

# Boyle's Law

# What is Boyle's Law?

- Boyle's Law is one of the laws in physics that concern the behaviour of gases
- When a gas is under pressure it takes up less space:
- The higher the pressure, the smaller the volume
- Boyle's Law tells us about the relationship between the volume of a gas and its pressure at a constant temperature
- The law states that **pressure is inversely proportional to the volume**

## How can we write Boyle's Law as a formula?

- Pressure is inversely proportional to the volume and can be written as:
- **Pressure  $\propto$  1/volume**

$P$ =pressure in  $\text{N/m}^2$

$V$ =volume in  $\text{dm}^3$  (litres)

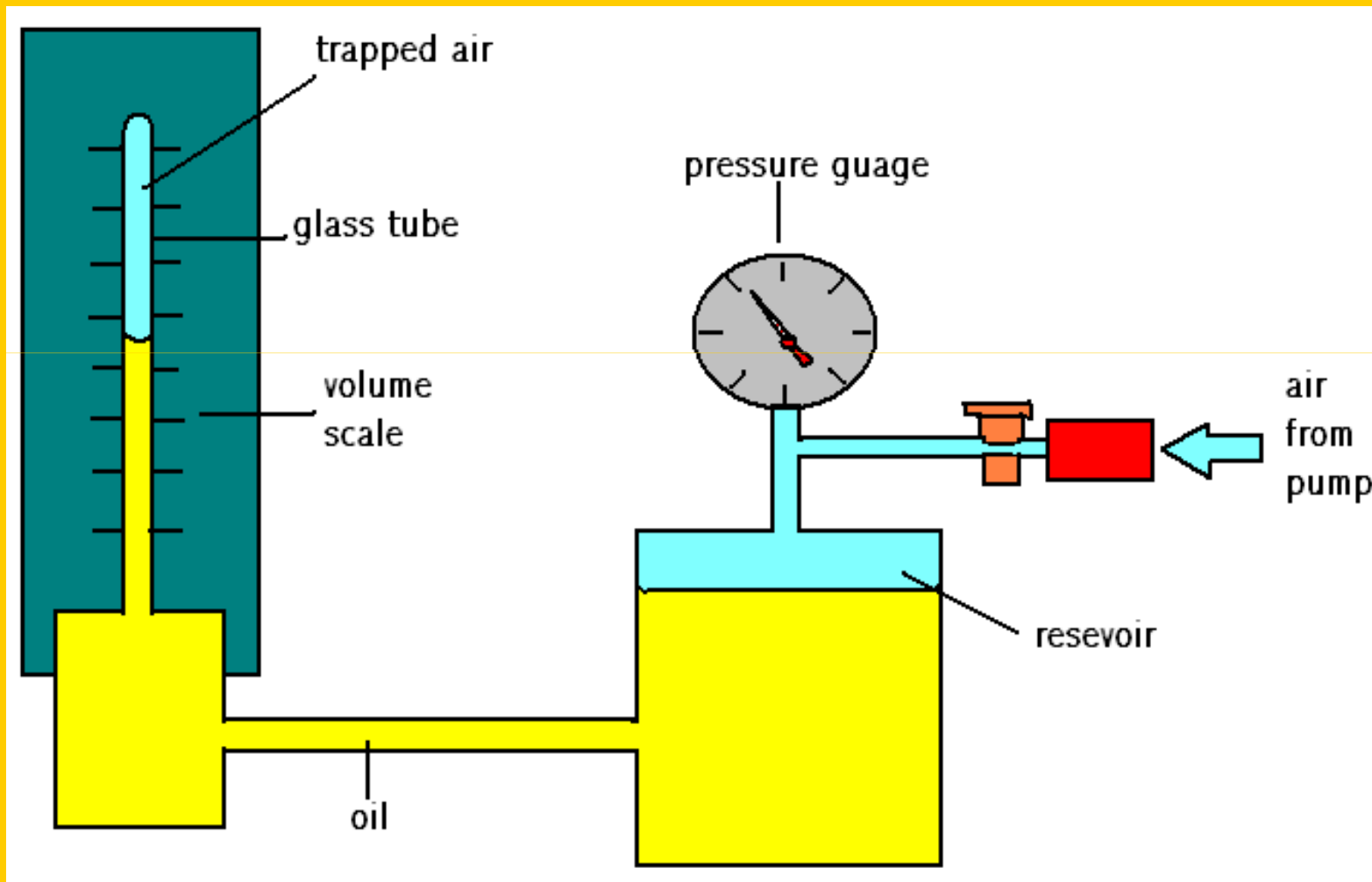
$k$ =constant

- This is more usually written as:
- **Pressure = constant  
volume**
- $PV = k$
- $P_1V_1 = P_2V_2$

## **How can we investigate Boyle's Law?**

- **When investigating Boyles law a given volume of gas is sucked into a cylinder and the end is sealed**
- **The temperature of the gas is kept constant**
- **Using several equal weights we can apply increasing pressure to the gas**
- **We can calculate the pressure by dividing the force applied by the area of the top of the cylinder**
- **The volume will be shown on the scale on the cylinder**

# Boyle's Law apparatus



## Below are some results of an experiment

Pressure p	Volume V	P x V
1.1	40	44
1.7	26	
2.2	20	
2.6	17	

- Calculate  $pV$  (pressure x volume) for each set of results. What do you notice?

## What these experimental results show

- The pressure x volume for each set of results remains constant
- This is called Boyle's Law
- For a fixed mass of gas, at constant temperature,  **$pV = \text{constant}$**  or

$$\mathbf{P_1 \times V_1 = P_2 \times V_2}$$

- Let us look at the results again

## Here are the results of the experiment

Pressure p	Volume V	P x V
1.1	40	44
1.7	26	44
2.2	20	44
2.6	17	44

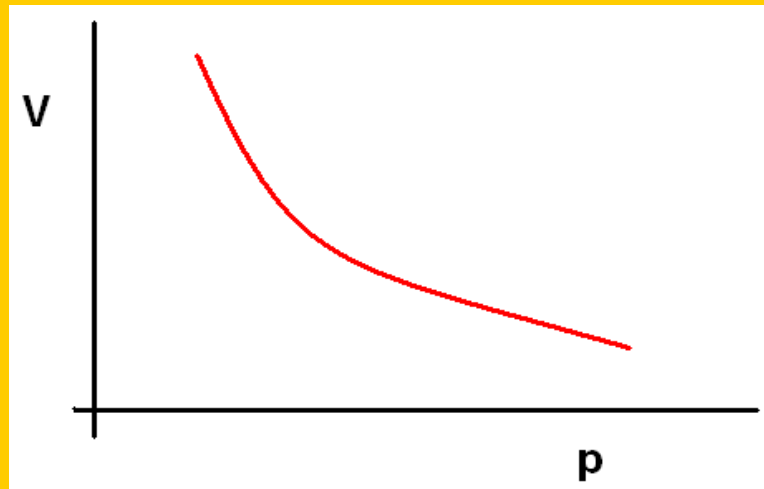
- Did you notice that if **p** is doubled, **V** is halved?
- If p increases to 3 times as much, V decreases to a 1/3<sup>rd</sup> .  
This means:
- Volume is inversely proportional to pressure, or

$$V \propto \frac{1}{p}$$



# What sort of graphs would this data give?

- If we plot volume directly against pressure we would get a downwards curve showing that volume gets smaller as the pressure gets larger, and vice versa.



# Another way of plotting the data

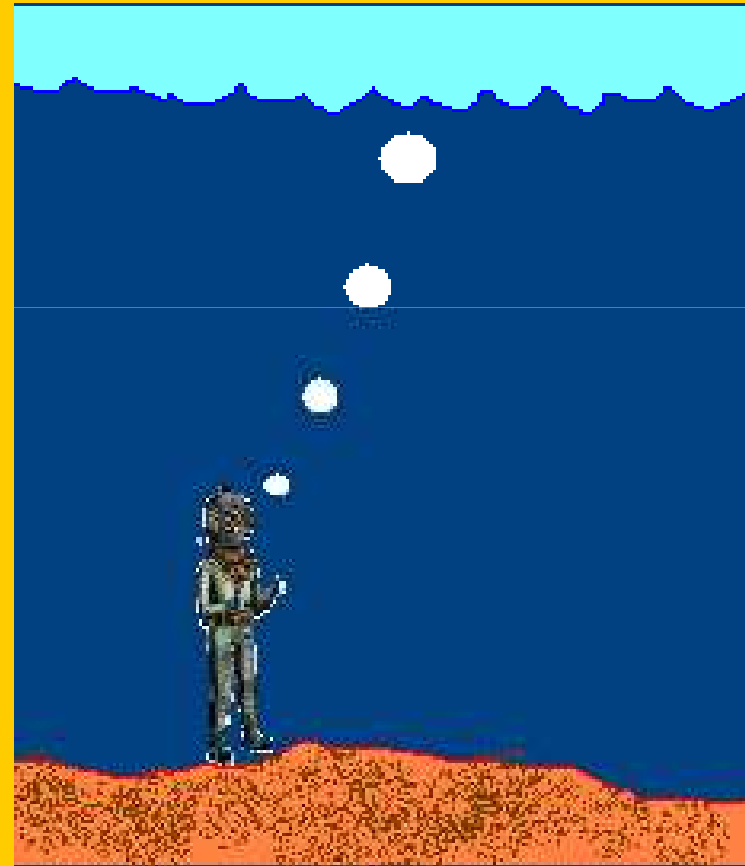
- Curved lines are hard to recognise, so we plot the volume against the reciprocal of pressure (ie.  $1/p$ )
- This time the points lie close to a straight line through the origin.
- This means **volume is directly proportional to  $1/\text{pressure}$**  or
- **volume is inversely proportional to pressure**

# This leads us back to Boyle's Law

**Boyle's Law: for a fixed mass of gas kept at constant temperature the volume of the gas is inversely proportional to its pressure.**

# Problem:

- A deep sea diver is working at a depth where the pressure is 3.0 atmospheres. He is breathing out air bubbles. The volume of each air bubble is 2 cm<sup>3</sup>. At the surface the pressure is 1 atmosphere. What is the volume of each bubble when it reaches the surface?



# How we work this out:

- We assume that the temperature is constant, so Boyle's Law applies:
- **Formula first:**  $P_1 \times V_1 = P_2 \times V_2$
- **Then numbers:=**  $1.0 \times 2 = 3.0 \times V_2$
- Now rearrange the numbers so that you have  $V_2$  on one side, and the rest of the numbers on the other side of the 'equals' symbol.

**Here's what you should have calculated**

$$V_2 = \frac{3.0 \times 2}{1.0}$$

therefore volume of bubbles = 6 cm<sup>3</sup>

Note that P<sub>1</sub> and P<sub>2</sub> have the same unit, as will V<sub>1</sub> and V<sub>2</sub>

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