4C Problem Set 3 – The First Law of Thermodynamics

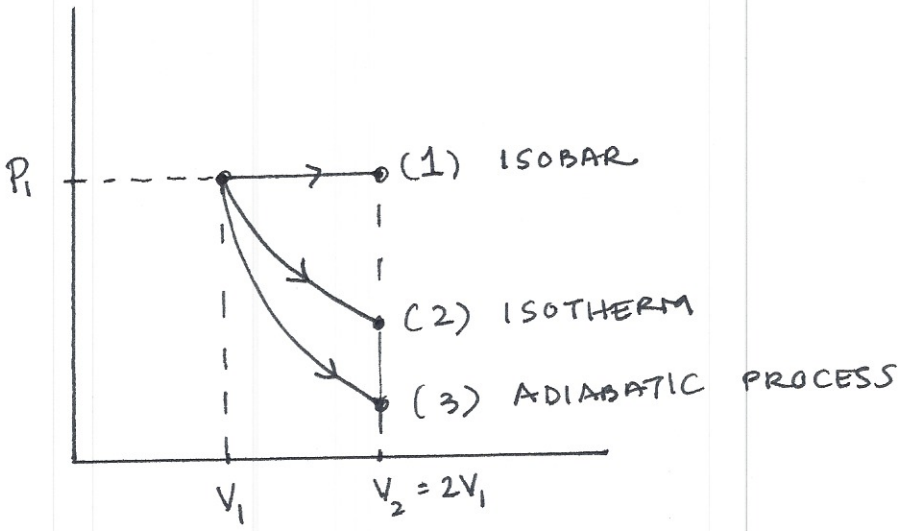
1. One mole of a monatomic ideal gas is initially at T_o and P_o. Q_1 joules of thermal energy are added at
a) constant pressure. Find the initial and final internal energy and the work done by the gas.
b) constant volume. Find the initial and final internal energy and the work done by the gas.
c) show both of these processes on a P-V diagram.

2. Two moles of an ideal monatomic gas have an initial pressure P_1 and initial volume V_1. The gas is taken through the following cycle:
i) It is expanded isothermally until the volume is doubled. ($V_2 = 2\ V_1$)
ii) Heated at constant volume until the pressure is the same as P_1 ($P_3 = P_1$)
iii) Cooled at constant pressure until back to the original state.
Show this cycle on at P-V diagram. Find the heat added (or removed) and the work done by the gas for each process.

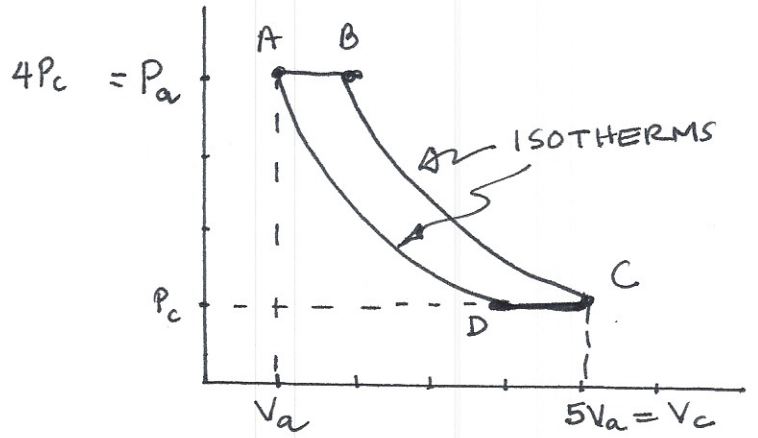
3. When an ideal gas undergoes a temperature change at constant volume, its energy changes by $\Delta U = nCv\ \Delta T$.
a) Explain why the result holds for an ideal gas for any temperature change regardless of the process. (You may need to read ahead to answer part a.)
b) Show that this result holds for the expansion of an ideal gas at constant pressure by calculating the work done (by the gas) in terms of ΔT and Q in terms of ΔT to find ΔU

4. An ideal gas at initial volume V_1 and pressure P_1 expands quasi-statically and adiabatically to volume V_2 and pressure P_2. Calculate the work done (by the gas) by directly integrating PdV.

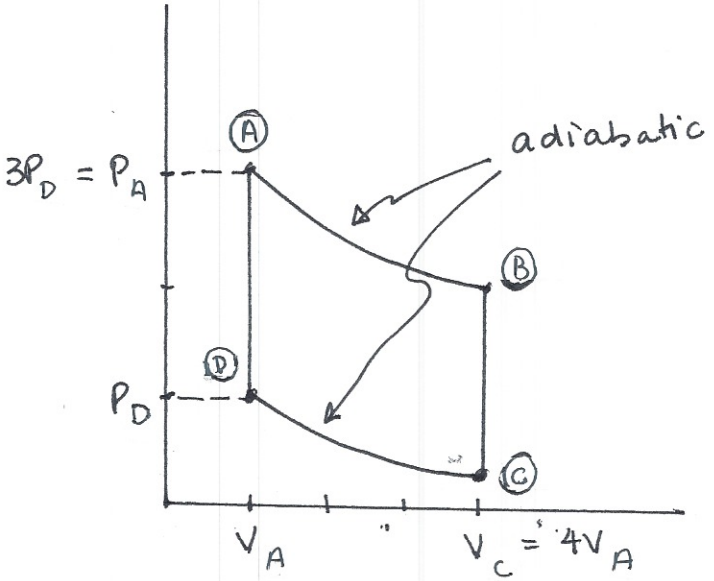
5. A monatomic gas expands slowly to twice it original volume doing work W on the surround in the process. Find the heat added to the gas and the change in internal energy for the three processes indicated in the P-V diagram.



6. One mole of an ideal monatomic gas is originally at point A on the P-V diagram shown. The paths AD and BC represent isothermal changes. If the system is brought to point C along path ABC, find the initial and final temperatures, the work done and the heat absorbed. Repeat for path ADC.



7. One mole of an ideal monatomic gas is originally at point A on the P-V diagram shown. Paths AB and DC represent adiabatic processes. How much work is done by the gas and how much heat is absorbed along path ABC?



8. Prove that the slope of the adiabatic curve passing through a point on the PV diagram is γ times the slope of the isothermal curve passing through that point.

9. A vertical heat-insulated cylinder is divided into two parts by a moveable piston of area *A*. Initially, the piston is held at rest. The top part is evacuated and bottom part is filled with 1 mole of diatomic gas at temperature T_i. After the piston is released and the system comes to equilibrium, the volume occupied by the gas is halved. ($V_f = ½ V_i$). Find (a) the final temperature of the gas and (b) the mass of the piston.