The Gay-Lussac-Joule Experiments

- Measuring the dependence of the internal energy of a gas on its volume.

- Results show that the internal energy is a function of T only.

- The internal energy does not depend on the volume V

- The GLJ experiment is designed based on the following relationship

$$\left(\frac{\partial u}{\partial \upsilon}\right)_T \left(\frac{\partial \upsilon}{\partial T}\right)_u \left(\frac{\partial T}{\partial u}\right)_\upsilon = -1.$$

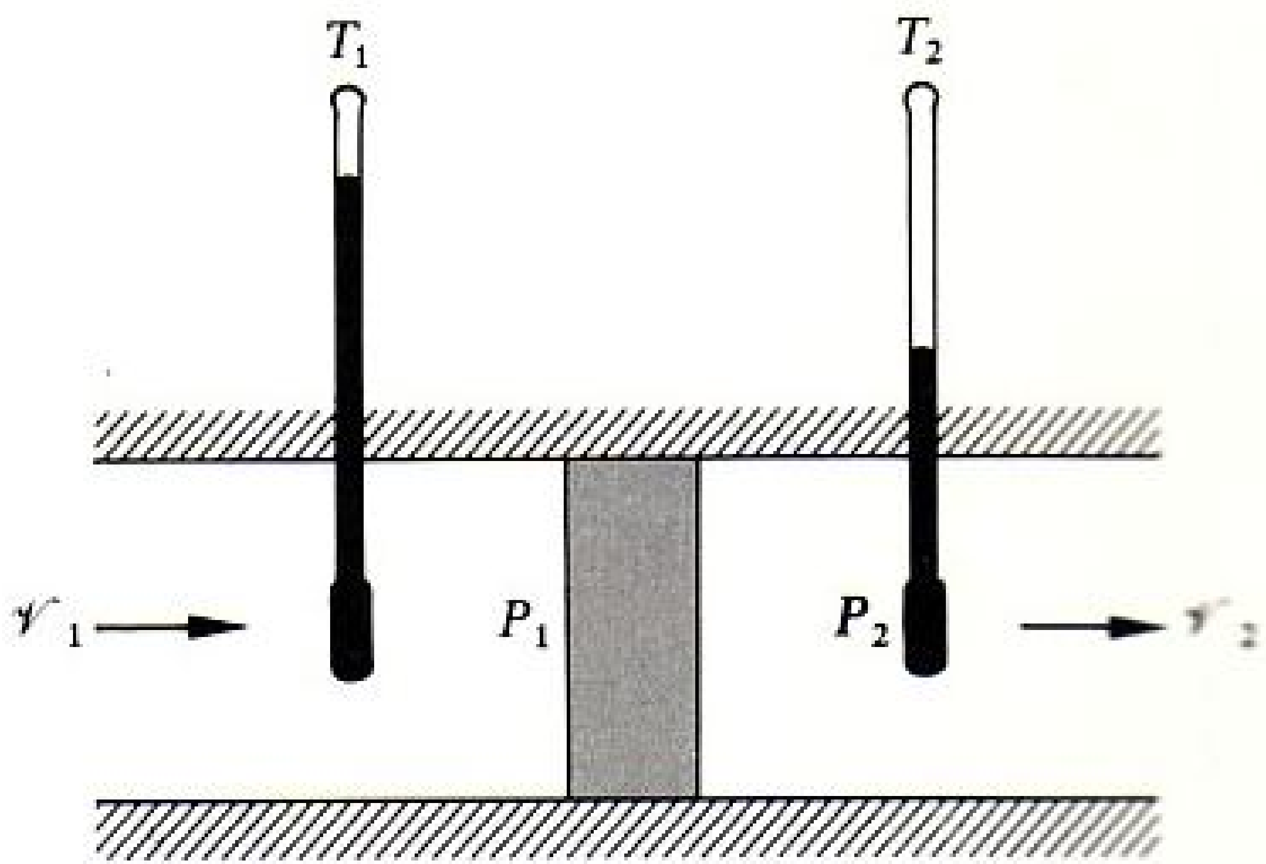
$$\left(\frac{\partial u}{\partial \upsilon}\right)_T = -c_v \left(\frac{\partial T}{\partial \upsilon}\right)_u,$$

which indicates that the variation of internal energy could be obtained via measuring the change of temperature with respect to volume under constant internal energy

- The key is: how to keep the internal energy constant during expansion.

- Considering *d*u = *d*q – *d*w, where *d*q = 0 during adiabatic changes

5.2 The Joule-Thomson Experiment

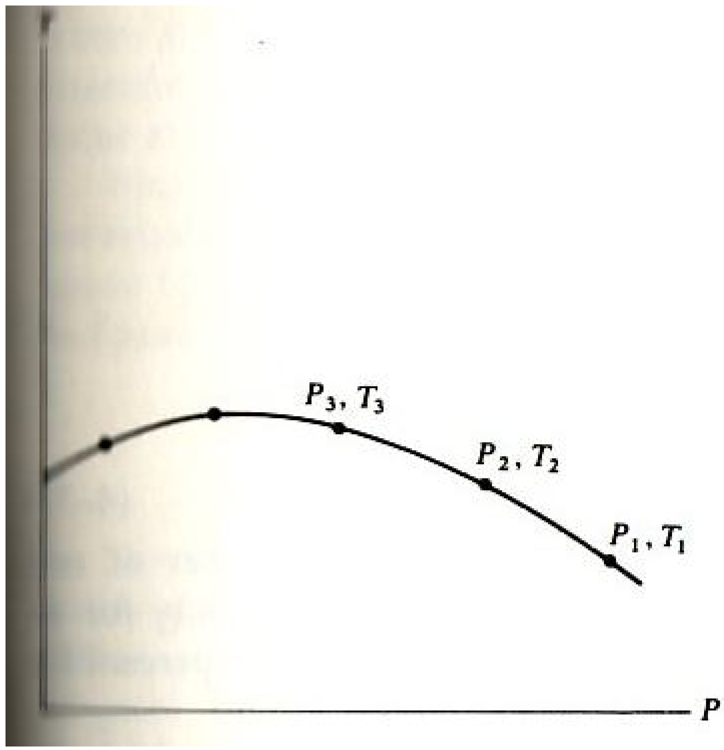


Theory of the Joule-Thomson Experiment

- In an insulated cylinder: $dq = 0$
- The work done by forcing the gas through the throat (or porous plug) is $-P_1V_1$
- The work done by the system in expansion is P_2V_2
- The total work is therefore: $P_2V_2 - P_1V_1$
- The variation in internal energy is

$$u_2 - u_1 = P_2V_2 - P_1V_1$$

- Both the P and T of the gas before passing through the throat are kept constant
- The Temperature at the exit is measured at different exiting P values

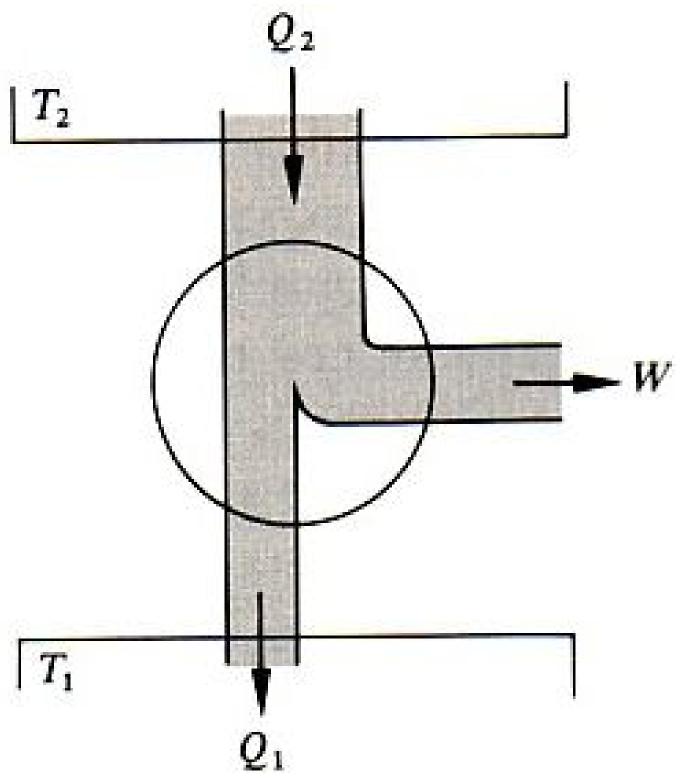


- The slope of the above curve at any point is called the Joule-Thomson coefficient μ, where μ = 0 is called the inversion point

- The Joule-Thomson experiment illustrates that the enthalpy of a gas is independent of pressure.
- Theoretical analysis will be shown on chalk board

5.3 Heat Engines and the Carnot Cycle

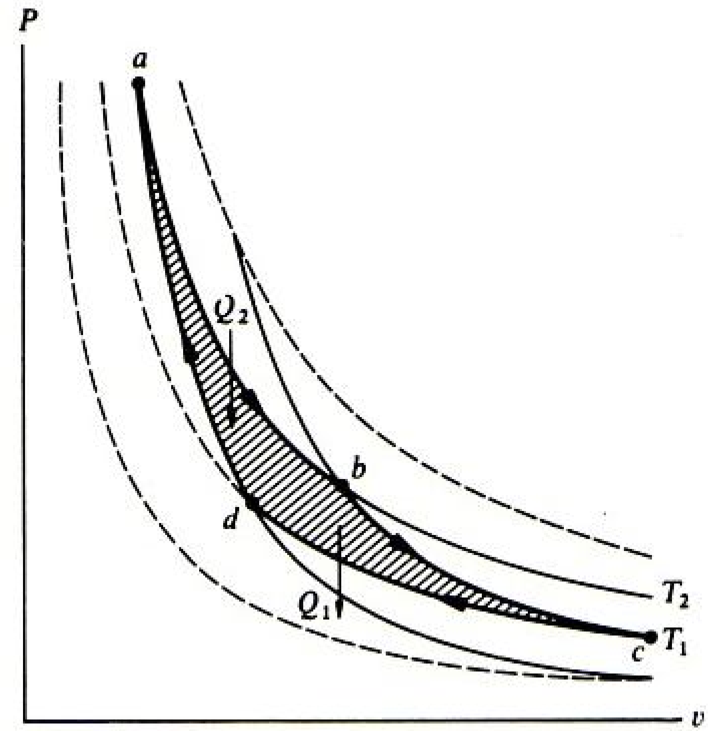
- A system that receives an input of heat at a high temperature, does mechanical work, and gives off heat at a lower temperature.



- The efficiency of the engine η is equal to the work done by the system divided by the heat absorbed Q_2.

- According to the first law, $\Delta u = Q_1 + Q_2 - W$

- When the engine returns to the initial state after each cycle, $\Delta u = 0$, therefore $Q_1 + Q_2 = W$



- $\eta = 1 - T_1/T_2$

- The efficiency would be 100% if T1 could be at absolute zero.

- A Carnor refrigerator is a Carnor engine in reverse
- The relationship $Q_1/Q_2 = - T_1/T_2$ still holds.
- The coefficient c is defined as $-Q_1/W = T_1/(T_2 - T_1)$
- c can be much larger than 1.