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
- Boyles 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 α 1/volume**

P=pressure in N/m^2

V=volume in dm^3 (litres)

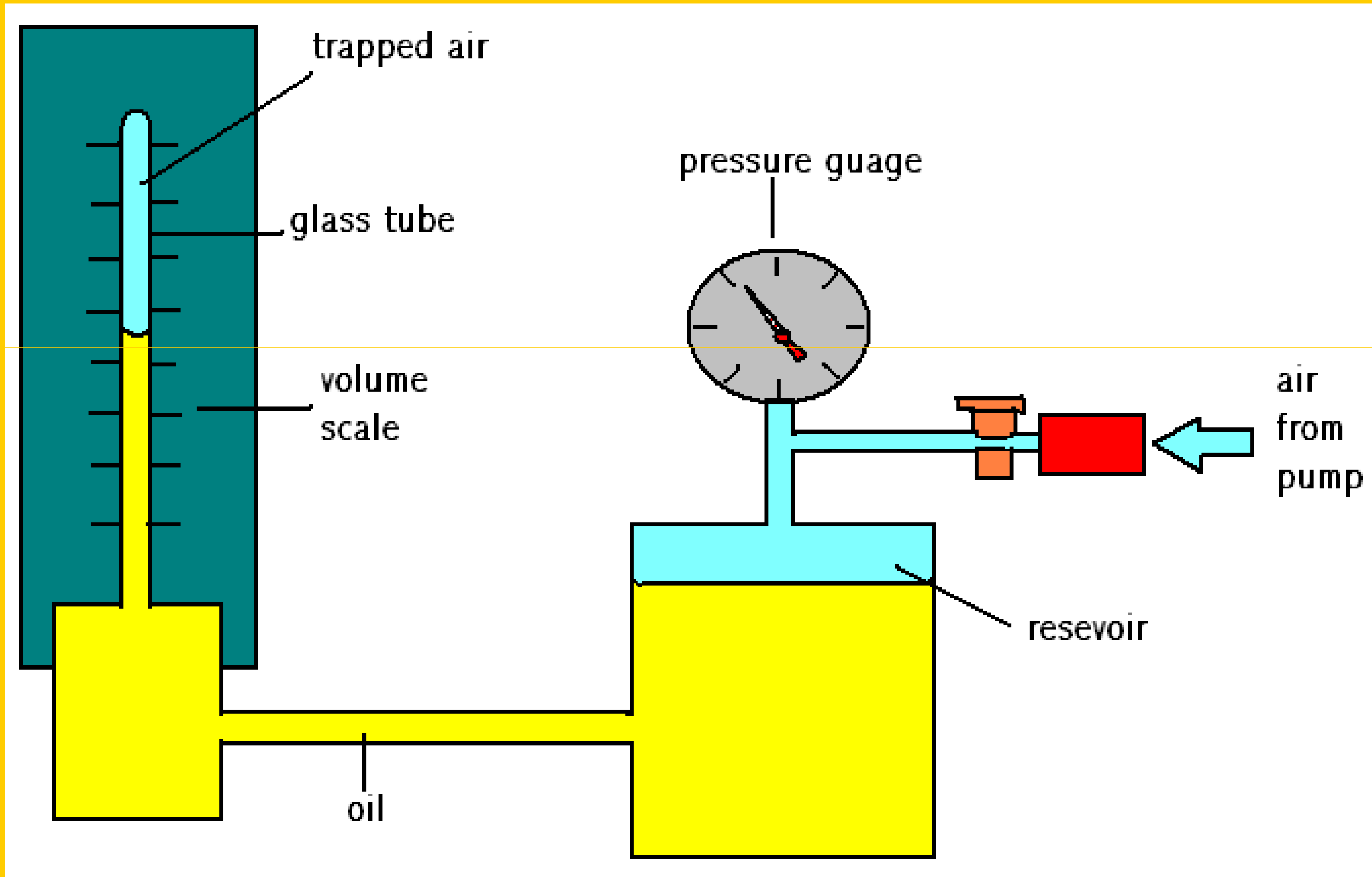
k=constant

- This is more usually written as:
- **Pressure = $\frac{\text{constant}}{\text{volume}}$**
- **$PV=k$**
- **$P_1V_1=P_2V_2$**

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 = 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

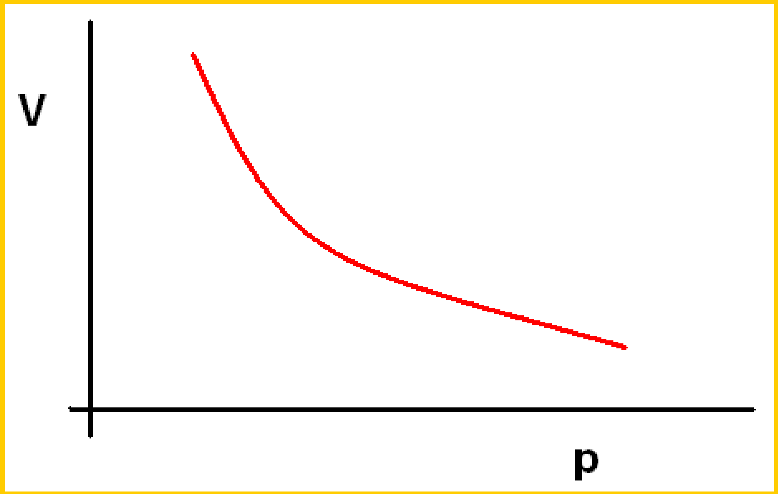
Pressure p	Volume V	P x V
1.1	40	44
1.7	26	44
2.2	20	44
2.6	17	44

- Did you notice that if **p** is doubled, **V** is halved?
- If p increases to 3 times as much, V decreases to a 1/3rd . 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

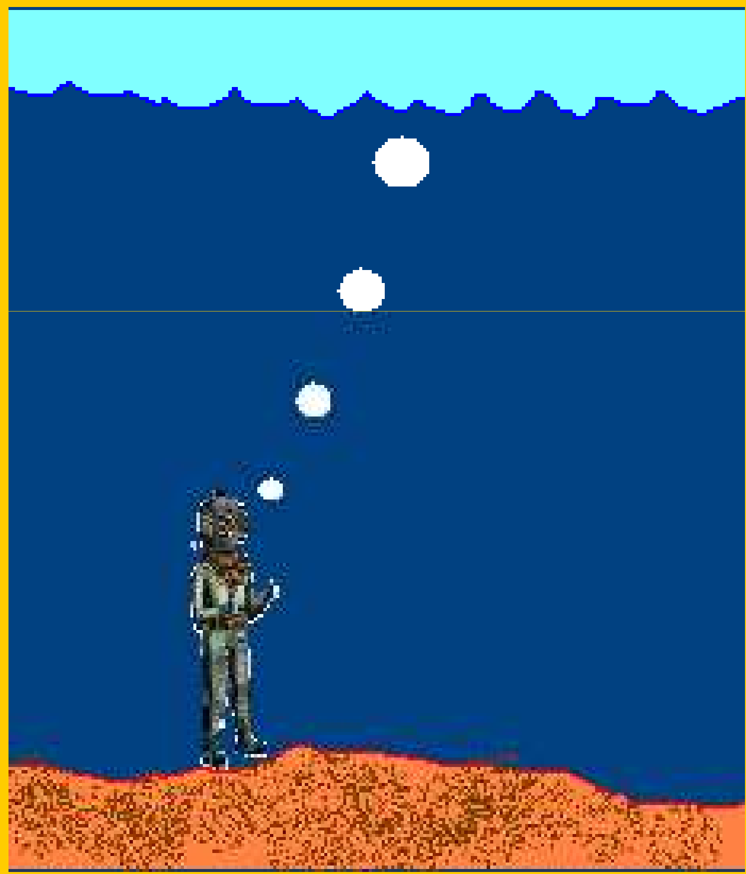
- Curved lines are hard to recognise, so we plot the volume against the reciprocal of pressure (ie. 1/p)
- This time the points lie close to a straight line through the origin.
- This means **volume is directly proportional to 1/pressure** or
- **volume is inversely proportional to pressure**

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^2. 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 V2 on one side, and the rest of the numbers on the other side of the 'equals' symbol.

Here's what you should have calculated

$$V2 = \frac{3.0 \times 2}{1.0}$$

therefore volume of bubbles = 6 cm^3

Note that P_1 and P_2 have the same unit, as will V_1 and V_2