EP20B022
KUNAL SHARMA
EP3290

Joule - Thomson Effect

AIM: To determination of the Joule - Thomson coefficients of CO_2 and NO_2.

PRINCIPLE: A stream of gas is fed to a throttling point, where the gas (CO_2 or N_2) undergoes adiabatic expansion. The differences in temperature established between the two sides of the throttle point are measured at various pressures and the Joule - Thomson coefficients of the gases in question are calculated.

EQUIPMENT: Joule - Thomson apparatus, Temperature meter digital, Temperature probe, Reducing values for CO_2 / N_2, Steel cylinders.

PROCEDURE:-

1.) Attach the vaccum between the reducing valve and the Joule - Thomson apparatus with ~~to~~ hose tube clips.
2.) Connect the temperature probe on the pressure side to inlet 1 and one on the unpressurized side to inlet 2 of the temparature measurement apparatus.
3.) Set the apparatus at temperature difference measurement

4. Change the pressure from 0 to 1 atm and back to 0, in stages, in each case reading off the temperature difference one minute after the particular pressure has been established.

5. Perform the measurement for both gases, and determine

DIAGRAM:-

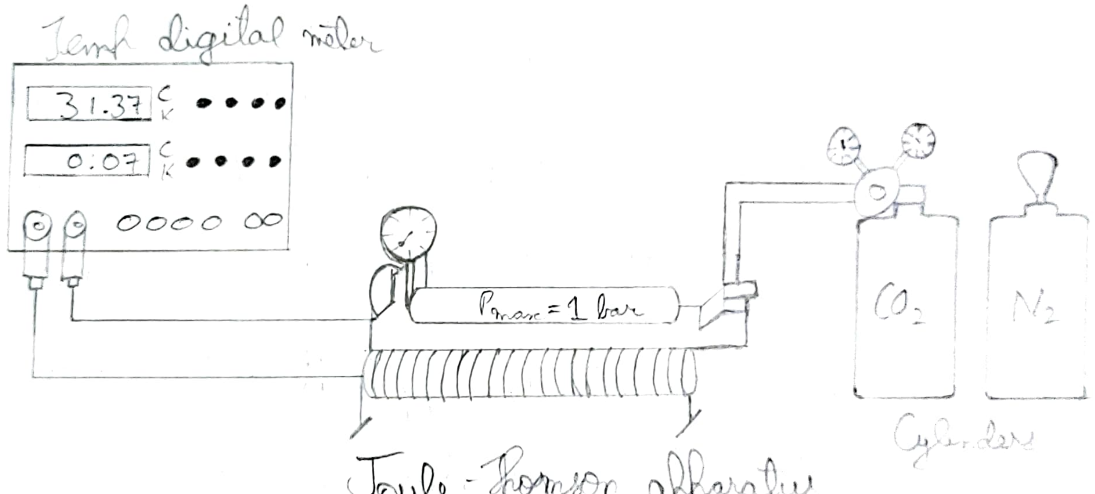

Fig 1: Experimental Setup

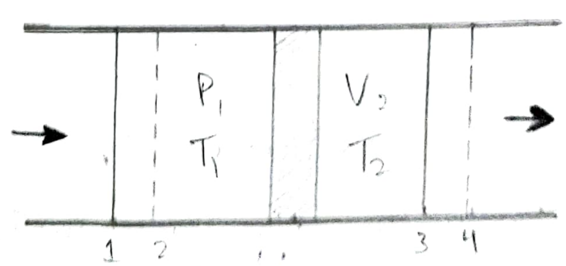

Fig 2: Throttling and Joule-Thomson effect

OBSERVATION :

P (in atm)	ΔT (for CO_2)	ΔT (for N_2)
0	-0.07	-0.05
0.05	0.02	-0.05
0.10	0.07	-0.02
0.15	0.09	0.00
0.20	0.14	0.02
0.25	0.21	0.03
0.30	0.25	0.04
0.35	0.29	0.05
0.40	0.35	0.06
0.45	0.40	0.07
0.50	0.46	0.07
0.55	0.51	0.08
0.60	0.58	0.09
0.65	0.62	0.10
0.70	0.67	0.11
0.75	0.72	0.11
0.80	0.78	0.12
0.85	0.83	0.12
0.90	0.89	0.13
0.95	0.94	0.14
1.00	0.99	0.15

FORMULA :

$$H_1 = U_1 + p_1 V_1 = U_2 + p_2 V_2 = H_2$$

Joule - Thomson coefficient $(\mu) = \frac{T_1 - T_2}{P_1 - P_2}$

CALCULATION :

Using graphical observation,

$$\mu_{N_2} = \frac{0.15 - (0.05)}{1 - 0.05}$$

$$\therefore \mu_{N_2} = 0.21 \times 10^{-5} \frac{K}{Pa}$$

$$\mu_{CO_2} = \frac{0.99 - (-0.07)}{1 - 0} \frac{K}{Bar}$$

$$\therefore \mu_{CO_2} = 1.06 \frac{K}{bar} = 10^{-5} \frac{K}{Pa}$$

$$\mu_{theoritical} = \left(\frac{2a}{RT} - b\right)\frac{1}{C_P}$$

$$\mu_{CO_2} = \left(\frac{2 \times 3.6}{8.314 \times 298} - 42.7 \times 10^{-6}\right)\frac{1}{36.94}$$

$$= 0.762 \times 10^{-5}\ K/Pa$$

$$\mu_{N_2} = \left(\frac{2 \times 1.4}{8.314 \times 303} - 39.1 \times 10^{-6}\right)\frac{1}{29.124}$$

$$= 0.18 \times 10^{-5} \frac{K}{Pa}$$

$\therefore$ Slope of graph gives value of Joule - Thomson coefficient.

PRECAUTION !

1.) The experimenting room and the experimental apparatus must be in thermal equilibrium at the start.

2.) The experimental apparatus should be kept out of direct sunlight and other sources of heating or cooling.

ERROR ANALYSIS:

For CO_2, $\% \text{ Error} = \dfrac{\mu_{real} - \mu_{theo}}{\mu_{real}}$

$$= \frac{1.06 - 0.76}{1.06} \times 100$$

$$\approx 25\%$$

For N_2, $\% \text{ Error} = \dfrac{0.21 - 0.18}{0.21} \times 100$

$$\approx 13\%$$

CONCLUSION:

1.) Temperature is directly proportional to pressure during experiment.

2.) Slope of T vs P graph gives Joule - Thomson coefficient (μ).

3.) We get considerable error in this experiment, since pressure values cannot be adjusted perfectly and thermal equilibrium cannot be maintained throughout experiment.

In [3]:

```
from matplotlib import pyplot as plt
x = [-0.07,0.02,0.07,0.09,0.14,0.21,0.25,0.29,0.35,0.40,0.46,0.51,0.58,0.62,0.67,0.72,0.78,0.83,0.89,0.94,0.99]
P = list(range(0,105,5))
p = [i/100 for i in P]
plt.plot(p,x)
x1 = [-0.05,-0.05,-0.02,0,0.02,0.03,0.04,0.05,0.06,0.07,0.07,0.08,0.09,0.10,0.11,0.11,0.12,0.12,0.13,0.14,0.15]
plt.xlabel("Pressure")
plt.ylabel("Temperature Difference")
plt.plot(p,x1)
plt.show()
```