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GCSE (9–1)

Examiners' report

TWENTY FIRST CENTURY SCIENCE PHYSICS B

J259

For first teaching in 2016

J259/01 Summer 2024 series

Version 1

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.

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Paper 1 series overview

This is the first of two papers taken by Foundation tier candidates studying Physics GCSE of the Twenty First Century Science suite. This paper tests across the breadth of the whole specification using short answer questions. The style of the questions enables candidates to put their physics knowledge and understanding into contextual situations.

The paper starts off with more straightforward questions which should give candidates some confidence before they move on to the more difficult questions and/or contexts. The final two questions overlap with the Higher tier paper (J259/03) and these questions tend to challenge some candidates taking this paper.

Candidates did better in topics such as simple electrical circuits, behaviour of waves and energy transfers in the context of a fairground ride. It was also good to see nearly all candidates tackling the calculation questions and attempting to show their working.

The questions in the context of practical activities, such as stretching a spring and investigating the electrical resistance of a wire, were not so well answered.

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
• laid out calculations clearly • showed good understanding of practical aspects of physics • interpreted and drew graphs correctly • applied their knowledge of physics in familiar and more unfamiliar contexts.	• were distracted by the contexts in the questions, and did not answer what was being asked • did not check units in calculation questions and, for example, forgot to convert masses in grams to kilograms • did not understand the command words.

Question 1 (a) (ii)

(ii) A third lamp is now connected in parallel.

What happens to the brightness of the original lamps?

Tick (✓) **one** box.

Lamps get brighter.	☐
Lamps get dimmer.	☐
Lamps stay the same brightness.	☐

[1]

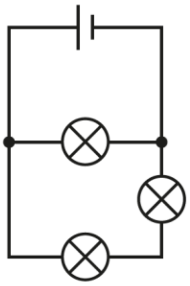
The most common incorrect response in part (ii) was that the lamps get dimmer, which is what would happen if more bulbs were connected in series.

Question 1 (b)

(b) The student now uses the same equipment to build a circuit with all three lamps in series.

Which circuit diagram shows this circuit?

Tick (✓) **one** box.



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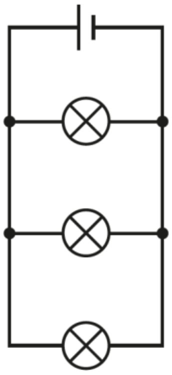

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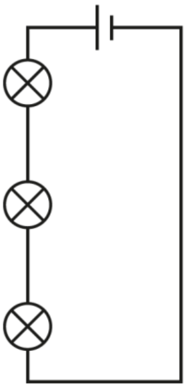

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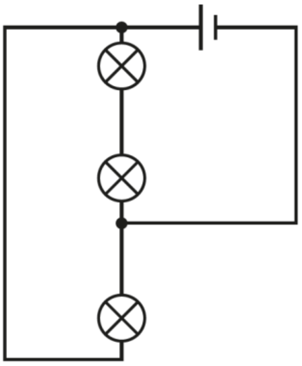


☐

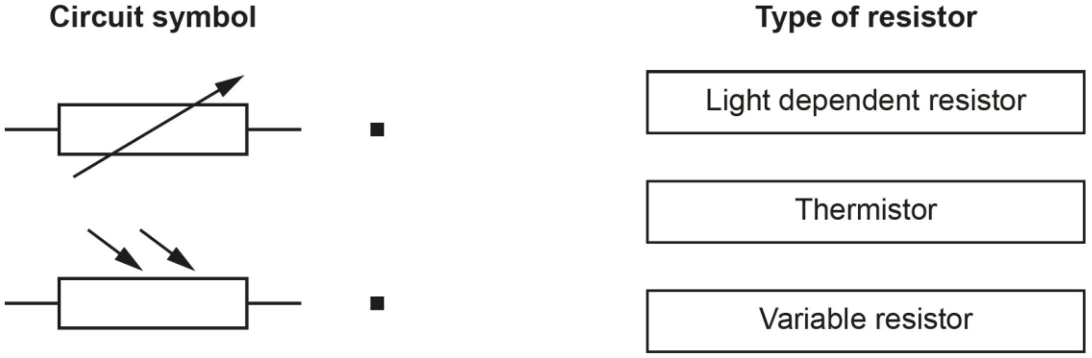
[1]

The most common incorrect response here was the circuit showing three bulbs in parallel. Part (a) did refer to parallel circuits but in part (b) the question moves on to series circuits.

Question 1 (c)

(c) The student then uses some resistors to control the brightness of the lamps.

Draw a line from each **circuit symbol** to the **type of resistor** it represents.



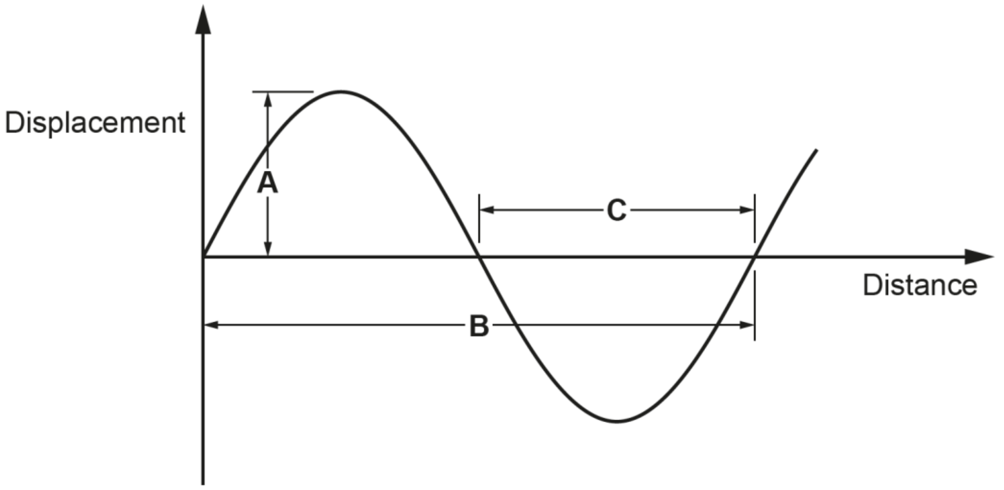
[2]

Most candidates correctly identified both symbols here. A common confusion was between a variable resistor and thermistor.

Question 2 (a)

2 Waves transfer energy in many ways.

(a) Which length, **A**, **B** or **C**, on the diagram represents the wavelength of the wave?



.... **[1]**

A large number of candidates identified C as the wavelength in this diagram.

Question 2 (c)

(c) Some waves are formed on the surface of water.

In 2 seconds, 7 waves pass a point.

Calculate the frequency of the wave.

Give the unit.

Frequency = ... Unit .... **[3]**

Most candidates showed a lack of understanding that frequency refers to the number of waves passing a point in each second. Commonly candidates copied down the equation,
wave speed = frequency × wavelength from the equation sheet, which did not help because they were not given the wave speed or the wavelength. Some candidates then attempted to substitute in the values they were given in a variety of ways, and most of them multiplied the time by the number of waves, giving a value of 14. Despite this, some candidates incorrectly stated the unit as w/s which could refer to waves per second, but is not a standard unit. Some candidates did correctly recall the units of frequency as Hz (or hertz).

Assessment for learning

Candidates need to understand the terms in any equation they are expected to recall, rearrange and/or use. In wave speed = wavelength × frequency:

- wave speed is the distance travelled by the wave divided by time taken
- wavelength is (for example) the distance between two crests of a wave
- frequency is the number of waves per second.

Question 2 (d)

(d) Microwaves can be used for both communication and heating.

Draw lines to connect **each use** to one **example** of that use.

Use	**Example**
	Cooking food
Communication	Detecting broken bones
	Lighting a room
Heating	Mobile phone
	Night vision

[2]

Most candidates correctly linked communication to mobile phone, and heating to cooking food. A common error was to link more than one example to each of the uses.

Question 2 (e)

(e) Complete the sentences about electromagnetic waves.

Use words from the list.

frequency	**light**	**longitudinal**	**speed**	**transverse**	**ultrasound**

Microwaves and .... are both electromagnetic waves.

All electromagnetic waves are .... and travel at the same

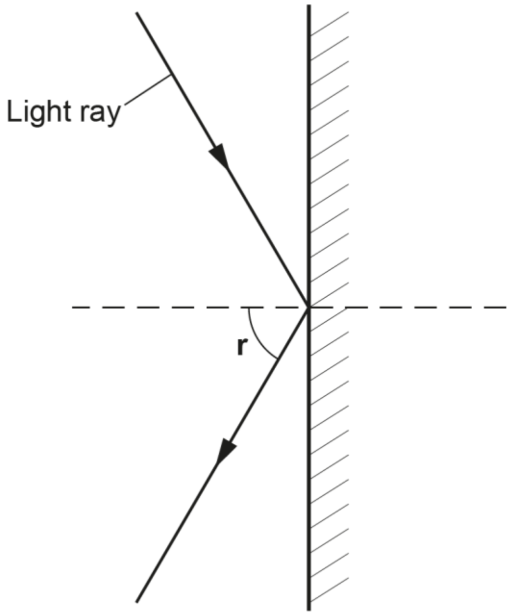
.... in space.

[3]

Most candidates correctly placed two out of the three words. The most common correct response included that all electromagnetic waves travel at the same speed in space. Common errors included thinking that ultrasound was a type of electromagnetic wave or that electromagnetic waves were longitudinal.

Question 2 (f) (i) and (ii)

(f) Waves reflect when they hit materials. The diagram shows a light ray reflecting.



(i) What does this symbol in the diagram mean? 

.... **[1]**

(ii) The angle of reflection, **r**, is labelled on the diagram.

Label the angle of incidence, **i**, on the diagram. **[1]**

Around half the candidates correctly identified the symbol for a mirror, and about half the candidates labelled the angle of incidence correctly on the ray diagram. Common errors were to give the response 'material' or to label the angle between the one of the rays and the mirror.

Question 3 (b) (i) and (ii)

(b) The total mass of the carriage with 12 riders is 2340 kg.

The total mass of the 12 riders is 840 kg.

(i) Calculate the mean mass of each rider.

Mean mass = ... kg **[2]**

(ii) Calculate the mass of the empty carriage.

Mass = ... kg **[1]**

Most candidates were able to correctly calculate the mean mass of the riders and the mass of the empty carriage. A common error was to divide the total mass of 2340 kg by 12 to try to find the mean mass of the riders.

Question 3 (c)

(c) The carriage and 12 riders are pulled up through a height of 60 m to get to the top of the ride.

Calculate the change in gravitational potential energy of the carriage and 12 riders when it has reached the top.

Use the equation:
gravitational potential energy = mass × gravitational field strength × height.

gravitational field strength = 10 N / kg.

Gravitational potential energy = ... J **[2]**

Most candidates were able to substitute values into the given equation correctly, but some did select an incorrect value for the mass. The question asked candidates to find the energy related to the carriage and the 12 riders, so they needed to use the total mass, not one of the mass values calculated in a previous part to the question.

Question 3 (e)

(e) The carriage has brakes to slow it down before it stops at the bottom.

The brakes transfer 20 kJ of energy during a 2 s time period.

Calculate the power of the ride transferred during this braking.

Use the Equation Sheet.

Power = ... W **[4]**

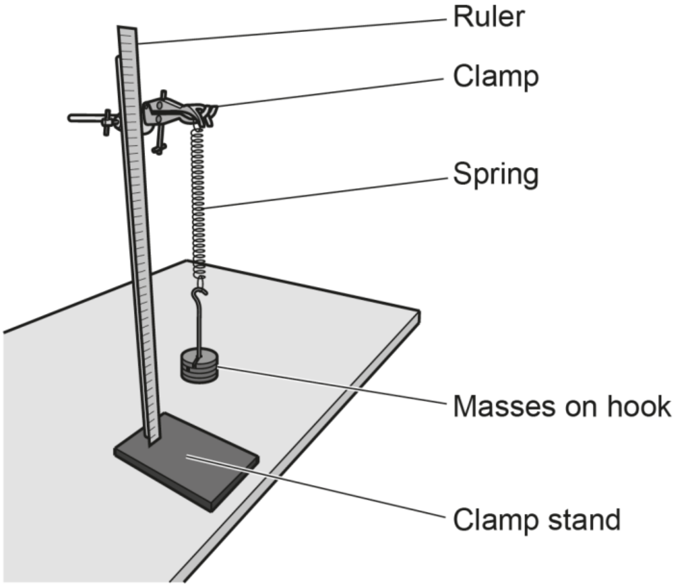
Nearly all candidates selected and used the correct equation from the equation sheet for Question 3 (e). Only a few candidates remembered to convert the energy from 20 kJ to 20 000 J.

Question 4 (a)

4 A student investigates how a spring stretches when masses are added.

Fig. 4.1 shows how the student sets up her equipment.

Fig. 4.1



(a) Identify a hazard and suggest a way to minimise the risk.

....

....

....

.... **[2]**

Candidates identified risks associated with the stand and/or the masses falling off the table, as well as the spring flying off and hitting someone in the face or eyes. The most common suggestion to minimise the risk was to put the whole apparatus into the centre of the table, rather than to wear safety glasses to protect eyes.

Question 4 (b)

(b) The student uses her equipment and follows a method to collect data.

The statements below show the steps in her method.

A Hang a hooked mass on the spring.

B Repeat for a larger mass.

C Measure and record the extension.

D Remove the mass from the spring.

E Wait for the mass to stop bouncing.

F Check the spring has returned to its original length.

Write the letters in the boxes to show the correct order of the steps.

The first step has been done for you.

A					

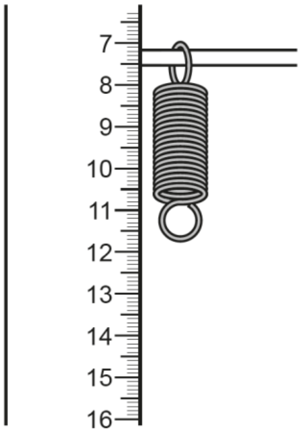
[3]

Most candidates answered this question well.

Question 4 (c)

(c) **Fig. 4.2** shows a close-up of the apparatus.

Fig. 4.2



Suggest **one** change the student can make to get more valid data.

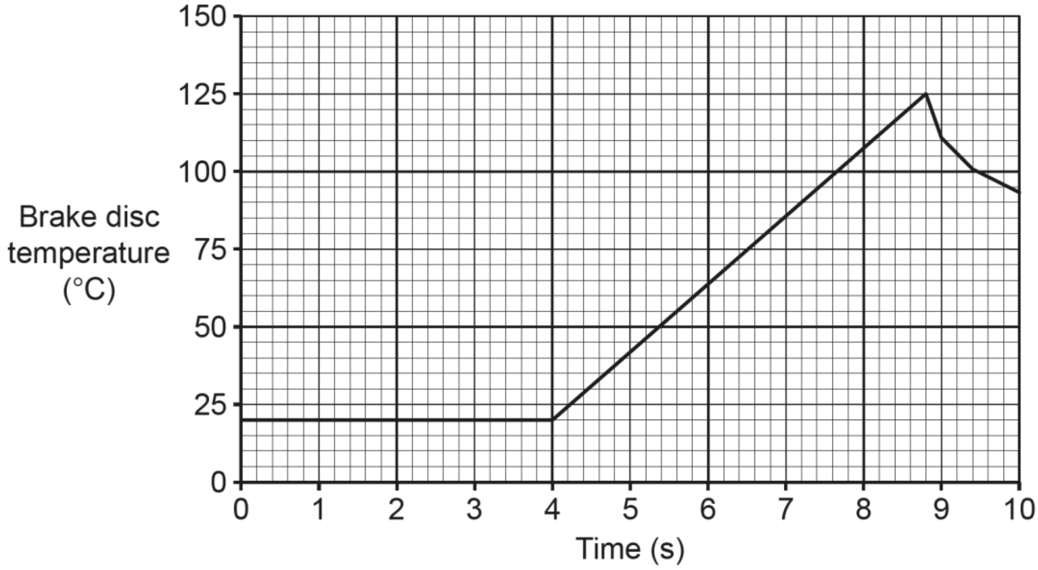
....

.... **[1]**

Although a number of candidates did correctly suggest to move either the ruler or the spring so it lined up with zero or a sensible number of cm, several candidates did not answer the question properly. Common incorrect responses included 'add some masses onto the spring' or 'move the spring along the rod'.

Question 5 (b)

(b) The graph shows the temperature of the brake disc on part of a bike journey.



What time did the rider apply the brakes?

Use data from the graph.

Time = ... s **[1]**

Most candidates correctly identified the time the rider applied the brakes as the time when the temperature began to rise. A common mistake was to suggest it was at the end of the temperature rise at 8.8 s.

Question 5 (c)

(c) Find the maximum temperature increase of the brake disc during braking.

Use data from the graph.

Temperature increase = ... °C **[2]**

Many candidates just read the maximum temperature of 125 °C from the graph instead of calculating the difference between the lowest temperature and the maximum temperature. Another common error was to mis-read the lower temperature as 25 °C instead of 20 °C. Some candidates found the temperature difference between the maximum temperature of 125 °C and the temperature at the end of the graph grid at 10 seconds.

Question 5 (d)

(d) Use your answer to part **(c)** to calculate the change in internal energy of the brake disc while the bike slows down.

The specific heat capacity of the brake disc is 500 J / kg °C.
The mass of the brake disc is 200 g.

Use the equation:
change in internal energy = mass × specific heat capacity × change in temperature

Change in internal energy = ... J **[3]**

Most candidates were able to use the given equation correctly using the temperature they had calculated in part (c), but most did not convert the mass of 200 g to 0.2 kg.

Question 5 (e)

(e) Complete the sentence to define specific heat capacity.

Use words from the list.

energy	**joule**	**kilogram**	**mass**	**temperature**	**time**

Specific heat capacity is the .... needed to change the .... of one .... of a material by 1 °C.

[3]

Many candidates were able to complete the sentence to define specific heat capacity correctly. Some candidates swapped the quantities and the units around. An example of this might be 'specific heat capacity is the joule needed to change the temperature of one mass of a material by 1 °C'.

Question 5 (f)

(f) When the rider stops applying the brakes, the brake disc will cool down.

Predict the temperature of the brake disc once it has stopped cooling down.

Use data from the graph.

Temperature = ... °C **[1]**

While many candidates answered this correctly, some showing the same error as in part (c) of reading the lowest temperature as 25 °C instead of 20 °C, some also read the temperature of the brake disc at 10 s, as that was the end of the decrease in temperature shown on the graph.

Question 6 (a)

6 Radium-223 is a radioactive isotope used in medical treatment.

(a) Complete the nuclear equation to show the decay of radium-223 (Ra) to radon (Rn).

$$^{223}_{88}\text{Ra} \rightarrow {}^{4}_{2}\alpha + {}^{\cdots\cdots}_{\cdots\cdots}\text{Rn}$$

[2]

Many candidates correctly balanced this nuclear equation. The most common error was to add 4 to the mass number and/or add 2 to the proton number of radium instead of subtracting. Some candidates divided the numbers.

Question 6 (b) (i) and (ii)

(b)

(i) Which of these is the correct definition of half-life?

Tick (✓) **one** box.

The activity after half the age of the sample. ☐

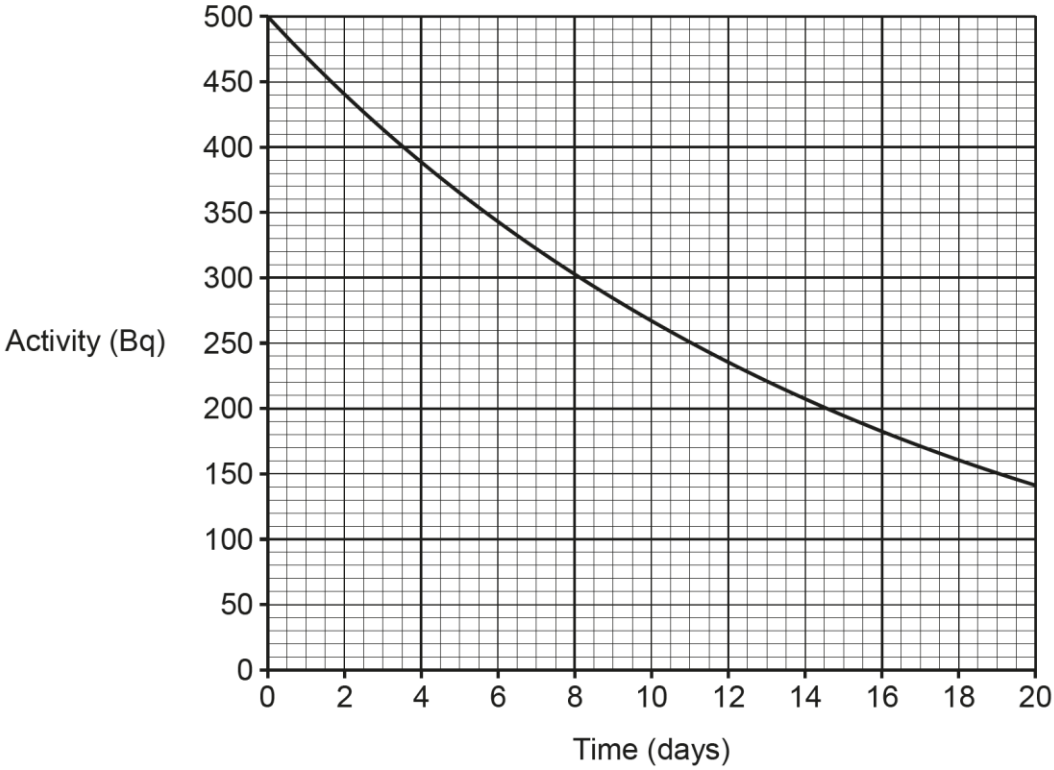
The time taken for the activity to reach 0.5Bq. ☐

The time taken for half a decay to happen. ☐

The time taken for the activity to fall to half. ☐

[1]

(ii) The graph shows the decay of radium-223.



Find the half-life of radium-223.

Use the graph.

Tick (✓) **one** box.

8 days ☐

10 days ☐

11 days ☐

250 Bq ☐

[1]

The most common incorrect choice for part (i) was 'the time taken for half a decay to happen'. However, many candidates who gave that answer in part (i) were able to correctly determine the half-life from the decay graph as the time taken for the activity of the sample to halve.

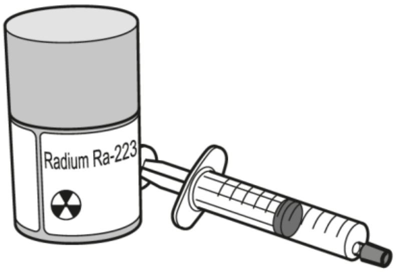
The most common incorrect choice in part (ii) was 10 days.

Question 6 (c) (i) and (ii)

(c) Radium-223 emits alpha particles.

It is injected into veins for medical treatment.

The diagram shows the radium-223 medicine and syringe.



(i) There is no lead shielding on the syringe.

Give a reason why this is safe.

....

....

.... **[1]**

(ii) Why is radium-223 far more effective at destroying unwanted tissue than beta or gamma-emitters?

Tick (✓) **one** box.

Alpha radiation is less harmful.	☐
Alpha radiation is more ionising.	☐
Alpha radiation is more penetrating.	☐
Alpha radiation is more stable.	☐

[1]

Many candidates misunderstood the context in part (i) and did not realise that this was about the penetration properties of alpha particles, giving answers relating to the toxic nature of lead rather than realising that alpha particles would be unable to penetrate the plastic of the syringe.

However, most candidates were able to recall that alpha particles were more ionising than beta or gamma radiation and answered part (ii) correctly.

Question 6 (d)

(d) Gamma emitting radioactive isotopes are used for scanning bones to check if the treatment was successful.

Table 6.1 shows some information about three isotopes that emit gamma radiation.

Table 6.1

Radioactive isotope	Half-life
Francium-232	5 seconds
Phosphorus-32	14 days
Technetium-99	6 hours

Which isotope from **Table 6.1** is most suitable for bone scans?

Explain your answer.

....

....

....

.... **[2]**

This question was not well answered; most candidates thought that the isotope with the lowest possible half-life would be the safest material to use. Some candidates suggested that a matter of seconds was a feasible length of time for doctors to carry out a bone scan.

Exemplar 1

Technetium-99 becase it last long enough that they can scan them but not long enouf that it can harm them or others. **[2]**

This candidate correctly identified technetium-99 as the most suitable isotope and gave a good explanation why this was the case. The half-life is an appropriate length for the scan to be performed, but not long enough to harm the patient or other people nearby.

Question 7 (a) (ii)

(ii) The current in the 25 000 V primary coil of the transformer is 18 000 A.

The secondary coil has a potential difference of 400 000 V.

Calculate the current in the secondary coil.

Use the equation:

$$\text{current in secondary coil} = \frac{\text{potential difference across primary coil} \times \text{current in primary coil}}{\text{potential difference across secondary coil}}$$

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

Current = ... A **[3]**

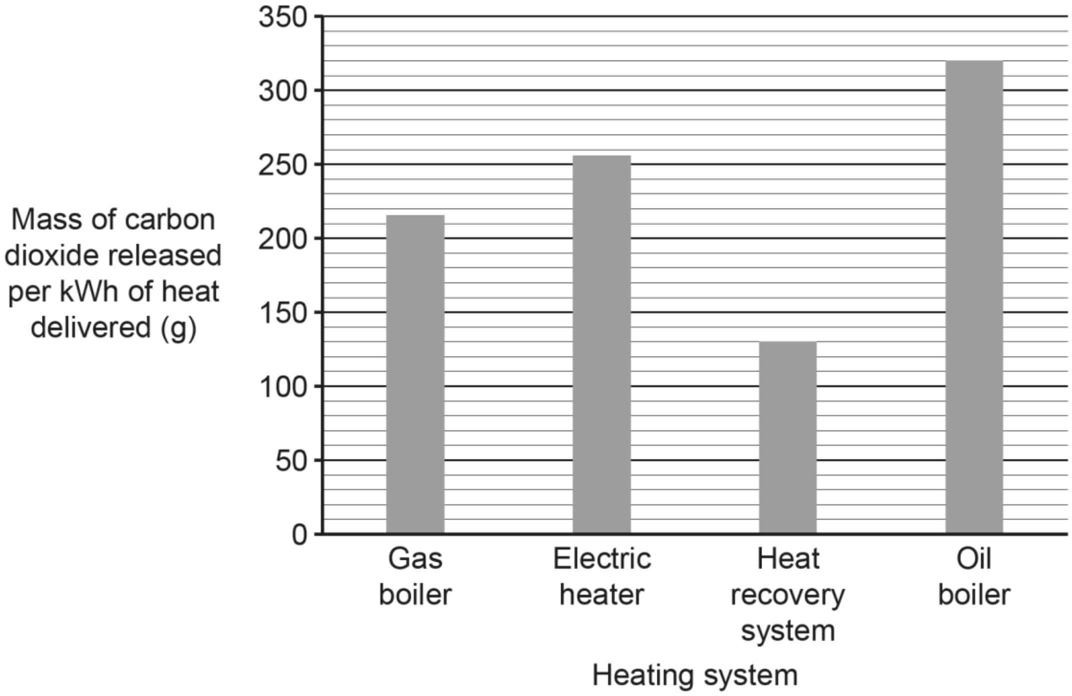
For Question 7 (a) (ii), many candidates correctly substituted the values into the equation and calculated the current to be 1125 A. Fewer than half correctly rounded the value to 2 significant figures. Many just left the final answer as 1125, some truncated the value to 11 and others put a decimal point in and wrote the answer down as 11.25.

Question 7 (b)

(b) Transformers get hot.

The thermal energy store from large transformers in the National Grid can be used to provide heating for nearby homes. This is known as a heat-recovery system.

The graph shows the mass of carbon dioxide released by different heating systems per kWh of heat they deliver.



A homeowner changes from using a gas boiler to using the heat recovery system.

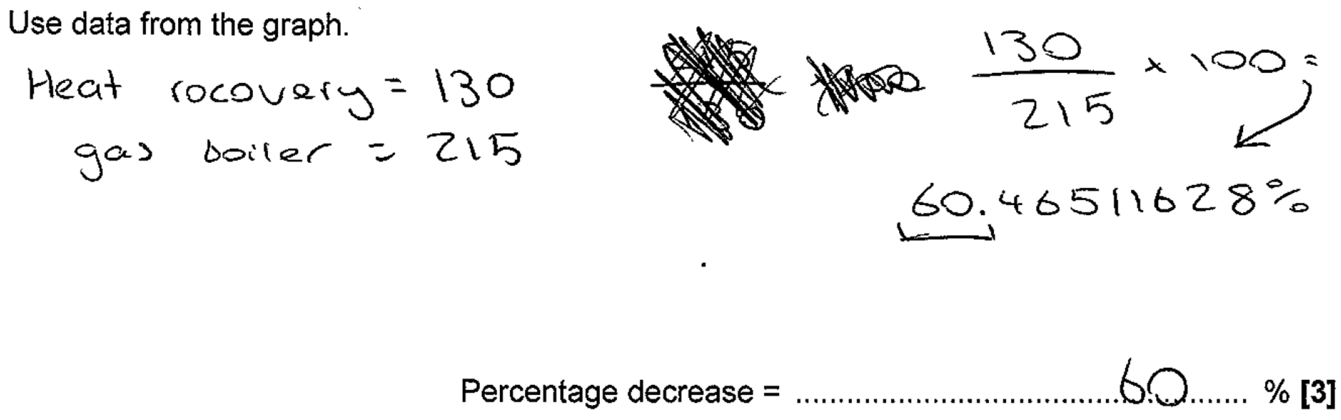
Calculate the percentage decrease in carbon dioxide released per kWh of heat.

Use data from the graph.

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

Most candidates were able to read the values indicated by the top of the bars in the graph. Some candidates found the difference between the two readings, but did not then go on to calculate the percentage difference between the two values.

Exemplar 2


Use data from the graph.

Heat recovery = 130
gas boiler = 215

$\frac{130}{215} \times 100 =$

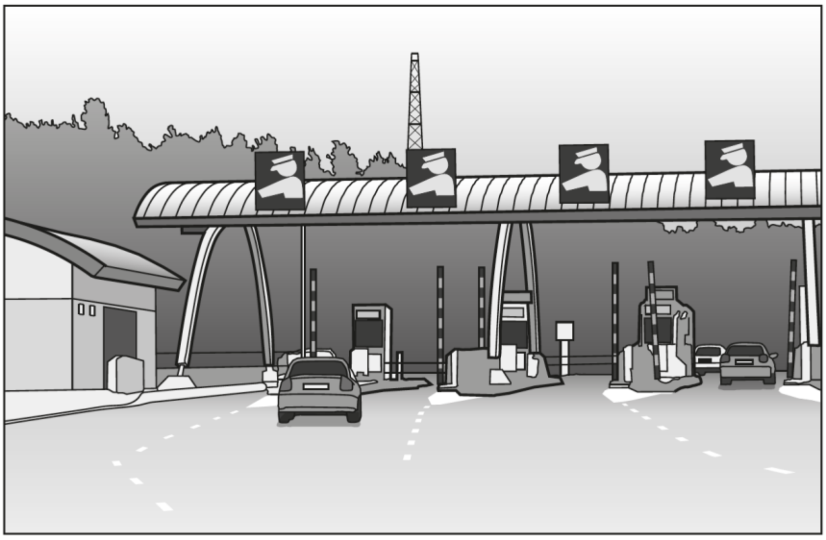
60.46511628%

Percentage decrease = ...60........ % [3]

This candidate clearly stated the values read from the graph for both heat recovery and gas boiler systems. This candidate did not find the difference, instead they then found the ratio between the two values and converted this correctly to a percentage. However, this percentage is not the percentage decrease in carbon dioxide released. They needed to then subtract this value of 60.5% from 100% to find the decrease. This equates to 39.5%.

Question 8 (a) (i), (ii) and (iii)

8 Drivers pay to use a toll road. Cars stop at a payment point and then accelerate to the usual road speed.



(a) A car leaves the payment point and accelerates:

- for 11 s
- to a speed of 22 m/s.

The car is a typical family car.

(i) Calculate the car's acceleration.

Use the equation: $\text{acceleration} = \dfrac{\text{change in speed}}{\text{time taken}}$

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

(ii) Estimate the mass of a typical family car.

Tick (✓) **one** box.

250 kg ☐

1500 kg ☐

5000 kg ☐

20000 kg ☐

[1]

(iii) Calculate the resultant force on the car.

Use:
- your answers to parts **(a)(i)** and **(a)(ii)**
- the Equation Sheet.

Resultant force = ... N **[3]**

Most candidates correctly calculated the acceleration of the car in part (i), and over half of them gave the correct estimate for the mass of a family car in part (ii).

In part (iii) candidates had to find an equation from the equation sheet to calculate the resultant force on the car. About half the candidates picked the correct equation; force = mass × acceleration and so were able to substitute the two values from parts (i) and (ii) and calculate the value correctly.

A common technique was to pick a different equation, which is actually only needed for the Higher tier paper, 'change in momentum = resultant force × time for which it acts'. A few candidates who seemed familiar with the concept of momentum were able to rearrange the equation and still managed to get the correct answer. Many candidates just wrote the equation down but got no further.

Question 8 (b)

(b) After a few minutes the driver needs to perform an emergency stop.

Suggest **one** danger caused by large deceleration.

....

.... **[1]**

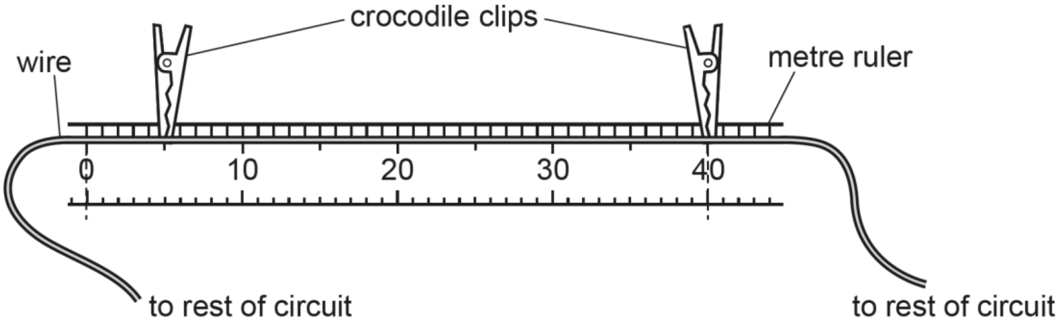
Some candidates correctly suggested that the people in the car might jolt forwards and suffer whiplash, and some suggested that the car could skid or go out of control. Common errors were to give vague suggestions of a car crash, and others incorrectly said that the car would take too long to stop.

Question 9 (a)

9 A student wants to find the resistance of a piece of wire.

They clip the wire into a circuit with an **ammeter**, **voltmeter** and **variable power supply**.

The diagram shows how they clip the wire into the circuit.



(a) Draw a circuit diagram to show the full circuit they use.

Use:

- this symbol for the wire 
- this symbol for the variable power supply 

[3]

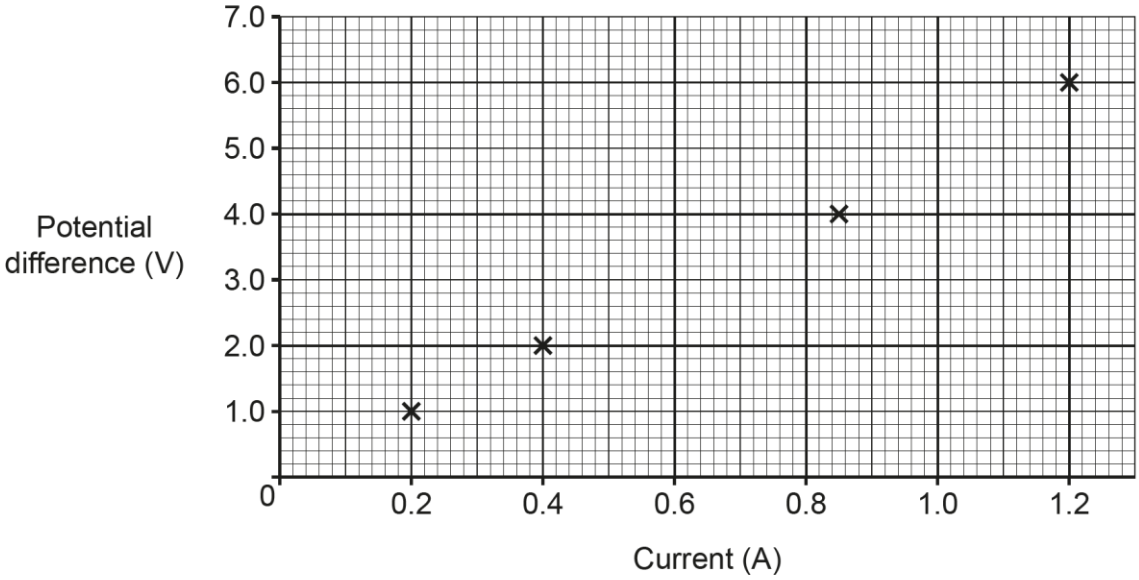
This question was not answered well. Many candidates were not able to draw circuit diagrams correctly. Many did recall the symbols for an ammeter and a voltmeter but if they were included in a circuit, often all the symbols were put in series. Only a few candidates put the voltmeter in parallel and some put it in parallel with the ammeter. Many candidates put several resistance wires in the circuit instead of just one.

Question 9 (b) (i) and (ii)

(b) The student records the data shown in the table and plots a graph.

Current (A)	Potential difference (V)
0.20	1.0
0.40	2.0
0.65	**3.2**
0.85	4.0
0.98	**4.8**
1.20	6.0

(i) Plot the **two** missing points on the graph.



[1]

(ii) Draw a line of best fit on the graph. **[1]**

Just under half the candidates correctly plotted the two points onto the graph grid, and just over half drew an acceptable line of best fit through the plotted points.

The most common plotting error was to plot the lower point at (0.7, 3.2) instead of (0.65, 3.2), but there were a handful of other plotting errors. Some candidates did not draw a straight line and others drew a line from one corner of the grid diagonally across to the other corner.

Question 9 (b) (iii) and (iv)

(iii) Calculate the gradient of the line.

Gradient = ... **[2]**

(iv) Find the resistance of the wire.

Resistance = ... Ω **[1]**

Most candidates were not able to find the gradient of a line in part (iii). A few candidates did attempt to find the difference in y-value divided by difference in x-value but tended to just use the number of squares rather than the scale bars.

However more candidates did get the correct value for resistance of the wire in part (iv), showing that they understood that resistance = potential difference ÷ current.

OCR support

There is a useful section about graphs in the OCR Mathematical Skills Handbook, which can be downloaded from Teach Cambridge.

Question 9 (c)

(c) The student clips a new piece of the same wire in the circuit and repeats their method to find the resistance.
The new piece of wire is double the length.

Describe how the resistance of the new length of wire is different to the resistance of the original length of wire.

....

....

....

.... **[2]**

This question was not well answered. Many candidates suggested that the resistance would be less, and some tried to explain the trend, instead of describing the trend. Candidates often mentioned power or strength or energy instead of resistance.

Question 10 (a)

10 The table shows information about some objects in the solar system.

Name	**Pluto**	**Charon**	**Earth**	**The Moon**
Type of object	dwarf planet	moon	planet	moon
Orbits around	The Sun	Pluto	The Sun	Earth
Diameter (km)	2370	1210	12700	3480
Mass (kg)	1.3×10^{22}	1.6×10^{21}	6.0×10^{24}	7.4×10^{22}
Radius of orbit (km)	5.9×10^{9}	2.0×10^{4}	1.5×10^{8}	3.9×10^{5}
Gravitational force between the two objects (N)	5.0×10^{16}	3.5×10^{18}	3.5×10^{22}	1.9×10^{20}

(a) Name another **type** of object in the solar system that is **not** listed in the table.

.... **[1]**

Most candidates were able to name another type of object such as a comet or an asteroid. Some candidates did not answer the question and named another **object** such as Jupiter, rather than a **type of object** in the solar system.

Question 10 (b)

(b) A student looked at the data and said:
'A moon is always approximately half the diameter of the object it orbits.'

Show that the student is **incorrect**.

Use data from the table.

....

....

....

....

.... **[2]**

About a third of candidates used the correct data from the table to show that the diameter of the Moon is a lot less than half the diameter of the Earth. A common error was to use the radius of orbit of the planet rather than the diameter of the planet.

Exemplar 3

Pluto → $\frac{2370}{2}$ = 1185km. Charon → $\frac{1210}{2}$ = 605km.

Earth → $\frac{12700}{2}$ = 6350km the moon = 3480km

So therefore the moon ~~two~~ is not approximately half the others. **[2]**

This candidate has clearly calculated half the diameter of both Pluto and Earth. Calculating half the diameter of Charon is not needed but the diameter of the Moon is shown. The statement at the end would be better as the Moon is not approximately half the diameter of the Earth, but when related to the question stem, it answers the question.

Question 10 (c)

(c) Explain the difference in the time taken for Pluto and Earth to orbit the Sun.

Use data from the table.

....

....

....

....

.... **[2]**

Many candidates stated that the Earth orbits the Sun quicker than Pluto and about a third of candidates explained that this was because Pluto was further from the Sun and/or had a much weaker gravitational force acting. Some candidates got the orbital time the wrong way round or were unable to explain the reason.

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