

GCSE (9-1)

Examiners' report

**GATEWAY
SCIENCE
PHYSICS A**

J249

For first teaching in 2016

J249/02 Summer 2022 series

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Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates.

The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. A selection of candidate answers are also provided. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report.

A full copy of the question paper and the mark scheme can be downloaded from OCR.

Advance Information for Summer 2022 assessments

To support student revision, advance information was published about the focus of exams for Summer 2022 assessments. Advance information was available for most GCSE, AS and A Level subjects, Core Maths, FSMQ, and Cambridge Nationals Information Technologies. You can find more information on our [website](#).

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Paper 2 series overview

This paper is designed to assess content from Topics P5 to P8 with assumed knowledge of Topics P1 to P4 and P9. Thus, this paper requires candidates to have knowledge and understanding of all the topics within the course.

There was no evidence to suggest that candidates were short of time in answering the paper.

It is important that candidates are able to practise interpreting data both qualitatively and quantitatively from different sources. There were a number of questions where candidates needed to interpret straight line graphs.

There were a number of questions where candidates needed to carry out a numerical calculation. Where an equation needs to be recalled, candidates should be encouraged to write the equation down as a first step. In other numerical questions candidates should identify the data to use and substitute the data into the equation, before calculating the answer. Candidates should also carefully consider the units of their data.

On this paper, Question 20 (a) gave candidates the opportunity to demonstrate their knowledge and understanding of physics by constructing their own answer. It is important that candidates answer the question set in a logical way with clear explanations.

There are a number of questions where an explanation is required. Candidates should be encouraged to use the number of answer lines and the marks for the particular sub-part mark as a guide to the length of their answers. Candidates should also make sure that they use appropriate physics terms correctly in their answers. Candidates should also be encouraged to include diagrams where appropriate.

Candidates who did well on this paper generally did the following:	Candidates who did less well on this paper generally did the following:
<ul style="list-style-type: none"> • added working to the multiple-choice questions • in numerical questions stated the equation used, rearranged the equation and substituted the data before writing the answer • used technical terms correctly • structured answers logically 	<ul style="list-style-type: none"> • attempted answers with no working • did not focus on the question set • did not offer answers with sufficient detail

Section A overview

Section A of the paper has fifteen multiple choice questions, each worth 1 mark. It is important for candidates not to spend too long on any particular question and to read the whole question including all the possible options.

Question 1

- 1 A motor transfers 4.3 kJ of energy.

What is 4.3 kJ converted into joules?

- A 0.0043 J
- B 0.43 J
- C 430 J
- D 4300 J

Your answer

[1]

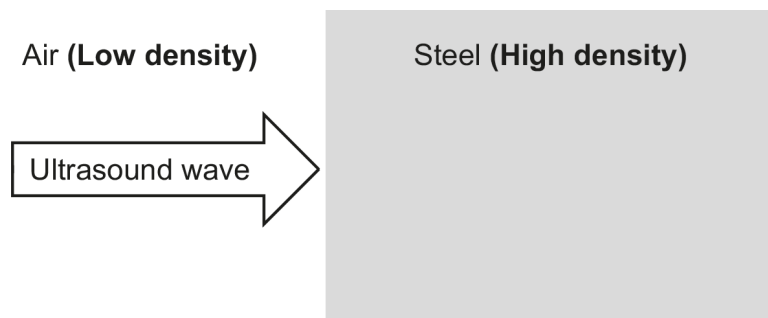
This question tested candidates understanding of the unit prefix k, kilo. This was reasonably well answered although a significant number of candidates gave incorrect responses.

Helpful Tip

Use the “white space” around the question to write down working and/or equations (to assist with answering the question and to help check answers at the end of the examination)

Question 2

- 2 The diagram shows an ultrasound wave hitting a steel block.



What happens to the ultrasound wave?

- A It is mainly absorbed.
- B It is mainly reflected.
- C It is completely refracted.
- D It is completely transmitted.

Your answer

[1]

This question tested the idea that sound is reflected from hard surfaces and echoes can be heard.

Question 3

- 3 An astronomer observes a red-shift of light from a distant galaxy.

What does red-shift of light mean?

- A The speed of the light has decreased.
- B The speed of the light has increased.
- C The wavelength of the light has decreased.
- D The wavelength of the light has increased.

Your answer

[1]

A common distractor in this question was B. The speed of light is constant in space.

Question 4

4 Which row describes nuclear **fusion**?

	What happens	Where it occurs
A	heavy nuclei split	in nuclear power stations
B	heavy nuclei split	in the Sun
C	light nuclei combine	in nuclear power stations
D	light nuclei combine	in the Sun

Your answer

[1]

Many candidates were confused between nuclear fission in a power station and nuclear fusion occurring in the Sun.

Misconception

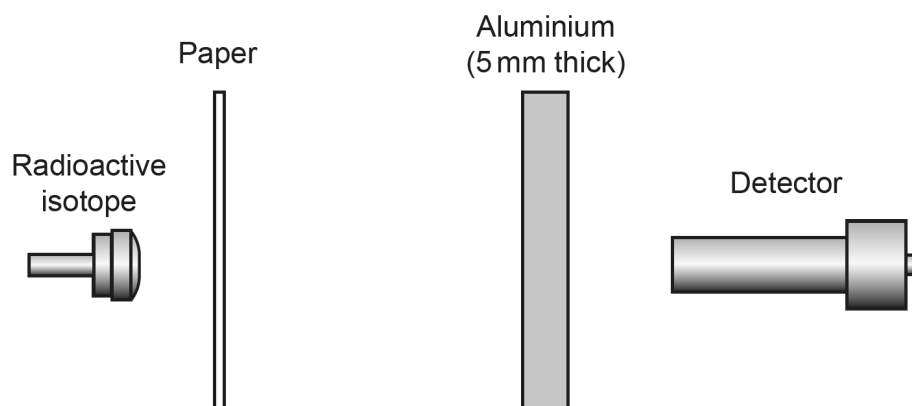


Understanding the difference between fission and fusion.

Understanding the processes in a nuclear power station.

Question 5

5 The diagram shows a radioactive isotope emitting alpha particles **and** beta particles.



Which particles are detected by the detector?

- A Alpha particles and beta particles
- B Alpha particles only
- C Beta particles only
- D No particles

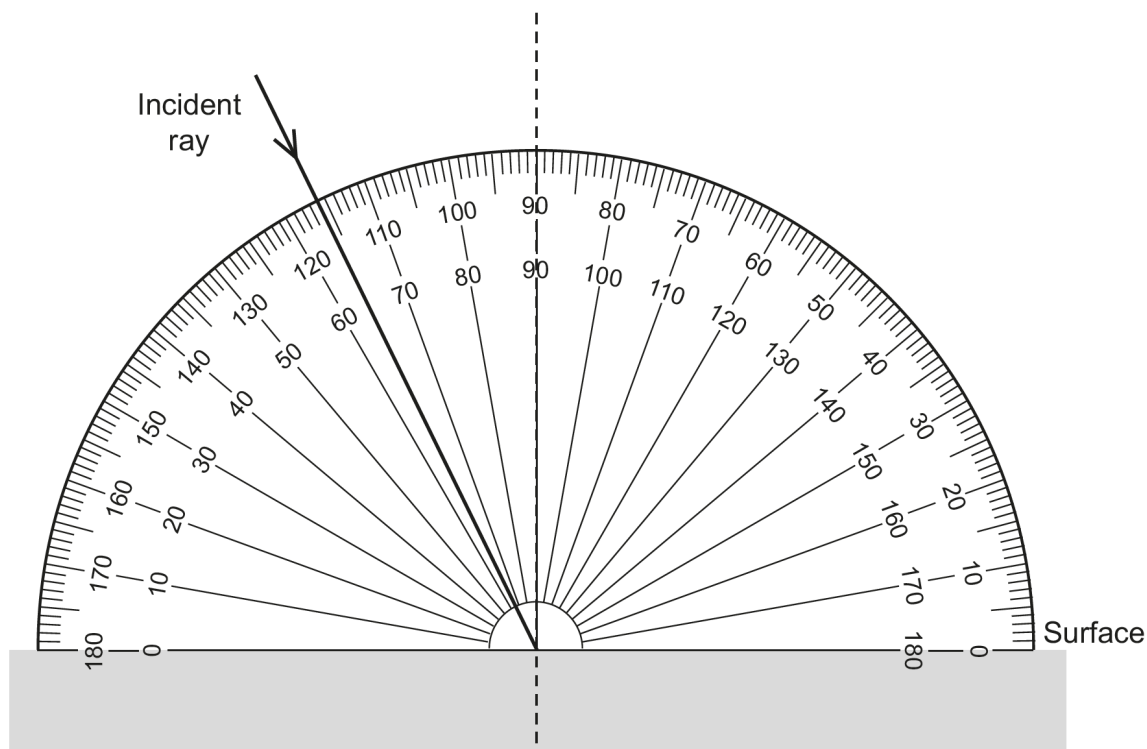
Your answer

[1]

This question had a range of different responses. Candidates needed to understand the penetration of alpha, beta and gamma radiation with different materials.

Question 6

6 A ray of light hits a surface.



What is the angle of incidence?

- A 26°
- B 64°
- C 76°
- D 116°

Your answer

[1]

A common incorrect response was B where candidates read the angle from the surface to the ray.

Question 7

7 What is a good estimate for the speed of an Olympic sprinter?

- A 1 m/s
- B 3 m/s
- C 10 m/s
- D 30 m/s

Your answer

[1]

An important skill for candidates to develop is the ability to estimate quantities.

Question 8

8 Which statement about the Solar System is correct?

- A Mars is a star.
- B Mercury is the planet closest to the Sun.
- C Neptune is the planet closest to the Earth.
- D Saturn is a moon.

Your answer

[1]

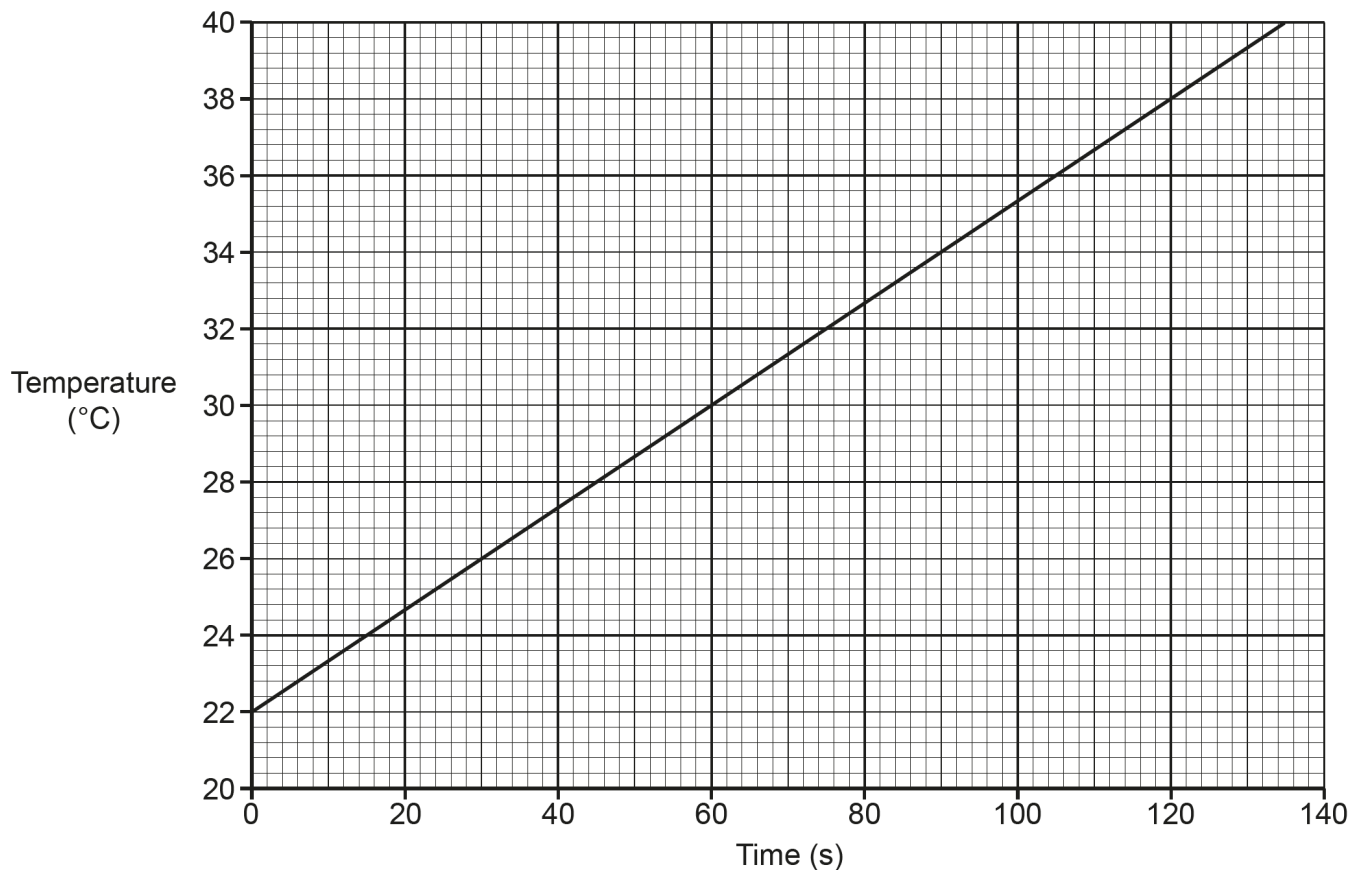
This question was generally answered well. Candidates had appeared to have good knowledge of the difference between a planet, moon and star. Most recalled that Mercury was the closest planet to the Sun.

Question 9

9 A student increases the temperature of a metal block.

They measure how the temperature of the metal block increases with time.

The graph shows their results.



What is the increase in temperature between 60s and 120s?

- A 8°C
- B 16°C
- C 30°C
- D 38°C

Your answer

[1]

This was very well answered. The majority of candidates read the information correctly from the graph. Often, more successful response drew lines indicating the read-offs

Question 10

10 When a car crashes, it undergoes a very large **deceleration**.

Which row describes the crash?

	Forces involved	Time for the car to decelerate
A	large	large
B	large	small
C	small	large
D	small	small

Your answer

[1]

This question tested the understanding of the definition of acceleration and the equation relating force, mass and acceleration.

Question 11

11 A lamp has an input energy of 200 J.

The useful output energy is 80 J.

What is the efficiency of the lamp?
Use the Data Sheet.

A 0.4

B 2.5

C 40

D 250

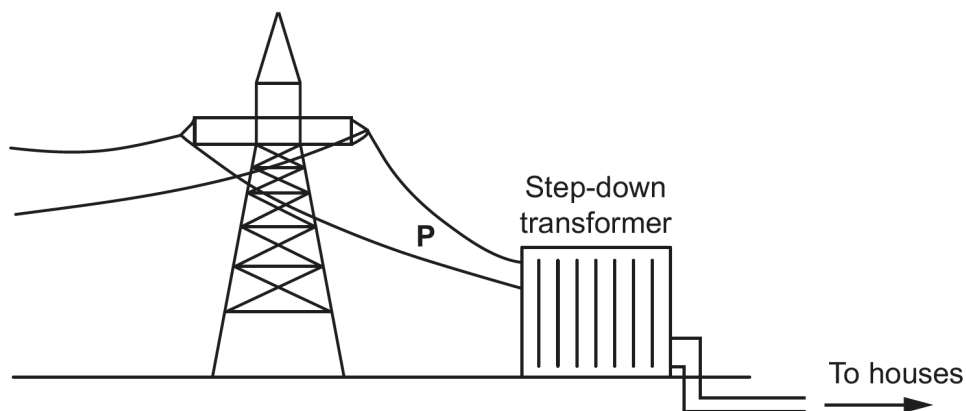
Your answer

[1]

Candidates who used the data sheet, were able to score well on this question.

Question 12

12 The diagram shows how a step-down transformer is used before electricity is transferred to houses.



Which row gives the correct potential difference and frequency of the electricity in the wires at **P**?

	Potential difference (V)	Frequency (Hz)
A	230	50
B	230	230
C	400 000	50
D	400 000	230

Your answer

[1]

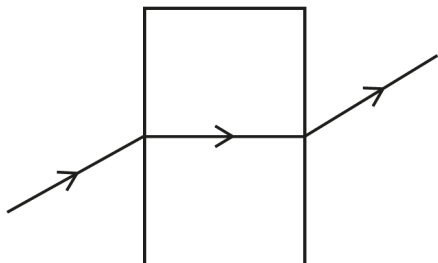
There seemed to be some confusion between the frequency of mains ac and the potential difference of main ac.

Question 13

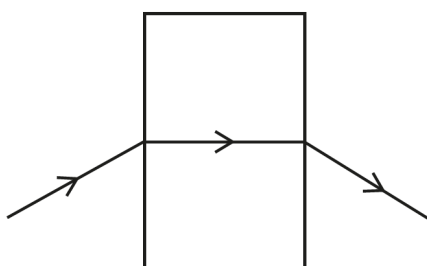
13 A student shines a ray of red light at different shaped glass blocks.

Which diagram shows a correct path for the ray?

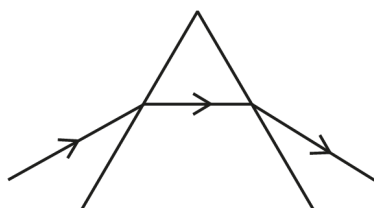
A



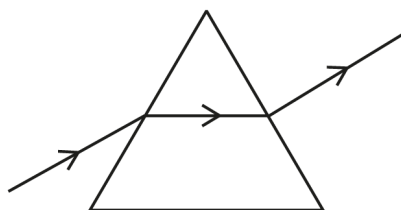
B



C



D



Your answer

[1]

The common incorrect response was A with the majority of candidates not able to evidence that the refracted ray within the glass is not possible unless the incident ray is along the normal.

Question 14

14 Which row describes the walls of a building with the **lowest** rate of cooling?

	Thickness of walls	Thermal conductivity of walls
A	thick	high
B	thick	low
C	thin	high
D	thin	low

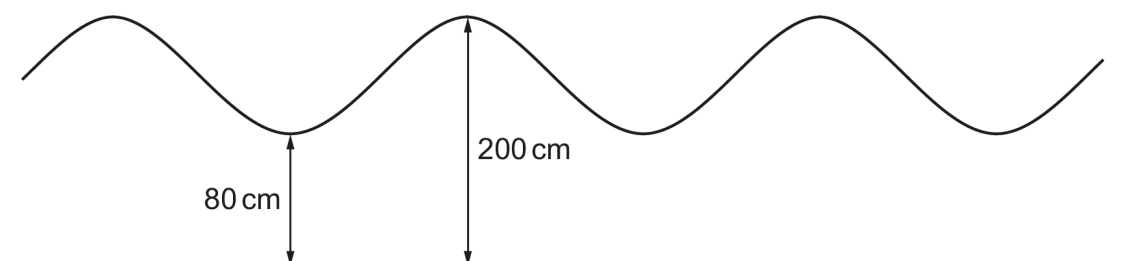
Your answer

[1]

There was some difficulty with the term thermal conductivity and how the thickness of walls may affect the cooling of a building.

Question 15

15 The diagram shows waves that are made in a pool of water.



What is the amplitude of the waves?

- A 60 cm
- B 80 cm
- C 120 cm
- D 200 cm

Your answer

[1]

The common distractors selected by candidates was C (peak to trough distance) and D (height from the bottom of the pool). Very few candidates calculated the height from the undisturbed position of the water.

Section B overview

Candidates need to make sure that they answer the question set and include the necessary detailed knowledge. Vague answers are not given marks.

Question 16 (a)

16 (a) This question is about electromagnetic waves.

Draw lines to connect each **wave** with its correct **use or property**.

Wave	Use or Property
Gamma-rays	Can cause sunburn
Infra-red	Highest frequency
Radio	Used in TV remotes
Ultra-violet	Longest wavelength

[3]

The majority of the candidates attempted this question. A large number of candidates correctly identified ultraviolet with causing sunburn. Common misunderstandings included linking gamma rays having the longest wavelength instead of the highest frequency and radio waves being used in TV remotes.

Question 16 (b) (i)

(b) (i) Which type of wave is the most dangerous?

Tick (✓) **one** box.

Infra-red	<input type="checkbox"/>
Microwaves	<input type="checkbox"/>
X-rays	<input type="checkbox"/>

[1]

A variety of responses were written by candidates.

Question 16 (b) (ii)

(ii) Identify **two** reasons for your answer to (b)(i).

1

2

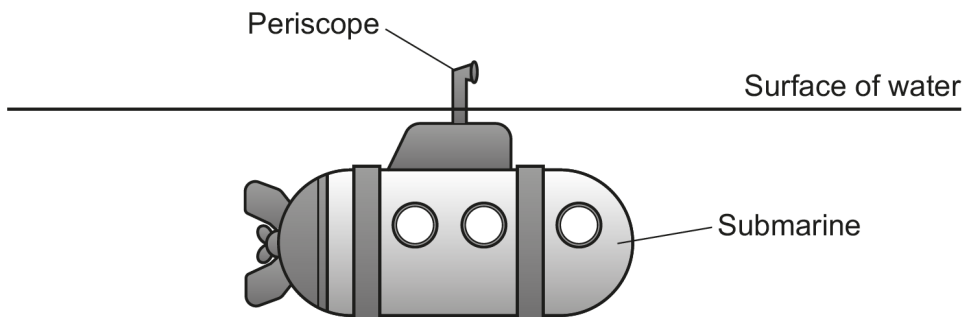
[2]

For this type of question, candidates should identify detailed reasons. For example, "it will cause damage" did not gain marks.

Question 16 (c)

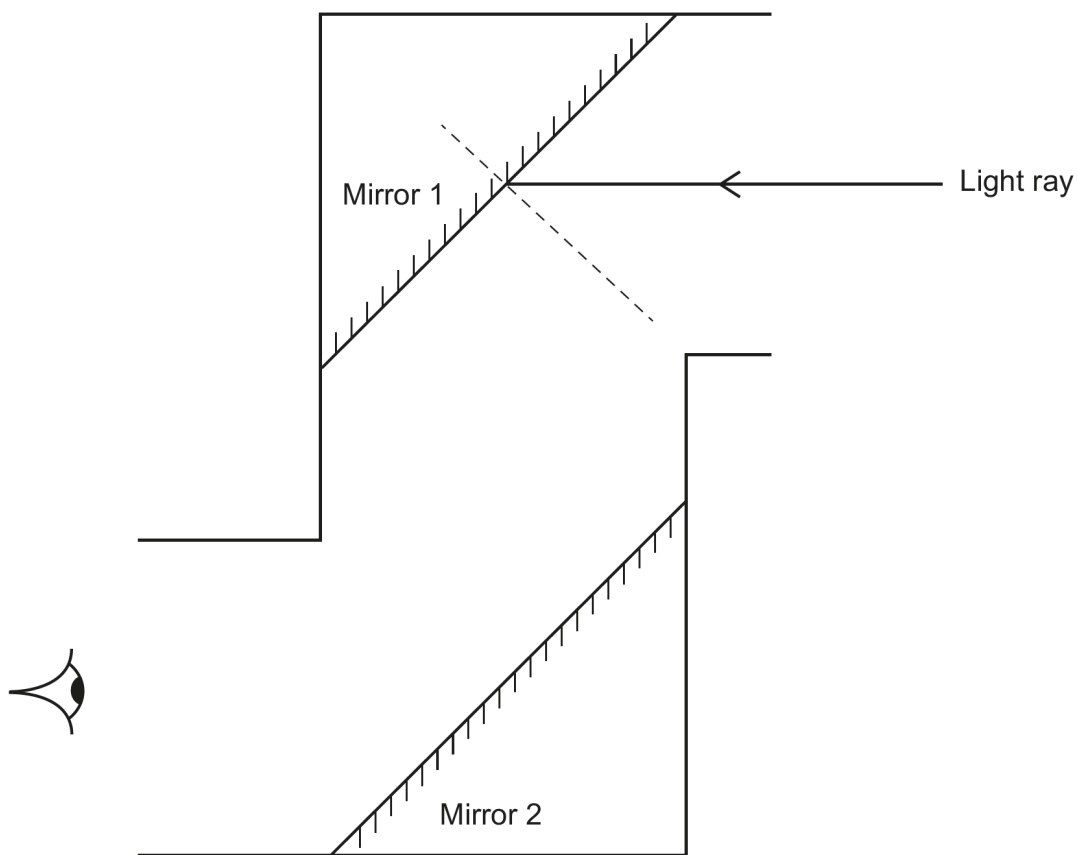
(c) Fig. 16.1 shows a submarine under water.

Fig. 16.1



A periscope is used to look above the water. Fig. 16.2 shows the periscope.

Fig. 16.2



Complete the ray diagram in Fig. 16.2 to show how light passes through the periscope to the eye.

You must include a normal line in your completed ray diagram on Mirror 2.

[3]

Many candidates did not include the normal line on mirror 2. Some candidates did not draw the ray accurately and either the angle of incidence did not equal the angle of reflection or the light ray did not enter the eye.

Question 16 (d) (i)

(d) (i) A sailor uses the periscope to observe some water waves.

Six complete waves pass the periscope in **one** minute.

Calculate the time period for one wave in seconds.

Time period = s **[2]**

This question was generally answered well. More successful responses often stated that one minute was equal to sixty seconds. Candidates should show their working.

Question 16 (d) (ii)

(ii) A different water wave has a frequency of 0.2 Hz.

The wavelength of the wave is 20 m.

Calculate the speed of the wave.

Use the Data Sheet.

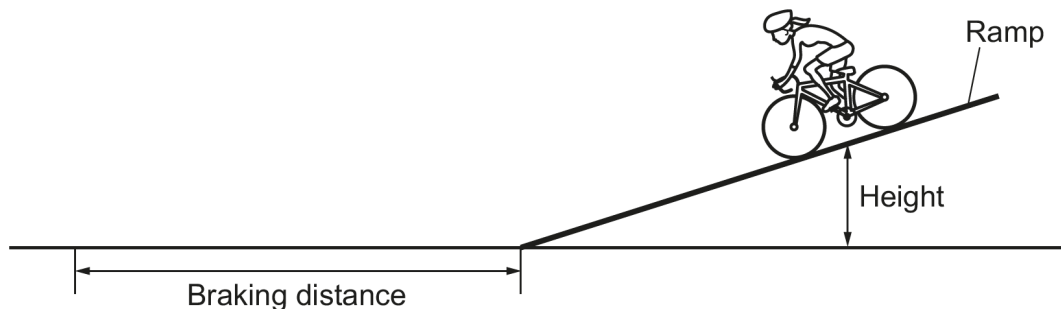
Speed of the wave = m/s **[3]**

This question was well answered. However, many candidates stated “4” without any working which is not in keeping with a 3 mark question.

Question 17 (a) (i)

17 Student **A** is investigating braking distance using a bicycle. This is their method:

- Freewheel down a ramp **without** pedalling.
- At the bottom of the ramp, press the brakes until the bicycle comes to a stop.
- Measure the braking distance of the bicycle from the bottom of the ramp.



(a) Student **A** repeats the investigation three times. Each time they start at the same height. Their results are shown in the table.

Measurement number	Braking distance (m)
1	4.4
2	8.0
3	5.6

(i) Suggest what equipment student **A** can use to measure the braking distance.

..... [1]

This question was well answered. Some candidates incorrectly suggested the use of a ruler. For distances larger than one metre, candidates should be suggesting to use a tape measure or trundle wheel.

Question 17 (a) (ii)

(ii) Use the results from the table to calculate the **mean** braking distance.

Mean braking distance = m [2]

This question was generally well answered. Most candidates added the three distances together and divided by three.

Marks were also given for responses that omitted the distance of 8.0 m and treated this distance as an anomaly. This is where it is essential to see working from candidates.

Question 17 (a) (iii)

(iii) Suggest why the values of the braking distance are **not** the same.

.....
..... [1]

Vague answers such as 'reaction time' were not given marks. It is expected such candidates should relate their answers to the experiment described in the question. Many candidates discussed different braking forces or not applying the brakes in the same position each time

Question 17 (b)

(b) Student **B** repeats the investigation using the same method.

The mass of student **B** and the bicycle is 80 kg.

The height of student **B** and the bicycle at the top of the ramp is 2.0 m.

Gravitational field strength = 10 N/kg.

Calculate the gravitational potential energy of student **B** and the bicycle at the top of the ramp.

Use the Data Sheet.

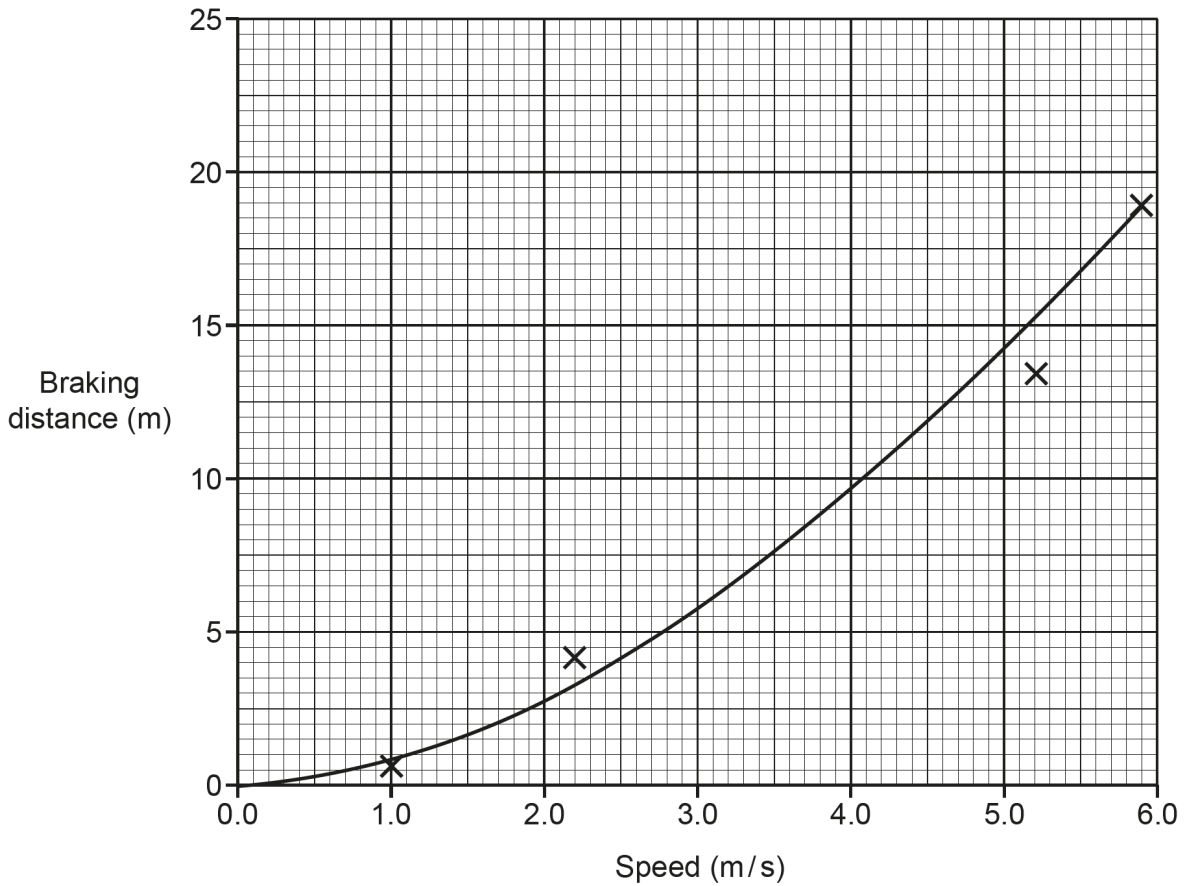
Gravitational potential energy = J [3]

Some candidates incorrectly converted 80 kg to 80,000 g. Other candidates omitted to include the gravitational field strength.

Question 17 (c) (i)

(c) Student C measures the braking distance for different speeds at the bottom of the ramp.

The graph shows student C's results.



(i) Use the graph to find the braking distance when the speed is 4.3 m/s.

Braking distance = m [1]

The majority of the candidates gained an answer of 11m. A common error was to record the braking distance as 12 m.

Question 17 (c) (ii)

(ii) It can be more dangerous to cycle quickly.

Use data from the graph to explain why.

.....

.....

.....

..... [2]

Many candidates explained that the braking distance increased as the speed increased and demonstrated this using data. Few candidates were able to explain why this was more dangerous.

Question 17 (c) (iii)

(iii) Suggest how student C's investigation could be improved.

.....

..... [1]

Candidates needed to suggest improvements linked to the investigation. In this investigation, sensible improvements included repeating the experiment for different speeds and ensuring that the brakes were pressed by the same amount at the same position for each experiment.

Question 17 (d)

(d) The students increase the mass of the bicycle.

What happens to the braking distance?

Tick (✓) **one** box.

Decreases

Increases

Stays the same

[1]

Many candidates did not understand that increasing the mass of the bicycle meant that the cyclist would have a larger kinetic energy and more work would be needed to be done to bring the cyclist to a stop. For the same braking force this would mean a larger braking distance.

Question 17 (e)

(e) Student **D** pedals the bicycle on a level surface.

They start from rest and reach a velocity of 6 m/s.

Estimate the acceleration of student **D** on the bicycle.

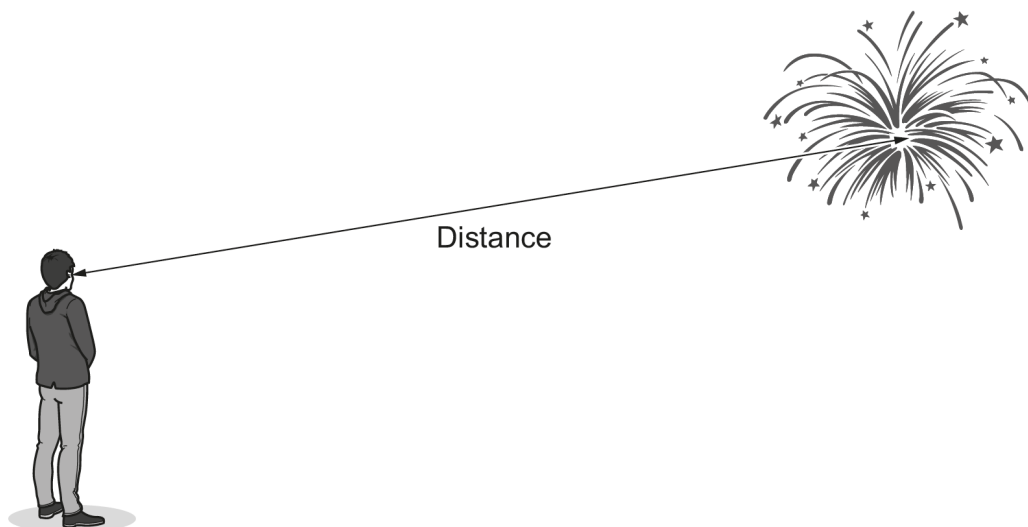
Use the equation: $\text{acceleration} = \frac{\text{change in velocity}}{\text{time}}$

Acceleration = m/s² [3]

This question required candidates to estimate the time it would take for a student cyclist to accelerate to 6 m/s. Many candidates incorrectly suggested a time of one second.

Question 18 (a)

18 A child is watching a firework display.



(a) The speed of light in air is 3×10^8 m/s.

Explain why the child sees the firework **before** they hear it.

.....
 [1]

The majority of the candidates were able to state that the speed of light is (much) faster than the speed of sound. This question required a comparison.

Question 18 (b)

(b) Complete each sentence below about sound travelling through air.

Use the words from the list.

- | | | |
|------------------------|---------------------|-----------------|
| electromagnetic | longitudinal | parallel |
| perpendicular | transverse | |

Sound waves are

The air particles vibrate to the direction of travel of the wave.

[2]

Many candidates did not state that sound waves are **longitudinal** and thus the air particles vibrate **parallel** to the direction of travel.

Question 18 (c)

(c) The child measures the time between seeing and hearing the firework.

The time they measure is 0.42 s.

The speed of sound in air is 330 m/s.

Calculate the distance from the child to the firework.

Give your answer to **2** significant figures.

Use the Data Sheet.

Distance = m [4]

The majority of candidates were able to calculate the distance. Of these candidates, just over half were able to correctly round the distance to two significant figures.

One common error was the rounding of 138 to 14 (omitting the zero).

Exemplar 1

Handwritten student work:
 distance travelled = speed x time
 $0.42 \times 330 = 138.6$
 $\underline{138.6}$
 $\div 100$
 $\underline{140}$

Distance = 140 m [4]

This candidate has demonstrated how to respond to a calculation question well.

The candidate has written the equation that is to be used (in this case from the data sheet).

Then the correct numbers from the question have been substituted. The candidate when reading the question has underlined the numerical data values.

Then the candidate has evaluated the equation and written the answer displayed by the calculator 138.6 – this response would have scored the candidate 3 marks. The candidate then correctly rounds the response to two significant figures.

Question 18 (d)

(d) Explain why the distance calculated in (c) is not the actual distance.

.....

.....

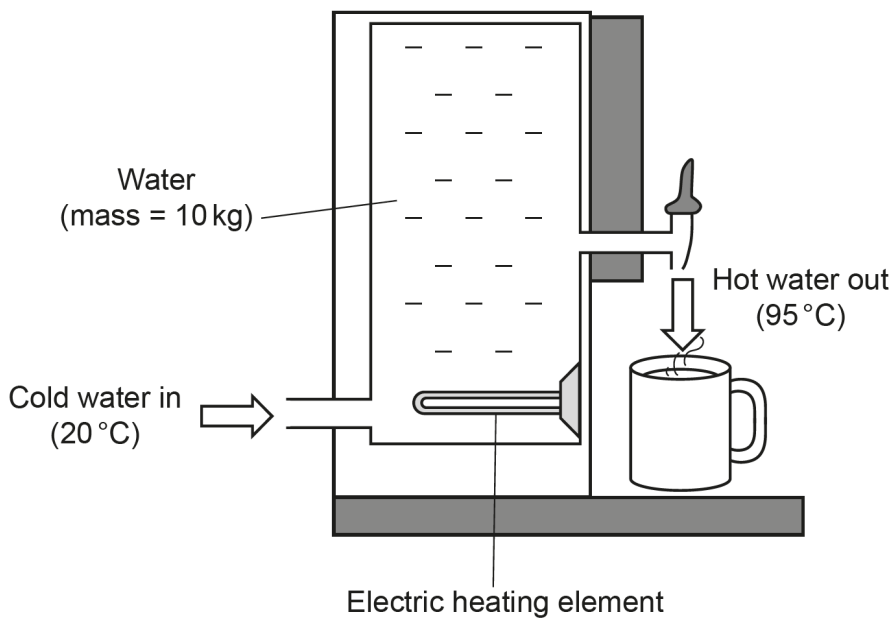
.....

..... [2]

For this question, candidates needed to identify that the distance calculated depended on the time measured and the speed of sound. To gain full marks, candidates needed to identify the quantity that was not accurate and suggest a reason as to why this quantity may have been different.

Question 19 (a)

19 An electric water heater is used to make hot water for drinks.



(a) The water heater is plugged into the mains supply and turned on.

Explain why the temperature of the water increases.
Write about energy stores in your answer.

.....

.....

.....

..... [2]

Few candidates were able to write about energy stores in their answers.

Question 19 (b)

- (b)** The temperature of the water increases from 20 °C to 95 °C.
The mass of water is 10 kg.
The specific heat capacity of water is 4200 J/kg °C.

Calculate the energy required to increase the temperature of the water.

Use the equation:

change in thermal energy = mass × specific heat capacity × change in temperature

Energy = J [3]

This question was well answered. Most candidates correctly worked out the temperature change and gained the correct answer.

Question 19 (c) (i)

- (c) (i)** The power of the water heater is 1840 W.
The p.d. of the mains supply is 230 V.

Calculate the current in the heating element.

Use the equation: power = potential difference × current

Current = A [3]

This question was well answered. The majority of the candidates correctly worked out the current. A significant minority of candidates multiplied the power by the potential difference.

Question 19 (c) (ii)

(ii) An engineer says, 'You should use a water heater with a higher current.'

Suggest **two** reasons why this is a good idea.

1

.....

2

.....

[2]

Many candidates stated that the temperature of the water would increase at a greater rate. Other candidates also mentioned that the power would be greater.

For this type of question two distinct suggestions should be made.

Question 19 (d)

(d) The water heater is plugged into the mains supply.
The water heater has a metal case.

Which wire(s) should be connected in the electric plug of the water heater?

Tick (✓) one, two **or** three boxes.

Earth wire	<input type="checkbox"/>
Live wire	<input type="checkbox"/>
Neutral wire	<input type="checkbox"/>

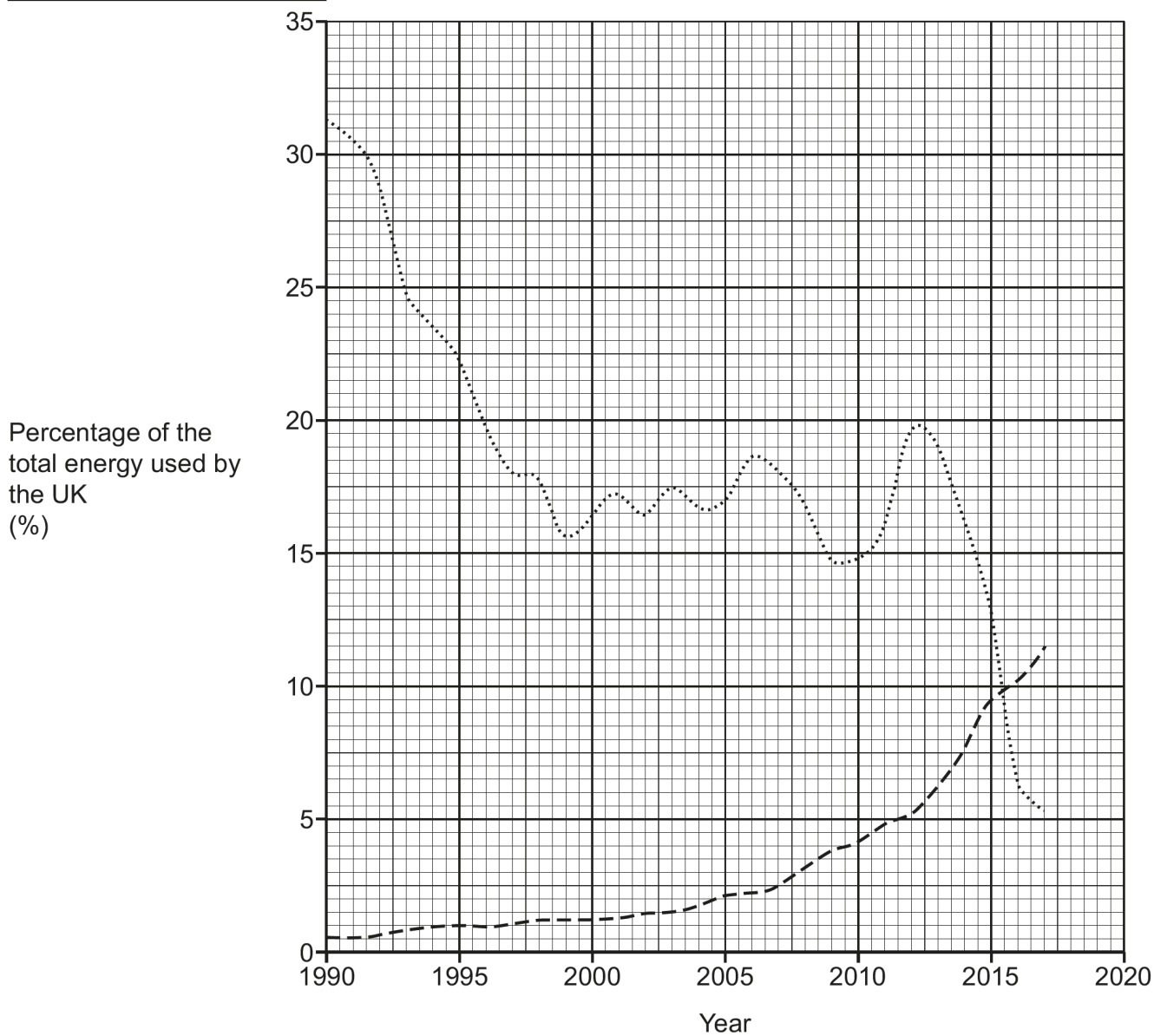
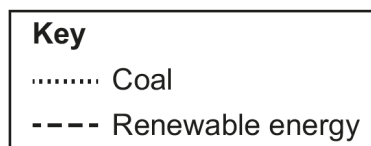
[1]

Only a significant minority suggested that all three wires should be connected to the electric plug.

Question 20 (a)*

20 (a)* The use of coal and renewable energy resources has changed in the UK over time.

The graph shows these changes.



Exemplar 2

Coal use has decreased from around 32.5% in 1990 to 5.5% in 2017. It has been going down as coal produces harmful emissions when used for power as when it is burnt it releases CO_2 into the atmosphere contributing to global warming, air pollution and respiratory issues. Coal also is a non-renewable resource and will run out because of this alternative energy sources must be used. This is why renewable energy has increased from 0.5% in 1990 to 10.5% in 2017. It is used as it is sustainable and won't run out, use less harmful emissions and are produced making it better for the environment and it means materials are used in a way so they are available for future generations. [6]

This candidate has carefully responded to the question set.

Firstly, the candidate has described the changes in coal and renewable energy resources and importantly has quoted data read from the graph. The candidate has then attempted to suggest reasons for these changes in terms of carbon dioxide, global warming, air pollution which causes respiratory issues and sustainability. This means that the response is Level 3.

On reading the response, the communication statement is met so 6 marks were given.

Question 20 (b)

(b) A power station has an output power of 2×10^6 kW.

Calculate the energy produced by the power station in 3 hours.

Give your answer in kWh.

Use the equation: energy transferred = power \times time

Energy = kWh [2]

The question was generally well answered with most candidates multiplying the power output by 3. Many candidates (correctly) gave their answer in standard form.

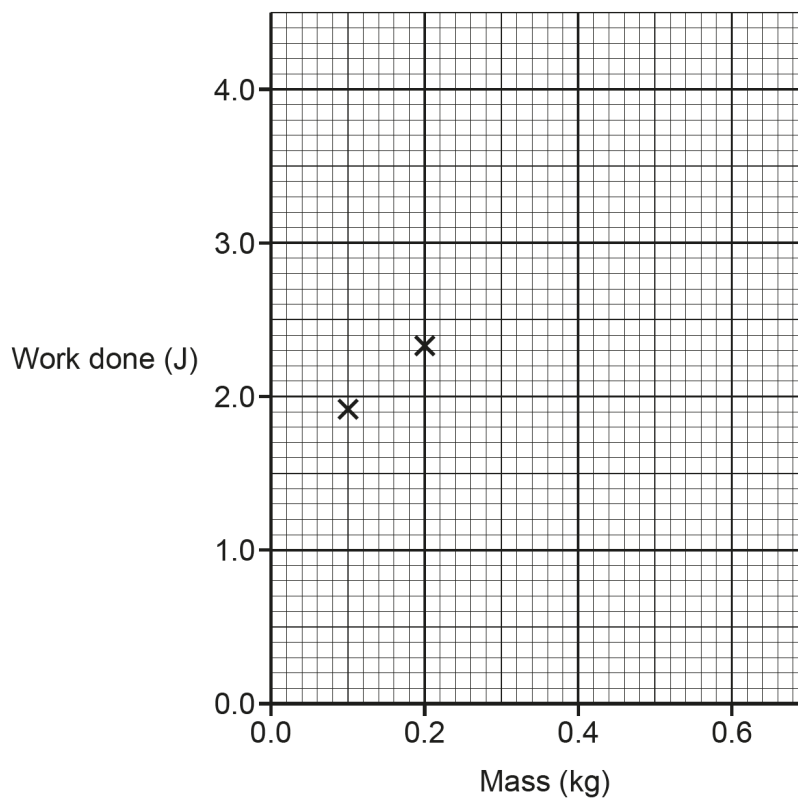
A significant number of candidates converted the time to minutes (and some candidates then to seconds).

Question 21 (b) (i)

(b) (i) Plot a graph of the data in the table and draw a line of best fit on **Fig. 21.2**.

Two of the points have already been completed for you.

Fig. 21.2

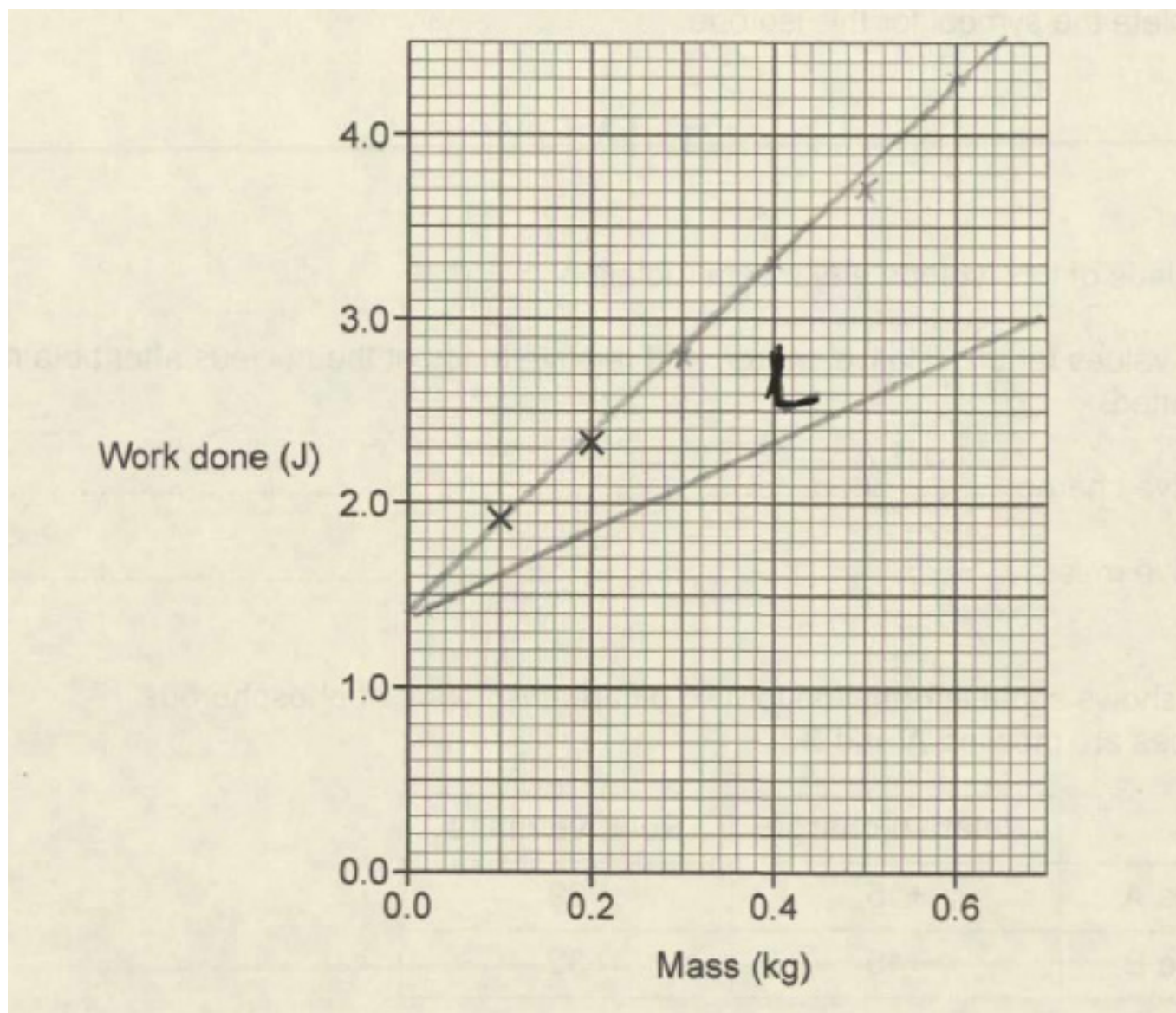


[3]

Most candidates were able to plot the points accurately with appropriately sized crosses.

Many lines of best fit were drawn from the top point to the bottom point which meant that the plotted data points were not balanced about the line.

Exemplar 3



The candidate has clearly plotted the four data points with the centre of the crosses indicating the correct points. The first 2 marking points are given.

The candidate has then drawn a line of best fit from the bottom plotted data point to the top plotted data point. As a result of the candidate's line, two data points are on the line and four are below the line – this is not the line of best fit. The line could have passed between the top two points.

The candidate's line could also have been narrower in width.

Question 21 (b) (ii)

(ii) Describe the relationship between work done and mass.

.....
..... [1]

Most candidates were able to state that as the mass increased the work done increased. It is important that candidates include the quantities.

Some candidates stated that the relationship was (directly) proportional – which was not given marks.

Similarly positive correlation did not gain marks.

Question 21 (c) (i)

(c) The teacher adds a lubricant between the surface and the block.

They keep the mass of the block and distance travelled the same as before.

(i) Sketch a line on the graph to show how work done varies with mass in this new experiment.
Label this line with the letter **L**. [1]

A significant minority of candidates omitted this question.

Question 21 (c) (ii)

(ii) Explain your reason for how you have drawn the line labelled **L** in (c)(i).

.....
..... [1]

It was expected that candidates would use technical terms such as less friction.

Question 22 (a) (i)

22 This question is about radioactivity.

(a) The nucleus of an isotope of phosphorous (P) has a relative charge of +15.
The relative mass of the nucleus is 32.

(i) Complete the symbol for this isotope.



[1]

Many candidates gave ${}_{32}^{15}\text{P}$, which is the order the data was given in the question.

Question 22 (a) (ii)

(ii) A nucleus of this isotope emits beta radiation.

State values for the relative charge and relative mass of the nucleus after beta radiation is emitted.

Relative charge

Relative mass

[2]

Few candidates understood the changes to the nucleus in beta decay.

Question 22 (b)

- (b) The table shows some information for two different isotopes of phosphorous. The isotopes are labelled **A** and **B**.

	Relative charge	Relative mass
Isotope A	+15	29
Isotope B	+15	32

Complete the sentences below to describe the nucleus of isotope **A** and the nucleus of isotope **B**.

Use phrases from the list.

less than B more than B the same as B

The number of protons in the nucleus of **A** is

The number of neutrons in the nucleus of **A** is

[2]

One method for candidates to gain marks in this type of question is to extend the given table to include a column for the number of protons and the number of neutrons.

The question was answered well. Some candidates used numbers rather than the given words.

Question 22 (c) (i)

(c) A doctor needs to explore a patient's internal organs. The doctor follows these steps:

- Injects a radioactive isotope into the patient.
- Sets up a special camera outside the patient's body.
- Uses the camera to detect radiation emitted from the isotope.

(i) Which radiation should be emitted by the isotope?

Tick (✓) **one** box.

Alpha

Beta

Gamma

State a reason for your answer.

.....

..... [2]

The majority of candidates were able to identify either beta or gamma radiation. However, many struggled to give a clear reason relating to the ability of the radiation(s) to pass through human tissue / skin. Many candidates discussed harm to the patient.

Question 22 (c) (ii)

(ii) There are three different isotopes with the following half-lives:

4 minutes	6 hours	18 days
------------------	----------------	----------------

The doctor chooses the isotope with a half-life of **6 hours**.

Suggest **two** reasons why **6 hours** is the most suitable half-life.

1

.....

2

.....

[2]

Candidates struggled to give detailed answers. Some candidates in effect stated the question by saying 4 minutes was too short and 18 days was too long.

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