Gas Laws - A Computational Approach

Boyle's Law

Introductory Investigation:

In this investigation, you will answer a few questions and make some observations. Make sure you write out your observations in complete sentences and include as much detail as you can!

1. How does the amount of gas affect the pressure of a fixed container? Use a soccer ball to explain. How does the soccer ball feel when you add air? How does it feel when you let air out?

2. Using the vacuum pump set-up at the lab bench, describe what is happening inside the bell jar as you remove the air with the syringe.
    a. What happened to the amount of particles in the jar?
    b. What happened to the number of collisions on the side of the jar? Relate that to pressure.

3. Place a small balloon that is tied off inside the bell jar and begin reducing the pressure in the jar. What happens to the volume of the balloon as you are decreasing the pressure surrounding it? Draw a diagram below of what you are observing.

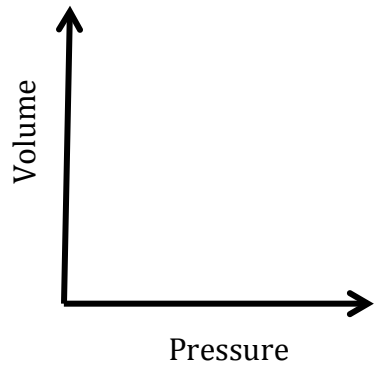
4. What other items could you put into the bell jar to determine the relationship between pressure and volume? Ask your teacher for the materials and give it a try. You must have a recorded observation for each additional try.

Discussion Questions:

5. What happens to volume as you increase pressure?

6. What happens to volume as you decrease pressure?

7. Draw a line on the graph below to represent you think you would see in a graphical relationship.



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Computational Investigation:

In this activity you will be using a NetLogo simulation to observe the behavior of a gas. You will be able to control the size of the container and observe the changes that happen within the container.

Your goal for this activity is to determine the relationship between the size of the container **(*volume)*** and the number of collisions the gas particles have on the sides of the container ***(pressure)*.**

NetLogo Launch Instructions

⇒ File
⇒ Open *Models Library*
⇒ Select *Curricular Models*
⇒ Select *Connected Chemistry*
⇒ Select *Connected Chemistry 6: Volume and Pressure*

The boxed words represent a button or action needed in the NetLogo program.

Activity

1) Move the ***initial-wall-position*** toggle to **20.**

2) Click ***Set-up***

3) Click ***go/stop*** and observe what is happening inside the yellow and orange box.

   a) What do the dots represent?

   b) What do the flashes on the walls of the box represent?

   c) What is the pressure vs. time graph doing?

   d) What is the volume vs. time graph doing?

4) What do you think will happen to the pressure graph if you make the box larger?

5) Click the ***Move Wall*** button.

6) Click in the empty space to the right of the orange wall to increase the size of the box.

7) Click ***go/stop*** and observe what happens. Be sure you have observed for at least 3 minutes.

   a) What happened to the movement of the gas particles?

   b) What is the pressure vs. time graph doing? Is it increasing (↑, going up) or decreasing (↓, going down)?

   c) What is the volume vs. time graph doing? Is it increasing (↑, going up) or decreasing (↓, going down)?

8) What do you think will happen to the pressure graph if you make the box even larger?

9) Click the ***Move Wall*** button.

10) Click in the empty space to the right of the orange wall to increase the size of the box.

11) Click ***go/stop*** and observe what happens. Be sure you have observed for at least 3 minutes.

   a) What happened to the movement of the gas particles?

   b) What is the pressure vs. time graph doing? Is it increasing (↑, going up) or decreasing (↓, going down)?

c) What is the volume vs. time graph doing? Is it increasing (↑, going up) or decreasing (↓, going down)?

12) Play around with the buttons and observe what can happen. Keep a log of what you did and how the program responded. (FYI – you should at least have 4 changes listed below!)

Extension:

1) Compare and contrast what happened in the bell jar to what happened in the NetLogo program.

2) If you were to write a computer model to demonstrate the relationship between pressure and volume, what variables would you like to include? Try to explain how the gas would respond to your changes.

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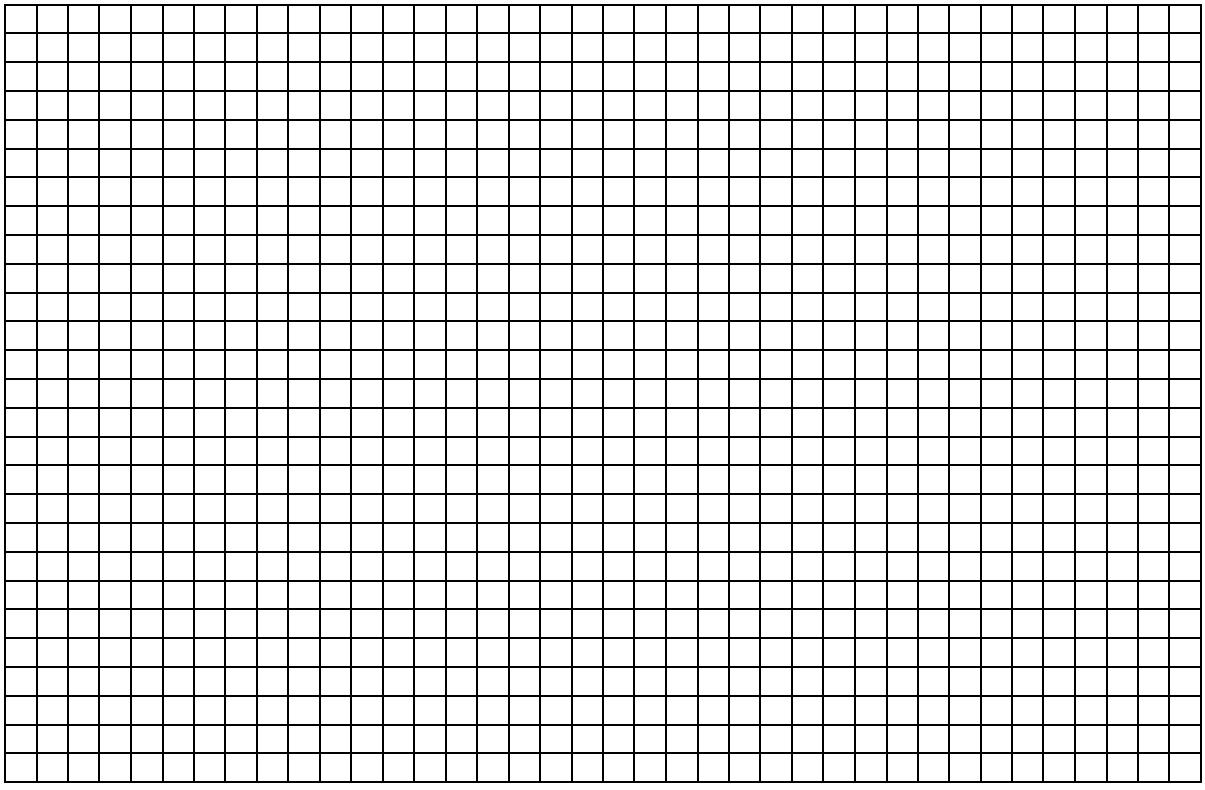
Mathematical Investigation:

1. Given the following data table, make a graph that shows how pressure varies with volume.
2. Pressure is the independent variable and volume is the dependent variable. Plot the points and connect them using a smooth line.

Pressure (mmHg)	Volume (mL)
760	23
912	19.2
1064	16.4
1216	14.4
1368	12.8
1520	11.5

Title: _____



3. As pressure decreases, volume _____.

4. As volume decreases, pressure _____.

   This is called an ***inverse*** relationship.

5. Predict the volume of a gas at 850 mmHg using your graph. (there must be a point on the graph from your prediction)

6. Predict the volume of the gas at 450 mmHg using your graph. (there must be a point on the graph from your prediction)

7. Predict the pressure exerted by the gas when the volume is 8.6 mL. (there must be a point on the graph from your prediction)

8. Predict the pressure exerted by the gas when the volume is 13.7 mL. (there must be a point on the graph from your prediction)

The relationship between pressure and volume is called Boyle's Law. It is shown by the mathematical relationship $P_1V_1=P_2V_2$. You can use any pressure units (kPa, mmHg, atm) and volume units (mL, L, etc.) you want!

$P_1V_1=P_2V_2$
P_1=original pressure V_1=original volume
P_2=final pressure V_2=final volume

Here is an example of how to use Boyle's Law:
Q: A balloon has a pressure of 179.1 kPa when it is 3.9 L in volume. What is the new pressure if the balloon shrinks to 2.3 L?
A: P_1=179.1 kPa V_1=3.9 L
P_2=? kPa V_2=2.3 L

Using $P_1V_1=P_2V_2$, (179.1 kPa)(3.9 L)=(? kPa)(2.3 L)
So (179.1 kPa x 3.9 L)/2.3 L = 303.7 kPa

Give it a try! Make sure to show all your work and circle your final answer with units!

9. **What is the original volume of a gas at 3.1 atm if the final volume and pressure are 2500 mL and 0.88 atm?**

10. **If a gas has a volume of 0.75 L and a pressure of 825 mmHg, what is the final volume of a gas if its new pressure is 1050 mmHg?**

11. **What is the original pressure of 150 mL of a gas if the new pressure is 200 kPa at a volume of 286 mL?**