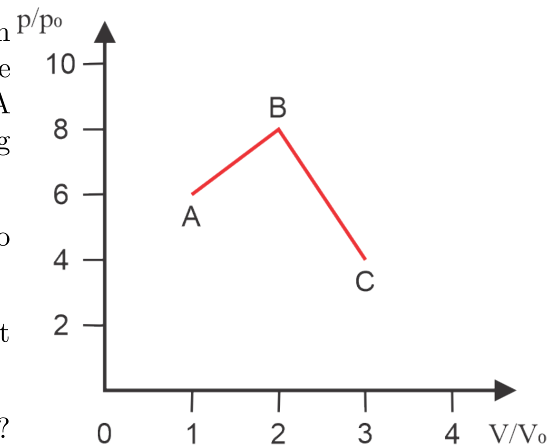
Physics 4311: Thermal Physics - Homework 10

due date: Tuesday, April 11, 2023, please upload your solution as a pdf on Canvas

Problem 1: Expansion process (16 points)

An ideal gas of N point particles undergoes a two-step expansion from volume V_0 at pressure $6p_0$ first to volume $2V_0$ and pressure $8p_0$ and then to volume $3V_0$ and pressure $4p_0$ (shown as path A $\rightarrow$ B $\rightarrow$ C in the figure.) Express the answers to the following questions in terms of N, V_0 and p_0.



a) Find the work done on the gas during the expansion from A to C.

b) Calculate the change in internal energy between the start (point A) and end (point C) of the process.

c) What is the heat absorbed or released by the gas in the process?

d) Find the change of entropy during the process.

Problem 2: Elastic rod (16 points)

An elastic rod has an unstretched length L_0. If it is stretched to length L, the tension force is given by $f = aT^2(L - L_0)$ where T is the temperature and a is a constant. The heat capacity C_L at constant length is given by $C_L = bT$ when $L = L_0$. Here, b is another constant.

a) Write down the first law in the appropriate variables.

b) Using a Maxwell relation, find $(\partial S/\partial L)_T$

c) Compute the change in entropy as the rod is stretched from length L_0 at temperature T_0 to length L at temperature T. (Hint: It may be useful to split the process into one at constant $L = L_0$ and one at constant temperature.)

d) The rod is stretched adiabatically (thermally isolated) from some initial length L_i at temperature T_i to a final length L_f. Find the final temperature T_f.

Problem 3: Maxwell relations (8 points)

Find all four Maxwell relations for a paramagnetic material for which the first law reads $dU = T\,dS - m\,dB$. (You can treat m and B as scalars as would be appropriate for a uniaxial magnet.)