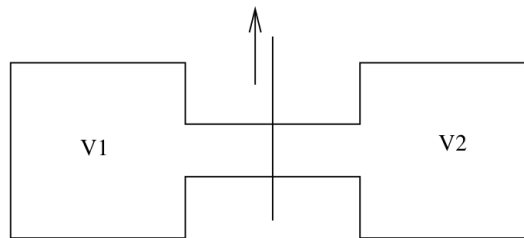


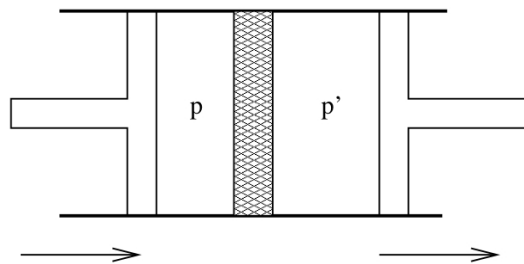
Aufgabe 4.1 Reversible and irreversible expansion

Let's consider the following three processes with an ideal gas as working substance:

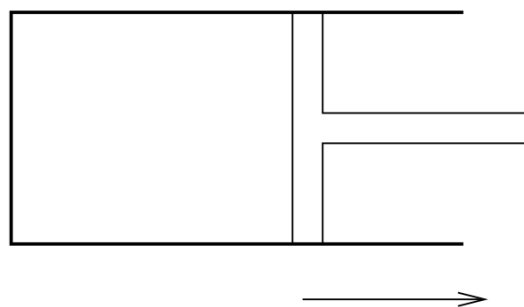
A) Gay-Lussac (irreversible)



B) Joule-Thomson (irreversible)



C) Cylinder-piston system (reversible)



C.1) Isotherm expansion (at each time step the system is in the thermal equilibrium with the environment).

C.2) Adiabatic expansion (the system is thermally isolated).

T_1 , V_1 and T_2 , V_2 are the temperature and the gas volume before and after the expansion.

- In both the configurations A and C.2 an adiabatic expansion takes place. How do T_2 and T_1 behave during these two processes? Explain this from the microscopic point of view.
- Set up the energy balances for the processes C.1 and C.2.
- Show that before and after the process the temperature is the same in B.

Aufgabe 4.2 Heat Exchange and Entropy

A body A with heat capacity (for $V = \text{constant}$) $c_V^{(A)}$ is made up of n_A moles and its temperature is T_A . The body A is in thermal contact with another body B (made up of n_B moles and with heat capacity $c_V^{(B)}$) at $T_B > T_A$. Assume that the only process which occurs is a heat exchange (we neglect the thermal expansion of the bodies).

- Is this process reversible or irreversible? Give an explanation to your answer.
- Calculate the final temperature T of the system made up of the two bodies, once the thermal equilibrium is achieved, as a function of T_A , T_B , n_A , n_B , $c_V^{(A)}$ and $c_V^{(B)}$. Verify that $T_A < T < T_B$.
- Prove that the total variation of entropy is

$$\Delta S = n_A c_V^{(A)} \ln \frac{T}{T_A} + n_B c_V^{(B)} \ln \frac{T}{T_B}. \quad (1)$$

and show that $\Delta S > 0$.

Aufgabe 4.3 Heat capacity

Using the fact that Entropy S is a function of state (S), find a general relation between the heat capacities c_P and c_V , defined by

$$c_P \equiv \left(\frac{\delta Q}{\partial T} \right)_P = \left(\frac{\partial H}{\partial T} \right)_P = \left(\frac{\partial(U + pV)}{\partial T} \right)_P \quad (2)$$

and

$$c_V \equiv \left(\frac{\delta Q}{\partial T} \right)_V = \left(\frac{\partial U}{\partial T} \right)_V. \quad (3)$$

Apply the final result to an ideal gas.