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OCR
Oxford Cambridge and RSA

GCSE (9-1)

Examiners' report

GATEWAY SCIENCE PHYSICS A

J249

For first teaching in 2016

J249/04 Summer 2022 series

Version 1

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 are also provided. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

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

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

Advance Information for Summer 2022 assessments

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

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Paper 4 series overview

J249/04 is one of the two Higher Tier papers for the GCSE (9-1) Physics A (Gateway Science).

It covers the topics:

- P5 Waves in matter
- P6 Radioactivity
- P7 Energy
- P8 Global challenges
- P9 Practical skills

Candidates who did well on this paper generally did the following:	Candidates who did less well on this paper generally did the following:
• Identified and applied or manipulated equations • Described experimental procedures • Answered questions in depth using appropriate scientific terminology, e.g. the Level of Response question • Interpreted graphs to describe trends and draw detailed conclusions	• Did not identify and apply or manipulate equations • Did not describe and apply ideas about planets in orbits • Did not offer a suitable amount of detail for the type of question.

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Section A overview

Section A consists of 15 multiple choice questions, concentrating on Assessment Objectives 1 and 2 (AO1 and AO2).

Almost all candidates attempted every question.

Most successful questions	Less successful questions
• Question 4 Half-life calculation • Question 7 Electromagnetic waves • Question 9 Specific latent heat calculation • Question 15 Calculating thinking distance	• Question 2 Determining the amplitude of a wave • Question 10 Radiation emitted by hot objects • Question 11 Refraction of light • Question 14 Energy stored in a spring

Assessment for learning

Candidates who did will on this section generally did the following:

Underlined keywords.

Understood key scientific terminology.

Wrote equations and/or calculations next to the relevant questions.

Worked through the options methodically, e.g. by crossing out and dismissing incorrect options.

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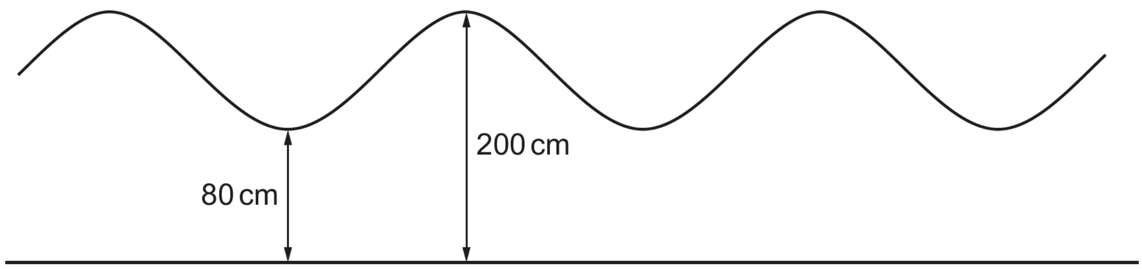
Question 2

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



What is the amplitude of the waves?

A 60 cm

B 80 cm

C 120 cm

D 200 cm

Your answer ☐ **[1]**

This question assessed candidates' knowledge of describing wave motion in terms of amplitude. Around two thirds of candidates did not determine the amplitude using the information on the diagram.

Question 3

3 Power can be measured in watts (W) or milliwatts (mW).

What is 1.5 mW converted into W?

A 1.5×10^{-6} W

B 1.5×10^{-3} W

C 1.5×10^{3} W

D 1.5×10^{6} W

Your answer ☐ **[1]**

This question assessed candidates' knowledge of unit prefixes and the majority of candidates chose the correct option.

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Question 4

4 A radioactive source has a count-rate of 64 counts per minute (cpm).
The half-life of the radioactive source is 10 minutes.

What is the count-rate of the radioactive source after 20 minutes?

A 8 cpm

B 16 cpm

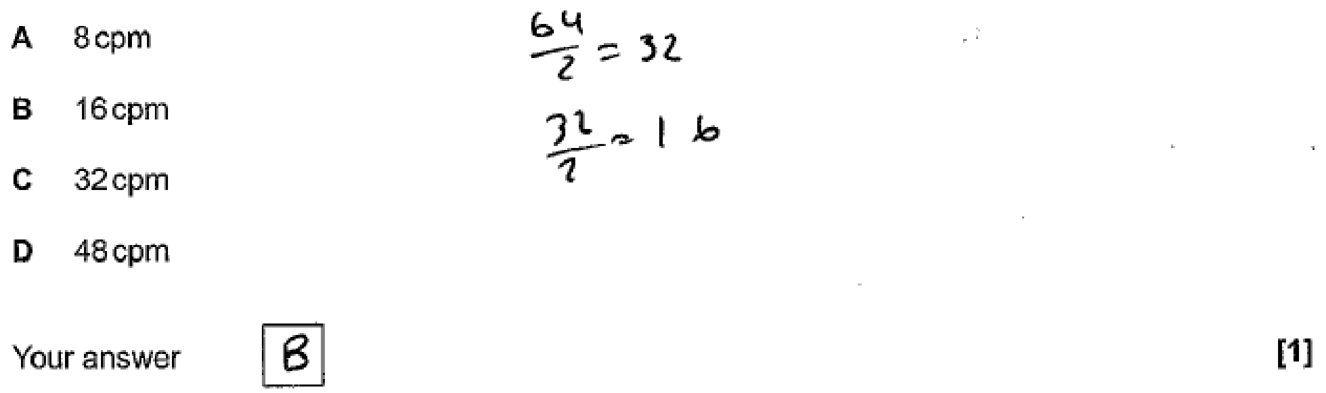
C 32 cpm

D 48 cpm

Your answer [ ] **[1]**

Most candidates were able to use the data in the question to correctly calculate the count-rate after 20 minutes.

Exemplar 1



A 8 cpm

B 16 cpm

C 32 cpm

D 48 cpm

$\frac{64}{2} = 32$

$\frac{32}{2} = 16$

Your answer B **[1]**

Exemplar 1 shows how the candidate writes down calculations to help them to determine the correct count-rate.

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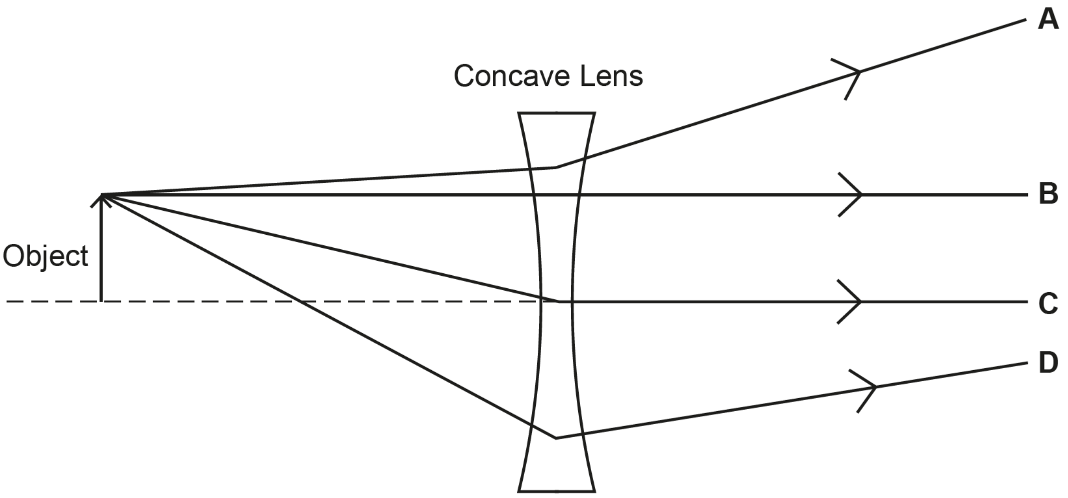
Question 5

5 The diagram shows four possible paths for a ray of light from an object passing through a concave lens.



Which letter shows the correct path of the ray?

Your answer [ ] **[1]**

> The most common incorrect answer for this question was option D.

Question 6

6 A student investigates absorption of coloured light in a dark laboratory.

The student shines green light onto a blue object.

What colour does the object appear?

A Black

B Blue

C Cyan

D Green

Your answer [ ] **[1]**

> Many candidates were unable to use differential absorption and reflection to determine the colour of the object (P5.3).

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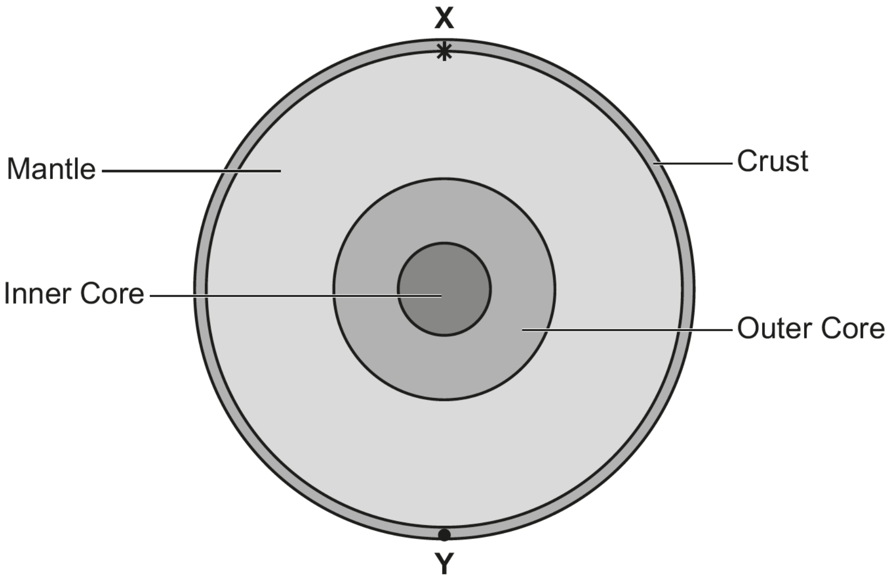
Question 8

8 The diagram shows a cross-section of the Earth.



An earthquake takes place at point **X**.

Which type(s) of seismic waves would be detected at point **Y**?

	P-Waves	S-Waves
A	no	no
B	no	yes
C	yes	no
D	yes	yes

Your answer **[1]**

Many candidates used their knowledge of the paths of seismic waves through the Earth to correctly choose option C.

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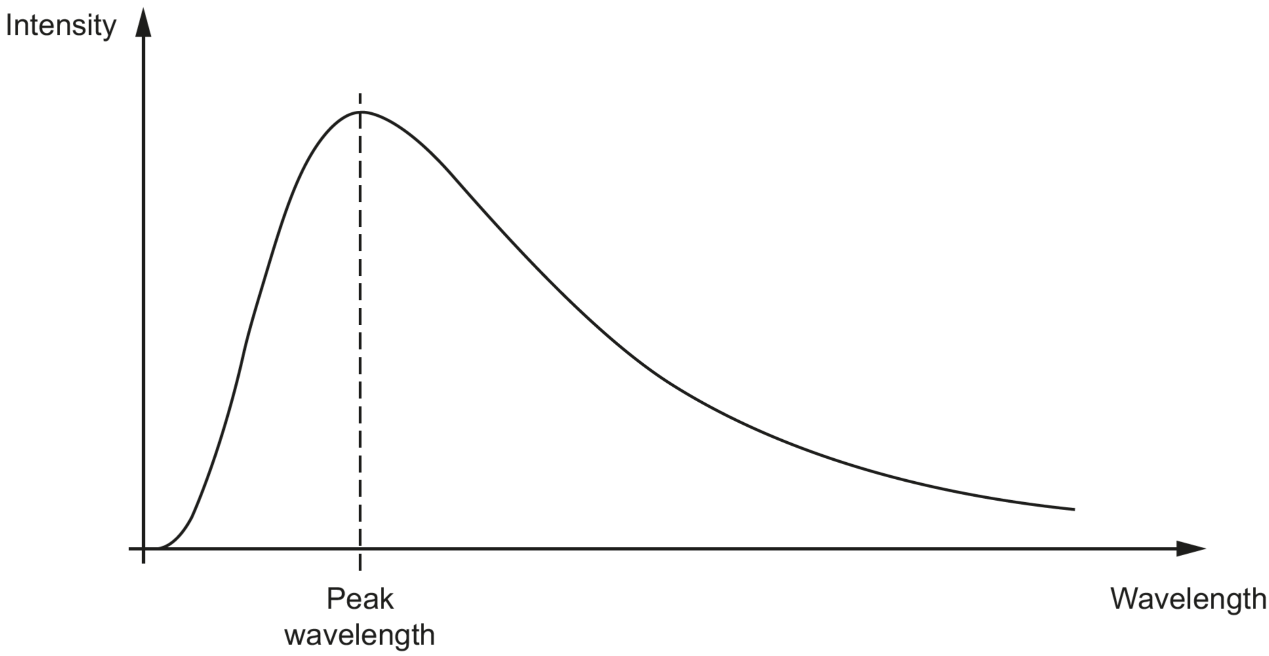
Question 10

10 A hot object emits radiation.
The graph shows how the intensity of the radiation varies with wavelength.



The temperature of the object **increases**.

Which row describes what happens to the peak wavelength and intensity of the radiation?

	Peak Wavelength	Intensity of the radiation
A	decreases	increases for all wavelengths
B	decreases	increases for the peak wavelength only
C	increases	increases for all wavelengths
D	increases	increases for the peak wavelength only

Your answer ☐ **[1]**

Many candidates did not demonstrate knowledge of how the intensity and wavelength distribution depends on the temperature of the object.

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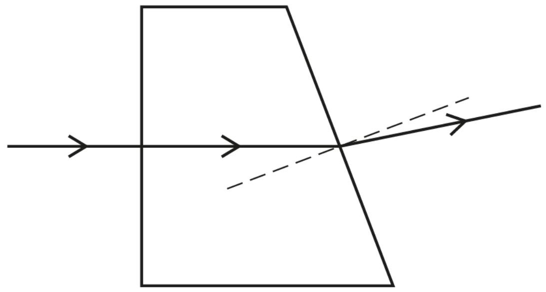
Question 11

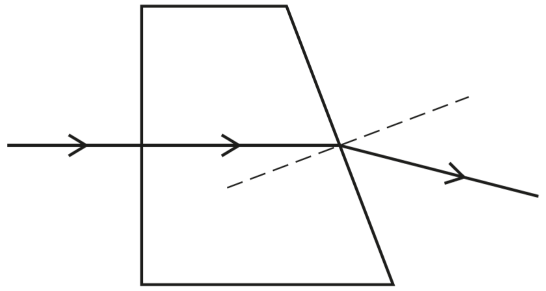
11 A student uses a ray box to shine a ray of light through a glass block.

Which diagram shows a correct path for the ray?

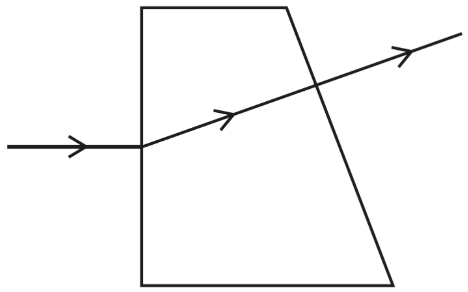
A



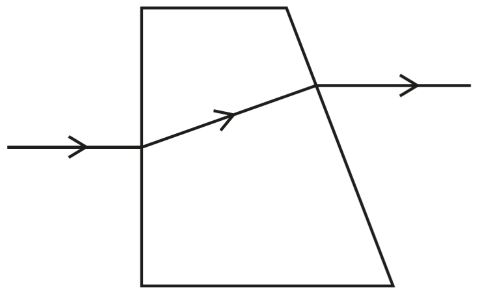
B



C



D



Your answer [ ] **[1]**

This question required candidates to apply their knowledge of how a light ray refracts as it passes through a glass block. Approximately two thirds of candidates chose the incorrect path.

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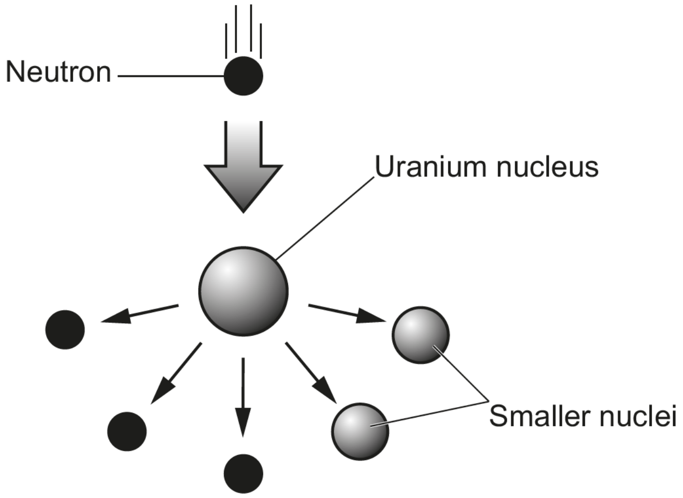
Question 12

12 A student models nuclear fission using this process:

Step 1

- A uranium nucleus absorbs one neutron.
- The uranium nucleus splits releasing **three** neutrons.

The diagram shows what happens in **step 1** of this process.



The three neutrons can each repeat this process again for step 2 and step 3. How many neutrons will be released after step 3?

A 6

B 9

C 18

D 27

Your answer [1]

This question assessed candidates' knowledge of nuclear fission. Most candidates correctly chose option D.

Exam Hint

Many candidates drew simple sketches of step 2 and step 3 to help them visualise what was happening in the model.

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Question 14

14 The energy stored in a stretched spring is 5 J.

What is the energy stored in the spring when the extension doubles?
Use the Data Sheet.

A 5 J

B 10 J

C 20 J

D 25 J

Your answer ☐ **[1]**

This question required candidates to take account of the squared relationship between energy stored in the spring and the extension of the spring. A number of candidates chose option B.

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Section B overview

Section B consisted of short, 1 mark, questions as well as questions requiring longer answer and the Level of Response question. It covered all of the AOs and many questions needed candidates to use mathematical skills. Questions 16 and 17 were the overlap questions with the Foundation Tier.

Most successful questions	Less successful questions
• Question 17 (c) (i) Using a radioactive isotope as a tracer in the body • Question 18 (a) (ii) Calculating distance using the speed of sound • Question 18 (b) (ii) Describing how sound travels through the ear • Question 20 (b) (i) Calculating specific heat capacity • Question 21 (a) (ii) Using the efficiency equation to calculate input energy.	• Question 17 (a) (i) Using conventional representation for nuclei • Question 18 (b) (i) Describing how sound travels from a student's hand to their ear • Question 22 (a) Explaining why the speed of a planet is constant but its velocity is changing.

Candidates who did well on this section generally did the following:	Candidates who did less well on this section generally did the following:
• Underlined key words and command words • Identified/rearranged equations and wrote down all of their calculations • Worked methodically in order to explain car safety and estimate decelerations (LoR question) • Interpreted graphs to draw conclusions.	• Did not identify or rearrange equations • Did not change unit prefixes • Gave answers without showing working • Gave answers that did not have the required amount of detail for the type of question

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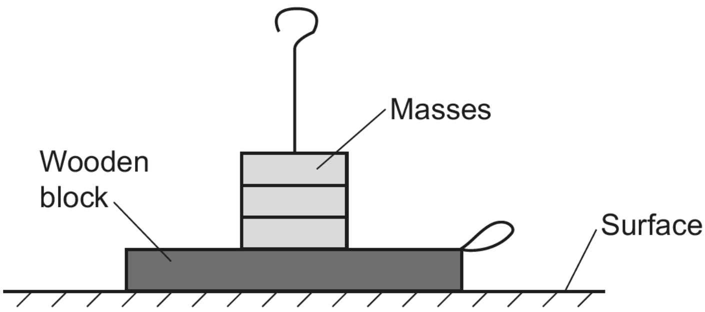
Question 16 (a)

16 **Fig. 16.1** shows a teacher's experiment.

The teacher pulls a wooden block through a fixed distance and calculates the work done from their measurements.

Fig. 16.1



The table shows the teacher's results.

Mass (kg)	Work done (J)
0.1	1.9
0.2	2.3
0.3	2.8
0.4	3.3
0.5	3.7
0.6	4.3

(a) Describe how the teacher can do this experiment, including any equipment used.
Use the Data Sheet.

....

....

....

....

....

.... **[3]**

This AO3 question assessed candidates' ability to apply their knowledge of how to calculate work done to a practical situation. Few candidates were given full marks. The majority of candidates used the Data Sheet to identify the correct equation for work. Many candidates referred to a different experiment that they may have carried out in their lessons. There were many references to pulleys and calculating force or weight using F=ma and light gates. Candidates often did not name the equipment that they would need to use to measure the force and distance.

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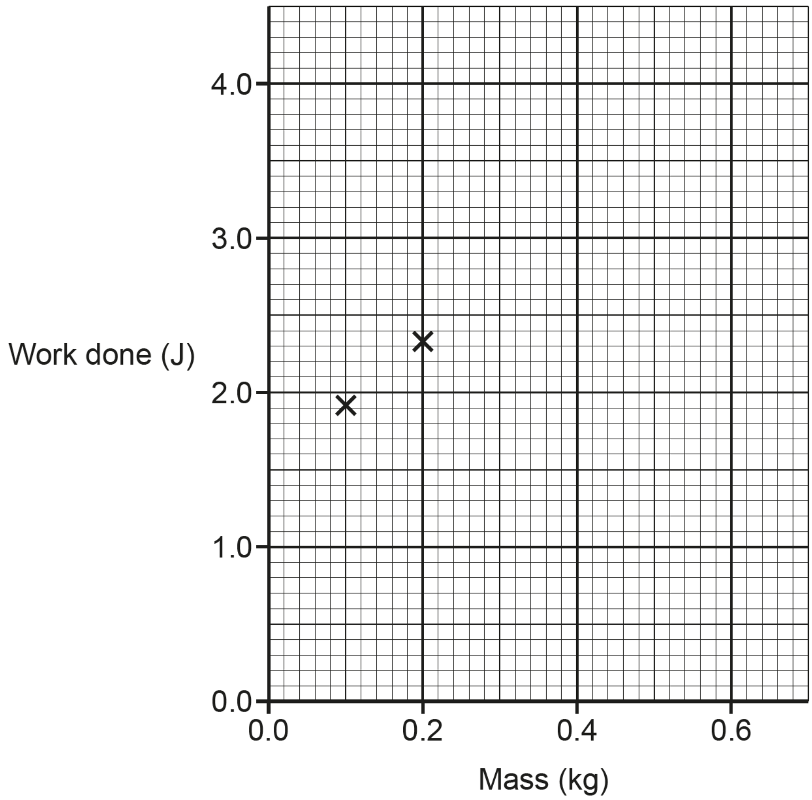
Question 16 (b) (i) and (ii)

(b) (i) Plot a graph of the data in the table and draw a line of best fit on **Fig. 16.2**.

Two of the points have already been completed for you.

Fig. 16.2



[3]

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

....

.... **[1]**

Nearly all candidates gained at least 2 marks for plotting the points correctly in part (b) (i). The line of best fit, however, was frequently incorrect.

Candidates were able to describe the relationship between work done and mass for part (b) (ii) but some responses also included an incorrect reference to a proportional relationship.

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Question 17 (a) (i) and (ii)

17 This question is about radioactivity.

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

(i) Complete the symbol for this isotope.

$$^{\cdots\cdots\cdots}_{\cdots\cdots\cdots}\text{P}$$

[1]

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

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

Relative charge ....

Relative mass ....

[2]

This standard demand question required candidates to using conventional representation for nuclei for part (a) (i) Some candidates either wrote the numbers the wrong way around, or added the charge and mass number to give 47.

Question 17 (c) (i) and (ii)

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

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

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

Tick (✓) **one** box.

Alpha ☐

Beta ☐

Gamma ☐

State a reason for your answer.

....

.... **[2]**

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

4 minutes	**6 hours**	**18 days**

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

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

1 ....

....

2 ....

....
[2]

Part (c) (i) assessed candidates' knowledge of the use of nuclear radiation for the exploration of internal organs. The majority of candidates gained at least 1 mark for identifying gamma. Some candidates lost the second mark as they referred to the effects of radiation on the body instead of the penetrating or ionising powers.

Part (c) (ii) assessed AO3 and was also well answered with nearly all candidates gaining at least 1 mark. Candidates not gaining the second mark usually resulted from lack of detail, e.g. 18 hours being 'too dangerous'.

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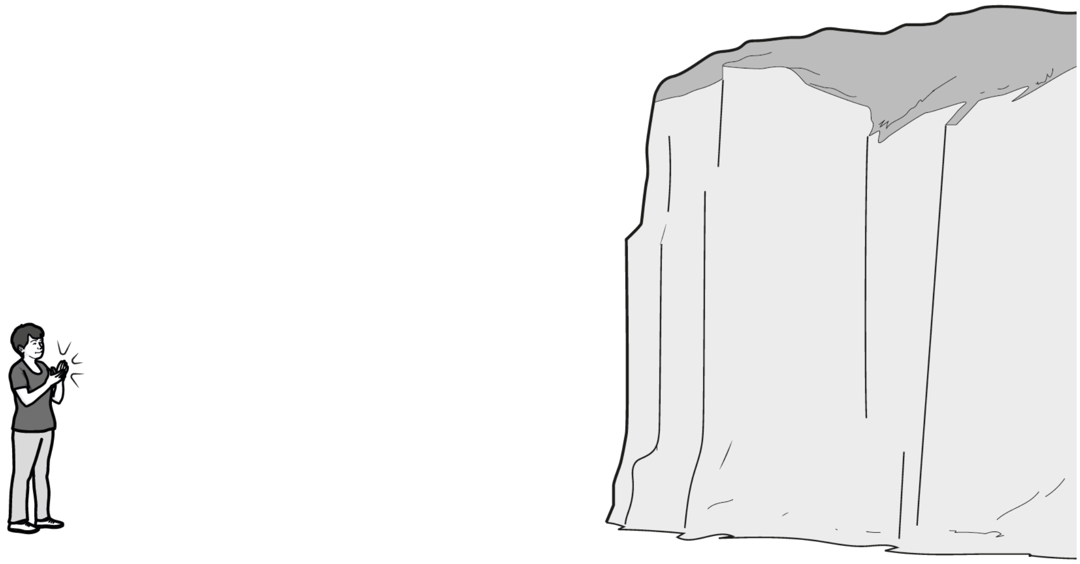
Question 18 (a) (i)

18 A student is trying to calculate how far away they are from a large cliff.



(a) The student claps loudly once.

After a short time, they hear a second clap. The second clap is quieter.

(i) Explain why they hear the second clap **and** why the second clap is quieter.

....

....

....

.... **[2]**

The majority of candidates gained both marks. Of those that did not, it was usually from the lack of scientific terminology, e.g. bounce back instead of reflect, or insufficient detail to explain why the second clap is quieter, e.g. energy is lost.

Question 18 (a) (ii)

(ii) The student measures the time between the first clap and the second clap.

The time taken is 1.40 s.
The speed of sound in air is 330 m / s.

Calculate the distance from the student to the cliff.
Use the Data Sheet.

Distance = ... m **[4]**

Nearly all candidates gained full marks or 3 marks. Several candidates did not gain the last mark because they did not divide either the time or their answer for distance by two.

Question 18 (a) (iii)

(iii) The student measures the time between the first and second clap with a stopwatch.

Suggest **two** reasons why the distance calculated in **(a)(ii)** is **not** accurate.

1 ....

2 ....
[2]

Most marks were gained for ideas about reaction time, pressing the stopwatch too early/late and the difficulty in clapping and pressing the stopwatch at the same time. Of the candidates who did not score both marks, most answers usually referred to human error.

Question 18 (a) (iv)

(iv) Suggest how the experiment could be improved.

....

.... **[1]**

The improvements suggested often followed on from the candidate's answer to part (a) (iii) and most candidates were given the mark. Incorrect responses often referred to inappropriate technology such as light gates or vaguely described sound-activated timers.

Assessment for learning

It would be beneficial for students to think about which improvements could be made to their method each time they carry out an experiment.

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Question 18 (b) (i)

(b) When the student claps, they hear the sound.

(i) Describe how the sound travels from the student's hand to their ear.

....

....

....

.... **[2]**

Many candidates described how sound travels through the ear. This question was a good discriminator and only the more able candidates gained both marks, usually by referring to air particles vibrating and compressions and rarefactions. Marks were not awarded for vague references e.g. 'sound waves vibrating'.

Question 18 (b) (ii)

(ii) Describe how the sound travels through the ear.

....

....

....

.... **[2]**

The majority of candidates gained at least 1 mark for this question. Nearly all candidates could name at least two parts of the ear, but some did not score the second mark as they did not mention that one or more parts of the ear had to vibrate for the sound to travel through.

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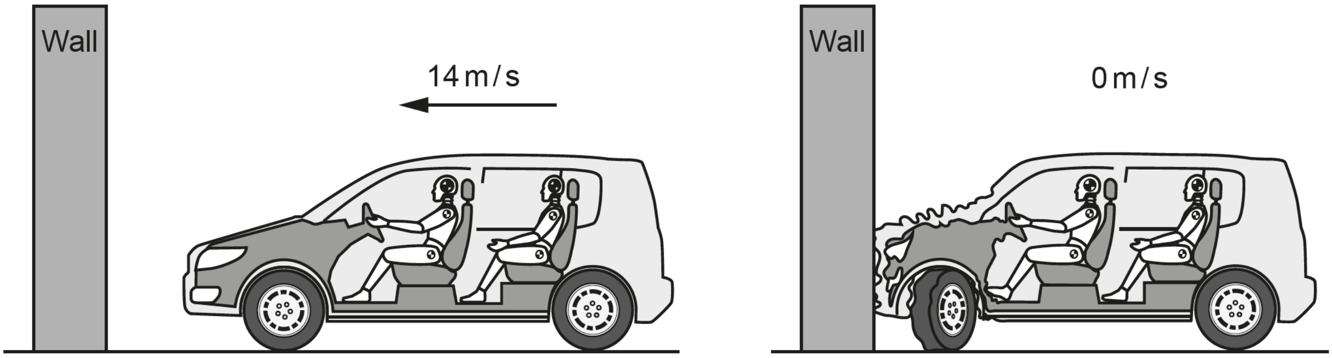
Question 19*

19* A car manufacturer tests two different cars of the same length, car **A** and car **B**.

Each car is pulled along at 14 m/s and crashes into a wall.

The diagrams show car **A** before and after the crash.



Before crash **After crash**

After hitting the wall, the rear wheel of car **A** takes **twice** the distance to stop compared to the rear wheel of car **B**.

Explain why car **A** is safer than car **B**.

In your answer, estimate the deceleration of car **A** during the crash.
Use the Data Sheet.

....

....

....

....

....

.... **[6]**

This was the Level of Response question, targeted up to Grade 9, and assessed AO1 and AO2. There was a wide range of marks achieved and the question discriminated very well. Very few candidates were not given any marks.

The majority of candidates were able to give a description of why car A was safer in terms of force and/or injuries or attempted to estimate the deceleration, although the values they used for time or distance were often very unrealistic. Many candidates discussed crumple zones. More detailed responses required for Level 2 and 3 included linking deceleration or rate of change of momentum to force with a reference to relevant equations.

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Exemplar 2

~~acceleration = change in velocity / time~~ $a = \frac{v-u}{t}$

= ~~0 − 14~~ $= \frac{14}{1.5}$

acceleration = ~~14 m/s²~~ 9.3 m/s²

the deacceleration of the car could be ~~14 m/s²~~ 9.3 m/s²

A is safer as it travels twice the distance before stopping. force = $\frac{\text{change in momentum}}{\text{time}}$ so by taking twice the distance it also takes twice the time to stop as both cars have the same speed. This increases the time taken for the momentum to change and so reduced force. Minimising the injuries from the crash. So car A is safer. This is the same principle with seatbelts **[6]**

This response achieved Level 3, 6 marks. The explanation is very detailed, using the equation to link more time for the momentum to change to less force. There is a good estimation of the deceleration using a correct equation from the Data Sheet and a realistic value for the time taken.

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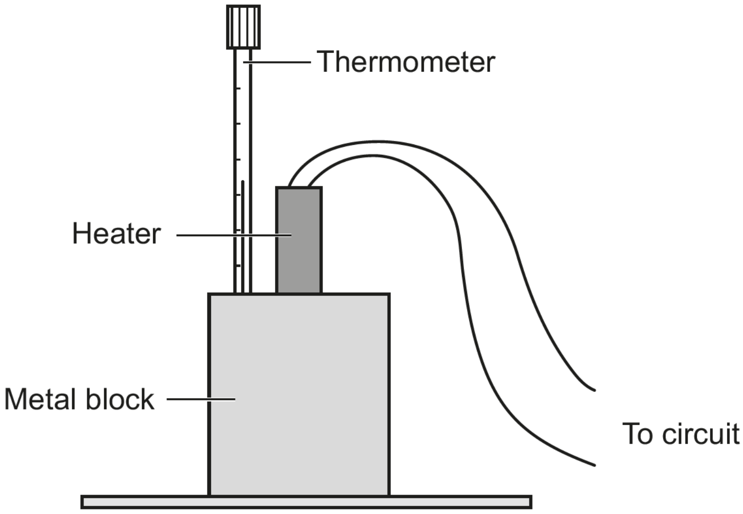
Question 20 (a)

20 A student does an experiment to measure the specific heat capacity of a metal block.

Fig. 20.1 shows the student's equipment.

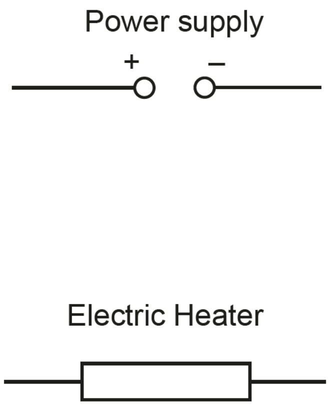
Fig. 20.1



(a) The student measures current and potential difference to calculate the power of the heater.

Complete the circuit diagram in **Fig. 20.2** to show how the student measures current and potential difference.

Fig. 20.2



[2]

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Question 20 (b) (i)

(b) (i) The table shows the student's results.

Energy supplied to heater	24kJ
Starting temperature	20°C
Final temperature	45°C
Change in temperature	25°C
Mass of block	2.0kg

Use the data in the table to calculate the specific heat capacity of the metal block.

Use the Data Sheet.

Specific heat capacity = ... J/kg °C **[4]**

This question was answered very well, nearly all candidates scored 3 or 4 marks. The main errors made included:

- incorrectly rearranging the equation
- using the starting or final temperature instead of the temperature change
- not converting kJ into joules.

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Question 20 (b) (ii) and (iii)

(ii) The value calculated in **(b)(i)** is higher than the actual value.
The student recorded all data correctly.

Suggest why the value calculated is higher than the actual value.

Use **Fig. 20.1**.

....

.... **[1]**

(iii) Suggest how the experiment could be improved.

Use **Fig. 20.1**.

....

.... **[1]**

Candidates usually lost the mark in part (b) (ii) for not giving enough detail in their response, e.g. heat lost on its own was not sufficient, it needed to say that the heat was being lost to the surroundings.

Most correct answers referred to insulating the block or repeating the experiment and calculating a mean.

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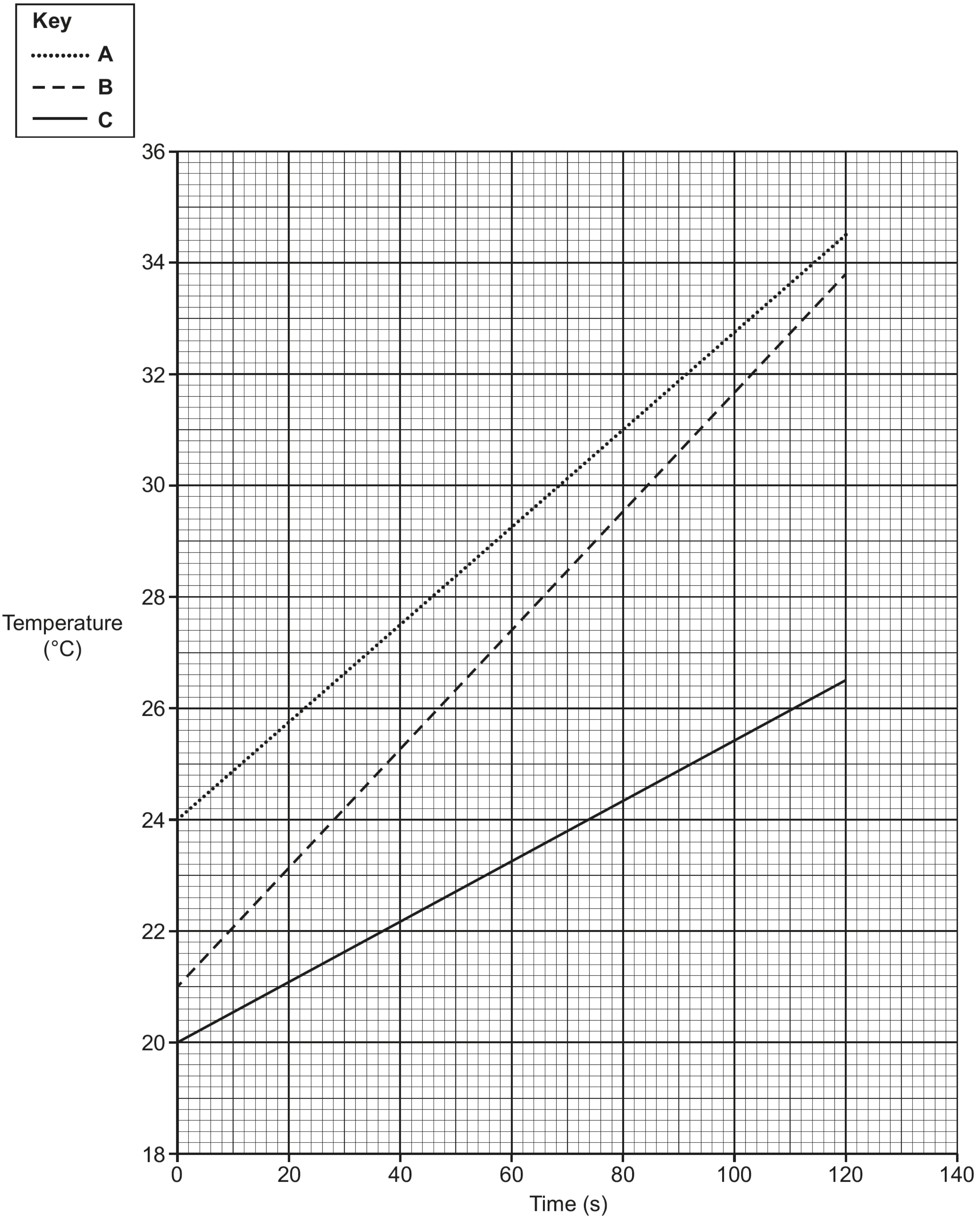
Question 20 (c)

(c) The student repeats the same experiment using 3 different blocks, **A**, **B** and **C**.

- Each block is made of a different metal but has the same mass.
- The power of the heater stays the same.

The graph shows how the temperature of blocks **A**, **B** and **C** change with time.



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Which metal has the **highest** specific heat capacity?
Tick (✓) **one** box.

A ☐

B ☐

C ☐

State a reason for your answer.

....

.... **[2]**

This AO3 question assessed candidates' ability to interpret the temperature-time graph and draw the correct conclusions about which metal had the highest specific heat capacity. Most candidates scored zero, as they identified the wrong metal, or 2 marks. Responses that gained just 1 mark usually included the idea that block C needed more energy to raise the temperature by 1 ^{O}C. This did not score as it was based on the definition of specific heat capacity and not what was shown by the graph.

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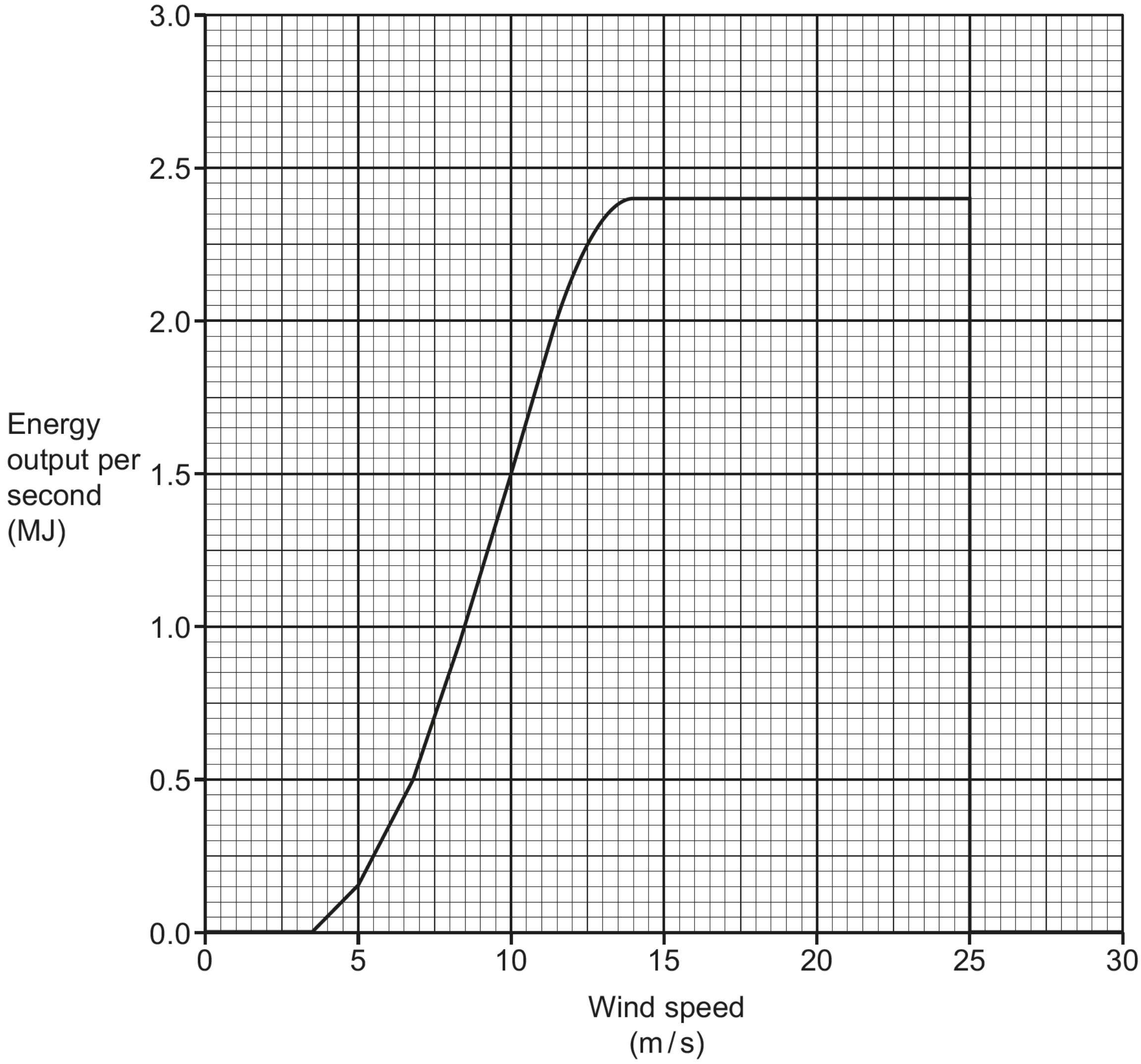
Question 21 (a) (i)

21 (a) **Fig. 21.1** shows how the energy output per second of a wind turbine depends on the wind speed.

Fig. 21.1



(i) Suggest a reason why energy output per second is zero when the wind speed is:

1 Less than 3.5 m / s.

....

....

2 Greater than 25 m / s.

....

.... **[2]**

Question 21 (a) (ii)

(ii) The wind turbine has an efficiency of 0.35.

Calculate the input energy per second when the wind speed is 10 m/s.

Use **Fig. 21.1** and the Data Sheet.

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

Input energy per second = ... MJ **[5]**

This question required candidates to identify the correct equation from the Data Sheet, which made the question more accessible. They then had to rearrange the equation, substitute in the correct value for output energy transferred per second for a speed of 10 m/s from the graph and give their answer to two significant figures. Nearly all candidates scored full marks. The main error was using the value for the wind speed (10 m/s) as the output energy in the equation. As candidates usually showed their calculations, they were still able to gain compensatory marks.

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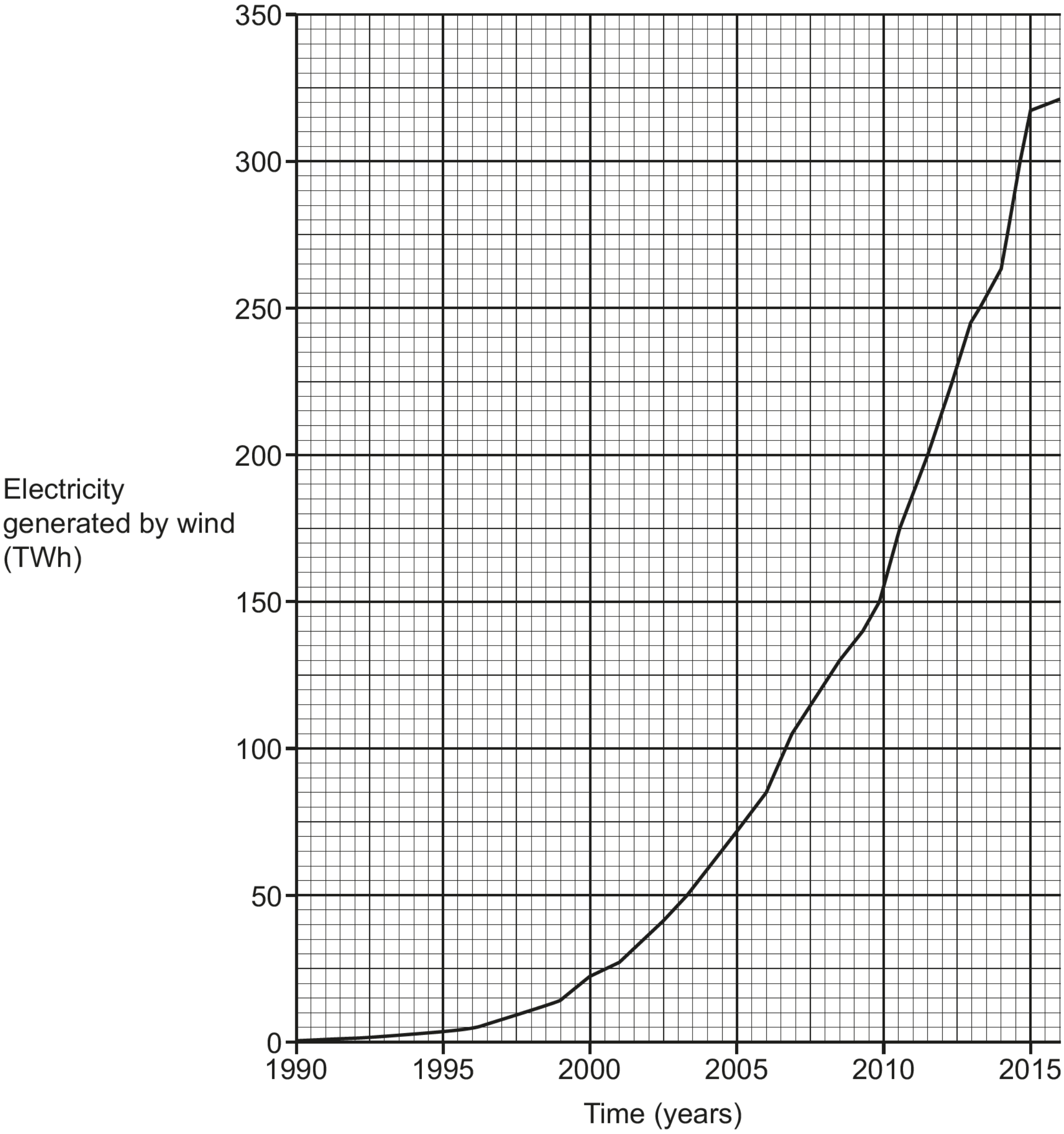
Question 21 (b) (i)

(b) **Fig. 21.2** shows how the amount of electricity generated by wind in Europe has changed with time.

Fig. 21.2



(i) State the amount of electricity generated by wind in 2012 in joules.

$1\,TWh = 3.6 \times 10^{15}\,J$

Give your answer in standard form.

Electricity generated = ... J **[2]**

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Question 21 (b) (ii)

(ii) Suggest **two** reasons for the change shown in **Fig. 21.2**.

1 ....

....

2 ....

....
[2]

Most candidates gained at least 1 mark, usually for the idea of renewable energy. Answers such as 'no pollution', 'environmentally friendly', or just 'global warming' were not given any marks.

Question 21 (c) (i)

(c) The wind turbine generates electricity at 900 V.

The wind turbine is connected to the national grid using a transformer.

(i) The potential difference across the primary coil is 900 V.
The potential difference across the secondary coil is 36 000 V.
The current in the primary coil is 2800 A.

Calculate the current in the **secondary** coil.

Use the Data Sheet.

Current = ... A **[2]**

This question required candidates to identify the correct equation from the Data Sheet, which made the question more accessible.

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Question 21 (c) (ii)

(ii) Explain why the use of the transformer in **(c)(i)** reduces power loss in the national grid.

....

....

....

....

....

.... **[3]**

Many candidates gained 1 mark for the idea of less energy lost (as heat) but only the more successful responses were able to link this to higher voltages resulting in a lower current.

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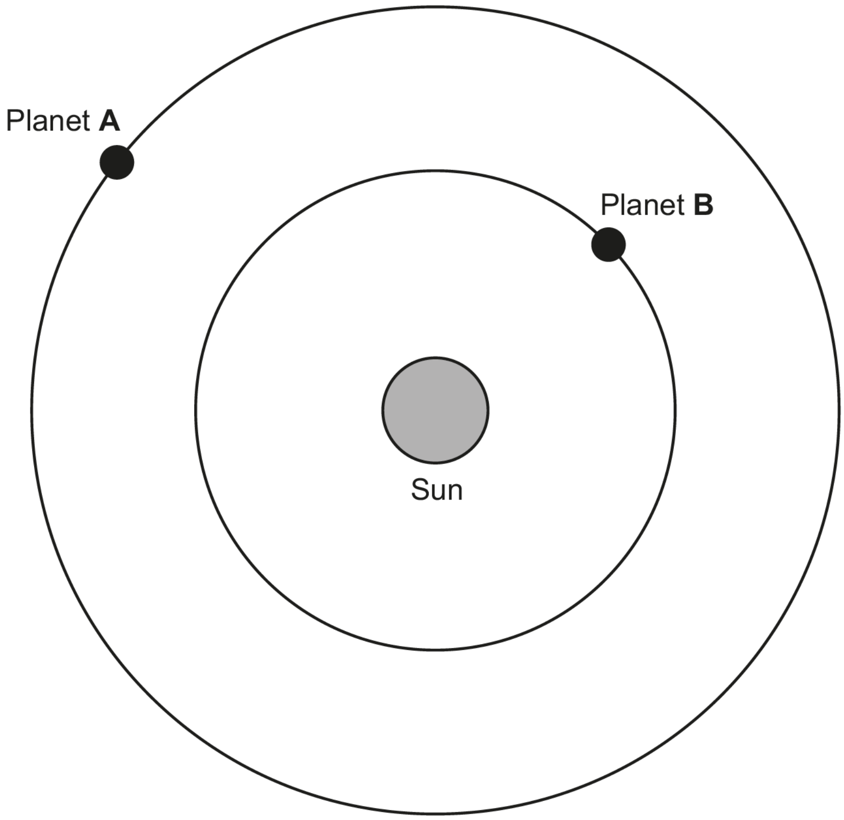
Question 22 (a)

22 The diagram shows two planets orbiting the Sun in our Solar System.



(a) Read the two statements about planet **A**:

- The speed of planet **A** is constant.
- The velocity of planet **A** is changing.

Explain why these two statements are correct. Write about forces.

....

....

....

....

....

.... **[3]**

Few candidates gained more than 1 mark for this question. The question required candidates to explain why the speed of a planet is constant but its velocity is changing, using ideas about forces. Most candidates achieved 1 mark for mentioning that speed is a scalar and velocity is a vector or that the direction of the planet changes. Very few candidates also scored marks for the idea that the resultant force is provided by the gravitational pull of the Sun or that the planet is accelerating.

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Question 22 (b) (i)

(b) The table shows data for the planets.

	Radius of orbit (metres)	Time to orbit Sun (years)	Mean orbital speed (km/s)
Planet A	2.28×10^{11}	1.88	24
Planet B	1.08×10^{11}	0.62	35

(i) Explain why the speed of a planet changes when the radius of orbit changes.

....

....

....

.... **[2]**

This question assessed candidates' abilities to explain why the speed of a planet must change if the radius changes (P8.3g). The majority of candidates were given at least 1 mark, usually for describing the correct link between the radius and speed. However, the command word for this question was 'Explain' and only some candidates progressed to explain why the speed changes in terms of the gravitational force.

Question 22 (b) (ii)

(ii) Two students look at the data.

Student P says, 'The time to orbit the Sun is proportional to the radius of orbit.'

Student Q disagrees.

Use the data in the table to show that **Student Q** is correct.

....

.... **[2]**

This question was well answered and many candidates gained at least 1 mark with some scoring full marks. Candidates with the correct answer calculated one of the many different possible pairs of ratios to show that the time to orbit the Sun was not proportional to the radius of the orbit. Some candidates calculated the value of k for one planet's data and then showed that this value of k did not give the correct value for the radius or time to orbit for the other planet.

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