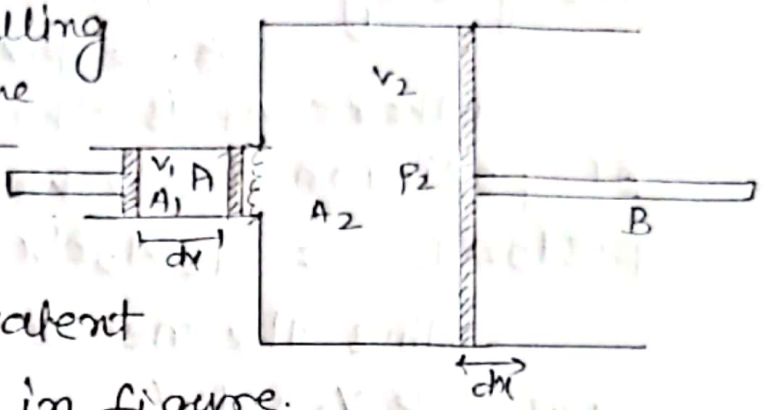
Prof. Vidya Sagar
Department of Physics
Raja Singh College, Siwan

B. Sc (Part-I) Hons
paper - II

Theory of porous plug experiment

To observed cooling or heating effect the porous plug experiment has been replaced by a simple equivalent arrangement shown in figure.



It consists of an insulated cylinder containing a porous plug and fitted with two non-conducting piston A and B. The gas is allowed to pass through the porous plug and fitted from the high pressure side to the low pressure side. The velocity of the gas as it comes out of the porous plug is very high and there is increase in the kinetic energy of the molecules. A fixed mass of gas is filled between the piston A and the plug at a pressure p_1 and volume v_1. The piston B is kept on the other side just behind the plug. Now both the pistons are simultaneously moved in such a way that a constant pressure p_1 is maintained on the left hand side and a lower constant pressure p_2 on the right hand side of the plug. After all the gas passed through the plug, the final state is

reached as shown in the figure. Now the gas expands to a greater volume V_2.

When the piston A is moved through a certain distance dx, the piston B also moves through the same distance dx. The work done on the gas by the piston A

$$= P_1 A_1 dx = P_1 V_1$$

where A_1 is the area of cross-section of position A. The work done by the gas on the piston B $= P_2 A_2 dx = P_2 V_2$

Thus the net external work done by the gas $= P_2 V_2 - P_1 V_1$

since there is no heat-exchange between the gas and its surroundings this external work must come from the energy of the gas. Thus if U_1 and U_2 be the internal energies of the gas before and after passing through the plug, we have from the first law of thermodynamics.

$$U_1 - U_2 = P_2 V_2 - P_1 V_1 \quad \text{---------} (1)$$

$$\text{or, } U_1 + P_1 V_1 = U_2 + P_2 V_2 = \text{Constant}$$

The quantity $U+PV$ is called the 'enthalpy'. Thus in Joule-Thomson effect the initial and final enthalpies are equal i.e, the enthalpy remains constant.

$$\therefore U + PV = \text{Constant}$$

Since in this process enthalpy remains constant, hence this process is called isenthapic process.

For a perfect gas, the internal energy U as well as the product PV depends on temperature only. Thus enthalpy $U+PV$ depends on temperature only. Since $U+PV$ is same on the two sides of the plug, the temperature must also be the same. Therefore, the Jule-Thomson effect is zero for a perfect gas.