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GCSE (9-1)

Examiners' report

GATEWAY SCIENCE COMBINED SCIENCE A

J250

For first teaching in 2016

J250/12 Summer 2023 series

Version 1

ocr.org.uk/science

Contents

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 is 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.

Paper 12 series overview

J250/12 is one of six Higher tier papers for the GCSE (9-1) Gateway Science Combined Science A qualification. It is the second of the two physics papers, covering Topics P4 Waves and Radioactivity, P5 Energy, P6 Global challenges and CS7 Practical skills. There is assumed knowledge of P1–P3 and this paper includes synoptic assessment.

Candidates who used the Data Sheet and clearly showed steps in calculations performed well.

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
• read the questions carefully, considered the command words and gave full responses for questions asking about, e.g., describe, explain, suggest, draw, use a labelled diagram and evaluate • considered the number of marks available for the question and provided a suitable detailed response as required for the allocated marks, e.g., Question 13 (a) and Question 13 (b) • worked through calculations in a methodical manner, showing clear steps in their calculations • gave well-developed lines of reasoning which were clear, logically structured and used the graph in the question by annotating the calculation of half-life for the Level of Response (LOR) question, Question 16.	• left several multiple choice questions blank, or tried to overwrite the original letter with another letter, and in doing so making it unclear what the final choice was • did not consider the command words, often giving descriptions rather than explanations • only gave final values for calculations, without showing the steps involved. This means that no marks can be given when there is just one error in the calculation • gave very brief or inaccurate descriptions about half-life for the LOR question, Question 16 • did not annotate or use diagrams when these could help describe or explain an answer.

Section A overview

This section consists of 10 multiple choice questions testing AO1 and AO2.

Question 1

1 Which sentence describes the **law of conservation of energy**?

A Energy can be created in a power station.

B Energy can be transferred into power.

C Energy can only be transferred between stores.

D Energy can only be destroyed in the surroundings when it is wasted.

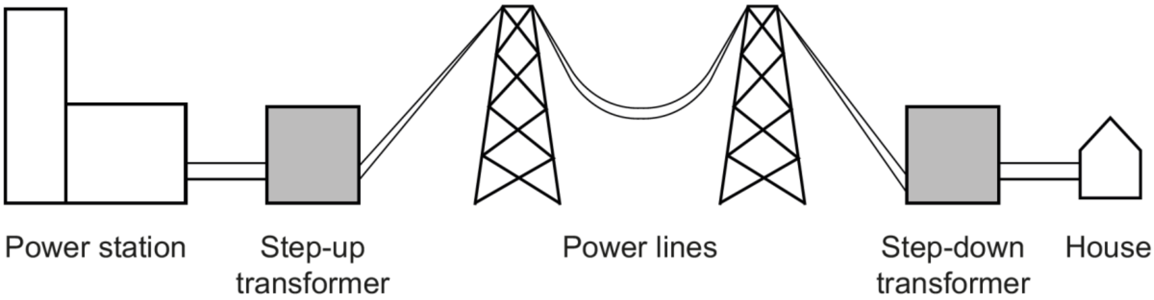
Your answer ☐ **[1]**

The majority of candidates gave the correct response of C showing a clear understanding of the law of conservation of energy. A few candidates thought that energy could be transferred into power.

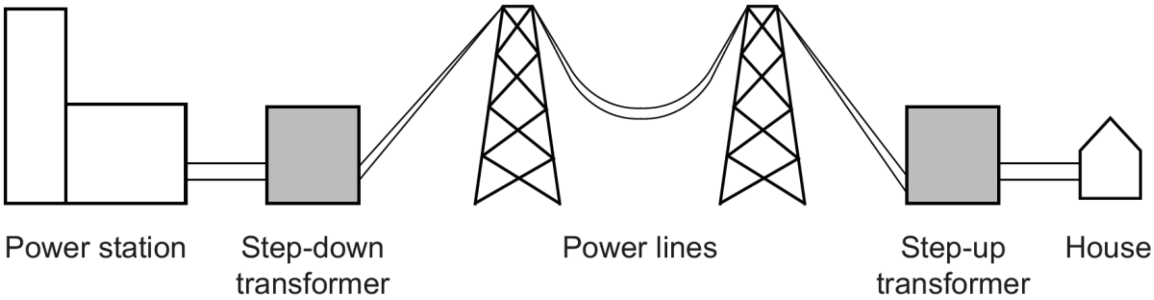
Question 2

2 Which diagram shows how transformers are used in the national grid?

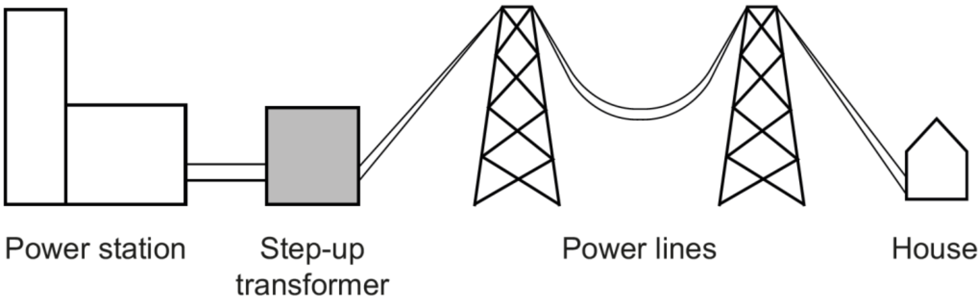
A



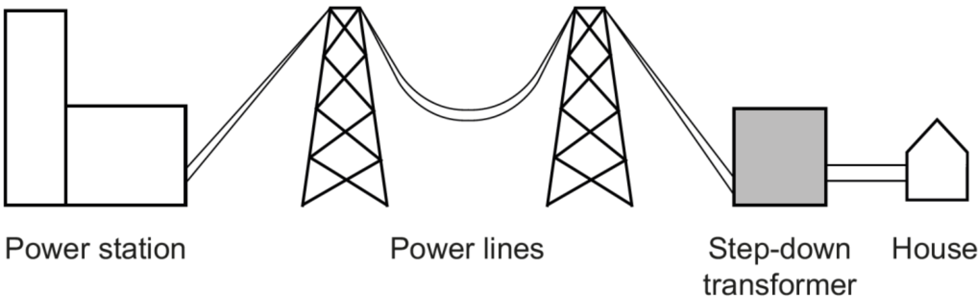
B



C



D



Your answer **[1]**

The majority of candidates were able to identify the correct diagram as A, where there is a step-up transformer between the power station and the power lines and a step-down transformer between the power line and the house. The most common incorrect response was C, where there is only a step-up transformer.

Question 3

3 An electric plug contains a live wire, a neutral wire and an earth wire.

Which statement is correct?

A The neutral wire completes the circuit.

B The neutral wire only carries a current if there is a fault.

C The potential difference between the earth wire and the neutral wire is 230 V.

D The potential difference between the live wire and the neutral wire is 400 000 V.

Your answer ☐ **[1]**

This question was not answered well, with a high number of candidates selecting either B or C, rather than the correct response A.

Question 4

4 This is the nuclear equation for an alpha particle hitting a beryllium nucleus.

$${}^{4}_{2}\text{He} + {}^{9}_{4}\text{Be} \rightarrow {}^{12}_{6}\text{C} + \mathbf{X}$$

What is **X**?

A ${}^{1}_{0}\text{n}$

B ${}^{0}_{-1}\text{e}$

C ${}^{4}_{2}\text{He}$

D ${}^{0}_{0}\gamma$

Your answer ☐ **[1]**

About half the candidates gave the correct response A. The other options, B, C and D, were about equally seen as an incorrect response. Candidates appear to be unfamiliar with nuclear notation.

Question 5

5 A driver drives a car along a road.
The driver presses the brakes to stop.

Energy is transferred between stores.

Kinetic store of car → Thermal store of surroundings

How is the energy transferred between these stores?

A By heating only

B Electrically and by heating

C Work done by forces and by heating

D Work done by forces only

Your answer ☐ **[1]**

The majority of candidates correctly selected response C and demonstrated good knowledge about energy transferred between these stores as work done by forces and by heating.

Question 6

6 A 6 V battery provides a current of 0.4 A in a circuit for 20 seconds.

How much energy is transferred by the battery?

Use the equations: charge flow = current × time

energy transferred = charge × potential difference

A 0.12 J

B 0.75 J

C 15 J

D 48 J

Your answer ☐ **[1]**

The majority of candidates were able to correctly calculate the energy transferred by the battery as D, 48 J. These candidates tended to show all the steps for their calculation in the space beside the question. The most common incorrect response was C, 15 J.

Exemplar 1

How much energy is transferred by the battery?

Use the equations: charge flow = current × time

energy transferred = charge × potential difference

$V = 6V$
$I = 0.4$
$t = 20s$

$Q = It$
$Q = 8$

$\mathcal{E} = QV$
8×6

A 0.12 J

B 0.75 J

C 15 J

D 48 J

Your answer D

In this response, it was evident that the candidate had substituted the given values into the first equation and then substituted this value into the second equation. Candidates who used this method and showed steps in the two calculations like this performed well. Candidates who tried to perform the two calculations without writing anything tended to give an incorrect response.

Question 7

7 The table shows how braking distance changes with the speed of a car.

Speed (mph)	Braking distance (m)
20	6
30	14
40	24
60	56

What is the braking distance at 80 mph?

A 48 m

B 96 m

C 110 m

D 216 m

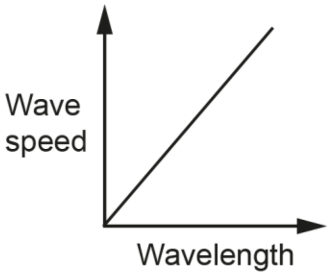
Your answer **[1]**

The majority of candidates were able to correctly calculate the braking distance at 80 mph to be B, 96 m. A few candidates gave the answer of C, 110 m.

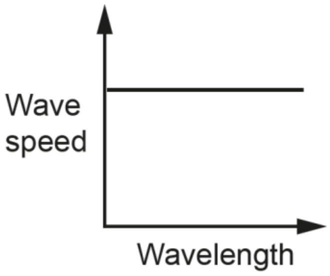
Question 8

8 Which graph shows how wave speed varies with wavelength for electromagnetic waves in space?

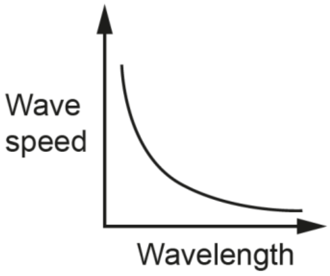
A



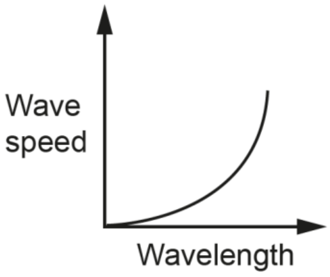
B



C



D



Your answer ☐ **[1]**

This question was not answered well, with a high number of candidates selecting either A or C, rather than the correct response B.

Misconception

Candidates are usually familiar with the idea that the speed of light is 3×10^8 m/s in vacuum. However, they have not appreciated that this speed is also the speed of all electromagnetic waves in vacuum. Candidates appear to have confused speed, wavelength and frequency in this graphical question.

Question 9

9 A 0.5 kg mass is placed on the end of a vertical spring with spring constant 125 N/m. The extension of the spring is 0.04 m.

What happens to the energy stored in the spring when a 1.0 kg mass is placed on the end instead?

Assume the spring obeys Hooke's Law.

Use the Equation Sheet.

A Doubles

B Halves

C Quadruples

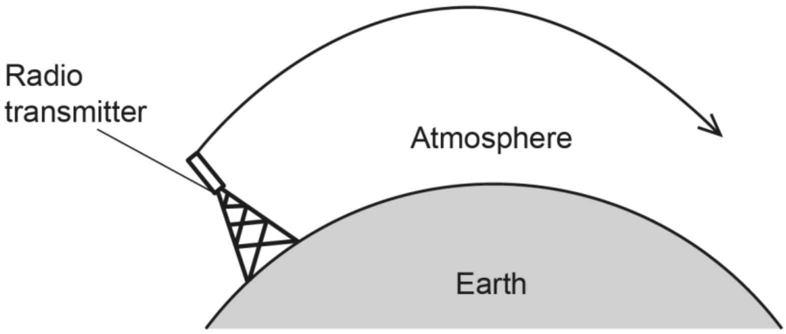
D Stays the same

Your answer ☐ **[1]**

The majority of candidates correctly selected response C and demonstrated good understanding that the energy stored in the spring quadruples when the mass is doubled.

Question 10

10 In summer, a layer of warm air forms above a layer of dense cool air in the atmosphere.
This causes radio waves to bend instead of travelling in straight lines.



Which statement explains why the radio waves bend?

A The frequency of the wave changes.

B The speed of the wave changes.

C The wave is absorbed by the cool air.

D The wave spreads out.

Your answer ☐ **[1]**

This question was not answered well, with a high number of responses selecting option A rather than option B.

Section B overview

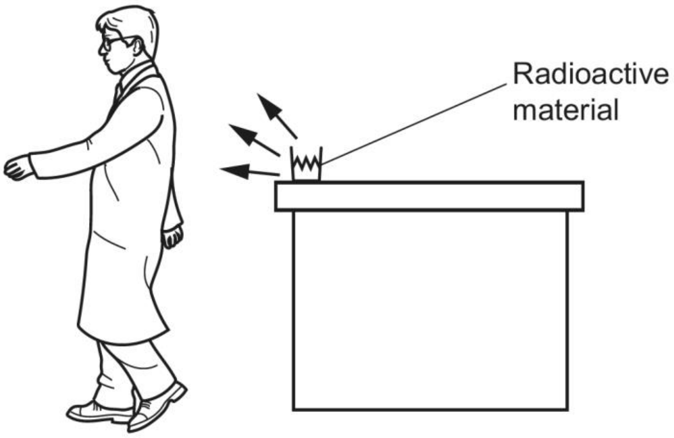
This section consists of seven multiple part questions testing AO1, AO2 and AO3.

Question 11 (a)

11 A scientist is working with a radioactive material.
The radioactive material emits **beta** radiation.

(a) **Fig. 11.1** shows the scientist walking very close to the radioactive material.

Fig. 11.1



Describe the effect of the radioactive material on the scientist as they walk past.

Tick (✓) **one** box.

They have been irradiated only.	☐
They have been contaminated only.	☐
They have been irradiated and contaminated.	☐
They have **not** been irradiated or contaminated.	☐

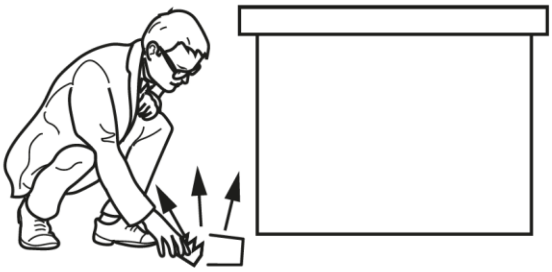
[1]

The majority of candidates were able to describe the effect of the radioactive material on the scientist as they walk past as that they have been irradiated only. A few candidates thought that the effect was that they had been contaminated only.

Question 11 (b)

(b) In **Fig. 11.2**, the scientist knocks the radioactive material onto the floor.
They pick up the radioactive material with their bare hands.

Fig. 11.2



Describe the effect of the radioactive material on the scientist as they pick it up.

Tick (✓) **one** box.

They have been irradiated only.	☐
They have been contaminated only.	☐
They have been irradiated and contaminated.	☐
They have **not** been irradiated or contaminated.	☐

[1]

The majority of candidates were able to describe the effect of the radioactive material on the scientist as they pick it up as that they have been irradiated and contaminated. A few candidates thought that the effect was that they had been irradiated only.

Question 11 (c)

(c) **Fig. 11.3** shows the scientist standing behind a lead screen and a lead-glass window. They use a robotic arm to handle the radioactive material.

Fig. 11.3

Describe the effect of the radioactive material on the scientist when they are behind the lead screen.

Tick (✓) **one** box.

They have been irradiated only.	☐
They have been contaminated only.	☐
They have been irradiated and contaminated.	☐
They have **not** been irradiated or contaminated.	☐

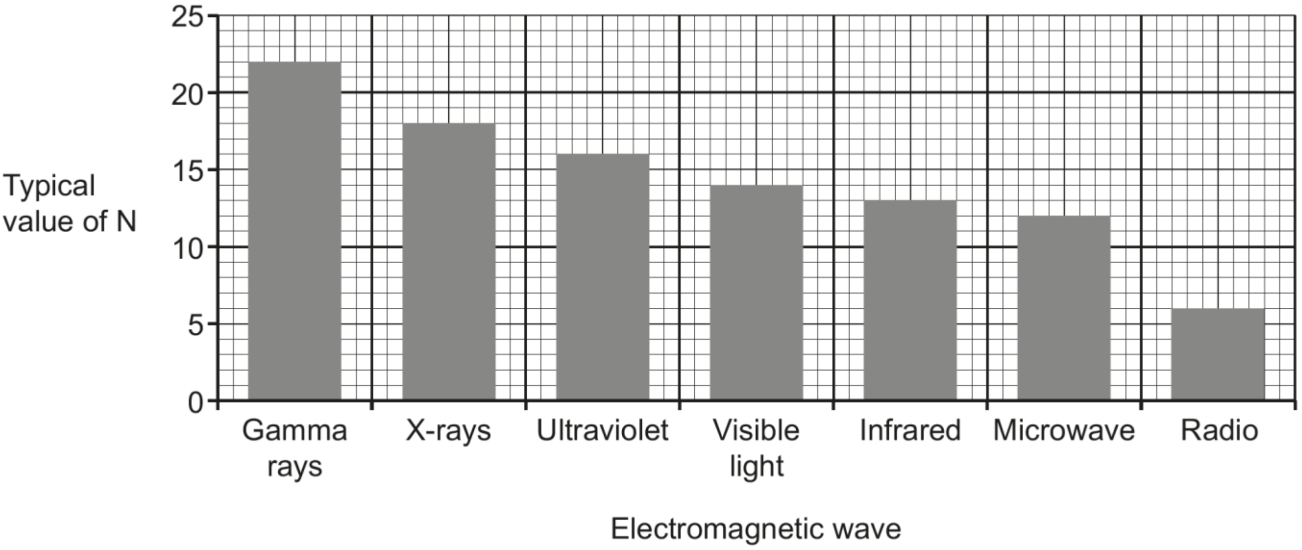
[1]

Almost all candidates were able to describe the effect of the radioactive material on the scientist when they are behind the lead screen as that they have not been irradiated or contaminated.

Question 12 (a)

12 The frequency of electromagnetic waves can be written as 1×10^N Hz.
N is an integer (a whole number).

The graph shows the typical values of N for different electromagnetic waves.



(a) Which electromagnetic wave has the **highest** frequency?

.... **[1]**

The majority of candidates were able to name the electromagnetic wave with the highest frequency as gamma rays.

Question 12 (b)

(b) Which electromagnetic wave is the **most** dangerous?

.... **[1]**

The majority of candidates were able to name the electromagnetic wave which is the most dangerous as gamma rays.

Question 12 (c)

(c) Ultraviolet waves have a greater frequency than visible waves.

How many times greater?

Put a (ring) around the correct answer.

10^2 10^3 10^{13} 10^{14} 10^{16}

[1]

The majority of candidates were able to identify that ultraviolet waves have a frequency that is 10^2 times greater than visible waves.

Question 12 (d)

(d) What is the frequency of a typical radio wave on the graph?

Write your answer as an ordinary number without standard form.

Frequency = ... Hz **[2]**

The majority of candidates were able to state that the frequency of a typical radio wave is 1 000 000 Hz. A few candidates did not read/follow the instruction to give the frequency as an ordinary number without standard form. The answer of 10^6 Hz only gained 1 of the 2 marks available.

Question 12 (e)

(e) Which sentence is true about electromagnetic waves?

Tick (✓) **one** box.

Infrared waves do not have any harmful effects on human body tissue. ☐

Only microwaves transfer energy. ☐

Our eyes can detect all electromagnetic waves. ☐

They are transverse waves. ☐

[1]

The majority of candidates were able to state that the sentence which is true about all electromagnetic waves is that they are transverse waves.

Question 12 (f)

(f) A 0.8 kW microwave oven is used to cook food.
The microwave oven transfers 0.56 kWh when it is used to cook food.

Calculate the time the microwave oven is used for.

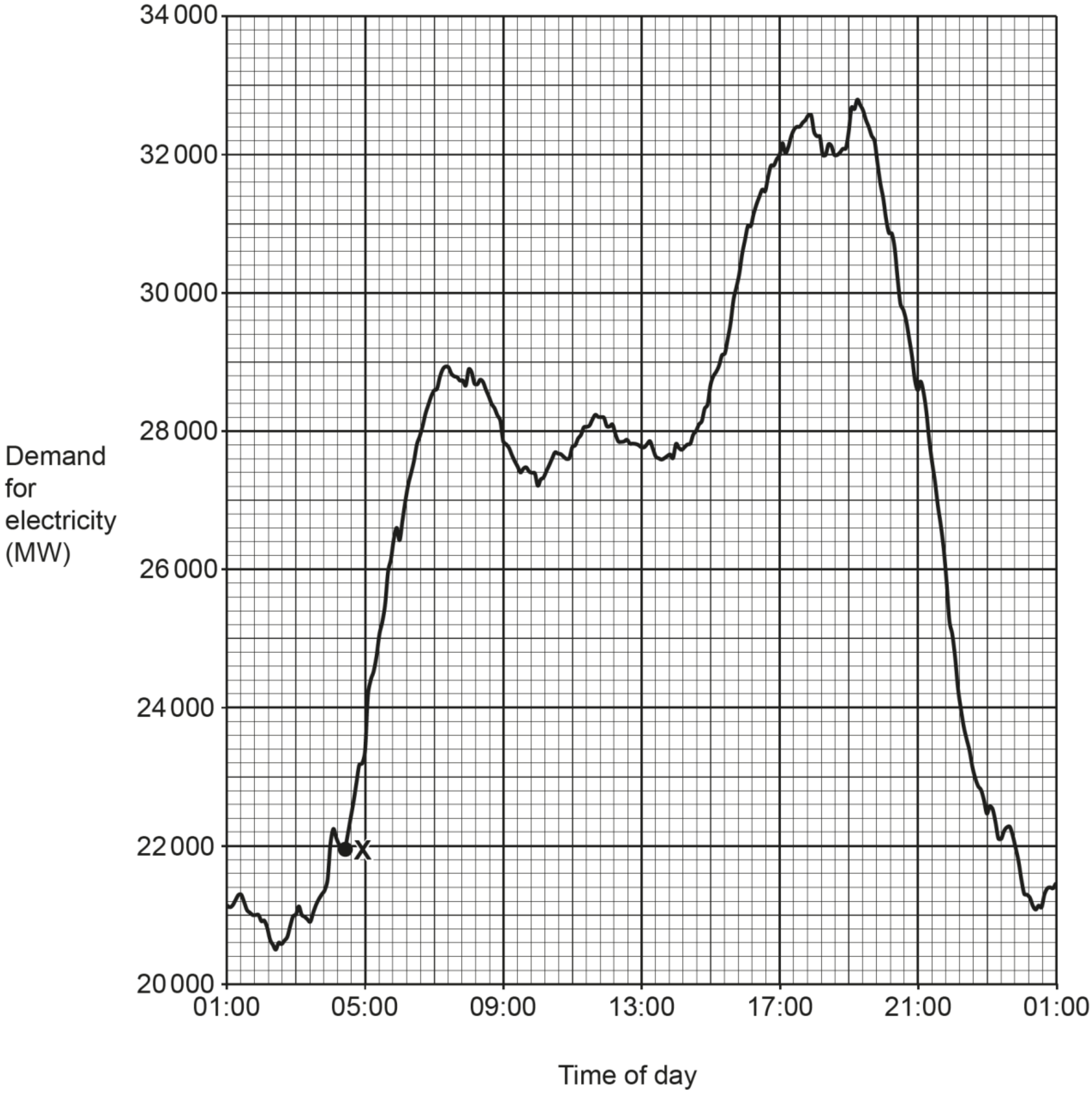
Use the equation: energy transferred = power × time

Time = ... h **[3]**

The majority of candidates correctly calculated the time. These candidates usually rearranged the equation, energy transferred = power × time to make time the subject. They then substituted the values for energy transferred and power into the equation.

Question 13 (a)

13 The graph shows how demand for electricity changes during a typical day in the UK.



Different energy sources can be used by the national grid at different times.

(a) Describe how the demand for electricity changes from 14:00 to 23:00.

....

....

....

.... **[2]**

The majority of candidates were given 2 marks. These candidates often marked the values of 14:00 and 23:00 on the graph and then used this range to describe how the demand for electricity changes with words such as increases, peaks, decreases used as well as the number of MW when these changes happen. A few candidates found it difficult to use the 24-hour clock and others found it difficult to read the scale. Some candidates also just gave reasons why the demand changed, such as cooking lunch and going to bed rather than how the demand changed, so these candidates tended not to gain any marks.

Question 13 (b)

(b) Explain why a gas fired power station is started at **X**.

....

....

....

.... **[2]**

The majority of candidates were given at least 1 mark. These candidates tended to realise that the gas fired power station is started at about 05:00 as there is an anticipated increase in demand when people are waking up a little later. Candidates who gained the second mark usually realised that the time between start up and the peak in demand was short, so this had to be from the use of a gas fired power station that was quick to start up.

Question 13 (c) (i)

(c) The baseload demand is the minimum demand for electricity during the day.

(i) Use the graph to calculate the baseload demand as a percentage of the maximum demand.

Percentage = ... % **[3]**

Half of all candidates gained all 3 marks available for this question. These candidates usually wrote all the steps in their calculations, giving the peak as 32 800 and the base load as 20 500 separately before starting the calculation. These candidates then gave the next step as their values for (baseload ÷ peak) × 100. Some candidates gave values for peak and/or baseload outside the acceptable range, but if they showed all the steps in their calculations, they were given either 1 or 2 marks. A few candidates did not multiply by 100 and gave an answer of 0.625, gaining just 2 marks.

Question 13 (c) (ii)

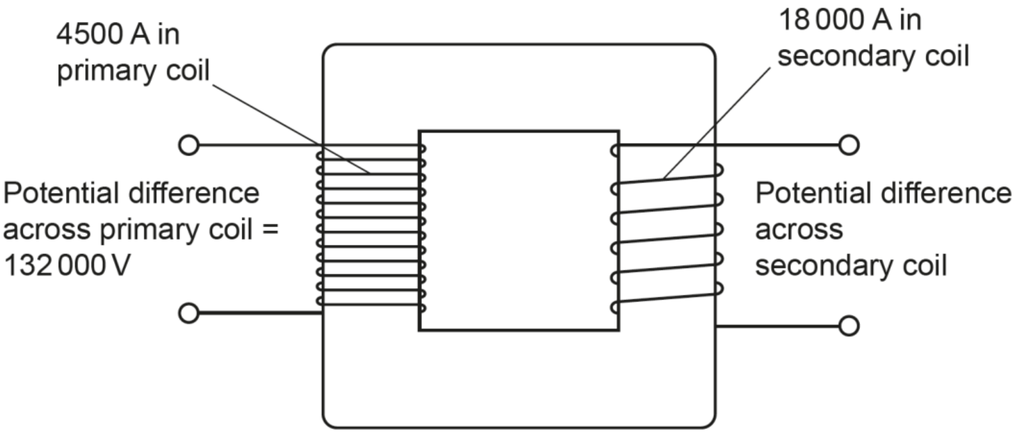
(ii) Suggest a type of power station which is suitable for supplying the baseload.

.... **[1]**

The majority of candidates gave an unsuitable type of power station for supplying the baseload.

Question 14 (a)

14 (a) The diagram shows a transformer.



Calculate the potential difference across the secondary coil of the transformer.

Use the Equation Sheet.

Potential difference across the secondary coil = ... V **[2]**

The majority of candidates correctly calculated the potential difference across the secondary coil. These candidates used the correct equation from the Equation Sheet and then rearranged the equation to make the subject 'potential difference across the secondary coil'. A common error in this question was to multiply 4 500 x 13 200 (rather than 132 000)to get the incorrect answer of 54 900 000 instead of 549 000 000.

Question 14 (b)

(b) The manufacturer says, 'The transformer is 98% efficient.'

Explain what this statement means.

....

.... **[1]**

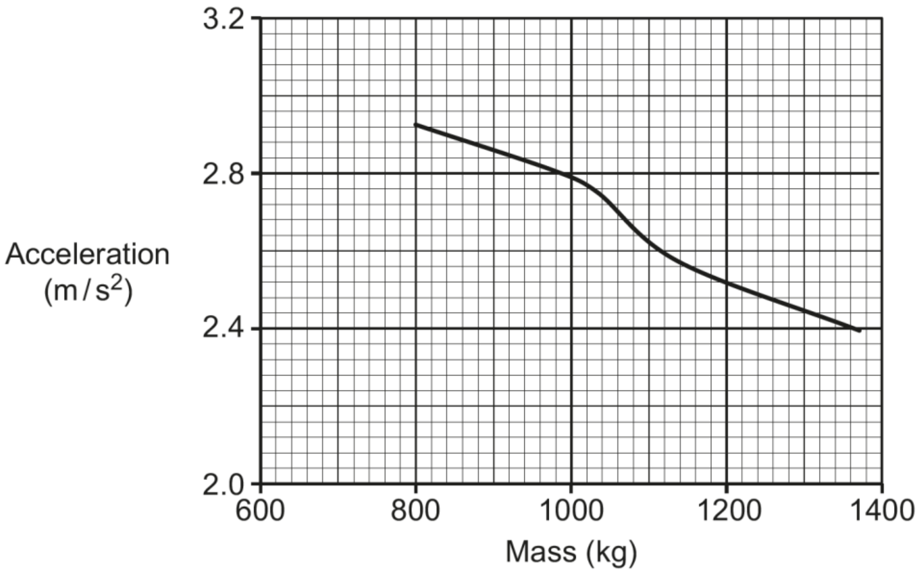
About half of all candidates gave a correct answer for this question. Many good responses explained that this means that 98% of the energy is useful and 2% of the energy is wasted. Some candidates gave very general answers, such as, it is very efficient, it is almost 100% efficient and not much is wasted.

Misconception

A significant number of candidates thought that efficiency was a measure of how often the transformer was working, for example, the transformer works 98% of the time or the transformer is only used for 98% of a day. These candidates did not realise that efficiency is how good the transformer is at transferring energy input to useful energy output.

Question 15 (a) (i)

15 **(a)** The graph shows how acceleration changes with the mass of a car.



(i) Use the graph to determine the acceleration of a car with a mass of 1250 kg.

Acceleration = ... m/s^2 **[1]**

The majority of candidates were able to determine the acceleration of a car with a mass of 1250 kg. These candidates usually added a vertical line to the graph at 1250 kg to help determine the acceleration. Some candidates did not use a ruler and so often gave a value for acceleration outside the acceptable range.

Question 15 (a) (ii)

(ii) Use the graph to estimate the acceleration of a car with a mass of 700 kg.

Acceleration = ... m/s^2 **[2]**

The majority of candidates were able to determine the acceleration of a car with a mass of 700 kg. These candidates usually extrapolated the line on the graph back to the y-axis and then added a vertical line to the graph at 700 kg to help determine the acceleration.

Question 15 (b)

(b) A car is travelling at 60 mph.

Which statement most likely describes what the car is doing?

Tick (✓) **one** box.

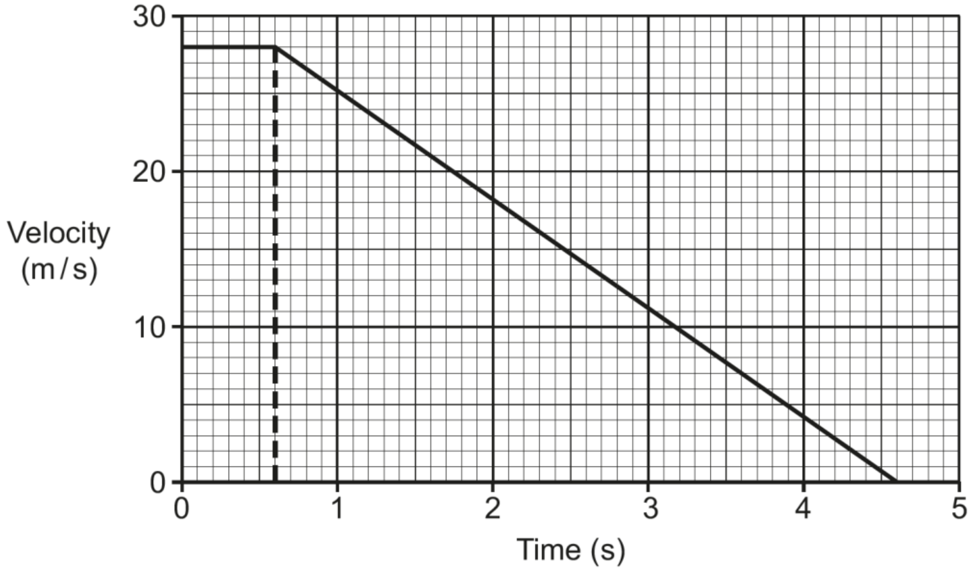
Reversing into a parking space	☐
Travelling along a motorway	☐
Travelling along a road near a school	☐
Travelling in a town centre	☐

[1]

Almost all candidates were able to select the statement that most likely describes what the car is doing as travelling along a motorway.

Question 15 (c) (i)

(c) This graph shows how the velocity of a car changes when driver **A** sees a hazard in the road at time = 0 seconds.



(i) Describe how the graph shows that the reaction time of driver **A** is 0.6 s.

....

.... **[1]**

The majority of candidates were able to describe how the graph shows that the reaction time of driver A is 0.6 s. These candidates used the information on the graph in terms of the line being horizontal for 0.6 s or the velocity only decreasing after 0.6 s. A few candidates only described what reaction time was, rather than using the graph.

Question 15 (c) (ii)

(ii) Calculate the braking distance on the graph.

Braking distance = ... m **[2]**

This question proved challenging. Candidates were required to calculate the braking distance on the graph by calculating the area under the graph. The majority of candidates did not attempt to calculate the area under the graph, but instead tried to calculate the braking distance by using distance = velocity × time or by using stopping distance = thinking distance + braking distance.

Question 15 (c) (iii)

(iii) Driver **B** then drives the same car with the same road conditions and sees the same hazard.

Driver **B**:

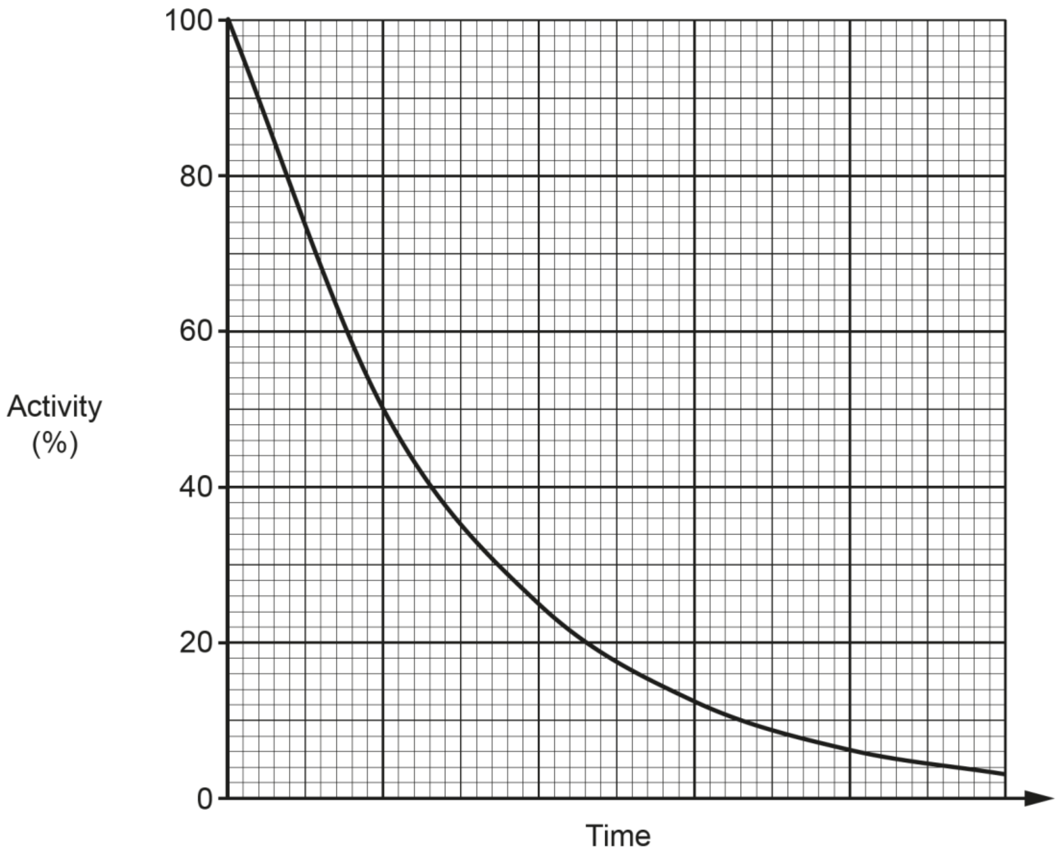
- drives at the same speed as driver **A**
- has been drinking alcohol
- applies the brakes harder than driver **A**.

Draw another line on the graph to show how the velocity changes for driver **B**. **[2]**

The majority of candidates were able to draw another line on the graph that was longer horizontally (showing a larger stopping distance) and then steeper diagonally (showing a higher deceleration) than the original line. A few candidates only showed the line steeper diagonally than the original line and a few started the horizontal line at a different velocity to driver A.

Question 16*

16* The graph shows how the activity of a radioactive isotope changes with time. The graph can be used to determine the half-life of the isotope.



Explain what is meant by half-life.

Describe how the half-life of this radioactive isotope is measured using a radiation detector. Draw on the graph to support your answer.

....

....

....

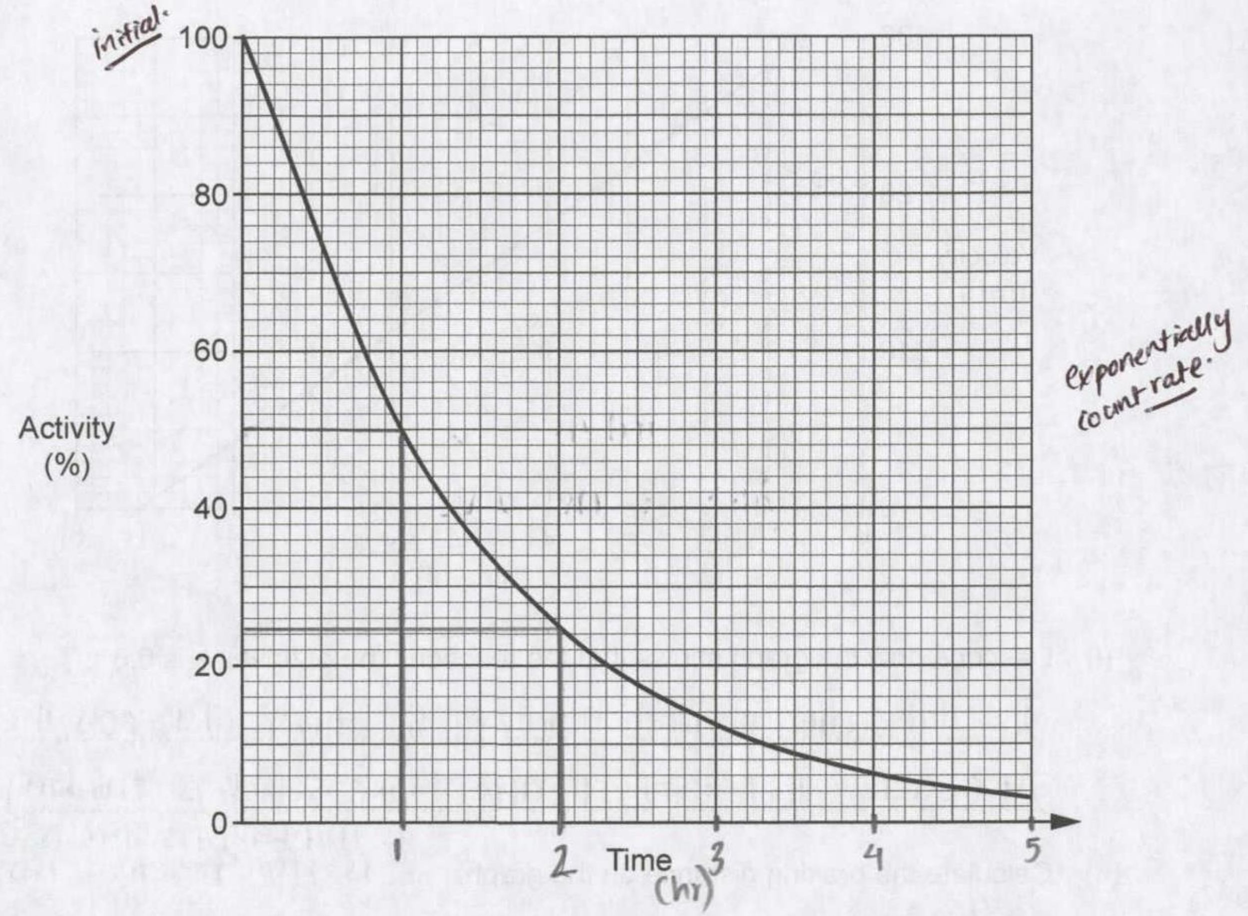
....

....

.... **[6]**

This is the Level of Response question. This question was attempted by the majority of candidates, and the full range of the marks available were given. Many candidates gained marks for demonstrating knowledge and understanding of half-life, by giving a clear description of half-life or by showing how the half-life can be determined from the graph, by the time taken for the activity to halve. Fewer candidates gained marks for giving a description of an experiment to measure half-life. A significant number of candidates were unable to give a clear description of half-life. These candidates wrote about the half-life being half the time taken to decay, the decay of half the atoms or the time taken for the nucleus to halve.

Exemplar 2



Explain what is meant by half-life.

Describe how the half-life of this radioactive isotope is measured using a radiation detector. Draw on the graph to support your answer.

Half life is the time taken for the activity of a radioactive isotope (source) to decay by half. The activity (count rate) of radioactive isotope decreases exponentially over time. Radiation detector detects the amount of radiation (activity/counts) that is reaching to it. The initial activity of radioactive source is 100%. when the reading on the radiation dector decreases ~~by~~ to 50% which means half of the undecayed isotopes have been decayed ~~ot~~ (they are now stable). Only remaining half unstable isotope will emit out radiation and when the count rate on the reading of detector decreases by 50%. and the time taken for the activity to fall to 50% is measured using stop watch which is the half life. Two half lives will be when activity has fallen to 25%. This process of undecayed isotopes to decay into other elements is radioactive decay where there is emission of radiation (activity) **[6]**

Continued on page 24.

If the x-axis line is give for time in hours, then 1 half live when it's 50% then it will be 1 hour; similarly when its 25% → 2 half lives will be 2 hours and so on. the activity never drops to 0 as they will never have been fully decayed.

In this response, the candidate has annotated the graph to demonstrate how the half-life can be determined. They have added numbers and lines to show that when the activity is reduced from 100% to 50% the time taken is 1 hour. The candidate has also linked this to an explanation on the answer lines. The candidate has also given a good description of half-life in terms of the time taken for the activity of the isotope to decay by half. A clear description about how to measure the count rate to determine the half-life is also given.

This is a good example of a response that meets all the criteria for Level 3 and was given 6 marks.

Question 17 (a)

17 (a) Describe the motion of air particles in a sound wave.
You may include a labelled diagram.

....

....

.... **[2]**

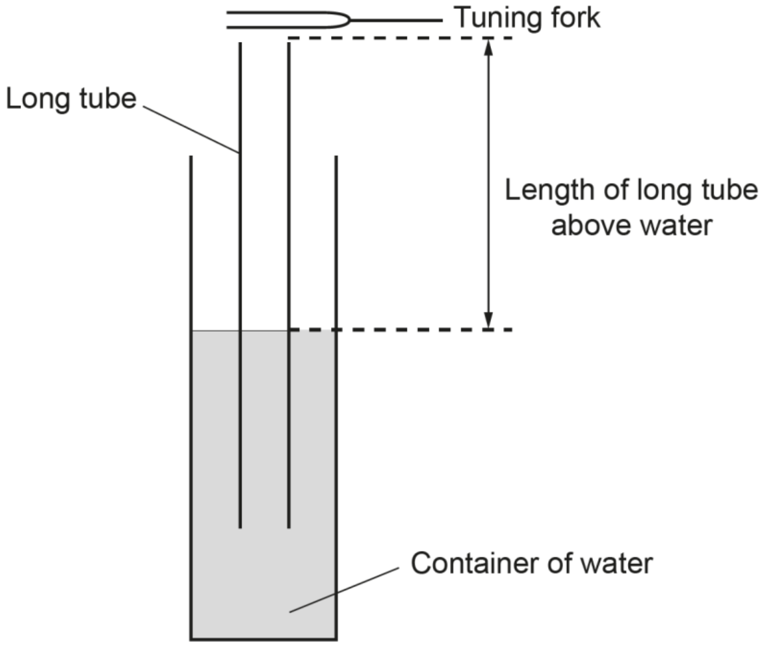
This question was not answered well, with few candidates gaining both marks. Many candidates did not appreciate that a sound wave is a longitudinal wave. Most of the diagrams were of a poor standard with many just showing a transverse wave without labels. The few good quality diagrams showed a clear longitudinal sound wave made up of vertical lines with areas of compression and areas of rarefaction and the wavelength clearly labelled. The written descriptions about the motion of air particles were usually incorrect with the particles moving perpendicular to the direction of the travel.

Assessment for learning

Candidates would benefit from drawing and labelling diagrams of transverse and longitudinal waves.

Question 17 (b) (i)

(b) A group of students measure the speed of sound at a temperature of 20 °C using this equipment.



This is the method they follow:

- Place a long tube in a container of water.
- Hold a vibrating tuning fork over the top of the long tube.
- Pull the long tube out of the water slowly, until a loud sound is heard.
- Measure the length of the long tube above the water.

(i) **Table 17.1** shows the results for one student.

Table 17.1

Length of tube above the water	0.175 m
Frequency of tuning fork	480 Hz

The wavelength of the sound = 4 × the length of the tube above the water.

Calculate a value for the speed of sound using this student's results.

Use the Equation Sheet.

Speed of sound = ... m/s **[3]**

Nearly all candidates correctly calculated the speed of sound. These candidates usually gave the equation: wave speed = frequency × wavelength to start with. Then they substituted the values of frequency as 480 and wavelength as 4 x 0.175. A few candidates used wavelength as 0.175 rather than the 4 × the length of the tube above the water given in the question.

Question 17 (b) (ii)

(ii) **Table 17.2** shows the results for the group of students.

Table 17.2

Student	Speed of sound (m / s)
1	314
2	320
3	330
4	315
5	321

The quality of these results can be judged using percentage uncertainty.

The percentage uncertainty in an experimental value is given by the equation.

$$\text{percentage uncertainty} = \left(0.5 \times \frac{\text{range}}{\text{mean value}}\right) \times 100\ \%$$

Calculate the percentage uncertainty in the students' results from **Table 17.2**.

Percentage uncertainty = ... % **[3]**

The majority of candidates were able to calculate the percentage uncertainty correctly. These candidates usually wrote the value for the range as 16 m / s and the mean as 320 m / s before substituting these values into the equation given in the question. A significant number of candidates gave incorrect values for range and/or mean or forgot to multiply the answer by 100.

Question 17 (b) (iii)

(iii) The speed of sound at 20 °C is 343 m/s.

Evaluate the **precision** and **accuracy** of the results in **Table 17.2**.

Precision ....

....

Accuracy ....

....

[2]

About half of all candidates gained marks for this question. There was confusion between the meanings of the words 'precision' and 'accurate' with many candidates giving the same answer for both words. Some candidates just described the meaning of the words and did not evaluate the precision and accuracy of the results in Table 17.2.

Question 17 (b) (iv)

(iv) Which statement improves the **accuracy** of the results?

Tick (✓) **one** box.

Holding the tuning fork as close as possible to the end of the tube ☐

Measuring the volume of water in the container ☐

Using a tube with a shorter length ☐

Using a tuning fork with a higher frequency ☐

[1]

Less than half of all candidates were able to identify the statement that improves accuracy of the results is holding the tuning fork as close as possible to the end of the tube. A significant number of candidates thought that using a tuning fork with a higher frequency was a way to improve the accuracy of the results.

Question 17 (v)

(v) Which statement describes a **systematic** error in the experiment?

Tick (✓) **one** box.

Background noise in the laboratory ☐

Changes in the temperature of the air ☐

Measuring the length of the tube below eye level ☐

Using a ruler with a zero error ☐

[1]

The majority of candidates were able to identify that the statement which describes a systematic error in the experiment is using a ruler with a zero error.

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