Higher
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Gases
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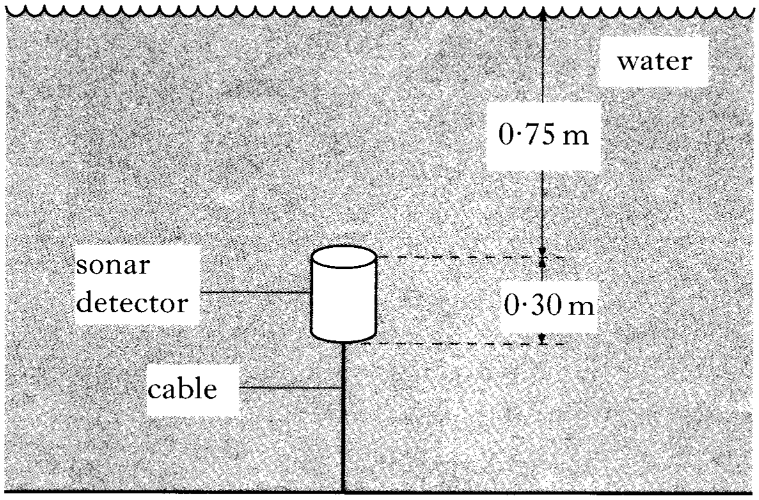
Past Paper questions
2000 - 2010

2000 Q23.

A sonar detector is attached to the bottom of a fresh water loch by a vertical cable as shown.



The detector has a mass of 100 kg. Each end of the detector has an area of 0.40 m^2.

Atmospheric pressure is 101 000 Pa.

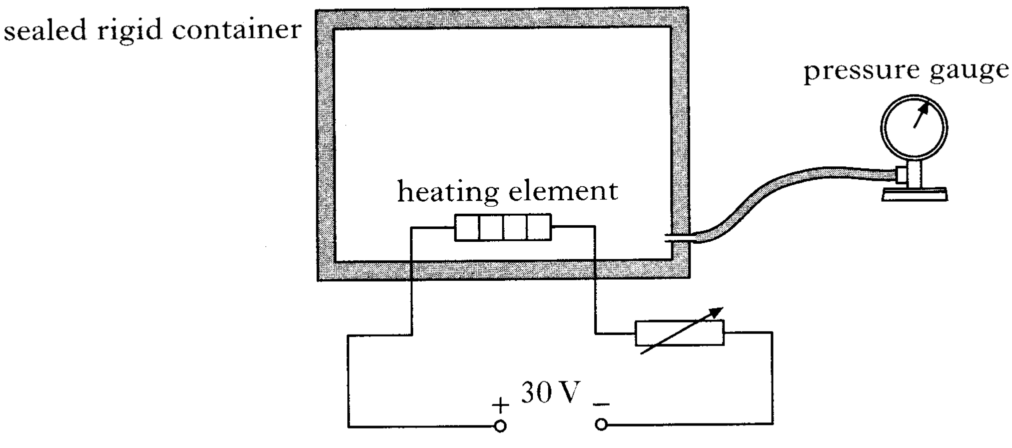
(a) The total pressure on the top of the detector is 108 350 Pa.
Show that the total pressure on the bottom of the detector is 111 290 Pa.

(b) Calculate the upthrust on the detector.

(c) The sonar detector is now attached, as before, to the bottom of a **sea water** loch.
The top of the detector is again 0.75 m below the surface of the water.
How does the size of the upthrust on the detector now compare with your answer to (b)?
You must justify your answer.

2003 Q24.

A technician designs the following apparatus to investigate the pressure of a gas at different temperatures.

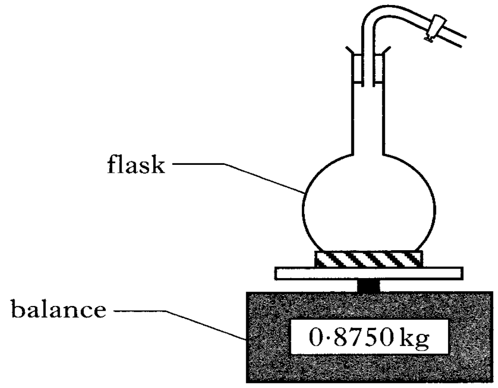


The heating element is used to raise the temperature of the gas.

(a) Initially the gas is at a pressure of 1.56×10^5 Pa and a temperature of 27°C.
The temperature of the gas is then raised by 50ºC.
Calculate the new pressure of the gas in the container.

2001 Q22.

(a) In an experiment to find the density of air, a student first measures the mass of a flask full of air as shown below.



The air is now removed from the flask and the mass of the evacuated flask measured.
This procedure is repeated a number of times and the following table of measurements is obtained.

	Experiment number					
	1	2	3	4	5	6
Mass of flask and air/kg	0·8750	0·8762	0·8748	0·8755	0·8760	0·8757
Mass of evacuated flask/kg	0·8722	0·8736	0·8721	0·8728	0·8738	0·8732
Mass of air removed/kg						

The volume of the flask is measured as $2.0\text{x}10^{-3}$ m^3.

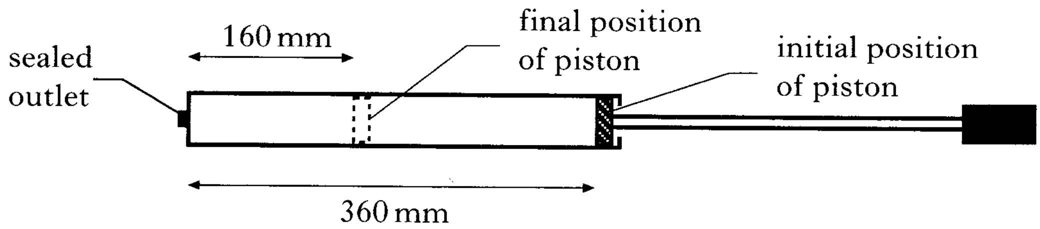
(i) Copy and complete the **bottom row** of the table.

(ii) Calculate the mean mass of air removed from the flask **and** the random uncertainty in this mean. Express the mean mass and the random uncertainty in kilograms.

(iii) Use these measurements to calculate the density of air.

(iv) Another student carries out the same experiment using a flask of larger volume. Explain why this is a better design for the experiment.

(b) The cylinder of a bicycle pump has a length of 360 mm as shown in the diagram.
The outlet of the pump is sealed.
The piston is pushed inwards until it is 160 mm from the outlet.



The initial pressure of the air in the pump is $10\text{x}10^5$ Pa.

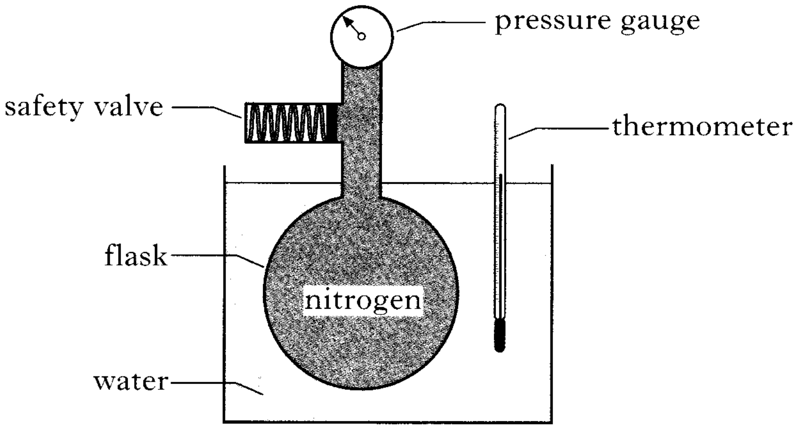
(i) Assuming that the temperature of the air trapped in the cylinder remains constant, calculate the final pressure of the trapped air.

(ii) State one other assumption you have made for this calculation.

(iii) Use the kinetic model to explain what happens to the pressure of the trapped air as its volume decreases.

2002 Q22.

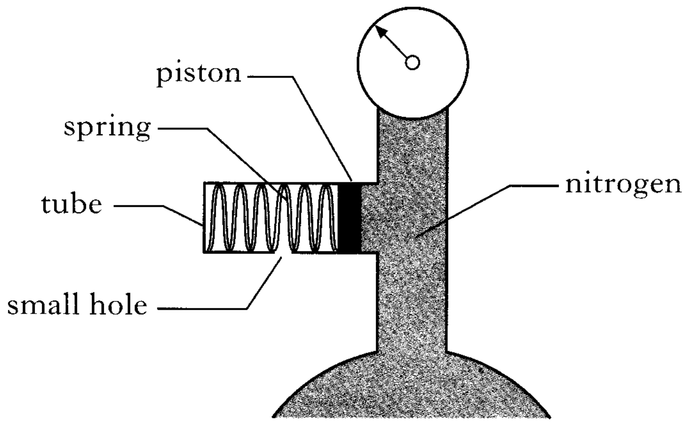
A technician designs the apparatus shown in the diagram to investigate the relationship between the temperature and pressure of a fixed mass of nitrogen which is kept at a constant volume.



(a) The pressure of the nitrogen is 109 kPa when its temperature is 15ºC.
The temperature of the nitrogen rises to 45 °C.
Calculate the new pressure of the nitrogen in the flask.

(b) Explain, in terms of the movement of gas molecules, what happens to the pressure of the nitrogen as its temperature is increased.

(c) The technician has fitted a safety valve to the apparatus.
A diagram of the valve is shown below.



The piston of cross-sectional area 4.0×10^{-6} m^2 is attached to the spring.
The piston is free to move along the tube.
The following graph shows how the length of the spring varies with the force exerted by the nitrogen on the piston.

(i) Calculate the force exerted by the nitrogen on the piston when the reading on the pressure gauge is 1.75×10^5 Pa.

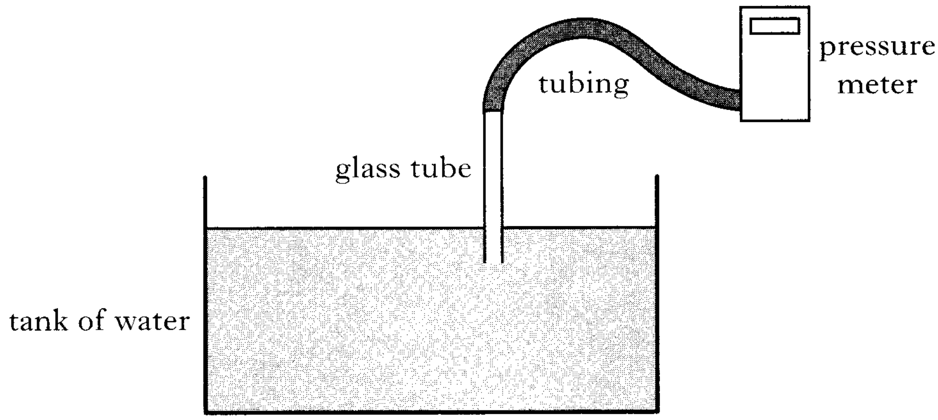
(ii) What is the length of the spring in the safety valve when the pressure of the nitrogen is 1.75×10^5 Pa?

(d) The technician decides to redesign the apparatus so that the bulb of the thermometer is placed inside the flask.
Give **one** reason why this improves the design of the apparatus.

2003 Q23.

A tank of water rests on a smooth horizontal surface.

(a) A student takes measurements of the pressure at various depths below the surface of the water, using the apparatus shown.



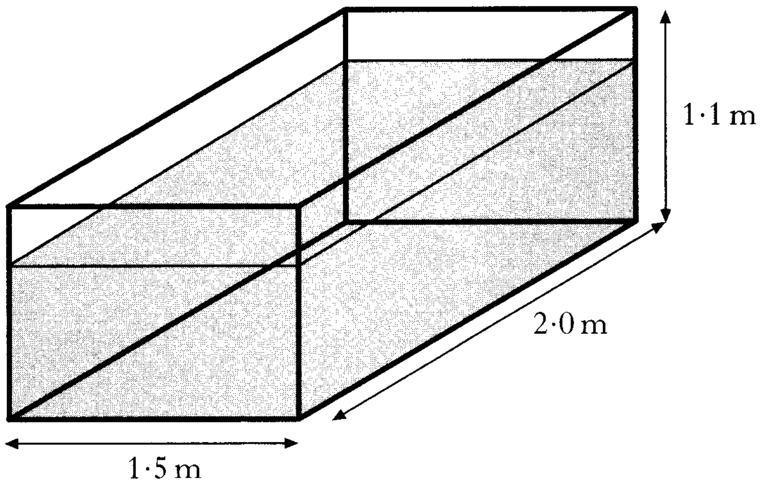
The pressure meter is set to zero before the glass tube is lowered into the water.

(i) Sketch a graph to show how the pressure due to the water varies with depth below the surface of the water.

(ii) Calculate the pressure due to the water at a depth of 0.25 m below its surface.

(iii) As the glass tube is lowered further into the tank, the student notices that some water rises inside the glass tube.
Explain why this happens.

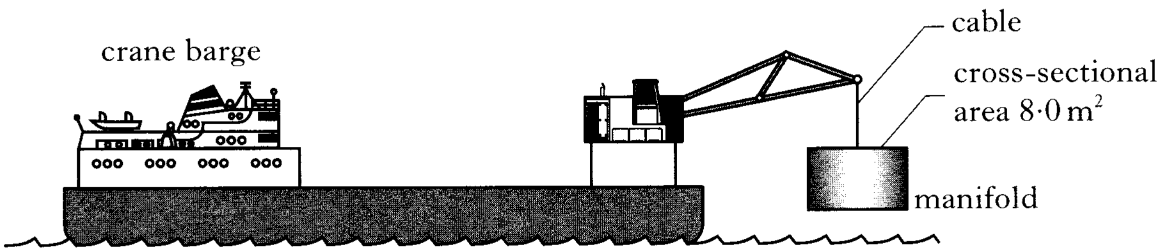
(b) The mass of water in the tank is 2.7×10^3 kg.
The tank has a mass of 300 kg and a flat rectangular base.
The dimensions of the tank are shown in the diagram below.
Atmospheric pressure is 1.01×10^5 Pa.



Calculate the total pressure exerted by the base of the tank on the surface on which it rests.

2004 Q23.

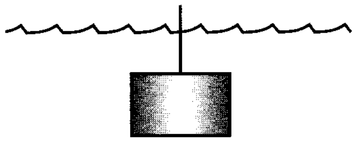
A crane barge is used to place part of an oil well, called a manifold, on the seabed.



The manifold is a cylinder of uniform cross-sectional area 8.0 m^2 and mass $5.0x10^4$ kg.
The mass of the cable may be ignored.

(a) Calculate the tension in the cable when the manifold is held stationary above the surface of the water.

(b) The manifold is lowered into the water and then held stationary just below the surface as shown.



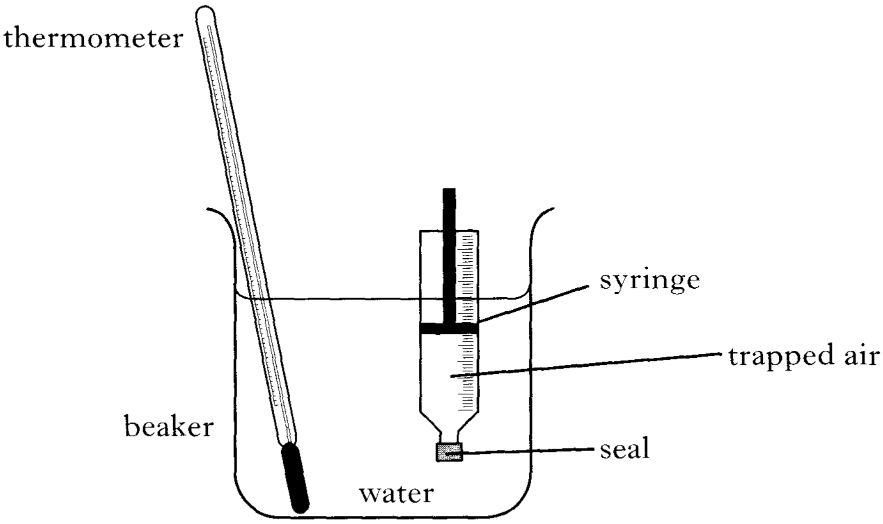
(i) Draw a sketch showing all the forces acting vertically on the manifold. Name each of these forces.

(ii) The tension in the cable is now $2.5x10^5$ N. Show that the difference in pressure between the top and bottom surfaces of the manifold is $3.0x10^4$ Pa.

(c) The manifold is now lowered to a greater depth. What effect does this have on the difference in pressure between the top and bottom surfaces of the manifold? You must justify your answer.

2005 Q24.

The apparatus used to investigate the relationship between volume and temperature of a fixed mass of air is shown.



The volume of the trapped air is read from the scale on the syringe.
The temperature of the trapped air is altered by heating the water in the beaker.
It is assumed that the temperature of the air in the syringe is the same as that of the surrounding water. The pressure of the trapped air is constant during the investigation.

(a) Readings of volume and temperature for the trapped air are shown.

Temperature/ °C	25	50	75	100
Volume/ml	20·6	22·6	24·0	25·4

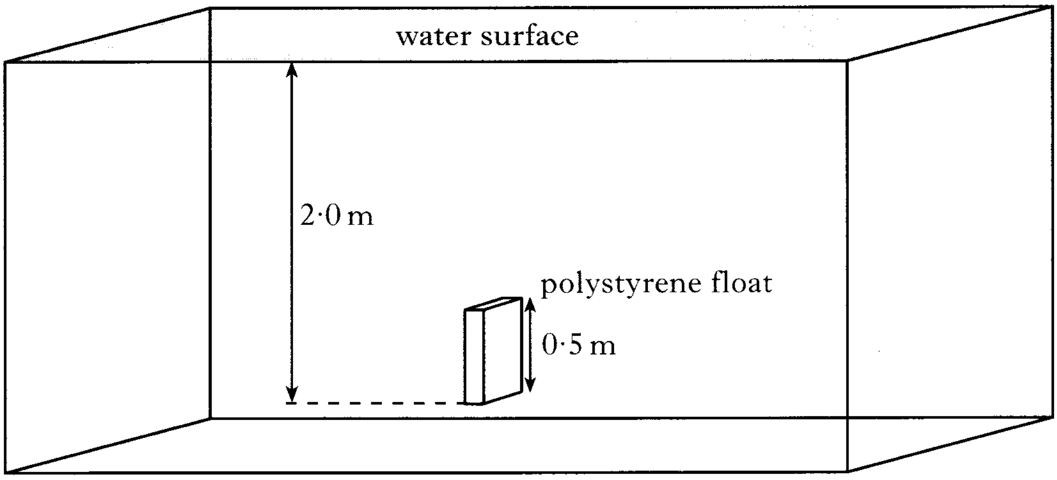
(i) Using **all** the data, establish the relationship between temperature and volume for the trapped air.

(ii) Calculate the volume of the trapped air when the temperature of the water is 65 °C.

(iii) Use the kinetic model of gases to explain the change in volume as the temperature increases in this investigation.

2005 Q23.

A polystyrene float is held with its base 2.0 m below the surface of a swimming pool.



(a) The float has a mass of 12 g and its dimensions are 0.50 m x 0.30 m x 0.10 m.
Calculate the density of the float.

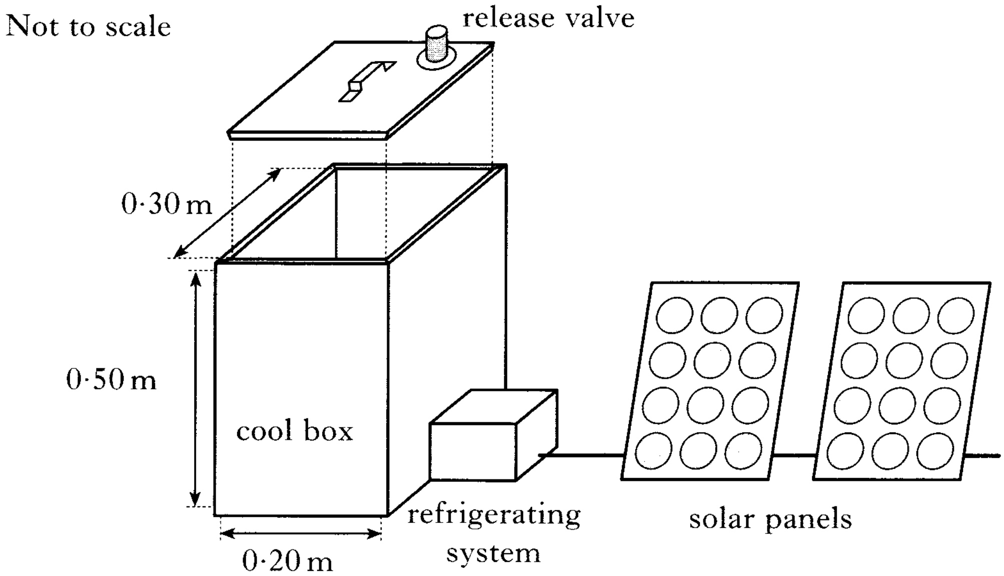
(b) Explain why a buoyancy force acts on the float.

(c) The float is released and accelerates towards the surface. Taking into account the resistance of the water, state what happens to the acceleration of the float as it approaches the surface.
You must justify your answer.

(d) Another float made of a more dense material with the same dimensions is now held at the same position in the pool.
The float is released as in part (c).
State how the initial acceleration of this float compares with the polystyrene float.
You must justify your answer.

2006 Q23.

A refrigerated cool box is being prepared to carry medical supplies in a hot country.
The **internal** dimensions of the box are 0.30 m x 0.20 m x 0.50 m.



The lid is placed on the cool box with the release valve closed. An airtight seal is formed.
When the lid is closed the air inside the cool box is at a temperature of 33°C and a pressure of 1.01×10^5 Pa.
The refrigerating system then reduces the temperature of the air inside the cool box until it reaches its working temperature.
At this temperature the air inside is at a pressure of 9.05×10^4 Pa.

(a) (i) Calculate the temperature of the air inside the cool box when it is at its working temperature.

(ii) Describe, using the kinetic model, how the decrease in temperature affects the air pressure inside the cool box.

(b) (i) Atmospheric pressure is 1.01×10^5 Pa.
Show that the magnitude of the force on the lid due to the difference in air pressure between the inside and outside of the cool box is now 630 N.

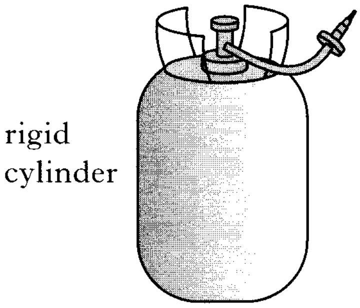
(ii) The mass of the lid is 1.50 kg.
Calculate the minimum force required to lift off the lid when the cool box is at its working temperature.

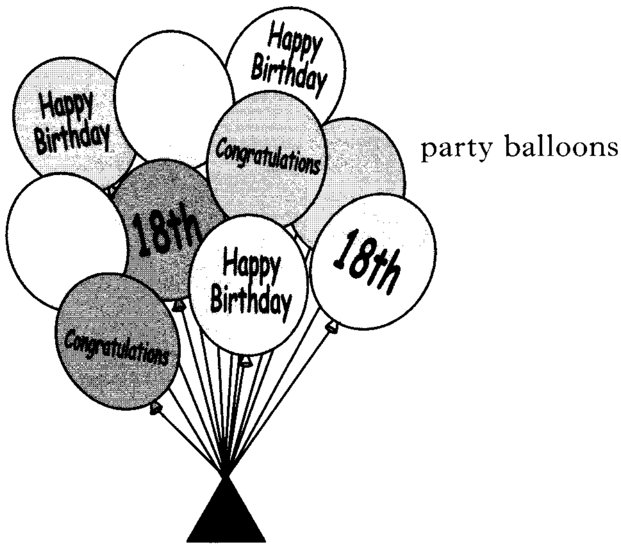
(iii) The release valve allows air to pass into or out of the cool box.
Explain why this valve should be opened before lifting the lid.

(c) The refrigerating system requires an average current of 0.80 A at 12 V.
Each solar panel has a power output of 3.4 W at 12 V.
Calculate the minimum number of solar panels needed to operate the refrigerating system.

2007 Q23.

A rigid cylinder contains 8.0×10^{-2} m^3 of helium gas at a pressure of 750 kPa.
Gas is released from the cylinder to fill party balloons.





During the filling process, the temperature remains constant.
When filled, each balloon holds 0.020 m^3 of helium gas at a pressure of 125 kPa.

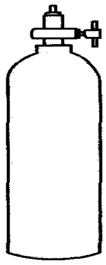
(a) Calculate the total volume of the helium gas when it is at a pressure of 125 kPa.

(b) Determine the maximum number of balloons which can be fully inflated by releasing gas from the cylinder.

(c) State how the density of the helium gas in an inflated balloon compares to the initial density of the helium gas inside the cylinder.
Justify your answer.

2008 Q23.

A cylinder of compressed oxygen gas is in a laboratory.



(a) The oxygen inside the cylinder is at a pressure of 2.82×10^6 Pa and a temperature of 19.0°C. The cylinder is now moved to a storage room where the temperature is 5.0°C.

(i) Calculate the pressure of the oxygen inside the cylinder when its temperature is 5.0°C.

(ii) What effect, if any, does this decrease in temperature have on the density of the oxygen in the cylinder?
Justify your answer.

(b) (i) The volume of oxygen inside the cylinder is $0.030 m^3$.
The density of the oxygen inside the cylinder is 37.6 kgm^{-3}.
Calculate the mass of oxygen in the cylinder.

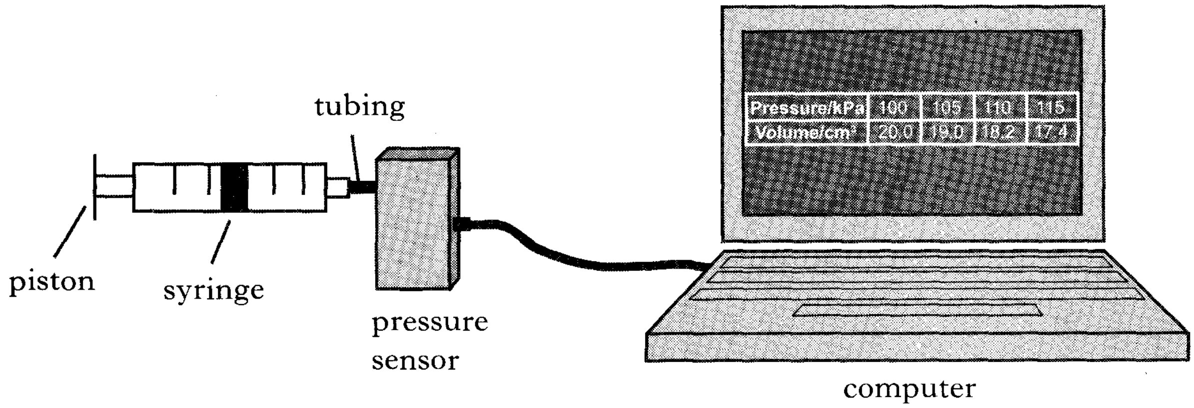
(ii) The valve on the cylinder is opened slightly so that oxygen is gradually released.
The temperature of the oxygen inside the cylinder remains constant.
Explain, in terms of particles, why the pressure of the gas inside the cylinder decreases.

(iii) After a period of time, the pressure of the oxygen inside the cylinder reaches a constant value of 1.01×10^5 Pa. The valve remains open.
Explain why the pressure does not decrease below this value.

2009 Q23.

A student is training to become a diver.

(a) The student carries out an experiment to investigate the relationship between the pressure and volume of a fixed mass of gas using the apparatus shown.



The pressure of the gas is recorded using a pressure sensor connected to a computer.
The volume of the gas is also recorded.
The student pushes the piston to alter the volume and a series of readings is taken.
The temperature of the gas is constant during the experiment.
The results are shown.

Pressure/kPa	100	105	110	115
Volume/cm^3	20·0	19·0	18·2	17·4

(i) Using **all** the data, establish the relationship between the pressure and volume of the gas.

(ii) Use the kinetic model to explain the change in pressure as the volume of gas decreases.

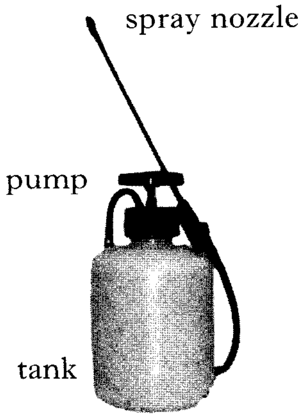
(b) (i) The density of water in a loch is 1.02×10^3 kgm^{-3}.
Atmospheric pressure is 1.01×10^5 Pa.
Show that the **total** pressure at a depth of 12.0 m in this loch is 2.21×10^5 Pa.

(ii) At the surface of the loch, the student breathes in a volume of 1.50×10^3 m^3 of air.
Calculate the volume this air would occupy at a depth of 12.0 m.
The mass and temperature of the air are constant.

(c) At a depth of 12.0 m, the diver fills her lungs with air from her breathing apparatus.
She then swims to the surface.
Explain why it would be dangerous for her to hold her breath while doing this.

2010 Q28.

A garden spray consists of a tank, a pump and a spray nozzle.



The tank is partially filled with water.

The pump is then used to increase the pressure of the air above the water.

(a) The volume of the compressed air in the tank is $1.60 \text{x} 10^3$ m^3.

The surface area of the water is $3.00 \text{x} 10^2$ m^2.

The pressure of the air in the tank is $4.60 \text{x} 10^5$ Pa.

(i) Calculate the force on the surface of the water.

(ii) The spray nozzle is operated and water is pushed out until the pressure of the air in the tank is $1.00 \text{x} 10^5$ Pa.

Calculate the volume of water expelled.