1)

(a) Outline what is meant by an *ideal gas*.

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(2 marks)

(b) An ideal gas at a temperature of 22 °C is trapped in a metal cylinder of volume $0.20\,m^3$ at a pressure of 1.6×10^6 Pa.

(b) (i) Calculate the number of moles of gas contained in the cylinder.

number of moles ..... mol

(2 marks)

(b) (ii) The gas has a molar mass of $4.3 \times 10^{-2}\,kg\,mol^{-1}$.

Calculate the density of the gas in the cylinder.

State an appropriate unit for your answer.

density ..... unit .....

(3 marks)

(b) (iii) The cylinder is taken to high altitude where the temperature is –50 °C and the pressure is 3.6×10^4 Pa. A valve on the cylinder is opened to allow gas to escape.

Calculate the mass of gas remaining in the cylinder when it reaches equilibrium with its surroundings.

Give your answer to an appropriate number of significant figures.

mass ..... kg

(3 marks)

2)

(i) State **two** assumptions about the **movement** of molecules that are used when deriving the equation of state, $pV = \frac{1}{3} N m (c_{rms})^2$ for an ideal gas.

[2 marks]

1 .....

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2 .....

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(ii) Three molecules move at the speeds shown in **Table 2**.

Table 2

molecule	speed / m s^{-1}
1	2000
2	3000
3	7000

Calculate their mean square speed.

[1 mark]

mean square speed ..... $m^2 s^{-2}$

(b) (i) State **two** assumptions about the **movement** of molecules that are used when deriving the equation of state, $pV = \frac{1}{3} N m (c_{rms})^2$ for an ideal gas.

[2 marks]

1 .....

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2 .....

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(b) (ii) Three molecules move at the speeds shown in **Table 2**.

Table 2

molecule	speed / m s^{-1}
1	2000
2	3000
3	7000

Calculate their mean square speed.

[1 mark]

mean square speed ..... $m^2 s^{-2}$

(c) The average molecular kinetic energy of an ideal gas is 6.6×10^{-21} J.
Calculate the temperature of the gas.

[2 marks]

temperature ..... K

3)

(a) Define the Avogadro constant.

[1 mark]

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(b) (i) Calculate the mean kinetic energy of krypton atoms in a sample of gas at a temperature of 22 °C.

[1 mark]

mean kinetic energy ..... J

(b) (ii) Calculate the mean-square speed, $(c_{rms})^2$, of krypton atoms in a sample of gas at a temperature of 22 °C.
State an appropriate unit for your answer.

mass of 1 mole of krypton = 0.084 kg

[3 marks]

mean-square speed..... unit .....

(c) A sample of gas consists of a mixture of krypton and argon atoms.
The mass of a krypton atom is greater than that of an argon atom.
State and explain how the mean-square speed of krypton atoms in the gas compares with that of the argon atoms at the same temperature.

[2 marks]

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4)

(a) 'The pressure of an ideal gas is inversely proportional to its volume', is an incomplete statement of Boyle's law.

State **two** conditions necessary to complete the statement.

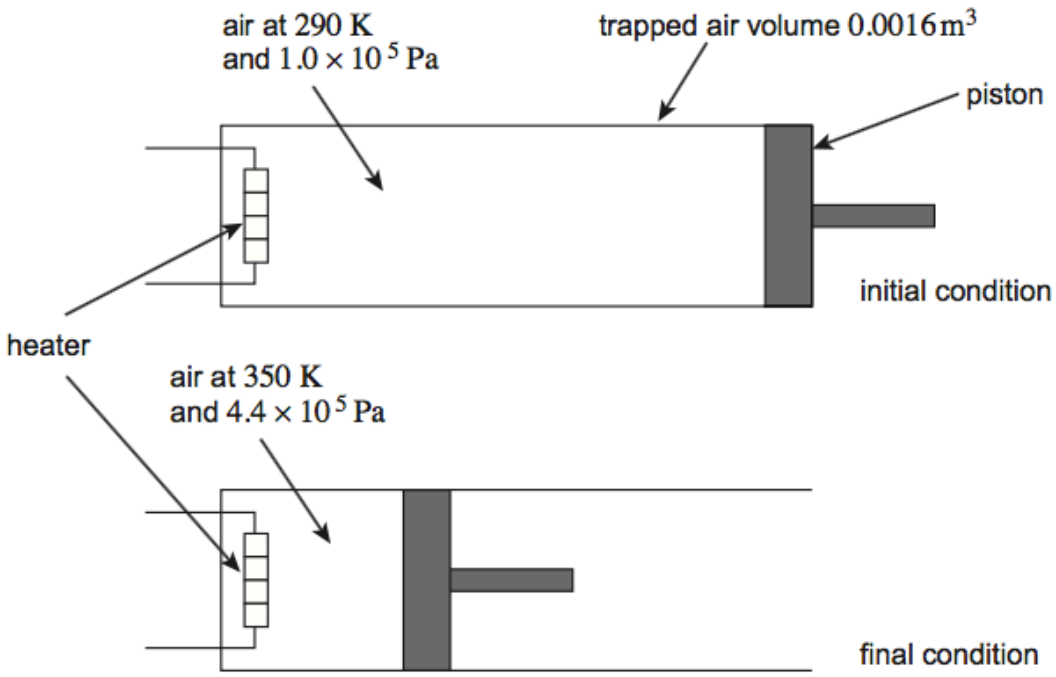
[2 marks]

1 _____

2 _____

(b) A volume of $0.0016\ m^3$ of air at a pressure of 1.0×10^5 Pa and a temperature of 290 K is trapped in a cylinder. Under these conditions the volume of air occupied by 1.0 mol is $0.024\ m^3$. The air in the cylinder is heated and at the same time compressed slowly by a piston. The initial condition and final condition of the trapped air are shown in **Figure 4**.

Figure 4



In the following calculations treat air as an ideal gas having a molar mass of $0.029\ kg\ mol^{-1}$.

(b) (i) Calculate the final volume of the air trapped in the cylinder.

[2 marks]

volume of air = _____ m^3

(b) (ii) Calculate the number of moles of air in the cylinder.

[1 mark]

number of moles = _____

(b) (iii) Calculate the initial density of air trapped in the cylinder.

[2 marks]

density = _____ kg m^{-3}

(c) State and explain what happens to the speed of molecules in a gas as the temperature increases.

[2 marks]

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5)

(a) The concept of an absolute zero of temperature may be explained by reference to the behaviour of a gas.
Discuss **one** experiment that can be performed using a gas which would enable you to explain absolute zero and determine its value.
It is not necessary to give full details of the apparatus. Your answer should:

- include the quantities that are kept constant
- identify the measurements to be taken
- explain how the results may be used to find absolute zero
- justify why the value obtained is absolute zero.

The quality of your written communication will be assessed in your answer.

[6 marks]

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6)

Figure 1

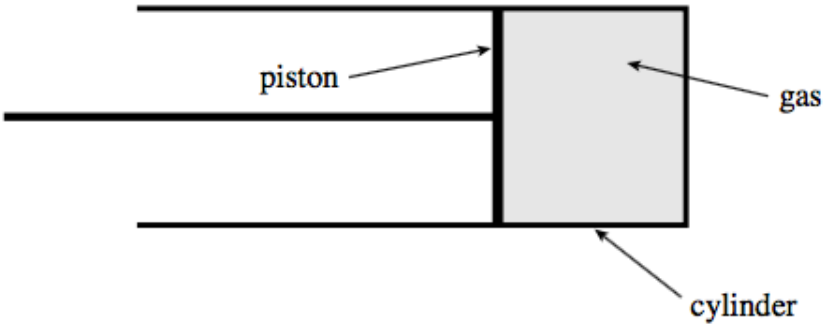
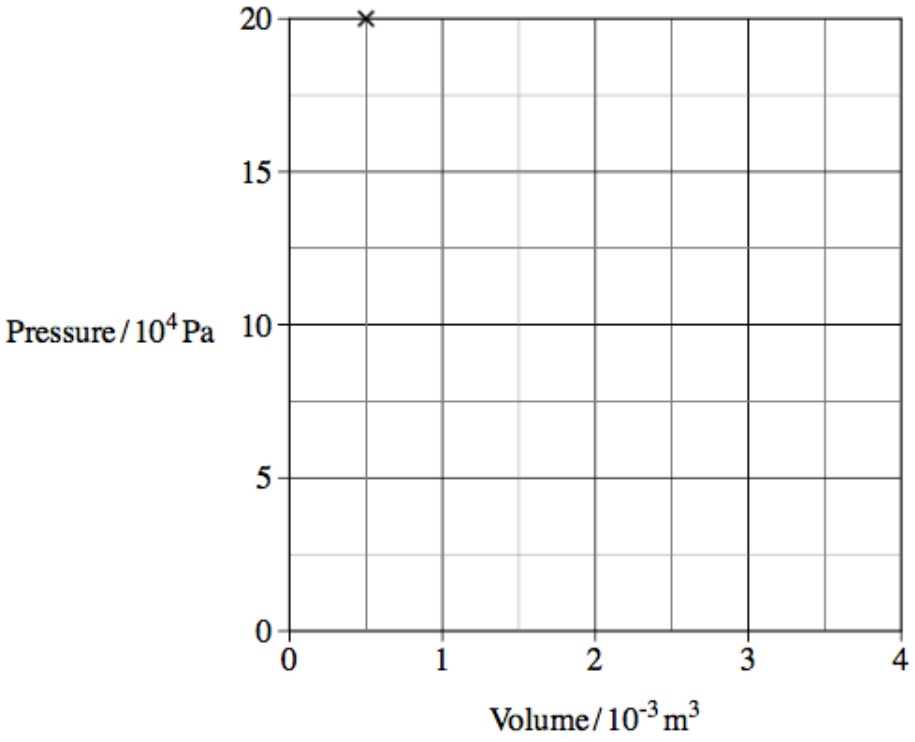


Figure 1 shows a cylinder, fitted with a gas-tight piston, containing an ideal gas at a constant temperature of 290 K. When the pressure, p, in the cylinder is 20×10^4 Pa the volume, V, is 0.5×10^{-3} m^3.

Figure 2 shows this data plotted.

Figure 2



(a) By plotting two or three additional points draw a graph, on the axes given in **Figure 2**, to show the relationship between pressure and volume as the piston is slowly pulled out. The temperature of the gas remains constant.

(3 marks)

(b) (i) Calculate the number of gas molecules in the cylinder.

answer = ... molecules
(2 marks)

(b) (ii) Calculate the total kinetic energy of the gas molecules.

answer = ... J
(3 marks)

(c) State **four** assumptions made in the molecular kinetic theory model of an ideal gas.

(i) .....

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(ii) .....

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(iii) .....

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(iv) .....

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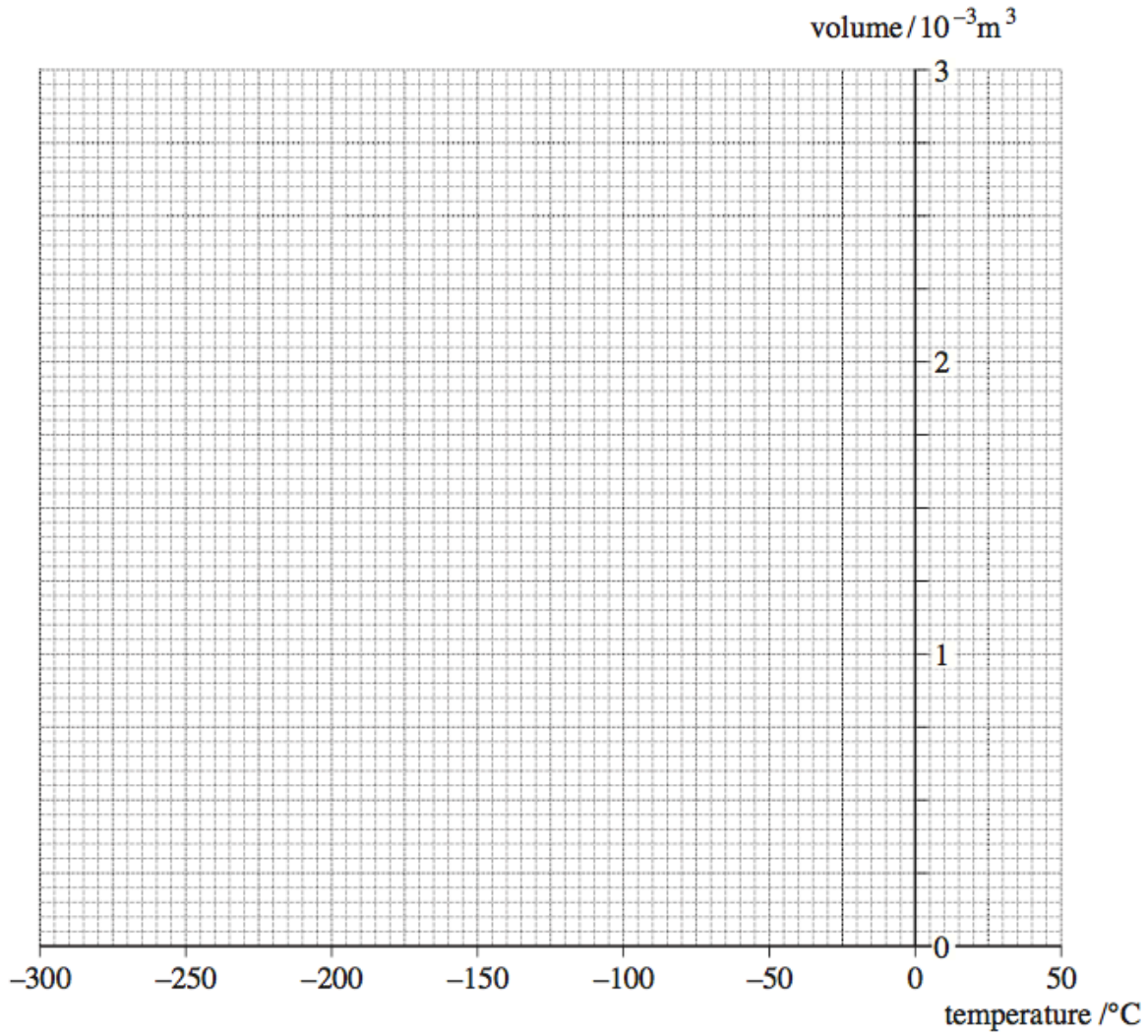
(4 marks)

7)

A fixed mass of ideal gas at a low temperature is trapped in a container at constant pressure. The gas is then heated and the volume of the container changes so that the pressure stays at 1.00×10^5 Pa.
When the gas reaches a temperature of 0 °C the volume is 2.20×10^{-3} m^3.

(a) Draw a graph on the axes below to show how the volume of the gas varies with temperature in °C.



(2 marks)

(b) Calculate the number of moles of gas present in the container.

answer = ...moles
(2 marks)

(c) Calculate the average kinetic energy of a molecule when this gas is at a temperature of 50.0 °C. Give your answer to an appropriate number of significant figures.

answer = ...J

(3 marks)

(d) Calculate the total internal energy of the gas at a temperature of 50.0 °C.

answer = ...J

(1 mark)

(e) By considering the motion of the molecules explain how a gas exerts a pressure and why the volume of the container must change if the pressure is to remain constant as the temperature increases.

The quality of your written communication will be assessed in this question.

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(6 marks)

8)

The pressure inside a bicycle tyre of volume $1.90 \times 10^{-3}\,m^3$ is $3.20 \times 10^5\,Pa$ when the temperature is 285 K.

(a) (i) Calculate the number of moles of air in the tyre.

answer = ... mol

(1 mark)

(a) (ii) After the bicycle has been ridden the temperature of the air in the tyre is 295 K.
Calculate the new pressure in the tyre assuming the volume is unchanged.
Give your answer to an appropriate number of significant figures.

answer = ... Pa

(3 marks)

(b) Describe **one** way in which the motion of the molecules of air inside the bicycle tyre is similar and **one** way in which it is different at the two temperatures.

similar .....

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different .....

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(2 marks)