# TEACHER NOTES
# Boyle's Law Program
## Robert Boyle 1627-1691 *(www.britannica.com)*

*This program is based around the Philip Harris apparatus for demonstrating Boyle's Law. Normally the apparatus would be used for a class demonstration, and the results taken and plotted.*

### Quiz Answers

| No. | Answer | Description |
|---|---|---|
| 1 | 1(A) | *Definition of Boyle's Law* |
| 2 | 4(D) | *Temperature kept constant throughout experiment* |
| 3 | 4(D) | *SI unit of pressure the Pascal or $N/m^3$* |
| 4 | 3(C) | *If you halve the pressure the volume doubles* |
| 5 | 2(B) | *Meniscus, relevant to reading burettes in chemistry* |
| 6 | 2(B) | *SI unit of volume* |
| 7 | 2(B)No | *Is the graph linear?* |
| 8 | 3(C) | *Sudden compression causing adiabatic heating* |
| 9 | 4(D) | *Value of PV, obtained from experiment using Hint* |
| 10 | 2(B)No | *Does the elastic limit apply to a gas?* |

### Notes
*The quiz works well if you go round the class asking students individually. If they all find a question difficult, they can vote.*

### Discussion
(a) If it is the same amount of gas in both bubbles, what is wrong with this image?

*As the bubble rises, the pressure would be less, so if Boyle's Law is obeyed the volume of the same bubble nearer the surface should be larger.*

(b) Where are gases kept under pressure in everyday life?
*Examples include cylinders for hospitals, divers, welding and laboratories plus balloons. Could consider reduced pressure such as TVs, computer monitors and bulbs.*

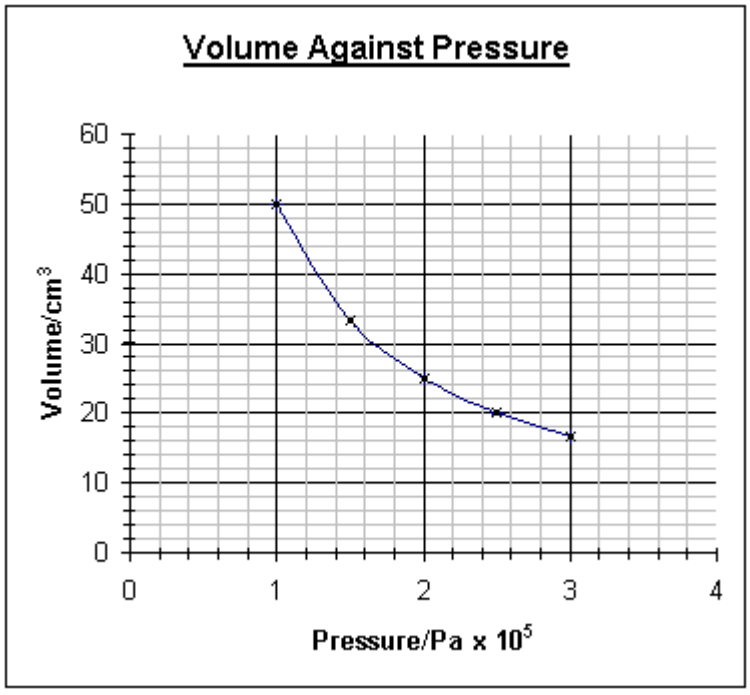
# Boyle's Law Worksheet

Use the program to fill in the values

*There could be a class discussion about experimental errors as to why the PV column is not exactly constant. If actual apparatus used, the PV column will vary because of heating with compression and cooling when expanding.*

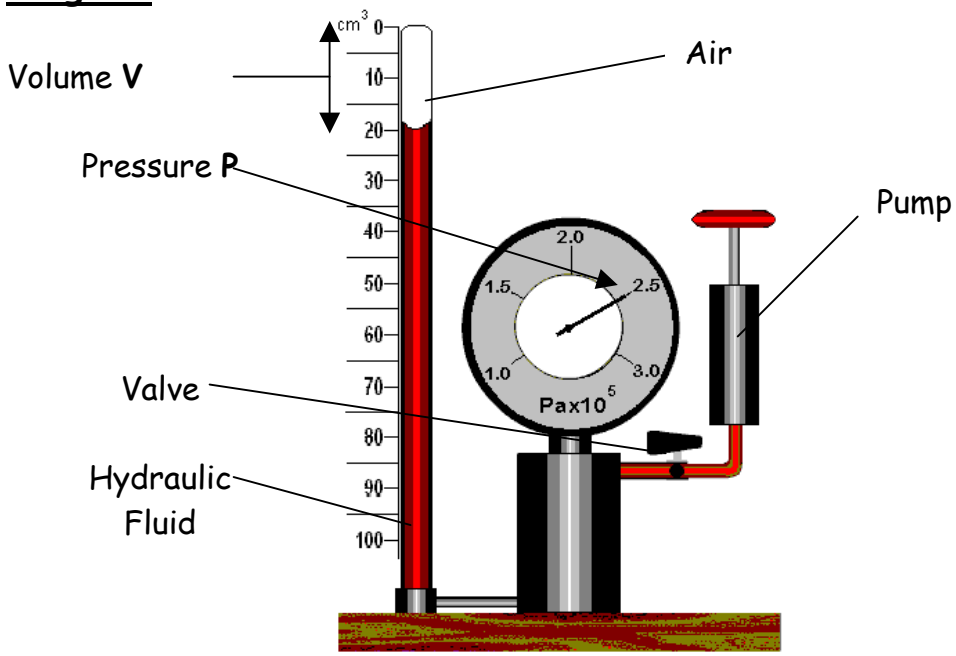
| **P**/1x10$^5$ Pa | **V**/cm$^3$ | **PxV**/1x10$^5$ Pa |
|---|---|---|
| 1.0 | 50.0 | 50.0 |
| 1.5 | 33.3 | 49.9 |
| 2.0 | 25.0 | 50.0 |
| 2.5 | 20.0 | 50.0 |
| 3.0 | 16.7 | 50.1 |

Now try plotting the graph.



# Boyle's Law Experiment

## Diagram




## Method

*Initially the volume V of the trapped air can be read at one atmosphere (if set up correctly.) The pump can then be used to build up the pressure P inside the apparatus. The oil compresses the trapped air, and decreases its volume. It may be necessary to allow the air to cool between measurements if there has been a very rapid compression. The readings can be checked by slowly releasing the pressure by opening the valve. This time cooling will occur, and this could lead to a discussion about refrigeration.*

## Results

| P/1x10$^5$ Pa | V/cm$^3$ | PxV/1x10$^5$ Pa cm |
|---|---|---|
| 1.0 | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

## Conclusion

*If Boyle's Law is obeyed, PxV should be a constant. Could be a chance to discuss experimental errors.*

# Boyle's Law Problems/Homework/Test

1. Define **Boyle's Law**

   *For a fixed mass of dry gas at constant temperature, the volume is inversely proportional to the pressure.*
   *(Mouse-over Boyle's Law on the first screen brings up the definition)*

2. In the Boyle's Law experiment you can have:
   *(Tick ✓ the correct statements.)*

| | |
|---|---|
| High Pressure and Low Volume | ✓ |
| Low Pressure and Low Volume | |
| High Pressure and High Volume | |
| Low Pressure and High Volume | ✓ |

3. A bicycle pump has its outlet closed off, and it contains air at a volume of 50 $cm^3$ and pressure of $1.0 \times 10^5$ Pa. If the volume is reduced to 12.5 $cm^3$, what will be the new pressure?
   $P_1V_1 = P_2V_2$ so $1.0 \times 10^5 \times 50 = P_2 \times 12.5$
   Hence $P_2 = 1.0 \times 10^5 \times 50 / 12.5 =$ $4.0 \times 10^5$ Pa
   N.B. The left hand side units must be the same as the right hand side units.

4. A fish in deep water at a pressure of 5 atmospheres releases a bubble of volume 2 $cm^3$. Calculate the volume of the bubble just before it breaks the surface (assume the pressure will now be 1 atmosphere.)
   $P_1V_1 = P_2V_2$ so $5 \times 2 = 1 \times V_2$
   $V_2 = 10\ cm^3$

5. A helium balloon at sea-level has a volume of 33 $m^3$ at a pressure of $1.0 \times 10^5$ Pa. When released into the upper atmosphere its volume becomes 50 $m^3$. What is the new pressure?
   $P_1V_1 = P_2V_2$ so $1 \times 10^5 \times 33 = P_2 \times 50$
   $P_2 = 1 \times 10^5 \times 33 / 50$
   $P_2 = 66000$ Pa or $6.6 \times 10^4$ Pa