

實驗一 Determination of C_P/C_V after Clement-Desormes

Object :

To measure the ratio of the specific heats of air at constant pressure and constant volume according to the method of Clement - Desormes.

Theory :

To determine the ratio C_P/C_V for an ideal gas, where C_P (or C_V) is the specific heat of gases for constant pressure (or constant volume), we expand the gas adiabatically, and record the process :

1. From Poission' s equation we have :

$$T_0^k P_0^{1-k} = T_1^k P_1^{1-k} \quad , \quad k = \frac{C_P}{C_V} \dots\dots\dots (1)$$

2. Then we wait until the temperature is again T_0 .

With the ideal gas equation we can describe this process :

$$P_1/T_1 = P_2/T_0 \quad , \quad V = \text{constant.} \dots\dots\dots (2)$$

Eliminating T_0/T_1 , we get :

$$(P_2/P_1)^k = (P_1/P_0)^{1-k} \quad \text{or} \quad k \ln(P_2/P_1) = (k - 1) \ln(P_0/P_1) \dots\dots\dots (3)$$

If the outside pressure is P , then :

$$P_0 = P + \rho g h_0 = P(1 + \rho g h_0/P)$$

$$P_1 = P + \rho g h_1 = P(1 + \rho g h_1/P)$$

$$P_2 = P + \rho g h_2 = P(1 + \rho g h_2/P)$$

where h_0 , h_1 , h_2 , are the heights of the water column in the experiment. Because $P \gg \rho g h_0$, and $P \gg \rho g h_1$, and $P \gg \rho g h_2$, we get as the first approximation :

$$k = \frac{h_0 - h_1}{h_0 - h_2} \dots\dots\dots (4)$$

Procedure :

1. Increase the pressure in the vessel, so that the water column in the U-tube reaches the end of the graph paper. Then wait at least five minutes until the temperature comes completely to an equilibrium. (The water column has to be motionless). Record the height h_0 .
2. Then open the valve of the vessel for a short time (less than one second), and record the lowest point of the water column. That is h_1 .
3. Then wait until the water column is again motionless, at the height h_2 .
4. Let h_2 be h_0 in your next experiment and continue in the same way as before. If necessary increase again the pressure in the vessel until you have done at least five experiments.
5. Use (4), you can get the value of k and compare with the standard value.