



Experiment C-30 Boyle's Law



Objectives

- To study the behavior of ideal gases.
- To investigate the relationship between volume and pressure according to Boyle's law.

Modules and Sensors

- PC + NeuLog application
- USB-200 module 
- NUL-210 Pressure logger sensor 

Equipment and Accessories

- 50 ml syringe
- The syringe is included in the NeuLog Utility accessories, UTL-KIT.

Introduction

An ideal gas can be characterized by three parameters: pressure, volume and temperature, for a certain amount of gas. The law that shows the relationship between these factors is called the **Ideal Gas Law: $PV = nRT$** where **P** is the pressure of the gas (in atm units), **V** is its volume (in L units), **n** is the number of moles (one mol= 6.022×10^{23} molecules), **R** is the gas constant (atm*L)/(mol*K) and **T** is its temperature (in K units).

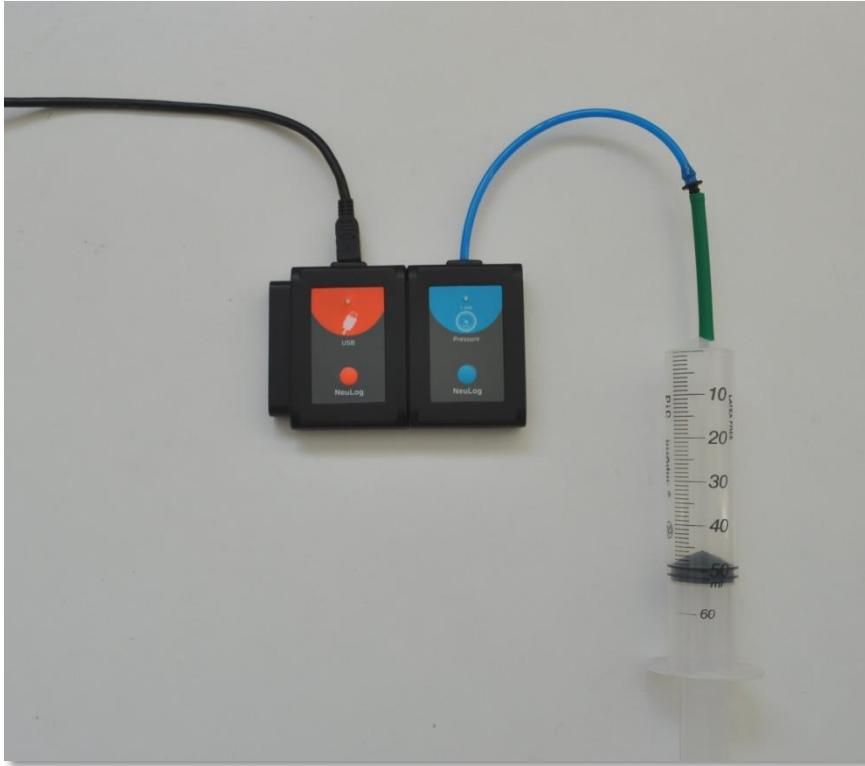
Boyle's law states that the volume and pressure of a gas with a constant temperature (and amount), are inversely proportional to each other. In these conditions **$PV=k$** or **$P_1V_1 = P_2V_2$** (nRT is constant). According to this equation, when the pressure increases the volume decreases, and when the volume increases the pressure decreases.

In this activity, we will change the volume of the air inside a syringe in order to measure how it affects its pressure (in kPa).

Procedure



Experiment setup

1. Set up the experiment as shown in the picture below.



2. Pull the syringe's plunger up to the 50 ml position and tightly connect the syringe to the sensor using the adaptor tube.

Sensor setup


3. Connect the USB-200 module  to the PC.
4. Check that the pressure sensor  is connected to the USB-200 module.

Note:

The following application functions are explained in short. It is recommended to practice the NeuLog application functions (as described in the user manual) beforehand.

5. Run the NeuLog application and check that the pressure sensor is identified.





Settings

6. Click on the **On-line Experiment** icon  in the NeuLog main icon bar.
7. Click on the **Sensor's Module** box.
8. Click on the **Range** button.
9. Select the "kPa" button to change the sensor's units to kilopascal.



10. This experiment is done in single step mode so the experiment duration and sample rate will not be set.




Testing and measurements

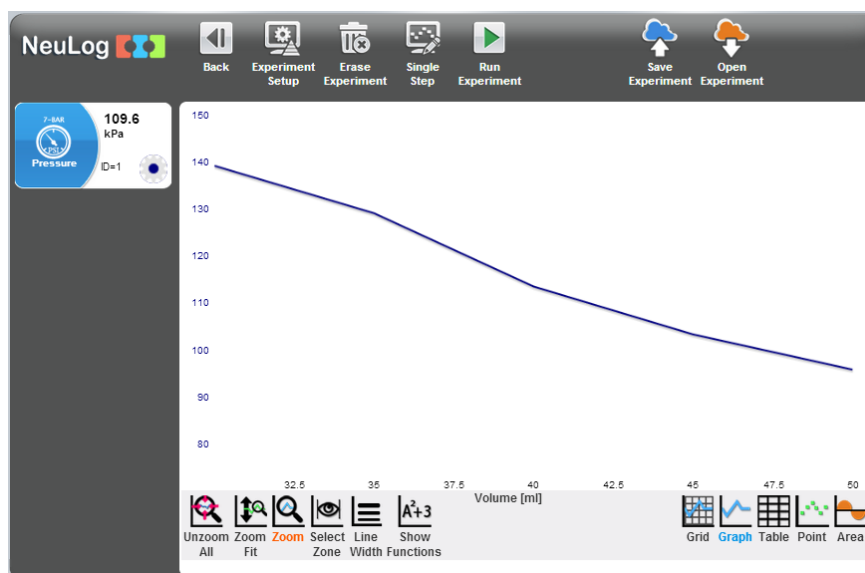
11. Make sure there is no air leakage; press on the syringe's plunger, the plunger should go back to the initial location.
12. Click on the **Single Step** icon  and measure the initial pressure (at the 50 ml position).
13. Click on the **Table** icon  on the bottom part of the screen. A table will be displayed for data record.
14. Change the "Manual values" column name to "Volume [ml]" (clicking on the title of the column will allow you to do so).
15. Insert the volume (50) into the "volume [ml]" column.
16. Press the syringe's plunger to the 45 ml position, hold it there and click again on the **Single Step** icon . If possible, one student should press the plunger while the other clicks on the **Single Step** icon  each time.
17. Insert the volume (45) into the "volume [ml]" column.
18. Continue with the measurements according to the following table.

Measurement number	Volume [ml]
1	50
2	45
3	40
4	35
5	30

19. Insert the volume values into the "Volume [ml]" column.
20. Your data should be similar to the following.

Step	● Pressure (ID=1) [kPa]	Volume [ml]
Step 1	95.7	50 <input type="text"/>
Step 2	103.2	45 <input type="text"/>
Step 3	113.4	40 <input type="text"/>
Step 4	129	35 <input type="text"/>
Step 5	139.1	30 <input type="text"/>

21. Save your data.
22. We can see that the pressure increases as the volume decreases.
23. Click on the **Graph** icon .
24. Click on the **Experiment Setup** icon  and change the X-axis to Volume [ml].
25. In order to focus on the desired range, click on the **zoom** icon  and locate the mouse cursor at a point above the graph and press its left button; keep it pressed and create a rectangle that includes the whole graph.
26. Your graph should be similar to the following:



We can see that we get a straight line that shows that pressure and volume are inversely proportional to each other.

Challenge research

27. Repeat the experiment, but now start with placing the syringe's plunger at the 30 ml position and pull it towards the 50 ml position.

Summary questions

28. Did the pressure values increase or decrease during the challenge experiment? Explain.
29. Point out whether it became more or less difficult to push the plunger in the first experiment? What about pulling the plunger in the challenge experiment? Explain.
30. What are the two other laws derived from the ideal gas law? Which experiments would you conduct for studying these laws?