Gas Laws Questions – NAT 5

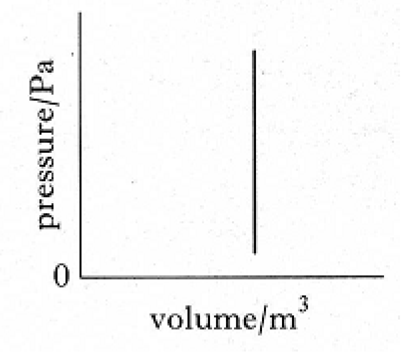
1) Ice at 0°C is heated until it becomes water at 80°C.

Find the **change in temperature** on the **Kelvin scale**.

2) A rectangular block of wood of mass **200kg** has dimensions **2m x 1m x 0.1m**.

Calculate the **greatest pressure** that the block can exert while lying on a level surface.

3) The pressure-volume graph below describes the behaviour of a constant mass of gas when it is heated.



Draw the corresponding pressure-temperature graph.

4) A spacecraft of mass **1200kg** has landed on a planet with a gravitational field strength of **5Nkg^{-1}**.The spacecraft rests on three pads of contact area **0.5m^2**.

Calculate the pressure exerted by the three pads on the surface of the planet.

5) Liquid nitrogen changes to its gaseous state at a temperature of -196°C.

a) What is the **temperature in Kelvin**?

b) Explain why the temperature of **0 Kelv**in is describes as

‘the absolute zero of temperature’.

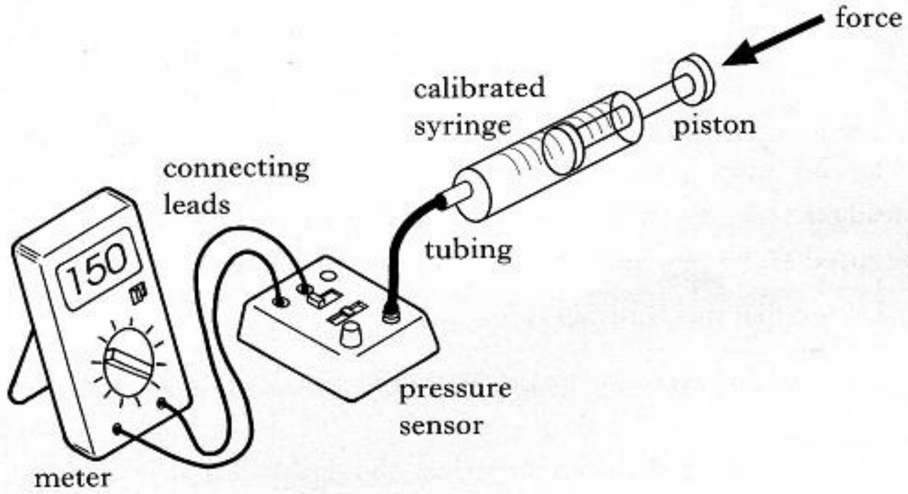
6)

The diagram below illustrates an experiment to investigate the relationship between pressure and volume of a gas.

The apparatus consists of a calibrated syringe fitted with a gas-tight piston. Air is trapped in the syringe and the pressure of the trapped air can be monitored using a pressure sensor and a meter.

The pressure of the trapped air can be altered by exerting a force on the piston.

The temperature of the trapped air is assumed to be constant during the experiment.



The following measurements of pressure and volume are recorded.

Pressure/kPa	100	150	200	250
Volume/cm^3	14·7	9·9	7·4	5·9

(*a*) Using all the data, establish the relationship between the pressure and volume of the trapped air.

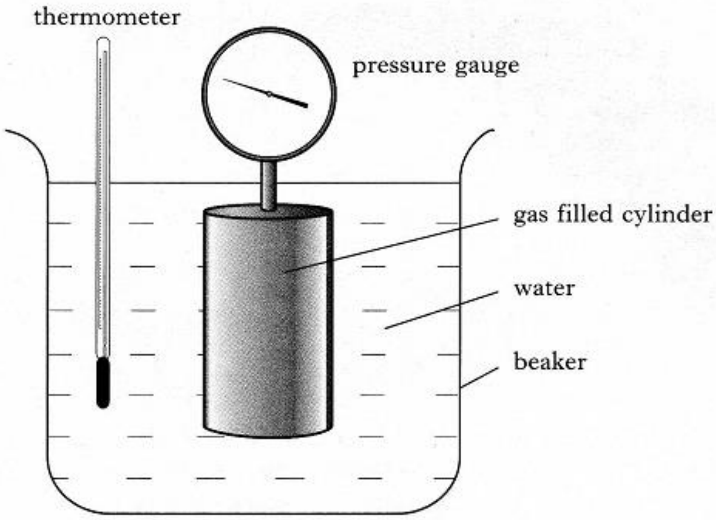
(*b*) The force on the piston is now altered until the volume of the trapped air is 5·0 cm^3.
Calculate the pressure of the trapped air.

(*c*) The force is now removed from the piston.
Explain the subsequent motion of the piston in terms of the movement of the air molecules.

(*d*) The tubing between the syringe and the pressure sensor is replaced by one of longer length. What effect would this have on the results of the experiment?

7)

A pupil uses the apparatus shown in the diagram to investigate the relationship between the pressure and the temperature of a fixed mass of gas at constant volume.



The cylinder is fully immersed in a beaker of water and the water is slowly heated.

You may assume that the volume of the cylinder does not change as the temperature of the water changes.

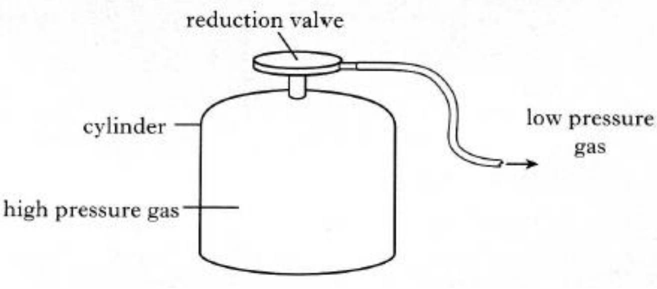
(*a*) Explain why the cylinder must be fully immersed in the beaker of water.

(*b*) The pressure of the gas in the cylinder is 100 kPa when the gas is at a temperature of 17 °C. Calculate the pressure of the gas in the cylinder when the temperature of the gas is 75 °C.

(*c*) The base of the cylinder has an area of $0{\cdot}001\ m^2$. What is the force exerted by the gas on the base when the temperature of the gas is 75 °C?

(*d*) What happens to the density of the gas in the cylinder as the temperature increases from 17 °C to 75 °C? Justify your answer.

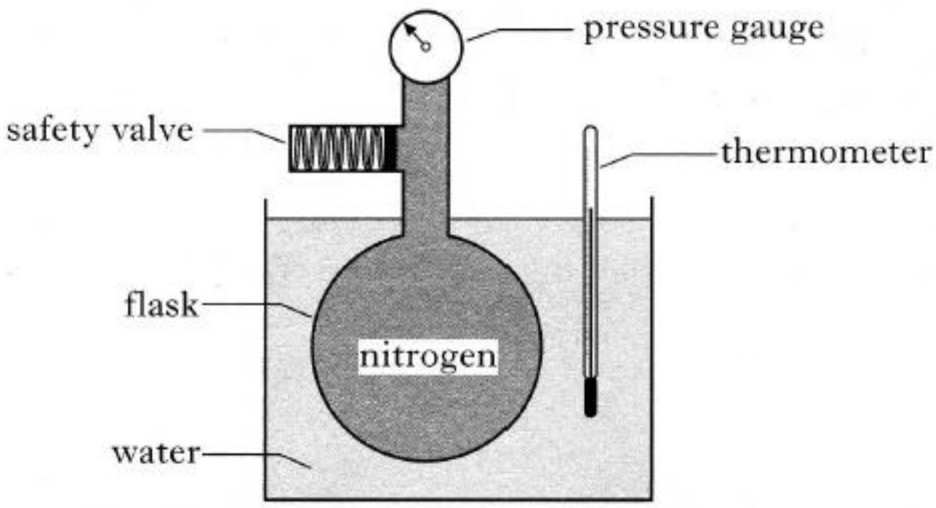
8) Gas is often stored in cylinders at high pressure. The pressure of the gas must be reduced by a reduction valve before the gas can be used.



The pressure of the gas in the cylinder is 2×10^6Pa. The pressure of the gas as it leaves the reduction valve is 4×10^5Pa.

Gas with a volume of $0.01m^3$ enters the reduction valve from the cylinder. **Calculate the volume of this gas** when it leaves the reduction valve, assuming that the temperature of the gas does not change.

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



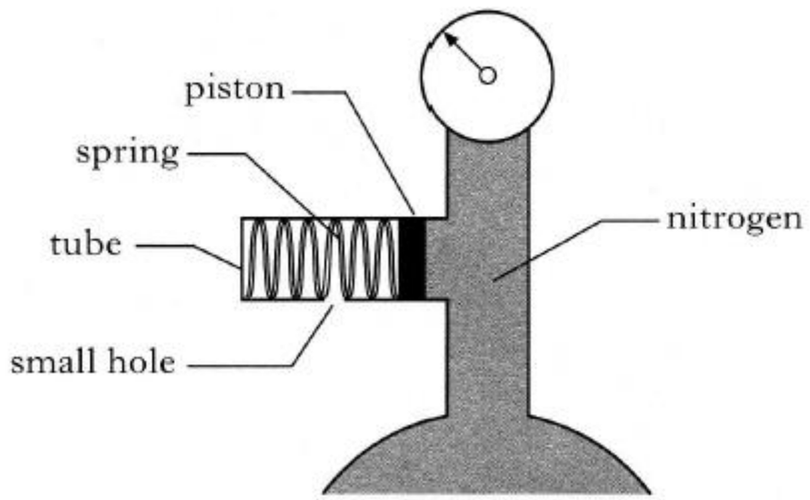
a) The pressure of the gas is 109kPa when its temperature of 15˚C.

The temperature of the gas then rises to 45˚C.

Calculate the new pressure of the nitrogen gas in the flask.

b) **Explain** in terms of the movement of the gas particles, what happens to the pressure of the nitrogen gas when its temperature in Kelvin is increased.

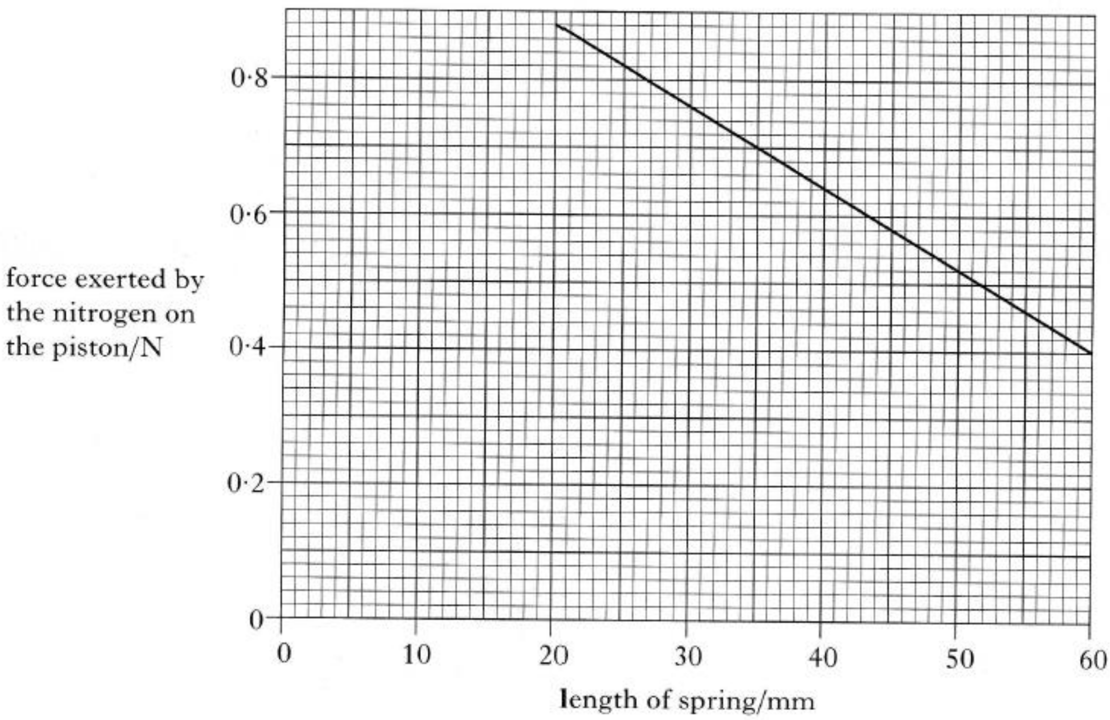
c) The technician has added a safety valve to the apparatus as shown in the diagram below.



The piston of cross-sectional area $\mathbf{4 \times 10^{-6} m^2}$ 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 graph on the piston.



i) **Calculate the force exerted** by the nitrogen gas on the piston when the reading on the pressure gauge is **$1.75 x 10^5$Pa**.

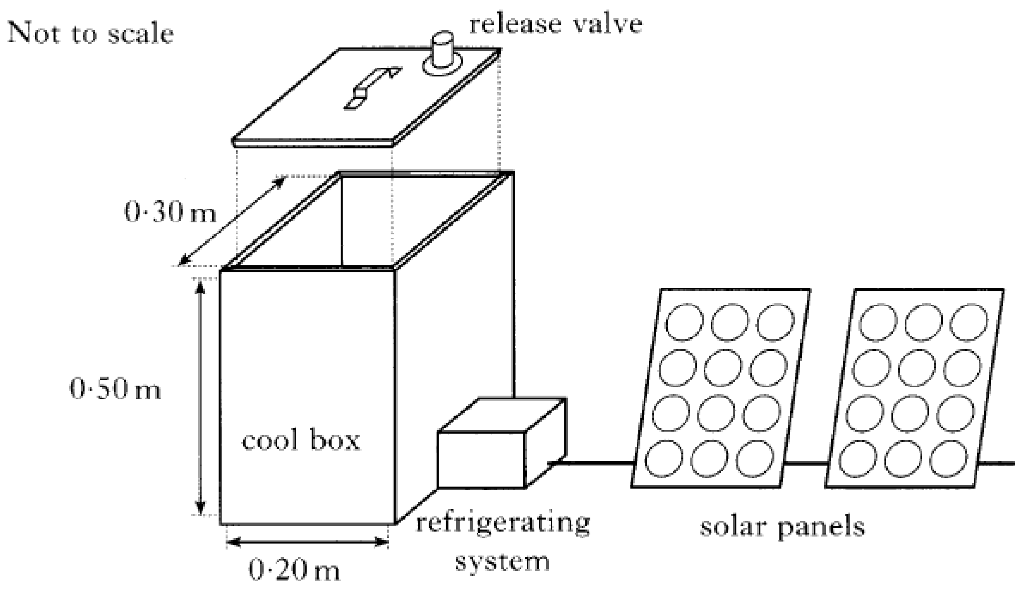
ii) **What is the length of the spring** in the safety valve when the pressure of the nitrogen gas is $1.75 x 10^5$Pa?

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.

10) A refrigerated cool box is being prepared to carry medical supplies in a hot country.

The **internal dimensions** of the box are 0.30m x 0.20m x 0.50m.



The lid is placed on a 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 1.01×10^5Pa.

The refrigeration 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 9.05×10^4Pa.

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

b) i) Atmospheric pressure is 1.01×10^5Pa.

Show that the magnitude of the force on the lid due to the difference in the air pressure between the inside and the outside of the cool box is now **630N**.

ii) The mass of the lid is **1.50kg**.

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 refrigeration system requires an average current of **0.80A and 12V**.

Each solar panel has a power output of **3.4W at 12V**.

Calculate the **minimum number** of solar panels needed to operate the refrigeration system.