Phys 362
Spring 2018

Statistical and Thermal Physics: Homework 4

Due: 13 February 2018

1 Gould and Tobochnik, *Statistical and Thermal Physics*, 2.29, page 91. This can be harder or easier, remember what implicit differentiation is?

2 Entropy change for an ideal gas at constant volume

An ideal gas undergoes a process in which its volume is fixed but the pressure is increased by a factor of 8. Don't forget what the definition of dQ is for a fixed volume process is.

a) Determine the change in entropy if the gas is monoatomic.

b) Determine the change in entropy if the gas is diatomic.

3 Entropy change and energy flow in constant volume processes

Consider a system that consists of two subsystems, each of whose volume is fixed. This system undergoes an infinitesimal process in which energy flows from one subsystem to another. Using the rule

$$\frac{1}{T} = \left(\frac{\partial S}{\partial E}\right)_{V,N}$$

show that the second law of thermodynamics implies that energy must flow from the higher to the lower temperature subsystem as they approach equilibrium.

4 Second law and volume changes

Consider two systems, A and B, which interact. The systems cannot exchange energy but their volumes can change subject to the constraint that the total volume remain constant. Suppose that the pressure in A is larger than the pressure in B. Use the infinitesimal version of the second law to predict which system will undergo an increase in volume as they come to equilibrium. Hints - $dq = 0$ and $dE_A = -P_B dV_a$. Hint - express everything in terms of dV_A.

5 Gould and Tobochnik, *Statistical and Thermal Physics*, 2.24, page 78. Hint $\Delta S = 0$ for part A. Also, assume a monoatomic gas for part A. For part C, eliminate V and use logarithm identities to separate P and T.

6 Gould and Tobochnik, *Statistical and Thermal Physics*, 2.55, page 103. For D, assume the volume changes as in part A. For E, add the entropy change in C and D.

7 Gould and Tobochnik, *Statistical and Thermal Physics*, 2.58, page 105. Do this problem in Kelvin.

8 Gould and Tobochnik, *Statistical and Thermal Physics*, 2.62, page 106. The water's final temperature will be the temperature of the bath. For B, use the algebraic results from part A, don't redo all the calculations.

9 System interacting with a heat bath

Consider a system with heat capacity C that interacts with a heat bath. Suppose that the system is initially at temperature $T_{\rm sys}$ and that the bath is a temperature T_B. The two are then placed in contact and during the process that follows the system remains at constant volume.

a) Show that the change in entropy of the system plus bath is

$$\Delta S = C\left[\ln\left(\frac{T_B}{T_{\rm sys}}\right) + \frac{T_{\rm sys}}{T_B} - 1\right]$$

and note that this involves a function of the form

$$f(x) = \ln x + \frac{1}{x} - 1.$$

b) Determine when $f(x)$ attains a minimum and what this minimum is. Use this to describe the condition under which $\Delta S = 0$. Write down what the system temperature and bath temperature need to be for this minimum to occur.