University of Louisville
College of Arts and Sciences

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

Spring 2015

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 mole of a monatomic ideal gas is taken from an initial state of pressure p and volume V to a final state of pressure 2p and volume 2V in two steps. First it expands isothermally until its volume is doubled, then its pressure is increased at constant volume to the final state.

(a) Show the path of this process on a pV diagram. (3)

(b) Determine the heat absorbed by the gas in each of the two steps. (6)

(c) Determine the work done by the gas in each of the two steps. (6)

(d) What is the overall change in internal energy of the gas from initial to final state ? (5)

(e) Calculate the overall change in entropy of the gas from initial to final state. (7)

N.B. In each of the above calculations your final answer should be written in terms of p, V and the gas constant R.

Suppose instead that the gas starts from the same initial state (p,V) but is initially compressed isothermally until its pressure is doubled, then its volume is increased at constant pressure to the final state (2p, 2V).

(f) Show the path of this process on a pV diagram. (3)

(g) What are the overall changes in internal energy and entropy for this process ? (5)

Thermal Physics Intermediate

A gas is initially confined to one half of a thermally isolated container. The other half is empty.

(a) Write the first law of thermodynamics for the gas. Assume a reversible process and that the volume is not fixed. (15)

(b) Derive/Justify

$$C_V = T\left(\frac{\partial S}{\partial T}\right)_V$$

(10)

(c) Derive/Justify

$$\left(\frac{\partial S}{\partial V}\right)_T = \left(\frac{\partial P}{\partial T}\right)_V$$

(10)

(d) Rewrite the first law of thermodynamics in terms of the internal energy as a function of temperature and volume, U(T,V). (10)

The gas is suddenly permitted to expand to fill the entire chamber. Assuming the initial temperature of the gas is T_i and C_V is constant, find the final temperature of the gas T_f for the following two cases:

(e) A gas with the equation of state, $PV = nRT$, (10)

(f) A gas with the equation of state, $b(P + a/V^2) = nRT$ (10)