A02-322P-Y01

Experiment: Boyle’s Law Experiment

Purpose

Measure the pressure and volume of a gas under atmospheric pressure and use Boyle’s Law to obtain the atmospheric pressure.

Theory

In 1660, a British scientist Robert Boyle discovered the inversely proportional relationship between the absolute pressure and volume of a gas. When the pressure of a gas increases, the volume inversely decreases. The equation as following,

$$PV = K \qquad (1)$$

K is a constant, and the value changes with the given condition.

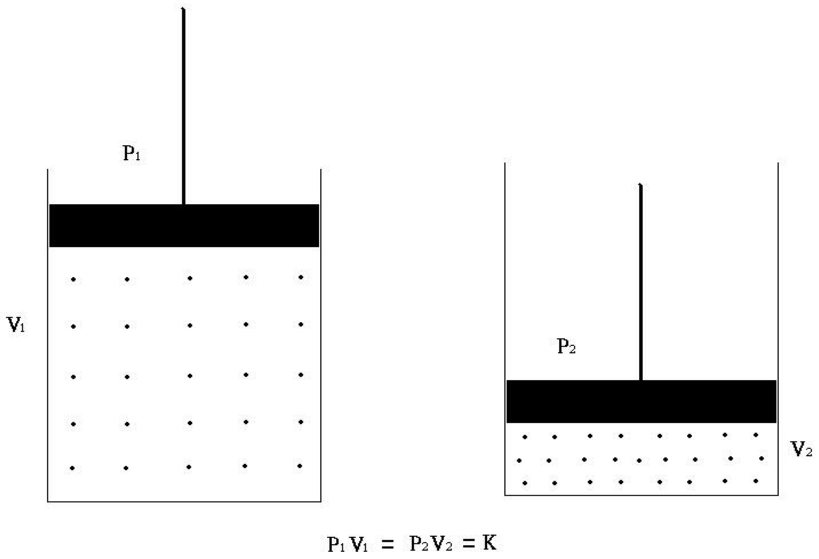

Figure 1

- ***Gay-Lussac's law*** :

—Constant volume: When the low-density gas volume V remains constant in a closed container, its pressure p is proportional to the absolute temperature T. p / T = constant value.

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• In 1811, an Italian scientist Avogadro published "Avogadro hypothesis" about the concept of molecules as follow:

1. In the condition of the same temperature and pressure, the same volume of gases has the same number of molecules.

2. 1 mole of any gas occupies a volume of 22.4 L at STP (standard temperature and pressure, taken as 0°C and 1 atmosphere pressure).

3. Avogadro's number is the number of particles that delivers a mole of a substance = $6.02 \times 10^{23}\ mol^{-1}$.

According to Boyle's law, Charlie's- Lussac's law and Avogadro's hypothesis, we know that when the gas is in the low-density, we obtain

$$\frac{PV}{T} = \text{constant value} = nR\text{, so } PV = nRT$$

It is the ideal equation.

N= the number of particles in a gas

R= the proportionality constant is called the gas constant

The value for the gas constant *R*

$$R = 0.0820\ \text{atm} \cdot \text{l} / \text{mol} \cdot \text{K}$$

This experiment is to measure the compression pressure, and then using the Boyle's law to obtain the value of atmospheric pressure. When the number of moles of gas in a closed container and the experimental temperature stay constant, n, R and T are the constant values, which is Boyle's law.

By the Boyle's law, we know the relationship between the gas before and after compression and volume is

$$P_0 V_0 = P_{in} V_{in} = K \quad (2)$$

P= the difference of the pressure P_{in} in the closed container minus the atmospheric pressure P_0

$P = P_{in} - P_0$

So $P_{in} = P + P_0$, then the equation 2 can be rewritten as

$$P_0 V_0 = (P + P_0) V_{in} \quad (3)$$

We obtain

$$P_0 = \frac{V_{in}}{V_0 - V_{in}} P \quad (4)$$

The measure of area of the circle multiplied by the height is the cylindrical volume

So we obtain $\frac{V_{in}}{V_0 - V_{in}}$

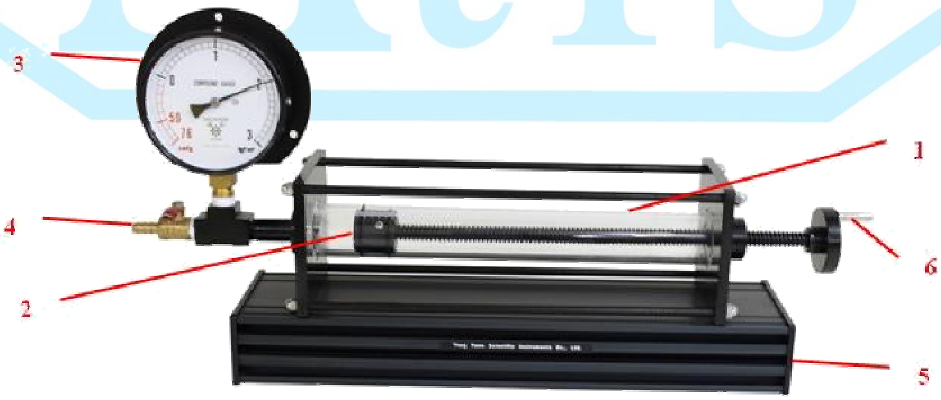
Then reduce πr^2, we obtain $\frac{L_{in}}{L_0 - L_{in}}$

So $$P_0 = \frac{L_{in}}{L_0 - L_{in}} P \quad (5)$$

We can measure the compression pressure and the length of the air column to obtain the atmospheric pressure.

Instrument

NO	Accessory	Qty	NO	Accessory	Qty
1	Precision Pressure Pump	1	2	Adjustable Pressurized Piston	1
3	Manometer	1	4	Valve	1
5	Experimental Base	1	6	Rotating Handle	1



Note: manometer values (black number Kgf / cm^2; red number $cmHg$)

Procedure

1. Open the valve (when the handle parallel to the tube is open and when vertical is

close), rotate the handle to make the piston move to 24 cm on the right (make the piston rubber point at the scale as shown in Figure 2).

2. Close the valve, and record the piston position at this time and the manometer take-off position (the manometer will not necessarily take off from zero).

3. Slowly turn the knob to the left to compress the air column 6cm long, at this time, the piston is located at 18cm on the right of the scales.

4. Record the manometer pressure kPa on the experimental data form 1.
(If the manometer doesn't take off from zero, the pressure must be counted from the take-off position and do not directly see the manometer value)

5. Slowly turn the knob to the left to compress the air column 1cm long, and record the manometer pressure kPa on the experimental data form 1.

6. Based on the experimental data form 1, repeat the procedure 5 and record the pressure value when compress every 1 cm.

7. Because we don't consider the volume between the underside of the manometer and the air column. Please check the following Note and compare the experimental data with the actual atmospheric pressure.

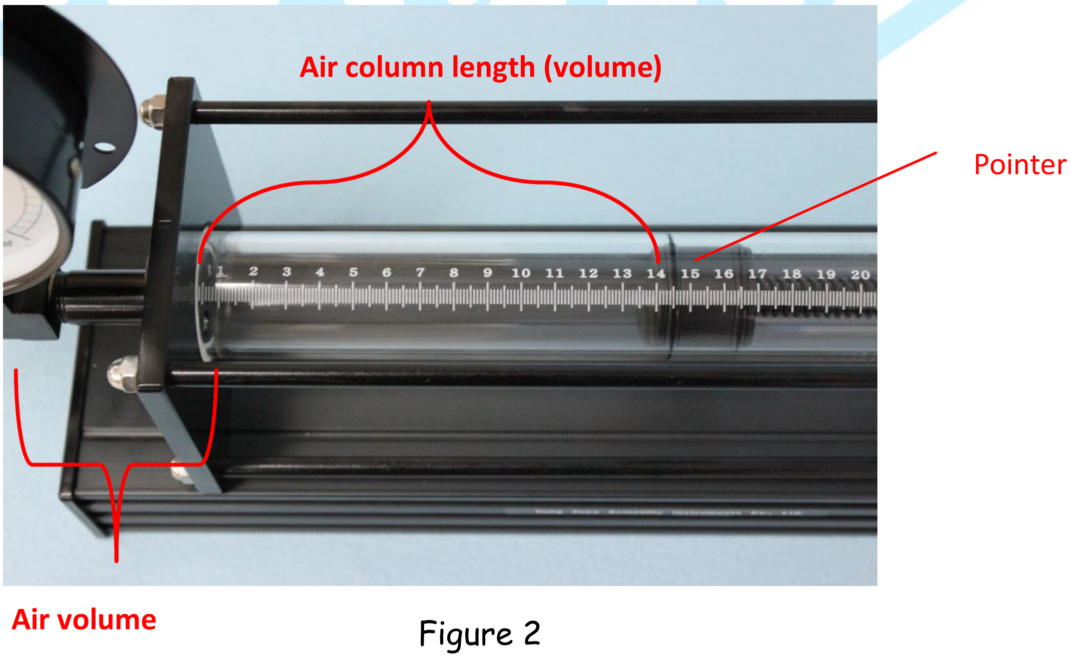


Figure 2