LAB SHEET · SIMULACIENCIA

Lab sheet: Boyle’s law

Name	Class	Date	Set-up number

Aim

To find out how the pressure of a fixed amount of air changes when its volume changes, without changing its temperature.

Background

A trapped gas pushes on the walls of its container: that is its **pressure** (P). Here it is measured in kilopascals (kPa). The air in the room also has a pressure, **atmospheric pressure**, which is about 101 kPa at sea level and about 94 kPa in a high city such as Madrid.

If we trap some air and change its **volume** (V) without changing its temperature, its pressure changes too. **Boyle’s law** says that, at constant temperature, pressure multiplied by volume does not change:

P · V = constant

To test it, you trap air in a syringe, change its volume with the plunger and read the pressure on a pressure gauge. If the law holds, P · V should come out almost the same in every measurement.

Equipment

The practical is done in the simulated lab at simulaciencia.es/en/simulations/practica-boyle, at the **Open** level.

- 60 mL syringe (each mark is 1 mL) or 20 mL syringe (each mark is 0.5 mL).
- Absolute pressure gauge, 0 to 200 kPa (each mark is 2 kPa). If your teacher tells you to, a gauge (relative) pressure gauge, −100 to 100 kPa, with a barometer on the wall.
- Three-way valve. The lever points to the outlet it closes: **pointing up**, the syringe is open to the room air; **pointing down**, the air in the syringe is trapped.
- Magnifier to read the scales.
- The set-up number your teacher gives you.

Before you start

Answer these before measuring.

1. With the valve open, what pressure do you think the gauge will show? Why does it not show zero?
2. If you trap 40 mL of air and push the plunger in to 20 mL, what do you think will happen to the pressure? Will it go up, go down or stay the same? By how much?
3. Why must you move the plunger slowly and wait for the needle to stop before reading?

Answers

Method

1. Choose your set-up number, the syringe and the pressure gauge you have been given in the panel.
2. With the valve **open**, move the edge of the rubber touching the air (the left-hand one) to **40 mL**. If you are using the 20 mL syringe, move it to **15 mL**.
3. Take the magnifier to the needle, read the pressure and write it in measurement 1. As the valve is open, the air in the syringe is connected to the room air and has the same pressure: this is the room pressure. If you are using the relative gauge, also write down what the barometer on the wall shows.
4. Close the valve (lever pointing down). Do not open it again from now on.
5. Push the plunger in **slowly** to a different volume. Wait for the needle to stop, read the volume and the pressure with the magnifier and write them down.
6. Repeat step 5 until you have at least four measurements pushing the plunger in and two pulling it out, above the starting volume. Do not push so far that the needle goes past the end of the scale, or pull beyond the last mark on the syringe.

Results table

Barometer pressure (relative gauge only): ..... hPa = ... kPa

Measurement	Volume V (mL)	Pressure shown by the gauge (kPa)	Absolute pressure P (kPa)	P · V (kPa·mL)	1/V (L^{-1})
1 (valve open)					
2					
3					
4					
5					
6					
7					

With the absolute gauge, the absolute pressure is what it shows. With the relative gauge, add the barometer reading in kPa (1 kPa = 10 hPa). For 1/V in L^{-1}, divide 1000 by the volume in mL.

Calculations

Write each calculation with its numbers and units.

Calculation	Working and result
P · V for measurement 2 (as an example)	
Mean of P · V	
Difference between the highest and lowest P · V, as a % of the mean	

Graphs

On graph paper or in a spreadsheet:

1. **P against V.** Volume on the horizontal axis and absolute pressure on the vertical axis. Join the points with a smooth curve.
2. **P against 1/V.** 1/V on the horizontal axis and absolute pressure on the vertical axis. Draw the line of best fit.

Questions

1. Is P · V the same in all your measurements? Where might the small differences come from?
2. What shape is the graph of P against V? And the graph of P against 1/V? Where does the line go if you extend it?
3. Using your mean P · V, calculate what pressure the gauge would show at 45 mL. Then move the plunger to 45 mL and check.
4. What would happen if you measured with the valve open? And if you moved the plunger very quickly and read straight away?
5. Use the particle model to explain why the pressure rises when you push the plunger in.

Answers

Conclusion

Explain in a few lines how the pressure and volume of a gas are related at constant temperature and how you showed it with your measurements.

Conclusion

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