

# Boyle's Law

## The Relationship Between Pressure & Volume




**Purpose:** to determine the mathematical relationship between pressure & volume.

- Gather together the following equipment: a plastic syringe (with red cap and wooden platforms on the top and bottom), 6 books from the stack at the front of the room (note: average book weight = 850 g).
- Remove the cap from the bottom of the syringe. Remove the piston. Measure the inside diameter of the syringe. Calculate the area of contact between the air and the piston (using "area =  $\pi r^2$ ").

diameter: \_\_\_\_\_ cm (to three significant digits)      radius (= diameter  $\div$  2): \_\_\_\_\_ cm  
 area of contact (=  $\pi r^2$ ): \_\_\_\_\_  $\text{cm}^2$

- Calculate the pressure that one book will exert on the gas in the syringe:

$$\text{book pressure} = \frac{\text{average book weight}}{\text{area of contact}} = \frac{\text{_____ g}}{\text{_____ cm}^2} = \text{_____ g/cm}^2$$

- The atmosphere also pushes down on the piston: the total pressure on the piston equals the pressure from the books plus the atmospheric pressure ( $1034 \text{ g/cm}^2$ ). Complete the "P" column below.
- Remove the cap from the syringe. Adjust the volume to 35 mL (i.e.  $35 \text{ cm}^3$ ). Replace the cap. Place the platform holding the syringe flat on your lab bench so read here  that the syringe is standing up (red cap at bottom). Read the volume in the syringe (see above). If the volume is not exactly  $35 \text{ cm}^3$ , remove the cap and adjust the piston.
- Place one book on the platform connected to the top of the piston. Record the new volume.
- Continue to add books to the piston, one at a time, recording the volume after each book is added.

# of books	P	V	1/V	PV	P/V
	Total pressure ( $\text{g/cm}^2$ )	Volume of gas ( $\text{cm}^3$ )	1/volume of gas ( $\text{cm}^{-3}$ )	Pressure x volume	Pressure $\div$ volume (or $P \times 1/V$ )
0	_____ x0 + 1034 = 1034	35	0.0286	36,190	29.5
1	_____ x1 + 1034 =				
2	_____ x2 + 1034 =				
3	_____ x3 + 1034 =				
4	_____ x4 + 1034 =				
5	_____ x5 + 1034 =				
6	_____ x6 + 1034 =				

- Draw a horizontal line across the middle of a piece of graph paper to separate the top half from the bottom half. On the top half, plot P vs. V (V on the x-axis). On the bottom, plot P vs.  $1/V$  ( $1/V$  on the x-axis). The axes for both graphs should start at 0 and increase in a linear fashion (no breaks).

### Conclusions and Questions:

- Which graph shows a constant/linear relationship? For this graph, draw a line of best fit starting from the origin of the graph (0, 0). A straight line has the equation  $y=mx+b$ , where y is the variable plotted on the y-axis (P on your graph), x is the variable plotted on the x-axis, m is the slope (constant), and b is the "y-intercept" (0 for your graph). Thus, using  $y=mx+b$ , we get  $P=(\text{constant})(1/V)+0$ . Rearrange  $P=(\text{constant})(1/V)+0$  to isolate "constant": \_\_\_\_\_ = constant
- Which column in the chart above shows a roughly constant value? Thus, \_\_\_\_\_ = constant.
- Based on 2, what happens to the volume of a balloon if the pressure surrounding it doubles? Triples?
- Read pages 427 – 428. Give Boyle's law in words and as an equation.
- Using ideas from the kinetic molecular theory, explain why pressure increases as volume decreases.
- At 103 kPa, a gas has a volume of 5.2 L. What is its volume if the pressure is increased to 400 kPa?
- A gas at 700 mm Hg has a volume of 200 mL. \_\_\_ atm of pressure will make the volume 950 mL.
- Answer questions 6 – 9 on pg. 428.