Do not write outside the box

## Section A

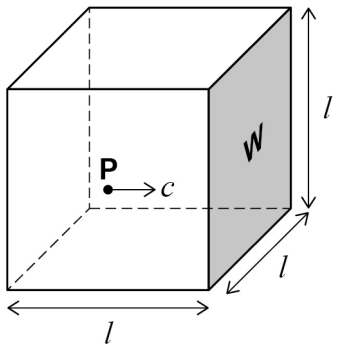
Answer **all** questions in this section.

**0 1 . 1** State what is meant by the internal energy of an ideal gas.

**[1 mark]**

**Figure 1** shows a single gas particle **P** of an ideal gas inside a hollow cube.

**Figure 1**




The cube has side length $l$ and volume $V$.
**P** has mass $m$ and is travelling at a velocity $c$ perpendicular to side **W**.

**0 1 . 2** Explain why **P** has a change in momentum of $-2mc$ during one collision with **W**.

**[1 mark]**

**0 1 . 3** **P** collides repeatedly with **W**.

Show that the frequency $f$ of collisions is $\frac{c}{2l}$.

**[1 mark]**

**0 1 . 4** Deduce an expression, in terms of $m$, $c$ and $V$, for the contribution of **P** to the pressure exerted on **W**.
Refer to appropriate Newton's laws of motion.

**[2 marks]**

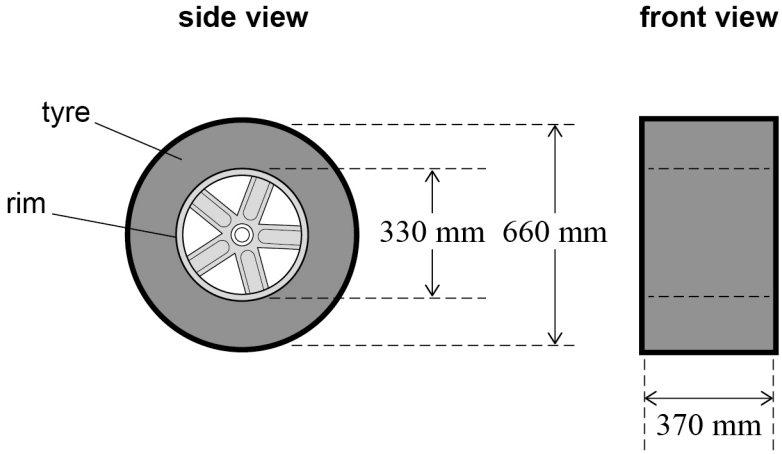
5

**Turn over for the next question**

**0 2** **Figure 2** shows a wheel used in motorsport. A rubber tyre is fitted around a cylindrical metal rim. The tyre is filled with a gas.
The dimensions shown in **Figure 2** are for the volume of the gas in the tyre.

Assume that this volume remains constant throughout this question.

**Figure 2**




**0 2 . 1** The mass of the wheel is measured when the gas in the tyre is at a pressure of $1.01 \times 10^5$ Pa.
More of the same gas is added to the tyre and the mass of the wheel is measured again.

**Table 1** shows the pressure in the tyre and the mass of the wheel before and after the addition of the extra gas.
The gas is kept at a constant temperature of 100 °C.

**Table 1**

| | **Pressure in tyre / Pa** | **Mass of wheel / kg** |
|---|---|---|
| Before | $1.01 \times 10^5$ | 14.897 |
| After | $2.11 \times 10^5$ | 14.991 |

Determine, in $\mathrm{kg\ mol^{-1}}$, the molar mass of the gas.

**[5 marks]**

molar mass = _____ $\mathrm{kg\ mol^{-1}}$

**0 2 . 2** Motorsport regulations specify a minimum amount of gas in the tyre.

The amount of gas in the tyre is checked by measuring the pressure before the wheel is put onto the car. The regulations also specify a maximum temperature for the tyre when making this measurement.

Explain why a maximum temperature is specified.

**[2 marks]**

_____

_____

_____

_____

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_____

**7**

## Section B

Each of Questions **08** to **32** is followed by four responses, **A**, **B**, **C** and **D**.

For each question select the best response.

Only **one** answer per question is allowed.
For each question, completely fill in the circle alongside the appropriate answer.

CORRECT METHOD 

WRONG METHODS 

If you want to change your answer you must cross out your original answer as shown. 

If you wish to return to an answer previously crossed out, ring the answer you now wish to select as shown. 

You may do your working in the blank space around each question but this will not be marked. Do **not** use additional sheets for this working.

**0 8** A $1000\ \text{W}$ heater is $75\%$ efficient. The heater is used to increase the temperature of some water from $10\ ^\circ\text{C}$ to $85\ ^\circ\text{C}$ in $7$ hours.

What mass of water is heated?

specific heat capacity of water $= 4200\ \text{J kg}^{-1}\ \text{K}^{-1}$

**[1 mark]**

**A** $1.0\ \text{kg}$ ⬭

**B** $13\ \text{kg}$ ⬭

**C** $60\ \text{kg}$ ⬭

**D** $110\ \text{kg}$ ⬭

**0 9** Which can lead to a value for the absolute zero of temperature?

**[1 mark]**

**A** Boyle's law ⬭

**B** Brownian motion ⬭

**C** Charles's law ⬭

**D** Rutherford scattering ⬭

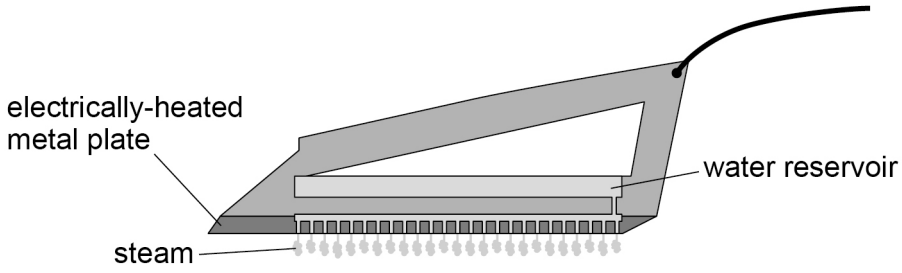
*Do not write outside the box*

## Section A

Answer **all** questions in this section.

**0 1** **Figure 1** shows an electric steam iron.

**Figure 1**




Water from a reservoir drips onto an electrically-heated metal plate. The water boils and steam escapes through holes in the metal plate.

The electrical power of the heater inside the iron is $2.1\ \text{kW}$.

Assume that all the energy from the heater is transferred to the metal plate.

**0 1 . 1** The metal plate has a mass of $1.2\ \text{kg}$ and is initially at a temperature of $20\ °\text{C}$. The heater is switched on. After a time $t$ the metal plate reaches its working temperature of $125\ °\text{C}$.

Calculate $t$.

specific heat capacity of the metal = $450\ \text{J kg}^{-1}\ \text{K}^{-1}$

**[2 marks]**

$t$ = _____ s

**0 1 . 2** The metal plate is maintained at its working temperature.
Water at $20\ °C$ drips continuously onto the metal plate.
Steam at $100\ °C$ emerges continuously from the iron.

The maker claims that the iron can generate steam at a rate of $60\ g\ min^{-1}$.

Determine whether this claim is true.

specific latent heat of vaporisation of water = $2.3 \times 10^6\ J\ kg^{-1}$
specific heat capacity of water = $4200\ J\ kg^{-1}\ K^{-1}$

**[3 marks]**

5

**0 2 . 1** In the kinetic theory model, it is assumed that there are many identical particles moving at random.

State **two** other assumptions made in deriving the equation $pV = \frac{1}{3}Nm\,(c_{\text{rms}})^2$.

**[2 marks]**

1 _____

_____

_____

2 _____

_____

_____

**0 2 . 2** Explain why molecules of a gas exert a force on the walls of a container.
Refer to Newton's laws of motion in your answer.

**[3 marks]**

_____

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_____

**0 2 . 3** A sealed flask of volume $0.35\ \text{m}^3$ contains an ideal gas at a pressure of $220\ \text{kPa}$. The mean kinetic energy of the gas molecules is $6.7 \times 10^{-21}\ \text{J}$.

Calculate the amount of gas in the container.

**[3 marks]**

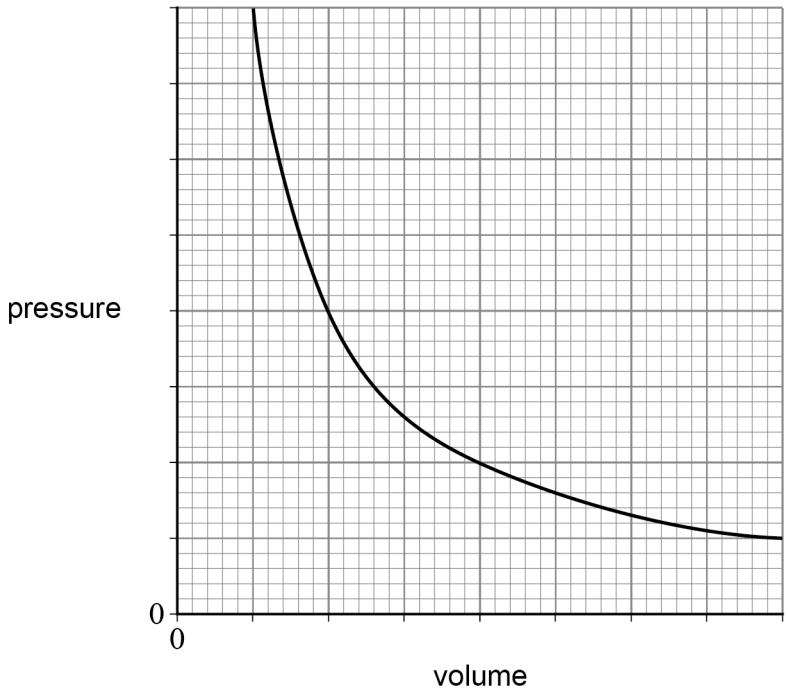
amount of gas = _____ mol

**0 2 . 4** **Figure 2** shows the variation of pressure with volume for a fixed mass of an ideal gas at constant absolute temperature $T$.

Draw, on **Figure 2**, the graph for the same gas at temperature $2T$.

**[2 marks]**

**Figure 2**




10

## Section B

Each of Questions **07** to **31** is followed by four responses, **A**, **B**, **C** and **D**.

For each question select the best response.

Only **one** answer per question is allowed.
For each question, completely fill in the circle alongside the appropriate answer.

CORRECT METHOD  WRONG METHODS 

If you want to change your answer you must cross out your original answer as shown. 

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You may do your working in the blank space around each question but this will not be marked. Do **not** use additional sheets for this working.

**0 7** An ideal gas, initially at $300\ \mathrm{K}$, is compressed to half its original volume. It is then cooled at constant volume until the pressure is restored to its initial value.

What is the final temperature of the gas?

**[1 mark]**

**A** $150\ \mathrm{K}$ ⬭

**B** $200\ \mathrm{K}$ ⬭

**C** $300\ \mathrm{K}$ ⬭

**D** $600\ \mathrm{K}$ ⬭

**0 8** A fixed volume of an ideal gas is heated.

Which row gives quantities that double when the kelvin temperature of the gas doubles?

**[1 mark]**

| | | | |
|---|---|---|---|
| **A** | rms speed of the molecules | pressure of the gas | ⬭ |
| **B** | density of the gas | rms speed of the molecules | ⬭ |
| **C** | internal energy of the gas | density of the gas | ⬭ |
| **D** | pressure of the gas | internal energy of the gas | ⬭ |

**0 9** A planet of radius $R$ and mass $M$ has a gravitational field strength of $g$ at its surface.

Which row describes a planet with a gravitational field strength of $4g$ at its surface?

**[1 mark]**

| | **Radius of planet** | **Mass of planet** | |
|---|---|---|---|
| **A** | $2R$ | $2M$ | ⬭ |
| **B** | $R\sqrt{2}$ | $\frac{M}{2}$ | ⬭ |
| **C** | $\frac{R}{\sqrt{2}}$ | $\frac{M}{2}$ | ⬭ |
| **D** | $\frac{R}{\sqrt{2}}$ | $2M$ | ⬭ |