AQA

Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

I declare this is my own work.

GCSE
COMBINED SCIENCE: SYNERGY

H

Higher Tier Paper 4 Physical Sciences

Friday 13 June 2025 Morning Time allowed: 1 hour 45 minutes

Materials

For this paper you must have:
- a ruler
- a protractor
- a scientific calculator
- the periodic table (enclosed)
- the Physics Equations Sheet (enclosed).

Instructions
- Use black ink or black ball-point pen.
- Pencil should only be used for drawing.
- Fill in the boxes at the top of this page.
- Answer **all** questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- Do all rough work in this book. Cross through any work you do not want to be marked.
- In all calculations, show clearly how you work out your answer.

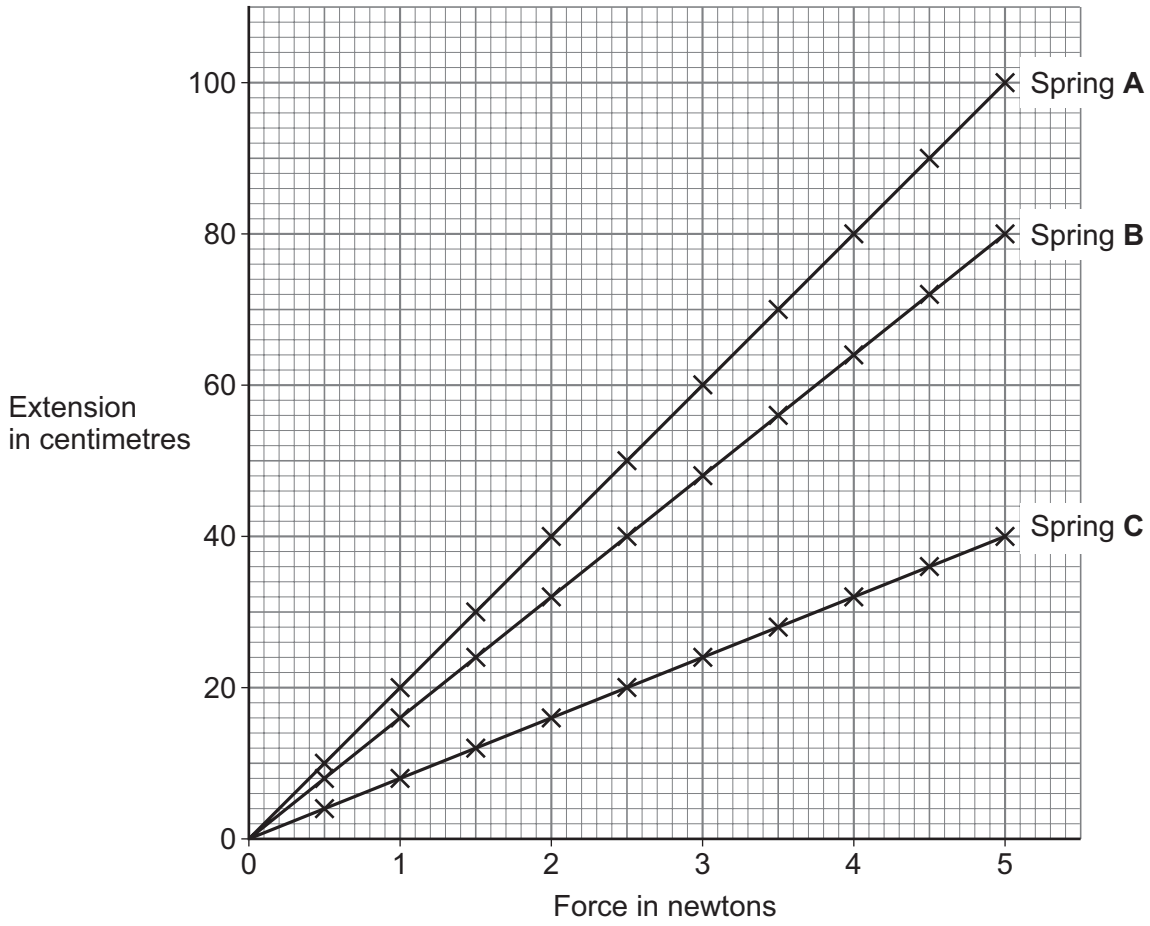
For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
TOTAL	

Information
- The maximum mark for this paper is 100.
- The marks for questions are shown in brackets.
- You are expected to use a calculator where appropriate.
- You are reminded of the need for good English and clear presentation in your answers.

Do not write outside the box

0 1 **Figure 1** shows how the extension of three different springs varies with the force applied to each spring.

Figure 1



0 1 . 1 Describe the relationship between force and extension for spring **A**.

[2 marks]

Do not write outside the box

0 1 . 2 Which spring in **Figure 1** has the greatest spring constant?

Give a reason for your answer.

[2 marks]

Tick (✓) **one** box.

Spring **A** ☐ Spring **B** ☐ Spring **C** ☐

Reason _____

_____

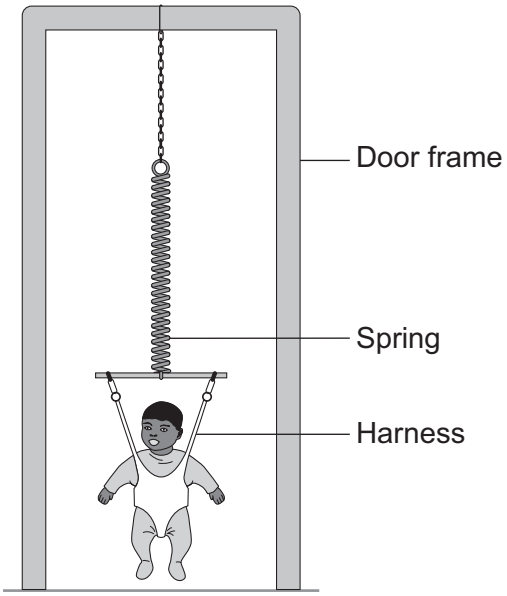
Question 1 continues on the next page

Figure 2 shows a baby in a ‘baby-bouncer’.

The baby sits in a harness which is held by a spring.

When the baby jumps, the baby bounces up and down.

Figure 2



Do not write outside the box

0 1 . 3 The spring of the baby-bouncer is extended by 0.60 m.

The elastic potential energy stored by the spring is 75.6 J.

Calculate the spring constant of the spring.

Use the Physics Equations Sheet.

Choose the unit from the box.

N m	**N/m**	**N/m^2**

[4 marks]

Spring constant = _____ Unit _____

0 1 . 4 The spring does **not** extend past the limit of proportionality when the baby is in the baby-bouncer.

How does the work done to stretch the spring compare with the elastic potential energy stored in the spring?

[1 mark]

Tick (✓) **one** box.

Work done is less than elastic potential energy stored. ☐

Work done is equal to elastic potential energy stored. ☐

Work done is greater than elastic potential energy stored. ☐

9

0 2 This question is about acids and alkalis.

Universal indicator is used to measure the pH of solutions.

Figure 3 shows the colours of universal indicator at different pH values.

Figure 3

Colour	pH value
Red	1 2 3
Orange	4 5
Green	6 7 8
Blue	9 10 11
Purple	12 13 14

A student added universal indicator to nitric acid in a beaker.

The student added drops of potassium hydroxide solution to the nitric acid until pH 7 was reached.

0 2 . 1 The student could **not** be sure that the pH of the mixture was 7

Give **one** reason why.

Use **Figure 3**.

[1 mark]

_____

_____

0 2 . 2 Name a piece of equipment that could be used to give a more accurate measurement of pH.

[1 mark]

_____

0 2 . 3 Name the type of reaction when potassium hydroxide solution reacts with nitric acid.

[1 mark]

_____

0 2 . 4 The formula of nitric acid is HNO_3

Calculate the relative formula mass (M_r) of nitric acid.

Relative atomic masses (A_r): H = 1 N = 14 O = 16

[2 marks]

_____

_____

_____

Relative formula mass = _____

Do not write outside the box

0 2 . 5 Potassium hydroxide is an alkali.

Which ion do all alkalis contain?

[1 mark]

Tick (✓) **one** box.

H^+ ☐ K^+ ☐ O^{2-} ☐ OH^- ☐

0 2 . 6 The concentration of the solution of potassium hydroxide was 5.6 g/dm^3.

Calculate the mass of potassium hydroxide in 5 cm^3 of the solution.

1 dm^3 = 1000 cm^3

[3 marks]

Mass = _____ g

9

Do not write outside the box

Turn over for the next question

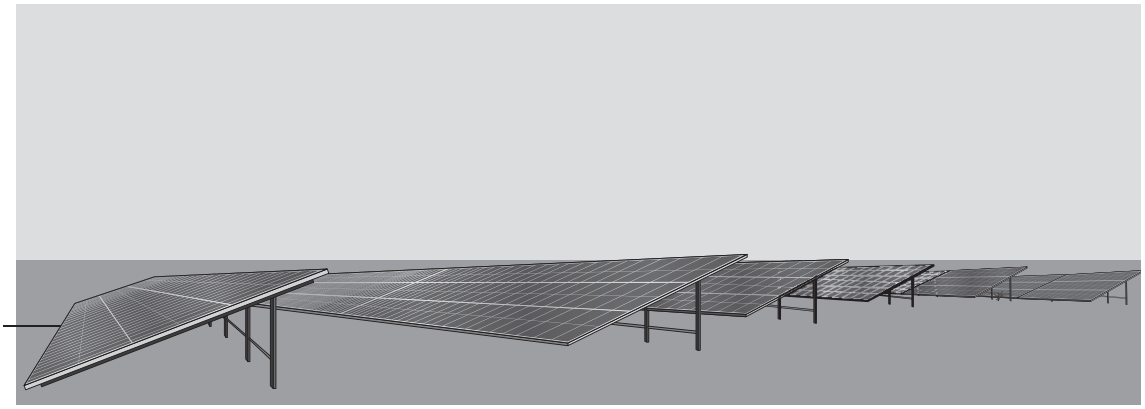
DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Do not write outside the box

0 3 **Figure 4** shows solar panels in a field on a small remote island.

The solar panels provide electricity to a small village.

Figure 4



0 3 . 1 On a sunny day, the power input to the solar panels is 468 000 W.

The total area of the solar panels is 720 m^2.

Calculate the power input to an area of 1 m^2 of the solar panels.

[2 marks]

Power input to 1 m^2 = _____ W

Do not write outside the box

Use the Physics Equations Sheet to answer questions **03.2** and **03.3**.

0 3 . 2 Which equation links efficiency, total power input and useful power output?

[1 mark]

Tick (✓) **one** box.

efficiency = $\frac{\text{useful power output}}{\text{total power input}}$ ☐

efficiency = $\frac{\text{total power input}}{\text{useful power output}}$ ☐

efficiency = total power input × useful power output ☐

0 3 . 3 On a cloudy day, the total power input to the solar panels is 250 000 W.

The efficiency of the solar panels is 0.20

Calculate the useful power output of the solar panels.

[3 marks]

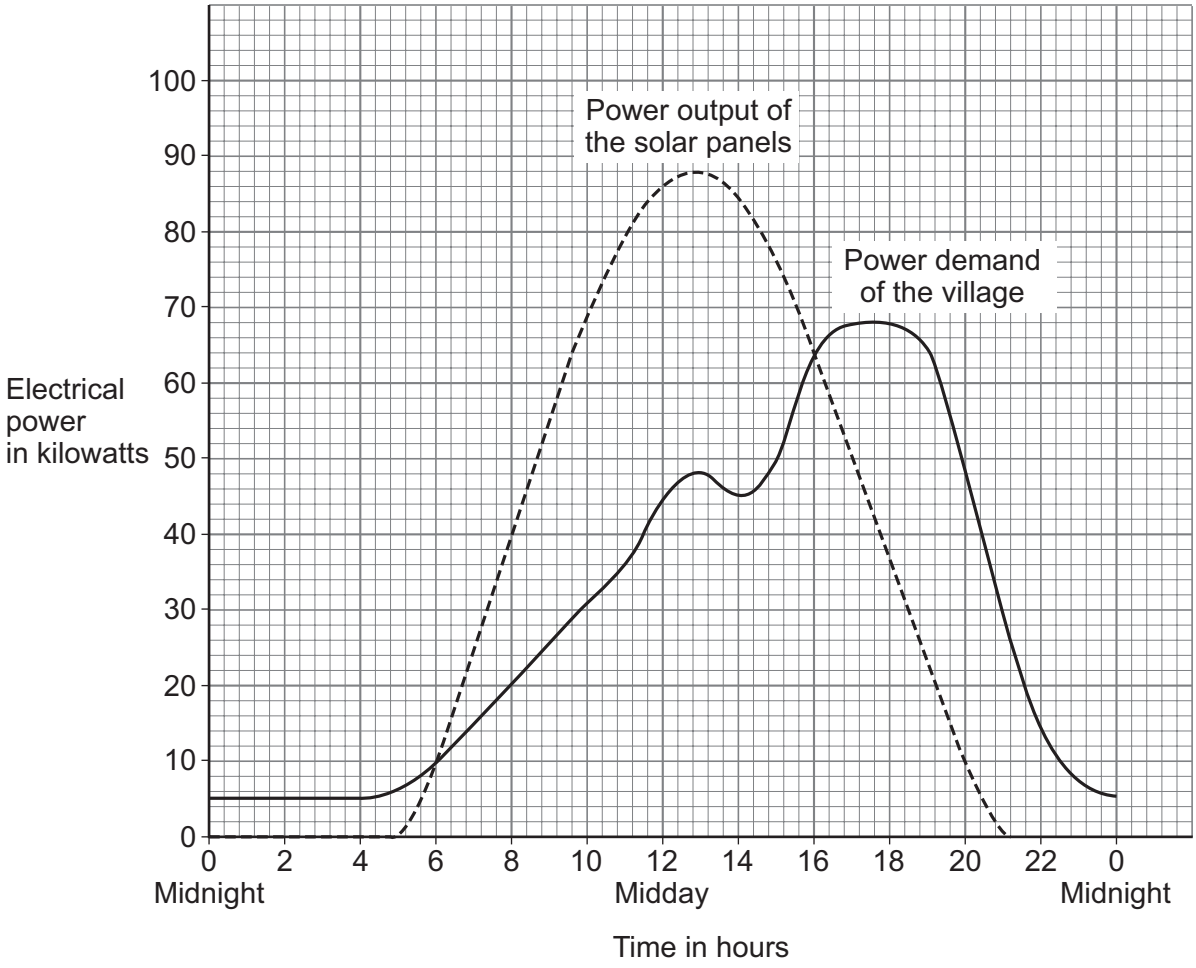
Useful power output = _____ W

Question 3 continues on the next page

Figure 5 shows during one day:

- the electrical power demand of the village
- the electrical power output of the solar panels.

Figure 5



0 3 . 4 Determine for how much time the electrical power demand was greater than the electrical power output.

[2 marks]

Time = _____ hours

Do not write outside the box

0 3 . 5 A large battery is used to store excess energy from the solar panels.

The battery transfers power to the village when the power output of the solar panels is less than the demand.

The village is **not** connected to the National Grid.

Explain why the village needs the solar panels **and** the battery for a continuous electricity supply.

Use information from **Figure 5**.

[4 marks]

Extra space

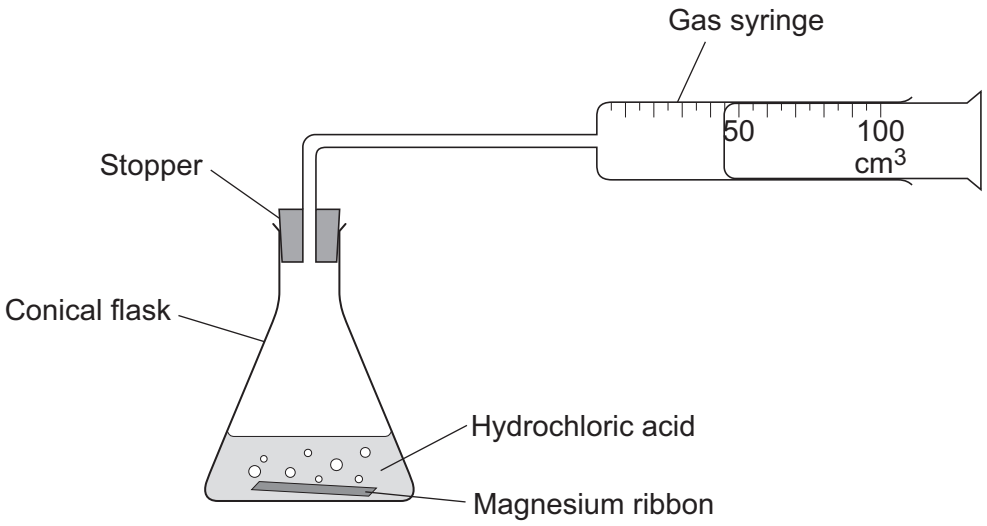
12

Turn over for the next question

0 4 A student investigated how the surface area of magnesium affects the rate of the reaction between magnesium and hydrochloric acid.

Figure 6 shows the apparatus.

Figure 6



This is the method used.

1. Add 50 cm^3 of hydrochloric acid to the conical flask.
2. Add 0.07 g of magnesium ribbon to the hydrochloric acid.
3. Insert the stopper into the conical flask as quickly as possible.
4. Start a stopclock.
5. Record the volume of gas collected in the gas syringe every 15 seconds for 90 seconds.
6. Repeat steps 1 to 5 with 0.07 g of magnesium powder.

Do not write outside the box

0 4 . 1 Why is the stopper inserted into the conical flask as quickly as possible in step 3?

[1 mark]

_____

_____

0 4 . 2 Give **one** control variable in the investigation.

[1 mark]

_____

_____

0 4 . 3 Why do some variables in an investigation need to be controlled?

[1 mark]

Tick (✓) **one** box.

To ensure the investigation is valid. ☐

To make the investigation safe. ☐

To prevent a systematic error. ☐

Question 4 continues on the next page

Do not write outside the box

0 4 . 4 **Table 1** shows the results for magnesium ribbon.

Table 1

Time in seconds	Volume of gas collected in cm^3
0	0
15	41
30	57
45	59
60	68
75	69
90	69

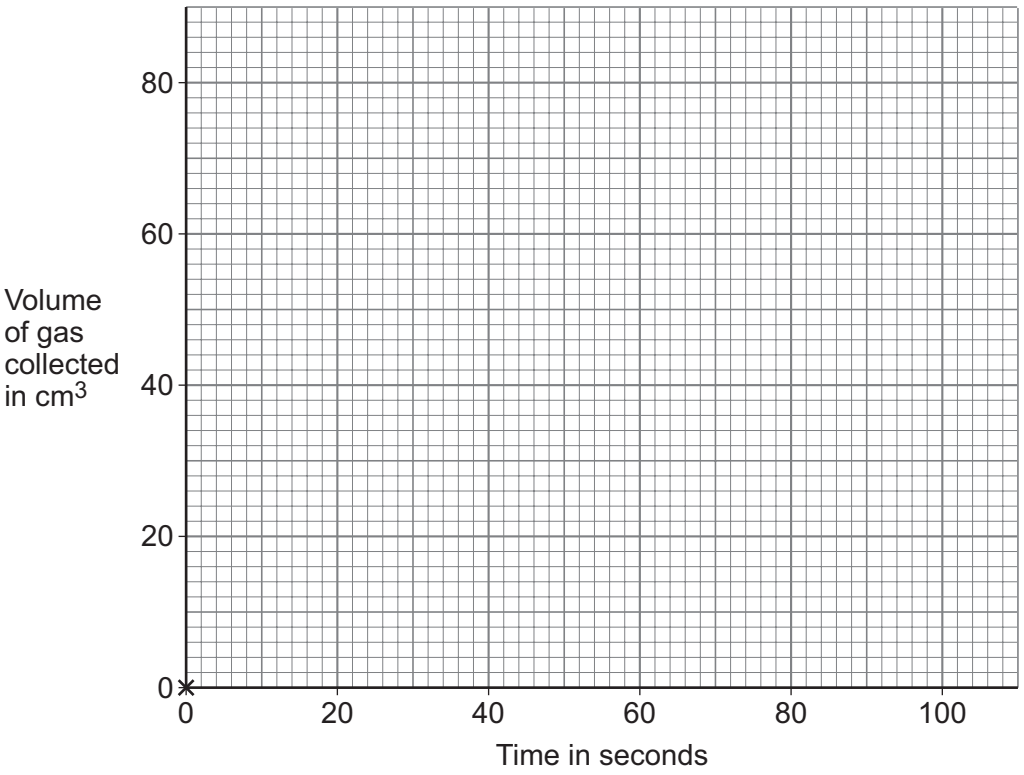
Do not write outside the box

Plot the data from **Table 1** on **Figure 7**.

Draw a line of best fit.

[3 marks]

Figure 7



0 4 . 5 Explain how the rate of reaction would be affected by using magnesium powder instead of magnesium ribbon.

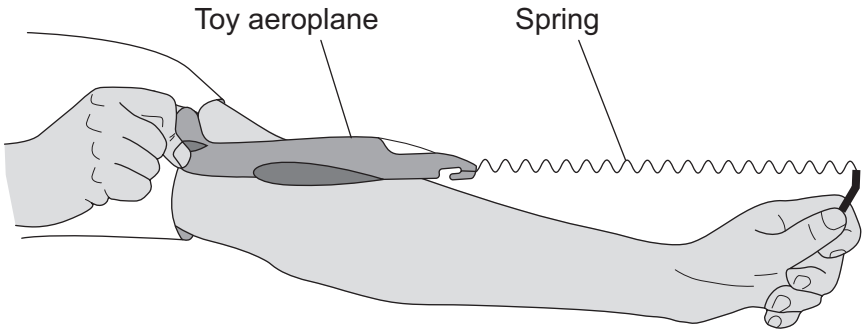
[3 marks]

9

Turn over ▶

0 5 **Figure 8** shows a student about to launch a toy aeroplane horizontally.

Figure 8



The student pulled on the aeroplane to stretch the spring.

The student then released the aeroplane.

0 5 . 1 After the aeroplane was released, the aeroplane accelerated until it passed the student's hand.

Describe how the energy stores of the aeroplane **and** spring changed as the aeroplane accelerated.

[3 marks]

Do not write outside the box

0 5 . 2 The spring exerted a force on the aeroplane to make the aeroplane accelerate.

As the aeroplane accelerated, it moved through a distance of 40 cm.

The work done by the spring on the aeroplane was 3.0 J.

Calculate the mean force exerted by the spring on the aeroplane.

Use the Physics Equations Sheet.

[4 marks]

Mean force = _____ N

Question 5 continues on the next page

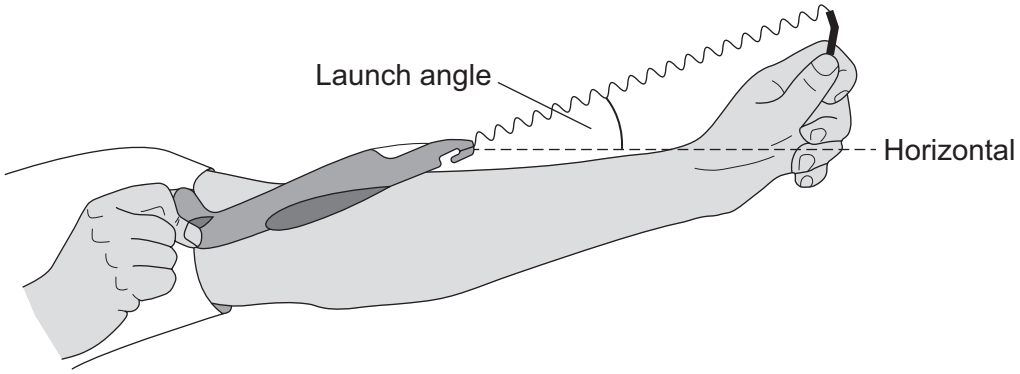
Do not write outside the box

0 5 . 3 The student launched the aeroplane at different angles to the horizontal.

The student then measured the horizontal distance travelled by the aeroplane.

Figure 9 shows the launch angle of the aeroplane.

Figure 9



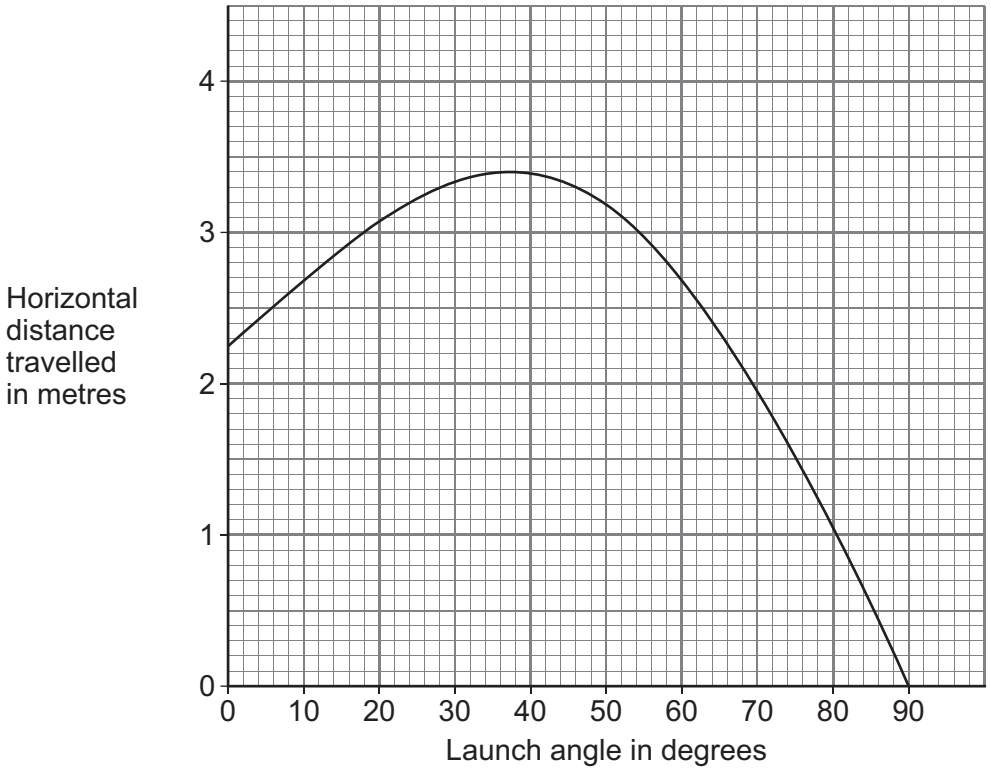
After being launched, the aeroplane flew through the air and landed on the ground.

Do not write outside the box

Figure 10 shows how the horizontal distance travelled varies with the launch angle.

The extension of the spring was the same in each test.

Figure 10



Describe how the horizontal distance travelled varies with the launch angle.

[3 marks]

Question 5 continues on the next page

Do not write outside the box

0 5 . 4 Explain how increasing the extension of the spring would affect the horizontal distance travelled by the aeroplane.

[2 marks]

_____

_____

_____

_____

12

Do not write outside the box

Turn over for the next question

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Do not write outside the box

0 6 This question is about cracking and the products of cracking.

0 6 . 1 Alkane molecules are often cracked.

Describe the conditions needed for cracking.

[2 marks]

0 6 . 2 Explain how cracking alkane molecules helps to meet the demand for fuels.

[2 marks]

0 6 . 3 The products of cracking include another type of hydrocarbon called alkenes.

Give **one** use of alkenes.

Do **not** refer to the use of alkenes as fuels.

[1 mark]

Do not write outside the box

0 6 . 4 Ethene is an alkene.

Figure 11 represents the reaction of ethene with chlorine.

Figure 11

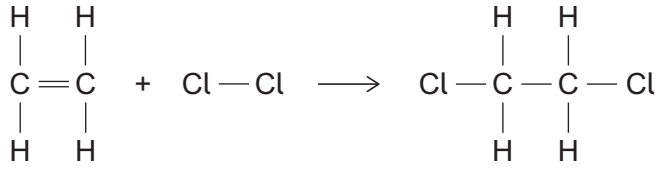


Table 2 shows some bond energy values.

Table 2

Bond	Bond energy in kJ/mol
C — H	413
C = C	612
Cl — Cl	243
C — C	347
C — Cl	346

Calculate the overall energy change for the reaction of ethene with chlorine.

[3 marks]

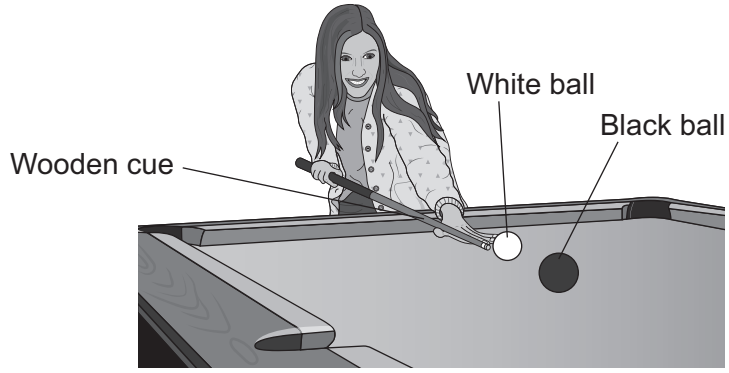
Overall energy change = _____ kJ/mol

8

Turn over ▶

0 7 **Figure 12** shows a student playing a game called 'pool'.

Figure 12



In a game of pool, the player hits the white ball with a wooden cue.

Use the Physics Equations Sheet to answer questions **07.1** and **07.2**.

0 7 . 1 Which equation links kinetic energy (E_k), mass (m) and speed (v)?

[1 mark]

Tick (✓) **one** box.

$E_k = \frac{1}{2} mv$ ☐

$E_k = mv^2$ ☐

$E_k = \frac{1}{2} mv^2$ ☐

Do not write outside the box

0 7 . 2 At one time during the game, the kinetic energy of the white ball is 0.0441 J.

The mass of the white ball is 0.180 kg.

Calculate the speed of the white ball.

[3 marks]

Speed = _____ m/s

Question 7 continues on the next page

The moving white ball collides with a stationary black ball.

Figure 13 shows the two balls before and after the collision.

Figure 13

0 7 . 3 Momentum is conserved in the collision.

What is meant by 'momentum is conserved'?

[1 mark]

Do not write outside the box

0 7 . 4 Determine the velocity of the black ball after the collision.

mass of white ball = 0.180 kg

mass of black ball = 0.160 kg

Use the Physics Equations Sheet.

[6 marks]

Velocity = _____ m/s

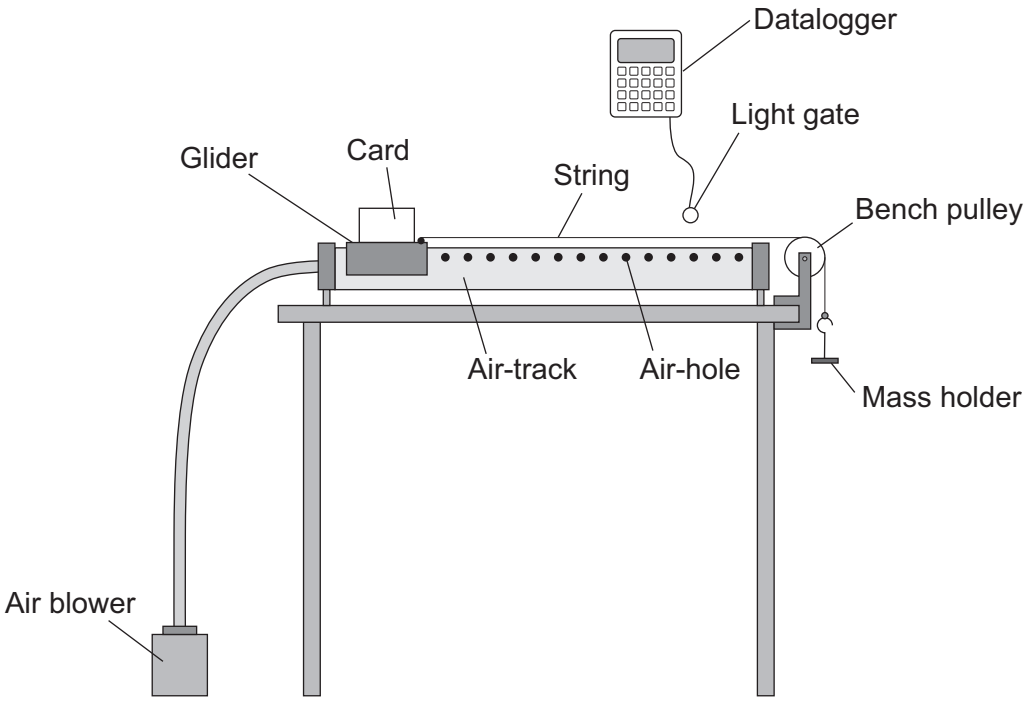
11

Turn over for the next question

0 8 A student investigated how the acceleration of a glider on an air-track varies with the mass of the glider.

Figure 14 shows the apparatus used.

Figure 14



The air blower allows the glider to move along the air-track with almost no friction.

The datalogger calculates the velocity of the glider as the glider passes through the light gate.

The resultant force acting on the glider was constant.

This is the method used.

1. Release the glider from rest at the end of the air-track.
2. Record the velocity of the glider from the datalogger.
3. Calculate the acceleration of the glider.
4. Repeat steps 1 to 3 two more times.
5. Repeat steps 1 to 4 using gliders of different mass.

Do not write outside the box

0 8 . 1 Which **two** measurements does the datalogger need to determine the velocity of the glider?

[2 marks]

Tick (✓) **two** boxes.

Gravitational field strength ☐

Length of card ☐

Mass of glider ☐

Temperature of surroundings ☐

Time for card to pass light gate ☐

0 8 . 2 **Table 3** shows the results for a glider with a mass of 0.75 kg.

Table 3

Mass of glider in kilograms	**Acceleration in m/s^2**				
	Test 1	**Test 2**	**Test 3**	**Test 4**	**Test 5**
0.75	0.95	0.97	1.05	0.99	1.04

Determine the uncertainty in the recorded values of acceleration.

[2 marks]

_____

_____

_____

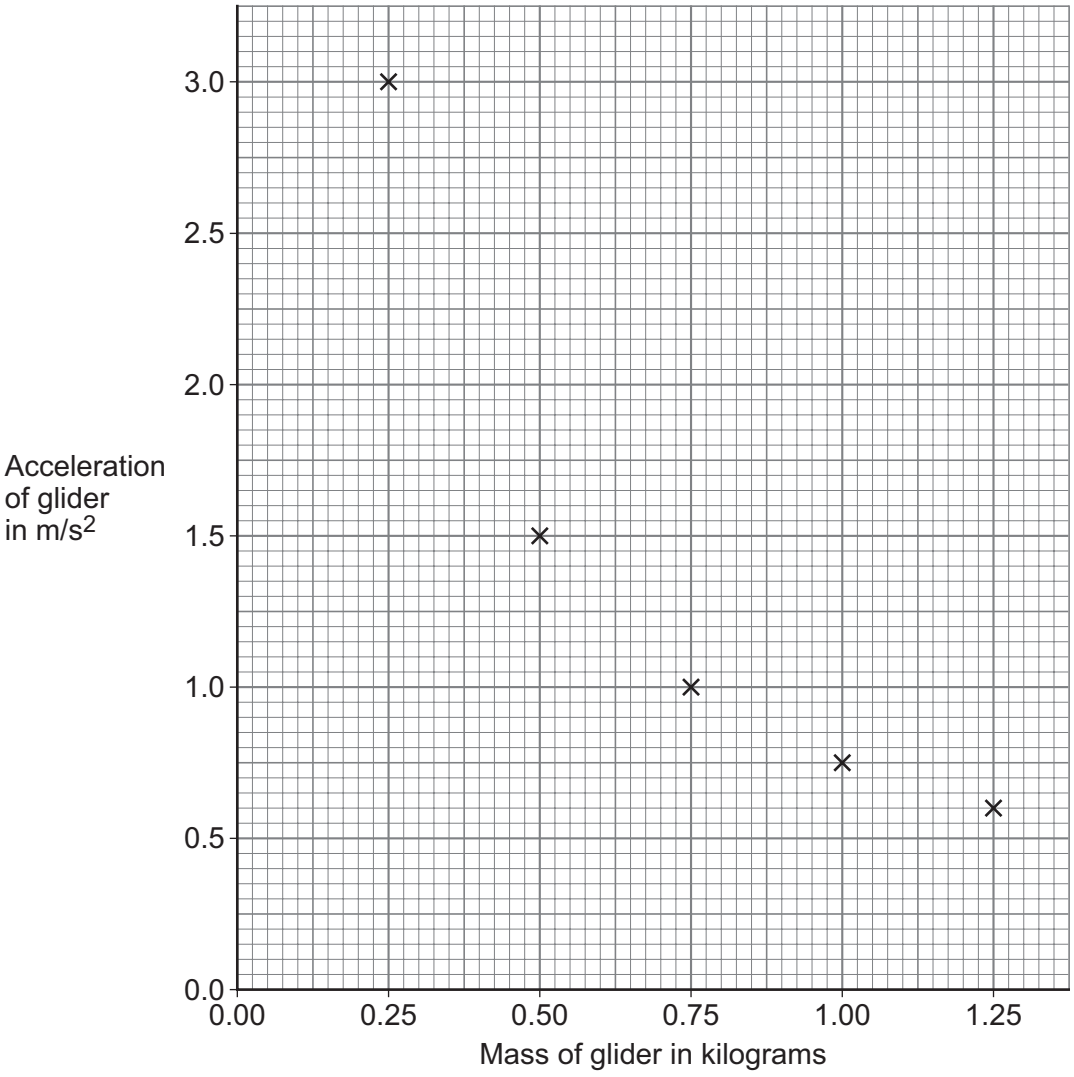
Uncertainty = ± _____ m/s^2

Turn over ▶

Do not write outside the box

Figure 15 shows the results.

Figure 15



Do not write outside the box

0 8 . 3 The student concluded:

'The acceleration of the glider was inversely proportional to the mass of the glider.'

Explain how the results in **Figure 15** show that the student was correct.

[3 marks]

_____

_____

_____

_____

_____

_____

7

Turn over for the next question

0 9 Crude oil is a mixture of compounds.

Most of the compounds are hydrocarbons called alkanes.

0 9 . 1 Propane is an alkane.

The formula of propane is C_3H_8

Complete the general formula for alkanes.

[1 mark]

C_nH _____

Table 4 shows information about some alkanes.

Table 4

Alkane	Number of carbon atoms in a molecule	Boiling point in °C
Methane	1	−164
Ethane	2	−89
Propane	3	−42
Butane	4	**X**
Pentane	5	36
Hexane	6	69
Heptane	7	98

Do not write outside the box

0 9 . 2 Predict the value of **X** in **Table 4**.

[1 mark]

_____ °C

0 9 . 3 Explain the trend in boiling points shown in **Table 4**.

[4 marks]

Extra space _____

0 9 . 4 Propane is used as a fuel.

Write a balanced equation for the complete combustion of propane (C_3H_8).

[3 marks]

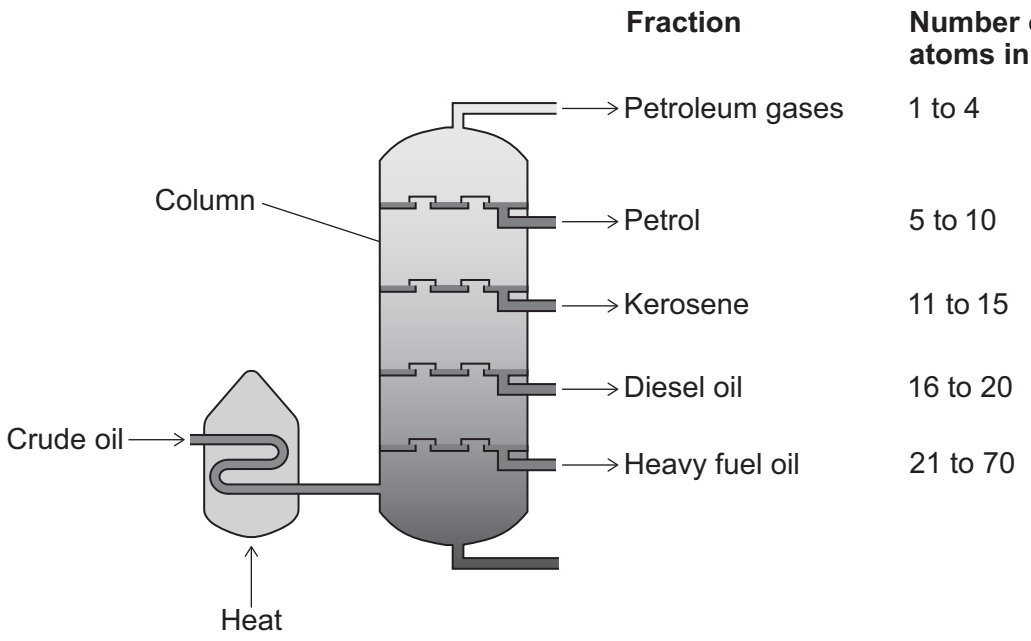
_____ + _____ ⟶ _____ + _____

Question 9 continues on the next page

Hydrocarbons in crude oil are separated into fractions using fractional distillation.

Figure 16 shows a fractional distillation column.

Figure 16



0 9 . 5 Explain how crude oil is separated into fractions by fractional distillation.

[4 marks]

Extra space

Do not write outside the box

0 9 . 6 How do the viscosity and boiling point of heavy fuel oil compare with the other fractions in **Figure 16**?

[1 mark]

Tick (✓) **one** box.

Heavy fuel oil is the least viscous and has the highest boiling point. ☐

Heavy fuel oil is the least viscous and has the lowest boiling point. ☐

Heavy fuel oil is the most viscous and has the highest boiling point. ☐

Heavy fuel oil is the most viscous and has the lowest boiling point. ☐

14

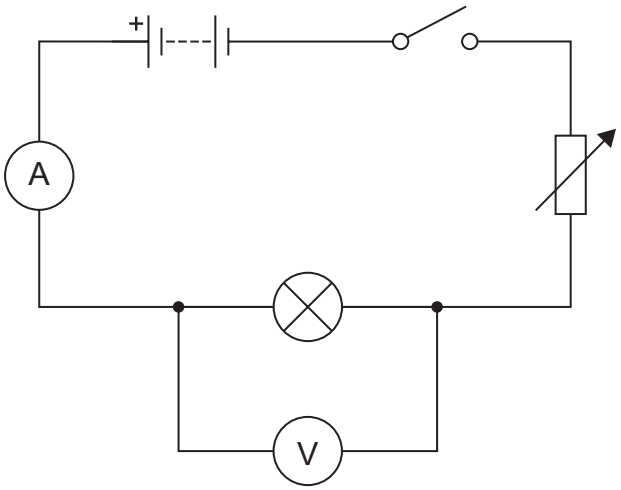
Turn over for the next question

Do not write outside the box

1 0 A student investigated how the resistance of a filament lamp varies with the current in the lamp.

Figure 17 shows the circuit used.

Figure 17



1 0 . 1 Describe a method the student could use to show how the resistance of the filament lamp varies with the current.

[4 marks]

Extra space

Do not write outside the box

1 0 . 2 When the potential difference across the filament lamp was 12.0 V, the resistance of the lamp was 30 Ω.

Calculate the power output of the lamp when the potential difference across the lamp was 12.0 V.

Use the Physics Equations Sheet.

[5 marks]

Power output = _____ W

9

END OF QUESTIONS

Do not write outside the box

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Do not write outside the box

Question number	**Additional page, if required.** **Write the question numbers in the left-hand margin.**

Do not write outside the box

Question number	**Additional page, if required.** **Write the question numbers in the left-hand margin.**

Do not write outside the box

Question number	**Additional page, if required.** **Write the question numbers in the left-hand margin.**

Do not write outside the box

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED