IB · SL · Physics

2 hours 13 questions

Structured Questions

Gas Laws

Gas Pressure / Amount of Substance / Gas Laws / Ideal Gas Equation / Kinetic Theory of Gases / Derivation of the Kinetic Theory of Gases Equation / Average Kinetic Energy of a Molecule

Easy (5 questions)	/46
Medium (5 questions)	/56
Hard (3 questions)	/32
Total Marks	**/134**

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Easy Questions

1 (a) Define the mole.

(1 mark)

(b) 4.7×10^{23} molecules of neon gas is trapped in a cylinder.

Calculate the number of moles of neon gas in the cylinder.

(2 marks)

(c) The molar mass of neon gas is 20 g mol^{-1}.

Calculate the mass of the neon gas in the cylinder.

(4 marks)

(d) The cylinder containing the neon gas has a volume 5.2 m^3 and pressure of 600 Pa.

Calculate the temperature of the gas.

(3 marks)

2 (a) State what is meant by an ideal gas.

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(1 mark)

(b) State the conditions for a real gas to approximate to an ideal gas.

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(3 marks)

(c) Describe how the ideal gas constant, *R,* is defined.

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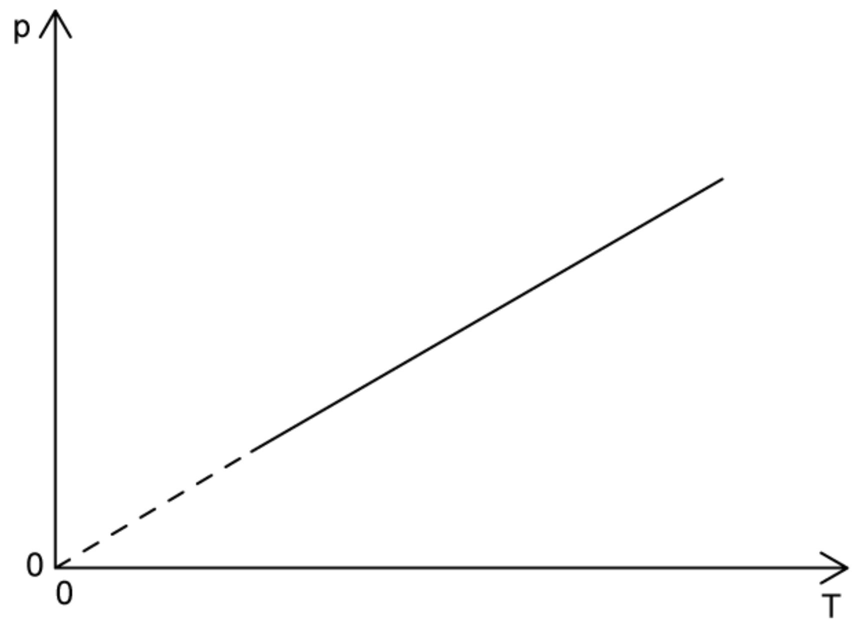
(2 marks)

(d) The graphs shows how pressure, *p*, varies with absolute temperature, *T,* for a fixed mass of an ideal gas.



Outline the changes, or otherwise, to the volume and density of the ideal gas as the absolute temperature increases.

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(2 marks)

3 (a) State three assumptions of the kinetic model of an ideal gas.

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(3 marks)

(b) A tank of volume 21 m^3 contains 7.0 moles of an ideal monatomic gas. The temperature of the gas is 28 °C.

Calculate the average kinetic energy of the particles in the gas.

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(3 marks)

(c) The following paragraph explains, with reference to the kinetic model of an ideal gas, how an increase in temperature of the gas leads to an increase in pressure.

A _______ temperature implies _______ average speed and therefore higher _______. This increases the change in _______ of collisions with the walls and leads to _______ frequent collisions. This increased _______ per collision leads to an increased _______.

Complete the sentences using keywords from the box below.

These words can be used once, more than once, or not at all				
	pressure	force	momentum	
higher	lower	less	more	kinetic energy

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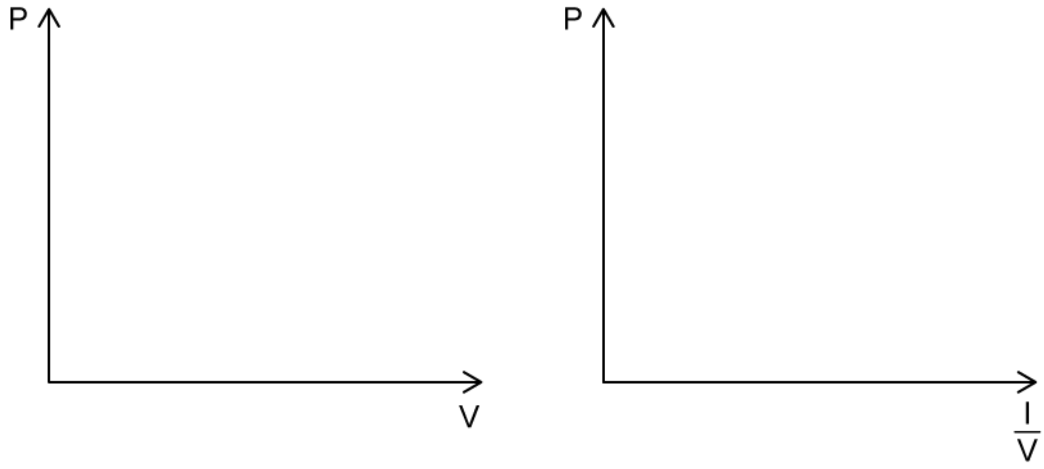
(3 marks)

(d) Calculate the pressure of the gas described in part (b).

(3 marks)

4 (a) Sketch on both axes the change in pressure and volume for an ideal gas at constant temperature.



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(2 marks)

(b) Sketch the graphs in part (a) at a higher temperature.

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(2 marks)

(c) For an ideal gas at constant volume, the pressure, *p*, and temperature, *T*, are directly proportional:

$$p \propto T$$

State the equation for an initial pressure p_1 at temperature T_1 and final pressure p_2 and temperature T_2.

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(1 mark)

(d) The final pressure of an ideal gas is 500 Pa and its temperature rises from 410 K to 495 K.

Calculate the initial pressure of the gas.

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(3 marks)

5 (a) Define pressure.

(1 mark)

(b) When there are a large number of particles in a container, their collisions with the walls of the container give rise to gas pressure.

An ideal gas with a pressure of 166 kPa collides with the walls of its container with a force of 740 N.

Calculate the internal surface area of the container.

(4 marks)

(c) An ideal gas is one that obeys the relationship

$$pV \propto T$$

If the volume an ideal gas increases, explain how this affects the:

(i) Pressure, if the temperature remains constant.

[1]

(ii) Temperature, if the pressure remains constant. [1]

(2 marks)

(d) The ideal gas equation can be rearranged to give

$$\frac{pV}{T} = \text{constant}$$

This relationship only holds true under a certain condition.

State the condition required for the equation to apply to an ideal gas.

....

(1 mark)

Medium Questions

1 (a) This question is about a monatomic ideal gas.

Outline what is meant by an ideal monatomic gas.

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(2 marks)

(b) Neon gas is kept in a container of volume 7.1×10^{-2} m^3, temperature 325 K and pressure 3.7×10^5 Pa.

(i) Calculate the number of moles of neon in the container.

[2]

(ii) Calculate the number of atoms in the gas.

[2]

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(4 marks)

(c) The volume of the gas is decreased to 4.2×10^{-2} m^3 at a constant temperature.

(i) Calculate the new pressure of the gas in Pa

[2]

(ii) Explain this change in pressure, in terms of molecular motion.

[2]

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(4 marks)

(d) Following the change in part (c), energy is then supplied to the gas at a rate of 10 J s^{-1} for 10 minutes. The specific heat capacity of neon is 904 J kg^{-1} K^{-1} and its atomic mass number is 21. The volume of the gas does not change.

Determine the new pressure of the gas.

(3 marks)

2 (a) This question is about an ideal gas in a container.

An ideal gas is held in a glass gas syringe.

Calculate the temperature of 0.726 mol of an ideal gas kept in a cylinder of volume 2.6×10^{-3} m^3 at a pressure of 2.32×10^5 Pa.

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(2 marks)

(b) The average kinetic energy of the gas is directly proportional to one particular property of the gas.

(i) Identify this property.

[1]

(ii) Calculate the average kinetic energy, $\bar{E}$, per molecule of the gas.

[1]

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(2 marks)

(c) Energy is supplied to the gas at a rate of 0.5 J s^{-1} for 4 minutes. The specific heat capacity of the gas is 519 J kg^{-1} K^{-1} and the atomic mass number is 4 u.

Calculate the change in kinetic energy per molecule of the gas.

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(4 marks)

(d) The gas is heated until its temperature doubles.

Determine the factor the average speed of the molecules increases by.

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(2 marks)

3 (a) This question is about the specific heat capacity of an ideal gas.

Outline two assumptions made in the kinetic model of an ideal gas.

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(2 marks)

(b) Xenon–131 behaves as an ideal gas over a large range of temperatures and pressures.

One mole of xenon–131 is stored at 20 °C in a cylinder of fixed volume. The xenon gas is heated at a constant rate and the internal energy increased by 450 J. The new temperature of the xenon gas is 41.7 °C.

(i) State the number of atoms in one mole of xenon.

[1]

(ii) Calculate the specific heat capacity of gaseous xenon–131.

[2]

(iii) Calculate the average kinetic energy of the molecules of xenon at this new temperature.

[2]

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(5 marks)

(c) The volume of the sealed container is 0.054 m^3.

Calculate the change in pressure of the gas due to the energy supplied in part (b).

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(4 marks)

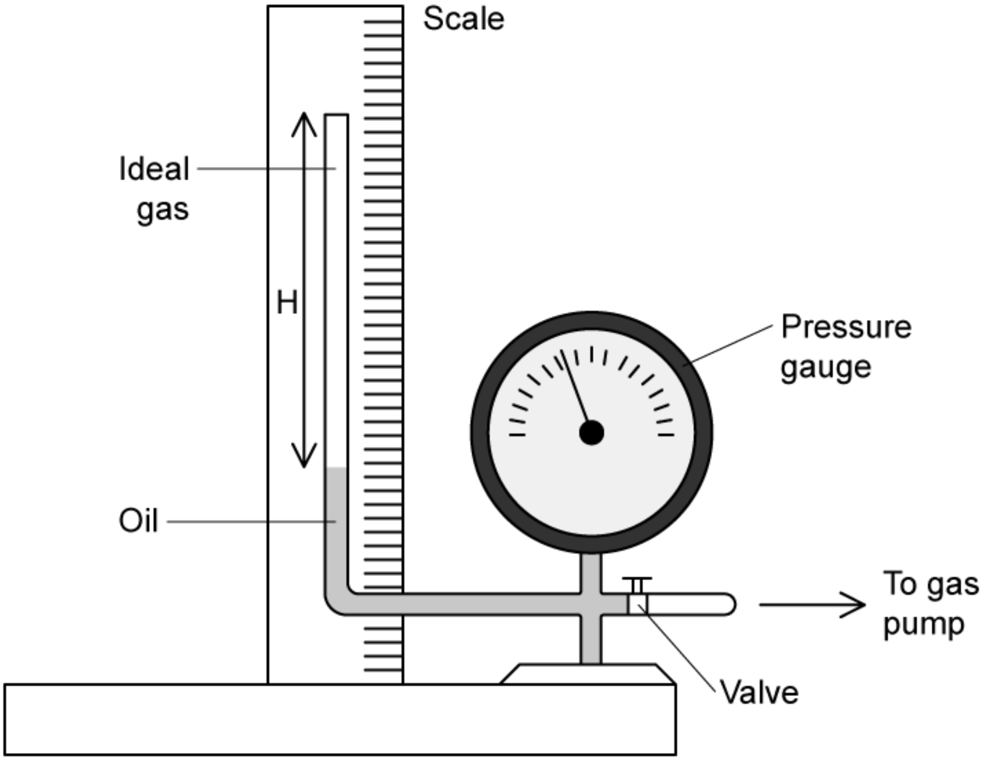
(d) One end of the container is replaced with a moveable piston. The piston is compressed until the pressure of the container is 67000 Pa. The temperature remains constant.

Determine the new volume of the container.

(3 marks)

4 (a) This question is about an experiment to investigate the variation in the pressure p of an ideal gas with changing volume V.

The gas is trapped in a cylindrical tube of radius 0.5 cm above a column of oil.



The pump forces the oil to move up the tube and so reduces the volume of the gas. The scientist measures the pressure p of the gas and the height H of the column of gas.

Calculate the volume of the gas when the height is 1 cm.

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(2 marks)

(b) When the system is at a constant temperature of 20 °C, the pressure is 9600 Pa.

Calculate:

(i) the amount of moles of gas trapped in the cylinder

[2]

(ii) the average kinetic energy of the molecules of trapped gas

[1]

(3 marks)

(c) The scientist plots their results of p against $\frac{1}{H}$ on a graph.

Describe the shape of the graph and explain why this is to be expected.

(3 marks)

(d) When conducting the experiment, the scientist waits for a period of time between taking each reading.

(i) Explain the reason for waiting this short period of time.

[1]

(ii) Describe what will happen to the shape of the graph if the scientist does not wait a sufficient period of time between readings.

[2]

(3 marks)

5 (a) State the Pressure law of ideal gases.

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....

(2 marks)

(b) The pressure exerted by an ideal gas containing 9.7×10^{20} molecules in a container of volume 1.5×10^{-5} m^3 is 2.8×10^5 Pa.

Calculate the temperature of the gas in the container in °C.

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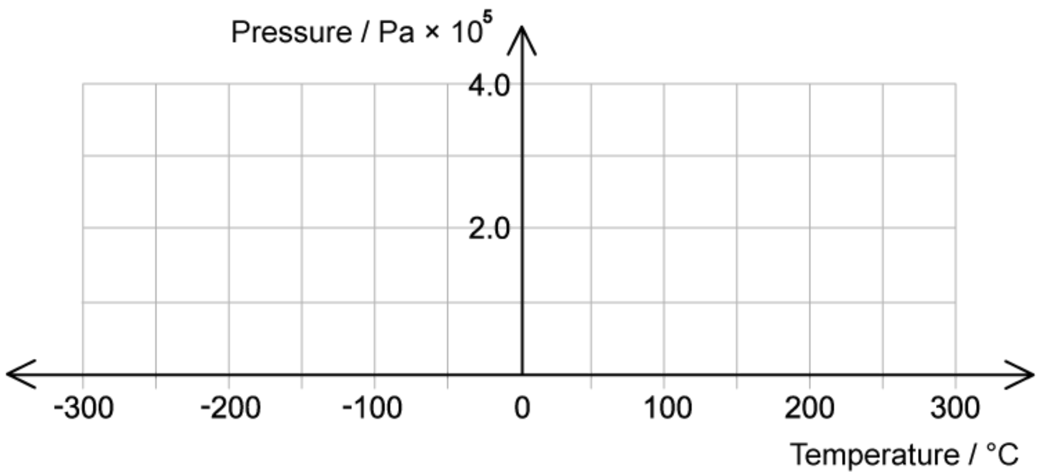
(3 marks)

(c) The pressure of the gas is measured at different temperatures whilst the volume of the container and the mass of the gas remain constant.



On the grid, sketch a graph to show how the pressure varies with the temperature.

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(3 marks)

Hard Questions

1 (a) A cylinder is fixed with an airtight piston containing an ideal gas of temperature 20 °C.

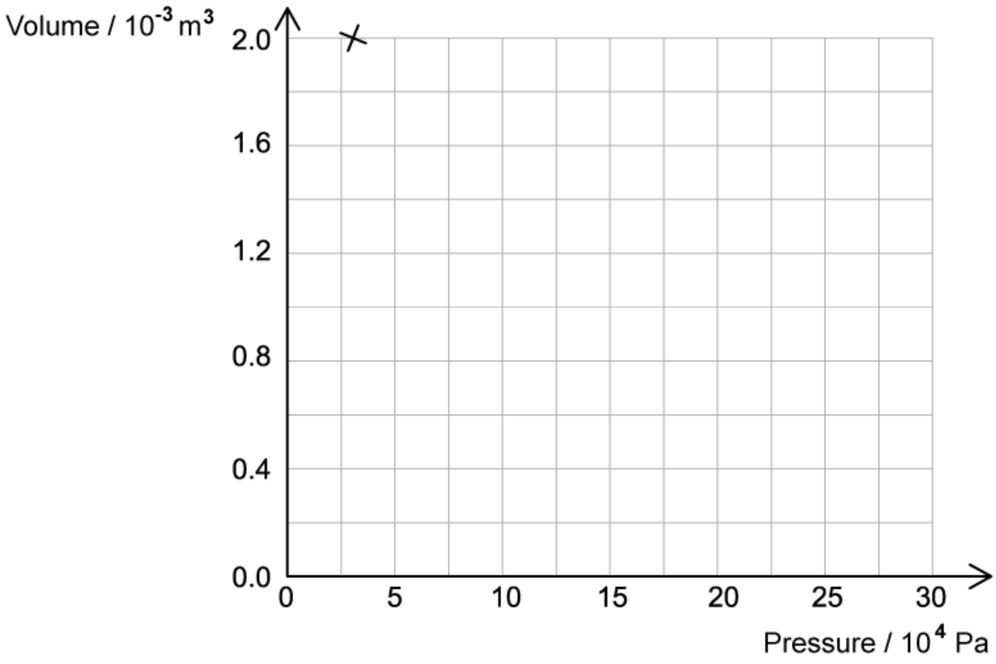
When the pressure, P in the cylinder is 3×10^4 Pa the volume, V is 2.0×10^{-3} m^3.

Calculate the number of gas molecules present in the cylinder.

(2 marks)

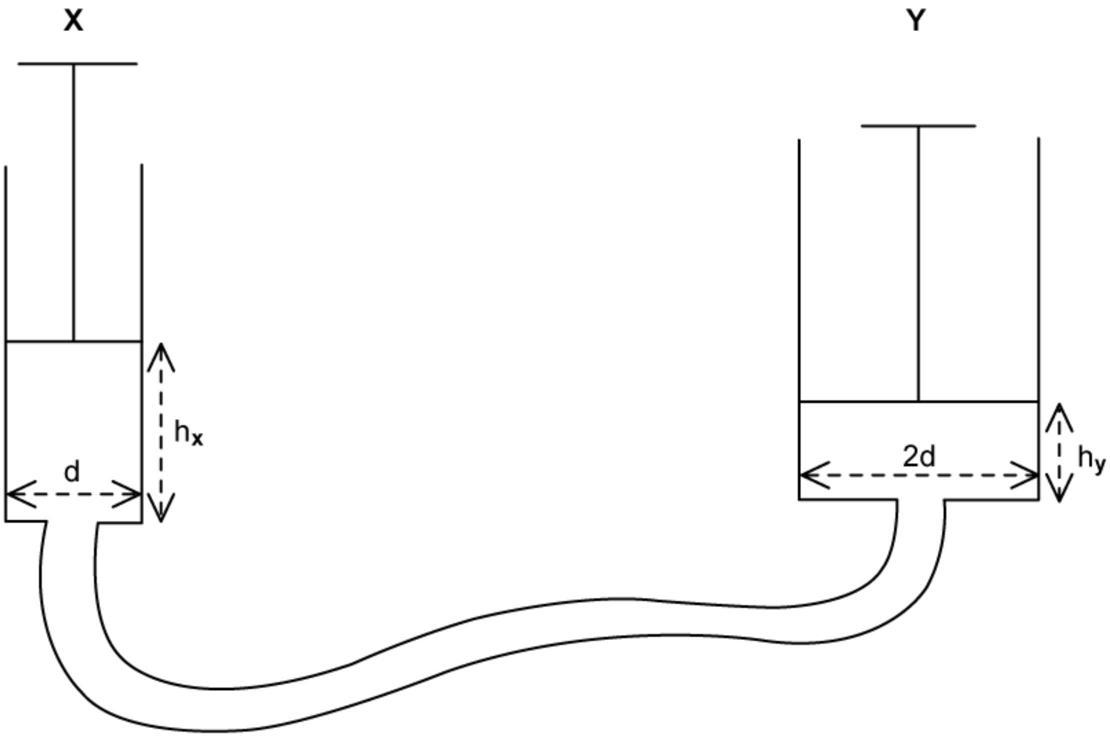
(b) The piston is slowly pushed in and the temperature of the gas remains constant.

Draw a graph by plotting three additional points on the axis to show the relationship between pressure and volume as the piston is slowly pushed in.



(2 marks)

(c) The cylinder, cylinder X is connected now to a second cylinder, cylinder Y which is initially fully compressed. Cylinder Y has a diameter two times that of the diameter of cylinder X. The total number of molecules in the system remains the same.



Cylinder X is pushed down by a distance Δh_x causing Y to move up a distance Δh_y. The pressure and temperature within the system both remain constant.

Determine the ratio $\Delta h_x : \Delta h_y$.

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(2 marks)

(d) Initially, the gas molecules are divided between both cylinders. The diameter, *d*, of cylinder X, is 16 cm. The piston in cylinder X is compressed at a constant rate until all of the gas is moved into cylinder Y over a period of 5 seconds.

Assume that the volume of the connecting tube is negligible.

(i) Sketch and label a graph to show how the length of the cylinder Y, h_y changes with time.

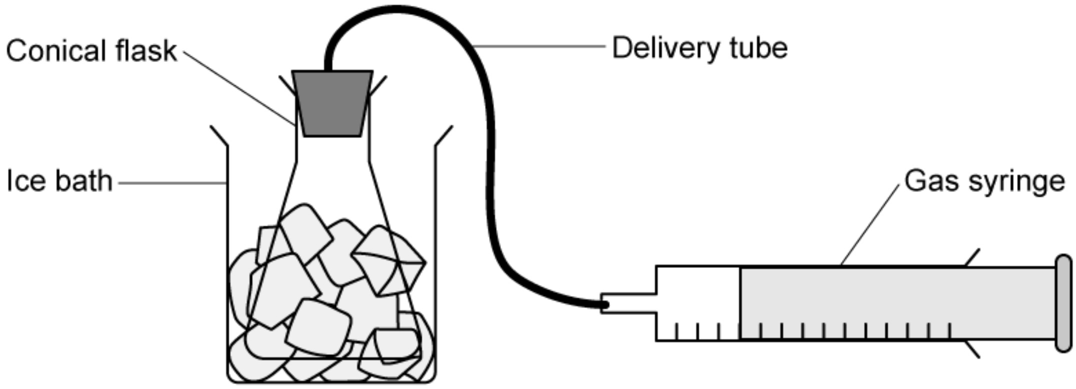
[3]

(ii) Calculate the power exerted during the compression.

[2]

(5 marks)

2 (a) A gas syringe is connected through a delivery tube to a conical flask, which is immersed in an ice bath. The syringe is frictionless so the gas pressure within the system remains equal to the atmospheric pressure 101 kPa.



The total volume of the conical flask and delivery tube is 275 cm^3, and after settling in the ice bath whilst the ice is melting the gas syringe has a volume of 25 cm^3.

Calculate the total number of moles contained within the system.

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(2 marks)

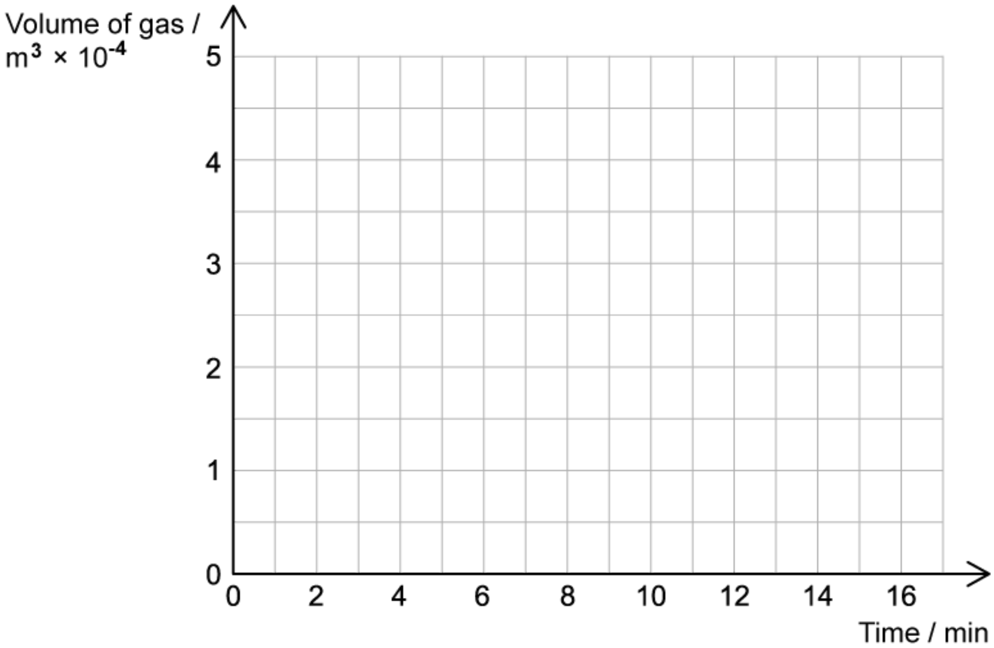
(b) When the ice bath is heated at a constant rate it takes the following time to melt the ice and heat the water:

- Time for ice to melt is 3 minutes
- Time from ice melting to water boiling is 10 minutes
- Time for water to boil is 3 minutes

(i) Calculate the volume of the gas when the surrounding water reaches its boiling point.

[1]

(ii) Sketch a graph on the axes below to show the process above.



[2]

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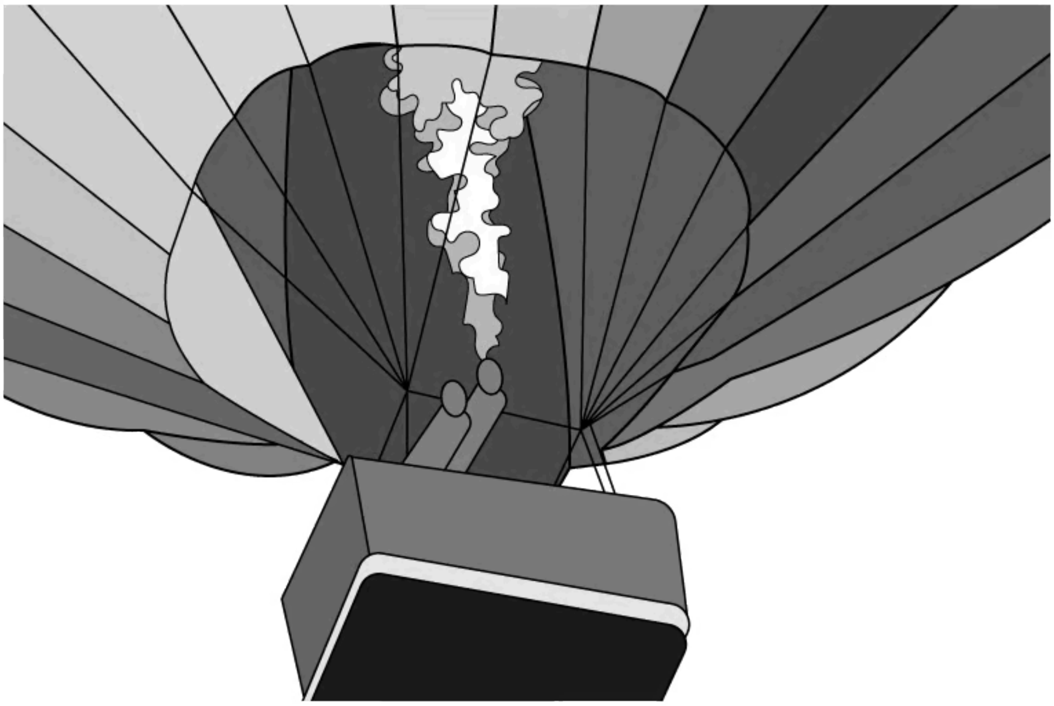
(3 marks)

(c) A burner in the base of a hot air balloon is used to heat the air inside the balloon.



The mass of the balloon can be reduced by releasing sand from the basket of the balloon.

(i) Explain how the burner is used so the balloon can rise.

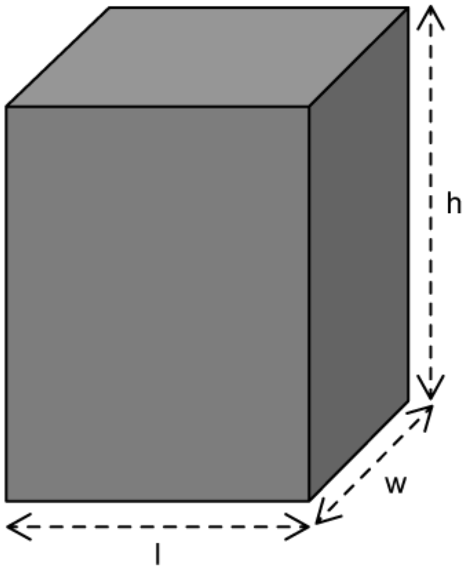
[3]

(ii) Explain how the forces on the balloon change with altitude and as the mass of the balloon decreases.

[3]

(7 marks)

3 (a) A sealed container C has the shape of a rectangular prism and contains an ideal gas. The dimensions of the container are *l*, *w* and *h*.



- The average force exerted by the gas on the bottom wall of the container is *F*
- There are *n* moles of gas in the container
- The temperature of the gas is *T*

Obtain an expression in terms of F, *n* and *T* for the height of the container.

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(2 marks)

(b) A second container D contains the same ideal gas. The pressure in D is a fifth of the pressure in C and the volume of D is four times the volume of C. In D there are three times fewer molecules than in C.

The temperature of cylinder D is 600 K.

Calculate the temperature of cylinder C in °C.

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(2 marks)

(c) The temperature of a different container *E* is 60 °C. At this temperature, the pressure exerted by the ideal gas is 1.75 × 10^5 Pa. The container is a cube and has a height of 4 cm.

Calculate the number of molecules of gas in this container.

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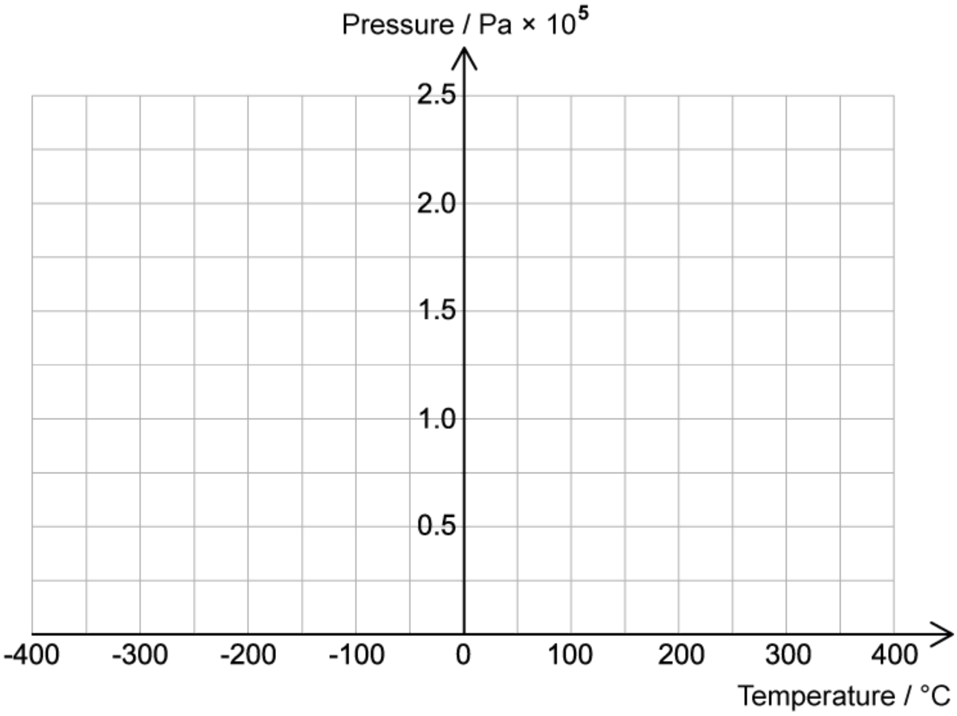
(3 marks)

(d) In a different container F the pressure of the gas is measured at different temperatures whilst the volume and number of moles are kept the same. At a temperature of 273 K the pressure is 125 kPa.

Plot a graph to show how the pressure varies with temperature for this gas.



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(2 marks)