AA103 Homework 1 - Review of thermodynamics

Cantwell Spring 2020-21

Due April 6, 2021

Suggested reading - AA210 Course notes Chapter 2

Problem 1

In the figure below five moles of Helium gas are contained in Volume A at State 1. Volume B is at vacuum. A small leak is opened between Volumes A and B. The gas in A expands slowly while the jet of gas from the leak fills B until the pressures in volumes A and B are equal. At the moment the pressures equalize, the leak is sealed. The volumes and the wall between them are adiabatic. The two volumes are equal. The molar specific heat, C_p, is constant.

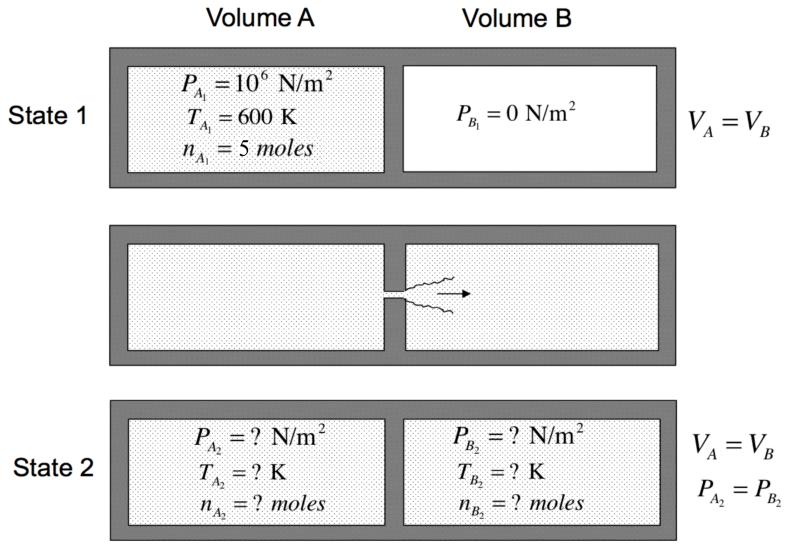

Figure 1: Slow transfer of gas from volume A to volume B.

1) Use the first law of thermodynamics to relate the internal energy of the gas in Volume A at State A_1 to the internal energy of the gas in volumes A and B at states A_2 and B_2 respectively.
2) Relate the pressure and temperature in Volume A at state 2 to the initial pressure and temperature in Volume A at state 1.
3) Determine T_{A_2} , T_{B_2} , n_{A_2} , n_{B_2} and P_{A_2} .
4) Determine the dimensionless entropy change of the system $(S_2 - S_1)/(nC_p)$ where n is the total number of moles of gas in the system.

Problem 2

In Problem 1, suppose the barrier between volumes A and B is removed completely. What is the final pressure, temperature and entropy of the gas in the combined volume A plus B?

Problem 3

Consider the nearly isentropic flow of an ideal gas across a low pressure fan such as an aircraft propeller. Assume that the pressure change ΔP is small. Show that the corresponding temperature change is

$$\frac{\Delta T}{T_0} = \frac{\gamma - 1}{\gamma} \frac{\Delta P}{P_0} \tag{1}$$

where T_0 and P_0 are the undisturbed values ahead of the fan.

Problem 4

Mars has an atmosphere that is about 96 % Carbon Dioxide at a temperature of about $200K$. Determine the scale height of the atmosphere and compare it with Earth. The pressure at the surface of Mars is only about $1000Pa$. Entry, descent and landing of spacecraft on Mars is considered to be in some ways more difficult than on Earth. Why do you think this is?