Oxford Cambridge and RSA

Monday 16 June 2025 – Morning

GCSE (9–1) Physics A (Gateway Science)

J249/04 (Higher Tier)

Time allowed: 1 hour 45 minutes

You must have:
- a ruler (cm/mm)
- the Equation Sheet for GCSE (9–1) Physics A (inside this document)

You can use:
- a scientific or graphical calculator
- an HB pencil

H

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

INFORMATION
- The total mark for this paper is **90**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has **28** pages.

ADVICE
- Read each question carefully before you start your answer.

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Section A

You should spend a **maximum** of **30 minutes** on this section.

Write your answer to each question in the box provided.

1 An electromagnetic wave travels in a vacuum.

A second electromagnetic wave travelling in a vacuum has a smaller wavelength.

Which row describes how the frequency and velocity of the second electromagnetic wave compares with the frequency and velocity of the original wave?

	Frequency	**Velocity**
A	larger	equal
B	larger	larger
C	smaller	equal
D	smaller	larger

Your answer ☐ **[1]**

2 A sound wave travels from air to water. The speed of the sound wave is directly proportional to its wavelength.

The wavelength of the sound wave in air is 80 cm.

The speed of the sound wave increases by a factor of 4 when it enters the water.

What is the wavelength of the sound wave in the water?

A 20 cm

B 40 cm

C 160 cm

D 320 cm

Your answer ☐ **[1]**

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3 What is the function of the **neutral** wire in an electrical device?

A To cause a potential difference between this wire and the earth wire

B To complete the circuit from the device back to the power supply

C To melt if the current through it is too high due to a fault

D To provide a low resistance path for the current if there is a fault

Your answer ☐ **[1]**

4 A scientist is doing an experiment using a radioactive source that emits only gamma rays.

Which safety procedure does **not** reduce irradiation of the scientist?

A The scientist places a lead shield between themselves and the source.

B The scientist points the source away from them.

C The scientist uses very long tongs to handle the source.

D The scientist wears gloves while handling the source.

Your answer ☐ **[1]**

5 Red light has a maximum wavelength of 750 nm.

Which part of the electromagnetic spectrum contains radiation with a wavelength of 850 nm?

A infrared

B ultraviolet

C visible light

D X-ray

Your answer ☐ **[1]**

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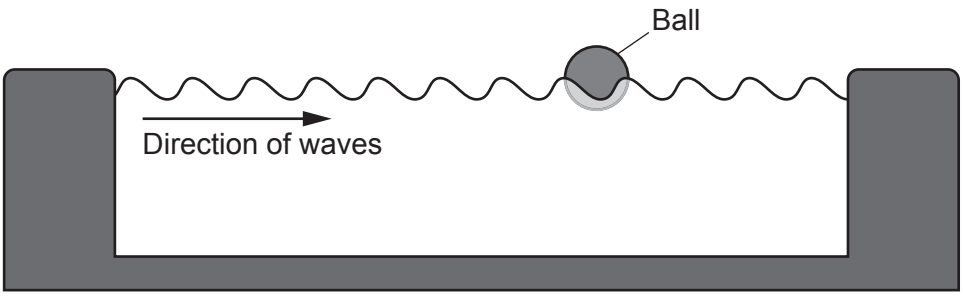
6 A ball is floating on the surface of some water.

Waves are created on the surface of the water as shown.



Which arrow shows the direction of movement of the ball due to the water waves?

A ↕ **B** →

C ↔ **D** ←

Your answer ☐ **[1]**

7 Which value could be the speed of a person running?

A 0.50 m/s

B 5.0 m/s

C 50 m/s

D 500 m/s

Your answer ☐ **[1]**

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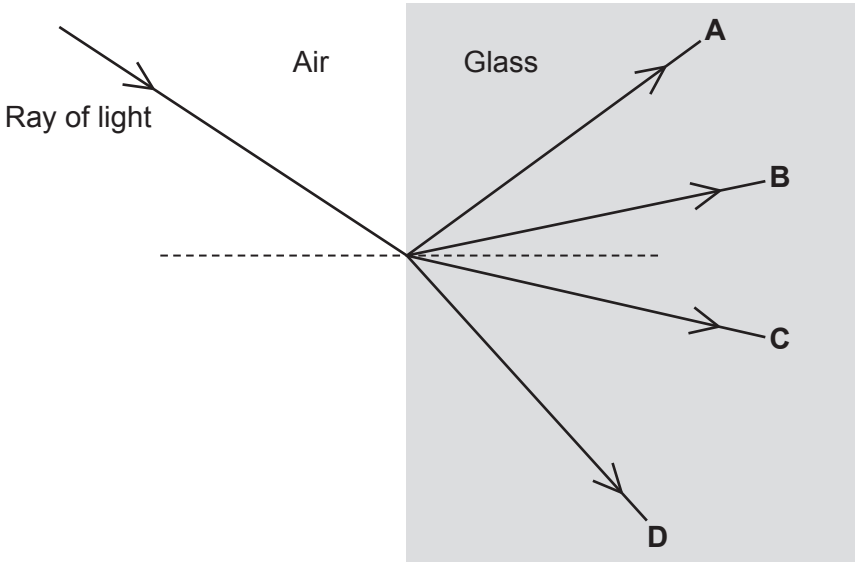
8 Which row describes the domestic mains supply in the UK?

	Voltage (V)	Frequency (Hz)	Type of voltage output
A	50	230	alternating
B	50	230	direct
C	230	50	alternating
D	230	50	direct

Your answer ☐ **[1]**

9 The diagram shows a ray of light travelling from air into glass.



Which line shows the **refracted** ray of light?

Your answer ☐ **[1]**

10 Which value is equal to 450 μJ of energy?

A 4.5×10^{-6} J

B 4.5×10^{-5} J

C 4.5×10^{-4} J

D 4.5×10^{-3} J

Your answer ☐ **[1]**

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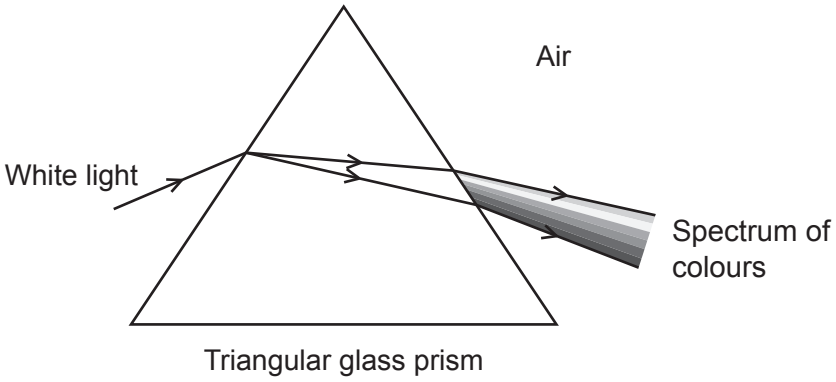
11 Which row describes how a nucleus of an atom changes when a beta particle is emitted?

	Number of neutrons	Number of protons	Total number of protons and neutrons
A	decreases	increases	changes
B	decreases	increases	stays the same
C	increases	decreases	changes
D	increases	decreases	stays the same

Your answer ☐ **[1]**

12 The diagram shows white light passing through a triangular glass prism.



Which sentence describes why white light disperses into a spectrum of different colours?

A Each colour changes frequency by different amounts when they cross the boundary between glass and air.

B Each colour changes speed by different amounts when they cross the boundary between glass and air.

C Each colour decreases in amplitude by different amounts.

D Each colour transfers energy at different rates while in the glass.

Your answer ☐ **[1]**

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13 Which sentence explains why the Sun maintains a constant size?

A The force due to gravity is balanced by the repulsive force between positively charged hydrogen nuclei in the high temperature gas.

B The force due to gravity is balanced by the force due to the energy released from nuclear fission inside the core of the star.

C The force due to gravity is balanced by the force due to gas pressure caused by the energy released from fusion.

D The force due to gravity is balanced by the force from the radiation emitted from the high temperature gas inside the star.

Your answer ☐ **[1]**

14 The energy released from the fission of a single uranium-235 nucleus is 3.2×10^{-11} J.

A uranium-235 nucleus splits and releases 3 neutrons, causing a chain reaction.

These neutrons are absorbed by 3 further uranium-235 nuclei causing these nuclei to split.

What is the total energy released?

A 6.4×10^{-11} J

B 9.6×10^{-11} J

C 1.3×10^{-10} J

D 2.9×10^{-10} J

Your answer ☐ **[1]**

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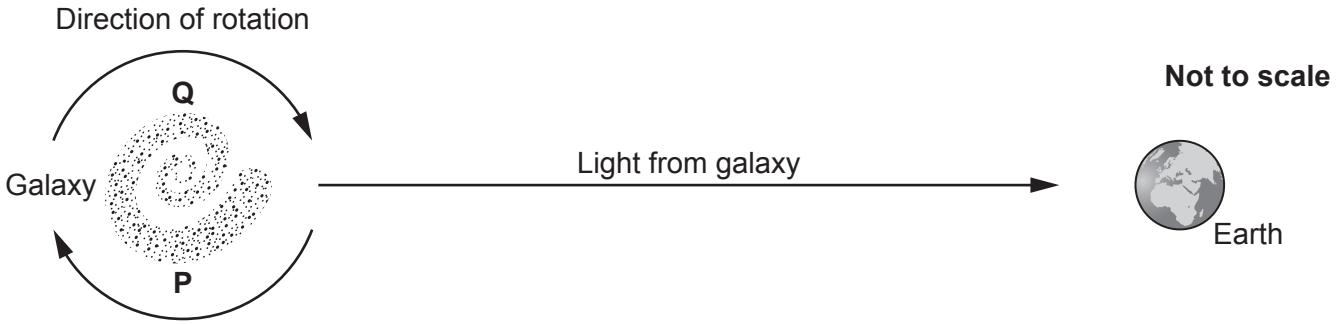
15 The diagram shows a distant galaxy that is receding from the Earth. The galaxy is rotating in the direction shown.

Visible light from both sides of the galaxy is detected on the Earth.

The galaxy recession and its rotation cause redshift of this visible light.

Which row correctly compares the wavelengths of the visible light detected on the Earth from side **Q** of the galaxy, from side **P** of the galaxy and from the Sun?



	Shortest wavelength ⟶		**Longest wavelength**
A	Light from **P**	Light from **Q**	Light from Sun
B	Light from **Q**	Light from **P**	Light from Sun
C	Light from Sun	Light from **P**	Light from **Q**
D	Light from Sun	Light from **Q**	Light from **P**

Your answer ☐ **[1]**

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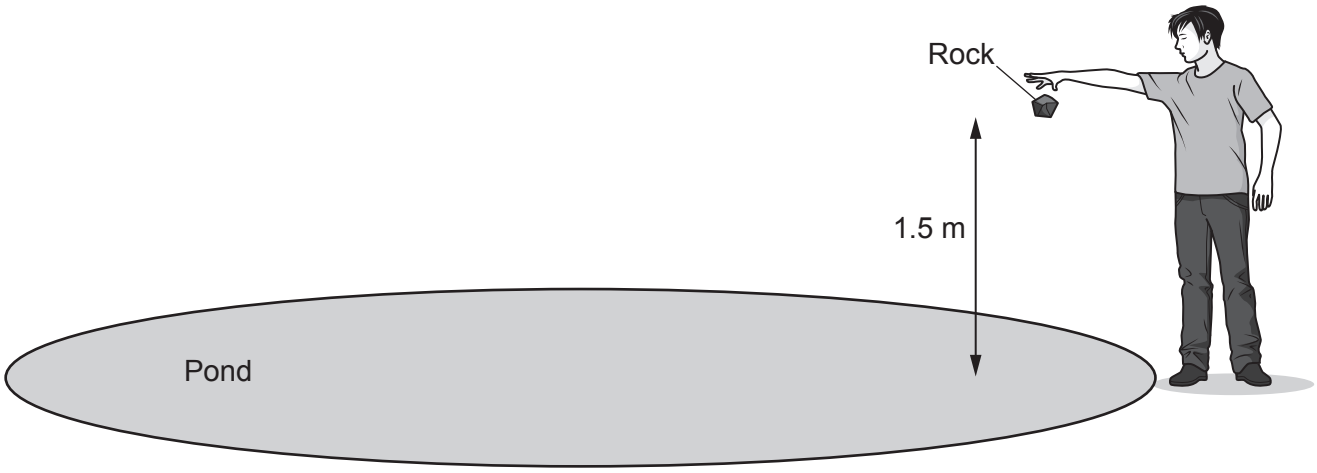
Section B

16 A student drops a rock into a pond from a height of 1.5 m.



(a) When the rock hits the water, it makes a sound. At the same time ripples form on the surface of the water.

The sound and the ripples are different types of waves.

Complete the table to describe the two waves.

	Type of wave	Direction of particle vibration
Sound	.....	Particles vibrate ..... to wave direction
Water ripples	.....	Particles vibrate ..... to wave direction

[4]

(b) The student drops an identical rock from a height of 2.0 m.

The student notices that the ripples produced by this rock have a larger amplitude than the ripples produced by the first rock.

(i) Explain why the rock dropped from a greater height produces ripples with a larger amplitude.

.....

.....

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

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(ii) Describe how the student uses a metre ruler and a stop clock to determine the speed of the ripples.

.....

.....

.....

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

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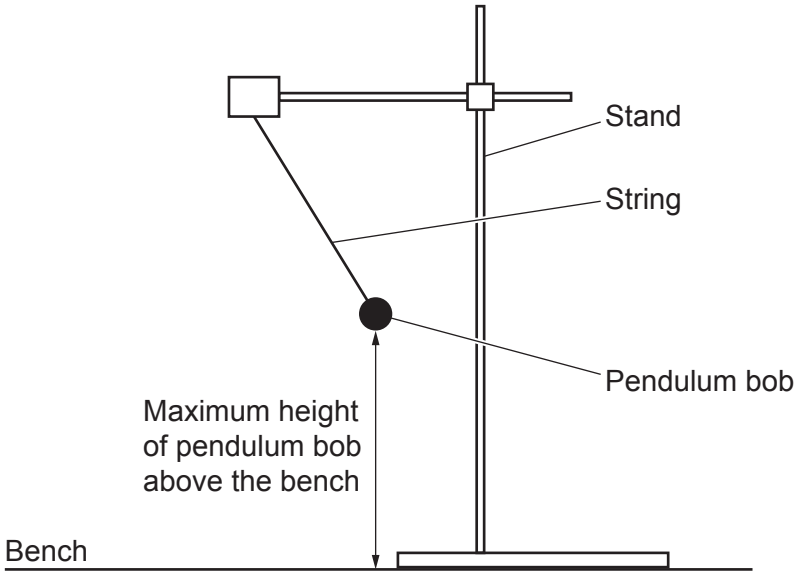
17 The diagram shows a pendulum bob attached to a stand using string.



A student lifts the pendulum bob to the position shown on the diagram.

The student then releases the pendulum bob so that it swings freely.

(a) The student notices that the maximum height of the pendulum bob above the bench decreases after each swing.

Explain why the maximum height of the pendulum bob decreases after each swing.

.....

.....

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

(b) The student holds a metre ruler behind the swinging pendulum bob and measures the maximum height of the pendulum bob above the bench.

(i) Give **two** reasons why the student's method might **not** give an **accurate** value for the maximum height of the pendulum bob.

1 .....

.....

2 .....

.....
[2]

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(ii) Describe **two** ways to improve the student's method to obtain a more accurate value of the maximum height of the pendulum bob at the end of each swing.

1 .....

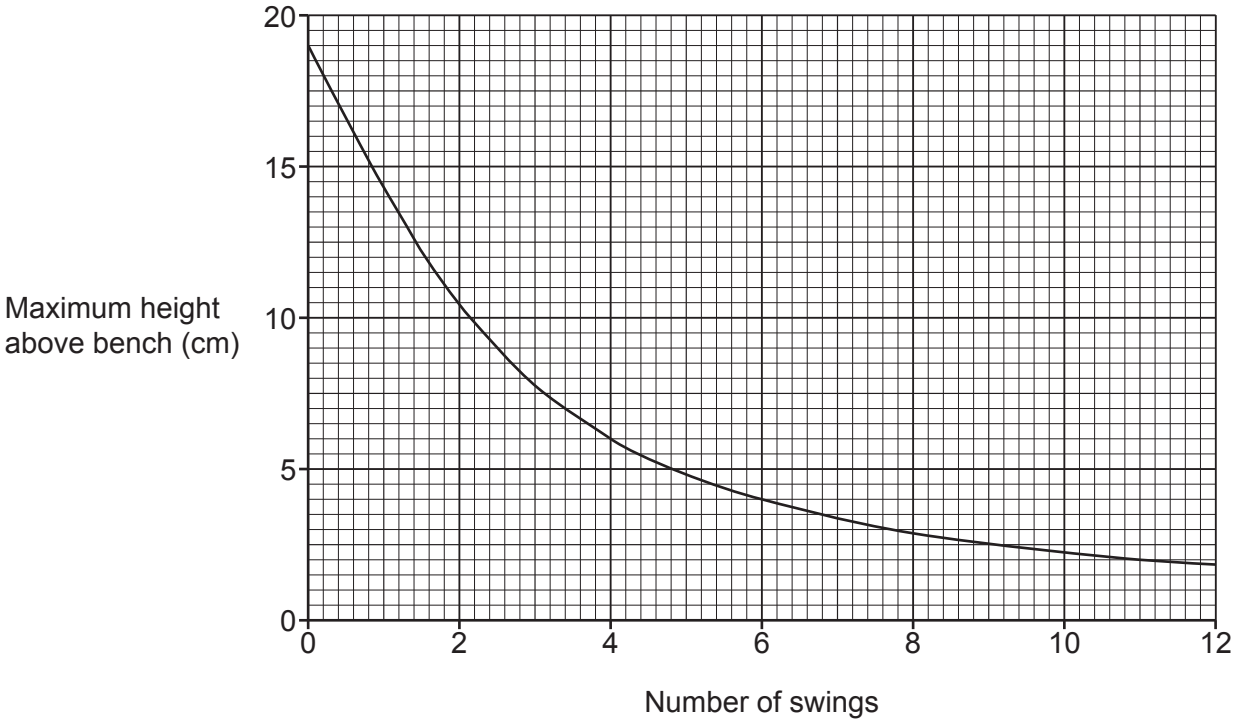
.....

2 .....

.....

[2]

(c) The graph shows how the maximum height of the pendulum bob above the bench changes as the pendulum bob swings.



The initial release height of the pendulum bob above the bench is 19 cm.

Determine the maximum height after 6 swings as a percentage of the initial release height.

Percentage of the initial release height = ... % **[3]**

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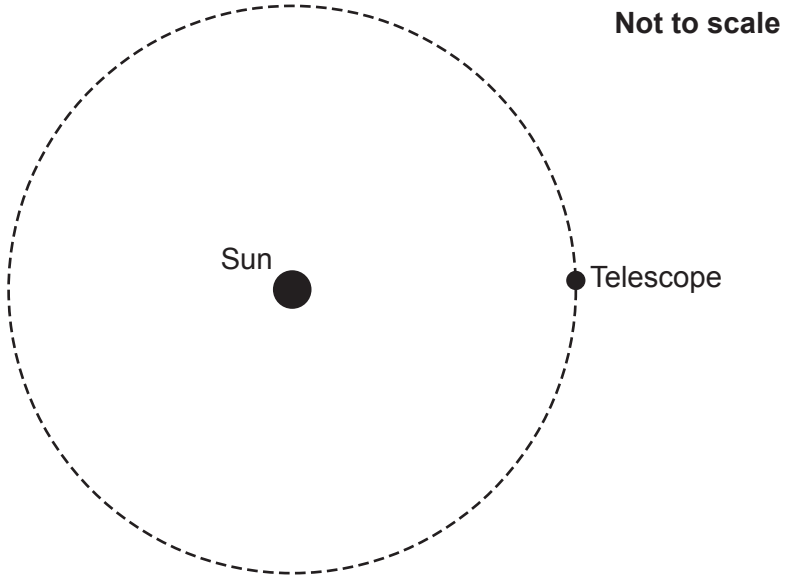
18 The James Webb space telescope orbits the Sun in a circular orbit.

Fig. 18.1 shows the orbital path of the telescope around the Sun.

Fig. 18.1



(a) A force acts on the telescope to keep it in orbit around the Sun.

(i) State the name of this force.

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

(ii) Draw an arrow on **Fig. 18.1** to show the direction of the force acting on the telescope. **[1]**

(b) The telescope is accelerating towards the Sun.

Explain why the telescope is accelerating even though its speed remains constant.

.....

.....

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

(c) The James Webb space telescope is always within 1.5 million kilometres of the Earth.

The telescope is in constant use by scientists on the Earth.

Suggest a reason why it is important for the telescope to remain close to the Earth.

.....

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

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(d) The James Webb space telescope detects electromagnetic radiation from stars and galaxies.

Some telescopes on the Earth's surface also detect electromagnetic radiation from stars and galaxies.

Describe an advantage of using the James Webb space telescope to detect this radiation instead of a telescope on the Earth's surface.

.....

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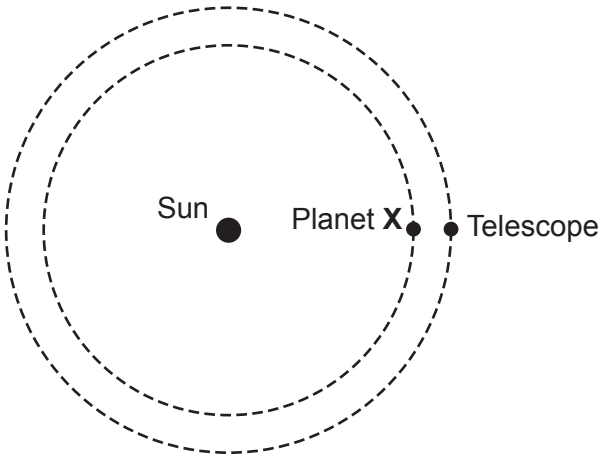
..... **[1]**

(e) **Fig. 18.2** shows the paths of the orbits around the Sun of both the James Webb space telescope and a planet labelled **X**.

Fig. 18.2



Not to scale

Compare the speeds of planet **X** and the telescope.

Explain your answer.

.....

.....

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

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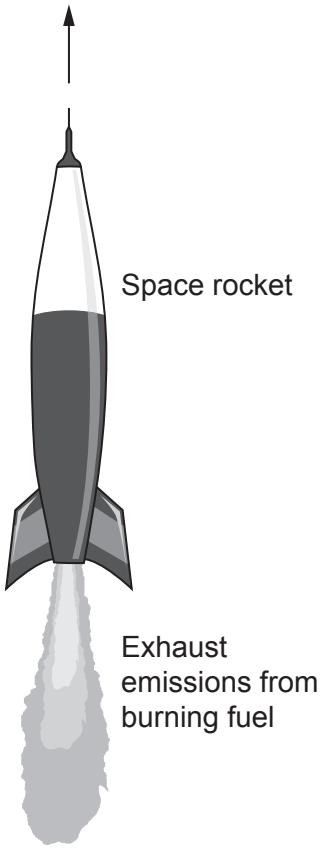
19 A student researches rockets.

Fig. 19.1 shows a rocket burning fuel as it moves away from the Earth.

Fig. 19.1



The rocket accelerates vertically upwards.

Fig. 19.2 shows how the energy in the chemical store of the fuel is transferred to other energy stores in the rocket and in the surroundings.

Fig. 19.2

(a) The energy in the gravitational potential store of the rocket increases as the rocket accelerates vertically upwards.

Why does the energy in the gravitational potential store of the rocket increase?

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

(b) The energy in the thermal store of the rocket increases as the rocket accelerates vertically upwards.

What effect does this have on the rocket?

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

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(c) When the fuel burns, it transfers 510 MJ of energy in one second.

(i) Explain why the total energy gained by other energy stores must also be 510 MJ in one second.

.....

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

(ii) When the fuel burns, 320 MJ of energy is wasted in one second.

Calculate the efficiency of the rocket.

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

Efficiency = ... **[3]**

(d)

(i) The student finds out that:

- the energy in the kinetic store of the rocket increases by 1.2×10^8 J every second as the fuel burns
- the initial mass of the rocket is 8.5×10^4 kg.

Calculate the minimum speed of the rocket after the fuel has been burning for 12 seconds if the rocket starts at rest.

Use the equation: kinetic energy = $\frac{1}{2} \times \text{mass} \times (\text{speed})^2$

Speed = ... m/s **[4]**

(ii) Explain why the actual speed of the rocket after the fuel has been burning for 12 seconds is **greater** than the value calculated in **(d)(i)**.

.....

.....

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

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20 A technician investigates an unknown radioactive metal as shown in **Fig. 20.1**.

Fig. 20.1

(a)

(i) Describe how the technician obtains a precise measurement of the count rate from the radioactive metal.

Include the name of any extra equipment the technician uses.

You may draw on **Fig. 20.1**.

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

(ii) Explain how the technician shows that the radioactive metal emits **only** gamma radiation.

Include the name of any extra equipment the technician uses.

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

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(b) The technician thinks that the radioactive metal is one of the four metals shown in **Table 20.1**.

Table 20.1

Metal	Nuclear radiation emitted	Half-life
A	gamma	4 hours
B	gamma	10 years
C	gamma	2 years
D	gamma	28 days

(i) The technician uses equal masses of each metal in **Table 20.1**.

Explain which metal in **Table 20.1** is likely to be the most hazardous to the technician while doing the experiment.

Metal .....

Explanation .....

.....

[2]

(ii) Metal **D** is considered to be safe when the count rate drops to $\frac{1}{32}$ of the original count rate.

Calculate the time required for metal **D** to be safe.

Time required = ... days **[3]**

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21 Scientists are working on nuclear fusion technology so that, in the future, nuclear fusion power stations could be built to generate electricity.

(a) The expected power output of a nuclear fusion power station in the future is 1.3×10^{9} W.

The average energy output of an individual fusion reaction is 2.8×10^{-12} J.

Calculate the number of fusion reactions that would occur per second in the power station.

Number of fusion reactions per second = ... **[2]**

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(b)* Scientists think that nuclear **fusion** would be a better energy source than nuclear **fission**.

The table gives information about nuclear fission power stations and nuclear fusion power stations.

Type of power station	Fuel used	Power output from power station (W)	Waste products
Nuclear fission	uranium	1.0×10^9	very radioactive with long half life
Nuclear fusion	hydrogen	1.3×10^9 (expected)	slightly radioactive with short half life

Use the information in the table to compare a nuclear fission power station with a nuclear fusion power station.

In your answer, write about

- differences between a fission reaction and a fusion reaction
- the benefits of using nuclear fusion instead of fission
- the difficulties associated with using nuclear fusion.

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

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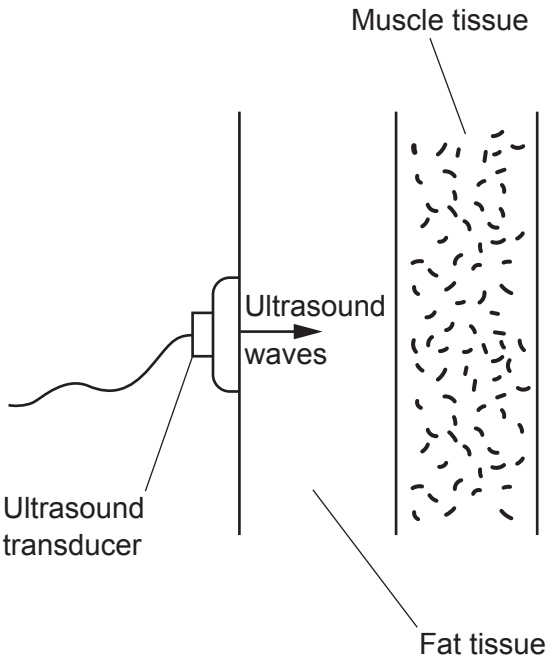
22 Ultrasound waves are used to produce images of the inside of the human body.

The ultrasound waves reflect from the boundary between two different materials inside the human body.

The diagram shows an ultrasound transducer that emits and receives ultrasound waves.



A computer is connected to the ultrasound transducer.

The computer records a time of 2.8×10^{-7} s between emitting one ultrasound wave and receiving the reflection of this wave from the boundary between the fat tissue and the muscle tissue.

The speed of ultrasound waves in fat tissue is 1500 m / s.

(a) Calculate the thickness of the fat tissue.

Use the Equation Sheet.

Thickness of fat tissue = ... m **[3]**

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(b) The wavelength of the ultrasound wave in the fat tissue is 4.3×10^{-4} m.

Calculate the frequency of the ultrasound wave.

Use the equation: wave speed = frequency × wavelength

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

Frequency = ... Hz **[4]**

(c) When the ultrasound wave hits the boundary between the fat tissue and the denser muscle tissue, the ultrasound wave is partially reflected and partially transmitted.

The transmitted ultrasound wave continues into the denser muscle tissue.

Explain the change in wavelength of the ultrasound wave as it passes from fat tissue into muscle tissue.

.....

.....

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

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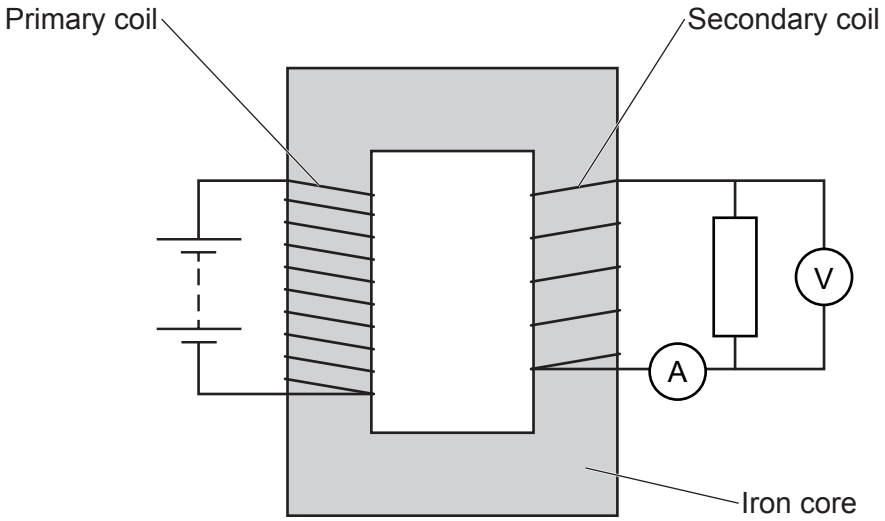
23 A student investigates the relationship between

- the number of turns of wire on the secondary coil of a transformer
- the potential difference across the secondary coil
- the current in the secondary coil.

The diagram shows the equipment the student uses to make their transformer.



(a) When the battery is connected to the primary coil the transformer does **not** work and the voltmeter reads zero.

Describe what change the student needs to make to their equipment so that the voltmeter shows that there is a continuous potential difference across the secondary coil.

Explain your answer.

Change .....

.....

Explanation .....

.....

[2]

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(b) The student changes the equipment in the diagram so that the transformer works.

The student obtains the results shown in the table.

Number of turns on secondary coil	Potential difference across secondary coil (V)	Current in secondary coil (A)
160	6.4	0.47
120	4.8	
80	3.2	0.94

(i) Describe the relationship between the number of turns on the secondary coil and the potential difference across the secondary coil.

.....

.....

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

(ii) Calculate the current in the secondary coil when there are 120 turns on the secondary coil.

Assume the transformer is 100% efficient.

Use the Equation Sheet.

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

(iii) The potential difference across the primary coil in the student's transformer is 12 V.

The student suggests that this transformer is the same as the type of transformer used between a power station and the power lines.

Explain why this type of transformer is **not** the same as the type of transformer used between a power station and the power lines.

.....

.....

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

END OF QUESTION PAPER

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EXTRA ANSWER SPACE

If you need extra space use these lined pages. You must write the question numbers clearly in the margin.

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