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GCSE (9-1)

Examiners' report

GATEWAY SCIENCE PHYSICS A

J249

For first teaching in 2016

J249/02 Summer 2024 series

Version 1

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Contents

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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 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 2 series overview

This paper is designed to assess content from Topics P5 to P8 as well as P9 and with assumed knowledge of Topics P1 to P4. Thus, this paper requires candidates to have knowledge and understanding of all the topics within the course. The last two questions overlap with the Higher tier paper.

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

A number of questions required candidates to analyse information and ideas. Candidates should be encouraged to practise interpreting data both qualitatively and quantitatively from different sources. There were also a number of questions where candidates needed to interpret graphs.

For numerical calculations, 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, there was one question, Question 18 (b), where candidates had 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. They should use the bullet points as a guide. Candidates should also make sure that they answer the question set.

In 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 confident to describe experimental procedures including both the method of conducting an experiment and analysing the data.

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
• used the white space in multiple-choice questions for working • read all the options and eliminated incorrect responses in the multiple-choice questions • in numerical questions, stated the equation used, rearranged the equation and substituted the data before writing the answer, e.g. Question 22 (b) • structured answers logically • related their explanations to the question set.	• did not understand definitions • in numerical questions often guessed the answer by multiplying the data together, e.g. Question 20 (b) • did not describe experimental procedures with sufficient practical detail, e.g. Question 18 (b) • did not use technical terms correctly in their answers.

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Section A overview

Section A of the paper has 15 multiple-choice questions, each worth 1 mark. Candidates should be given the opportunity to practise these types of questions under timed conditions. In particular, candidates should be encouraged not to spend too long on any question, but also to read the whole question including all the possible options.

In numerical questions, candidates should be encouraged to use the 'white' space around the question equations and working. This should help them to answer the question and assist them with checking their answer.

In other questions, as candidates read through the question, a useful technique is to use small crosses to eliminate incorrect options.

Question 1

1 Which statement describes the nucleus of an atom?

A It contains electrons and protons only.

B It contains neutrons only.

C It contains protons and neutrons only.

D It contains protons, neutrons and electrons.

Your answer ☐ **[1]**

This question was generally well answered. A small minority of candidates chose either A or D. Perhaps candidates who selected D ignored the reference to nucleus in the question.

Assessment for learning

When practising answering multiple-choice questions, candidates should be encouraged to underline key terms in the question. In this case 'nucleus' and 'atom' were useful terms to highlight.

Candidates should also be encouraged to consider each of the four answers and put small crosses next to answers they have 'ruled out'.

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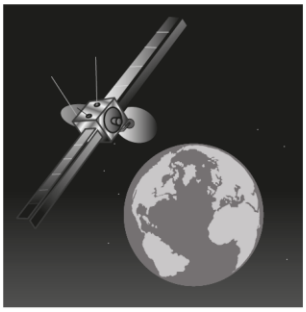
Question 2

2 The diagram shows an object in orbit around the Earth.



not to scale

What is the name of the object?

A A moon

B A natural satellite

C An artificial satellite

D An asteroid

Your answer ☐ **[1]**

This was very well answered.

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Question 3

3 One atom of carbon contains 6 protons, 6 electrons and 6 neutrons.

Another atom of carbon contains 6 protons, 6 electrons and 7 neutrons.

Which answer describes these different atoms of carbon?

A Alpha particles

B Ions

C Isotopes

D Nuclei

Your answer ☐ **[1]**

This answer was generally well answered, although a range of incorrect choices were observed.

Assessment for learning

Candidates should be encouraged to learn basic definitions and practise applying their knowledge.

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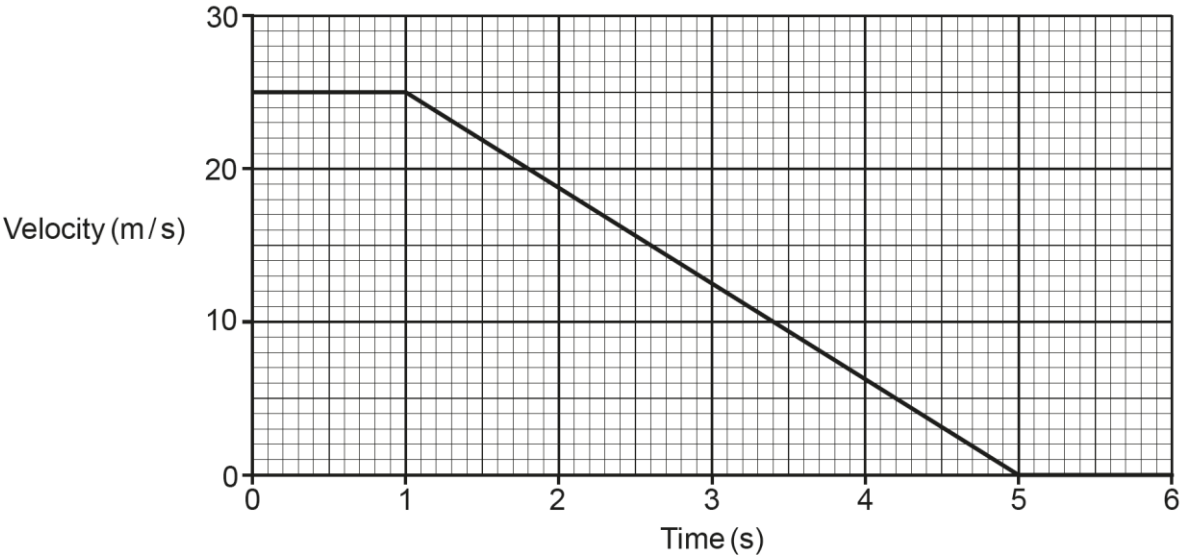
Question 4

4 The graph shows how the velocity of a car changes when the driver sees a hazard in the road at time = 0 seconds.



Which statement is correct?

A The driver brakes for 1 second.

B The driver brakes for 5 seconds.

C The driver takes 1 second to react.

D The driver takes 5 seconds to react.

Your answer ☐ **[1]**

Although the majority of the candidates correctly identified that it took 1 second for the drive to react there were many incorrect responses.

Distractor B was often chosen, perhaps indicating that the graph was not correctly interpreted. Candidates should be encouraged to read all the responses eliminating those that are wrong. Then carefully looking at the remaining responses. A number of candidates chose A, perhaps not understanding the terms 'brake' and 'react'.

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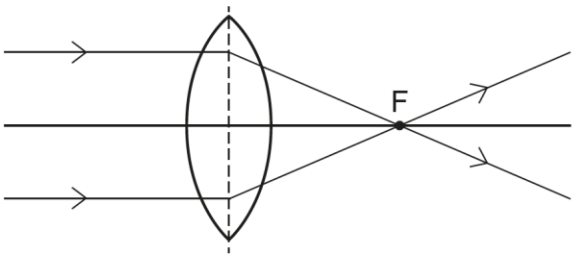
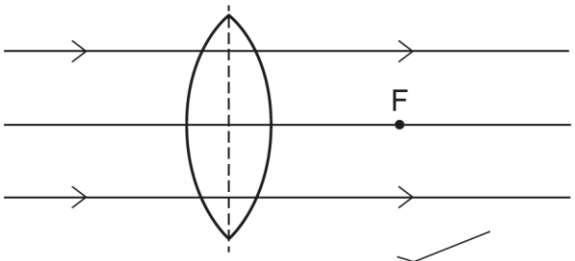
Question 5

5 Which ray diagram correctly shows rays of light passing through a lens with principal focus F?

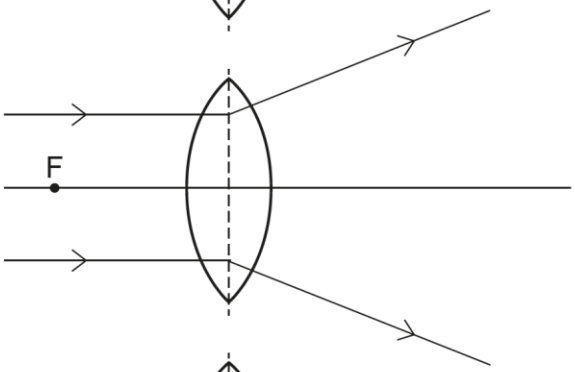
A



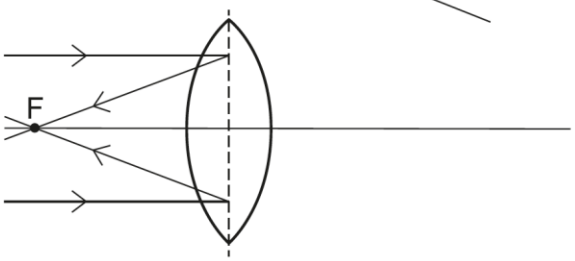
B



C



D



Your answer ☐ **[1]**

Most candidates answered this question correctly, understanding that the rays were passing through a converging lens. The other three distractors were all chosen by the small minority of candidates who did not gain the correct answer.

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Question 6

6 Which statement about some typical values of speed is correct?

A The speed of a car is greater than the speed of a jet plane flying.

B The speed of a car is greater than the speed of sound in air.

C The speed of a runner is greater than the speed of a jet plane flying.

D The speed of sound in air is greater than the speed of the wind.

Your answer ☐ **[1]**

This question was answered well.

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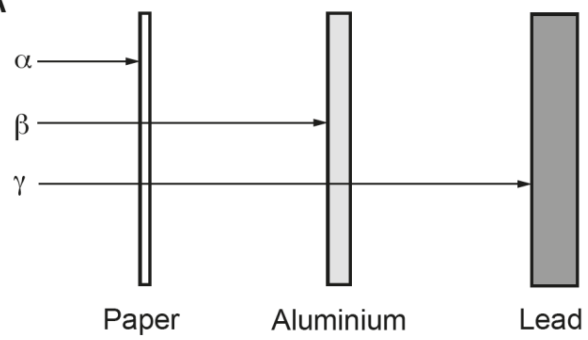
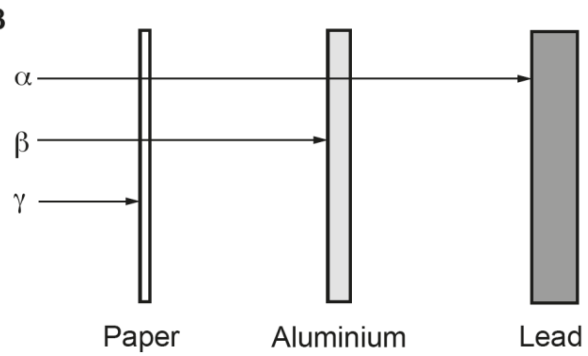
Question 7

7 Which diagram shows how alpha particles (α), beta particles (β) and gamma rays (γ) penetrate different materials?

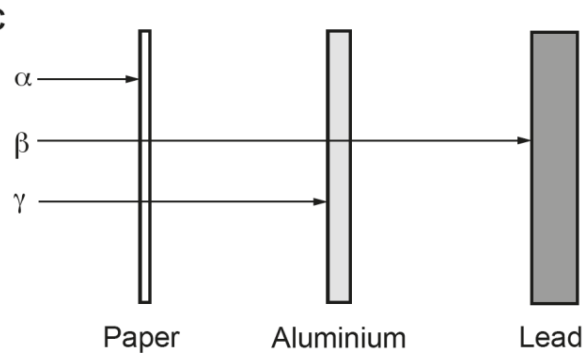
A



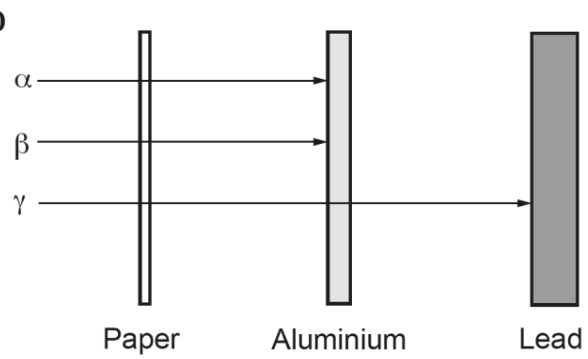
B



C



D



Your answer ☐ **[1]**

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The majority of the candidates identified A as the correct answer. The majority of the incorrect answers were either C (confusing beta and gamma radiation) or D (thinking that alpha radiation can pass through paper).

Question 8

8 What happens in the process of nuclear fusion?

A A chain reaction starts.

B A heavy nucleus splits and releases energy.

C A uranium nucleus absorbs a neutron.

D Light nuclei join to form a heavier nucleus.

Your answer ☐ **[1]**

This question proved challenging, with only a very small majority of the candidates understanding the process of fusion. The incorrect answers were generally either A or B, perhaps indicating that candidates were confusing the terms 'fission' and 'fusion'.

Question 9

9 A shirt appears green in white light.

Which colour will the shirt appear in **red** light?

A Black

B Blue

C Green

D Red

Your answer ☐ **[1]**

Candidates found this question to be the most challenging in the multiple-choice section. The majority of the incorrect answers were option B.

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Question 10

10 Which statement about electromagnetic waves in air is **always** correct?

A High frequency waves have a higher velocity than low frequency waves.

B High frequency waves have a longer wavelength than low frequency waves.

C Low frequency waves have a longer wavelength than high frequency waves.

D Low frequency waves have a lower amplitude than high frequency waves.

Your answer ☐ **[1]**

This question, testing a basic understanding of the frequency and wavelength of electromagnetic waves, appeared to be challenging. All the options were regularly chosen.

For this type of question, candidates should be encouraged to read each response and eliminate the options one by one. For example, A is incorrect because the speed of electromagnetic waves in air is constant for all electromagnetic waves; D is incorrect, since amplitude is independent of frequency (or wavelength). Thus, the candidate is left with a choice of B or C. This then becomes a test of understanding of the wave equation.

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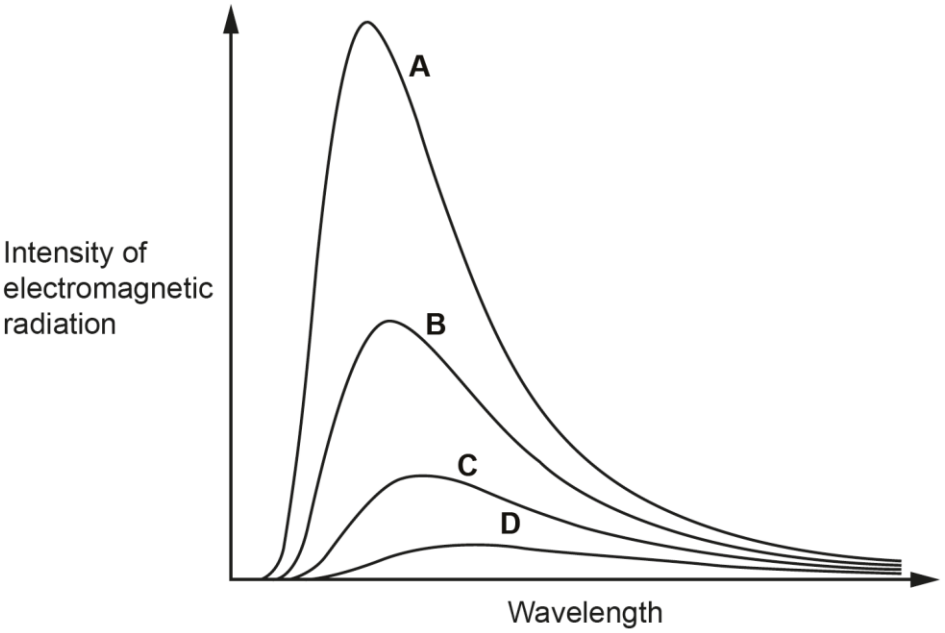
Question 11

11 The graph shows the electromagnetic radiation emitted by four objects at different temperatures.

Which object has the **highest** temperature?



Your answer ☐ **[1]**

This question was well answered, with the majority of candidates correctly indicating curve A.

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Question 12

12 A book is lifted a vertical distance, x, from the floor to a table.

The gravitational potential energy store of the book increases by 10 J.

The book is then lifted a further vertical distance, x, from the table onto a shelf.

What is the **total** increase in the gravitational potential energy store of the book when it is lifted from the floor to the shelf?

A 5 J

B 10 J

C 20 J

D 40 J

Your answer ☐ **[1]**

The majority of candidates correctly answered C. Most candidates who did not gain credit answered B, which corresponds to the increase in gravitational potential energy for a distance *x* from the table to the shelf, but not the **total** increase in gravitational potential energy from the floor to the shelf. Candidates should be encouraged to underline the key words. As shown in the exemplar below, a quick sketch/diagram is helpful in questions like this.

Exemplar 1

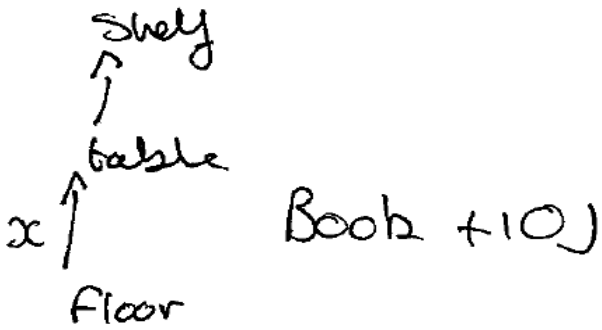
A 5 J

B 10 J

C 20 J

D 40 J

Your answer C



In this response, the candidate has used the white space around the question to help interpret the question. The diagram has assisted in understanding what is meant by 10 J as well as indicating the change in moving the book from the floor to the shelf.

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Question 13

13 An electrician measures the potential difference (p.d.) between two different wires, **X** and **Y**, in a plug.

The plug is wired correctly and working safely.

The p.d. between wire **X** and wire **Y** is 0 V.

Which row shows the correct name of wire **X** and wire **Y**?

	Wire X	**Wire Y**
A	earth	live
B	earth	neutral
C	live	earth
D	live	neutral

Your answer ☐ **[1]**

A small majority of the candidates understood that the potential difference between the earth and the neutral wires is 0 V when the plug is operating normally. All the other responses were seen, with most incorrect answers being C. Many candidates perhaps understand that the potential of the earth is 0 V, but do not understand the potential difference between the wires.

Question 14

14 A force of 1200 N moves an object a distance of 16 m.

What is the work done on the object?

Use the equation: work done = force × distance

A 75 J

B 9600 J

C 19200 J

D 153600 J

Your answer ☐ **[1]**

The majority of candidates correctly multiplied the force by the distance.

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Question 15

15 Which row describes the potential difference for a washing machine and for a battery-operated torch?

	Washing machine	Torch
A	6 V a.c.	6 V a.c.
B	6 V d.c.	230 V d.c.
C	230 V a.c.	230 V d.c.
D	230 V a.c.	6 V d.c.

Your answer ☐ **[1]**

This question was generally answered well. Lower-scoring candidates were unsure of the answer, often giving C, perhaps not interpreting that the torch was battery-operated. Distractors A and B were also seen.

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Section B overview

As candidates read a question, they should be encouraged to underline key information and data.

When answering explanation type questions, candidates' responses should relate to the question and include detailed knowledge and understanding. Vague answers do not gain credit. A guide to detail required is included in the mark box, e.g. [2] indicates two specific points should be made.

In numerical questions candidates should be encouraged to write down the equation they are using, substitute the numbers into the equation and then evaluate the answer, e.g.

- equation
- rearrange the equation
- substitute the data
- consider the units
- evaluate
- consider the whether the answer looks correct.

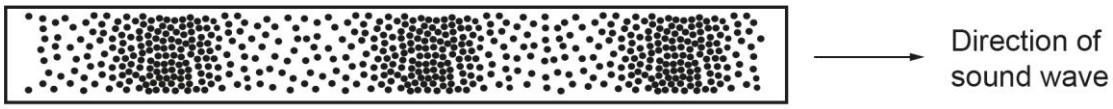
The level of response (LOR) question required candidates to explain an experimental procedure. Candidates should have the opportunity to practise writing methods for experiments. Their plans should include appropriate technical terms, how measuring instruments are used, identify the quantities that need to be kept constant and also relevant safety precautions.

Question 16 (a) (i)

16 This question is about waves.

(a) **Fig. 16.1** shows a diagram of a sound wave travelling through air.

Fig. 16.1



The dots in the diagram represent air particles.

(i) Which type of wave is a sound wave?

Put a (ring) around the correct answer.

electromagnetic **longitudinal** **radio** **transverse**

[1]

Only a small majority of the candidates could correctly state that a sound wave is a longitudinal wave.

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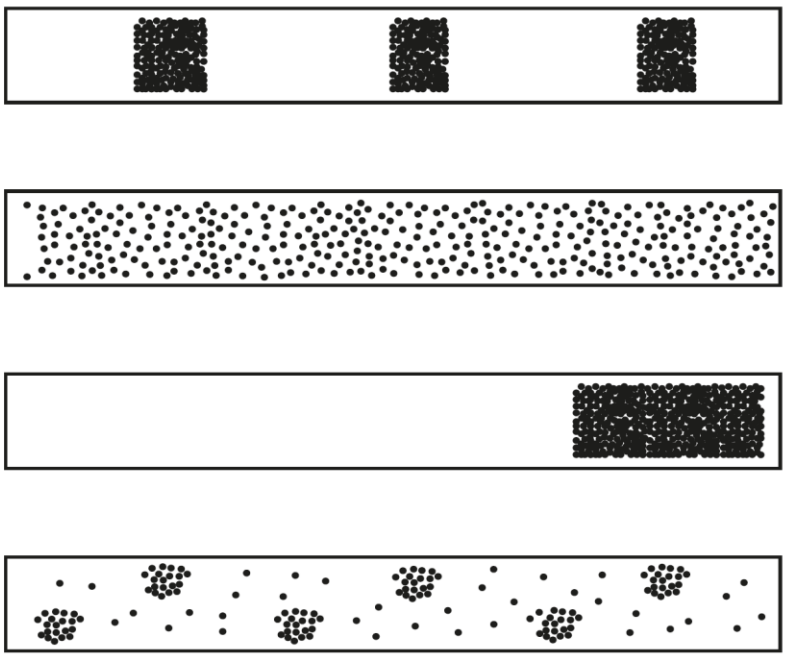
Question 16 (a) (ii)

(ii) **Fig. 16.2** shows four diagrams of the air particles after the sound wave has passed.

Which diagram is correct?

Tick (✓) **one** box.

Fig. 16.2



[1]

A significant minority of candidates did not identify the second box representing the air particles after the sound wave had passed. This suggests that the candidates need to understand how the particles move as a sound wave passes through the medium.

Misconception

Many candidates chose the third and fourth boxes indicating a lack of understanding of the arrangement of particles in a gas.

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Question 16 (b)

(b) Complete the sentences to describe what happens to the properties of a sound wave as it travels **from** air **into** water.

Use words from the list.

decreases	**increases**	**stays the same**

The frequency of the sound wave ..... .

The velocity of the sound wave ..... .

The wavelength of the sound wave ..... .

[2]

This appeared to be a very challenging question. Many candidates did not realise that the frequency of the sound wave would stay the same. Other candidates did not realise that the velocity of the sound wave increases as it moves into a denser medium and therefore the wavelength would also increase.

There was evidence that many candidates guessed the words using all three of words.

Assessment for learning

Candidates should understand how refraction of a wave affects the speed and wavelength of the wave depending on the whether the wave is moving from denser medium to a less dense medium or vice versa.

Candidates should also understand that the frequency remains constant.

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Question 16 (c)

(c) The lists show two groups of words about waves: a **start** of a sentence and an **end** of a sentence.

Draw **one** line from each **start** of the sentence to the matching **end** of the sentence.

Start	End
Amplitude	is an electromagnetic wave.
Light	is the maximum displacement of a wave.
Wavelength	is the distance between one wave peak and the next wave peak.

[2]

The majority of candidates knew that light is an electromagnetic wave. A minority of candidates were confused with the definitions for amplitude and wavelength.

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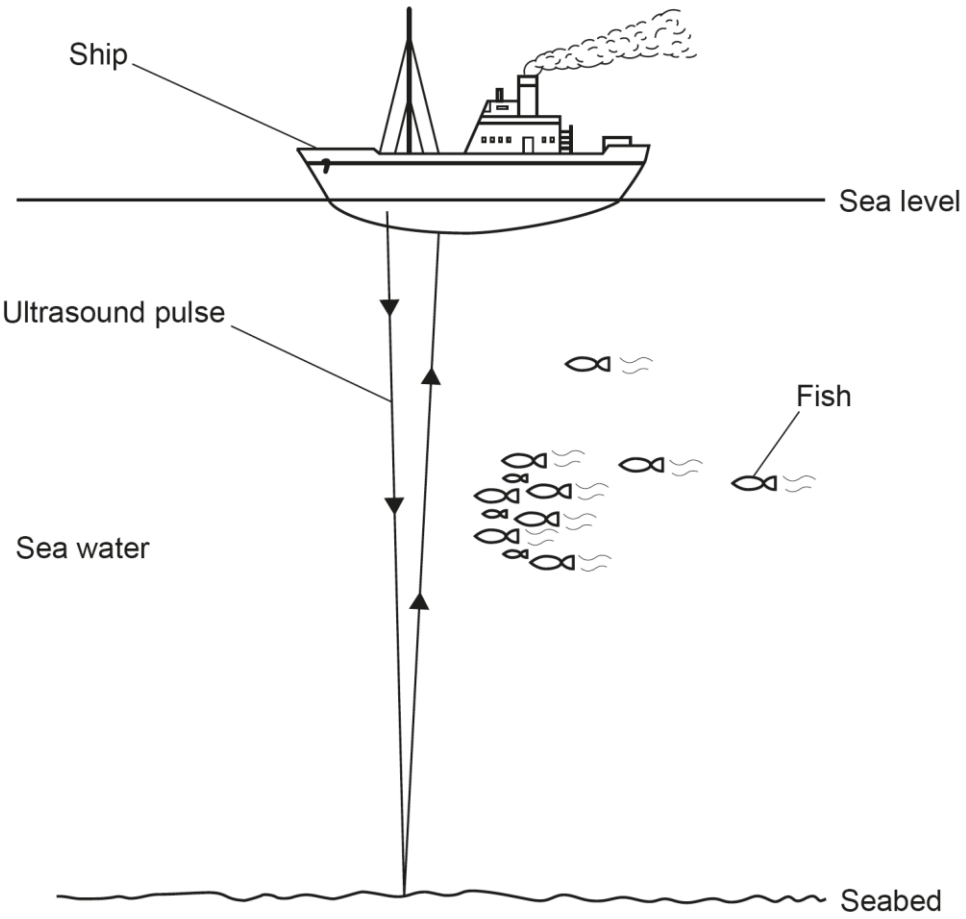
Question 16 (d) (i)

(d) **Fig. 16.3** shows how ultrasound pulses can be used to find distances in water.

Fig. 16.3



(i) Sometimes more than one echo is received by the ship from each ultrasound pulse.

Suggest why.

.....

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

There were many vague answers. Some candidates stated that the pulse was just reflected from the seabed without making reference to multiple reflections due to the uneven surface. The common correct answer was part of the pulse was reflected from fish. Examiners expected any additional reflection to be stated from a named object – object on its own did not score.

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Question 16 (d) (ii)

(ii) An ultrasound pulse takes 0.60 s to travel to the seabed and back to the ship.

The speed of ultrasound in sea water is 1500 m/s.

Calculate the distance from the ship to the seabed.

Use the equation: distance travelled = speed × time

Distance to the seabed = ... m **[3]**

Only a small minority of candidates scored full marks. The common incorrect answer was 900 m, which gained 2 marks. These candidates substituted the data into the given equation and calculated the distance travelled, but this was the distance the pulse travelled from the ship to the seabed **and back** to the ship.

High-scoring candidates clearly showed that the time of 0.6 s was divided by 2 to give 0.3 s, and then used this value in the equation. A few candidates found the total distance the pulse travelled, before dividing by 2.

Candidates should be encouraged to show their working.

Exemplar 2

$0.60 \div 2 = 0.3$

$0.3 \times 1500 = 450$

Distance to the seabed = 450 m

In this response, the candidate has clearly shown the division by 2. Then the candidate has substituted the data into the given equation to determine the distance to the seabed.

Since the equation given does not need to be rearranged, there was no need to write down the given equation. If the equation had needed to be rearranged, then the rearranged equation should be written down in a candidate's answer.

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Question 16 (e)

(e) A sound wave has a frequency of 500 Hz.

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

Calculate the wavelength of the sound wave.

Use the equation: wave speed = frequency × wavelength

Wavelength = ... m **[3]**

The majority of candidates were able to rearrange the equation to give an answer of 0.66 m. Some candidates left the answer as 0.6, which did not gain credit.

The common error was just to multiply the two numbers together.

A large number of candidates did not show any working. Full marks were still given for a correct answer, but with no working show, an incorrect answer could not score any marks.

Assessment for learning

In numerical questions candidates should be encouraged to use the following method:

- equation
- rearrange the equation
- substitute the data
- consider the units
- calculate the answer
- consider the whether the answer looks correct.

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Question 17 (a)

17 Since 2009, filament lamps in the home have often been replaced by other lamps, called LED lamps.

The table compares a filament lamp and an LED lamp which produce the **same** intensity of light.

	Filament lamp	**LED lamp**
Power	60 W	0.01 kW
Lifetime	2000 hours	26 000 hours
Cost to buy	£1.00	£5.00
Cost to run over 1 year	£22.00	£3.65
Dimmable	Yes	No
Structure	Glass	Plastic

(a) State the power of the filament lamp in kW.

..... kW **[1]**

This was well answered. A common incorrect answer was 0.6 kW.

Question 17 (b)

(b) Calculate the energy transferred by the LED lamp during its lifetime.

Use the equation: energy transferred = power × time

Give your answer in kWh.

Energy transferred = ... kWh **[2]**

This question was answered well. Where errors occurred, it was either using 0.1 instead of 0.01 or calculating the energy transferred for the filament lamp.

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Question 17 (c)

(c) In 1 year, the filament lamp transfers 110 kW h of energy.

This costs £22.00.

What is the cost of 1 kW h of electricity?

Cost = £ ..... **[1]**

This question proved to be a little challenging. The common incorrect answer was £5 where, in effect, the candidates had inversely found the energy transferred per pound of cost, i.e. 5 KW h per pound.

Question 17 (d)

(d) Calculate the number of filament lamps a person must buy during the lifetime of **one** LED lamp.

Number of filament lamps = ... **[1]**

The majority of the candidates correctly determined 13 filament lamps. Lower-scoring candidates tended to find this question more challenging with various answers given. Little working was given.

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Question 17 (e)

(e) Suggest **one** reason **for** and **one** reason **against** using LED lamps.

Use the data in the table.

For .....

.....

Against .....

.....

[2]

Most candidates were able to gain at least 1 mark – often the 'for' mark. There were some vague answers: 'cheap' or 'expensive' without a reason did not score, whereas 'LEDs are cheap to run' (for example) did score.

A number of candidates discussed the LEDs being bad for the environment – this was considered too vague. Higher-scoring candidates usually mentioned that the LEDs were bad for the environment because they were not recyclable.

Question 17 (f)

(f) One LED lamp has an efficiency of 0.4.

In one second, the input energy transferred by the lamp is 10 J.

Calculate the energy **wasted** by the lamp in one second.

Use the equation: $\text{efficiency} = \frac{\text{useful output energy transfer}}{\text{input energy transfer}}$

Energy wasted = ... J **[3]**

Many candidates correctly calculated 4 J (the useful energy) but then did not subtract it from 10 J to determine the energy wasted.

Some high-scoring candidates correctly subtracted 0.4 from 1 to give the proportion wasted, and successfully used that value to find the energy wasted.

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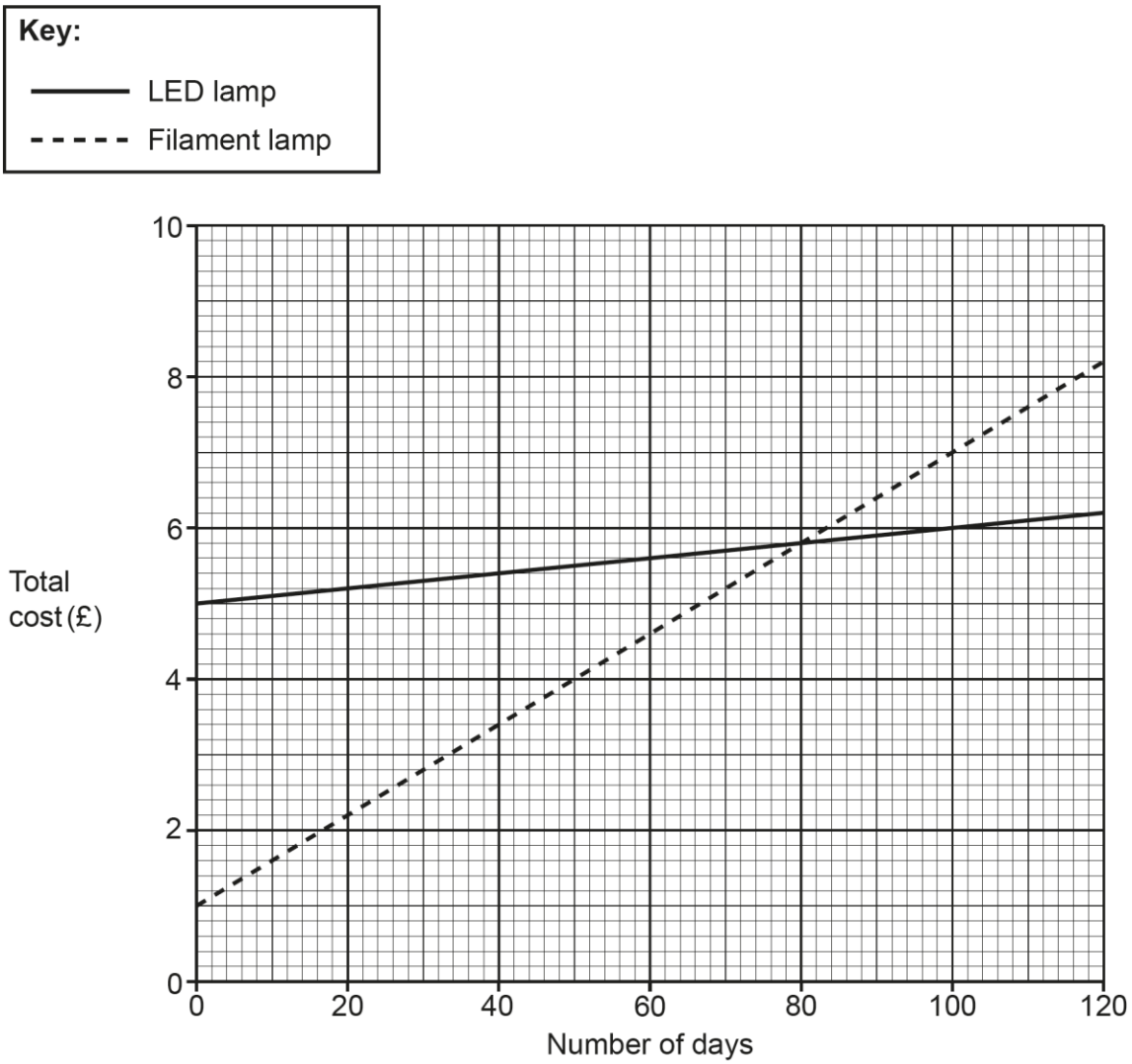
Question 17 (g) (i)

(g) The graph shows how the total cost of buying and using each lamp varies with the number of days each lamp is used.



(i) A person buys an LED lamp.

After how many days is the total cost of the LED lamp the same as the total cost of the filament lamp?

Use the graph.

Number of days = ... days **[1]**

Most candidates correctly read 80 days from the point where the two lines crossed.

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Question 17 (g) (ii)

(ii) The person uses the LED lamp for 100 days.

How much money does the person save by buying and using the LED lamp instead of the filament lamp?

Use the graph.

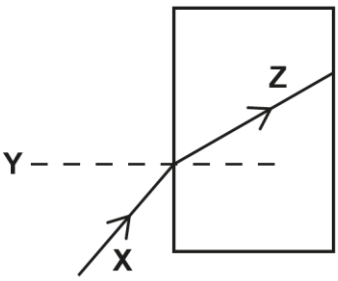
Money saved = £ ..... **[2]**

The majority of candidates obtained a value of £1.00. High-scoring candidates tended to show their working, by writing down the total cost for the filament lamp and the total cost for the LED after 100 days from the graph before calculating the answer.

Question 18 (a)

18

(a) A student draws a ray diagram to show the refraction of a light ray through a glass block.



X is the incident ray. What are the names of line **Y** and line **Z**?

Y .....

Z .....

[1]

Candidates found this question to be one of the most challenging questions. Few candidates were able to identify Y as the normal, and many candidates could not identify Z as the refracted ray.

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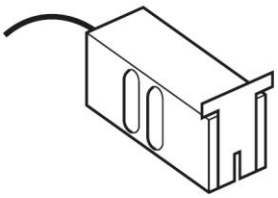
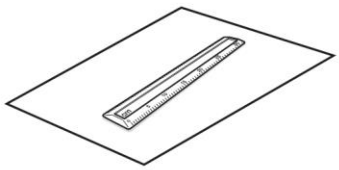
Question 18 (b)*

(b)* The student does an experiment to investigate the reflection of light from a plane mirror.

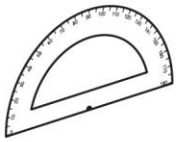
The diagram shows the equipment the student uses.



Ray box with one slit



Ruler and paper



Protractor

Plane mirror

Describe how the student does the experiment.

In your answer include:

- how the student sets up the equipment
- what the student will measure
- a prediction of what the student will find out from their results.

You can draw a labelled diagram to support your answer.

.....

.....

.....

.....

.....

..... **[6]**

Candidates found this question challenging. Candidates who scored higher marks tended to draw a diagram in the white space before the answer lines. Candidates should be encouraged to follow the bullet points in the question to structure their answers.

To answer this question well, candidates needed to draw a diagram showing the position of the mirror and the ray box together with the incident ray, normal and reflected ray marked. The angle of incidence and the angle of reflection should also be indicated on the diagram. Candidates should also have included a description of how the ray could be drawn, e.g. the use of crosses and using the ruler to join the crosses.

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Then all that needed to be stated was that the protractor would be used to help in the drawing of the normal at 90° to the mirror and to measure the angle of incidence and angle of reflection.

The prediction expected was that the angle of reflection was equal to the angle of incidence. It was also expected that the experiment would be repeated for different angles of incidence. The description of the experiment could also have included the use of a dark room and using a single slit in the ray box.

Candidates often gave incorrect answers by drawing inaccurate diagrams often with the mirror drawn in the ray box or the incident ray drawn along the normal. Other answers were vague with little detail of an experiment.

Assessment for learning

Candidates should have the opportunity to write plans of experiments including predictions.

Question 19 (a) (i)

19

(a) Hydrogen gas is placed in a glass tube in a laboratory.

Fig. 19.1 shows the emission spectrum of hydrogen.

Each line in the emission spectrum has a different colour.

Fig. 19.1

(i) Complete the sentences to explain the cause of the lines in the emission spectrum.

Use words from the list.

atoms	**electrons**	**light**	**protons**	**sound**

..... move from a higher energy level to a lower energy level

and emit ..... . **[2]**

The majority of candidates scored 1 mark. The common errors were confusing atoms with electrons and sound with light.

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Question 19 (a) (ii)

(ii) There is a potential difference of 3000 V across the tube.

A charge of 0.08 C flows in the tube.

Calculate the energy transferred.

Use the equation: energy transferred = charge × potential difference

Energy transferred = ... J **[2]**

The majority of candidates correctly multiplied the potential difference by the charge.

Question 19 (a) (iii)

(iii) A special power supply is needed to provide the high potential difference of 3000 V.

Describe **one** risk of using this power supply.

.....

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

There were many vague answers of the power supply being dangerous or causing death. It was expected that candidates would refer to the risk of electrocution or electric shock.

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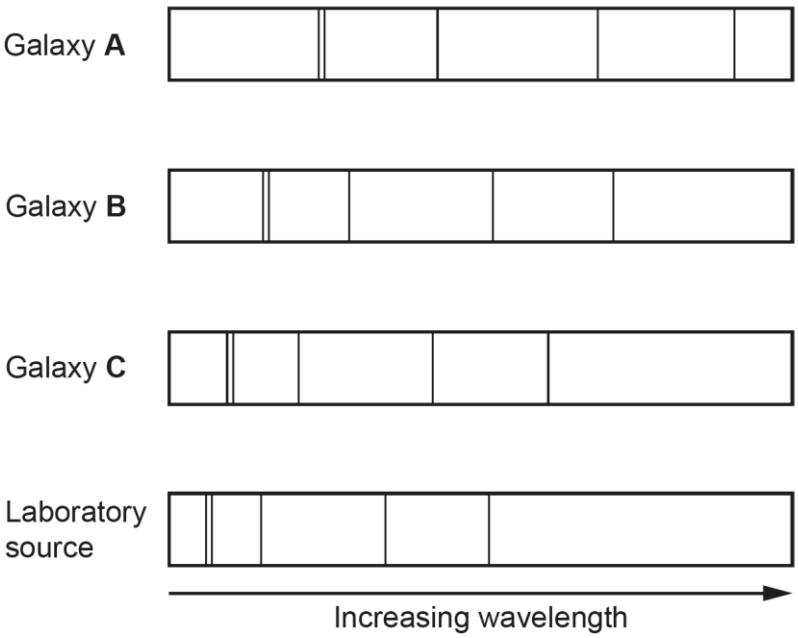
Question 19 (b) (i)

(b) **Fig. 19.2** shows the emission spectrum for each of three different galaxies.

The same emission spectrum is also shown for an equivalent laboratory source on the Earth.

Fig. 19.2



(i) The emission spectrum for each galaxy shows red-shift.

Use **Fig. 19.2** to explain what is meant by the term **red-shift**.

.....

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

Few candidates stated that red-shift referred to an increase in wavelength. Some candidates referred to the movement of planets or galaxies without really answering the question.

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Question 19 (b) (ii)

(ii) Which galaxy in **Fig. 19.2** is furthest from the Earth?

Give a reason for your answer.

Galaxy .....

Reason .....

.....

[2]

The majority of candidates identified galaxy A correctly. However, the reason was often vague. Candidates needed to interpret the diagram and explain how the wavelength of the lines differed in either the value of the wavelength of each line or the spacing between the adjacent lines.

Question 19 (b) (iii)

(iii) State which theory the spectra from each galaxy in **Fig. 19.2** gives evidence for.

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

This question was challenging for most candidates. Most of the correct answers were for the Big Bang theory although there were also a number who stated the expanding Universe.

Some candidates incorrectly guessed red-shift (or blue-shift). Some candidates just wrote 'neutrons'.

Question 20 (a) (i)

20 This question is about the acceleration and deceleration of cars.

(a) A student wants to estimate a typical value for the accelerating force on a car.

The student writes down **three** possible values for the car's acceleration.

3 m/s^2 **50 m/s^2** **100 m/s^2**

(i) Put a (ring) around the value the student should use as the car's acceleration. **[1]**

Most candidates incorrectly estimated 50 m/s^2.

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Question 20 (a) (ii)

(ii) The car has a mass of 1800 kg.

Use the value for the acceleration you chose in **(a)(i)** to estimate the accelerating force on a car.

Use the equation: force = mass × acceleration

Force = ... N **[2]**

Most of the candidates gained 2 marks, multiplying the mass by their estimate for the acceleration.

Question 20 (b)

(b) In a crash, the change in velocity of a car is 18 m/s.

The time for the crash is 0.15 s.

Calculate the deceleration of the car.

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

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

Most candidates correctly substituted the data into the given equation.

A number of lower-scoring candidates incorrectly multiplied velocity by the time.

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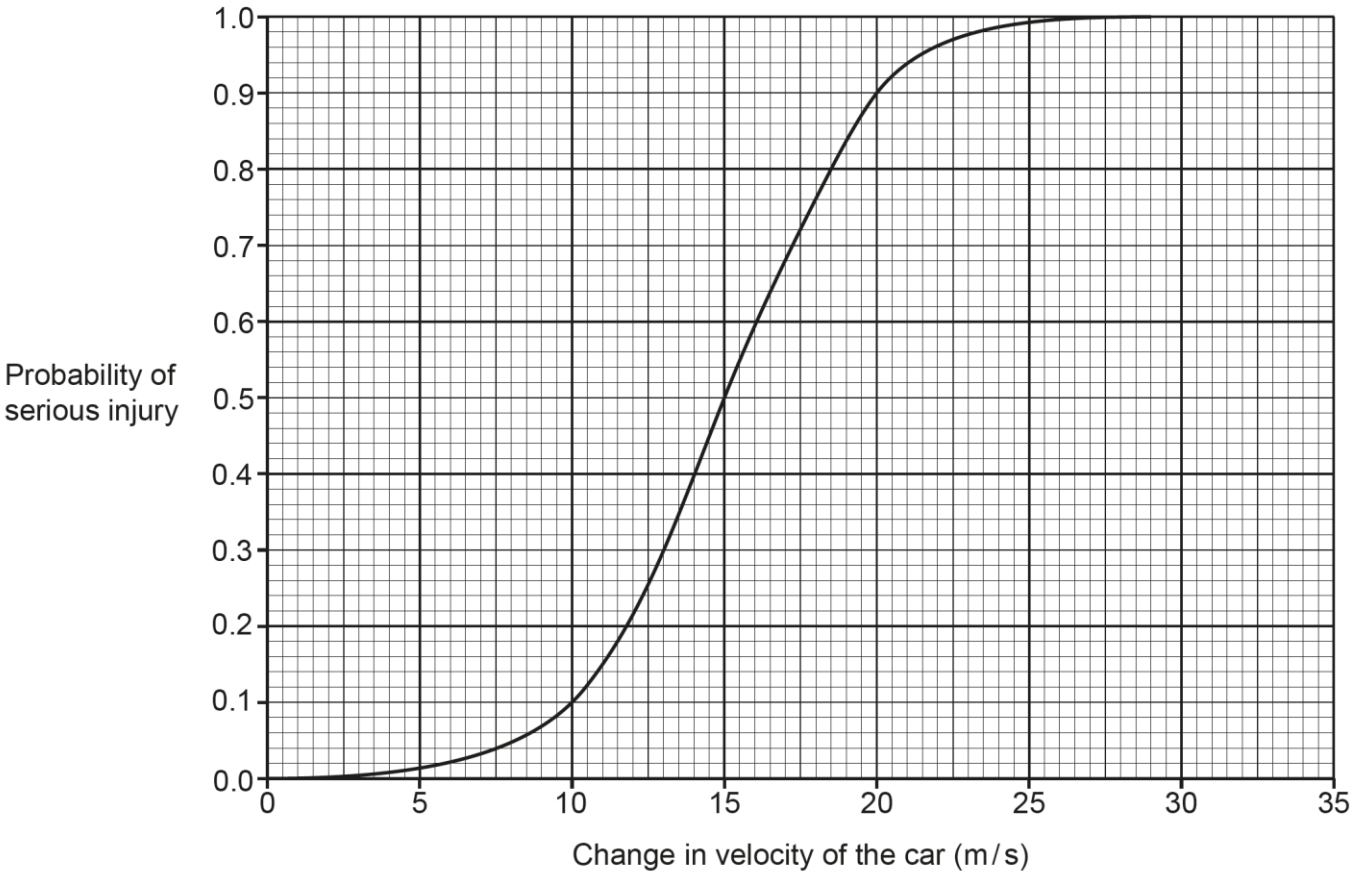
Question 20 (c) (i)

(c) In America, many cars have a 'black box' fitted.

The 'black box' records the change in velocity of the car if it crashes and comes to a stop.

The graph shows how the probability of serious injury to passengers in the car varies with the change in velocity of the car.



(i) Describe how the probability of serious injury changes as the change in velocity of the car increases from 10 m/s to 20 m/s.

Use values from the graph.

.....

.....

.....

.....

..... **[3]**

Most of the candidates scored 2 marks, often describing that the probability increased as the speed increased and using the graph to determine that the change in probability was 0.8. A few candidates described extra details, such as the increase not being linear or proportional. To gain full credit candidates also needed to describe the initial curved section of the line.

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Question 20 (c) (ii)

(ii) Use the graph to estimate the minimum change in velocity which **definitely** causes serious injury.

Change in velocity = ... m/s **[1]**

This question required candidates to understand that to definitely cause serious injury, the probability needed to be equal to 1.

Candidates found this question challenging, with only a minority of candidates correctly reading off the value of speed when the probability reached 1.

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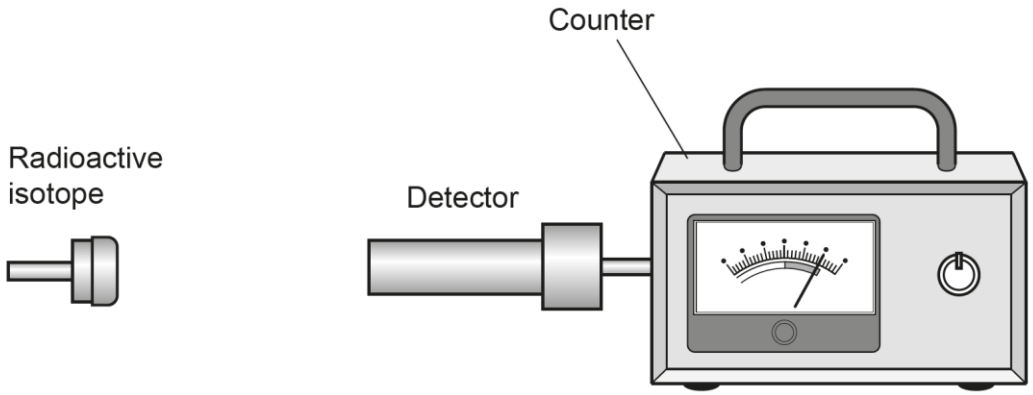
Question 21 (a) (i)

21

(a) A scientist measures the activity, in counts per minute (cpm), of different radioactive isotopes.

The diagram shows the equipment the scientist uses.



The scientist:

- Records the activity on the counter before the detector is switched on.
- Switches on the detector and records the activity with the radioactive isotope nearby.

The table shows the scientist's results.

	Activity (cpm)
Detector switched off	5
Detector switched on	420

(i) How can the scientist make the results more accurate?

Tick (✓) **one** box.

Handle the radioactive isotope using tongs. ☐

Move the radioactive isotope further away from the detector. ☐

Place lead in front of the radioactive isotope. ☐

Zero the counter and take another reading. ☐

[1]

Most of the candidates correctly identified that the last box was the correct answer. Across the range of marks other answers were observed.

This was a question where candidates should be advised to read each statement and place a small cross to eliminate an incorrect statement.

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Question 21 (a) (ii)

(ii) The activity of a different radioactive isotope is 480 counts per minute (cpm).

Calculate the activity in counts per second.

Activity = ... counts per second **[1]**

Most of the candidates gained the correct answer by dividing 480 by 60. A significant proportion of the candidates incorrectly multiplied 480 by 60.

Question 21 (b) (i)

(b) A radioactive isotope called yttrium-90 can be used to treat liver cancer.

(i) Yttrium-90 has a short half-life of 64 hours.

Explain why a short half-life is important for the patient.

.....

.....

..... **[2]**

This question was challenging for all the candidates. Many candidates did not understand the term half-life, and there were many answers suggesting that the radioactivity would only be present for 64 hours. It was expected that candidates would explain that the damage caused to the body related to tissue or organs or cells. Vague responses did not score.

Assessment for learning

Candidates should have the opportunity to write explanations using and applying their knowledge to novel situations.

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Question 21 (b) (ii)

(ii) Problems of using yttrium-90 to treat liver cancer include:

- poor appetite, abdominal pain, fever or sickness
- people in contact with the patient can be exposed to small doses of radiation.

Explain why patients are treated with yttrium-90 despite these problems.

.....

.....

..... **[2]**

This explanation question was also found to be challenging for all the candidates. Many vague responses were observed.

Some candidates answered it in terms of half-life which did not answer the question set. A significant number of candidates scored 1 mark, either for identifying that the side-effects were temporary, or for giving an answer in terms that it is better to suffer the side-effects and treat the liver cancer. Very few responses combined these ideas.

Another way of answering this question was in terms of why other radioactive isotopes would not be suitable.

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Question 22 (a)

22 This question is about how electricity is transferred from a power station to homes.

(a) Draw:

- **one** line to connect **each** type of transformer with the **one** box that describes what it does
- **one** line to connect what each type of transformer does with the **one** box that gives the reason for its use.

Type of transformer	What it does	Reason for its use
Step-down transformer	Decreases current	For safety
Step-up transformer	Decreases potential difference	Increases heat losses
	Generates current	Reduces heat losses

[2]

This question appeared to be very demanding, with very few candidates understanding the different types of transformers and why transformers are used in specific places as electricity is transferred from the power station to a home.

Assessment for learning

Candidates should understand the effect on current and potential difference of using step-down and step-up transformers.

Candidates should be able to apply their understanding to reason the use of step-down and step-up transformers in different situations.

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Question 22 (b)

(b) The table shows information for a transformer.

Potential difference across primary coil	132 000 V
Current in secondary coil	1800 A
Potential difference across secondary coil	33 000 V

Calculate the current in the primary coil of the transformer.

Use the Equation Sheet.

Current in primary coil = ... A **[2]**

A significant majority of candidates scored full marks. These candidates correctly identified the equation from the equation sheet. This equation was then rearranged, with the data substituted into it, before the answer was calculated. Other candidates calculated the output power and then divided this by the potential difference across the primary coil to obtain the correct answer.

There were some answers where the ratio was calculated but then used incorrectly to give an answer of 7200 A. Candidates should be encouraged to look at their final answer to see whether it was sensible. In this case the current in the primary coil needed to be less than the current in the secondary coil so 7200 A could not be correct.

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Exemplar 3

$P_1 \times V_1 = P_2 \times V_2$

$132000 \times 450 = 33000 \times 1800$

$I_2 = \frac{59400000}{132000} = 450$

Current in primary coil = 450 A

In this response, the candidate has equated the input and output power.

They have substituted in the data and calculated the output power. The candidate has then shown the division to gain the correct answer.

This candidate has clearly demonstrated a workable method to gain the correct answer.

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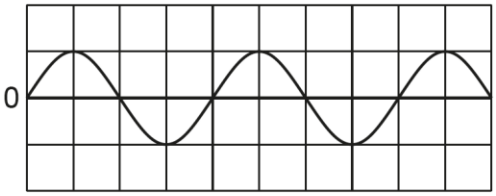
Question 22 (c)

(c) A teacher connects the primary coil of a transformer to the domestic mains supply.

The teacher uses an oscilloscope to view the potential difference across the secondary coil of the transformer.

The graph shows the oscilloscope trace.



Use the graph to explain which type of current is supplied by the mains supply.

Type of current .....

Explanation .....

[2]

Candidates found this question very challenging, with very few candidates stating alternating current.

The explanation given was often vague with candidates often referring to up and down (which could also refer to varying d.c.).

Assessment for learning

Candidates should be able to describe the difference between alternating and direct current. In particular it is important that they understand the difference in the direction of the current.

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Question 23 (a)

23 In 1986, there was an accident when a nuclear reactor in a power station exploded.

In the explosion, radioactive materials from inside the reactor were spread over the power station.

(a) Explain why workers at the power station were both contaminated **and** irradiated in the accident.

Contaminated because .....

.....

Irradiated because .....

.....

[2]

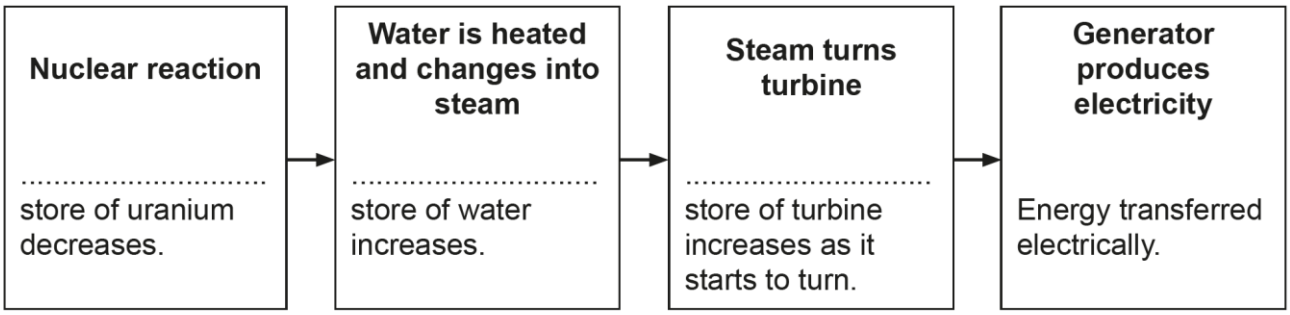
Candidates found this question challenging and often did not use appropriate terminology.

Assessment for learning

Candidates should be able to define the terms 'contaminated' and 'irradiated' and understand the difference between them.

Question 23 (b)

(b) The flow diagram shows energy transfers when electricity is generated in a nuclear power station.



Complete the flow diagram to show the changes in energy stores. **[3]**

Few candidates identified all three stores correctly.

Examiners did not allow 'heat' for the thermal store, since the box already had the word heated'.

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Question 23 (c) (i)

(c) One of the elements released in the accident when the nuclear reactor exploded was caesium-137.

Caesium-137 has a half-life of 30 years.

(i) Explain what is meant by the phrase 'a half-life of 30 years'.

.....

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

Higher-scoring candidates were more often able to give an explanation. Many did not refer to the number of atoms or the activity halving.

Question 23 (c) (ii)

(ii) Which sentence explains why we use the idea of half-life in radioactive decay?

Tick (✓) **one** box.

Radioactive decay is a random process. ☐

When a nucleus decays, it splits in half. ☐

With large numbers, it is easier to count half of the nuclei. ☐

[1]

Few candidates understood that half-life was a random process. The common answer was that a nucleus split in half when it decays.

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Question 23 (c) (iii)

(iii) In the accident, 28 kg of caesium-137 was released into the atmosphere.

What mass of caesium-137 remains undecayed after 90 years?

Mass = ... kg **[2]**

A small minority of candidates obtained the correct value.

A good method was to work out that 90 years corresponded to three half-lives and then take the 28 and halve it three times, e.g. 28 → 14 → 7 → 3.5 (kg).

Question 23 (d)

(d) A nuclear reactor needs neutrons to start a nuclear fission reaction.

A plutonium nucleus (Pu) decays into a uranium nucleus (U) and an alpha particle ($^{4}_{2}$He).

The alpha particle then joins with a beryllium nucleus (Be) to produce a carbon nucleus (C) and a neutron (n).

Complete the equations.

$$^{238}_{94}\text{Pu} \longrightarrow {}^{\cdots\cdots}_{\cdots\cdots}\text{U} + {}^{4}_{2}\text{He}$$

$$^{9}_{4}\text{Be} + {}^{4}_{2}\text{He} \longrightarrow {}^{12}_{6}\text{C} + {}^{\cdots\cdots}_{\cdots\cdots}\text{n}$$

[3]

Most of the candidates scored at least 3 marks. Most of these were for correctly identifying the mass number and atomic number correctly. A significant number of candidates incorrectly gave the mass number of the neutron as –1.

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