

BGCSE PHYSICS TUTORIALS

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Suggested Physics texts;

Explaining Physics: GCSE Edition by Stephen Pople

GCSE Physics by Duncan and Kennett



What to expect in this lesson?

- ✓ Pressure and the gas laws
 - Pressure
 - Pressure in liquids
 - Pressure in gases – the gas laws
 - Charles Law
 - Boyles law
 - The pressure law

Introducing pressure.....

- When we look at forces we have to look at two variables:
 - The strength of the force itself
 - The area over which the force acts
- Look at the following examples.....

Skiing....

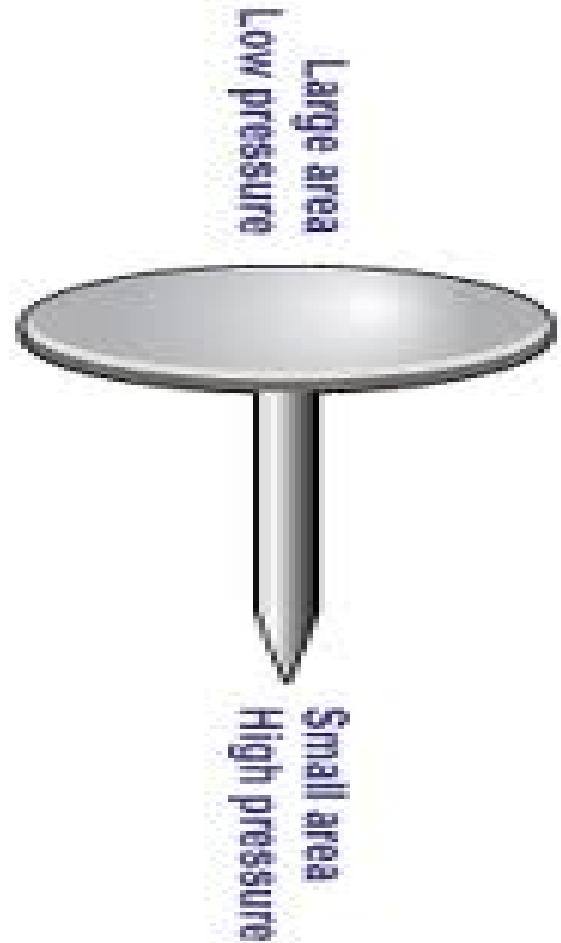
- Wearing skis prevents you from sinking into soft snow because your weight is spread over a greater area.
- You cannot skate on snow why?
- The small area of the blade will sink into the snow – Skis spread the weight of the skier over a wider area.
- **THIS MEANS THE PRESSURE OVER A GIVEN AREA IS LESS**

Skis and Skates



Pressure on a thumb tack

- The effect of sitting a thumb tack is greater when it points up than when it points down.
- The force applied is the same but the area of contact is much smaller when the tack points up.



Tractor tyres...

- Tractors have tyres which have a large diameter WHY?
- To prevent the wheels sinking – the tyres spread the weight of the tractor over as wide an area as possible



What is Pressure?

- The force or thrust acting on a unit area and is calculated from the following three variables:

$$\text{Pressure (pa)} = \text{Force (N)} / \text{Area (m}^2\text{)}$$

- The greater the area over which a force acts the **LESS** the pressure
- The smaller the area over which a force acts the **GREATER** the pressure

What does the equation mean?

Pressure is calculated by dividing a force **F** by the area **A** over which the force acts.

F is measured in Newton's

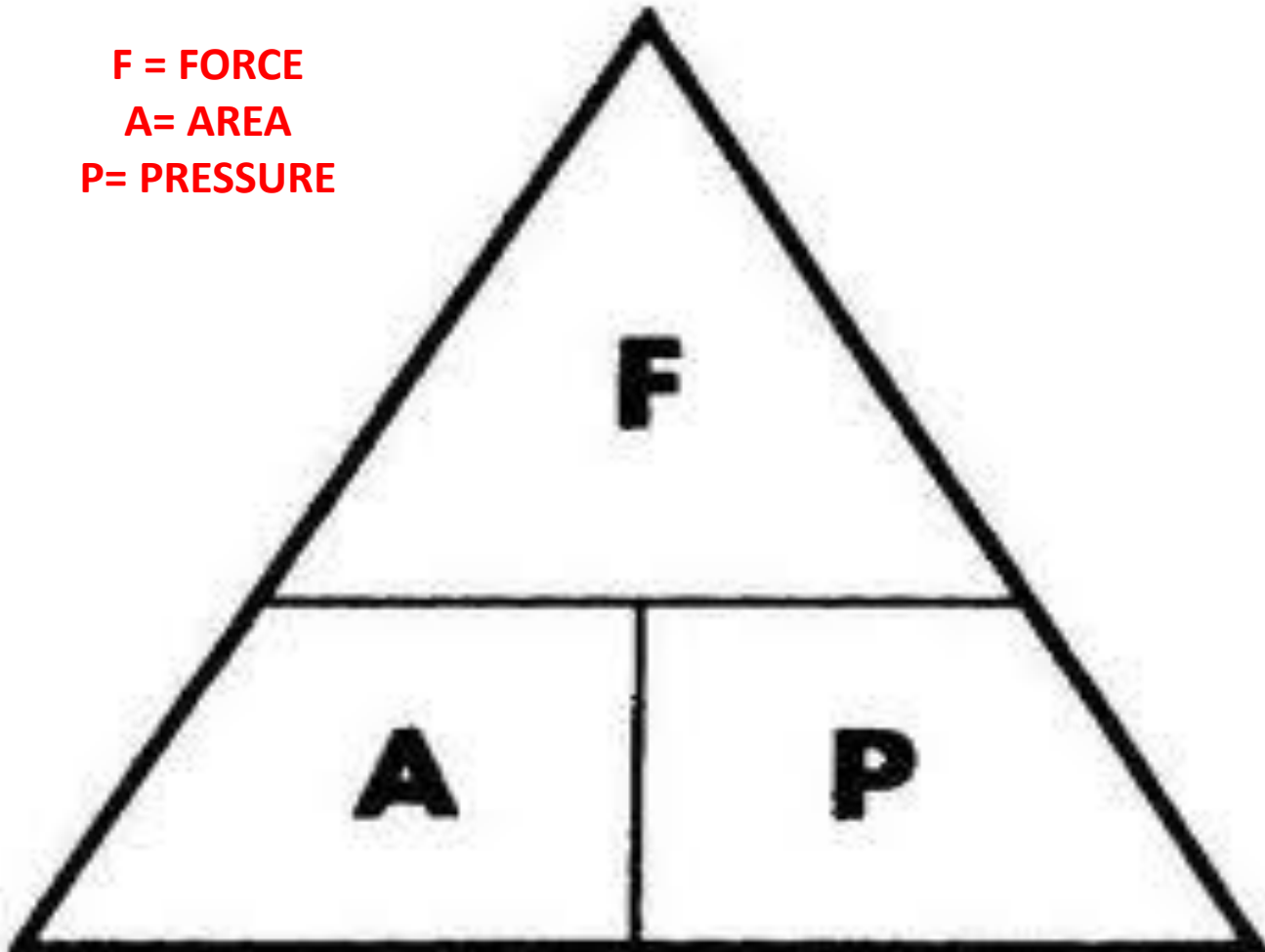
A is measured in m²

The unit of pressure is the Pascal (pa) and equals 1 newton per m² (n/m²)

Clearly, solids, liquids and gases all exert a pressure

The magic triangle

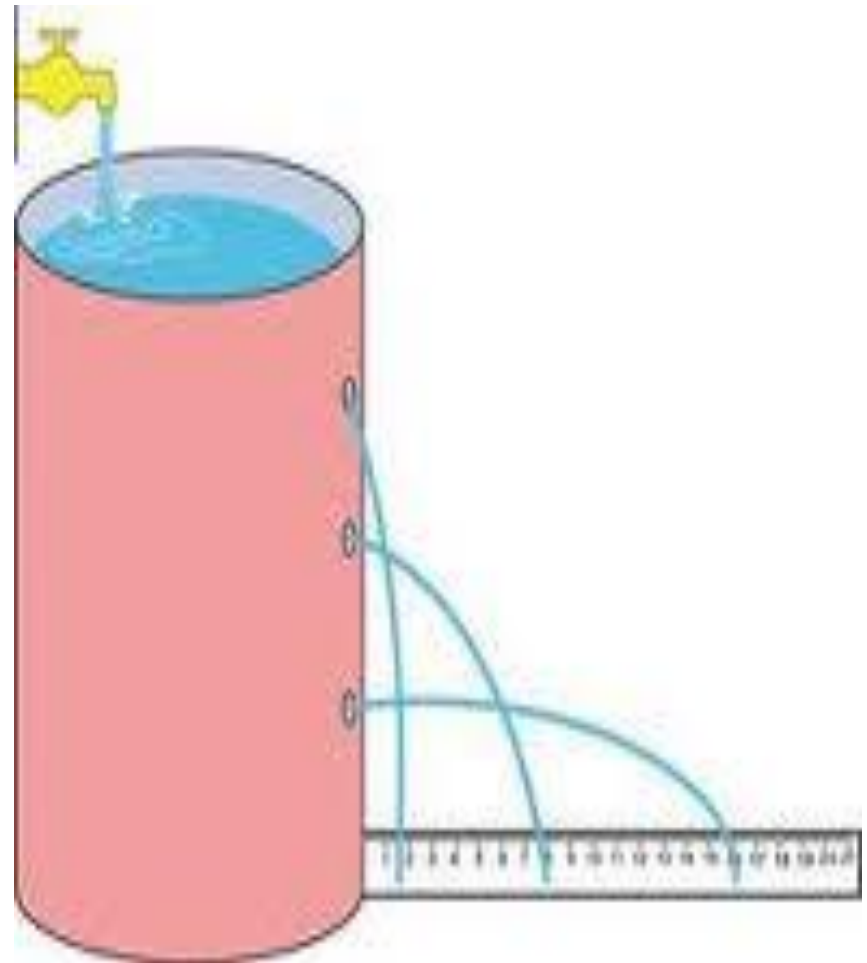
F = FORCE
A = AREA
P = PRESSURE



Pressure in liquids 1

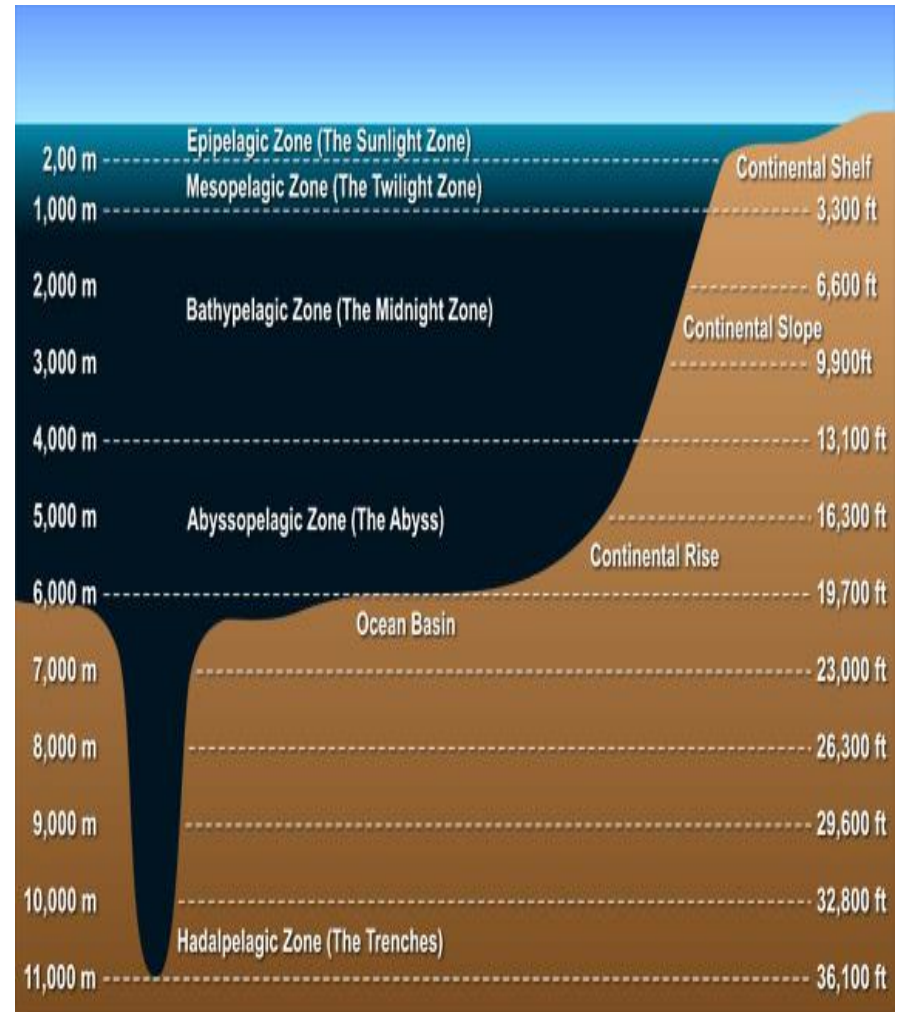
- Pressure in a liquid increases with depth
- The denser the liquid the greater the pressure at any given depth
- The further down you go the more weight of liquid acting per unit area.....

So the water at the bottom is pushed further outside the container



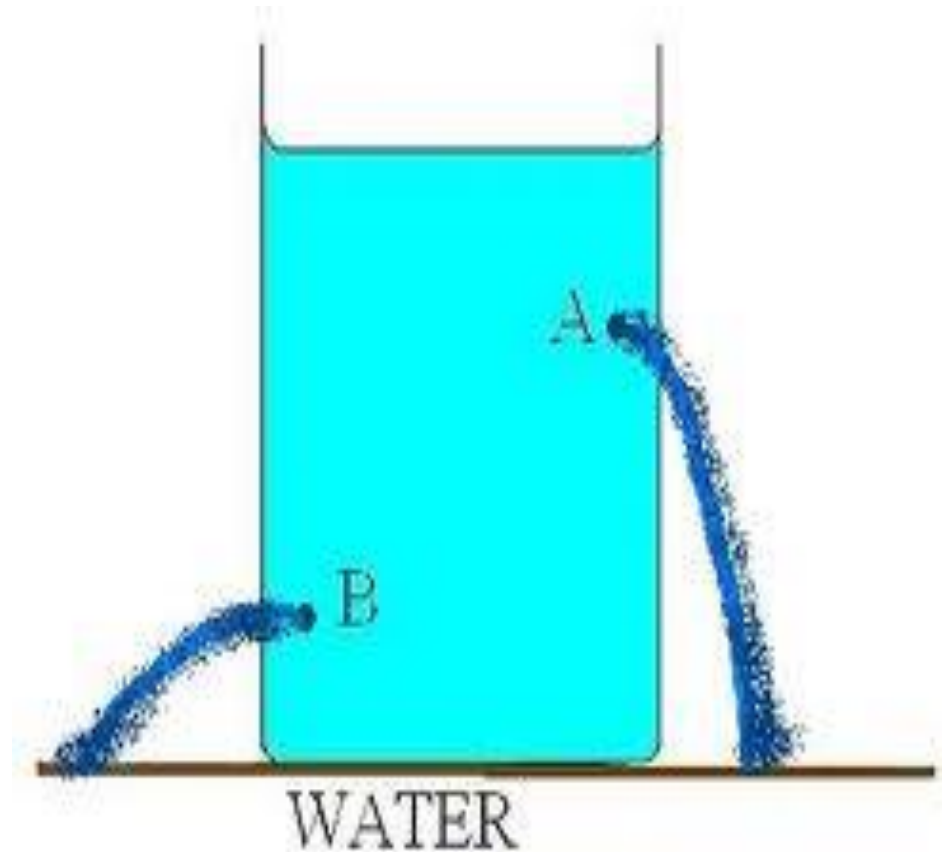
Pressure in the deep ocean

- Pressure in the ocean increases by about 1 atmosphere (100kpa) for each per 10metres.
- The deepest part of the ocean is the Marianas Trench
- The deepest point of the ocean is at just under 11km
- The pressure is 1000 atmospheres (1000 X 100Kpa)
- This is the same as about 8 tonnes per square inch

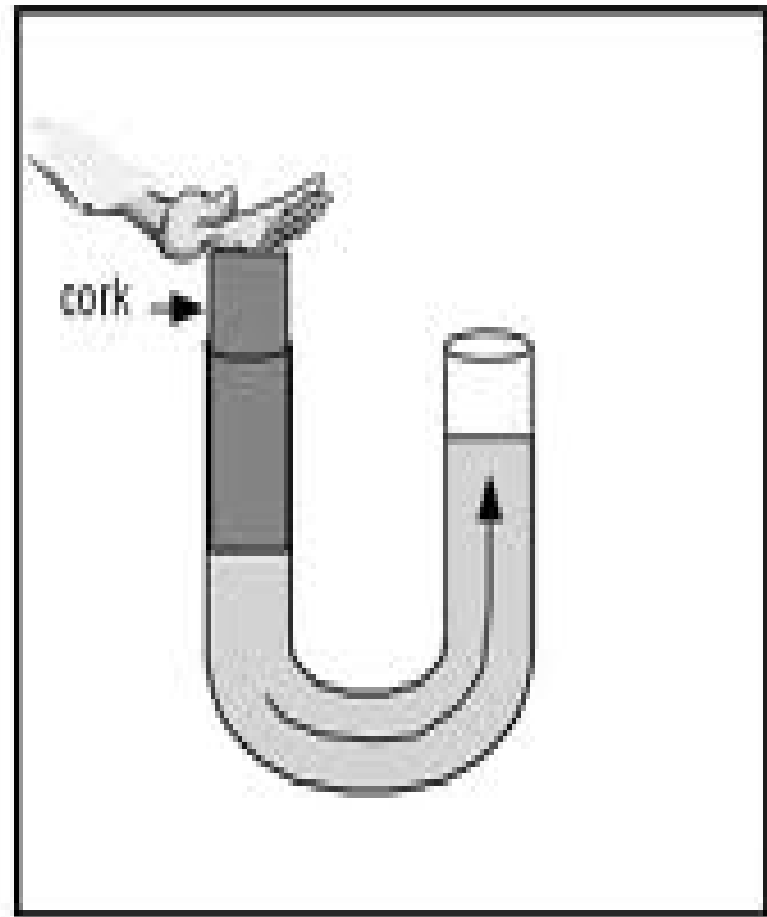
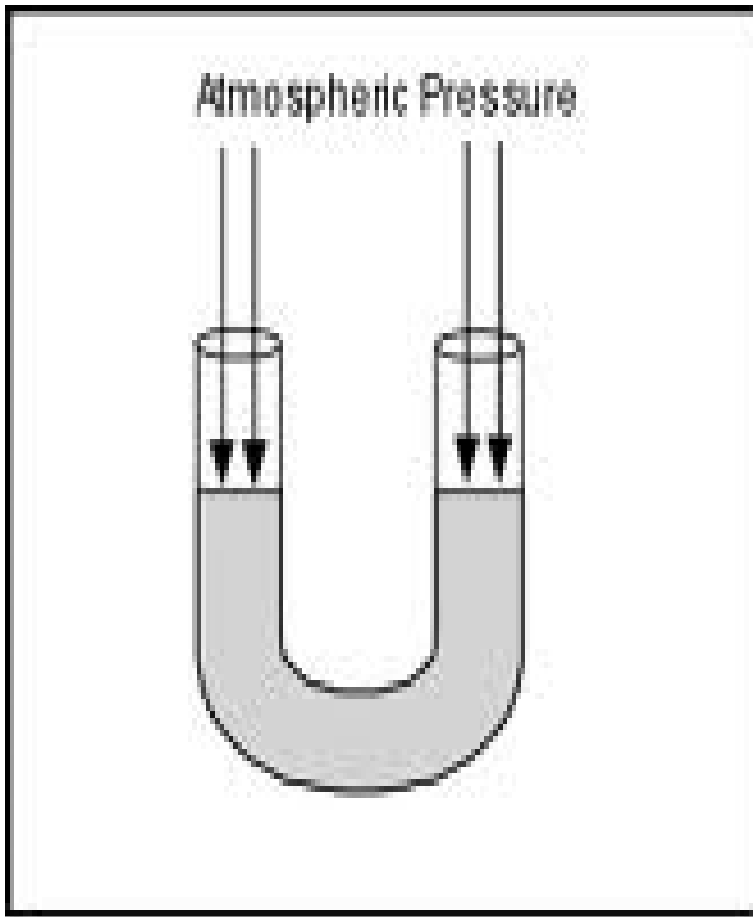


Pressure in Liquids 2

- Pressure at one depth acts equally in all directions
- The water is leaving this container at the same rate in all directions.....
- **So the pressure exerted by the water must be the same in all directions**



Water finds its own level



Water finds its own level 2

- In the picture on the right the water is at the same level
- In the picture on the left pressure is exerted.
- The length of column has been changed
- So the water will flow until the pressure and level are the same
- Pressure will also vary depending on the diameter of the column and volume of water

Pressure of a gas

- Air has weight the air in an average sized room weights about 500N.
- This means that the weight of the atmosphere exerts a large pressure at sea level.
- This pressure acts equally in all directions.
- A gas in a container exerts pressure on the walls of the container.....

Remove the air and....

- The air inside the container is removed – this creates a vacuum
- The container collapses
- The air pressure is greater outside than it is on the inside



Gas in a balloon

- Pressure inside a balloon is caused by the gas particles striking the inside surface of the balloon
- If the gas is heated pressure increases because the particles have more energy
- The gas particles hit the inner surface more quickly
- When a gas is heated such as in a jet engine its pressure and volume change.
- The relationship between volume and temperature is established in Charles Law

Pressure on the in and outside



Charles Law

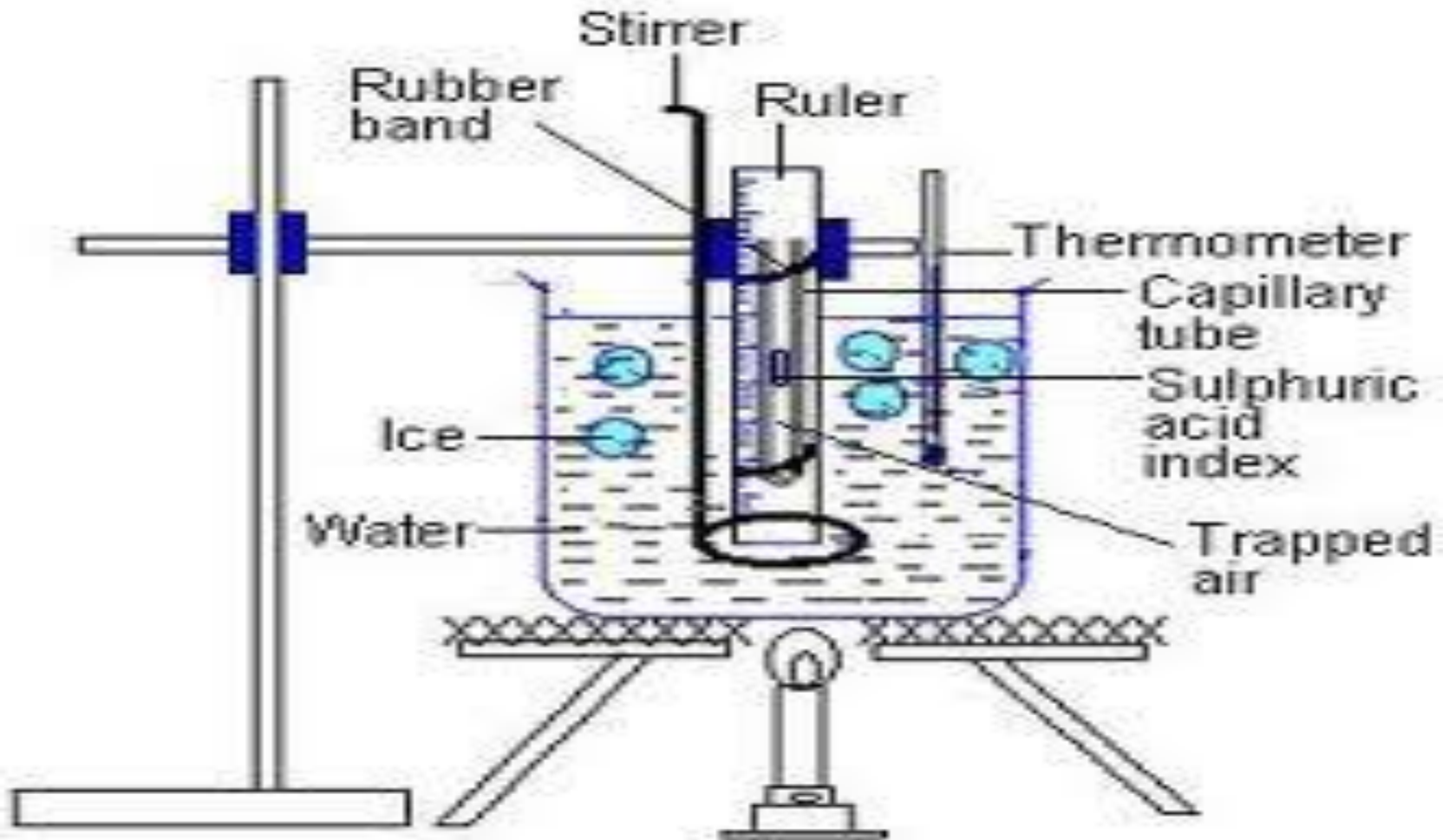
- 1781 the French scientist Jacques Alaxandre Cesar Charles studied the effect of temperature on the pressure and volume of gases.
- He concluded after thousands of experiments that:

WHEN THE TEMPERATURE OF A GAS IS INCREASED THE VOLUME ALSO INCREASES

This is Charles law

- It applies to any fixed mass of gas
- It can be demonstrated in the laboratory.....

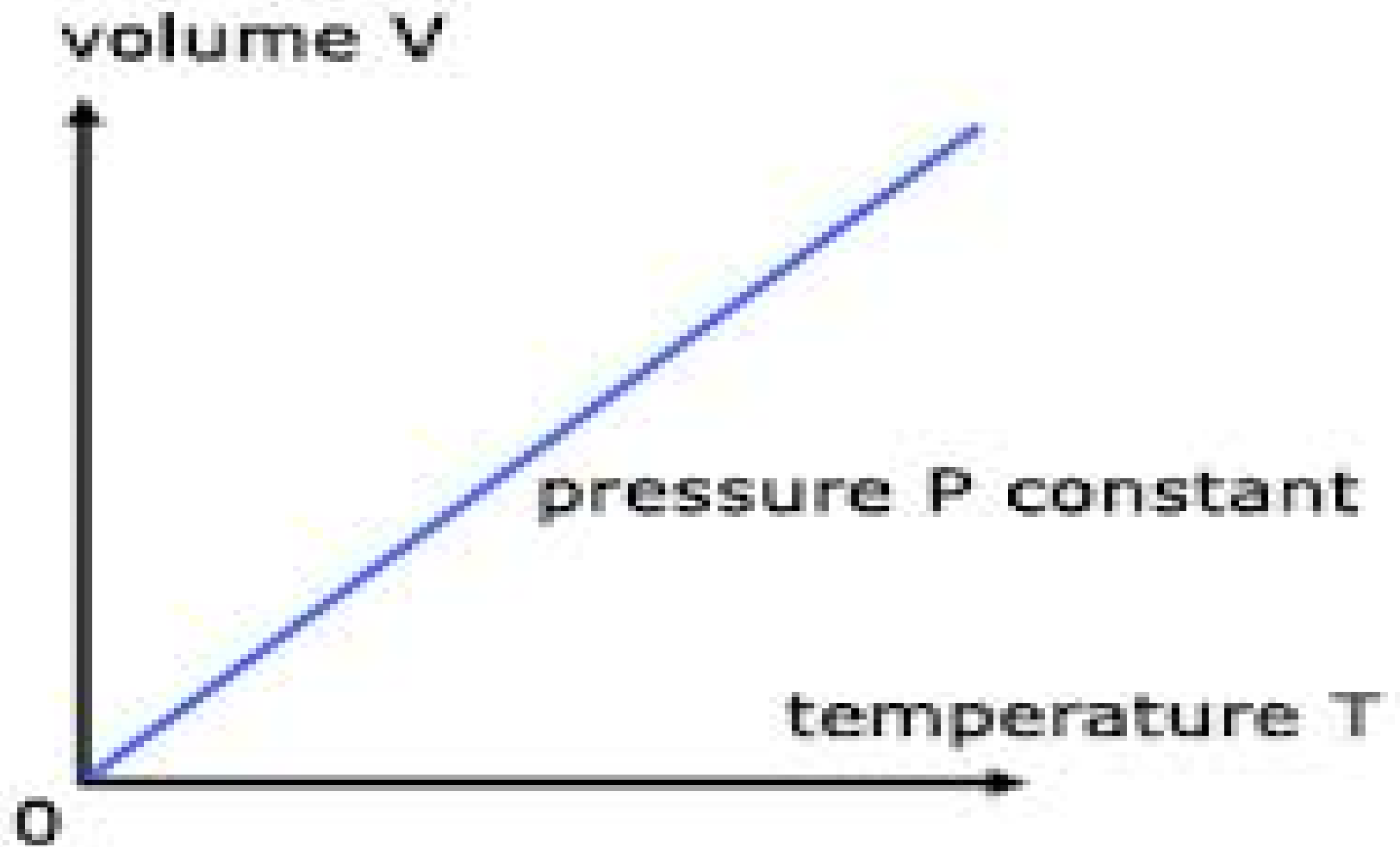
Charles law Experiment



How it works.....

- The sulphuric acid traps the air and dries it
- The capillary tube is adjusted so that it set a against a mark on the ruler
- Heat the water to different temperatures and record how much the trapped air moves by measuring against the ruler
- The pressure on the air column is constant and equals atmospheric pressure plus the pressure of the acid
- Record the results in a table (volume and temperature) and plot a graph.....

Charles law graph



What does this tell us?

- The straight line through the origin tells us that
- The gas expands uniformly (at the same rate) with temperature (when pressure is constant)
- This demonstrates the accuracy of Charles Law
- The volume of gas is directly proportional to its temperature if the pressure is constant

Charles and his equation....

$$V \propto T \text{ or } \frac{V}{T} = \text{constant}$$

Where V = volume

T= temperature (in kelvin or degrees)

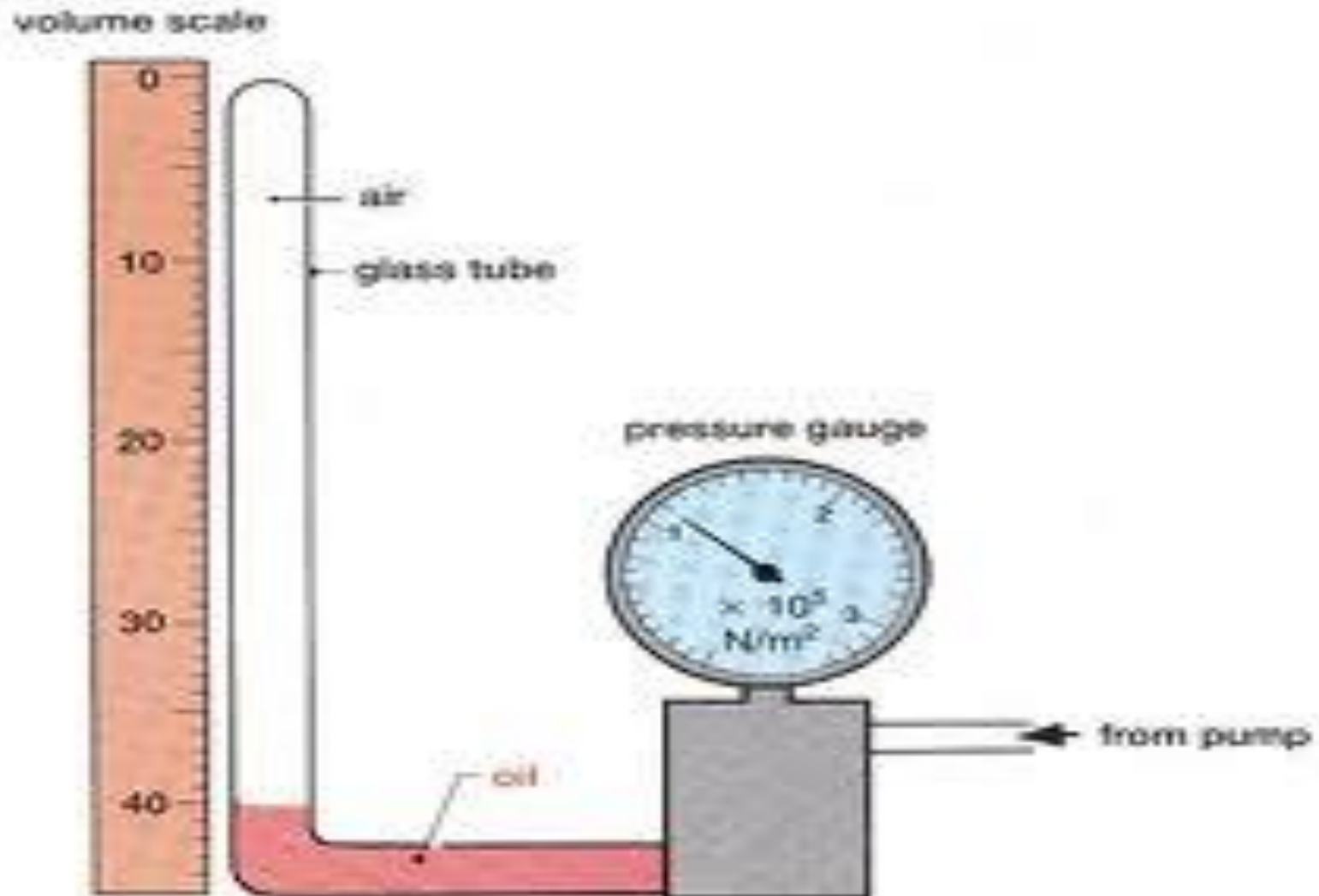
Constant = Constant Pressure



Boyles Law

- Like Charles Robert Boyle worked out after thousands of experiments another law...
- When pressure is increased the volume of gas is reduced
- Another relationship between volume and pressure.

Boyles law apparatus

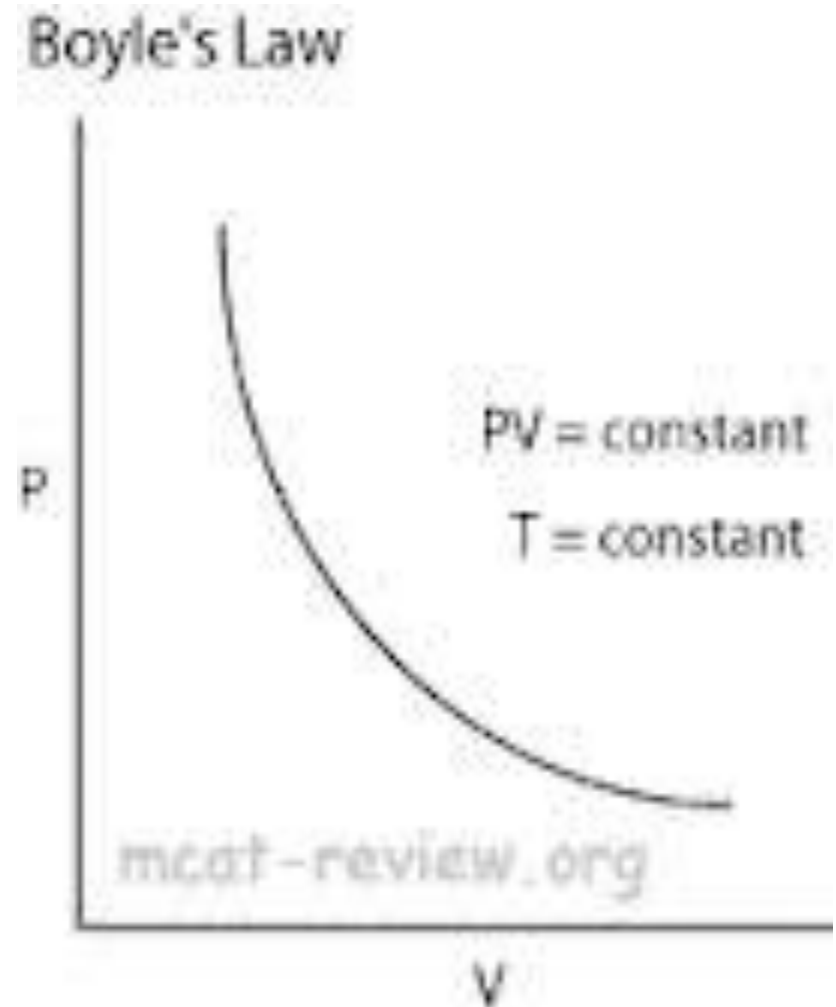


How does it work?

- The volume of trapped air (V) is read off the ruler.
- The pressure is changed by pumping in air into the space above the oil reservoir.
- This forces more oil into the glass tube and increases the pressure P on the trapped air
- This pressure is measured with a device called a Bourdon gauge
- As with Charles law record the results in a table

Plotting the graphs 1

- If you plot pressure against volume you get a graph like this
- When you look at the numbers it shows that if P is doubled V is halved
- P is inversely proportional to V



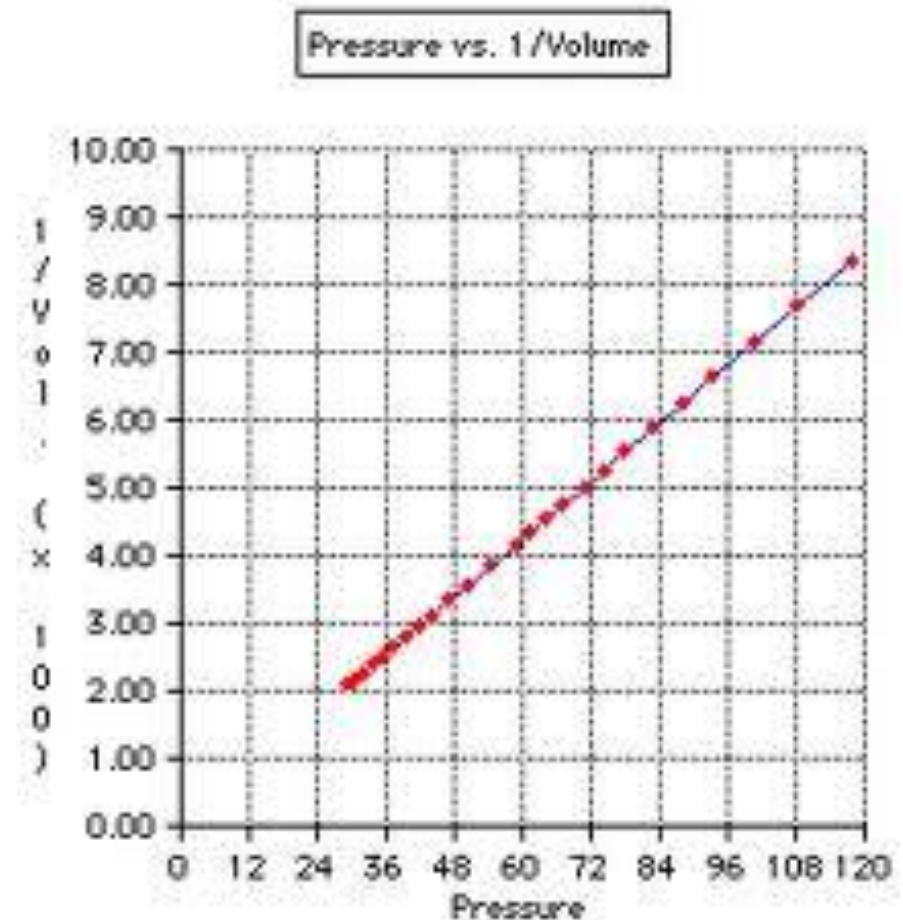
Robert Boyle and the law

- **THE PRESSURE OF A
FIXED MASS OF GAS IS
INVERSELY
PROPORTIONAL TO ITS
VOLUME IF THE
TEMPERATURE IS KEPT
CONSTANT**



Plotting the graphs 2

- Because P is inversely proportional to V then p is directly proportional to $1/V$
- So a graph of p against $1/V$ is a straight line



Boyles law equations

- V is proportional to $1/p$
- $V = \text{constant temperature} / P$
- $pV = \text{constant}$

Why is all of this important

- Ask a scuba diver....
- Divers carry tanks of compressed gas as they go deeper pressure increases.
- The air they breathe from the tanks has to be regulated so that it is the same as the surrounding water
- They can descend quickly but ascend they need to ascend very slowly because the water pressure doubles every 10 metres

Scuba divers



You should now be able to...

- Define pressure and its unit
- Relate force and density
- Relate pressure in a fluid with its depth and density
- Use the pressure magic triangle
- State and apply Boyle and Charles Law
- Use the equations to perform simple calculations

Extra Work for BGCSE Students

“assignments on pressure and the gas laws”

For extra practice, download past papers from
www.TheStudentShed.com

