University of Louisville
College of Arts and Sciences

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

Spring 2013

Paper C – Thermodynamics & Statistical Mechanics

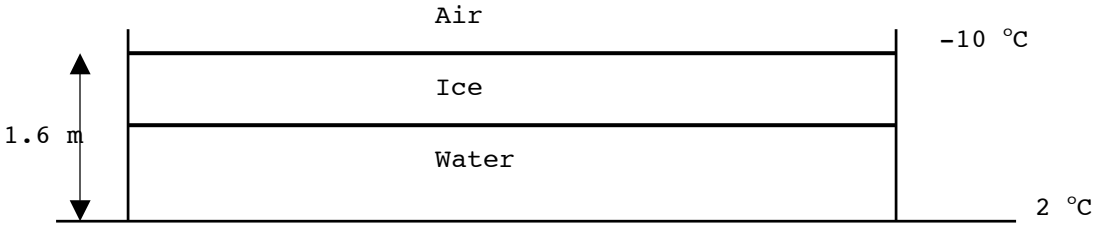
Time allowed – 90 minutes

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 is clearly indicated

Thermo & SM Basic

An outdoor swimming pool is left uncovered in the Winter. Assume a constant air temperature of -10 °C and that the bottom of the pool remains at 2 °C. Ice forms uniformly on the surface of the pool.



(a) What is the temperature of the interface between the ice and the water ? (3)

In this scenario the rate of heat transfer through a medium is equal to the product of the temperature gradient, the cross-sectional area perpendicular to the direction of heat transfer and the thermal conductivity of the medium.

Assuming that no heat transferred through the sides of the pool,

(b) if the total depth of ice and water is 1.6 m. Use thermal conductivities for ice and water of 1.8 and 0.6 W/m.K, respectively, to determine the thickness of the ice. (16)

(c) How many Joules per second per square meter are conducted through the ice into the air ? (9)

(d) Suppose a heater maintains the bottom of the pool at 15 °C. How much ice will form in this case ? (7)

Thermo & SM Intermediate

Two identical ideal monatomic gases with the same pressure P and the same number of particles N, but with different temperatures T_1 and T_2, are confined in two vessels of volume V_1 and V_2, which are then connected. The system eventually reaches the equilibrium.

(a) Work within the framework of thermodynamics and find the change of entropy of the system after it has reached the equilibrium. Please note that the final entropy does not depend on how the final state is reached, so it can be calculated as if it were reached isobarically. This is possible since the final pressure is also P. (25)

(b) Now you can use the method of statistical mechanics to study the same system. First, find the partition function of a system of a monatomic ideal gas with N particles inside volume V at temperature T. (10)

(c) Find the entropy of the system mentioned in (b). (15)

(d) Apply the result in (c) to find the change of entropy of the original system and compare your result with that of part (a). (15)