given temperature T,

(a) Calculate the partition function of the system. (25)

(b) Calculate the heat capacity of the system. (20)

(c) Calculate the average values of x and x^2. (20)