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Examiners' report

GCSE

TWENTY FIRST CENTURY SCIENCE PHYSICS B

OCR Level 1/Level 2 GCSE (9-1) in Physics B (Twenty First Century Science)

J259

For first teaching in 2016

J259/04 Summer 2025 series

Version 1

Contents

Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates.

The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. A selection of candidate responses 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 Teach Cambridge.

Paper 4 series overview

J259/04 Depth in Physics is one of the two examination components aimed at Higher tier candidates studying GCSE (9–1) Twenty First Century Science suite, which assesses content across the teaching chapters P1 to P7, and assessment of P8 Practical Skills. Questions 1–2 are overlap questions with the Foundation paper. The examination assesses the three Assessment Objectives: AO1 demonstrating knowledge and understanding of scientific ideas, techniques and procedures; AO2 applying that knowledge to solve problems; and AO3 analysing information, drawing conclusions and improving experimental procedures. Most of the paper assesses candidates' demonstration and application of their knowledge with 20% of the paper assessing their ability to analyse, interpret and evaluate information. With all J259 examinations there is a requirement to assess mathematical and practical skills. The assessment of mathematical skills makes up approximately 30% of the paper which include calculations and graphical interpretation. The assessment of practical skills is assessed in no less than 15% of questions and these questions can assess any of the apparatus and techniques as described in the specification. This paper includes two Level of Response Questions, 2 (a) and 7, which were also synoptic questions where candidates are required to demonstrate and apply knowledge from the different teaching chapters in the specification.

Only a very small number of candidates achieved marks that indicated that the Foundation tier examination would have been a more appropriate paper for them. Candidates' overall performance indicates the accessibility of the paper and that candidates have been entered for the correct tier of entry.

<table>
<tr><th>Candidates who did well on this paper generally:</th><th>Candidates who did less well on this paper generally:</th></tr>
<tr><td>

selected, rearranged and substituted numbers into equations with their working shown clearly. This was evident when selecting and applying equations for electrical circuits, kinetic energy and momentum calculations
generally, had good comprehension of command terms such as describe, explain, evaluate, etc.
had good understanding of the ionising effect of ultraviolet radiation and the accompanying risk to human tissue
had a good understanding of the principle of moments and applying and calculating gear ratios.

</td><td>

did not convert units, e.g. cm to m or converted quantities when there was no requirement to, e.g. converting kg to g when calculating kinetic energy
did not demonstrate understanding and use of specific scientific terminology to explain:

inertial mass and that it is a measure of the tendency in resisting an objects state of motion. It is defined as the ratio of force over acceleration
possible variables identified in practical activities, e.g. volume or mass of water and instead used vague descriptions such as ‘amount’ without any further qualification
the purpose of practical methods to minimise thermal energy transfer to the surroundings and instead described this mechanism using informal language such as heat being trapped or heat was prevented from rising
how radio waves can be produced by, or can themselves induce, oscillations in electrical circuits

confused the rules for the behaviour of current, potential difference and resistance in series and parallel circuits, e.g. current is shared in components in a series circuit.

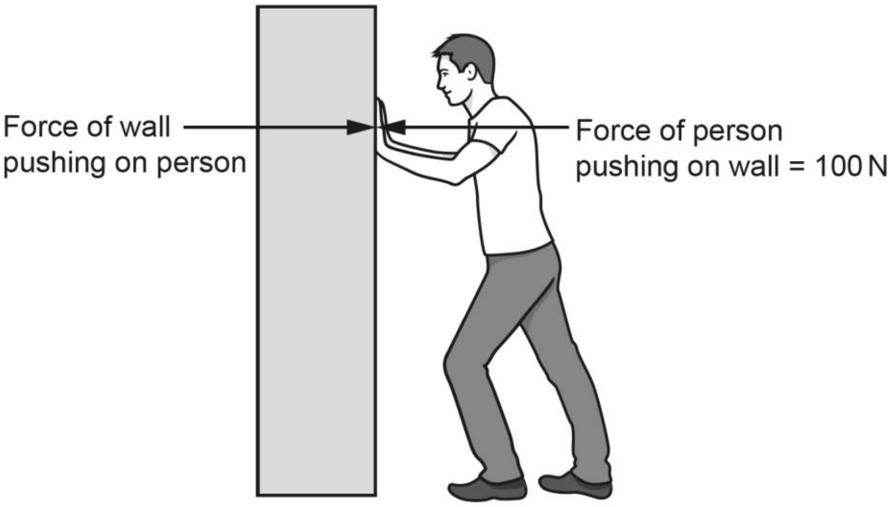
</td></tr>
</table>

Question 1 (a)

1 According to Newton's third law, when two objects interact, they apply forces on each other.

(a) A person pushes on a wall with a force of 100 N.

The diagram shows two forces that form an interaction pair between the person and the wall.



Which statements about this pair of forces are **true** and which are **false**?

Tick (✓) **one** box in each row.

	True	False
Both forces are acting on the person.		
The forces are the same kind of force.		
The forces are opposite in direction.		
The force of the wall on the person equals 100 N.		

[3]

Candidates performed well on this question as most candidates achieved 2 marks or more. The most common incorrect answer was identifying that the 'The forces are the same kind of force' as false. Candidates did not apply understanding of Newton's Third Law and that the two forces in an interaction pair are the same kind of force but there was good understanding the two forces were equal in size and opposite in direction and act on the two objects: the wall and the person.

Question 1 (b)

(b) Which of these forces is a **contact** force?

Tick (✓) **one** box.

Electrostatic ☐

Friction ☐

Gravitational ☐

Magnetic ☐

[1]

Candidates performed well on this question with nearly all of candidates identifying that 'friction' was a contact force.

Question 1 (c)

(c) Complete the sentences in the table to describe each interaction pair of forces.

Use words from the list.

attracting	**Earth**	**Moon**	**negatively**
positively	**repelling**	**Sun**	

A magnet attracting an iron bar.	The iron bar .... the magnet.
A positively charged rod attracting a piece of paper.	The piece of paper attracting the .... charged rod.
The gravitational force of the Earth on the Moon.	The gravitational force of the .... on the ....

[4]

Candidates generally performed well on this question as nearly half of candidates achieved 4 marks for correctly describing each interaction pair of forces. The most common incorrect response was describing the gravitational interaction pair of forces on the Earth and the Moon and recognising that the Moon exerted a gravitational force on the Earth in the interaction pair of forces.

Question 2 (a)*

2 Scientists advise people to use sunscreen when they are outside on a sunny day.

Sunscreen absorbs the UV radiation from the Sun.

(a)* Explain:

- how exposure to UV radiation can cause damage to human tissue
- why it is important to use sunscreen when outside on a sunny day.

....

....

....

....

....

.... **[6]**

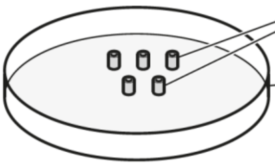
Candidates performed well on this Level of Response question as most of all candidates gave a minimum Level 2 response and with over half of candidates giving a Level 3 response. Candidates confidently explained the dangers of UV radiation and the effect that this has on human tissue, e.g. damage to cells caused by mutations to DNA which could lead to skin cancer. Many candidates also explained the process in which atoms changed when exposed to UV radiation in terms of ionising radiation and the effect that this has on an atom by removing electrons. Candidates were also able to explain the damage ionising radiation had on skin cells and link it to the importance of using sunscreen to minimise absorption of UV radiation by the skin and so reduce the risk posed by ionising UV radiation.

Question 2 (b) (i)

(b) The sun protection factor (SPF) is a measure of the strength of sunscreen.

A student investigates the SPF of different suncreens.

They use beads that change colour when they are exposed to UV radiation.



They use this method:

- Dip five beads in sunscreen with a SPF of 10.
- Spread the beads out in a petri dish and place them outside in the sun.
- Record the time taken for all the beads to change colour.
- Repeat the steps using different sunscreens with SPFs of 20, 30 and 40.

(i) Describe **two** improvements the student can make to their method.

1 ....

....

2 ....

....

[2]

Generally, candidates performed well on this question with about a half of all candidates achieving a minimum of 1 mark. Most candidates were able to describe an improvement, with the most common response being to carry out the investigation at the same time of day to ensure that the exposure to UV radiation was the same for all beads. Some candidates qualified this point with more detail by describing that a UV lamp could be used to ensure a constant exposure to UV radiation. The use of repeats measurements of either time for the beads to change colour or for different SPFs to calculate a mean value was a valid improvement. However, candidates would often simply describe repeat readings as an improvement without developing their response and describing that a mean can be calculated. Some candidates would also give undeveloped and unspecific responses such as using more beads or spreading the beads out on the petri dish which were not a sufficient improvement for the investigation.

Question 2 (b) (ii)

(ii) The table shows the student's results.

SPF	Time taken for all beads to change colour
10	3.25
20	6
30	10
40	14

The table of results contains mistakes.

State **two** mistakes made by the student.

1 ....

....

2 ....

....
[2]

Candidates performed well on this question as most candidates achieved a minimum of 1 mark. The most common response for 1 mark was stating that the 'Time taken' did not include units or that it wasn't known what the time was measured in, e.g. seconds or minutes. Some candidates attempted to identify a mistake in the values of time taken rather than the 'table of results'. These candidates attempted to describe a linear relationship in the time taken by suggesting that the time taken for SPF 10 should be 2 and not 3.25 and did not recognise that the mistake was the inconsistency in the resolution of the values of time taken in terms of the number decimal places or significant figures. Also, a significant number of candidates suggested that repeat measurements were not included in the table, which was an improvement to the method rather than a mistake in the table of results.

Question 3 (a)

3 Uranium-235 is a radioactive isotope.

(a) Uranium-235 can be written as:

$^{235}_{92}U$

How many protons and neutrons are contained in the nucleus of uranium-235?

Number of protons = ...

Number of neutrons = ...

[2]

Candidates performed well on this question as the majority of candidates correctly identified the number of protons and neutrons in the nucleus of uranium-235. Common mistakes by candidates were to correctly determine the number of protons and neutrons but to state the values in reverse or to give the number of neutrons as 235 rather than 143.

Question 3 (b)

(b) Uranium-235 undergoes alpha decay.

Which of these is the correct equation for this decay?

Tick (✓) **one** box.

$^{235}_{92}U \rightarrow ^{231}_{92}U + ^{4}_{0}He$ ☐

$^{235}_{92}U \rightarrow ^{231}_{92}U + ^{4}_{1}He$ ☐

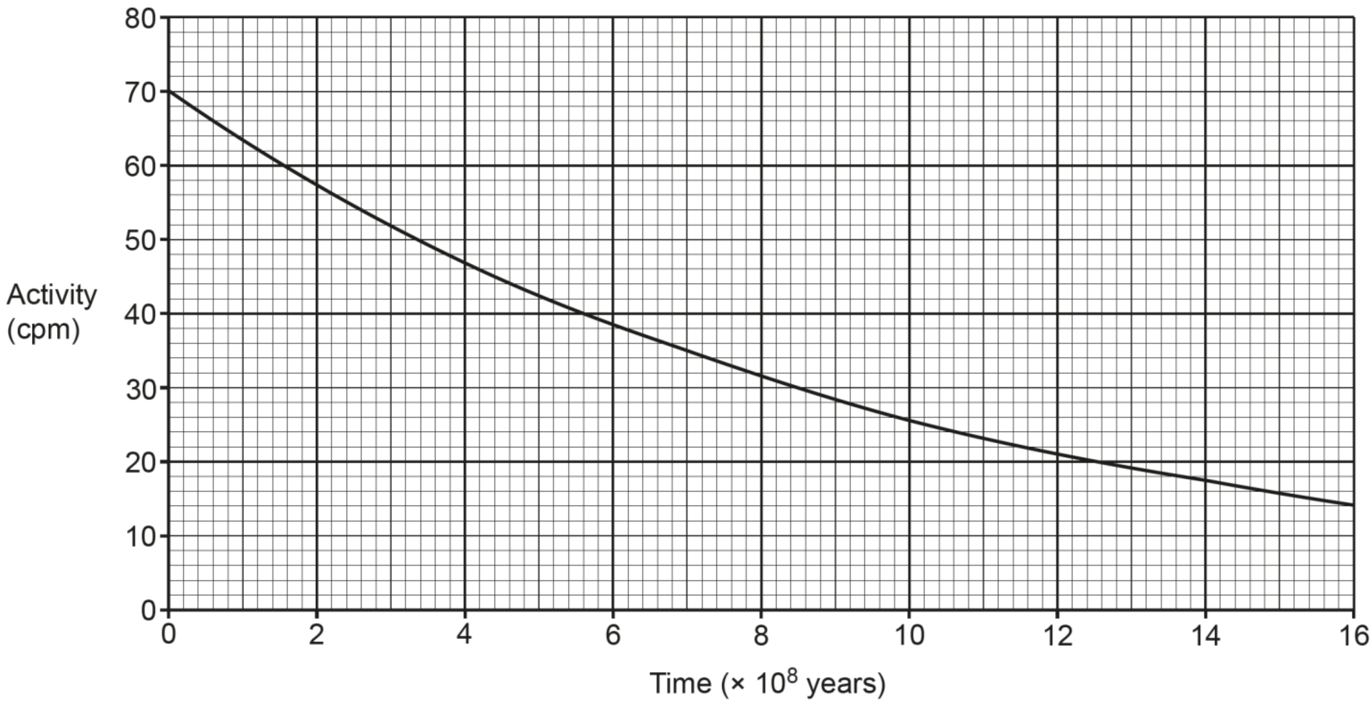
$^{235}_{92}U \rightarrow ^{231}_{90}Th + ^{4}_{2}He$ ☐

[1]

Candidates performed well on this question as most of all candidates correctly identified the nuclear decay equation for uranium-235 by alpha decay.

Question 3 (c) (i)

(c) The graph shows how the activity of a sample of uranium-235 changes with time.
The activity is measured in counts per minute (cpm).



(i) What is meant by the half-life of a radioactive isotope?

Tick (✓) **one** box.

Half of the decrease in activity per second.	☐
The number of atoms formed in half a year.	☐
The time taken for the activity to fall by half.	☐
The time taken for the activity to reach 0.5 cpm.	☐

[1]

Candidates performed well on this question with nearly all candidates identifying the correct definition of half-life of a radioactive isotope.

Question 3 (c) (ii)

(ii) Find the activity of the sample at 14×10^8 years.

Use the graph.

Activity at 14×10^8 years = ... cpm **[1]**

Candidates performed well on this question as most of all candidates correctly used the graph to determine the activity of the sample at 14×10^8 years.

Question 3 (c) (iii)

(iii) The half-life of uranium-235 is 7×10^8 years.

Calculate the activity at 21×10^8 years.

Activity at 21×10^8 years = ... cpm **[2]**

Overall, candidates performed well on this question with the majority of candidates achieving 2 marks for a correct calculation of the activity at 21×10^8 years. Candidates were credited for either determining that 3 half-lives had passed by 21×10^8 years and then using the graph to give the initial activity of 70 (cpm) or by halving their value from part (c) (ii) at 14×10^8 years to calculate the activity at 21×10^8 years.

Question 3 (d)

(d) Complete the sentences about the use of uranium-235 in a nuclear fission reactor.

Use words from the list.

chain	**chemical**	**electrons**	**gamma**
kinetic	**neutrons**	**protons**	**ultraviolet**

A neutron is absorbed by a nucleus of uranium.

The nucleus splits into two smaller parts.

This releases more ...., which may go on to make further reactions. This is known as a .... reaction.

The energy released from the nucleus is transferred as .... energy of the particles.

Energy is also emitted as .... radiation.

[4]

Candidates performed well on this question as most of all candidates achieved a minimum of 3 marks for correctly completing the sentences on nuclear fission. The most common incorrect responses were stating that more electrons were released when a nucleus splits rather than more neutrons or that energy was emitted as ultraviolet radiation rather than gamma radiation.

Question 4 (a) (i)

4 A student investigates how the number of layers of insulation affects how quickly a beaker of hot water will cool.

They use this method:

- Wrap three beakers in a different number of layers of bubble wrap insulation.
- Leave one beaker without any bubble wrap.
- Pour hot water into each beaker.
- Put a lid on all the beakers.
- Take the initial temperature of the water in each beaker using a thermometer.
- Continue to take the temperature every 5 minutes for 25 minutes.

(a)
(i) State **two** variables that need to be controlled in this experiment.

1 ....

....

2 ....

....

[2]

Generally, candidates performed well on this question as around half of all candidates achieved 1 mark and many higher performing candidates achieved 2 marks. The most common stated variables to be controlled were the volume of water in each beaker, the type of bubble wrap used or the size/material of the beaker. Many candidates stated that the temperature of the water needed to be controlled but did not specify that this was the initial temperature of the water. Many candidates referred to the need to control the external temperature and conditions. This was not credited as it did not refer to the specific variables of the investigation linked to how the number of layers of insulation affected how quickly the hot water in the beaker cooled down.

Practical Skills - Variables and use of language

This question highlights the necessity and importance of using specific scientific language to practical skills linked to measurements of variables in an investigation; as many candidates stated that the 'amount' of water needed to be controlled, which wasn't credited, rather than the specific and correct use of scientific terminology such as the volume or mass of water as a measurable variable.

OCR support

OCR provide resources to support students prepare for the Twenty First Century Science practical activities, including a 'Practical support guide'.

Question 4 (a) (ii)

(ii) Explain why putting a lid on the beakers will make the water stay warmer for longer.

....

.... **[1]**

Candidates performed less well on this question as only about a half of candidates achieved 1 mark. Candidates were required to explain that using a lid made the water stay warmer for longer as thermal energy transfer to the surroundings was reduced. Many candidates gave unqualified descriptions such as heat or steam not being able to escape without referring to thermal energy transfer to the surroundings or evaporation being reduced. Higher achieving candidates performed better as they demonstrated a more confident understanding of methods for reducing thermal energy transfer to the surroundings and demonstrated a sound use of correct scientific terminology.

Disciplinary literacy – Substantive knowledge

This question highlights the importance of understanding **substantive knowledge** which is referred to as scientific knowledge and conceptual understanding in the curriculum. This question required candidates to apply knowledge to the concept of energy transfers and specifically to methods of minimising thermal energy transfers. There were many answers that demonstrated an underdeveloped understanding of the concept of energy transfers. Responses such as 'heat is trapped' demonstrated an issue with using scientific language to explain their substantive knowledge of energy transfers.

Misconception

There were some candidates who attempted to explain the purpose of the lid to prevent 'heat from rising' from the beaker. This demonstrates a common misconception and an incorrect phrase that is used colloquially that can still be held by candidates and given in examinations when describing thermal energy transfer to surroundings.

OCR support

Our Teaching and Delivery guides identify common misconceptions that students may have and above all resources to help save time and support students in preparing for exams.

Question 4 (b) (i)

(b) The graph shows the student's results.

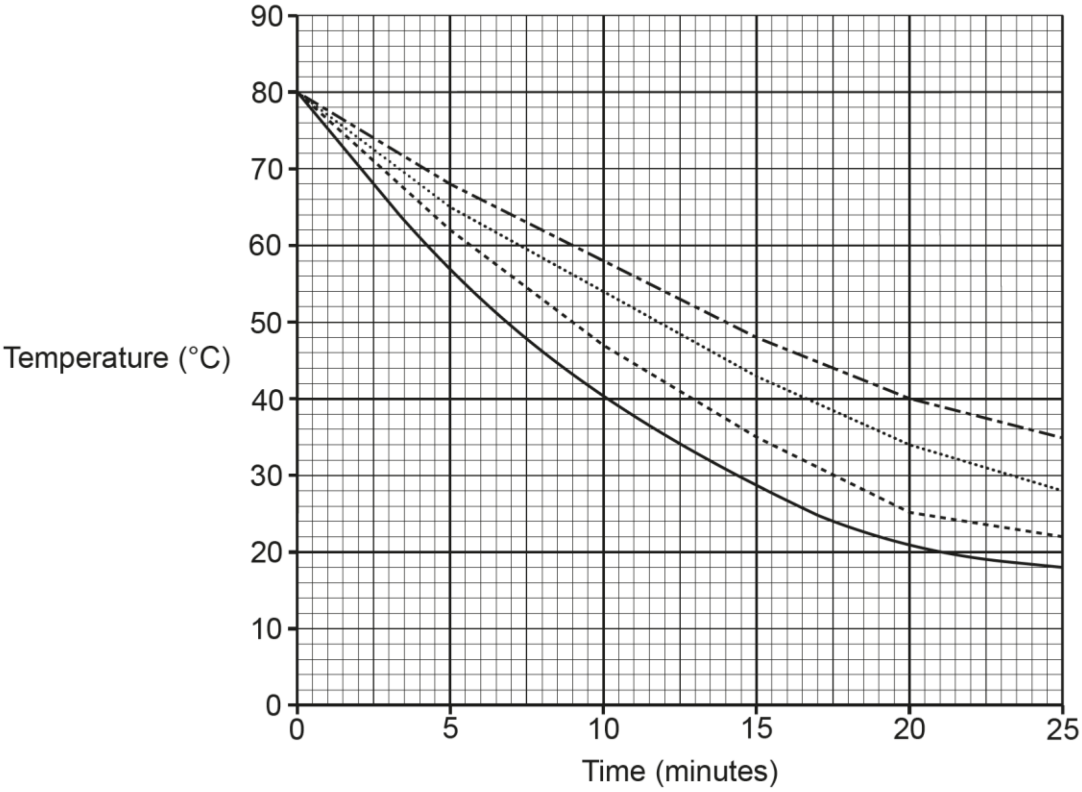
Key:

-·-·-·- 3 layers of bubble wrap

·········· 2 layers of bubble wrap

-------- 1 layer of bubble wrap

——— No bubble wrap



(i) Describe how the number of layers of bubble wrap affects the change in temperature over the 25 minutes.

....

.... **[1]**

Candidates performed well on this question as most of all candidates were able to describe the relationship between the number of layers of bubble wrap and the change in temperature by either describing that "the change of temperature decreased" or "the beaker stayed warmer with increased layers of bubble wrap".

Question 4 (b) (ii)

(ii) How does the **rate of change** in temperature of the water in each beaker change over the 25 minutes?

Use the graph.

Tick (✓) **one** box.

Decreases ☐

Increases ☐

Stays the same ☐

[1]

Candidates performed well on this question as most candidates correctly identified that the **rate of change** in temperature over time decreases.

Question 4 (b) (iii)

(iii) Explain how the graph shows this.

....

.... **[1]**

Performance on this question was variable as only half of candidates, mostly higher performing candidates, correctly explained how the graph showed a decrease in the **rate of change** of temperature to achieve 1 mark. These candidates were able to explain that the gradient of the graph decreased or explained how the line was steep then became shallower as time increased. Most candidates just described that the temperature decreased or that the gradient was negative which did not fully explain the decrease in the **rate of change** of temperature over the 25 minutes.

Question 4 (b) (iv)

(iv) The student repeats the experiment with a different material for the insulation.

This new material has the same thickness but a greater thermal conductivity in comparison to the bubble wrap.

Predict the temperature of the water after 10 minutes when the beaker is wrapped in **one** layer of the new material.

Use the graph.

Temperature of water after 10 minutes = ... °C **[1]**

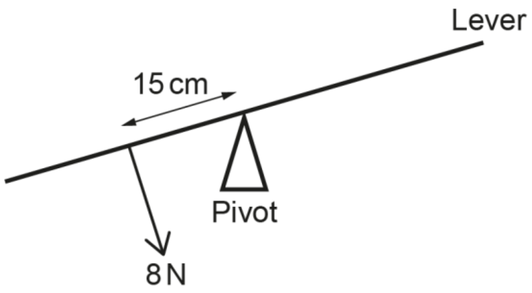
This was a more challenging question and it was mainly higher performing candidates that correctly used the graph to predict the temperature of the water for the new material. The question required candidates to determine that the temperature of the water with the same thickness of one layer of the new material with greater thermal conductivity was between 40°C < 47°C but most candidates assumed that the material had a lower thermal conductivity as they predicted a temperature > 47°C.

Question 5 (a) (i)

5 Levers and gears are used to transmit rotational forces.

(a) **Fig. 5.1** shows a simple lever with a force of 8 N applied 15 cm from the pivot.

Fig. 5.1



(i) Calculate the moment of the 8 N force about the pivot.

Use the Equation Sheet.

Give your answer in **Nm**.

Moment = ... Nm **[3]**

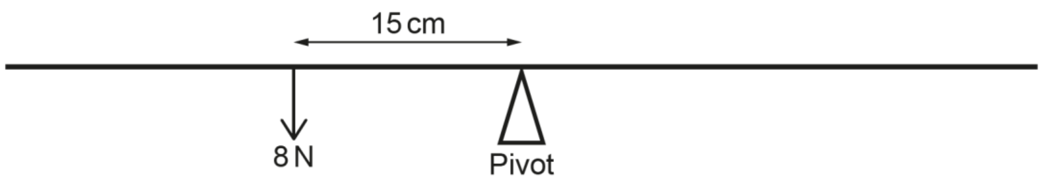
Candidates performed well on this question as most candidates achieved 3 marks for correctly calculating the moment of the simple lever as 1.2 Nm. Around a third of candidates achieved 2 marks for either omitting to convert cm to m or an incorrect conversion of cm to m.

Question 5 (a) (ii)

(ii) A second force of 4 N is applied to the lever and the lever becomes balanced.

Fig. 5.2 shows the balanced lever.

Fig. 5.2



The 4 N force is missing from **Fig. 5.2**.

Describe the direction and position that this 4 N force is applied to the lever to keep it balanced.

You can draw the 4 N force on **Fig. 5.2** or describe it in the answer space below.

....

....

....

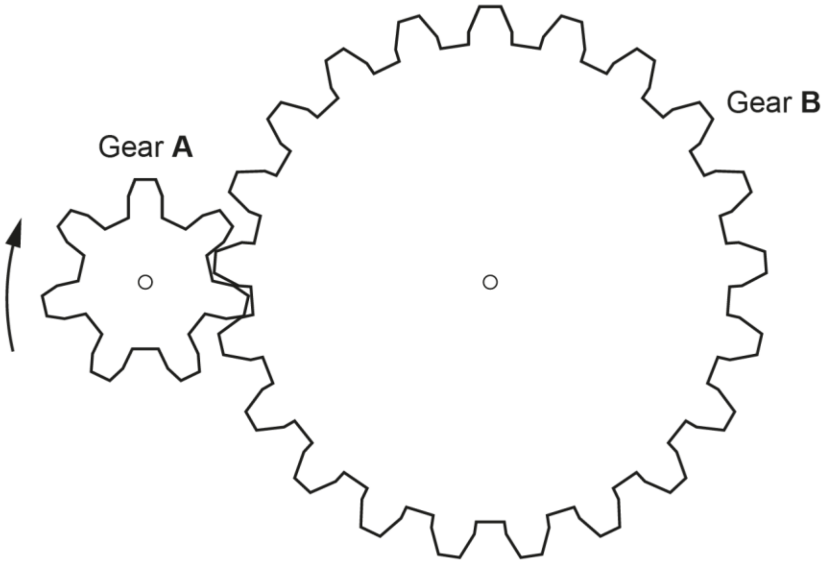
.... **[2]**

Candidates performed well on this question as candidates correctly applied the principle of moments to describe the direction and position of the 4 N force to balance the lever. Most candidates achieved the 2 marks by drawing the 4 N force acting downwards on the right-hand side of the lever with the perpendicular distance of 30 cm to the pivot correctly labelled.

Question 5 (b) (i)

(b) **Fig. 5.3** shows a simple two-gear system.

Fig. 5.3



(i) The arrow on **Fig. 5.3** shows that gear **A** is rotating in a clockwise direction.

Draw an arrow on **Fig. 5.3** to show the direction that gear **B** rotates. **[1]**

Candidates performed well on this question as most candidates correctly determined that Gear **B** would rotate anticlockwise. There were some candidates that omitted answering this question.

Exam Technique

Candidates should read each question carefully and be aware that if there is a mark given in a [ ] that it indicates a question to be answered. Candidates should be reminded to check their work, if time allows for mistakes or missed questions.

OCR support

OCR provide resources to support students prepare for the Twenty First Century Science suite of exams including 'exam hints for students'.

Question 5 (b) (ii)

(ii) Gear **A** has 7 teeth.

Gear **B** has 21 teeth.

Both gears have the same size teeth.

Gear **A** completes 3 full rotations.

Calculate the number of full rotations completed by gear **B**.

Number of full rotations = ... **[2]**

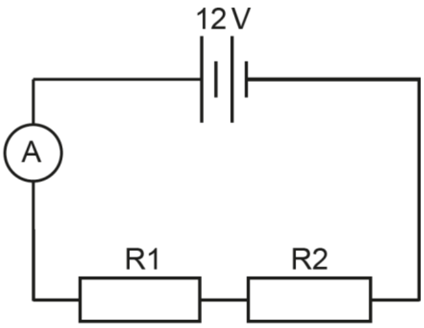
Candidates performed well on this question as most candidates correctly calculated the number of full rotations completed by gear **B** as 1. Candidates determined the ratio of 7:21 teeth and hence the ratio of 1:3 rotations for the two gears.

Question 6 (a) (i)

6 A student investigates series and parallel circuits with two resistors, R1 and R2.

(a) **Fig. 6.1** shows the series circuit they build.

Fig. 6.1



(i) Describe the change in the energy stores, when there is a current in the circuit.

....

....

....

.... **[2]**

Generally, candidates performed well on this question as around two thirds of candidates achieved 1 mark for describing a correct change in the energy stores, which was most commonly the chemical store in the battery. Around a third of candidates achieved 2 marks for either correctly describing that energy was transferred by electrical work or as the thermal store in the resistors or wires.

Misconception

A common misconception was to describe a kinetic energy store transferred from moving charges or electrical energy transferred by the current. The specification states that energy can be stored in limited ways and that the energy store of charges is electrostatic and therefore energy transferred by electric current is by electrical working.

Question 6 (a) (ii)

(ii) Show that the reading on the ammeter in the circuit in **Fig. 6.1** is less than 0.25A.

- The potential difference across the battery is 12V.
- The resistance of R1 is 30Ω.
- The resistance of R2 is 30Ω.

Use the Equation Sheet.

Reading on ammeter = ... A **[4]**

Candidates performed well on this question as most candidates achieved 4 marks for correctly calculating the reading on the ammeter. Candidates correctly selected and rearranged the equation potential difference = current × resistance and evaluated that the total resistance in the series circuit was 60 Ω to calculate the current in **Fig. 6.1**.

Question 6 (a) (iii)

(iii) Calculate the work done by the 12 V battery in 20 seconds.

Use the Equation Sheet.

Work done = ... J **[4]**

Generally, candidates performed well on this question as most of candidates achieved 4 marks for correctly calculating the work done by the 12 V battery. Candidates correctly selected either:

- charge = current × time and potential difference = work done (energy transferred) ÷ charge, or
- power = potential difference × current and power = energy transferred ÷ time

to calculate the work done.

The most common incorrect response was an attempt to apply the equation potential difference = work done (energy transferred) ÷ charge by using the current in part (a) (ii) as charge to calculate the incorrect value of 2.4 J.

Question 6 (a) (iv)

(iv) Calculate the power delivered by the 12 V battery.

Use the Equation Sheet.

State the units.

Power = ... Unit .... **[3]**

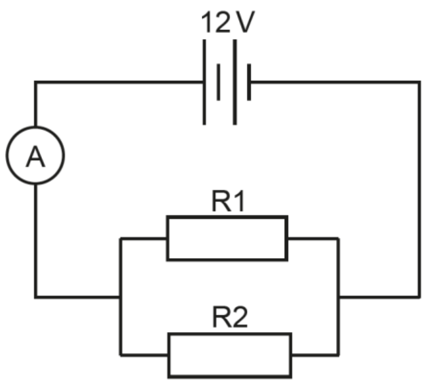
Generally, candidates performed well on this question as most candidates achieved a minimum of 1 mark for either an attempt in selecting and applying a correct equation or stating the correct units for power. Higher performing candidates performed well on this question as they commonly selected the equation power = energy transferred ÷ time and used their value of work done from part (a) (iii) to calculate the power delivered by the 12 V battery including the correct units of watts, W.

Question 6 (b) (i)

(b) The student reconnects the same components from **Fig. 6.1** so that the resistors are now in parallel.

Fig. 6.2 shows this parallel circuit.

Fig. 6.2



The resistance of R1 = 30 Ω.
The resistance of R2 = 30 Ω.

(i) Calculate the current in R1 in the circuit in **Fig. 6.2**.

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

Candidates performed well on this question as over three quarters of all candidates applied the rearranged equation resistance = potential difference ÷ current. This was then applied to the potential difference, 12 V across the resistor R1 to calculate the current in R1 as 0.4 A., Some candidates used a correct method but they calculated the total current in the **Fig. 6.2** rather than the current in R1.

Question 6 (b) (ii)

(ii) Explain why the reading on the ammeter in the parallel circuit in **Fig. 6.2** is greater than the reading on the ammeter in the series circuit in **Fig. 6.1**.

....

....

....

.... **[2]**

This was a more challenging question. Some candidates, mostly higher performing candidates were able to explain that the total resistance in the parallel circuit (**Fig. 6.2**) was less compared to the series circuit, (**Fig. 6.1**). However, they did not always develop their response to explain this as two resistors in parallel provide more paths for charges to move along than either resistor on its own, or that for the two resistors placed in series the battery has to move charges through both of them, so the current through each resistor is the same.

Misconception

?

This question demonstrated misconceptions that candidates have regarding the rules of current, potential difference and resistance. For example, candidates would describe how current was shared across the two resistors connected in a series circuit or that potential difference was shared across two resistors connected in a parallel circuit.

Question 7*

7* The Sun was formed from a cloud of dust and gas.

The dust and gas particles were pulled together by the force of gravity.
The cloud collapsed and fusion reactions started.
The Sun then became a stable star.

The table shows typical temperatures of a cloud of dust and gas and of a stable star.

	Temperature (°C)
Cloud of dust and gas	1.0×10^1
Stable star	1.5×10^7

Explain how the work done by the force of gravity on a cloud of dust and gas, forms a stable star.

Use the particle model of matter and the data in the table.

....

....

....

....

....

.... **[6]**

Candidates' performance on the Level of Response question was variable. Around two thirds of candidates either achieved a Level 1 or Level 2 response. To award a Level 3 response candidates were required to explain how the work done by the force of gravity caused the temperature of the cloud of dust and gas to increase. This would provide the conditions required for nuclear fusion and then to maintain a stable star an explanation of hydrostatic equilibrium in terms of balanced forces.

Many candidates were able to explain the conditions required for nuclear fusion but explanations using the particle model to explain how the work done by the force of gravity on a cloud of dust and gas were sometimes underdeveloped. Many candidates were able to describe that the temperature of the cloud increased but did not link this to the particle model to explain that particles would be closer together and moving faster which would increase the temperature and pressure in the cloud (and so provide the conditions required for nuclear fusion).

Only a small number of candidates, mostly higher performing candidates, gave a fully developed Level 3 response which included an explanation that for a stable star the inward force of gravity is balanced by the outward force of radiation pressure from nuclear fusion reactions.

Exemplar 1

When a stable star is being formed the first stage is called a nebula which is a cloud of dust and gas which get pulled ~~together~~ together by ~~a~~ the force of gravity and at this point it is only at 10°c. However as the cloud builds up it collapses and fusion reaction start and during this temperature increaces dramatically to ~~15,000,000~~ 15 million degrees due to all the fusion reactions which then forms a star. It goes from a gas to a solid. **[6]**

In this exemplar lower Level of Response. the conditions required for nuclear fusion as the high temperature of the stable star is linked to 'fusion reactions' rather than due to the work done on collapsing the cloud to produce high pressure and temperatures, which are the conditions required for nuclear fusion to occur. The exemplar does not include any explanation of hydrostatic equilibrium for a stable star which limits it from accessing a higher Level of Response.

Exemplar 2

Use the particle model of matter and the data in the table.

Gravity causes the cloud of dust and gas (nebula) to collapse together.
This decreases the volume causing the particles to collide with ~~the~~ each other and boundary more.
This results in work being done since force × distance = work done, the distance being how far gas & dust were pulled together and the force = gravity
This increase the temperature & density of the nebula until hydrogen nuclei fuse together (nuclear fusion) forming a protostar
The protostar continues to expand due to outwards pressure (caused by nuclear fusion) until it is ~~is~~ equal to the force of gravity (inwards force).
It reaches a point of equilibrium becoming a main sequence star or a stable star
Work can be clearly be seen done through the change in temperature from a ~~star~~ nebula ~~[illegible]~~ 1×10^{1} °C to a stable star 1.5×10^{7} °C since the work done is converted to ~~[illegible]~~ internal energy (kinetic and thermal) in the particles of gas & dust

[6]

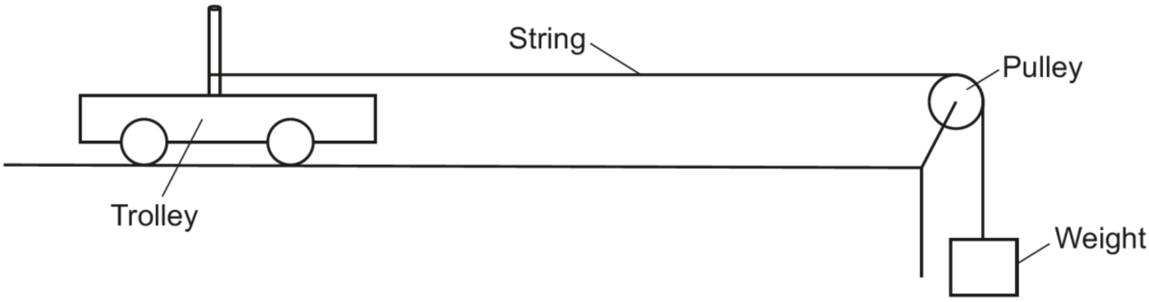
Turn over

Exemplar 2 shows a higher Level of Response. This exemplar demonstrates a clear and developed response explaining how a decrease in the volume of the cloud causes the particles to collide and the conditions required for nuclear fusion to occur including a description of nuclear fusion. The response also explains hydrostatic equilibrium for a stable star in terms of the inward gravitational forces balanced with outwards radiation pressure from fusion energy. The exemplar is communicated logically with well-structured reasoning to achieve a Level 3 response.

Question 8 (a) (i)

8 A teacher demonstrates the acceleration of a trolley along a smooth surface.

The diagram shows the equipment the teacher uses.



The trolley is connected to a weight of 5 N using a string.

When the weight falls the trolley accelerates towards the pulley.

(a) The trolley has a mass of 1.2 kg.

(i) Calculate the kinetic energy store of the trolley when it has a velocity of 0.5 m / s.

Use the Equation Sheet.

Kinetic energy store = ... J **[3]**

Candidates performed well on this question as nearly all candidates correctly selected the equation for the store of kinetic energy. Most of all candidates calculated the kinetic energy store of the trolley as 0.15 J but the most common mistake carried out by some candidates was to convert the mass of 1.2 kg to 1200 g to substitute into the equation.

Question 8 (a) (ii)

(ii) Calculate the change in momentum when the trolley accelerates from 0.5 m/s to 1.2 m/s.

Use the Equation Sheet.

Change in momentum = ... kg m/s **[3]**

Higher achieving candidates performed well on this question as most of these candidates correctly selected the equation momentum = mass × velocity to go on to calculate the change in momentum as the trolley accelerated. Lower performing candidates tended to select the equation change in momentum = resultant force × time for which it acts, and attempted to calculate time incorrectly from the change in velocity from 0.5 m/s to 1.2 m/s.

Question 8 (a) (iii)

(iii) The accelerating force on the trolley is 5 N.

Calculate the time taken for the trolley to increase its velocity from 0.5 m/s to 1.2 m/s.

Use:
- the Equation Sheet
- your answer to **(a)(ii)**.

Give your answer to **2** decimal places.

Time taken = ... s **[4]**

Performance on this question was variable as only around a half of candidates, mostly higher performing candidates, achieved 4 marks for correctly selecting and applying the equation change in momentum = resultant force × time for which it acts, using their value from part (a) (ii) to calculate the time taken to 2 decimal places. Candidates who performed less well selected the equation acceleration = (change in speed) ÷ time taken and substituted the 5 N force for acceleration to attempt to calculate the time taken. Using this equation was an alternative correct method if candidates also selected and applied the equation force = mass × acceleration.

Question 8 (b)

(b) In reality, frictional forces act on the trolley.

The actual time taken for the trolley to accelerate from 0.5 m/s to 1.2 m/s is different to the answer calculated in **(a)(iii)**.

Explain how frictional forces affect the time taken.

....

....

....

....

....

.... **[3]**

This was a more challenging question. Some candidates achieved 1 mark for describing that the time taken increased when frictional forces acted on the trolley. Around a quarter of candidates, mostly higher achieving candidates achieved 2 marks as they either explained that this was a result of either the acceleration decreasing or more commonly for energy transferred to the surroundings (from the kinetic energy store of the trolley due to the frictional force). To achieve 3 marks candidates needed to further explain the reduction in the time taken to accelerate due to either the resultant force decreasing or work being done against friction.

Question 8 (c)

(c) The teacher repeats the same experiment with a new trolley which has a greater inertial mass than the original trolley.

Explain why the statement below is **true**:

The new trolley will have a smaller acceleration than the original trolley.

....

....

....

.... **[2]**

To achieve marks, candidates were required to explain that inertial mass of an object is a measure of its resistance to any change in its motion and then relate this to the definition that inertial mass is the ratio of the force applied to the acceleration , so the trolley will have a smaller acceleration due to a greater inertial mass. The most typical response given by candidates was that a greater inertial mass required a larger force to accelerate the trolley. Candidates did not recognise that as the experiment was repeated the force applied was the same and the relationship acceleration = force ÷ mass could be applied to explain why the statement was **true**. This was a more challenging question.

Exemplar 3

(c) The teacher repeats the same experiment with a new trolley which has a greater inertial mass than the original trolley.

Explain why the statement below is **true**:

$F = Ma$

The new trolley will have a smaller acceleration than the original trolley.

Greater inertial mass means it ~~xxxx~~ has a greater tendancy ~~tendacy~~ to stay at a constant acceleration (stationary)
Require more force to change its acceleration
Since the force applied is constant (5N) the acceleration will decrease **[2]**

$F = m\uparrow \times a\downarrow$

Constant

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Exemplar 3 shows a response which demonstrates a good understanding of inertial mass in terms of the resistance to change its motion. The candidate has understood that the force applied is the same and then applied the relationship $F = ma$ to explain that when the inertial mass increases the acceleration decreases for a constant force applied.

Question 9 (a) (i)

9 Radio waves and microwaves are electromagnetic waves used for telecommunication.

(a)
(i) State **two** differences between microwaves and radio waves.

1 ....

2 ....
[2]

Candidates' performance on this question was variable. Candidates were required to state two different differences between microwaves and radio waves, but most candidates gave the two differences as frequency and wavelength which were only credited as one difference due to the relationship wave speed = frequency × wavelength. Accepted differences that could be given were difference in energy and properties such as transmission and reflection as the electromagnetic waves travel through the atmosphere for the use of telecommunication. Most candidates gave comparative differences instead of stating the differences, such as radio waves have a longer wavelength or lower frequency but there were a significant number of answers that gave contradictory differences, such as radio waves having a shorter wavelength or higher frequency when compared to microwaves.

Question 9 (a) (ii)

(ii) State **two** similarities between microwaves and radio waves.

1 ....

2 ....
[2]

Candidates' performance on this question was higher than part (a) (i). The most typical similarity stated was that microwaves and radio waves were not ionising for 1 mark. Some candidates, mostly higher performing candidates, also stated another similarity. This was most typically that the waves were transverse or travelled at the same speed. There were a significant number of candidates that stated that both waves were part of the electromagnetic spectrum, but this was not credited as it was given in the stem of the question.

Question 9 (b)

(b) Radio waves are produced in a radio transmitter.

Describe how radio waves are produced from an electrical current.

....

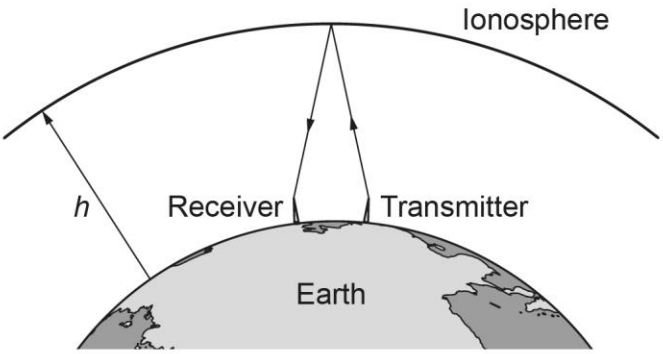
.... **[1]**

Some candidates, mostly higher performing ones, were able to recall that radio waves can be produced by oscillations in electrical circuits. This proved a more challenging question for candidates.

Question 9 (c)

(c) A radio transmitter on the surface of the Earth emits a radio wave to the ionosphere.

The radio wave reflects from the ionosphere and is detected by a radio receiver on the surface of the Earth.



Estimate the time for the radio wave to travel from the transmitter to the receiver.

The speed of radio waves is 3×10^8 m/s.

The height of the ionosphere h above the surface of the Earth is 6×10^4 m.

Assume the distance between the transmitter and receiver is very small compared to the height of the ionosphere.

The height of the transmitter and receiver are negligible.

Use the Equation Sheet.

Give your answer in **standard form**, in **seconds**.

Time = ... s **[3]**

Generally, candidates performed well on this question as under a half of candidates correctly calculated the time for the radio wave to travel from the transmitter to the receiver, expressed in standard form. The most common error was not determining that the total distance travelled by the radio wave was 12×10^4 m and instead a time value of 2×10^{-4} s was calculated using the distance 6×10^4 m. Also, there were a significant number of answers where the equation speed = distance ÷ time was incorrectly rearranged. Sometimes an incorrect answer expressed in standard form to achieve 1 mark.

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